Annex D

Report of the Sub-Committee on the Revised Management Procedure

Members: Bannister (Convenor), Allison, Almeida, Amerson, An, D., An, R., Atkinson, DeMaster, Audunsson, Baba, Baker, Bando, Bell, Bjørge, Brandão, Brierley, Brownell, Butterworth, Curtis, de la Mare, de Moor, Diallo, Donovan, Double, Elvarsson, Feindt-Herr, Fujise, Funahashi, Gunnlaugsson, Hakamada, Haug, Iñíguez, Ivashchenko, Johnson, K., Johnson, M., Kato, Ketele, Kim, Kishiro, Kitakado, Lang, Leaper, Leslie, Lundquist, Manley, Mduduzi Seakamela, Melcon, Mikhno, Miyashita, Mizroch, Monnahan, Morishita, Moronuki, Muraki, Murase, Nda, Øien, Okazoe, Palka, Pampoulie, Paniego, Panigada, Park, Pastene, Prewitt, Punt, Reeves, Rendell, Roel, Sigourney, Simeone, Sironi, Sitar, Skaug, Solvang, Tamura, Thuok, Tiedemann, Uoya, Velasco, Víkingsson, Wade, Walløe, Wang, Williams, Witting, Yasokawa, Yoshida, Zharikov.

1. CONVENOR'S OPENING REMARKS

As Convenor, Bannister welcomed the participants.

2. ELECTION OF CHAIR, APPOINTMENT OF RAPPORTEURS

Bannister was elected Chair. Punt acted as rapporteur.

3. ADOPTION OF AGENDA

The adopted Agenda is shown in Appendix 1.

4. AVAILABLE DOCUMENTS

The documents considered by the sub-committee were SC/66a/RMP01, SC/66a/RMP02, SC/66a/RMP03-RMP08, SC/66a/RMP10, SC/66a/RMP12, SC/66a/Rep04, SC/66a/Rep05, SC/66a/EM02, and relevant extracts from past reports of the Committee.

5. GENERAL ASSESSEMENT ISSUES WITH A FOCUS ON THOSE RELATED TO THE REVISED MANAGEMENT PROCEDURE (RMP)

5.1 Relationship between $MSYR_{mat}$ and $MSYR_{1+}$

SC/66a/EM02 provided a progress report on results from a two year project that uses an individually based energetics model (IBEM) to examine the relationship between $MSYR_{1+}$ and $MSYR_{mat}$. The current results are from a model parameterised with life-history characteristics that approximate those of humpback whales. Different yield curves are obtained by varying the amount of prey available to a population. This model indicates that MSY rates of 1.1% to 7% for the mature population translate into a range for MSY rates for the population aged one and above of 1.0% to 5.5%. The IBEM results in density-dependence in a wide range of demographic parameters. It produces density-dependent adult and juvenile mortality rates that decline with lower population size and pregnancy rates that increase. However, calf death rates increase at lower population sizes because more frequent pregnancies reduce some birth and weaning weights which in turn lead to a higher probability of calf deaths. Death rates for pregnant and lactating females are also higher than for resting females, an effect that is not normally included in simple age-structured models. The project will finish in the coming year and produce results from populations with life-history parameters that approximate those of minke whales. Population trajectories and summary statistics of population parameters from the results so far are available on request.

The sub-committee welcomed the update on progress, and noted that the development and parameterisation of the energetics-based model was the first step of a work plan established last year. That work plan addresses two aspects related to evaluating the energetics-based model: (a) exploration of whether a simpler model can exhibit the same dynamical behaviour as the energetics-based model and determining what can be learnt about that model based on the simpler model; and (b) examination of the data for gray and right whales to determine whether the emergent relationships from the energetics-based model are consistent with the data for these species. The sub-committee noted that diagnostic statistics and plots would need to be developed to understand the behaviour of the model more fully. It re-established the Steering Group (de la Mare [Convenor], Allison, Butterworth, Cooke, Kitakado and Punt) to coordinate intersessional work, including identification of diagnostic statistics and plots.

The sub-committee noted that the energetics-based model could be used as an operating model to evaluate *CLA* variants, but that it would be more efficient to use a simpler model that can mimic (emulate) the energetics-based model. It noted that a set of steps was identified last year (IWC, 2015b) to develop emulation models. Once fully developed and parameterised for minke whales, the energetics-based model and the emulation models should be used to conduct simulations of *CLA* performance that would then be reviewed by the Committee.

SC/66a/RMP01 outlined how density-dependence on natural mortality has been implemented for the trials to evaluate amendments of the *CLA*. It then explored the relationship between MSYR and MSYL and the parameters that define the density-dependence relationship when density-dependence operates on natural mortality. The results suggested that the joint parameter space for which $MSYR_{1+}$ is larger than 0.04 and $MSYR_{mat}$ is larger than 0.07 is small. The ratio $MSYR_{1+}/MSYR_{mat}$ was found to be virtually constant across $MSYR_{mat}$ and $MSYL_{mat}$ when density-dependence operates on natural mortality and the biological parameters are set to those on which the single stock trials are based.

The sub-committee noted that density-dependent 'fecundity' as it is modelled in SC/66a/RMP01 includes the combined effects of changes in density on fecundity, maturation, and calf survival. Future work on parameterising a yield function could explore: (1) placing constraints within simple age-structured models to avoid biologically unrealistic outcomes such as fecundity exceeding 1; and (2) simultaneously allowing for density-dependence on multiple

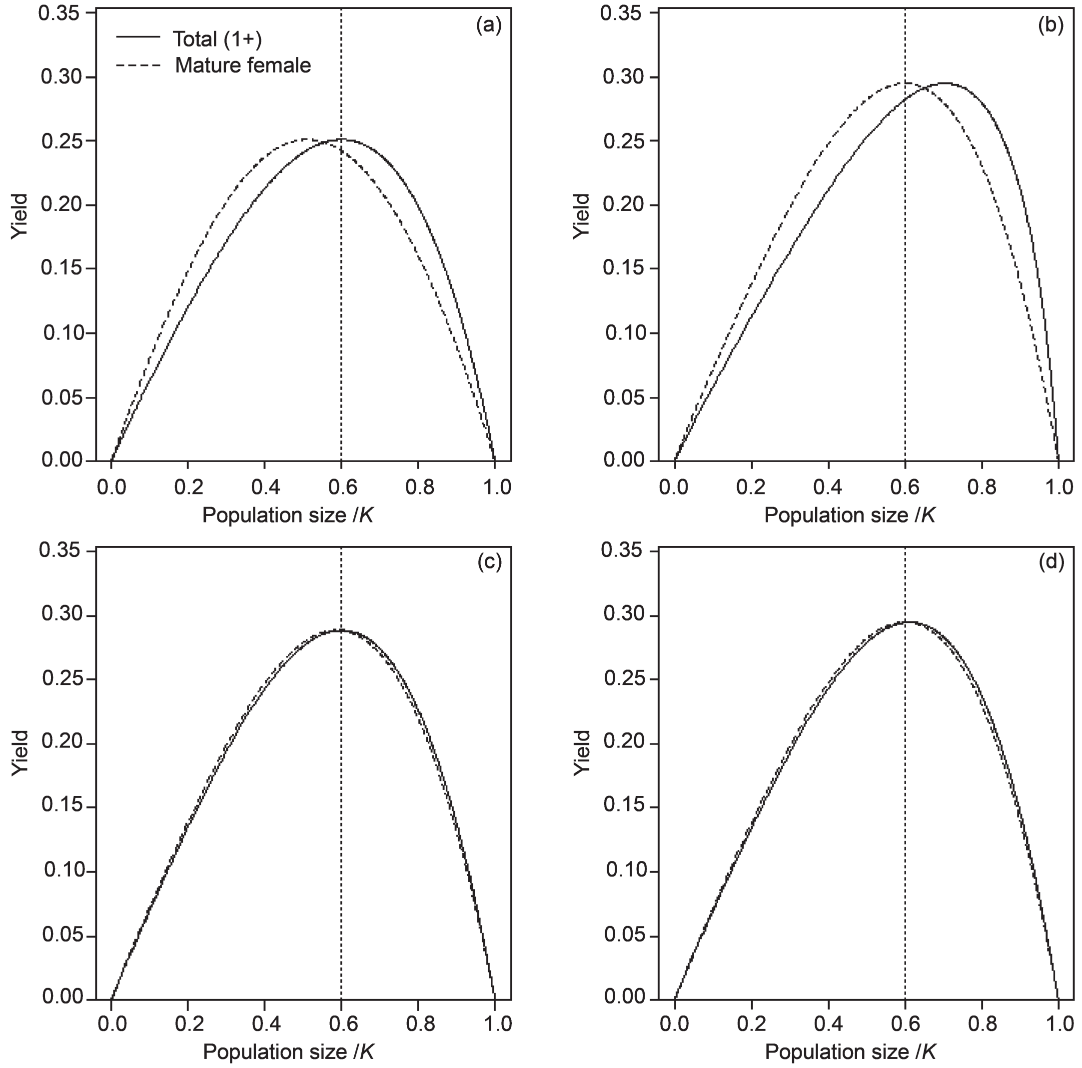


Fig. 1. Yield curves (equilibrium catch *vs* population size expressed relative to *K*). MSYR=4% pertains to harvesting of the mature female component of the population. The upper and lower panels show results when density-dependence operates on fecundity and natural mortality respectively. The left and right panels respectively show results when MSYL and density-dependence pertain to the 1+ component of the population and the mature female component of the population.

processes. The latter could be used to ensure that predicted population growth rates can match those for species such as humpbacks for which 1+ growth rates are in excess of the maximum possible when density- dependence is assumed to act on natural mortality. Full exploration of this issue may require the use of more complex population models.

5.1.1 Population component for density-dependence and MSYL

The Committee agreed in 2013 that the lower bound for MSYR for use in trials would be 1%, defined in terms of harvesting of the 1+ component of the population. It had also agreed that trials would be conducted for MSYR=4%. The sub-committee now further **agreed** that MSYR=4% would pertain to harvesting of the mature component of the population; this latter specification is consistent with how the trials used to evaluate the *CLA* were conducted.

The Committee has not specified which population component MSYL and density-dependence should relate to when conducting simulation trials. Yield curves based on standard age-structured models (Cooke and de la Mare, 1994) indicate that the yield curve for the 1+ population is always to the right of that for the mature female component of the population (i.e. setting MSYL for the 1+ component to 0.6 will lead to MSY occurring at a female population size that is less than 0.6). The extent of difference between yield curves for the 1+ and mature female components of the population increases with MSYR, and the difference between the two types of yield curves is larger when density-dependence operates on 'fecundity' rather than on natural mortality (Fig. 1). The sub-committee noted that the models used to evaluate *CLA* and RMP variants assumed that density-dependence acts on 'fecundity' or natural mortality for computational ease; in reality density-dependence probably impacts several population dynamics processes and this could be explored using a model that is more biologically explicit (e.g. the model of SC/66a/EM02).

Leaper *et al.* (2000) reviewed the then available information for baleen whales regarding the component of the population to which density-dependence applies. Although Leaper *et al.* (2000) could not draw definite general conclusions, they noted that it appears that segregation of population components on feeding grounds is the most common situation for *Balaenoptera*, although perhaps less so for *Megaptera* and *Eubalaena*. This observation would suggest that density-dependence should be a function of the mature component of the population. The sub-committee

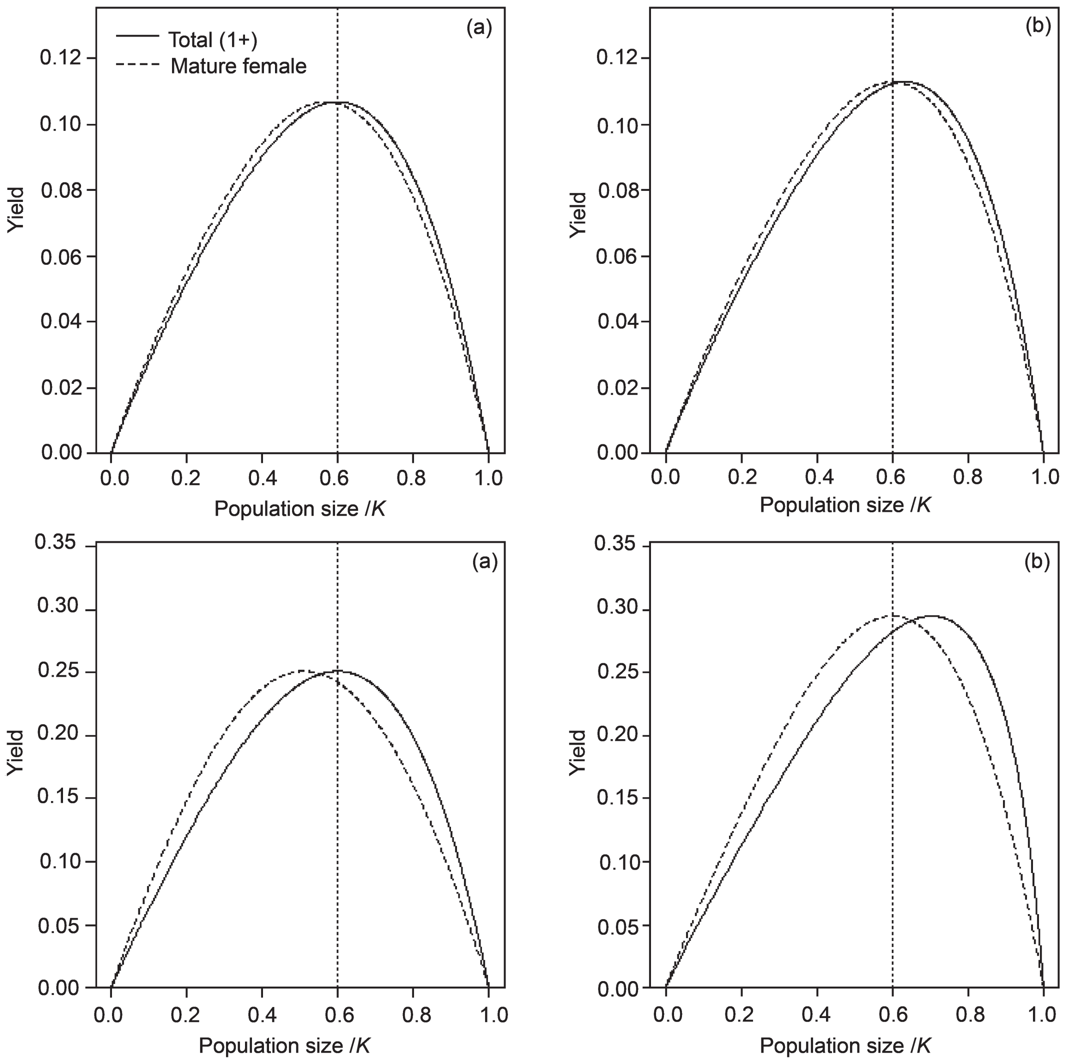


Fig. 2. Yield curves (equilibrium catch *vs* population size expressed relative to *K*) when density-dependence acts on fecundity. The upper and lower panels show results for $MSYR_{1+}$=1% and $MSYR_{mat}$=4% respectively. The left and right panels respectively show results when MSYL and density-dependence pertain to the 1+ component of the population and the mature female component of the population.

noted that the difference in yield curves was very minor for $MSYR_{1+}$=1% and not substantial even for $MSYR_{mat}$=4% (Fig. 2). It also noted that the AWMP SWG had agreed that density-dependence and MSYL should relate to the 1+ component of the population. Given the small effect evident in Fig. 2 and the previous agreement of the Committee in relation to population component for density-dependence and MSYL for AWMP work, it **agreed** that density-dependence and MSYL should relate to the 1+ component of the population for future trials.

5.2 Finalise the approach for evaluating proposed amendments to the *CLA*

The Committee had agreed in 2006 that two steps needed to be completed before the evaluation of the Norwegian proposal to amend the *CLA* could be finalised. The first was the review of MSY rates (which was completed in 2013), and the second was specification of additional trials for testing the *CLA* and amendments thereto and to the RMP. Last year, the Committee had agreed that allowing natural mortality to be density-dependent would provide a more stringent test for the impacts of environmental change; further it had recommended that the common control program be extended to allow for density-dependence to act on natural mortality, and that results of tests of the *CLA* using trials in which density-dependence acts on natural mortality be presented to the current meeting.

Punt reported that he and Johnson had modified the common control program used to evaluate *CLA* variants to allow density-dependence to act on natural mortality (SC/66a/RMP01), and that the results of tests based on both density-dependent fecundity and natural mortality were included in SC/66a/RMP10 and SC/66a/RMP12.

The Norwegian tuning of the *CLA* is based on achieving a desired median final depletion for a development (initial depletion=0.99*K*) trial (T1-D1) of 0.69 when population projections are conducted for 300 years and MSYR is 1% when harvesting is on the total (1+) population. The decision to base the tuning on 300-year projections was made because simulations across multiple projection periods indicate that population size is not stable until approximately 300 years under *CLA* management (Aldrin and Huseby, 2007; Aldrin *et al.*, 2008).

The sub-committee **agreed** that it was necessary to develop a protocol to compare the current tuning of the *CLA* with the alternative tuning proposed by Norway (and any future suggestions for amendments to the *CLA*). The Norwegian proposed (‘Alternative *CLA*’) and current tuning of the *CLA* (‘Adopted *CLA*’) differ in terms of the parameter

Table 1

Specification of the four *CLA* variants. The C and NH variants are tuned to a median final depletion of 0.723 for a trial in which $MSYR_{mat}$=1% and density-dependence and MSYL pertain to the mature female component of the population (F2-T1-D1). The CL and N variants are tuned to a median final depletion of 0.681 for a trial in which $MSYR_{1+}$=1% and density-dependence and MSYL pertain to the 1+ component of the popultion (F1-T1-D1).

	Original		Alternate	
Parameter	C	CL	NH	N
PROBABILITY LEVEL (PPROB)	**0.4020**	**0.769**	0.50	0.50
MIN MSY % (PYMIN)	0.00	0.00	0.00	0.00
MAX MSY % (PYMAX)	0.05	0.05	0.05	0.05
DEPLETION MIN (DTMIN)	0.00	0.00	0.00	0.00
DEPLETION MAX (DTMAX)	1.00	1.00	1.00	1.00
BIAS MIN (PBMIN)	0.00	0.00	0.00	0.00
BIAS MAX (PBMAX)	1.67	1.67	1.67	1.67
SCALE FACTOR (PSCALE)	4.00	4.00	4.00	4.00
PHASEOUT PERIOD (PHASET)	8.00	8.00	8.00	8.00
PHASEOUT PROPORTION (PHASEP)	0.20	0.20	0.20	0.20
ASSESSMENT CYCLE (PCYCLE)	5.00	5.00	5.00	5.00
INTERNAL PROTECTION LEVEL	0.54	0.54	0.54	0.54
CATCH CONTROL SLOPE (PSLOPE)	3.00	3.00	**1.83**	**4.7157**
ACCURACY TOLERANCE (ACCTOL)	0.00	0.00	0.00	0.00
NOFRULE	8.00	8.00	8.00	8.00
Median final depletion				
F2-T1-D1 (100 years)	0.723		0.723	
F1-T1-D1 (300 years)		0.681		0.681

modified to achieve a desired tuning (the slope parameter for the Norwegian proposal and the posterior percentile for the current tuning) as well the final population size when a stock initially at 0.99*K* is managed for 100 (or 300) years (the 'T1-D1' trial). The sub-committee **agreed** to develop two additional *CLA* tunings to allow the impact of the choice of the median final population size and the choice of parameter to tune the *CLA* to be explored separately. This results in four *CLA* variants, where for each variant the performance statistics are based on 400 replicates.

(1) Current *CLA* tuned to 0.723 for the T1-D1 trial when $MSYR_{mat}$=1% and density-dependence and MSYL act on the mature component of the population with a projection-period of 100 years (denoted **C**).
(2) Alternative *CLA* tuned to 0.723 for the T1-D1 trial when $MSYR_{mat}$=1% and density-dependence and MSYL act on the mature component of the population with a projection-period of 100 years (denoted **NH**).
(3) Current *CLA* tuned to 0.681 for the T1-D1 trial when $MSYR_{1+}$=1% and density-dependence and MSYL act on the 1+ component of the population with a projection-period of 300 years (denoted **CL**).
(4) Alternative *CLA* tuned to 0.681 for the T1-D1 trial when $MSYR_{1+}$=1% and density-dependence and MSYL act on the 1+ component of the population with a projection-period of 300 years (denoted **N**).

The tuning level for the T1-D1 trial for variants C and NH is 0.723 (rather than 0.72) because the adopted *CLA* is tuned to a median final depletion of 0.72 for the T1-D1 base-case trial based on 20,000 replicates rather than 400. The tuning level for variants CL and N is 0.681 (rather than 0.69) because of the smaller number of replicates for tuning and because of computational issues associated with the calculations conducted by Aldrin and Huseby (2007). Tuning of the current *CLA* is based on modifying the percentile parameter (fixing the slope parameter to 3), whereas tuning of the alternative *CLA* is based on modifying the slope parameter (fixing the percentile parameter to 0.5). The specifications of the four *CLA* variants are given in Table 1.

The sub-committee conducted an initial comparison of the four *CLA* variants using the same approach used by the Committee to select among the five candidate *CLA*s in 1991 (IWC, 1992b). This involves applying the four *CLA* variants to the following core set of trials:

(a) The base-case D1, S1, R1, D4, R4, D7, R7 trials when multiplicative survey bias=1; D refers to an initial population size of 0.99*K*, S to an initial population size of 0.6*K*, and R to an initial population size of 0.3*K*. '1', '4' and '7' refer to the MSY rate;
(b) D1 and R1 with sightings bias=0.5 (trial T2); and
(c) D1, R1 and S1 with sightings bias=1.5 (trial T3).

These trials were conducted for: (1) $MSYR_{mat}$=1% when density-dependence and MSYL act on the mature component of the population; and (2) $MSYR_{1+}$=1% when density-dependence and MSYL act on the 1+ component of the population, with a projection-period of 100 years and 400 replicates.

The results of these trials were used to compute the set of comparison statistics as used by the Committee in 1991 (Fig. 3; Table 2).

The sub-committee noted that the Committee had recommended three tunings of the *CLA* (tunings of the 'C' procedure to achieve median final depletions of 0.6, 0.66 and 0.72 for the T1-D1 trial when $MSYR_{mat}$=1%) to the Commission in 1991. The sub-committee therefore **agreed** that the minimum requirement for any amendment to the *CLA* that could be recommended for possible adoption by the Commission would be that its performance on conservation-related statistics be no poorer than the lowest of these three tunings of the 'C' procedure.

Specifically, the sub-committee **agreed** that lower 5% percentiles of the final and lowest depletion distributions

Table 2

Trials in the core set used to evaluate the performance of the currently implemented *CLA* (IWC, 1992a).

			Trial		
	Description	MSYR	1%	4%	7%
T.1	Age structured model, maturity=7 years				
	D=Development (initial population 0.99*K*)		T1-D1	T1-D4	T1-D7
	R=Rehabilitation (initial population 0.30*K*)		T1-R1	T1-R4	T1-R7
	S=Sustainable (initial population 0.60*K*)		T1-S1		
T.2	Survey bias 0.5		T2-D1		
			T2-R1		
T.3	Survey bias 1.5		T3-D1		
			T3-R1		
			T3-S1		

for the T1-D1, T1-S1, and T1-R1 trials when $MSYR_{1+}$=1% should be no less than the values achieved by the 0.6 tuning of the 'C' procedure when it is applied to trials in which $MSYR_{mat}$=1% and the projection period is 100 years. The trials for evaluating performance are based on $MSYR_{1+}$=1% rather than $MSYR_{mat}$=1% because the Committee decided in 2013 that the lowest value for MSYR in trials would be $MSYR_{1+}$=1%. The sub-committee noted that a *CLA* variant that satisfies this conservation criterion would need further review before it could be presented for possible adoption by the Commission. In particular, trade-offs between conservation performance and catch would need to be considered, as well as the results of additional trials (e.g. those listed in Tables 1 and 2 of SC/66a/RMP10).

The sub-committee **agreed** that the evaluation of the Norwegian variants would occur in two stages: (1) a review of performance for the original trials used to choose the 'C' procedure in 1991 (IWC, 1992a; 1992b; Table 2); (2) if the results from (1) showed that it had acceptable conservation performance and superior catch performance, then the procedure would be further evaluated against the set of additional trials for evaluation agreed in 2006 (IWC, 2007).

5.3 Complete evaluation of the Norwegian proposal for amending the *CLA*

SC/66a/RMP10 and SC/66a/RMP12 included results from trials specified by the Committee to evaluate the performance of the adopted *CLA* and an amendment to the *CLA* proposed by Norway in 2004. Results included trials in which density-dependence impacted fecundity and natural mortality for both 100- and 300-year projection periods. Summary statistics (total catch, final population size, lowest population size and average annual catch variation (AAV)) were reported for the base-case trials in SC/66a/RMP10, along with 'response curve' plots for ranges in depletion, error in catch, and survey bias. SC/66a/RMP12 included 'Zeh plots' (IWC, 1992a; 1992b) for the larger range of trials, including those related to the effects of possible environmental degradation.

The full set of 'Zeh plots', detailed results for all of the trials considered, as well as comparison plots for the four *CLA* variants identified by the sub-committee as necessary for the evaluation of the amendment to the *CLA*, are shown in Appendix 2.

5.3.1 Review of results

The Committee then reviewed the Norwegian proposal for a *CLA* using the procedure outlined in Item 5.2.

The conservation performance of the CL variant (see Item 5.2 for the definitions of the *CLA* variants considered in this section) was markedly poorer than that of the N variant (a value for the lower 5th percentile for the final and lowest depletion distributions much lower than that of N variant) even though these two variants were tuned to the same median final depletion for the T1-D1 trial (Fig. 4). This result was expected because variant CL had a value for the posterior percentile parameter of 0.769 (Table 1), i.e. the CL variant has the undesirable property that increased uncertainty would lead to higher rather than lower catch limits. The sub-committee **agreed** that the conservation performance of the CL variant was unacceptable and that variants of the *CLA* in which the posterior percentile parameter exceeds 0.5 should not be considered for possible adoption in the future.

The sub-committee then focused on the comparison between the C and N variants. These variants achieve different performance metrics because they are tuned to different median final depletions. However, both variants could in principle be chosen to be the *CLA*, in particular because neither of these *CLA* variants has a posterior percentile larger than 0.5.

Fig. 5 compares the catch and conservation performance of variants C and N graphically. The C variant satisfies the criterion that conservation performance is no worse than that of the 0.6 tuning of the 'C' procedure. The N variant achieves a median final depletion for the T1-D1 trial of 0.6 (i.e. is equivalent to the 0.6 tuning of the 'C' procedure in this respect). However, the final depletion distribution for the N variant is wider than that of the 0.6 tuning of the 'C' procedure. Consequently, the lower 5th percentiles of the lowest and final depletion distributions for the N variant are

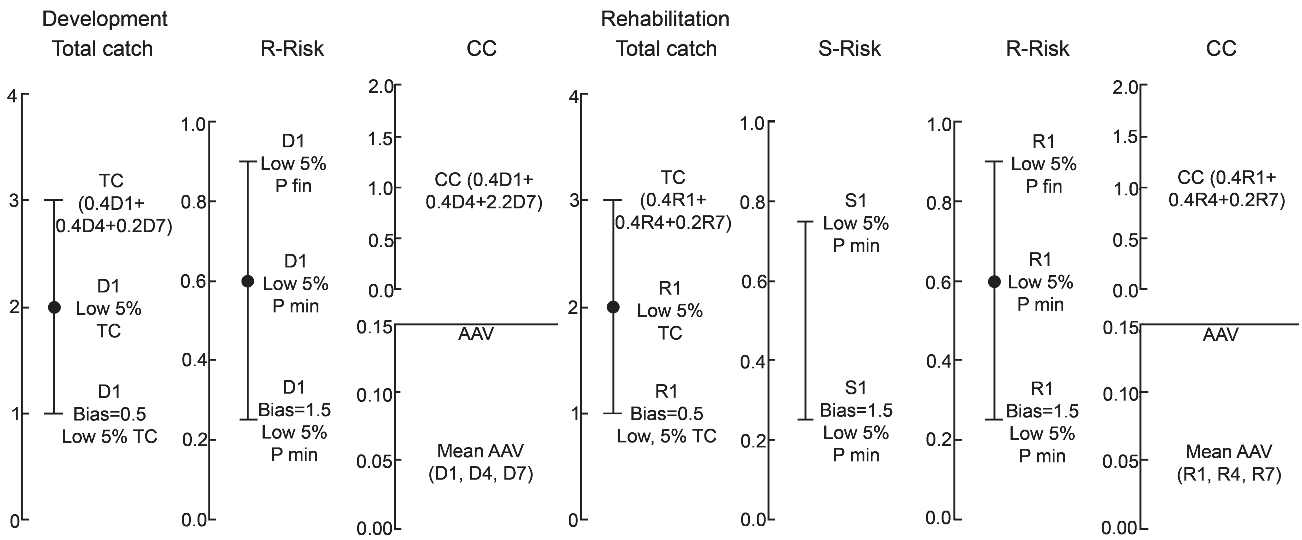


Fig. 3. A key to comparison statistics plotted for each of the *CLA* variants in Fig. 4. Statistics are calculated similarly for the 'Development' (D; initial depletion=0.99*K*) and 'Rehabilitation' (R; initial depletion=0.3*K*) plots. Additional S-Risk (S; initial depletion=0.6*K*) statistics are included in the 'Rehabilitation' plots. Values related to total catch (TC), final population size (P fin), lowest population size (P min), continuous catch (CC), and average annual catch variation: AAV; IWC (1991) are plotted from left to right for each plot type. TC, CC, and AAV are weighted averages of results from three maximum sustainable yield rates (0.01, 0.04, and 0.07) where weights are unequal (0.4, 0.4, and 0.2) for TC and CC and equal for AAV. Some statistics are reported for when survey results are biased, either low (0.5) or high (1.5), denoted with 'Bias'. The CC is the average over the last ten years of the projection period of the lower of the catch and the 'sustainable yield' (IWC, 1992a). The 'sustainable yield' is actual long-term equilibrium replacement yield for population sizes below MSYL or the MSY for population sizes above MSYL (IWC, 1992a).

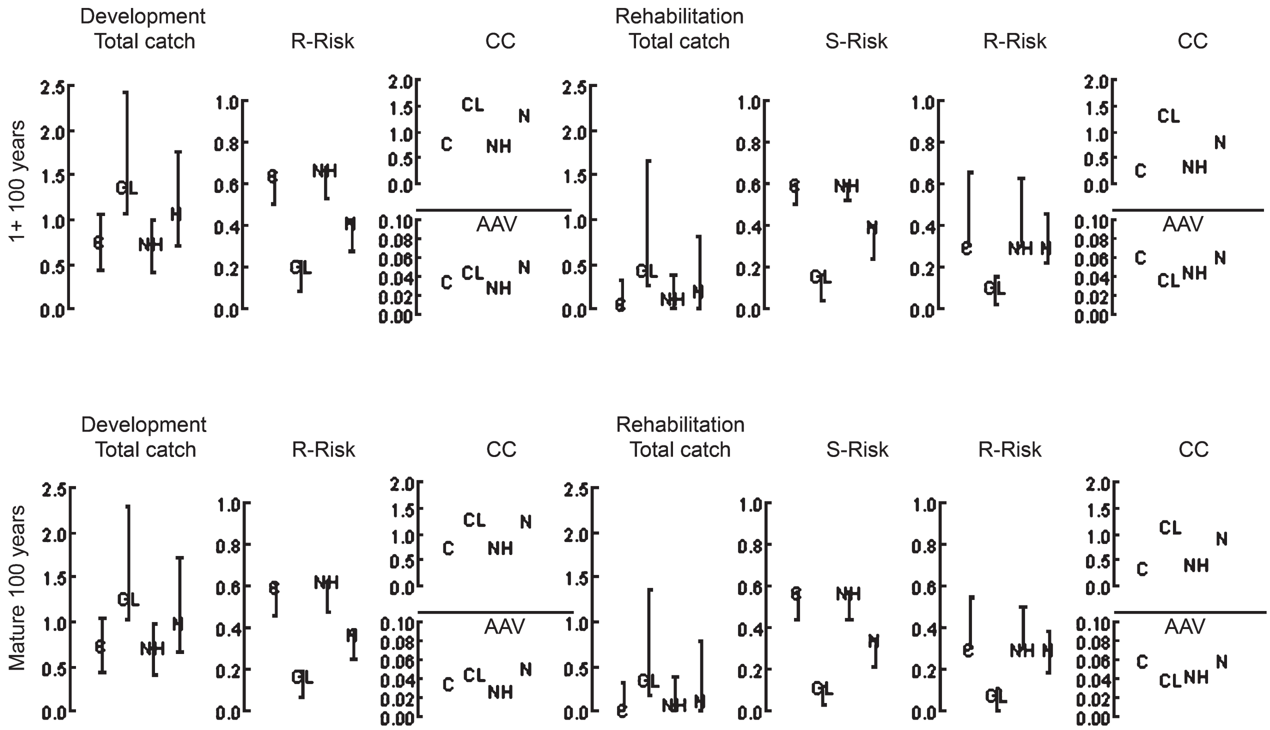


Fig. 4. Comparison statistics for four *CLA* variants for when density-dependence, MSYR, and MSYL pertain to the total (1+) (upper panel) or mature (lower panel) component of the population, using a 100-year projection period. *CLA* variants C and CL involved probabilities of 0.4020 and 0.769 and a slope of 3.0, respectively. *CLA* variants NH and N involved a probability of 0.500 and slopes of 1.83 and 4.7157, respectively. Total catch and population size statistics are expressed relative to carrying capacity.

less than those of the 0.6 tuning of the *CLA*. Given this, the sub-committee **agreed** that the conservation performance of this variant, whilst considerably better than the CL variant, was insufficient for the sub-committee to recommend it for continued evaluation using the 2007 trials. It was noted that the catch performance of the CL variant was superior to that of the N variant, but that this came at the expense of satisfactory conservation performance.

The sub-committee speculated that the conservation performance of the N variant might be due to the parameter chosen to tune it (the slope parameter), and that basing tuning on other parameters such as the maximum MSY rate parameter (perhaps in addition to the slope parameter) could lead to narrower distributions for final and lowest population size.

The sub-committee **agreed** that this concludes the review of the proposed Norwegian amendment to the *CLA*. The sub-committee wished to express its considerable thanks to Kelli Johnson without whose tireless work to run ever increasing numbers of trials and produce additional tables and figures, it would not have been possible to complete the review of the proposed amendment. The sub-committee also wished to acknowledge Cherry Allison whose immaculate record keeping meant that it was possible to reconstruct the approaches used by the Committee to select a *CLA* in 1991.

5.4 Other computing matters related to the *CLA*

Allison noted that the Norwegian implementation of the *CLA* is included in the common control program and this was the version of the program used in the evaluation of the Norwegian proposal for an amendment to the *CLA*. Punt advised that some of the simulations included in SC/66a/RMP10 and SC/66a/RMP12 failed to complete because the Norwegian implementation of the *CLA* issued an error message. The sub-committee **recommended** that any error messages encountered in simulations be communicated by the Secretariat to the Norwegian Computing Centre who developed this implementation of the *CLA* as such problems need to be resolved.

5.5 Requirements and Guidelines for conducting surveys and *Implementations*

The existing Committee's Requirement and Guidelines were written for design-based surveys only. Recently, the Committee recognised a need to consider what circumstances might require approval when the survey and analysis are conducted based on spatial modelling or quasi design-based approaches. The Committee agreed in 2012 (IWC, 2013) that a review of this issue should take place intersessionally, but due to the unavailability of contracted experts during the last intersessional period, comprehensive discussion will be deferred to 2016.

The sub-committee was advised that Bravington would continue to be involved in conducting this review and developing a guidelines manual related to how to conduct survey analyses based spatial modelling or quasi design-based approaches. This work is expected to be completed by the 2016 Annual Meeting. The sub-committee noted that a demonstration of the software implementing the analysis method should occur, preferably during a Workshop held as a pre-meeting to SC/66b. This Workshop would test the guidelines against several test cases of model-based abundance estimation.

The sub-committee established a Steering Group under Butterworth (Chair) with members Bravington, Cooke, Kitakado and Leaper, to co-ordinate intersessional work, develop an agenda for the Workshop and facilitate preparations for the Workshop.

5.6 Work plan

Before the 2016 Annual Meeting	During the 2016 Annual Meeting
(1) Conduct work to evaluate the energetics-based model (Item 5.1): (a) produce a table of model outputs (de la Mare); (b) develop emulator models (de la Mare, Butterworth, Punt, Cooke)[1]; (c) conduct simulations of the *CLA* for the energetics-based model (de la Mare); and (d) conduct simulations of the *CLA* for the emulator models (de la Mare, Butterworth, Punt, Cooke)[1].	(1) Review intersessional progress on evaluating the energetics-based model (Item 5.1).
Develop simple-to-use diagnostic software that uses model-based analysis to assist in evaluating design based estimates (Bravington and David Miller [CREEM], Item 5.5).	Hold a pre-meeting Workshop with Terms of Reference: (i) to test proposed new Guidelines against several test cases of model-based abundance estimates developed specifically for and during the Workshop; and (ii) to demonstrate and discuss the proposed diagnostic software with a wider Committee audience. There will be costs involved for travel and subsistence (Item 5.5).

[1]This is a multi-year process – completion of these tasks depends on progress relative to issues (a) and (b).

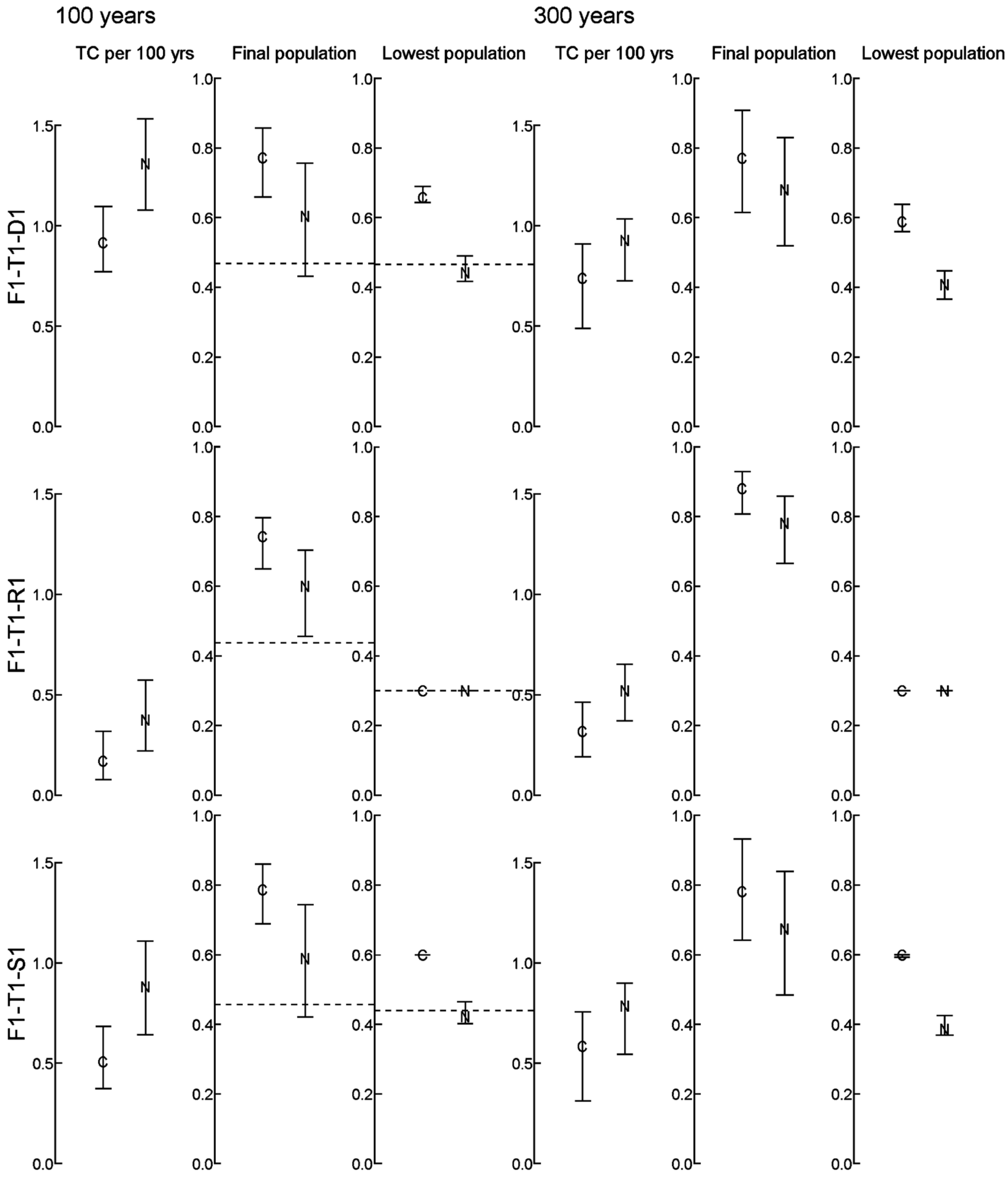


Fig. 5. Comparison of the performance of the C and N variants for total catch (TC), final population size and lowest population size for three trials (T1-D1, T1-R1, and T1-S1) when $MSYR_{1+}$=1% and density-dependence and MSYL pertain to the 1+ component of the population. Results are shown for 100- and 300-year projection periods. The horizontal dashed lines in the final and lowest population columns for the 100-year projection period indicate the performance of the 0.6 tuning of the 'C' procedure when $MSYR_{mat}$=1%. Total catch and population size statistics are expressed relative to carrying capacity.

Table 3

The *Implementation Simulation Trials* for North Atlantic fin whales. All trials assume the following unless otherwise stated: the 'best' catch series; future surveys will occur in sub-areas EG, WI and EI/F; and $g(0)$ is taken to be equal to 1.

Trial no.	Stock hypothesis	$MSYR_{mat\,\%}$	No. of stocks	Trial weight	Trial description
Baseline					
NF-B1	I	1,2.5,4%	4	H	Base case: 4 stocks, separate feeding areas
NF-B2	II	1,2.5,4%	4	M	4 stocks; 'W' and 'E' feed in central sub-areas
NF-B3	III	1,2.5,4%	4	M	4 stocks; 'C1' and 'C3' feed in adjacent sub-areas
NF-B4	IV	1,2.5,4%	4	M	4 stocks without sub-stock dispersion (i.e. no interchange)
NF-B5	V	1,2.5,4%	4	M	4 stocks as in hypothesis I but stock 'S' in adjacent sub-areas
NF-B6	VI	1,2.5,4%	3	M	3 stocks (no 'E' stock)
NF-B7	VII	1,2.5,4%	4		4 stocks as in hypothesis III but WI/EG are combined; 2 'C' sub-stocks
NF-B8	VIII	1,2.5,4%	4		4 stocks as in hypothesis IV but WI/EG are combined; 2 'C' sub-stocks (no dispersal)
Other factors					
NF-H1	I	1, 4%	4	M	High historical catch series
NF-H3	III	1, 4%	4	M	High historical catch series
NF-H4	IV	2.5, 4%	4	H	High historical catch series
NF-X3	III	1, 4%	4	M	N Iceland catch including in WI sub-area
NF-P3	III	1, 4%	4	M	Survey WI only with greater precision
NF-Q3	III	1, 4%	4	M	Future WI and EI/F surveys exc. strata S 60ºN
NF-A3	III	1, 4%	4	M	Pro-rate abundance data for conditioning
NF-C3	III	1, 4%	4	M	Inc. CPUE data in the likelihood calculation
NF-T1	I	1, 4%	4	M	Tag loss=20% in year 1; 10%/year thereafter
NF-T3	III	1, 4%	4	M	Tag loss=20% in year 1; 10%/year thereafter
NF-T4	IV	1, 4%	4	M	Tag loss=20% in year 1; 10%/year thereafter
NF-U1	I	1, 4%	4	M	Selectivity decreases by 4%/year for age 8+; M=0.04
NF-W1	I	1, 4%	4	M	Weight tag likelihood by factor of 10
NF-G1	I	1, 4%	4	M	C2 sub-stock enters EG beginning year 1985 (opt. a)
NF-G3	III	1, 4%	4	M	C2 sub-stock enters EG beginning year 1985 (opt. a)
NF-F1	I	1, 4%	4	M	C2 sub-stock enters EG 1985-2025 (opt. b)
NF-F3	III	1, 4%	4	M	C2 sub-stock enters EG 1985-2025 (opt. b)
NF-S3	III	1, 4%	4		Selectivity estimated for pre and post 2007
NF-S4	IV	1, 4%	4		Selectivity estimated for pre and post 2007
NF-Y3	III	1, 4%	4		8 year future survey interval
NF-Y4	IV	1, 4%	4		8 year future survey interval
NF-R3	III	1, 4%	4		Exclude tags recaptured after one year
NF-R4	IV	1, 4%	4		Exclude tags recaptured after one year

6. RMP – *IMPLEMENTATION*-RELATED MATTERS

6.1 North Atlantic fin whales (*Implementation Review*)

6.1.1 Report of the intersessional Workshop

Donovan reported on the intersessional Workshop on the *Implementation Review* for North Atlantic fin whales held in Copenhagen from 16-20 February 2015 (SC/66a/Rep04). This Workshop was approved by the Scientific Committee in 2014 (IWC, 2015a, p.76) to further the work on the *Implementation Review* for North Atlantic fin whales. The Committee has developed an initial trials structure and work has commenced to code the trials and condition them. The objectives of this Workshop were to: (a) review the conditioning of the trials; (b) update the specifications of the trials by defining a full set of sensitivity tests; and (c) discuss management variants to consider intersessionally.

The Workshop was a technical workshop, and a considerable amount of time was spent undertaking and reviewing the conditioning of the trials that had been agreed at the 2014 Scientific Committee meeting. The trials structure is complex (e.g. there are eight stock structure hypotheses – see Fig. 6) and thus satisfactory conditioning is a major task. Fits of the operating model to three data sources were examined: abundance estimates; age-compositions; and *Discovery* mark data. After examining the data it was agreed that conditioning should be based upon all of the data apart from the early (1967 and 1969) age-composition data and the 2007 abundance estimates for the sub-area EI-F as these were not comparable with the rest of the series.

After reviewing all of the available conditioning results, the Workshop concluded that none of the fits were sufficiently poor for any of stock-structure hypotheses to be rejected from further consideration at this stage (SC/66a/Rep04, table 2). It noted that the quality of the fits to the data used for conditioning can be taken into account when plausibility ranks are assigned to individual trials. In this context the Workshop stated that that the best fits were for the trials based on Hypotheses I, II, III, V and VII for $MSYR_{mat}$=4% and Hypothesis VI for both MSY rates. The Workshop agreed that these trials should form the focus for the sensitivity tests, but it was not possible to undertake the conditioning of these at the Workshop.

The Workshop agreed to drop the 'bridging' trials. In addition, as a result of the satisfactory fits to the data by the base-case trials, the Workshop agreed that trials considering alternative starting years as well as those allowing for density-dependent and -independent dispersal between sub-areas were no longer needed.

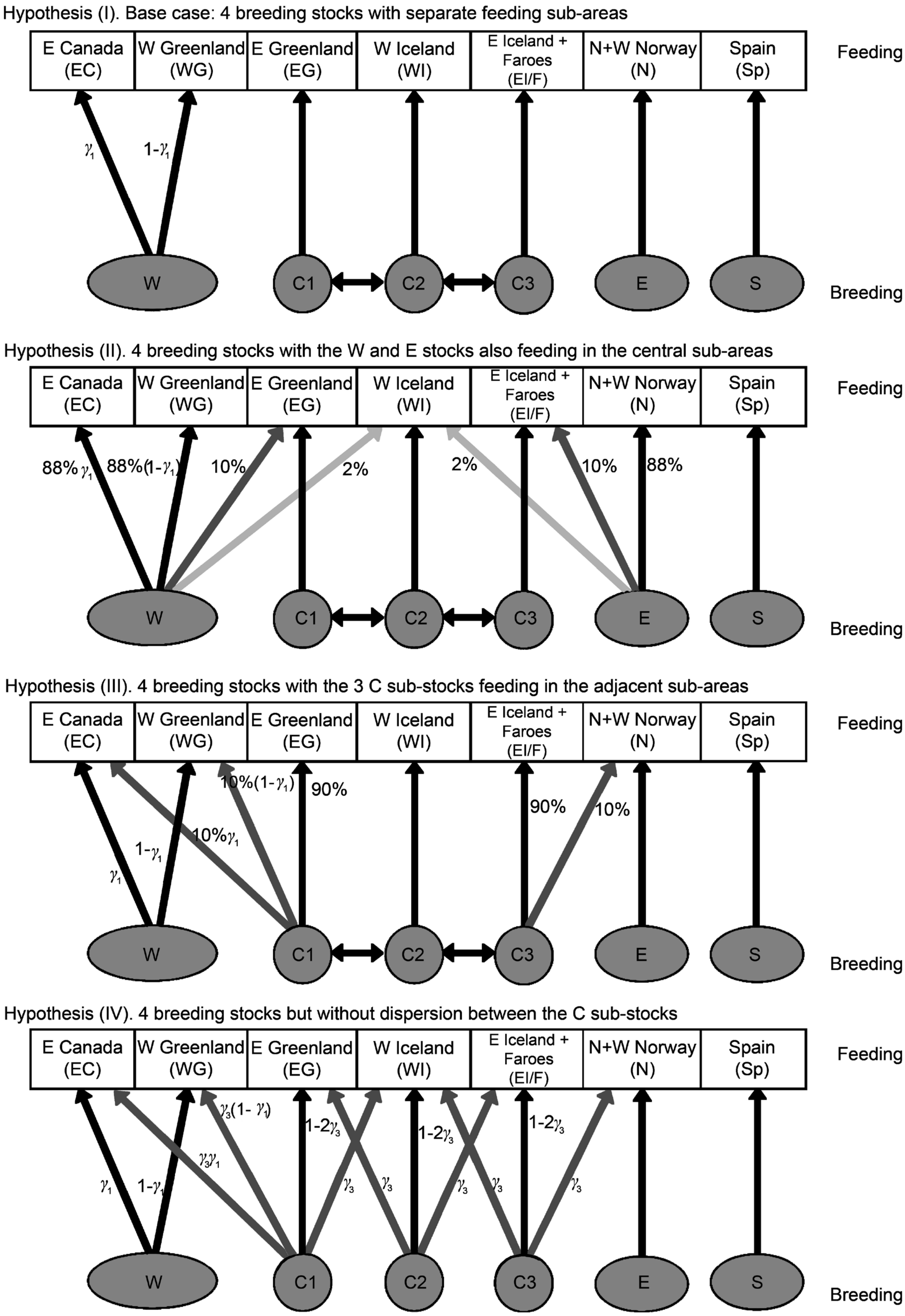
The final revised trials specifications are summarised in Appendix 3 and listed in Table 3.

In the light of a change in the distribution of fin whale catches by Iceland (and the fin whales themselves) in 2014, Iceland wished consideration of at least one variant that allowed for catching in sub-area EI. The revised list of management variants is therefore as follows.

(a) Based on calculating catch limits by *Small Area*:

V1: Sub-area WI is a *Small Area*;

V2: Sub-areas WI+EG is a *Small Area*. All of the catch is taken in sub-area WI;


Hypothesis (I). Base case: 4 breeding stocks with separate feeding sub-areas
E Canada (EC)
W Greenland (WG)
E Greenland (EG)
W Iceland (WI)
E Iceland + Faroes (EI/F)
N+W Norway (N)
Spain (Sp)
Feeding
γ_1
1-γ_1
W
C1
C2
C3
E
S
Breeding
Hypothesis (II). 4 breeding stocks with the W and E stocks also feeding in the central sub-areas
E Canada (EC)
W Greenland (WG)
E Greenland (EG)
W Iceland (WI)
E Iceland + Faroes (EI/F)
N+W Norway (N)
Spain (Sp)
Feeding
88% γ_1
88%(1-γ_1)
10%
2%
2%
10%
88%
W
C1
C2
C3
E
S
Breeding
Hypothesis (III). 4 breeding stocks with the 3 C sub-stocks feeding in the adjacent sub-areas
E Canada (EC)
W Greenland (WG)
E Greenland (EG)
W Iceland (WI)
E Iceland + Faroes (EI/F)
N+W Norway (N)
Spain (Sp)
Feeding
10%(1-γ_1)
90%
10%γ_1
1-γ_1
γ_1
90%
10%
W
C1
C2
C3
E
S
Breeding
Hypothesis (IV). 4 breeding stocks but without dispersion between the C sub-stocks
E Canada (EC)
W Greenland (WG)
E Greenland (EG)
W Iceland (WI)
E Iceland + Faroes (EI/F)
N+W Norway (N)
Spain (Sp)
Feeding
γ_3(1- γ_1)
$\gamma_3\gamma_1$
γ_1
1-γ_1
1-2γ_3
1-2γ_3
1-2γ_3
γ_3
γ_3
γ_3
γ_3
γ_3
W
C1
C2
C3
E
S
Breeding

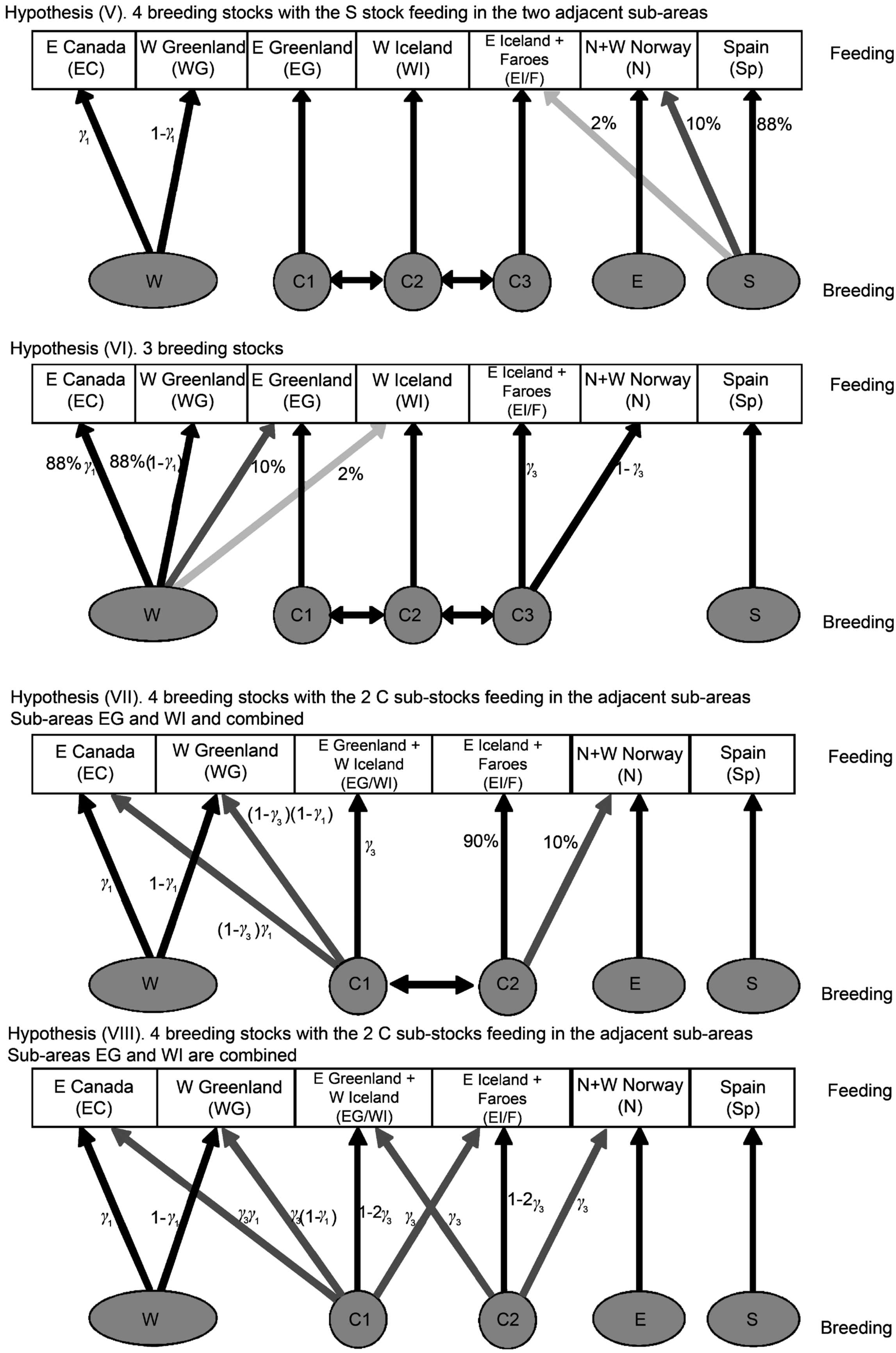


Fig. 6. Stock structure hypotheses for North Atlantic fin whales.

V3: Sub-areas WI+EG+EI/F is a *Small Area*. All of the catch is taken in sub-area WI; and

V4: Sub-area WI is a *Small Area*. Catch limits will be set based on survey estimates for the WI sub-area north of 60°N (both historical and future surveys)[1]. The catch series is unchanged as all historical catches in sub-area WI were taken north of 60°N.

(b) Based on applying catch cascading:

V5: Sub-areas WI and EG are taken to be *Small Areas* and sub-areas WI+EG are taken to be a *Combination Area*. The catch limits set for the EG *Small Area* are not taken;

V6: Sub-areas WI, EI/F and EG are taken to be *Small Areas* and sub-areas WI+EI/F+EG are taken to be a *Combination Area*. The catch limits set for the EG and EI/F *Small Areas* are not taken; and

V7: Sub-areas WI+EG and EI/F are taken to be *Small Areas* and sub-areas WI+EI/F+EG are taken to be a *Combination Area*. The catch limits set for the WI+EG *Small Area* are taken in sub-area WI.

The catch limit for the sub-area EI/F is taken there.

The Workshop had agreed that considerable intersessional work was required for the Committee to be able to complete the *Implementation Review* by the 2015 Annual Meeting and it recognised that this may not be possible. This work related to: (1) finalising any outstanding coding required (and updating associated datasets); (2) completing the conditioning; and (3) running the revised trials and presenting the results in the standard format. A Steering Group was established to facilitate progress.

The sub-committee thanked Donovan for chairing the Intersessional Workshop and the participants for their work during the Workshop and subsequently, in particular Elvarsson, Allison and de Moor. It **endorsed** the Workshop recommendations.

6.1.2 Intersessional progress

Allison noted that substantial changes had been made to the control program implementing the trials during the intersessional period. The sub-committee took note of the updated specifications for the trials (Appendix 3). It **agreed** that the pseudo age composition data used when conditioning the operating model be generated from a multinomial distribution with expected values given by the fit of the operating model to the actual data for North Atlantic fin whales, and an overdispersion parameter computed using the approach of McAllister and Ianelli (1997).

6.1.3 Implementation Review

SC/66a/RMP02 presented the distribution of fin whale catches by Iceland in 2014. This distribution was unlike that in any previous season for which catch positions exist. The season started with good catches on the traditional whaling grounds west of Iceland, but very few fin whales were seen there by the start of July, and by mid-July, after intensive searching, the whalers turned to successfully hunt in the southern area. The whalers had little reason to search the western grounds again as the sailing time to the southern grounds is even shorter. The 2014 fin whale distribution was more in line with the distribution of sei whale catches in earlier seasons. SC/66a/RMP02 also analysed sightings of the whalers per search hour in this southern area for the three periods 1979-85, 86-89 and 2014. The frequency of blue and humpback whale sightings has increased (doubled) in this area as also seen in other areas, and indicated from dedicated sighting effort. Sei whale occurrence has fluctuated greatly and was higher during the 1979-85 than during 2014. Fin whale sightings (n=378) were tenfold higher in 2014 than during the first period. Sighting surveys (1987 to 2007) had shown an increase in fin whale densities, in particular in the Irminger Sea (including the western grounds). It is uncertain if the fin whales had moved to the southern area or into other areas. In general, a northward shift has been observed in this ecosystem, so that the fin whales in the south area might well have come from farther south.

Gunnlaugsson suggested that the information in SC/66a/RMP02 be taken into account when assigning plausibility ranks to the *Implementation Simulation Trials* for North Atlantic fin whales.

Allison advised that given workload issues, it had been impossible to complete coding of the *Implementation Simulation Trials*. This precluded completion of the *Implementation Review* at the present meeting.

6.1.4 Recommendations

The sub-committee developed a work plan for the intersessional period. It re-established the Steering Group under Elvarsson (Chair), with members Allison, Butterworth, de Moor, Donovan, Gunnlaugsson, Punt and Witting, to assist with implementing the intersessional work plan.

6.2 North Atlantic common minke whales (*Implementation Review*)

6.2.1 Report of the intersessional Workshop

Donovan reported on the intersessional Workshop on the *Implementation Review* for North Atlantic common minke whales held in Copenhagen from 16-20 February 2015 (SC/66a/Rep05). This Workshop was approved by the Scientific Committee in 2014 (IWC, 2015a, p.76) to further the work on the *Implementation Review* for North Atlantic common minke whales which it hoped will be completed in 2015. The Committee has developed an initial trials structure and work has commenced to code the trials and condition them. The objectives of this workshop were to: (a) review progress with the conditioning of the trials; (b) finalise trial specifications; and (c) specify the management variants to consider intersessionally.

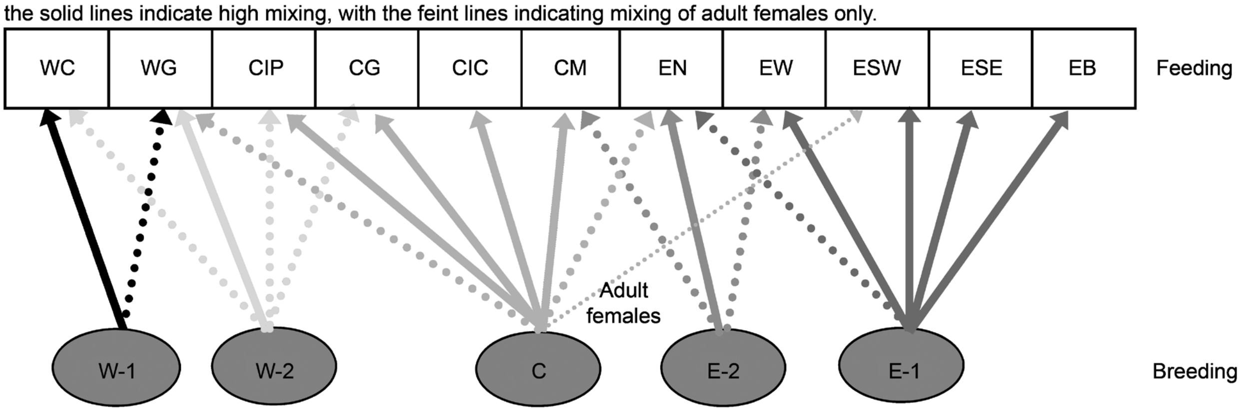
The Workshop was a technical workshop and a considerable amount of time was spent undertaking and reviewing the conditioning of the trials that had been agreed at the 2014 Scientific Committee meeting. The trials structure is relatively complex (e.g. there are four stock structure hypotheses – see Fig. 7) and thus satisfactory conditioning is a large task. Fits of the operating model to three data sources were examined: abundance estimates; sex-ratios by sub-area in the month when the surveys take place ('survey' sex-ratios), and sex-ratios by sub-area when the catches take place ('fishery' sex-ratios).

After reviewing all of the available conditioning results, the Workshop concluded that the fits were acceptable (in the few exceptional cases the explanation for the poorer fits was sufficient to conclude that the operating model was satisfactory).

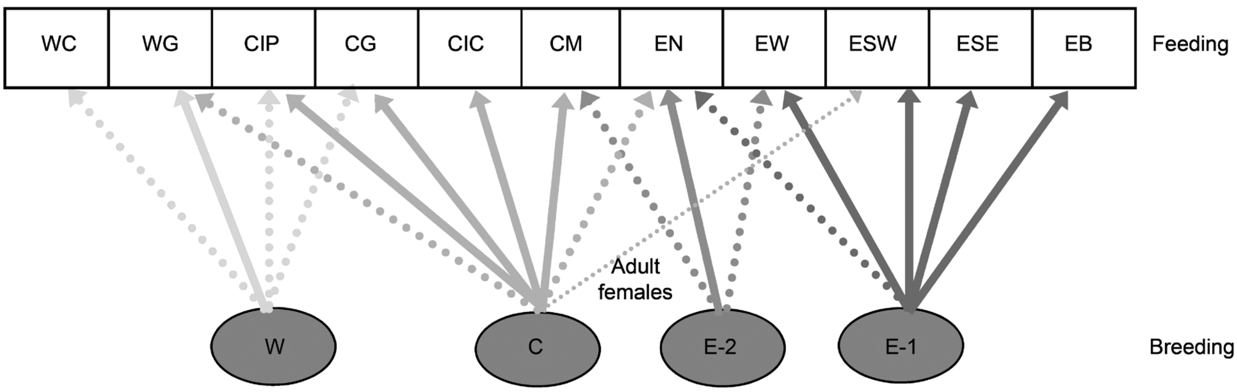
The revised trials specifications are summarised in SC/66a/Rep04, table 2 and repeated in Appendix 4. The modifications were minor and involved removing the trials with lower proportions of males in northern waters (rendered unnecessary after obtaining good fits for the baseline operating models), together with addition of trials related to uncertainty over the size of the E-2 sub-stock in

[1]Note: Trial NF15 is not applicable for this variant. The same proportions are used in setting future abundance estimates as for trial NF15.

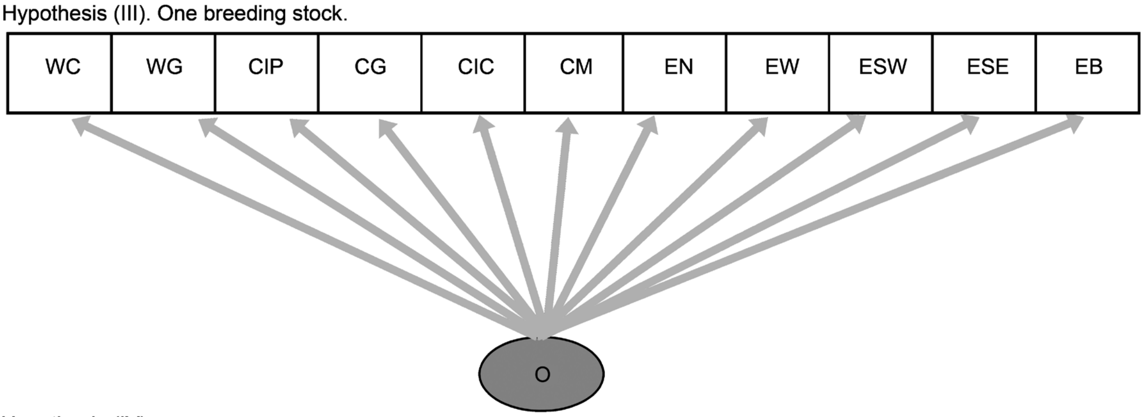
Hypothesis (I). Base case: three breeding stocks, two with two sub-stocks. The solid lines indicate low mixing. The dotted lines in addition to the solid lines indicate high mixing, with the feint lines indicating mixing of adult females only.



Hypothesis (II). Three breeding stocks, one with two sub-stocks.



Hypothesis (III). One breeding stock.



Hypothesis (IV). Two cryptic breeding stocks.

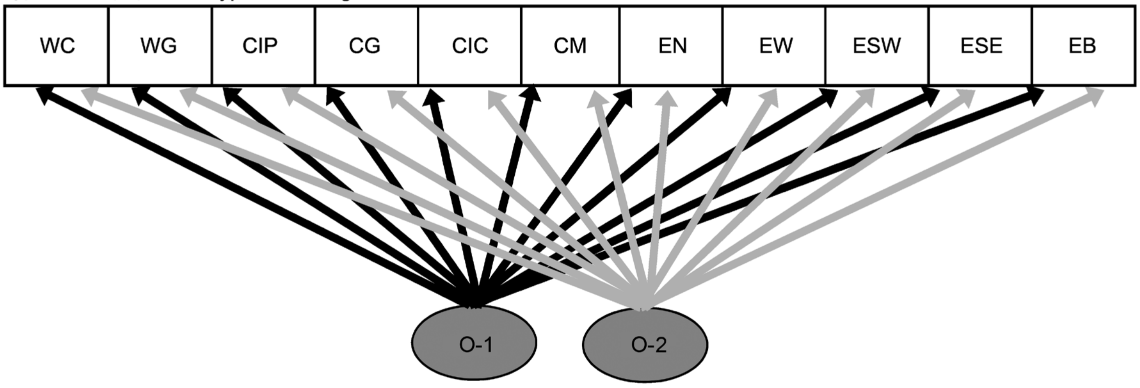


Fig. 7. Stock structure hypotheses for North Atlantic minke whales.

sub-area EN and the poorer fit for the 'survey' sex ratio in sub-area EN. The Workshop also finalised the specification for the 'cryptic stock' trials.

There were no suggested revisions to the list of management variants previously agreed (IWC, 2015a; 2015b).

The Workshop had agreed that considerable intersessional work was required for the Committee to be able to complete the *Implementation Review* by its 2015 meeting and had recognised that this might not be possible. This work related to: (1) finalising any outstanding coding required (and updating associated datasets); (2) completing the conditioning; and (3) running the revised trials and presenting the results in the standard format. A Steering Group was established to facilitate progress.

The sub-committee thanked Donovan for chairing the intersessional Workshop and the participants for their work during it and subsequently, in particular Allison and de Moor. It **endorsed** the Workshop recommendations.

6.2.2 Implementation Review

Allison reported that the trials specifications had been updated. The key changes to the trial specifications were as follows.

(1) The original sub-area ES was split into two sub-areas (ESE and ESW) at the 2014 Annual Meeting to investigate sensitivity to the boundary between sub-areas ES and CM. Initially, this split was implemented by halving the catch and abundance in sub-area ES. To better reflect the intention to consider sub-area ESW as an extension of sub-area CM and for sub-area ESE to comprise the traditional catching fields off Spitsbergen, the boundary was modified as shown in Fig. 8. The shift in boundary also reflects the often seen extended coverage of ice in sub-area ESW.
(2) The abundance estimates for West Greenland for 1987 and 1993 were not included in the conditioning because they were uncorrected for animals missed by observers.
(3) The future catch limits assigned to sub-area CM as a result of catch cascading will not be taken; if a catch is proposed in this sub-area in the future, that possibility should be considered during an *Implementation Review*.
(4) A procedure was developed to allow for both aboriginal and commercial catches in sub-area CG.

The final trial specifications are listed in Appendix 4 and the trials are summarised in Table 4.

Conditioning involves fitting the operating model to the available data to ensure that for each set of hypotheses (e.g. about stock structure, MSYR), the operating model used for projection purposes is consistent with the data. In the case of the North Atlantic minke whales, the conditioning involves fitting the operating model to three sources of data:

(a) abundance estimates (from surveys that take place in July for all sub-areas except West Greenland where surveys take place in September);
(b) sex-ratios by sub-area for the month in which surveys take place (the 'survey' sex-ratios); and
(c) sex-ratios by sub-area when catches take place (the 'fishery' sex-ratios).

The 'fishery' sex-ratios differ from the 'survey' sex-ratios because they apply to the season as a whole, not to the month in which the survey takes place. Unlike the 'survey' sex-ratios that are computed using data from the earliest period of relatively substantial whaling, the 'fishery' sex-ratios are computed using catches for 2008-13 (except for trials NM07-1 and NM07-4 for which these sex-ratios are based on catches for 2002-07) as the 'fishery' sex-ratios are used in the projections to determine the sex-ratio of future catches. Because catch-by-sex data are available for all sub-areas and seasons for which future catches will be simulated, the fishery sex-selectivity parameter estimated for each sub-area provides the flexibility for an exact fit by the operating model to this information.

Allison and de Moor presented conditioning results for 16 of the 20 *Implementation Simulation Trials*, and the sub-committee reviewed the conditioning results. Presented results included the following plots (see Appendix 5 for an example set of results for trials NM01 and NM01 (MSYR=1% and 4%):

(1) medians and 90% intervals for the time-trajectory of 1+ population size by sub-area across 100 replicates, along with associated abundance estimates and their 90% sampling intervals;

Table 4

The *Implementation Simulation Trials* for North Atlantic minke whales (Trial NM08 was deleted and so is not shown here).

Trial No.	Stock hypothesis	*MSYR*	No. of stocks	Boundaries	Catch sex-ratio for selectivity	Trial weight	Notes
NM01-1	I	1%[1]	3	Baseline	2008-13		3 stocks, E and W with sub-stocks
NM01-4	I	4%[2]	3	Baseline	2008-13		3 stocks, E and W with sub-stocks
NM02-1	II	1%[1]	2	Baseline	2008-13		2 stocks, E with sub-stocks
NM02-4	II	4%[2]	2	Baseline	2008-13		2 stocks, E with sub-stocks
NM03-1	III	1%[1]	1	Baseline	2008-13		1 stock
NM03-4	III	4%[2]	1	Baseline	2008-13		1 stock
NM04-1	IV	1%[1]	2	Baseline	2008-13		2 cryptic stocks
NM04-4	IV	4%[2]	2	Baseline	2008-13		2 cryptic stocks
NM05-1	I	1%[1]	3	Stock C not in ESW	2008-13		3 stocks, E and W with sub-stocks
NM05-4	I	4%[2]	3	Stock C not in ESW	2008-13		3 stocks, E and W with sub-stocks
NM06-1	II	1%[1]	2	Stock C not in ESW	2008-13		2 stocks, E with sub-stocks
NM06-4	II	4%[2]	2	Stock C not in ESW	2008-13		2 stocks, E with sub-stocks
NM07-1	I	1%[1]	3	Baseline	**2002-07**		Alternative years to adjust selectivity-at-age
NM07-4	I	4%[2]	3	Baseline	**2002-07**		Alternative years to adjust selectivity-at-age
NM09-1	I	1%	3	Baseline	2008-13		E-2 stock in EN 10%
NM09-4	I	4%	3	Baseline	2008-13		E-2 stock in EN 10%
NM10-1	I	1%	3	Baseline	2008-13		E-2 stock in EN 90%
NM10-4	I	4%	3	Baseline	2008-13		E-2 stock in EN 90%
~~NM11-1~~	~~I~~	~~1%~~	~~3~~	~~Baseline~~	~~2008-13~~		~~Force fit to EN survey sex ratio~~
NM12-1	I	1%[1]	3	Stock E1 not in ESW	2008-13		3 stocks, E and W with sub-stocks
NM12-4	I	4%[2]	3	Stock E1 not in ESW	2008-13		3 stocks, E and W with sub-stocks
NM13-1	II	1%[1]	2	Stock E1 not in ESW	2008-13		2 stocks, E with sub-stocks
NM13-4	II	4%[2]	2	Stock E1 not in ESW	2008-13		2 stocks, E with sub-stocks

1–1+; 2–mature

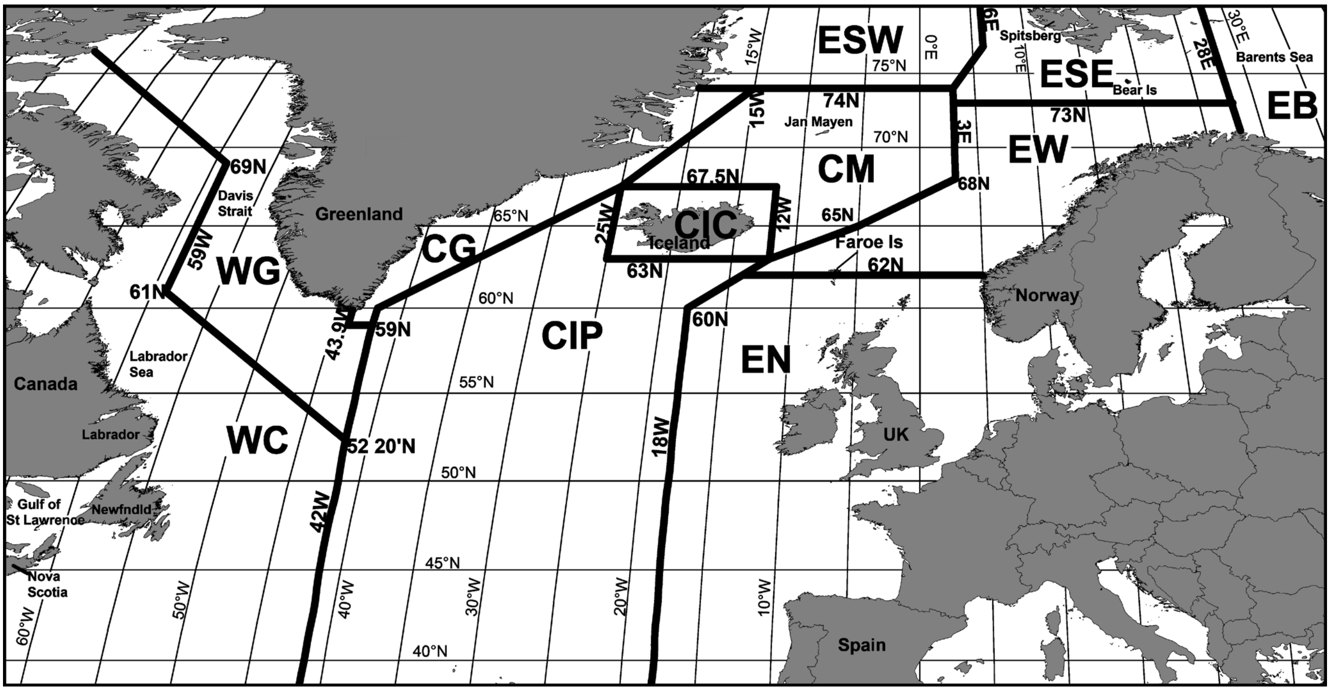


Fig. 8. Map of the North Atlantic showing the sub-areas defined for the North Atlantic minke whales.

(2) medians and 90% intervals for the time-trajectory of mature female abundance by sub-stock across 100 replicates; and
(3) medians and 90% intervals for the 'fishery' and 'survey' sex-ratios by sub-area across 100 replicates, along with observed sex-ratios and their 90% sampling intervals.

The fits of the operating models to the actual data were generally good. However, some of the plots identified concerns with the conditioning when the operating model was fitted to bootstrap data sets, as follows:

(1) the lower 5th percentile for number of mature females for the W-2 sub-stock seemed unrealistically low (trials based on stock structure hypothesis I). This appears to be a consequence of pre-specifying the mixing proportions for the W-1 and W-2 sub-stocks in sub-area WG, and specifically that the W-1 sub-stock is assumed to be in equal proportions in sub-areas WC and WG under the 'high' mixing matrix, combined with substantial differences in abundance estimates for these sub-areas;
(2) none of the trials were able to mimic the declining trends in abundance estimates for sub-area CIP or the high among-year variation in abundance estimates for sub-area CG;
(3) the distribution for 'survey' sex-ratio for sub-area CIP generated by the operating model does not include low values, unlike the observed distribution; and
(4) the distributions for 1+ abundance for sub-area ESW generated by the operating model are much wider than would be expected given the abundance estimates for this sub-area.

The sub-committee **agreed** that the inability to fit the abundance estimates for sub-areas CIP and CG was not a major concern given that the median/deterministic time-trajectory of 1+ abundance passes through the observed data. It noted that the truncated distribution for the operating model 'survey' sex-ratio for sub-area CIP occurs because the operating model assumes that the entire population is found in the modelled area and hence this proportion cannot be too low without resulting in a worse fit to the data for other sub-areas. The concerns with the trends in the abundance of mature females for the W-2 sub-stock and trends in the abundance of 1+ animals in sub-area ESW appear to be caused by the 'entry' specifications of the mixing matrices. The sub-committee **recommended** that the mixing matrices be changed as follows.

(a) The proportion of the W-1 sub-stock in sub-area WG in the 'high' mixing matrix should be estimated rather than being assumed to be equal to 0.5.
(b) The values for the proportion of the E-1 sub-stock in sub-area ESW needed to be adjusted by the Steering Group. Variation in spatial distribution is generated by randomly selecting between two mixing matrices ('high' and 'low'). However, the proportion of the E-1 sub-stock in sub-area ESW differs by a factor of 50 between the 'high' and 'low' mixing matrices. This leads to unrealistically large changes in abundance in sub-area ESW between years, particularly when the C stock is not located in sub-area ESW (trials NM05 and NM06).

The sub-committee **agreed** that despite considerable work by Allison and de Moor, the conditioning had not been successfully achieved. Rather, it noted that the issues identified above could only be detected once the full set of 100 replicates had been conducted. It also **agreed** that Allison and de Moor should work with the Steering Group to refine the specifications of the trials and provide updated conditioning results to the proposed next intersessional Workshop.

6.2.3 New information

SC/66a/RMP06 summarised a sighting survey conducted during the summer of 2014 in the ES *Small Area* (Svalbard and Bear Island including the Greenland Sea). This was the first year in a new survey cycle 2014-19, and ES was last surveyed in 2008. The area was covered by one vessel that operated over the period 16 June to 24 August. The total survey area was divided into four survey blocks and received

Table 5
Abundance estimates with associated coefficients of variation (CV) by *Small Area.*

Small Area	*N*	CV	CV additional
ES	27,390	0.16	0.29
EB	34,125	0.23	0.34
EW	21,218	0.21	0.32
EN	6,891	0.19	0.31
CM	10,991	0.26	0.36
Total	100,615	0.11	0.17
E Median Area	89,623	0.12	0.18

reasonably good coverage, and a total of 3,390 n.miles were conducted in primary search mode. The established sighting procedures during primary search included a double platform and tracking of minke whales. *Small Area* ES was partly covered by ice in the western and northern areas. The ice situation was very similar to that experienced in the previous survey of the area in 2008. Compared to that survey, the density of minke whales was considerably lower in 2014, especially in the southern areas, including the Bear Island area. In 2014, fin whales occurred westwards to the ice edge in addition to the usual distribution along the shelf slopes west of Spitsbergen. The number of humpbacks recorded in 2014 was much lower than in 2008. However, the records were from the same general area, which is around Bear Island. Many more sperm whales were observed in 2014 than in 2008, mostly west of the shelf slopes all the way from the Bear Island to north of Spitsbergen. Finally, the distribution and occurrence of *Lagenorhynchus* dolphins seemed to be very similar between 2008 and 2014. Biopsy samples were collected from three humpbacks and two blue whales, and photo-identifications from 26 humpbacks and two blue whales. Satellite tags were applied to two humpbacks, one blue whale and four minke whales.

Øien advised that the distribution of fin whales in *Small Are*a ES was unusual during 2014. These whales are generally found on the slope off Spitzbergen. However, they were observed in high density in the north of *Small Area* ES in 2014. Øien also advised that more blue whales were observed during the 2014 survey than had been the case in surveys of this *Small Area* in the past. He noted that an Arctic ecosystem survey sighted an unexpectedly high number of blue whales in the Hinlopen canyon, north of Spitsbergen during 2014.

SC/66a/RMP05 used the Markov modulated Poisson process to estimate variance in whale counts on individual transect legs. This model accounted for overdispersion relative to the Poisson distribution, and constitutes an simpler alternative to the Neyman-Scott process that has been used in the past for the Northeast Atlantic minke whales. A second change in methodology was that the parametric bootstrap method had been replaced with a somewhat cruder 'delta-method' for calculating the variance of the line transect abundance estimator. The new approach was validated on the 1996-2001 surveys and led to a CV of 9.3% for the estimate of total abundance, while the previous method led to a CV of 10.1%. The discrepancy was larger for individual survey blocks, and in particular the direct measure of overdispersion varied substantially between the old and new method.

The sub-committee **endorsed** the new variance estimation method described in SC/66a/RMP05. In discussion it was noted that the overdispersion parameter is probably not well estimated and that improved performance might be possible if this parameter was treated as a random effect.

SC/66a/RMP07 used a discrete approximation to model measurement error for the estimation of radial distance and angle during line transect surveys. The approach is based on a multiplicative errors model of Marques (2004). The distributions are assigned into arbitrary odd classes, e.g. three classes as seen in SC/66a/RMP07.The threshold to detect three classes was set as the 10, 20, 25 and 30 % quantile points. Using the probabilities for measurement errors of the experimental data collected over the period 2008-13, the effective strip half-widths (eshw) were calculated based on the statistical methods for abundance estimation in Skaug *et al.* (2004). The results indicated that eshw assuming measurement error was always smaller than assuming no measurement error. The abundance estimate is then lower than when any measurement error corrections are applied. Therefore, the abundance estimates without bias correction for measurement error are conservative. This is true for the 2008-13 and 1996-2001 periods. SC/66a/RMP07 assumed a multiplicative error model for both distance and angle, although an additive error model may be more appropriate for a given angle. A measurement error for radial distance should be included in the likelihood for Bernoulli trials (Skaug *et al.*, 2004) in the future.

The sub-committee **endorsed** the approach to handling measurement error suggested by SC/66a/RMP07. Cooke and Leaper (1998) developed methods for analysing measurement errors when angles are rounded. The sub-committee **recommended** that the authors of SC/66a/RMP07 explore whether the method of Cooke and Leaper (1998) could be incorporated into that of SC/66a/RMP07.

SC/66a/RMP08 presents abundance estimates for common minke whales in the Northeast Atlantic based on survey data collected over the period 2008-13. The survey area includes the RMP *Medium Area* E and *Small Area* CM. Cetaceans were searched for by naked eye from two independent platforms each manned with two observers following the protocols established for these surveys and used in previous survey cycles. The analyses have also followed along the same lines as in previous analyses, but with a simplification of the bias correction procedure and variance estimation which in earlier analyses have been carried out using a simulation module which is complicated. The simplified approaches to these problems are presented in SC/66a/RMP05 (new variance estimator) and SC/66a/RMP07 (measurement errors). The total estimate for the surveyed areas was 100,615 minke whales with a CV corrected for additional variance of 0.17. The estimate for the E *Medium Area* was 89,623 with CV of 0.18 (including additional variance). The point estimate for the total area has decreased (however, not significantly) compared to the two preceding survey periods. The decrease occurred within S*mall Area* CM (the Jan Mayen area, part of the C *Medium Area*), with an estimate being 40% of those from the 1996-2001 and 2002-07 cycles. This may have some unrevealed connection to the recent observed drop in minke whale abundance in the coastal waters of Iceland. Within the E *Medium Area*, the point estimate is slightly higher than in the previous two cycles. There are signs of a north- and eastwards distributional shift within this region from the Norwegian Sea to the Svalbard area and the Barents Sea as compared with the previous surveys.

The sub-committee **endorsed** the estimate of abundance for the entire survey area (the E *Medium Area* and *Small Area* CM) of 100,615 (CV 0.17) and the estimate for the E *Medium Area* of 89,623 (CV 0.18) for use in the *CLA*. Table 5 lists the estimates of abundance by *Small Area* for the 2008-13 surveys. The estimates of abundance for the *Small Area* CM exhibit substantial between-period variation.

6.2.4 Recommendations

The sub-committee recognised that the nature of the process of conducting an *Implementation Review* as well as complexities of the computing precluded completion of the *Implementation Review* this year. It **agreed** on a work plan to ensure that the *Implementation Review* is completed during the 2016 Annual Meeting (or during a pre-meeting before then). The work plan involves updating the mixing matrices in the trials' specifications, conditioning the trials, re-evaluating the conditioning, conducting an initial assignment of plausibility ranks to the trials, using the conditioned trials as a basis for projections under the agreed management variants, and applying the Committee's decision rules on how to evaluate RMP variants (IWC, 2012) to the results of the trials.

The sub-committee re-established the Steering Group under Walløe (Convenor) with members Allison, Butterworth, de Moor, Donovan, Palsbøll, Punt, Víkingsson and Witting, to guide the intersessional work.

6.3 North Atlantic sei whales

In 2014 the Correspondence Group on North Atlantic sei whales recommended genetic analysis of existing samples from different localities to aid in the development of stock structure hypotheses. An application for funding of these analyses from the IWC budget was unsuccessful in 2014. Owing to lack of funding for these analyses and time constraints, no progress had been made during the intersessional period. Taking into account the present workload of the Committee related to RMP *Implementations* and *Implementation Reviews*, the sub-committee **recommends** postponing the *pre-Implementation assessment* for the North Atlantic sei whales until the *Implementation Reviews* for the North Atlantic common minke and fin whales are completed.

6.4 North Pacific common minke whales

There was no discussion under this Item. However, several outstanding items remain before the *Implementation* can be considered completed. The sub-committee therefore re-established the Advisory Group under Butterworth (Convenor) with members Allison, An, Baker, de Moor, Donovan, Double, Gaggiotti, Hoelzel, Kelly, Kitakado, Miyashita, Park, Pastene, Punt, Wade and Waples, to provide feedback to those developing research programmes for North Pacific minke whales during the intersessional period.

6.5 Western North Pacific Bryde's whales

Last year, the Committee deferred the *Implementation Review* until 2017 because considerable new data should be available by then (IWC, 2015a). It furthermore recommended that this *Implementation Review* be a 'full review' like those currently being undertaken for North Atlantic minke and fin whales, where all aspects of the *Implementation* are reviewed, instead of only updating the abundance estimates and catches and determining whether new research suggests that the trial scenarios considered during the *Implementation* remain plausible.

6.6 Other

Appendix 6 lists the updated abundance estimates for North Atlantic whales.

6.7 Work plan (see below).

Before the 2016 Annual Meeting	During the 2016 Annual Meeting
(1) North Atlantic fin whales: (a) finalise the code for the *Implementation Simulation Trials* (Elvarssson, de Moor and Allison, Item 6.1.3); (b) condition the *Implementation Simulation Trials* (Elvarsson, de Moor and Allison, Item 6.1.3); and (c) hold an Intersessional Workshop to review the conditioning of the *Implementation Simulation Trials* and prepare for completion of the *Implementation Review*. There will be costs involved for travel and subsistence (Item 6.1.3) [1].	(1) North Atlantic fin whales: complete the *Implementation Review* (Item 6.1.3).
(2) North Atlantic minke whales: (a) distribute the steering-Group-suggested final trial specifications (Allison, Punt, de Moor, Item 6.2.2); (b) code finalisation and condition the trials (Allison, de Moor, Punt, Item 6.2.2); and (c) hold a Workshop to evaluate the conditioning and review the results of the projections using the protocol developed by the Committee (IWC, 2012). There will be costs involved for travel and subsistence (Item 6.2.2)[1].	(2) North Atlantic minke whales: complete the *Implementation Review* (Item 6.2.2).
	(3) Western North Pacific minke whales: (a) review the results of possible proposed 'hybrid' versions of RMP variants to allow an evaluation of any candidate 'variant with research' (Allison, based on advice from Japan, Item 6.4); (b) review any research proposals related to a candidate 'variant with research' (Item 6.4); and (c) agree the estimates of abundance for use in actual applications of the RMP (Item 6.4). (4) Continue to prepare for the 2017 *Implementation Review* (Item 6.5).

[1]These two Workshops should be held back-to-back to reduce costs given that there will be considerable overlap in participants. The sub-committee established a Steering Group under Donovan (Convenor) with members Allison, Butterworth, Punt, Víkingsson, Walløe and Witting, to organise and prepare for the Workshop.

7. BUDGET ISSUES

Two intersessional Workshops are proposed:

(1) a Workshop held as a pre-meeting before SC/66b to test the proposed new Guidelines against several test cases of model-based abundance estimates made specifically for and during the Workshop and to demonstrate and discuss the proposed diagnostic software with a wider Committee audience involved in basic line-transect abundance estimation (Convenor: Bravington) (£2,200; Item 5.5); and

(2) an intersessional Workshop to continue the *Implementation Reviews* for North Atlantic fin and minke whales, with a focus on evaluating conditioning and finalising trial specifications (Convenors: Walløe and Donovan) (£7,000; Items 6.1.3 and 6.2.2).

8. ADOPTION OF REPORT

The Report was adopted at 15:10 on 30 May 2015. The sub-committee thanked Bannister for his excellent Chairmanship, and Punt for his usual painstaking and indefatigable rapporteuring.

REFERENCES

Aldrin, M. and Huseby, R.B. 2007. Simulation trials 2007 for a re-tuned *Catch Limit Algorithm*. Paper SC/59/RMP4 presented to the IWC Scientific Committee, May 2007, Anchorage, USA (unpublished). 143pp. [Paper available from the Office of this Journal].

Aldrin, M., Huseby, R.B. and Schweder, T. 2008. A note on tuning the *Catch Limit Algorithm* for commercial baleen whaling. *J. Cetacean Res. Manage.* 10(3): 191-94.

Cooke, J. and Leaper, R. 1998. A model to account for the rounding of recorded angles and distances in shipborne sightings surveys. Paper SC/50/RMP19 presented to the IWC Scientific Committee, April 1998 (unpublished). [Paper available from the Office of this Journal].

Cooke, J.G. and de la Mare, W.K. 1994. Some aspects of the estimation and modelling of baleen whale sustainable yields. *Rep. int. Whal. Commn.* 44: 451-57.

International Whaling Commission. 1991. Report of the Sub-Committee on Management Procedures, Appendix 4. Report of the *ad-hoc* trials subgroup. *Rep. int. Whal. Commn.* 41:108-12.

International Whaling Commission. 1992a. Report of the Fourth Comprehensive Assessment Workshop on Management Procedures, Annex D. Single stock trials for finalised procedures. *Rep. int. Whal. Commn.* 42:317-18.

International Whaling Commission. 1992b. Report of the Scientific Committee, Annex D. Report of the Sub-Committee on Management Procedures. *Rep. int. Whal. Commn.* 42:87-136.

International Whaling Commission. 2007. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 5. Report of *Catch Limit Algorithm* (*CLA*) trials group. *J. Cetacean Res. Manage. (Suppl.)* 9:110-13.

International Whaling Commission. 2012. Requirements and Guidelines for *Implementations* under the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 13:495-506.

International Whaling Commission. 2013. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 14:103-17.

International Whaling Commission. 2015a. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 16:1-87.

International Whaling Commission. 2015b. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure (RMP). *J. Cetacean Res. Manage. (Suppl.)* 16:100-43.

Leaper, R., Cooke, J. and Van Waerebeek, K. 2000. Some aspects of the modelling of density-dependent processes in baleen whale populations. Paper SC/52/RMP20 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].

Marques, T.A. 2004. Predicting and correcting bias caused by error measurement in line transect sampling using multiplicative error models. *Biometrics* 60: 757-63.

McAllister, M.K. and Ianelli, J.N. 1997. Bayesian stock assessment using catch-age data and the sampling-importance resampling algorithm. *Can. J. Fish Aquat. Sci.* 54: 284-300.

Skaug, H.J., Øien, N., Schweder, T. and Bothun, G. 2004. Abundance of minke whales (*Balaenoptera acutorostrata*) in the northeastern Atlantic; variability in time and space. *Can. J. Fish Aquat. Sci.* 61(6): 870-86.

Appendix 1

AGENDA

1. Convenor's opening remarks
2. Election of chair, appointment of rapporteurs
3. Adoption of Agenda
4. Available documents
5. General assessment issues with a focus on those related to the Revised Management Procedure (RMP)
    - 5.1 Relationship between $MSYR_{mat}$ and $MSYR_{1+}$
        - 5.1.1 Population component for density-dependence and MSYL
    - 5.2 Finalise the approach for evaluating proposed amendments to the *CLA*
    - 5.3 Complete evaluation of the Norwegian proposal for amending the *CLA*
        - 5.3.1 Review of results
    - 5.4 Other computing matters related to the *CLA*
    - 5.5 Requirements and Guidelines for Conducting Surveys and *Implementations*
    - 5.6 Work plan
6. RMP – *Implementation*-related matters
    - 6.1 North Atlantic fin whales (*Implementation Review*)
        - 6.1.1 Report of intersessional Workshop
        - 6.1.2 Intersessional progress
        - 6.1.3 *Implementation Review*
        - 6.1.4 Recommendations
    - 6.2 North Atlantic common minke whales (*Implementation Review*)
        - 6.2.1 Report of intersessional Workshop
        - 6.2.2 Implementation Review
        - 6.2.3 New information
        - 6.2.4 Recommendations
    - 6.3 North Atlantic sei whales
    - 6.4. North Pacific common minke whales
    - 6.5 Western North Pacific Bryde's whales
    - 6.6 Other
7. Budget issues
8. Adoption of Report

Appendix 2

SUMMARY STATISTICS FOR THE COMPARISON BETWEEN THE CURRENTLY IMPLEMENTED *CATCH LIMIT ALGORITHM* (*CLA*) AND THE VARIANT PROPOSED BY NORWAY

Kelli F. Johnson and André E. Punt
School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA 98195-5020, USA

Summary and comparison statistics are reported for four variants of the *Catch Limit Algorithm* (*CLA*) to quantify the performance of the *CLA* variant proposed by Norway ('Alternative *CLA*') in 2004. Tuning of the current *CLA* is based on modifying the percentile parameter (fixing the slope parameter to 3.0), whereas tuning of the alternative *CLA* is based on modifying the slope parameter (fixing the percentile parameter to 0.5). The four variants (names follow in bold) are paramaterised as follows, each using 400 replicates:

(1) current *CLA* tuned to 0.723 for the T1-D1 trial when $MSYR_{mat}$=1% and density-dependence and MSYL act on the mature component of the population with a projection-period of 100 years (**C**);
(2) alternative *CLA* tuned to 0.723 for the T1-D1 trial when $MSYR_{mat}$=1% and density-dependence and MSYL act on the mature component of the population with a projection-period of 100 years (**NH**);
(3) current *CLA* tuned to 0.681 for the T1-D1 trial when $MSYR_{1+}$=1% and density-dependence and MSYL act on the 1+ component of the population with a projection-period of 300 years (**CL**); and
(4) alternative *CLA* tuned to 0.681 for the T1-D1 trial when $MSYR_{1+}$=1% and density-dependence and MSYL act on the 1+ component of the population with a projection-period of 300 years (**N**).

Reported summary statistics include median total catch (TC), 5th percentile of TC, 96th percentile of TC, mean TC, median final population size (*Pf*), 5th percentile of *Pf*, 96th percentile of *Pf*, median lowest population size (P_{min}), 5th percentile of P_{min}, 96th percentile of P_{min}, median continuous catch (CC), and average annual catch variation (AAV) (Figures 1-12). Additional comparison statistics are reported for a core set of trials (Table 1).

All trials in this appendix assume that density dependence impacts fecundity, though the impacted population component can either be the total (1+) or the mature component. For a given trial, density dependence and MSYL act on the same component of the population as MSYR, noted by the subscript in the specification of MSYR ($MSYR_{mat}$ or $MSYR_{1+}$) and the 'F' portion of the trial name, where F1 is 1+ and F2 is mature. The last letter number combination of the trial name specifies the initial population size relative to carrying capacity (*K*), where the initial population sizes for the development (D), rehabilitation (R), and sustainable (S) trials initialise the population at 0.99*K*, 0.3*K*, and 0.6*K*, respectively.

Table 1

Comparison statistics for the four *CLA* variants. Results are for when density-dependence impacts the **1+ population components for MSYR of 1%** and density-dependence impacts the **mature population components for MSYR of 4% and 7%**, for 100-year (upper panel) and 300-year projections (lower panel). For more information see the caption of Table 6.

Year	*CLA*	Med TC	Med CC	L5% TC DorR1	L5% TC B0.5 DorR1	L5% Pf DorR1	L5% Pmin DorR1	L5% Pmin S1	L5% Pmin S1B1.5	L5% Pmin B1.5	AAV
100				Development (D; Initial population=0.99*K*)							
	C	1.062	0.809	0.771	0.433	0.660	0.644	-	-	0.501	0.036
	CL	2.356	1.404	1.385	1.062	0.229	0.210	-	-	0.081	0.046
	NH	0.998	0.788	0.752	0.417	0.680	0.671	-	-	0.528	0.029
	N	1.760	1.347	1.078	0.702	0.431	0.417	-	-	0.276	0.051
				Rehabilitation (R; Initial population=0.30*K*)							
	C	0.356	0.424	0.077	0.000	0.650	0.300	0.600	0.503	0.300	0.053
	CL	1.408	1.240	0.450	0.251	0.155	0.112	0.164	0.039	0.018	0.038
	NH	0.418	0.487	0.134	0.000	0.626	0.300	0.600	0.518	0.300	0.040
	N	0.853	1.057	0.219	0.001	0.456	0.300	0.401	0.242	0.219	0.055
300				Development (D; Initial population=0.99*K*)							
	C	3.098	1.036	1.470	0.790	0.615	0.560	-	-	0.457	0.027
	CL	6.066	1.437	2.386	2.223	0.501	0.201	-	-	0.081	0.033
	NH	2.859	0.942	1.442	0.788	0.637	0.597	-	-	0.483	0.021
	N	5.092	1.419	2.174	1.410	0.519	0.366	-	-	0.270	0.039
				Rehabilitation (R; Initial population=0.30*K*)							
	C	1.161	0.339	0.574	0.010	0.807	0.300	0.593	0.443	0.300	0.031
	CL	4.707	1.437	1.189	0.858	0.566	0.112	0.157	0.039	0.018	0.021
	NH	1.308	0.396	0.619	0.055	0.821	0.300	0.600	0.465	0.300	0.022
	N	3.139	1.087	1.108	0.115	0.665	0.300	0.369	0.237	0.219	0.030

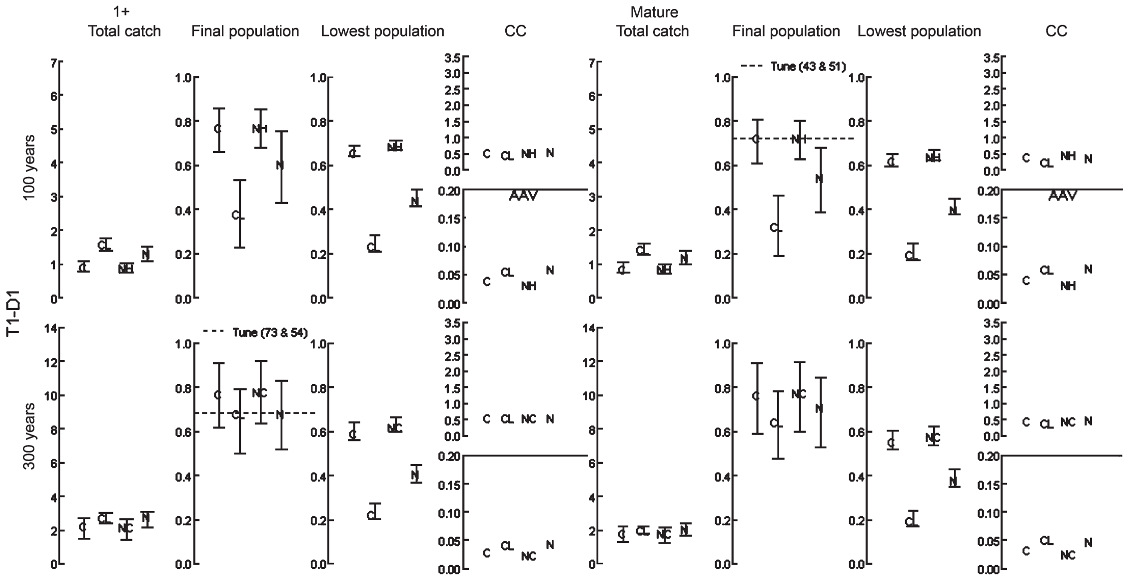


Fig.1. Summary statistics for trial T1-D1 (MSYR=1%) for four *CLA* variants for when density-dependence, MSYR and MSYL pertain to the total (1+)(left panel) component of the population, with a 100-year (upper panel) and 300-year (lower panel) projection period. *CLA* variants C and CL involved probabilities of 0.4020 and 0.769 and a slope of 3.0, respectively. *CLA* variants NC and N involved a probability of 0.500 and slopes of 1.83 and 4.7157, respectively.

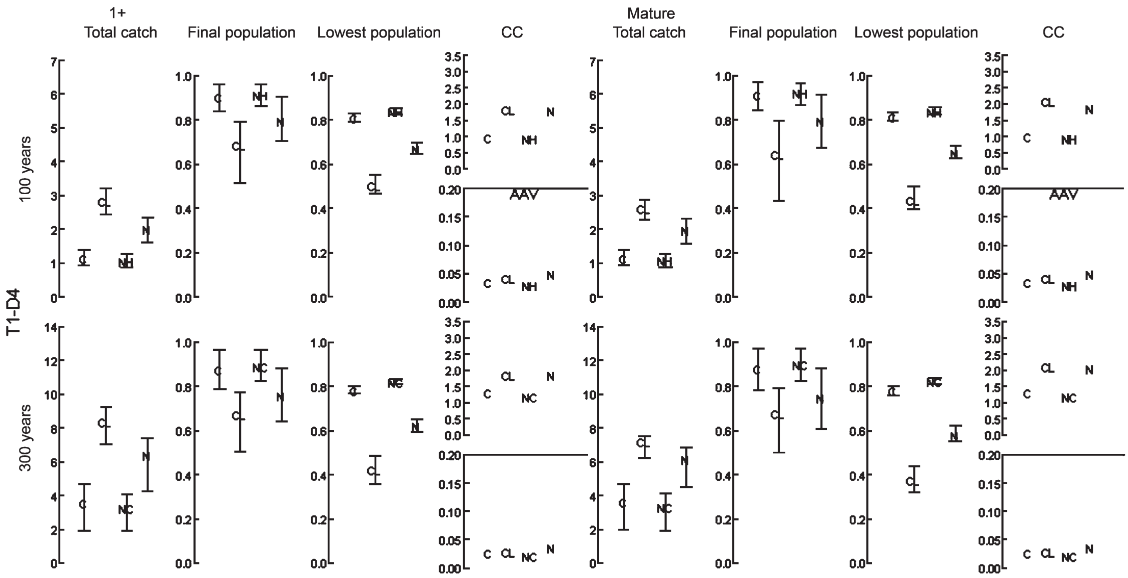


Fig. 2. Same as Fig.1., but for T1-D4.

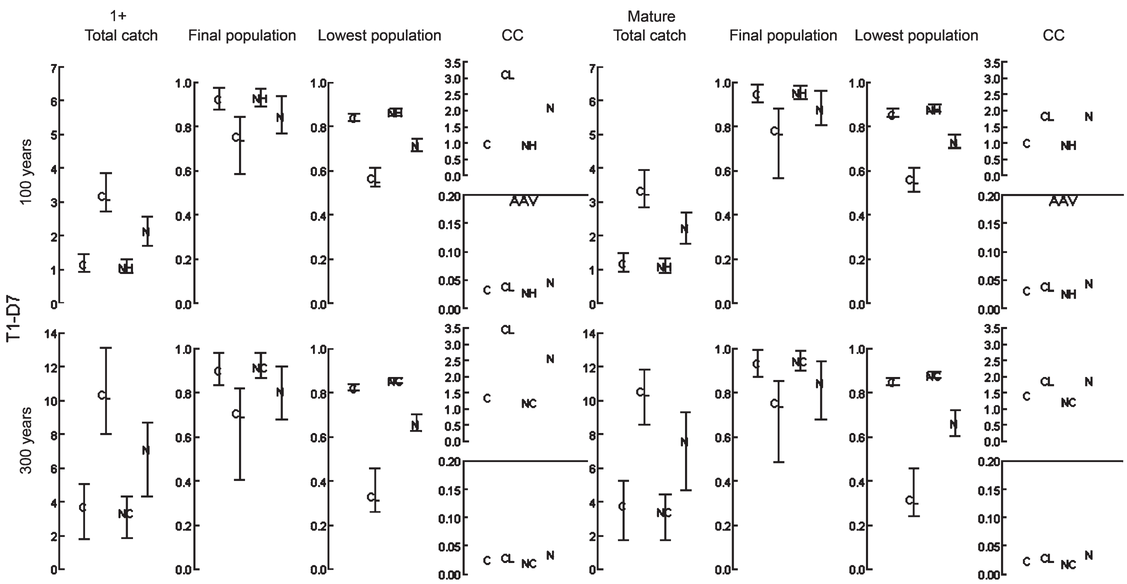


Fig. 3. Same as Fig.1., but for T1-D7.

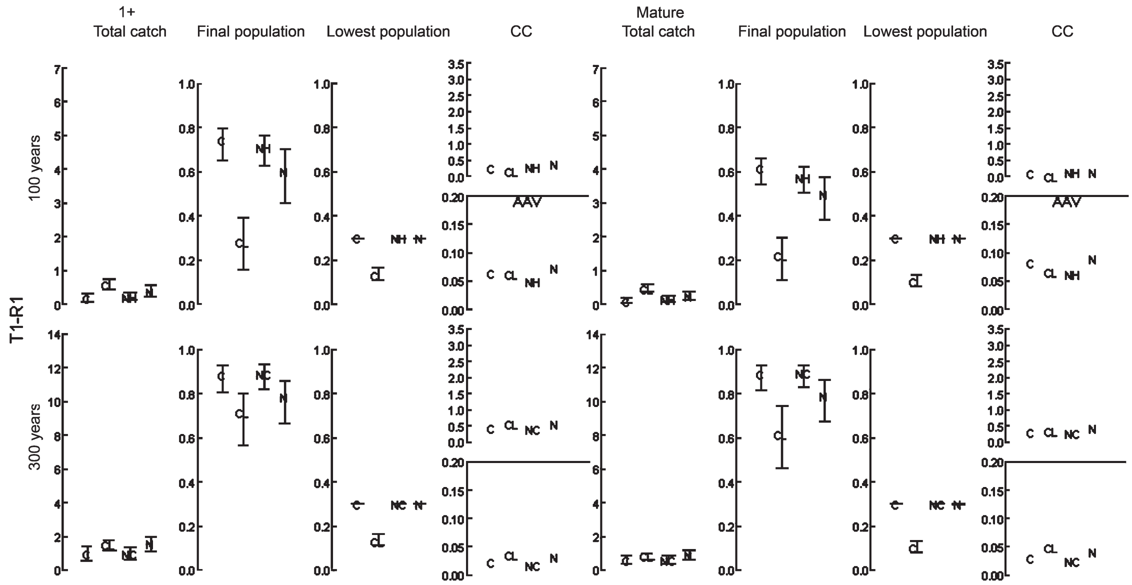


Fig. 4. Same as Fig. 1, except for Ti-R1.

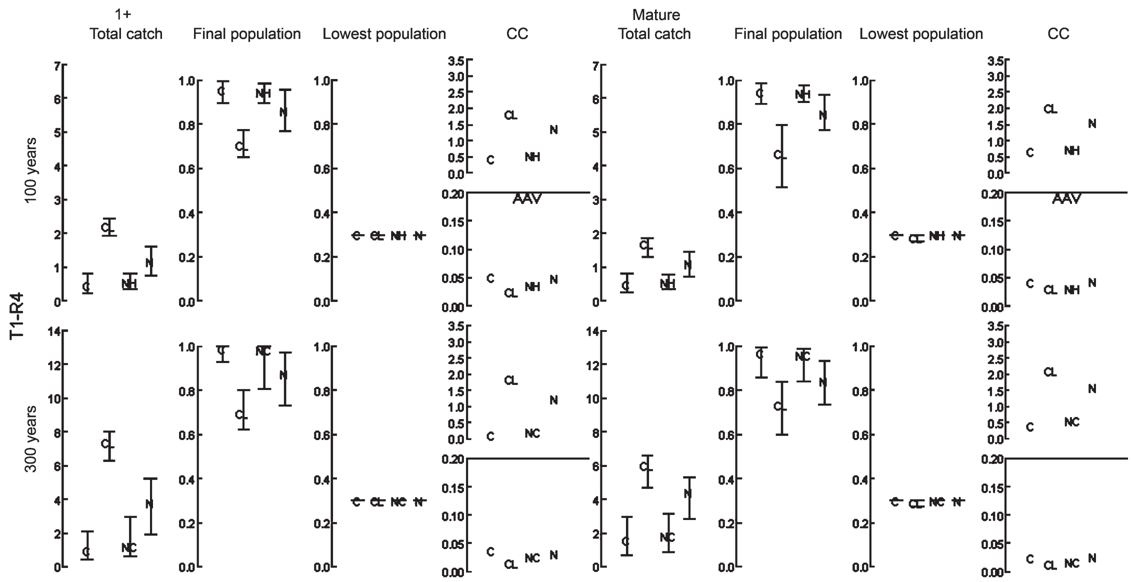


Fig. 5. same as Fig.1, except for T1-R4.

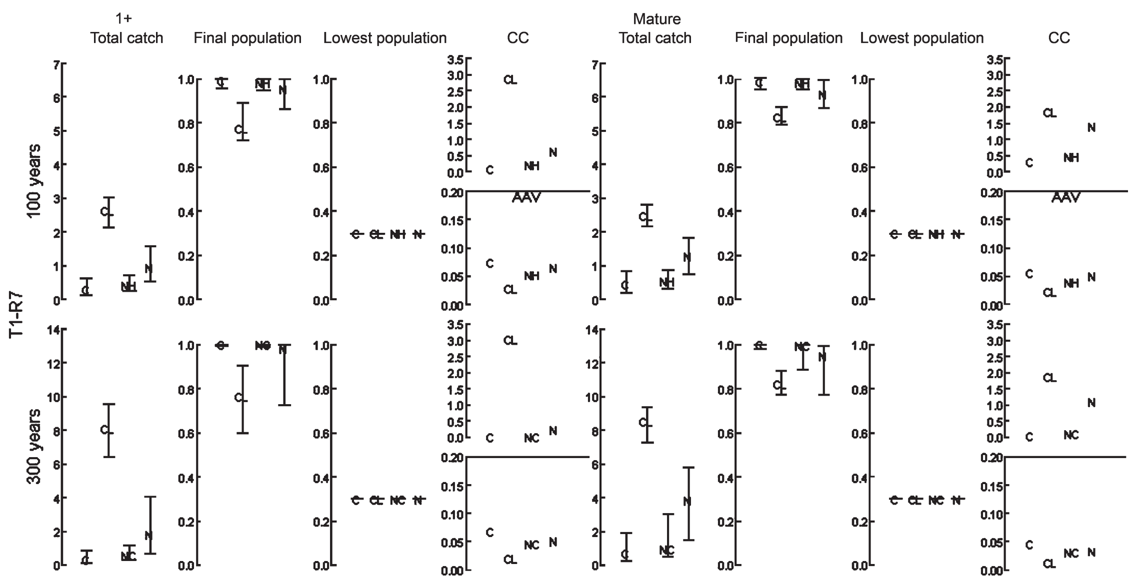


Fig. 6. same as Fig.1, except for T1-R7.

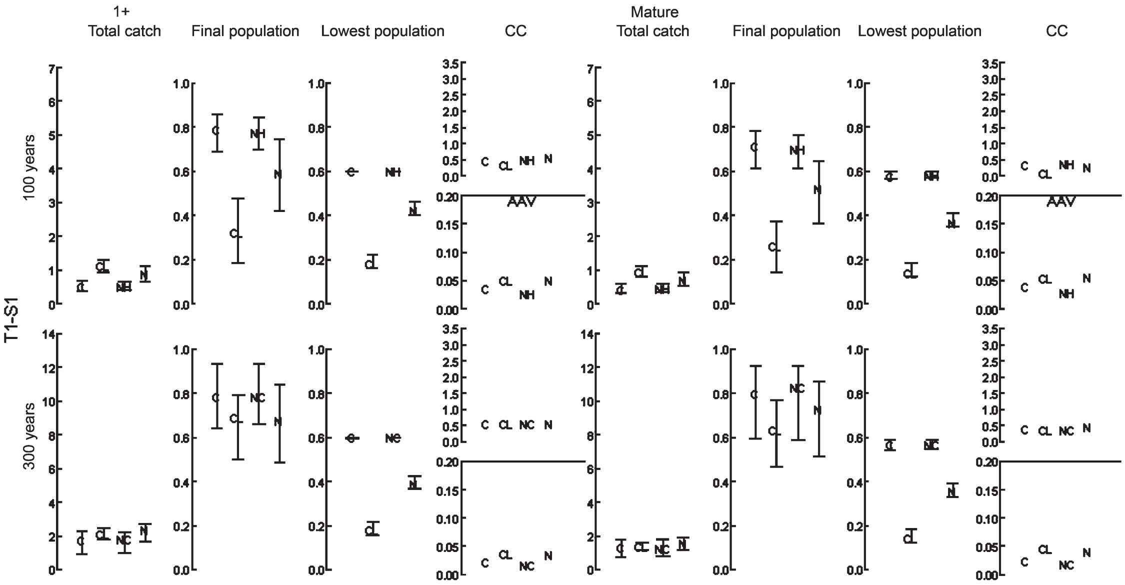


Fig. 7. Same as Fig. 1, except for T1-S1.

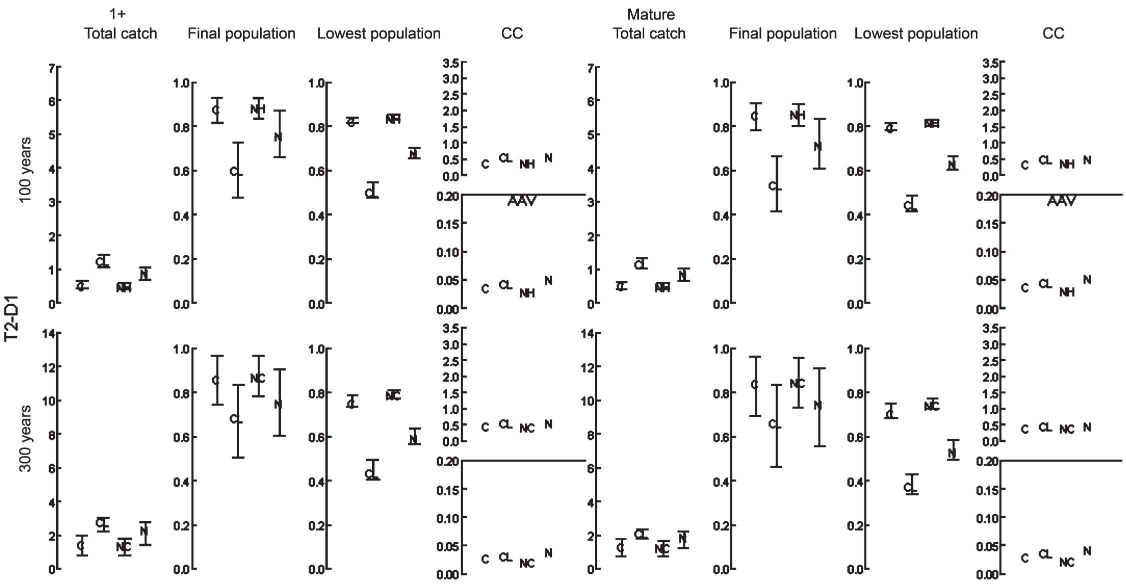


Fig. 8. Same as Fig.1, except for T2-D1.

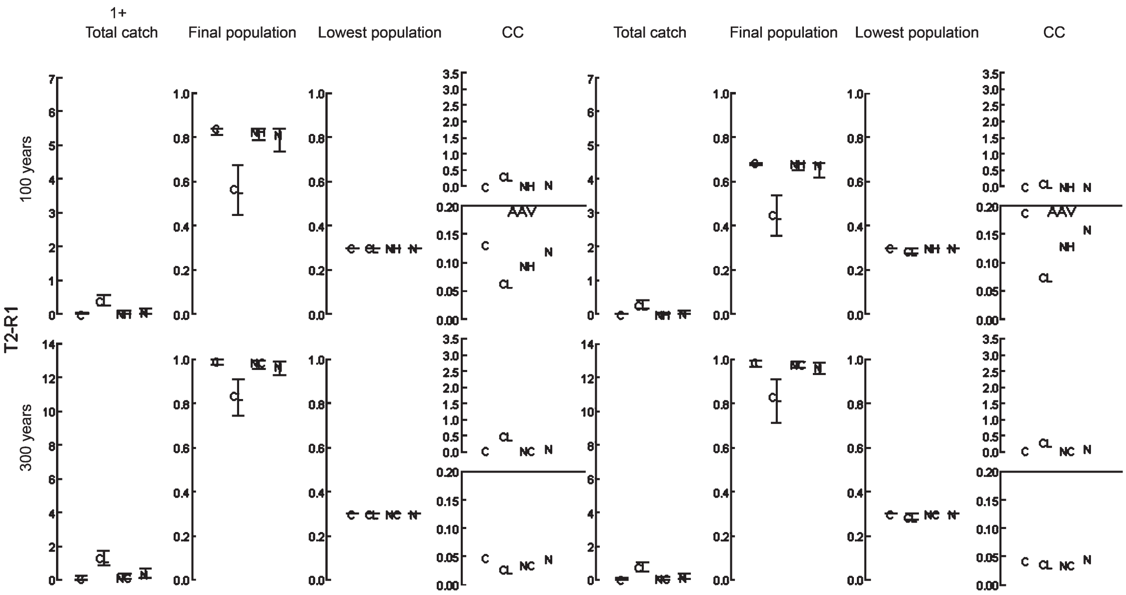


Fig. 9. Same as Fig.1, except for T2-R1.

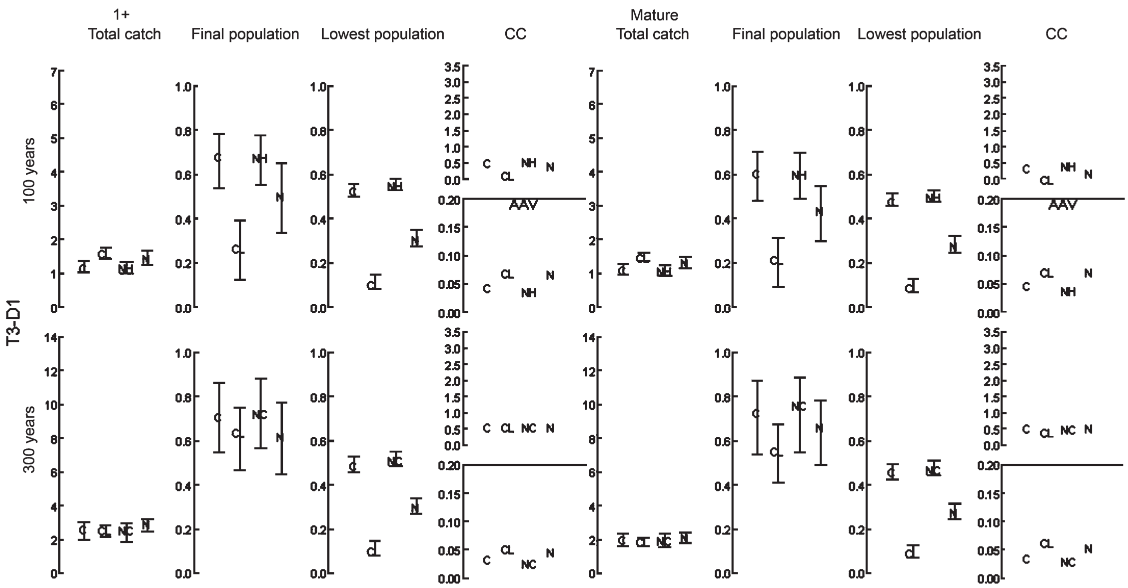


Fig.10. Same as Fig. 1., except for T3-D1.

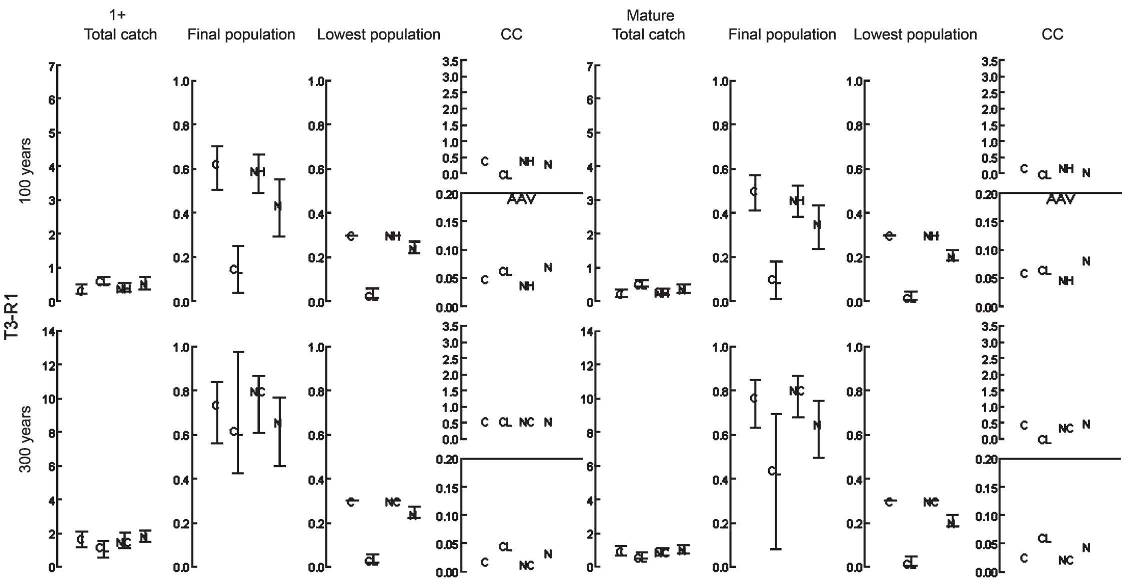


Fig. 11. Same as Fig. 1., except for T3-R1.

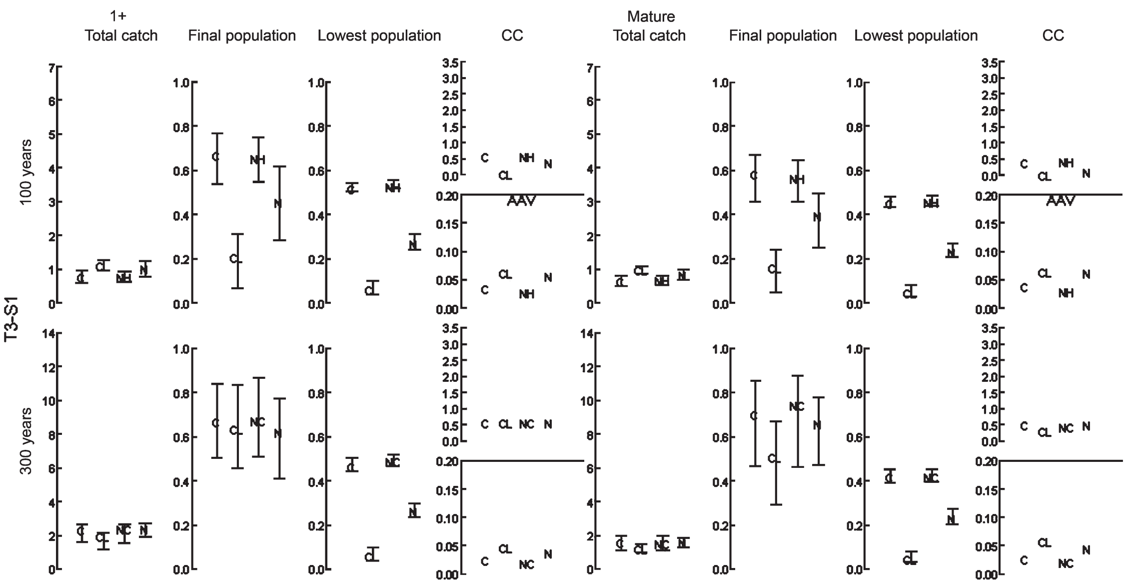


Fig. 12. Same as Fig.1., except for T3-S1.

Appendix 3

IMPLEMENTATION SIMULATION TRIAL SPECIFICATIONS FOR NORTH ATLANTIC FIN WHALES

A. Basic concepts and stock-structure

The objective of these trials is to examine the performance of the RMP when managing a fishery for North Atlantic fin whales off West Iceland. The underlying dynamics model allows for multiple stocks and sub-stocks and incorporates dispersal (permanent transfer of animals between stocks or sub-stocks). The model is age- and sex-structured.

The region to be managed (the Northern North Atlantic) is divided into 7 sub-areas (see Fig. 1). The term 'stock' refers to a group of whales from the same breeding ground. The model assumes there is a central 'C' stock (which feeds at least in the area between East Greenland and the Faroe Islands and possibly more widely), which is divided into two or three sub-stocks ('C1' and 'C2' or 'C1', 'C2' and 'C3'). In addition, there is a Spain stock 'S', and under most hypotheses an Eastern stock 'E' and/or a Western stock 'W' are assumed. There are six or seven feeding areas, namely Canada (EC); West Greenland (WG), East Greenland (EG) and West Iceland (WI) or EG/WI combined, East Iceland + Faroes (EI/F); North and West Norway (N) and Spain (Sp). There is no interchange (dispersion) of animals between stocks, but there is dispersion between sub-stocks 'C1' and 'C2' and between sub-stocks 'C2' and 'C3' for most trials. The rationale for the position of the sub-area boundaries is given in Item 3.1 of IWC (2009).

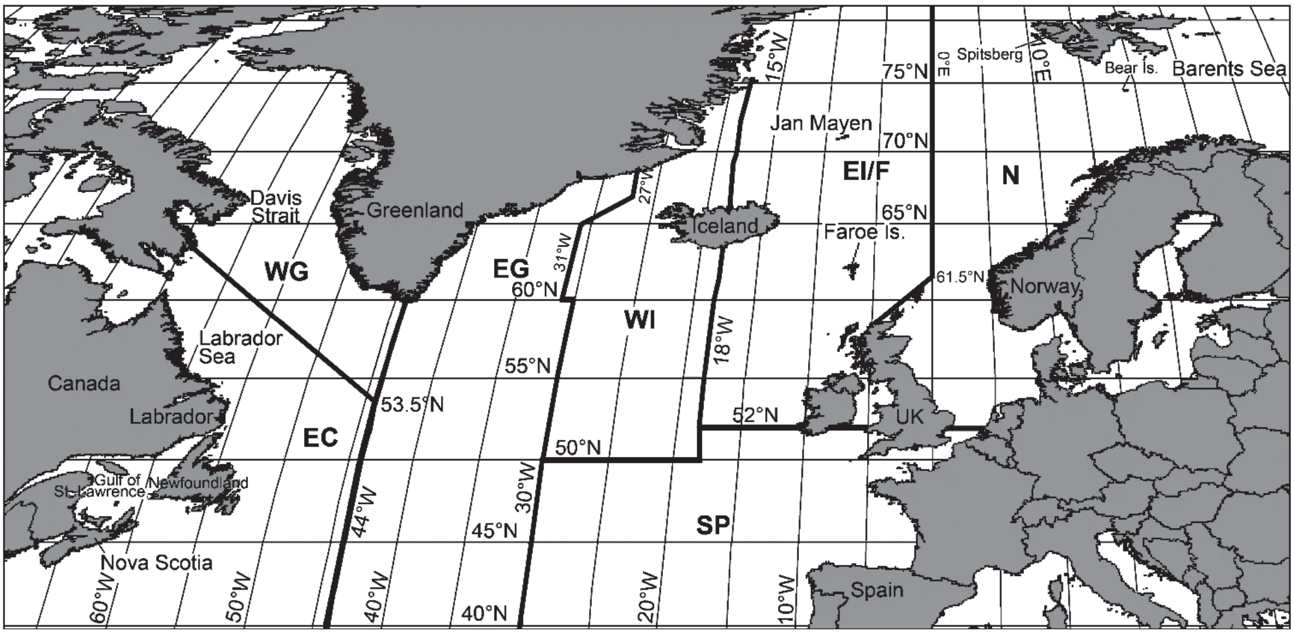


Fig. 1. Map of the North Atlantic showing the sub-areas defined for the North Atlantic fin whales. Sub-areas EG and WI are combined for Hypotheses VII and VIII.

There are seven general hypotheses regarding stock structure, as illustrated in Fig 2:

(I) *Four stocks with separate feeding areas*. There are 4 stocks, with the central 'C' stock divided into 3 sub-stocks. The 'W' stock feeds in the EC and WG sub-areas, sub-stock 'C1' in the EG sub-area, sub-stock 'C2' in the WI sub-area, sub-stock 'C3' in the EI/F sub-area, stock 'E' in the N sub-area, and stock 'S' in the Sp sub-area.

(II) *Four stocks with 'W' and 'E' feeding in the central sub-areas.* There are 4 stocks, with the central stock divided into 3 sub-stocks. The 'W' stock feeds in sub-areas EC, WG, EG and WI, sub-stock 'C1' in sub-area EG, sub-stock 'C2' in sub-area WI, sub-stock 'C3' in sub-area EI/F, stock 'E' in sub-areas WI, EI/F and N, and stock 'S' in sub-area Sp.

(III) *Four stocks with 'C' feeding in adjacent sub-areas*. There are 4 stocks, with the central stock divided into 3 sub-stocks. The 'W' stock feeds in sub-areas EC and WG, sub-stock 'C1' in sub-areas EC, WG and EG, sub-stock 'C2' in sub-area WI, sub-stock 'C3' in sub-areas EI/F and N, stock 'E' stock in sub-area N, and stock 'S' in sub-area Sp.

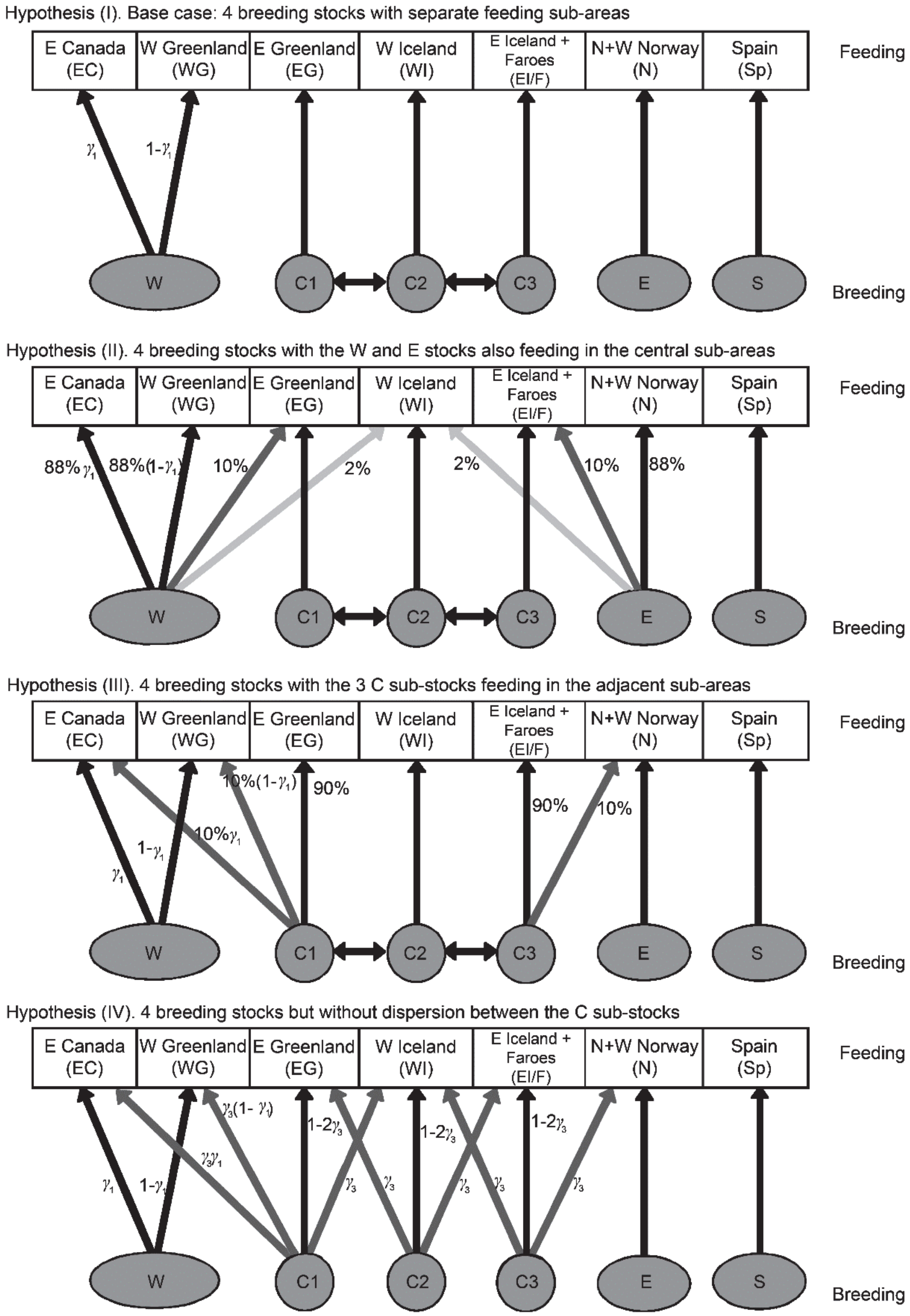
(IV) *Four stocks without sub-stock dispersion*. There are 4 stocks, with the central stock divided into 3 sub-stocks, but there is no dispersion between the sub-stocks. The 'W' stock feeds in sub-areas EC and WG; sub-stock 'C1' feeds in sub-areas EC, WG, EG and WI, sub-stock 'C2' in sub-areas EG, WI and EI/F, sub-stock 'C3' in sub-areas WI, EI/F and N, stock 'E' in sub-area N, and stock 'S' in sub-area Sp.

(V) *Four stocks with 'S' feeding in adjacent sub-areas*. There are 4 stocks, with the central 'C' stock divided into 3 sub-stocks. The stocks/sub-stocks feed as in hypothesis I except that stock 'S' feeds in sub-areas N and EI/F in addition to sub-area Sp.

(VI) *Three stocks*. There are 3 stocks, with the central 'C' stock divided into 3 sub-stocks. The 'W', 'C1', 'C2' and 'S' stock/sub-stocks feed as in hypothesis II. Sub-stock 'C3' feeds in sub-areas EI/F and N.

(VII) *As for hypothesis III (four stocks with 'C' feeding in adjacent sub-areas) except sub-areas EG and WI are combined and the central 'C' stock is divided into 2 sub-stocks.* Sub-stock 'C1' feeds in sub-areas EC, WG and EG/WI and sub-stock 'C2' in sub-areas EI/F and N.

(VIII) *As for hypothesis IV (four stocks without sub-stock dispersion) except sub-areas EG and WI are combined and the central 'C'stock is divided into 2 sub-stocks.* Sub-stock 'C1' feeds in sub-areas EC, WG, EG/WI and EI/F and sub-stock 'C2' in sub-areas EG/WI, EI/F and N.



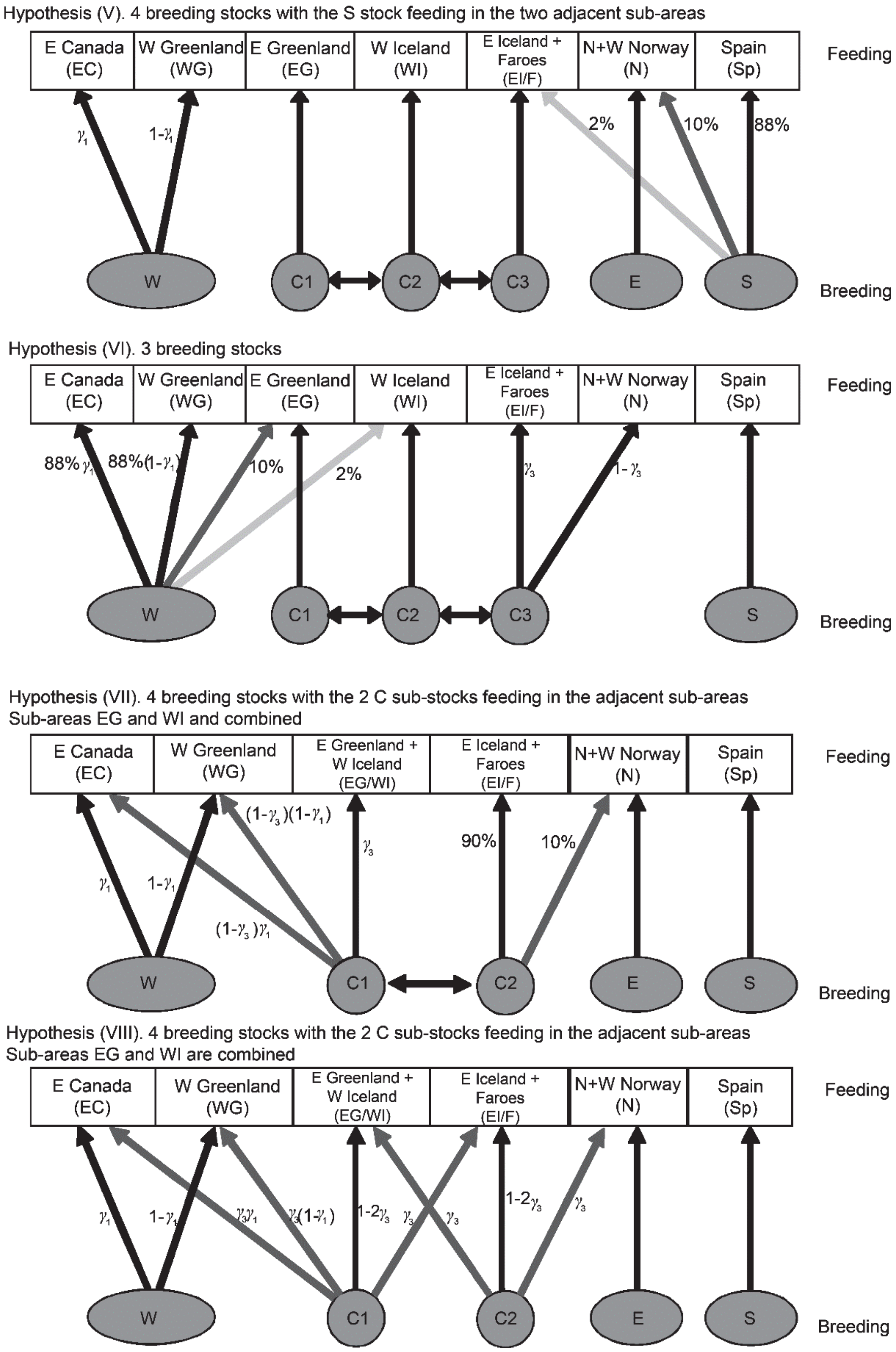


Fig. 2. Stock structure hypotheses for North Atlantic fin whales.

Possible sub-structure in the westernmost and easternmost regions has not been modelled (except as required by the nature of the abundance data) as the primary aim of these trials is not to investigate the full stock structure of fin whales in the North Atlantic, but rather to develop a broad set of hypotheses consistent with the data that will allow the conservation implications of future catches from the West Iceland sub-area to be examined.

B. Basic dynamics

The dynamics of the animals in stock/sub-stock *j* are governed by equations B.1(a) for the 'W', 'E' and 'S' stocks for which there is no dispersal (permanent movement) between stocks and by Equations B.1(b) for the 'C1', 'C2' and 'C3' sub-stocks:

$$N_{t+1,a}^{g,j} = \begin{cases} 0.5\, b_{t+1}^{j} & \text{if } a = 0 \\ (N_{t,a-1}^{g,j} - C_{t,a-1}^{g,j})\tilde{S} & \text{if } 1 \le a < x \\ (N_{t,x}^{g,j} - C_{t,x}^{g,j})\tilde{S} + (N_{t,x-1}^{g,j} - C_{t,x-1}^{g,j})\tilde{S} & \text{if } a = x \end{cases} \tag{B.1a}$$

$$N_{t+1,a}^{g,j} = \begin{cases} 0.5\, b_{t+1}^{j} & \text{if } a = 0 \\ \left(1 - \sum_{j' \neq j} D^{j,j'}\right)(N_{t,a-1}^{g,j} - C_{t,a-1}^{g,j})\tilde{S} + \sum_{j \neq j'} D^{j',j}(N_{t,a-1}^{g,j'} - C_{t,a-1}^{g,j'})\tilde{S} & \text{if } 1 \le a < x \\ \left(1 - \sum_{j' \neq j} D^{j,j'}\right)(N_{t,x}^{g,j} - C_{t,x}^{g,j} + N_{t,x-1}^{g,j} - C_{t,x-1}^{g,j})\tilde{S} + \sum_{j \neq j'} D^{j',j}(N_{t,x}^{g,j'} - C_{t,x}^{g,j'} + N_{t,x-1}^{g,j'} - C_{t,x-1}^{g,j'})\tilde{S} & \text{if } a = x \end{cases} \tag{B.1b}$$

where:

$N_{t,a}^{g,j}$ is the number of animals of gender g and age a in stock/sub-stock j at the start of year t (before any catch is taken);

$C_{t,a}^{g,j}$ is the catch (in number) of animals of gender g and age a in stock/sub-stock j during year t (whaling is assumed to take place in a pulse at the start of each year);

b_t^j is the number of calves born to females from stock/sub-stock j at the start of year t;

$\tilde{S}$ is the survival rate $= e^{-M}$ where M is the instantaneous rate of natural mortality (assumed to be independent of stock, time, age and sex);

x is the maximum age (treated as a plus-group); and

$D^{j,j'}$ is the dispersal rate (i.e. the probability of an animal moving permanently) from sub-stock j to j' (note: there is only dispersal between the C1 and C2 sub-stocks and between the C2 and C3 sub-stocks [when C3 is defined]).

Note that t=0, the year for which catch limits might first be set, corresponds to 2014.

Density-independent dispersal between stocks

The model allows density-independent dispersal (i.e. diffusion) between sub-stocks C1 and C2 and sub-stocks C2 and C3. Dispersal is assumed to occur after tagging, but prior to births and survey sightings.

The rates of dispersal between sub-stocks are constant over time, and selected so that at carrying capacity there is no net dispersal among sub-stocks. The values for the dispersal parameters are determined primarily by the mark-recapture data.

To ensure equilibrium in the pristine population:

$$K^{1+,C1}D^{C1,C2} = K^{1+,C2}D^{C2,C1} \quad \text{and} \quad K^{1+,C2}D^{C2,C3} = K^{1+,C3}D^{C3,C2} \tag{B.2a}$$

where: $$K^{1+,j} = \sum_{a=1}^{x}(N_{-\infty,a}^{m,j} + N_{-\infty,a}^{f,j}) \tag{B.2b}$$

In other words, given the estimated mean rate of dispersal between sub-stocks C1 and C2, $\alpha^{C1,C2}$, and sub-stocks C2 and C3, $\alpha^{C2,C3}$, the dispersal parameters are:

$$D^{C1,C2} = \alpha^{C1,C2}\frac{K^{1+,C1} + K^{1+,C2}}{0.5K^{1+,C1}} \quad \text{and} \quad D^{C2,C1} = D^{C1,C2}\frac{K^{1+,C1}}{K^{1+,C2}}$$

$$D^{C2,C3} = \alpha^{C2,C3}\frac{K^{1+,C2} + K^{1+,C3}}{0.5K^{1+,C2}} \quad \text{and} \quad D^{C3,C2} = D^{C2,C3}\frac{K^{1+,C2}}{K^{1+,C3}}$$

For this option the population dynamics are governed by equation B.1b.

C.1. Births

Density-dependence is assumed to act on the female component of the 'mature' population. The convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition.

$$b_t^j = B^j N_t^{f,j}\{1 + A^j(1 - (N_t^{f,j}/K^{f,j})^{z^j})\} \tag{C.1}$$

where:

B^j is the average number of births (of both sexes) per year for a mature female in stock/sub-stock j in the pristine population;

A^j is the resilience parameter for stock/sub-stock j;

z^j is the degree of compensation for stock/sub-stock j;

$N_t^{f,j}$ is the number of 'mature' females in stock/sub-stock j at the start of year t:

$$N_t^{f,j} = \sum_{a=a_m}^{x} N_{t,a}^{f,j} \tag{C.2}$$

a_m is the age-at-first-parturition; and

$K^{f,j}$ is the number of mature females in stock/sub-stock j in the pristine (pre-exploitation, written as t=-∞) population:

$$K^{f,j} = \sum_{a=a_m}^{x} N_{-\infty,a}^{f,j} \tag{C.3}$$

The values of the parameters A^j and z^j for each stock/sub-stock are calculated from the values for $MSYL^j$ and $MSYR^j$ (Punt, 1999). Their calculation assumes harvesting equal proportions of males and females.

D. Catches

It is assumed that whales are homogeneously distributed across a sub-area. The catch limit for a sub-area is therefore allocated to stocks/sub-stocks by sex and age relative to their true density within that sub-area and a mixing matrix V, i.e.:

$$C_{t,a}^{g,j} = \sum_k F_t^{g,k} V_t^{j,k} S_a^g N_{t,a}^{g,j} \tag{D.1}$$

$$F_t^{g,k} = \frac{C_t^{g,k}}{\sum_{j'} V_t^{j',k} \sum_{a'} S_{a'}^g N_{t,a'}^{g,j'}} \tag{D.2}$$

where:

$F_t^{g,k}$ is the exploitation rate in sub-area k on fully recruited ($S_a^g \to 1$) animals of gender g during year t;

S_a^g is the selectivity on animals of gender g and age a:

$$S_a^g = (1 + e^{-(a-a_{50}^g)/\delta^g})^{-1} \tag{D.3}$$

a_{50}^g, δ^g are the parameters of the (logistic) selectivity ogive for gender g;

$C_t^{g,k}$ is the observed catch of animals of gender g in sub-area k during year t; and

$V_t^{j,k}$ is the fraction of animals in stock/sub-stock j that is in sub-area k during year t.

In these trials the mixing matrix (V) is independent of year, sex and age (although the control program retains the option for dependency on year and age).

The catches by sub-area and year are set to one of two historical (pre-2013) series ('best' and 'high'[1]) as listed in Adjunct 1. The 'best' series includes an estimated lost whale rate of 30% in the early period (up to 1916) and allocates whales not identified to species based on the species proportions for the nearest group of years by operation or by sub-area depending on the available data. All of the unspecified whales are taken to be fin whales and a lost whale rate of 50% applied in the 'high' series. Further details of the assumptions used are included in Adjunct 1. Trials NF-H1, 3 and 4 use the 'high' catch series; all other trials use the 'best' series.

Future catches in the WI sub-area are determined using the RMP. A constant future annual catch of 19 whales, corresponding to the current aboriginal request for fin whales, is assumed to be taken in the WG sub-area. There are no future incidental catches. The sex ratio for historical catches of unknown sex and for future catches is assumed to be 50:50.

Trials NF-S3 and 4 test the sensitivity to the assumption of a time-invariant selectivity pattern, allowing the selectivity parameters to differ pre- and post-2007.

[1]In the 2007 trials, an additional, 'low' catch series was tested in which none of the unspecified whales were considered fin whales and a lost whale rate of 20% was applied. These trials are omitted in the current implementation.

E. Mixing

The entries in the mixing matrix *V* are selected to model the distribution of each stock/sub-stock at the time when the catch is removed/when the surveys are conducted. Mixing is deterministic in all the North Atlantic fin whale trials. Table 1 lists the mixing matrices for each of the stock structure hypotheses. (The problem of a mismatch between survey area and model sub-area, and the issue of surveyed whales moving out of the area before catching occurs is addressed in trials with process error due to boundary mis-specification (NF-X3) and alternative survey strategies (trials NF-P3 and NF-Q3)).

Table 1

The mixing matrices. The γs indicate that the entry concerned is to be estimated during the conditioning process.

	Feeding area	Stock W	Sub -stock C1	Sub-stock C2	Sub-stock C3	Stock E	Stock S
Hypothesis I	EC	γ_1	-	-	-	-	-
	WG	$1-\gamma_1$	-	-	-	-	-
	EG	-	1	-	-	-	-
	WI	-	-	1	-	-	-
	EI/F	-	-	-	1	-	-
	N	-	-	-	-	1	-
	SP	-	-	-	-	-	1
Hypothesis II	EC	$0.88\gamma_1$	-	-	-	-	-
	WG	$0.88(1-\gamma_1)$	-	-	-	-	-
	EG	0.10	1	-	-	-	-
	WI	0.02	-	1	-	0.02	-
	EI/F	-	-	-	1	0.10	-
	N	-	-	-	-	0.88	-
	SP	-	-	-	-	-	1
Hypothesis III	EC	γ_1	$0.10\gamma_1$	-	-	-	-
	WG	$1-\gamma_1$	$0.10(1-\gamma_1)$	-	-	-	-
	EG	-	0.90	-	-	-	-
	WI	-	-	1	-	-	-
	EI/F	-	-	-	0.90	-	-
	N	-	-	-	0.10	1	-
	SP	-	-	-	-	-	1
Hypothesis IV	EC	γ_1	$\gamma_3\gamma_1$	-	-	-	-
	WG	$1-\gamma_1$	$\gamma_3(1-\gamma_1)$	-	-	-	-
	EG	-	$1-2\gamma_3$	γ_3	-	-	-
	WI	-	γ_3	$1-2\gamma_3$	γ_3	-	-
	EI/F	-	-	γ_3	$1-2\gamma_3$	-	-
	N	-	-	-	γ_3	1	-
	SP	-	-	-	-	-	1
Hypothesis V	EC	γ_1	-	-	-	-	-
	WG	$1-\gamma_1$	-	-	-	-	-
	EG	-	1	-	-	-	-
	WI	-	-	1	-	-	-
	EI/F	-	-	-	1	-	0.02
	N	-	-	-	-	1	0.10
	SP	-	-	-	-	-	0.88
Hypothesis VI	EC	$0.88\gamma_1$	-	-	-	n/a	-
	WG	$0.88(1-\gamma_1)$	-	-	-	n/a	-
	EG	0.10	1	-	-	n/a	-
	WI	0.02	-	1	-	n/a	-
	EI/F	-	-	-	γ_3	n/a	-
	N	-	-	-	$1-\gamma_3$	n/a	-
	SP	-	-	-	-	n/a	1
Hypothesis VII	EC	γ_1	$(1-\gamma_3)\ \gamma_1$	-	n/a	-	-
	WG	$1-\gamma_1$	$(1-\gamma_3)\ (1-\gamma_1)$	-	n/a	-	-
	EG/WI	-	γ_3	-	n/a	-	-
	EI/F	-	-	0.90	n/a	-	-
	N	-	-	0.10	n/a	1	-
	SP	-	-	-	n/a	-	1
Hypothesis VIII	EC	γ_1	$\gamma_3\gamma_1$	-	n/a	-	-
	WG	$1-\gamma_1$	$\gamma_3(1-\gamma_1)$	-	n/a	-	-
	EG/WI	-	$1-2\gamma_3$	γ_3	n/a	-	-
	EI/F	-	γ_3	$1-2\gamma_3$	n/a	-	-
	N	-	-	γ_3	n/a	1	-
	SP	-	-	-	n/a	-	1

n/a denotes that the stock/sub-stock concerned is not included in the trial.

Trials NF-G1, NF-G3, NF-F1 and NF-F3 examine the possibility that the increase in abundance off East Greenland reflected in the recent abundance estimates is caused by changes in distribution. In these trials the rate of mixing of WI animals in *sub-area* EG increases from 1985 to 2005 [by linearly increasing the proportion of the C2 sub-stock in EG from 0% to 30%] and then (a) either remains at this level, or (b) declines to the 1985 level by 2025.

F. Generation of data

The actual historical estimates of absolute abundance (and their associated CVs) provided to the RMP are listed in Table 2. The proposed plan for future surveys is given in Table 3. The trials assume that it takes two years for the results of a sighting survey to become available for use by the management procedure, i.e. a survey conducted in 2015 could first be used for setting the catch limit in 2017. Trials NF-Y3 and 4 examine the possibility that future surveys would be conducted with longer intervals, with no application of the phase out rule.

Table 2

The estimates of abundance and their sampling standard errors (see IWC, 2009, Annex H and Adjunct 2). An abundance estimate of 1,613 in EI/F in 2007 (CV 0.26) is not used (see SC/66a/Rep04).

Sub-area	Year	Estimate	Sampling CV
EG	1988	5,269	0.221
EG	1995	8,412	0.288
EG	2001	11,706	0.194
EG	2007	12,215	0.20
WI	1988	4,243	0.229
WI	1995	6,800	0.218
WI	2001	6,565	0.194
WI	2007	8,118	0.26
EI/F	1987	5,261	0.277
EI/F	1995	6,647	0.288
EI/F	2001	7,490	0.255

Table 3

Sighting survey plan. The years in which catch limits are set are also shown.

Season	Sub-area EG	WI	EI/F	Set catch limits
2013-14	-	-	-	-
2015	Yes	Yes	Yes	Yes
2016-20	-	-	-	-
2021	Yes	Yes	Yes	Yes
2022-26	-	-	-	-
2027	Yes	Yes	Yes	Yes
	And so on in this pattern			

The future estimates of abundance for a survey area (a sub-area for these trials) (say survey area *K*) are generated using the formula developed for the first stage screening trials for a single stock (IWC, 1991, p.109):

$$\hat{P} = P\,Y\,w/\mu = P^*\,\beta^2\,Y\,w \tag{F.1}$$

where:

Y is a lognormal random variable $Y = e^{\varepsilon}$ where $\varepsilon \sim N(0;\sigma_\varepsilon^2)$ and $\sigma_\varepsilon^2 = \ell\text{n}(1+\alpha^2)$;

w is a Poisson random variable with $E(w) = \text{var}(w) = \mu = (P/P^*)/\beta^2$, *Y* and *w* are independent;

P is the current total (1+) population size in survey area *K*:

$$P = P_t^K = \sum_{k\in K}\sum_j V_t^{j,k}\sum_g\sum_{a\geq 1} N_{t,a}^{g,j} \tag{F.2}$$

P^* is the reference population level, and is equal to the total (1+) population size in the survey area prior to the commencement of exploitation in the area being surveyed; and

F is the set of sub-areas making up survey area *E*.

Note that under the approximation $CV^2(ab) \cong CV^2(a) + CV^2(b)$, $E(\hat{P}) \cong P$ and $CV^2(\hat{P}) \cong \alpha^2 + \beta^2 P^*/P$.

For consistency with the first stage screening trials for a single stock (IWC, 1991, p.109; 1994, pp. 85-86), the ratio $\alpha^2 : \beta^2 = 0.12 : 0.025$, so that:

$$CV(\hat{P}) = \tau(0.12 + 0.025P^*/P)^{1/2} \tag{F.3}$$

The value of τ is calculated from the survey sampling CV's of earlier surveys in sub-area *E*. If $\overline{CV^2}$ is the average value of CV^2 estimated for each of these surveys, and $\bar{P}$ is the average value of the total (1+) population sizes in area *E* in the years of these surveys, then:

$$\tau = \overline{CV^2} / \left(0.12 + 0.025P / \overline{P}\right) \quad \text{(F.4)}$$

and the CV of a survey estimate prior to the commencement of exploitation in the area being surveyed would be:

$$\sqrt{(\alpha^2 + \beta^2)} = 0.38\tau \quad \text{(F.5)}$$

The above equations apply in the absence of additional variance. If this is present with a *CV* of CV_{add}, then the following adjustment is made:

$$\sigma_\varepsilon^2 = \ell n\left(1 + \alpha^2 + CV_{add}^2\right) \quad \text{(F.6)}$$

An estimate of the *CV* is generated for each sighting survey estimate of abundance $\hat{P}$:

$$CV\left(\hat{P}\right)_{est}^2 = \sigma^2 \chi^2 / n \quad \text{(F.7)}$$

where $\sigma^2 = \ell n\left(1 + \alpha^2 + \beta^2 P^* / \hat{P}\right)$, and

χ^2 is a random number from a Chi-square distribution with *n* degrees of freedom (where *n*=10 as used for North Pacific minke whale *Implementation* trials (IWC, 2004)).

Three alternative survey strategies will be investigated in the robustness trials:

1. In trials NF-P3 future surveys will cover only the WI sub-area, but with greater survey sampling intensity. This is implemented by changing $n \rightarrow 3n$, $\alpha^2 \rightarrow \alpha^2/3$ and $\beta^2 \rightarrow \beta^2/3$ corresponding to a tripling of this intensity. The additional variance contribution to the estimate (CV_{add}) is unchanged.
2. In trials NF-Q3 future surveys in the WI and EI/F sub-areas do not cover the strata to the south of 60ºN. The generated abundance estimates are a proportion of the estimates for the full sub-area. In order to incorporate inter-annual variation, the proportion is drawn annually from a beta distribution with mean and variance based on the actual proportions from the NASS surveys. The same proportions are used in setting future abundance estimates under management variant V4 (see section I).
3. The effects of an 8-year period for abundance estimation are studied, without the phase-out rule being applied, in trials NF-Y3 and 4 to evaluate the maximum conservation risk associated with an 8-year inter-survey period.

G. Parameters and conditioning

The values for the biological and technological parameters are listed in Table 4.

Table 4

The values for the biological and technological parameters that are fixed.

Parameter	Value
Plus group age, *x*	25 years
Natural mortality, *M*	0.08yr^{-1} (see also below)
Age-at-first-parturition, a_m	Knife-edged at age 6
Maximum Sustainable Yield Level, *MSYL*	0.6 in terms of mature female component of the population

The natural mortality rate *M* is initially set to 0.08yr^{-1} for most trials, including the baseline. However, in the NF-U1 trials M=$0.04\text{yr}^{-1}$and the selectivity decreases by 4% per year geometrically for ages above 8 (see Item 4.5 of IWC (2009)) to allow for the possibility of dome-shaped selectivity, and noting that the Comprehensive Assessment meeting (IWC, 1992) used a value of M=0.04yr^{-1}.

The 'free' parameters of the above model are the initial (pre-exploitation) sizes of each of the sub-stocks/stocks, the values that determine the mixing matrices (i.e. the γ parameters), the dispersion rates between C1 and C2 and between C2 and C3, and the parameters for the gender specific selectivity ogive.

The process used to select these 'free' parameters is known as conditioning. The conditioning process involves first generating 100 sets of 'target' data as detailed in steps (a) to (d) below, and then fitting the population model to each (in the spirit of a bootstrap). The number of animals in sub-area *k* at the start of year *t* is calculated starting with guessed values of the initial population sizes and projecting the operating model forward to 2013 to obtain values of abundance etc. for comparison with the generated data[2].

The information used in the conditioning process is as follows.

(a) The 'target' values for the historical abundance by sub-area are generated using the formula:

$$P_t^k = O_t^k \exp[\mu_t^k - (\sigma_t^k)^2 / 2]; \; \mu_t^k \sim N[0; (\sigma_t^k)^2] \quad \text{(G.1)}$$

[2]Plots such as those shown in IWC (2003, pp.473-80) will be examined, together with time-trajectories of the fraction of each stock in each sub-area to check that the conditioning exercise has been successfully achieved.

where:

P_t^k is the abundance for sub-area k in year t;

O_t^k is the actual survey estimate for sub-area k in year t (Table 5); and

σ_t^k is the CV of O_t^k .

Additional variance was introduced for the surveys for the WG, EG, WI and EI/F sub-areas as described in IWC (2010b). Table 5 lists both the original sampling CV's associated with each estimate of abundance together with the conditioning CVs incorporating sub-area specific additional variance.

As some historical abundance estimates do not cover the full sub-area, the data used in conditioning robustness trials NF-A3 are pro-rated upwards. The revised estimates are listed in Table 5 (see also Adjunct 2). (These revised estimates will not be available to the *CLA*).

Table 5

The actual estimates of abundance, their sampling standard errors (see IWC (2009), Annex H for details) and the CV's including additional variance used in conditioning (IWC, 2010b). The pro-rated abundance estimates used in trials NF-A3 are also shown (see Adjunct 2 for details).

Sub-area	Year	Abundance estimate	Sampling CV	CV inc. additional variance	Pro-rated abundance (trials NF-A3)
EC	2007	10,105*	0.40	0.40	
WG	1987	1,096	0.35	0.566	
WG	2005	3,234	0.44	0.587	
WG	2007	4,359	0.45	0.67	
EG	1988	5,269	0.221	0.334	5,269
EG	1995	8,412	0.288	0.381	10,152
EG	2001	11,706	0.194	0.316	14,225
EG	2007	12,215	0.20	0.32	15,847
WI	1988	4,243	0.229	0.229	4,243
WI	1995	6,800	0.218	0.218	7,363
WI	2001	6,565	0.194	0.194	7,430
WI	2007	8,118	0.26	0.26	8,898
EI/F	1987	5,261	0.277	0.707	5,261
EI/F	1995	6,647	0.288	0.711	7,170
EI/F	2001	7,490	0.255	0.698	9,555
EI/F	2007	1,613	0.26	0.70	2,466
N	1995	3,964	0.21	0.21	
N	1999	3,749	0.24	0.24	
Sp	1989	17,355	0.265	0.265	

*The 2007 EC estimate (2,808, CV 0.302) is uncorrected and so is not used; the estimate of 10,105 from the IWC/NAMMCO workshop is used instead.

Table 6a

Summary of the fin whales marked (recorded as 'hits') and recovered in the North Atlantic. The following marks are excluded: nine off Africa in 1950, one off Nova Scotia in 1960; two in EC in 1965 and two in the Mediterranean in 1969, three marks not recorded as 'hits' but which were recovered; and one whale marked by Canada in 1968 and recovered the same day.

Year	EC	WG	EG	WI	EI/F	No	Sp
1965	0	0	0	13	0	0	0
1966	78	0	0	0	0	0	0
1967	53	5	8	0	0	0	0
1968	0	0	15	2	0	0	0
1969	46[1]	0	0	0	0	0	0
1970	3	0	3	1	0	0	0
1971	19	0	2	0	0	0	0
1972	59	0	0	3	0	0	0
1973	12	3	3	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	2	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	24	0
1979	27	3	0	33	0	0	0
1980	0	8	0	11	0	0	0
1981	0	4	26	62	0	0	3
1982	0	0	0	52	14	0	2
1983	0	0	5	10	0	0	17
1984	0	0	31	0	7	0	0
1985	0	0	0	0	0	0	0
1986	0	1	0	0	0	0	0
Total	299	24	93	187	21	24	22

[1]Including one whale marked between Oct. 68-Jan. 69.

Table 6b

Summary of the fin whales mark recovered in the North Atlantic.

	Release		Recovery				
MarkNo	Area	Year	Area	Year	Sex	Yrs to rec	Note:
34	EC	1966	EC	1966	F	0	
67	EC	1966	EC	1966	M	0	
16/410	EC	1966	EC	1966	M	0	
5/410	EC	1966	EC	1966	M	0	
C 177	EC	1966	EC	1967	F	1	
C 319	EC	1966	EC	1967	M	1	
94	EC	1966	EC	1967	M	1	
3/410	EC	1966	EC	1967	M	1	
63	EC	1966	EC	1967	M	1	
86	EC	1966	EC	1967		1	1
72	EC	1966	EC	1968	F	2	
15456	EC	1966	EC	1968	F	2	
89	EC	1966	EC	1968	M	2	
C 164	EC	1966	EC	1968	M	2	
15466	EC	1966	EC	1968	M	2	
70	EC	1966	EC	1968	F	2	
56	EC	1966	EC	1968		2	2
C 154	EC	1966	EC	1968		2	
73	EC	1966	EC	1968		2	
10/410	EC	1966	EC	1968		2	3
97	EC	1966	EC	1969	M	3	4
85	EC	1966	EC	1969	F	3	
3	EC	1966	EC	1969	M	3	
55	EC	1966	EC	1969	M	3	5
48	EC	1966	EC	1970	F	4	
58	EC	1966	EC	1970	F	4	
C 318	EC	1966	EC	1970	M	4	
C 183	EC	1966	EC	1971	M	5	
809	EC	1967	EC	1967	F	0	
816	EC	1967	EC	1968	F	1	
753	EC	1967	EC	1971	M	4	6
807	EC	1967	EC	1972	F	5	
912	EC	1967	EC	1969	M	2	4
~~15481~~	~~EC~~	~~1968~~	~~EC~~	~~1968~~	~~F~~	0	7
1083	EC	1969	EC	1971	F	2	
926	EC	1970	EC	1970	F	0	
1756	EC	1971	EC	1972	F	1	
1296	EC	1972	EC	1972	M	0	
1291	EC	1972	EC	1972	M	0	8
c1866	EC	1979	WI	1988	F	9	
16144	EG	1968	WI	1969	M	1	
16150	EG	1968	WI	1968	F	0	
15565	EG	1968	WI	1977	F	9	
15600	EG	1973	WI	1983	F	10	
38254	EG	1981	WI	1989	F	8	
39875	EG	1984	WI	1986		2	9
39876	EG	1984	WI	1988	M	4	10
~~39881~~	~~EG~~	~~1984~~	~~WI~~	~~1988~~	~~M~~	4	10
16110	WI	1965	WI	1966	M	1	11
16131	WI	1965	WI	1966	M	1	
16132	WI	1965	WI	1973	M	8	
16133	WI	1965	WI	1966	M	1	
16135	WI	1965	WI	1972	M	7	
15815	WI	1972	WI	1972	M	0	
36282	WI	1979	WI	1980	F	1	12
36289	WI	1979	WI	1979	F	0	
36298	WI	1979	WI	1982	F	3	
36310	WI	1979	WI	1980	M	1	
X74	WI	1979	WI	1981	?	2	
~~36226~~	~~WI~~	~~1979~~	~~WI~~	~~1979~~	~~F~~	0	13
29436	WI	1979	WI	1983	M	4	
36389	WI	1980	WI	1982	F	2	
36392	WI	1980	WI	1980	M	0	
36221	WI	1980	WI	1984	F	4	
29465	WI	1981	WI	1982	F	1	
38176	WI	1981	WI	1984	M	3	
38182	WI	1981	WI	1982	F	1	14
38184	WI	1981	WI	1981	F	0	
~~38220~~	~~WI~~	~~1981~~	~~WI~~	~~1981~~	~~M~~	0	15
38320	WI	1981	WI	1985	M	4	
38202	WI	1981	WI	1984	?	3	
38195	WI	1981	WI	1981	M	0	16
38199	WI	1981	WI	1984	F	3	
38201	WI	1981	WI	1985	F	4	
38204	WI	1981	WI	1982	M	1	
38316	WI	1981	WI	1981	F	0	
38193	WI	1981	WI	1982	M	1	
38217	WI	1981	WI	1983	?	2	
38213	WI	1981	WI	1984	F	3	
~~38214~~	~~WI~~	~~1981~~	~~WI~~	~~1981~~	~~M~~	0	17
38216	WI	1981	WI	1981	M	0	
38241	WI	1981	WI	1983	M	2	
38255	WI	1981	WI	1983	F	2	
38261	WI	1981	WI	1985	M	4	
40796	WI	1981	WI	1982	F	1	
24824	WI	1982	WI	1984	M	2	
24826	WI	1982	WI	1982	M	0	
24828	WI	1982	WI	1982	M	0	
24834	WI	1982	WI	1984	F	2	
24842	WI	1982	WI	1984	M	2	
24851	WI	1982	WI	1984	M	2	
24868	WI	1982	WI	1982	M	0	
24865	WI	1982	WI	1986	M	4	18
39794	WI	1982	WI	1983	M	1	
39806	WI	1982	WI	1989	F	7	19
39815	WI	1982	WI	1985	M	3	
39829	WI	1983	WI	1988	F	5	
39837	WI	1983	WI	1989	M	6	
~~39838~~	~~WI~~	~~1983~~	~~WI~~	~~1983~~	~~F~~	~~0~~	20
40278	EI/F	1982	EI/F	1982	F	0	

Notes

1. Recovery date given as 'before Jun 1968' (in cooker?) and elapsed time as ~11 months so recovery year set as 1967.
2. Mitchell (1977) says found before 10/8/68 and elapsed time 24-26 months but letter from Mitchell to Brown dated April 1968 says recovered from kvæner (cooker) 1967.
3. Recovery date given as 'before 3 July 1969' (in cooker?) and elapsed time as ~23 months so recovery year set as 1968.
4. Tags 97 (fired in 1966) and 912 (fired in 1967) were recovered from the same whale.
5. Also recovered 1966 tag 11/410 in this whale.
6. Tagging date given as 29/07/1967 and recovery date as 09/05/1971 but elapsed time as 9⅓ months.
7. One mark only, recovered on the same/next day. Not used in conditioning.
8. Mark 1293 fired during the same cruise was recovered in the same whale.
9. Found in cooking pot; prior to this season.
10. 39876 and 39881 recovered in same whale but not thought to be same whale on firing. Only one used in conditioning.
11. Whale double tagged; 2nd tag (16111) also recovered.
12. Whale double tagged; 2nd tag (36283) also recovered.
13. Recorded as protruding hit, recovered one month later. Not used in conditioning.
14. Whale double tagged; 2nd tag (38179) also recovered.
15. Recorded as protruding hit, recovered three days later and found to be permanent. Not used in conditioning.
16. Tag no. uncertain. 38195 and 6 both fired in 1981. Discrepancy re: which was recovered.
17. Recorded as miss, recovered same day. Not used in conditioning.
18. Recovery date given as 1986 in Icelandic data (with 1986 whale number) but as 1987 in Icelandic Progress Report.
19. Female in IMS records but male in Icelandic data.
20. Recorded as protruding hit, recovered two months later. Not used in conditioning.

(b) A ‘target’ for the numbers of animals tagged and recaptured is generated by selecting records at random and with replacement from the tag-recapture data (see Table 6). The objective function used to include the tagging data when conditioning is given below. The tag recapture data are assumed to be negative binomially (rather than Poisson) distributed to account for possible non-randomness in the tagging/recapture process. The dynamics of tagged animals are essentially the same as those of untagged animals, except that account needs to be taken of tagging. The following equations are used to determine the number of tagged animals of age *a* (for ages less than *x*) and gender *g* in stock/sub-stock *j* at the start of year *t*+1 originally tagged in sub-area *k*, $T^{g,j,k}_{t+1,a}$ (tagging is assumed to take place halfway through the fishing season):

For stocks with no dispersal:
$$T^{g,j,k}_{t+1,a} = T^{g,j,k}_{t,a-1}(1-\sum_{k'} V^{j,k'}_t S^g_{a-1} F^{g,k'}_t)\Omega_{2+} e^{-M} + Q^{g,j,k}_{t,a-1}(\Omega_1\ e^{-M})^{1/2} \quad \text{(G.2a)}$$

For stocks with dispersal:
$$T^{g,j,k}_{t+1,a} = \tilde{T}^{g,j,k}_{t+1,a} + \sum_{j\neq j'} \left\{ D^{j',j}\tilde{T}^{g,j'}_{t+1,a} - D^{j,j'}\tilde{T}^{g,j,k}_{t+1,a} \right\} \quad \text{(G.2b)}$$

where:

$Q^{g,j,k}_{t,a}$ is the number of animals of age *a* and gender *g* in stock/sub-stock *j* that were tagged in sub-area *k* during year *t*:

$$Q^{g,j,k}_{t,a} = \frac{(Q^k_t - SS^k_t / \Psi^k) C^{g,k}_t}{C^{\mathrm{f},k}_t + C^{\mathrm{m},k}_t} \frac{V^{j,k}_t N^{g,j}_{t,a}}{\sum_{j'} V^{j',k}_t \sum_{a'} N^{g,j'}_{t,a'}} \quad \text{(G.2c)}$$

Q^k_t is the number of releases during year *t* in sub-area *k*;

SS^k_t is the number of whales recovered in the same season as the tags were released in sub-area *k*;

$\tilde{T}^{g,j,k}_{t+1,a}$ is defined as for $T^{g,j,k}_{t+1,a}$ in the no dispersion case (i.e. is set using equation G.4a);

Ψ^k is the reporting rate parameter (usually set to 1); and

Ω_1 and Ω_2 are unity less the rates of tag-loss in year 1 and years 2 on (both are assumed to be unity for the baseline analyses).

The number of ‘recruits’ by age, sex and sub-stock to the tagged population therefore depends on the actual number tagged, assuming that an animal to be tagged is selected at random from the catch. Account is taken in Equation G.2 of mortality (both natural and fishing) from the time of tagging until the end of the year. If there is no catch in a sub-area *k* and year *t* when tagging takes place, then the tags are allocated using a 50:50 male:female ratio.

The model-predicted number of animals recaptured during year *t* in sub-area *k* that were originally tagged in sub-area k', $U^{k,k'}_t$ is given by:

$$U^{k,k'}_t = \Psi^k \left(\sum_g \sum_j \sum_a T^{g,j,k}_{t,a} V^{j,k}_t S^g_a F^{g,k}_t \right) \quad \text{(G.3)}$$

Same season recoveries are removed from the population, accounting for tag-reporting, but are not included in the likelihood function (i.e. they are included in Eqn G.2 but not G.3). Trials NF-R3 and 4 test the effect of excluding tags recaptured after one year (in addition to the same season recoveries) from the likelihood.

The mark reporting rate Ψ^k is taken to equal 1 in the base case except for tags released in Canada where it is treated as estimable. A loss rate of 0 is assumed in the base case. A loss rate of 0.2yr^{-1} in yr 1 (i.e. $\Omega_1 = e^{-0.2}$), and 0.1 thereafter (i.e. $\Omega_{2+} = e^{-0.1}$) is tested in trials NF-T1-3.

(c) In the base case, CPUE data will be used qualitatively to compare with model output rather than being included directly in the likelihood calculation. In addition trials NF-C3 will investigate the effect of including all the CPUE series (West Iceland 1962-87, East Iceland 1904-13 (Punt, 2009) and West Iceland 1902-14 (Gunnlaugsson series 2)) in the likelihood calculation. The CPUE series are listed in Table 7.

(d) A ‘target’ for the numbers of animals caught at age in the WI whaling grounds is generated using the formula:

$$P^{g,k}_{t,a} = P^{\hat{g},k}_{t,a} \Big/ \sum_{a'} P^{\hat{g},k}_{t,a'}$$

where $P^{g,k}_{t,a}$ the proportion of animals of age *a* and sex *g* caught during year *t* in sub-area *k*. $P^{\hat{g},k}_{t,a}$ is given by the formula:

$$P^{\hat{g},k}_{t,a} = O^{g,k}_{t,a} e^{\varepsilon^{g,k}_{t,a}}; \quad \varepsilon^{g,k}_{t,a} \sim N\left(0, \sigma^{g,k}_{t,a}\right)$$

where $O^{g,k}_{t,a}$ is the observed proportion of animals of age *a* and sex *g* caught during year *t* in sub-area *k* derived from Tables 1 and 2 in adjunct 3,

$$\sigma^{g,k}_{t,a} = \sqrt{\frac{\sigma^2}{O^{g,k}_{t,a}}}$$ and σ^2 is given in equation G.12 below.

Table 7

CPUE series for North Atlantic fin whales.

Earlier period			Later period				
	East Iceland	West Iceland		West Iceland			
Year	CPUE i=5	CPUE i=6	Year	CPUE i=1	CPUE i=2	CPUE i=3	CPUE i=4
1902	-	24.8	1962	0.1398	0.1512	0.1048	-
1903	-	21.2	1963	0.1363	0.0841	0.0671	-
1904	1.195	22.9	1964	0.0770	0.0551	0.0492	-
1905	1.621	28.3	1965	0.1979	0.1519	0.1204	-
1906	0.894	18.2	1966	0.1150	0.1083	0.0863	0.1310
1907	1.122	16.0	1967	0.1040	0.1280	0.1798	0.1350
1908	0.971	16.5	1968	0.1548	0.0990	0.1314	0.1672
1909	1.228	25.4	1969	0.0541	0.0880	0.0691	0.0495
1910	0.733	18.4	1970	0.1040	0.1596	0.1466	0.1282
1911	0.739	16.9	1971	0.0824	0.0591	0.0523	0.0703
1912	-	9.9	1972	0.0836	0.0718	0.0648	0.0601
1913	0.496	5.8	1973	0.0785	0.0853	0.0708	0.0791
1914	-	7.4	1974	0.0810	0.1134	0.0861	0.1132
			1975	0.1115	0.0958	0.0779	0.1011
			1976	0.1067	0.0909	0.0993	0.0779
			1977	0.0296	0.0651	0.0443	0.0390
			1978	0.0507	0.0583	0.0732	0.0675
			1979	0.1817	0.1494	0.1389	0.1276
			1980	0.0891	0.0933	0.1317	0.1220
			1981	0.1572	0.1134	0.1333	0.1271
			1982	0.1677	0.1190	0.1094	0.0974
			1983	0.0804	-	0.0597	0.0837
			1984	0.1169	-	0.1233	0.1283
			1985	0.1170	-	0.0777	0.0857
			1986	-	-	0.0744	0.0856
			1987	-	-	0.1792	0.0990

Table 8

The variance-covariance matrix for the late CPUE series obtained by quadratically de-trending the log-transformed data (Butterworth and Punt, 1992).

	1	2	3	4
1	0.171	0.089	0.102	0.118
2	0.089	0.103	0.105	0.076
3	0.102	0.105	0.156	0.104
4	0.118	0.076	0.104	0.127

Calculation of Likelihood

The likelihood function consists of up to five components (depending on whether the CPUE data are used when conditioning trials). Equations G.4-G.5, G.9, G.11 and G.12 list the negative of the logarithm of the likelihood for each of these components so the objective function minimised is L_1+L_2+L_3+L_4+L_5. An additional penalty is added to the likelihood if the full historic catch is not removed.

(a) Abundance estimates

$$L_1 = 0.5\sum_n \frac{1}{(\sigma_n)^2}\ell n\left(P_n / \hat{P}_n\right)^2 \tag{G.4}$$

where $\hat{P}_n$ is the model estimate of the 1+ abundance in the same year and sub-area as the n^{th} estimate of abundance P_n

(b) Tagging data

$$L_2 = \sum_t \sum_{k'} \sum_k \ell n\left(\frac{\Gamma(U_t^{k,k'} + \tilde{U}_t^{k,k'})}{\Gamma(\tilde{U}_t^{k,k'}+1)\Gamma(U_t^{k,k'})}\right) + U_t^{k,k'}\ell n\left(\frac{\lambda}{1+\lambda}\right) + \tilde{U}_t^{k,k'}\ell n\left(\frac{1}{1+\lambda}\right) \tag{G.5}$$

where:

$\tilde{U}_t^{k,k'}$ is the observed number of animals recaptured during year t in sub-area k that were originally tagged in sub-area k'; and

λ is an over-dispersion parameter.

In order to investigate the trade-off between fitting the tags recovered in the EC sub-area from tagging in that sub-area and tags recovered in sub-area WI from tagging conducted there, trials NF-W1 weight the contribution of all the tagging data to the objective function by a factor of 10.

(c) CPUE data
The *i*th CPUE series is assumed to be proportional to the selected abundance in the corresponding area *k* and year *t*.

$$CPUE_t^{k,i} = q^i N_t^{k,e} \tag{G.6}$$

$$N_t^{k,e} = \sum_j V_t^{j,k} \sum_g \sum_a S_a^g N_{t,a}^{g,j} \tag{G.7}$$

The catchability coefficient q^i for CPUE series i is set to its maximum likelihood value, which is given by:

$$\ell n\hat{q}^i = \tfrac{1}{n^i}\sum_t \left(\ell nCPUE_t^{k,i} - \ell nN_t^{k,e}\right) \tag{G.8}$$

where n^i is the number of data points for CPUE series i.

The negative log-likelihood for the later period CPUE series (i=1 to 4) over 1966 to 1982 is given by:

$$L_3 = -\ell nL^{CPUE1} = 0.5\sum_t \eta_t \left[V^{-1}\right]\eta_t^T \tag{G.9}$$

where V^{-1} is the inverse of the variance-covariance matrix V (Table 8) for the late series CPUE indices, and η_t is a vector comprised of four elements, the ith element of which is:

$$\eta_t^i = \ell nCPUE_t^{k,i} - \ell nq^i N_t^{k,e} \tag{G.10}$$

This method applies to the years in which values from all four series are available (1966-82). Where there are values available from only three (1962-65 and 1983-85) or two (1986-87) of the series, the contributions to $-\ell nL^{CPUE1}$ are similar but V and η_t are reduced by removing the row(s) and column(s) for which no values are available.

For the earlier period CPUE series (i=5 or 6) the negative log-likelihoods are:

$$L_4 = -\ell nL^{CPUE2} = \sum_{i=5}^{6}\left(\tfrac{1}{2\sigma_i^2}\sum_t \left[\ell nCPUE_t^{k,i} - \ell n\left(q^i N_t^{k,e}\right)\right]^2\right) \tag{G.11}$$

where values of σ_5=0.228 and σ_6=0.251 were obtained by quadratic de-trending of these data.

(d) Catch at age data
The log-likelihood function follows the approach of Punt and Kennedy (1997):

$$L_5 = \sum_{g,t,k,a}\left\{0.5\ell n\left(\sigma^2 / p_{t,a}^{g,k}\right) + \tfrac{p_{t,a}^{g,k}}{2\sigma^2}\left(\ell n\left(p_{t,a}^{g,k}\right) - \ell n\left(\pi_{t,a}^{g,k}\right)\right)^2\right\} \tag{G.12}$$

where: $\pi_{t,a}^{g,k} = \dfrac{S_a^g \sum_j V_t^{j,k} N_{t,a}^{g,j}}{\sum_{a'} S_{a'}^g \sum_{j'} V_t^{j',k} N_{t,a'}^{g,j'}}$, $p_{t,a}^{g,k} = C_{a,t}^{\text{obs},g,k} / \sum_{a'} C_{a',t}^{\text{obs},g,k}$ i.e. the predicted and observed proportions in sub-area *k*,

and $\sigma^2 = \sum_{g,t,k,a}\left\{p_{t,a}^{g,k}\left(\ell n\left(p_{t,a}^{g,k}\right) - \ell n\left(\pi_{t,a}^{g,k}\right)\right)^2\right\} / \sum_{g,t,k,a}(1)$

$C_{a,t}^{\text{obs},g,k}$, the observed catches by age and sex, are listed in Adjunct 3, except that the early age-compositions are excluded (see SC/66a/Rep04).

H. Trials
The *Implementation Simulation Trials* for the North Atlantic Fin whales are listed in Table 9. Adjunct 4 compares the trial numbers used here with those used in the previous *Implementation* (IWC, 2010a).

In these trials density dependence and MSYL are defined on the 1+ population; MSYR is defined in terms of 1^+ on 1% and mature on 4%.

Table 9

The *Implementation Simulation Trials* for North Atlantic fin whales. All trials assume the following unless otherwise stated: the 'Best' catch series; future surveys will occur in sub-areas EG, WI and EI/F; and $g(0)$ is taken to be equal to 1.

Trial no.	Stock hypothesis	*MSYR* [3]	No. of stocks	Trial weight	Trial description
Baseline					
NF-B1	I	1, 4%	4	H	Base case: 4 stocks, separate feeding areas
NF-B2	II	1, 4%	4	M	4 stocks; 'W' and 'E' feed in central sub-areas
NF-B3	III	1, 4%	4	M	4 stocks; 'C1' and 'C3' feed in adjacent sub-areas
NF-B4	IV	1, 4%	4	M	4 stocks without sub-stock dispersion (i.e. no interchange)
NF-B5	V	1, 4%	4	M	4 stocks as in hypothesis I but stock 'S' in adjacent sub-areas
NF-B6	VI	1, 4%	3	M	3 stocks (no 'E' stock)
NF-B7	VII	1, 4%	4		4 stocks as in hypothesis III but WI/EG are combined; 2 'C' sub-stocks
NF-B8	VIII	1, 4%	4		4 stocks as in hypothesis IV but WI/EG are combined; 2 'C' sub-stocks (no dispersal)
Other factors					
NF-H1	I	1, 4%	4	M	High historical catch series
NF-H3	III	1, 4%	4	M	High historical catch series
NF-H4	IV	2.54%	4	H	High historical catch series
NF-X3	III	1, 4%	4	M	N Iceland catch inc. in WI sub-area
NF-P3	III	1, 4%	4	M	Survey WI only with greater precision
NF-Q3	III	1, 4%	4	M	Future WI and EI/F surveys exc. strata S 60ºN
NF-A3	III	1, 4%	4	M	Pro-rate abundance data for conditioning
NF-C3	III	1, 4%	4	M	Inc. CPUE data in the likelihood calculation
NF-T1	I	1, 4%	4	M	Tag loss=20% in year 1; 10%/year thereafter
NF-T3	III	1, 4%	4	M	Tag loss=20% in year 1; 10%/year thereafter
NF-T4	IV	1, 4%	4	M	Tag loss=20% in year 1; 10%/year thereafter
NF-U1	I	1, 4%	4	M	Selectivity decreases by 4%/year for age 8+; M=0.04
NF-W1	I	1, 4%	4	M	Weight tag likelihood by factor of 10
NF-G1	I	1, 4%	4	M	C2 sub-stock enters EG beginning year 1985 (opt. a)
NF-G3	III	1, 4%	4	M	C2 sub-stock enters EG beginning year 1985 (opt. a)
NF-F1	I	1, 4%	4	M	C2 sub-stock enters EG 1985-2025 (opt. b)
NF-F3	III	1, 4%	4	M	C2 sub-stock enters EG 1985-2025 (opt. b)
NF-S3	III	1, 4%	4	-	Selectivity estimated for pre and post 2007
NF-S4	IV	1, 4%	4	-	Selectivity estimated for pre and post 2007
NF-Y3	III	1, 4%	4	-	8 year future survey interval
NF-Y4	IV	1, 4%	4	-	8 year future survey interval
NF-R3	III	1, 4%	4	-	Exclude tags recaptured after one year
NF-R4	IV	1, 4%	4	-	Exclude tags recaptured after one year

I. Management options

The following management variants will be considered.

Management variants based on calculating catch limits by *Small Area*:

V1 Sub-area WI is a *Small Area*;

V2 Sub-area (WI+EG) is a *Small Area*. All of the catch is taken in the WI sub-area;

V3 Sub-area (WI+EG+EI/F) is a *Small Area*. All of the catch is taken in the WI sub-area;

V4 Sub-area WI is a *Small Area*. Catch limits will be set based on survey estimates for the WI sub-area north of 60°N (both historical and future surveys). The same proportions are used in setting future abundance estimates as for trials NF-Q3 (see item F). The catch series is unchanged as all historical catches in the WI sub-area were taken north of 60°N;

Management variants based on applying catch cascading:

V5 Sub-areas WI and EG are taken to be *Small Areas* and sub-area WI+EG is taken to be a *Combination area*. The catch limits set for the EG *Small Area* are not taken;

V6 Sub-areas WI, EI/F and EG are taken to be *Small Areas* and sub-area WI+EI/F+EG is taken to be a *Combination area*. The catch limits set for the EG and EI/F *Small Areas* are not taken.

V7 Sub-areas WI+EG and EI/F are taken to be *Small Areas* and sub-area WI+EI/F+EG is taken to be a *Combination area*. The catch limits set for the WI+EG *Small Area* are taken in the WI sub-area. The catch limit for the EI/F sub-area is taken there.

The simulated application of the RMP is based on using the 'best' catch series (see Adjunct 1).

J. Output Statistics

Population-size and continuing catch statistics are produced for each stock/sub-stock and catch-related statistics for each sub-area.

(1) Total catch (TC) distribution: (a) median; (b) 5^{th} value; (c) 95^{th} value.

[3]MSYR in terms of 1^+ on 1% and mature on 4%.

(2) Initial mature female population size (P_{initial}) distribution: (a) median; (b) 5th value; (c) 95th value.

(3) Final mature female population size (P_{final}) distribution: (a) median; (b) 5th value; (c) 95th value.

(4) Lowest mature female population size (P_{lowest}) distribution: (a) median; (b) 5th value; (c) 95th value.

(5) Average catch by sub-area over the first ten years of the 100 year management period: (a) median; (b) 5th value; (c) 95th value.

(6) Average catch by sub-area over the last ten years of the 100 year management period: (a) median; (b) 5th value; (c) 95th value.

K. References

Butterworth, D.S. and Punt, A.E. 1992. Assessments of the East Greenland-Iceland fin whale stock. *Rep. int. Whal. Commn.* 42: 671-96.

International Whaling Commission. 1991. Report of the Sub-Committee on Management Procedures, Appendix 4. Report of the *ad-hoc* trials subgroup. *Rep. int. Whal. Commn.* 41:108-12.

International Whaling Commission. 1992. Report of the Comprehensive Assessment Special Meeting on North Atlantic Fin Whales, Reykjavík, 25 February-1 March 1991. *Rep. int. Whal. Commn.* 42: 595-644

International Whaling Commission. 1994. Report of the Scientific Committee, Annex D. Report of the Sub-Committee on Management Procedures, Appendix 2. Minimum Standards Trials. *Rep. int. Whal. Commn.* 44:85-88.

International Whaling Commission. 2003. Report of the Workshop on North Pacific common minke whale (*Balaenoptera acutorostrata*) *Implementation Simulation Trials*. *J. Cetacean Res. Manage. (Suppl.)* 5:455-87.

International Whaling Commission. 2004. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 10. North Pacific minke whale *Implementation Simulation Trial* specifications. *J. Cetacean Res. Manage. (Suppl.)* 6:118-29.

International Whaling Commission. 2009. Report of the First Intersessional RMP Workshop on North Atlantic Fin Whales, 31 March to 4 April 2008, Greenland Representation, Copenhagen. *J. Cetacean Res. Manage. (Suppl.)* 11:425-52.

International Whaling Commission. 2010a. Report of the 2nd Intersessional Workshop of the North Atlantic Fin Whale *Implementation*, 19-22 March 2009, Greenland Representation, Denmark. Annex B. The specifications for the *Implementation Simulation Trials* for North Atlantic fin whales. *J. Cetacean Res. Manage. (Suppl.)* 11(2):598-618.

International Whaling Commission. 2010b. Report of the 2nd Intersessional Workshop of the North Atlantic Fin Whale *Implementation*, 19-22 March 2009, Greenland Representation, Denmark. Annex C. Estimation of Additional Variance. *J. Cetacean Res. Manage. (Suppl.)* 11(2):618-19.

Mitchell, E.D. 1977. Canadian progress report on whale research - June 1975 to May 1976. *Rep. int. Whal. Commn.* 27: 73-85.

Punt, A.E. 1999. Report of the Scientific Committee. Annex R. A full description of the standard BALEEN II model and some variants thereof. *J. Cetacean Res. Manage. (Suppl.)* 1: 267-76.

Punt, A.E. 2009. Report of the First Intersessional RMP Workshop on North Atlantic Fin Whales, 31 March to 4 April 2008, Greenland Representation, Copenhagen. Annex I. Analysis of historical catch-rate data for East Iceland. *J. Cetacean Res. Manage. (Suppl.)* 11: 450-51.

Punt, A.E. and Kennedy, R.B. 1997. Population modelling of Tasmanian rock lobster, *Jasus edwardsii*, resources. *Mar. Freshw. Res.* 48: 967-80.

Adjunct 1

The Catch Series

The Catch Series used in the trials are given in Tables 1 (the 'best' series) and 2 (the 'high' series). The 'best' series includes an estimated lost whale rate of 30% in the early period (up to 1916) and allocates whales not identified to species based on the species proportions for the nearest group of years by operation or by sub-area depending on the available data. In the 'high' catch series all the unspecified whales are taken to be fin whales and a lost whale rate of 50% in the period up to 1916 is applied.

Table 3 lists the catches known by sex. A sex ratio of 50:50 is assumed for all other catches.

Table 1

'Best' Catch Series (total 95,975 whales). Catches from land-stations by area are listed followed by pelagic catches. Catches from the UK are allocated to the EI/F sub-area as Thompson 1928 showed that most fin whales were taken there. Pelagic catches of unknown area are allocated as follows: [a]WI sub-area; [b]N sub-area; [c]167:52 WI:N; [d]50:50 WI:N sub-areas.

Year	Canada (EC)	WGrnl. (WG)	EGrnl. (EG)	WIcel. (WI)	E.Icel. (EI/F)	Faroe (EI/F)	UK (EI/F)	Spitsb. (N)	N.Norw (N)	W.Norw (N)	Spain (Sp)	Pelag. WG	Pelag. EG	Pelag. WI	Pelag. EI/F	Pelag. N	Pelag. ?Area
1864	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
1865	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0
1866	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0
1867	0	0	0	0	19	0	0	0	1	0	0	0	0	0	0	0	0
1868	0	0	0	0	2	0	0	0	10	0	0	0	0	0	0	0	0
1869	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0
1870	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0	0	0
1871	0	0	0	0	5	0	0	0	20	0	0	0	0	0	0	0	0
1872	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0
1873	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0
1874	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0
1875	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0
1876	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
1877	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
1878	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0
1879	0	0	0	0	0	0	0	0	52	0	0	0	0	0	0	0	0
1880	0	0	0	0	0	0	0	0	65	0	0	0	0	0	0	0	0
1881	0	0	0	0	0	0	0	0	68	0	0	0	0	0	0	0	0
1882	0	0	0	0	0	0	0	0	366	0	0	0	0	0	0	0	0
1883	0	0	0	0	0	0	0	0	316	0	0	0	0	0	0	0	0
1884	0	0	0	3	0	0	0	0	338	0	0	0	0	0	0	0	0
1885	0	0	0	18	0	0	0	0	612	0	0	0	0	0	0	0	0
1886	0	0	0	14	0	0	0	0	867	0	0	0	0	0	0	0	0
1887	0	0	0	28	0	0	0	0	627	0	0	0	0	0	0	0	0
1888	0	0	0	47	0	0	0	0	509	0	0	0	0	0	0	0	0
1889	0	0	0	86	0	0	0	0	509	0	0	0	0	0	0	0	0
1890	0	0	0	105	0	0	0	4	481	0	0	0	0	0	0	0	0
1891	0	0	0	119	0	0	0	2	393	0	0	0	0	0	0	0	0
1892	0	0	0	164	5	0	0	0	530	0	0	0	0	0	0	0	0
1893	0	0	0	403	4	0	0	0	735	0	0	0	0	0	0	0	0
1894	0	0	0	273	0	18	0	0	710	0	0	0	0	0	0	0	0
1895	0	0	0	372	0	10	0	0	592	0	0	0	0	0	0	0	0
1896	0	0	0	235	0	26	0	0	1,051	0	0	0	0	0	0	0	0
1897	0	0	0	329	0	33	0	0	608	0	0	0	0	0	0	0	0
1898	106	0	0	249	0	49	0	0	670	0	0	0	0	0	0	0	0
1899	116	0	0	389	0	61	0	0	379	0	0	0	0	0	0	0	0
1900	123	0	0	425	0	86	0	0	388	0	0	0	0	0	0	0	0
1901	148	0	0	532	23	181	0	0	497	0	0	0	0	0	0	0	0
1902	237	0	0	485	121	174	0	0	640	0	0	0	0	0	0	0	0
1903	449	0	0	322	338	345	152	9	228	0	0	0	0	0	0	0	0
1904	897	0	0	255	383	260	575	62	256	0	0	0	0	0	0	0	0
1905	651	0	0	202	457	413	613	329	0	0	0	0	0	0	0	0	0
1906	407	0	0	151	296	243	426	132	0	0	0	0	0	0	0	0	0
1907	518	0	0	131	595	304	689	170	0	0	0	0	0	0	0	0	0
1908	514	0	0	138	594	282	520	76	0	0	0	0	0	0	0	0	0
1909	524	0	0	261	731	315	621	58	0	0	0	0	0	0	0	0	0
1910	384	0	0	198	460	334	564	149	0	0	0	0	0	0	0	0	0
1911	364	0	0	153	369	333	589	131	0	0	0	0	0	0	0	0	0
1912	325	0	0	97	105	142	428	53	0	28	0	0	0	0	0	0	0
1913	296	0	0	49	56	144	452	0	0	42	0	0	0	0	0	0	0
1914	242	0	0	26	0	152	516	0	0	0	0	0	0	0	0	0	0
1915	171	0	0	59	0	346	0	0	0	0	0	0	0	0	0	0	0
1916	59	0	0	0	0	208	0	0	0	0	0	0	0	0	0	0	0
1917	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1918	84	0	0	0	0	0	0	0	305	302	0	0	0	0	0	0	0
1919	40	0	0	0	0	0	0	0	194	283	0	0	0	0	0	0	22[a]
1920	0	0	0	0	0	272	409	15	44	106	0	0	0	0	0	0	36[a]
1921	0	0	0	0	0	174	0	0	0	37	323	0	0	0	0	0	0
1922	0	14	0	0	0	155	282	0	0	117	571	0	0	0	0	0	0
1923	66	20	0	0	0	193	312	0	0	147	1,080	0	0	0	0	0	0

Cont.

Year	Canada (EC)	WGrnl. (WG)	EGrnl. (EG)	WIcel. (WI)	E.Icel. (EI/F)	Faroe (EI/F)	UK (EI/F)	Spitsb. (N)	N.Norw (N)	W.Norw (N)	Spain (Sp)	Pelag. WG	Pelag. EG	Pelag. WI	Pelag. EI/F	Pelag. N	Pelag. ?Area
1924	144	94	0	0	0	245	501	0	0	272	1,218	0	0	0	0	0	0
1925	270	30	0	0	0	225	315	0	0	332	1,592	0	0	0	0	0	0
1926	329	24	0	0	0	156	400	24	0	376	1,312	0	0	0	0	0	0
1927	249	22	0	0	0	171	263	44	0	333	369	0	0	0	0	0	0
1928	358	24	0	0	0	280	139	0	0	427	0	0	0	0	0	0	0
1929	333	24	0	0	0	160	73	0	0	148	0	0	0	0	0	0	192[b]
1930	281	27	0	0	0	233	0	196	0	101	0	0	0	0	5	162	219[c]
1931	0	16	0	0	0	0	0	164	0	69	0	285	0	8	0	0	0
1932	0	25	0	0	0	0	0	0	0	190	0	41	3	191	0	0	208[b]
1933	226	17	0	0	0	90	0	148	0	197	0	7	57	290	5	51	0
1934	328	23	0	0	0	74	0	0	0	132	66	0	0	98	0	32	0
1935	156	23	0	25	0	75	0	0	0	106	0	0	0	0	0	0	0
1936	146	15	0	72	0	82	0	0	0	147	0	0	0	0	0	0	0
1937	439	9	0	56	0	142	0	0	0	224	0	0	8	158	32	0	263[d]
1938	0	7	0	113	0	183	0	0	0	261	0	0	0	0	0	0	0
1939	118	3	0	109	0	153	0	0	0	282	0	0	0	0	0	0	0
1940	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1941	65	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
1942	62	0	0	0	0	0	0	0	0	58	0	0	0	0	0	0	0
1943	141	0	0	0	0	0	0	0	0	110	0	0	0	0	0	0	0
1944	231	0	0	0	0	0	0	0	0	112	38	0	0	0	0	0	0
1945	346	0	0	0	0	30	0	0	0	159	36	0	0	0	0	0	0
1946	502	47	0	0	0	94	0	0	0	392	42	0	0	0	0	0	0
1947	413	51	0	0	0	196	0	0	0	285	111	0	0	0	0	0	0
1948	670	21	0	195	0	223	0	0	41	219	178	0	0	0	0	0	0
1949	425	21	0	249	0	222	0	0	138	204	69	0	0	0	0	0	0
1950	408	36	0	226	0	376	33	0	90	252	82	0	0	0	0	0	0
1951	483	15	0	312	0	156	13	0	70	251	72	0	0	0	0	0	0
1952	1	16	0	224	0	20	0	0	83	291	141	0	0	0	0	0	0
1953	1	15	0	207	0	87	0	0	60	215	58	0	0	0	0	0	0
1954	0	22	0	177	0	17	0	0	58	212	126	0	0	0	0	0	0
1955	2	22	0	236	0	80	0	0	95	115	134	0	0	0	0	0	0
1956	7	28	0	265	0	43	0	0	63	69	34	0	0	0	0	0	0
1957	23	21	0	348	0	141	0	0	47	92	63	0	0	0	0	0	0
1958	55	8	0	289	0	16	0	0	70	53	37	0	0	0	0	0	0
1959	14	0	0	178	0	0	0	0	82	98	54	0	0	0	0	0	0
1960	1	0	0	160	0	0	0	0	51	77	124	0	0	0	0	0	0
1961	0	0	0	142	0	0	0	0	43	119	159	0	0	0	0	0	0
1962	0	0	0	303	0	6	0	0	76	69	50	0	0	0	0	0	0
1963	0	0	0	283	0	3	0	0	21	21	19	0	0	0	0	0	0
1964	57	1	0	217	0	13	0	0	32	6	59	0	0	0	0	0	0
1965	141	1	0	288	0	10	0	0	101	5	155	0	0	0	0	0	0
1966	427	0	0	310	0	4	0	0	54	0	107	0	0	0	0	0	0
1967	745	0	0	239	0	0	0	0	28	6	99	0	0	0	0	0	0
1968	700	3	0	202	0	6	0	0	68	8	106	0	0	0	0	0	0
1969	533	0	0	251	0	0	0	0	14	2	116	0	0	0	0	0	0
1970	578	0	19	272	0	0	0	0	44	0	181	0	0	0	0	0	0
1971	418	0	0	208	0	0	0	0	37	0	98	0	0	0	0	0	0
1972	360	1	0	238	0	0	0	0	0	0	97	0	0	0	0	0	0
1973	0	2	0	267	0	0	0	0	0	0	112	0	0	0	0	0	0
1974	0	5	0	285	0	0	0	0	0	0	120	0	0	0	0	0	0
1975	0	1	0	245	0	0	0	0	0	0	137	0	0	0	0	0	0
1976	0	9	0	275	0	0	0	0	0	0	234	0	0	0	0	0	0
1977	0	13	0	144	0	0	0	0	0	0	151	0	0	0	0	0	0
1978	0	8	0	236	0	7	0	0	0	0	668	0	0	0	0	0	0
1979	0	7	0	260	0	11	0	0	0	0	562	0	0	0	0	0	0
1980	0	13	0	237	0	0	0	0	0	0	218	0	0	0	0	0	0
1981	0	7	0	254	0	3	0	0	0	0	146	0	0	0	0	0	0
1982	0	9	0	194	0	3	0	0	0	0	150	0	0	0	0	0	0
1983	0	8	0	144	0	5	0	0	0	0	120	0	0	0	0	0	0
1984	0	10	0	167	0	2	0	0	0	0	102	0	0	0	0	0	0
1985	0	9	0	161	0	0	0	0	0	0	48	0	0	0	0	0	0
1986	0	9	0	76	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	9	0	80	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	9	0	68	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	14	0	68	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Cont.

Year	Canada (EC)	WGrnl. (WG)	EGrnl. (EG)	WIcel. (WI)	E.Icel. (EI/F)	Faroe (EI/F)	UK (EI/F)	Spitsb. (N)	N.Norw (N)	W.Norw (N)	Spain (Sp)	Pelag. WG	Pelag. EG	Pelag. WI	Pelag. EI/F	Pelag. N	Pelag. ?Area
2000	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	10	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	10	0	125	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	6	0	148	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	9	0	134	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	17,971	1,181	20	16,287	4,595	9,296	8,885	1,766	14,770	8,165	11,944	333	68	745	42	245	940

Table 2

'High' Catch Series. Catches from land-stations by area are listed followed by pelagic catches. Pelagic catches of unknown area are allocated as follows: [a]WI sub-area; [b]N sub-area; [c]167:52 WI:N; [d]50:50 WI:N sub-areas.

Year	Canada	Greenl. W	Greenl. E	Icelnd W	Icelnd E	Faroe	UK	Spitsb.	Norwy N	Norwy W	Spain	Pelag. WG	Pelag. EG	Pelag. WI	Pelag. EI	Pelag. N	Pelag. ?Area
1864	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
1865	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0
1866	0	0	0	0	145	0	0	0	0	0	0	0	0	0	0	0	0
1867	0	0	0	0	133	0	0	0	1	0	0	0	0	0	0	0	0
1868	0	0	0	0	16	0	0	0	10	0	0	0	0	0	0	0	0
1869	0	0	0	0	3	0	0	0	25	0	0	0	0	0	0	0	0
1870	0	0	0	0	3	0	0	0	52	0	0	0	0	0	0	0	0
1871	0	0	0	0	26	0	0	0	29	0	0	0	0	0	0	0	0
1872	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0
1873	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0
1874	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0
1875	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0
1876	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
1877	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0
1878	0	0	0	0	0	0	0	0	152	0	0	0	0	0	0	0	0
1879	0	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0
1880	0	0	0	0	0	0	0	0	77	0	0	0	0	0	0	0	0
1881	0	0	0	0	0	0	0	0	83	0	0	0	0	0	0	0	0
1882	0	0	0	0	0	0	0	0	441	0	0	0	0	0	0	0	0
1883	0	0	0	0	2	0	0	0	498	0	0	0	0	0	0	0	0
1884	0	0	0	3	0	0	0	0	488	0	0	0	0	0	0	0	0
1885	0	0	0	48	0	0	0	0	707	0	0	0	0	0	0	0	0
1886	0	0	0	38	0	0	0	0	1,011	0	0	0	0	0	0	0	0
1887	0	0	0	72	0	0	0	0	741	0	0	0	0	0	0	0	0
1888	0	0	0	123	0	0	0	0	656	0	0	0	0	0	0	0	0
1889	0	0	0	153	0	0	0	0	708	0	0	0	0	0	0	0	0
1890	0	0	0	168	0	0	0	5	555	0	0	0	0	0	0	0	0
1891	0	0	0	177	0	0	0	5	563	0	0	0	0	0	0	0	0
1892	0	0	0	267	37	0	0	0	902	0	0	0	0	0	0	0	0
1893	0	0	0	528	27	0	0	0	1,145	0	0	0	0	0	0	0	0
1894	0	0	0	479	0	50	0	0	993	0	0	0	0	0	0	0	0
1895	0	0	0	680	0	35	0	0	767	0	0	0	0	0	0	0	0
1896	0	0	0	711	0	75	0	0	1,220	0	0	0	0	0	0	0	0
1897	0	0	0	896	0	117	0	0	702	0	0	0	0	0	0	0	0
1898	132	0	0	521	0	174	0	0	774	0	0	0	0	0	0	0	0
1899	134	0	0	789	0	173	0	0	485	0	0	0	0	0	0	0	0
1900	168	0	0	732	0	294	0	0	495	0	0	0	0	0	0	0	0
1901	270	0	0	1,221	27	300	0	0	621	0	0	0	0	0	0	0	0
1902	591	0	0	920	636	381	0	0	786	0	0	0	0	0	0	0	0
1903	518	0	0	642	837	516	176	11	311	0	0	0	0	0	0	0	0
1904	1,035	0	0	294	641	300	663	78	342	0	0	0	0	0	0	0	0
1905	794	0	0	248	731	506	723	380	0	0	0	0	0	0	0	0	0
1906	516	0	0	174	348	356	492	275	0	0	0	0	0	0	0	0	0
1907	837	0	0	152	687	471	795	299	0	0	0	0	0	0	0	0	0
1908	633	0	0	159	689	326	600	168	0	0	0	0	0	0	0	0	0
1909	683	0	0	302	855	381	717	96	0	0	0	0	0	0	0	0	0
1910	521	0	0	263	542	386	651	200	0	0	0	0	0	0	0	0	0
1911	485	0	0	191	435	384	680	152	0	0	0	0	0	0	0	0	0
1912	431	0	0	144	131	168	494	87	0	45	0	0	0	0	0	0	0

Cont.

Year	Canada	Greenl. W	Greenl. E	Icelnd W	Icelnd E	Faroe	UK	Spitsb.	Norwy N	Norwy W	Spain	Pelag. WG	Pelag. EG	Pelag. WI	Pelag. EI	Pelag. N	Pelag. ?Area
1913	344	0	0	57	102	167	522	0	0	48	0	0	0	0	0	0	0
1914	330	0	0	30	0	176	596	0	0	0	0	0	0	0	0	0	0
1915	171	0	0	68	0	438	0	0	0	0	0	0	0	0	0	0	0
1916	61	0	0	0	0	240	0	0	0	0	0	0	0	0	0	0	0
1917	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1918	101	0	0	0	0	0	0	0	305	302	0	0	0	0	0	0	0
1919	41	0	0	0	0	0	0	0	194	283	0	0	0	0	0	0	29[a]
1920	0	0	0	0	0	272	409	15	44	106	0	0	0	0	0	0	36[a]
1921	0	0	0	0	0	174	0	0	0	37	323	0	0	0	0	0	0
1922	0	14	0	0	0	155	282	0	0	117	571	0	0	0	0	0	0
1923	66	20	0	0	0	193	312	0	0	147	1,080	0	0	0	0	0	0
1924	144	94	0	0	0	245	501	0	0	272	1,218	0	0	0	0	0	0
1925	270	30	0	0	0	225	315	0	0	332	1,592	0	0	0	0	0	0
1926	329	24	0	0	0	156	400	24	0	376	1,312	0	0	0	0	0	0
1927	249	22	0	0	0	171	263	44	0	359	369	0	0	0	0	0	0
1928	358	24	0	0	0	280	139	0	0	427	0	0	0	0	0	0	0
1929	333	24	0	0	0	160	73	0	0	148	0	0	0	0	0	0	192[b]
1930	281	27	0	0	0	233	0	196	0	101	0	0	0	0	5	162	219[c]
1931	0	16	0	0	0	0	0	164	0	69	0	285	0	8	0	0	0
1932	0	25	0	0	0	0	0	0	0	190	0	41	3	191	0	0	208[b]
1933	295	17	0	0	0	90	0	148	0	197	0	7	57	290	5	51	0
1934	418	23	0	0	0	74	0	0	0	132	66	0	0	98	0	32	0
1935	156	23	0	25	0	75	0	0	0	106	0	0	0	0	0	0	0
1936	146	15	0	72	0	82	0	0	0	147	0	0	0	0	0	0	0
1937	439	9	0	56	0	142	0	0	0	224	0	0	8	158	32	0	263[d]
1938	0	7	0	113	0	183	0	0	0	261	0	0	0	0	0	0	0
1939	118	3	0	109	0	153	0	0	0	282	0	0	0	0	0	0	0
1940	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1941	65	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
1942	62	0	0	0	0	0	0	0	0	58	0	0	0	0	0	0	0
1943	141	0	0	0	0	0	0	0	0	110	0	0	0	0	0	0	0
1944	231	0	0	0	0	0	0	0	0	112	38	0	0	0	0	0	0
1945	346	0	0	0	0	35	0	0	0	159	36	0	0	0	0	0	0
1946	502	47	0	0	0	94	0	0	0	392	42	0	0	0	0	0	0
1947	413	51	0	0	0	196	0	0	0	285	111	0	0	0	0	0	0
1948	670	21	0	195	0	223	0	0	41	219	178	0	0	0	0	0	0
1949	425	21	0	249	0	222	0	0	138	204	69	0	0	0	0	0	0
1950	408	36	0	226	0	376	33	0	90	252	82	0	0	0	0	0	0
1951	483	15	0	312	0	156	13	0	70	251	72	0	0	0	0	0	0
1952	1	16	0	224	0	20	0	0	83	291	141	0	0	0	0	0	0
1953	1	15	0	207	0	87	0	0	60	215	58	0	0	0	0	0	0
1954	0	22	0	177	0	17	0	0	58	212	126	0	0	0	0	0	0
1955	2	22	0	236	0	80	0	0	95	115	134	0	0	0	0	0	0
1956	7	28	0	265	0	43	0	0	63	69	34	0	0	0	0	0	0
1957	23	21	0	348	0	141	0	0	47	92	63	0	0	0	0	0	0
Catches from 1958-2012 are the same as those in the 'Best' series listed in Table 1																	
Total	272	1,181	20	21,219	7,093	11,256	9,849	2,347	18,514	8,214	11,944	333	68	745	42	245	947

Table 3

Catches known by sex.

Subarea:	EC	EC	WG	WG	EG	EG	WI	WI	EI/F	EI/F	N	N	Sp	Sp
Year	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
1864	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1865	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1866	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1867	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1868	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1869	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1870	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1871	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1872	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1873	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1874	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1875	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1876	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1877	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1878	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1879	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1880	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1881	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Cont.

Subarea:	EC	EC	WG	WG	EG	EG	WI	WI	EI/F	EI/F	N	N	Sp	Sp
Year	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
1882	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1883	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1884	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1885	0	0	0	0	0	0	0	0	0	0	12	8	0	0
1886	0	0	0	0	0	0	0	0	0	0	15	22	0	0
1887	0	0	0	0	0	0	0	0	0	0	6	14	0	0
1888	0	0	0	0	0	0	0	0	0	0	11	10	0	0
1889	0	0	0	0	0	0	0	0	0	0	10	7	0	0
1890	0	0	0	0	0	0	0	0	0	0	17	19	0	0
1891	0	0	0	0	0	0	0	0	0	0	9	21	0	0
1892	0	0	0	0	0	0	0	0	0	0	22	22	0	0
1893	0	0	0	0	0	0	0	0	0	0	20	9	0	0
1894	0	0	0	0	0	0	0	0	0	0	10	12	0	0
1895	0	0	0	0	0	0	0	0	0	0	1	4	0	0
1896	0	0	0	0	0	0	0	0	0	0	20	16	0	0
1897	0	0	0	0	0	0	0	0	0	0	8	5	0	0
1898	0	0	0	0	0	0	0	0	0	0	10	11	0	0
1899	0	0	0	0	0	0	0	0	0	0	4	4	0	0
1900	0	0	0	0	0	0	0	0	0	0	1	2	0	0
1901	0	0	0	0	0	0	0	0	0	0	13	10	0	0
1902	0	0	0	0	0	0	0	0	0	0	13	7	0	0
1903	0	0	0	0	0	0	0	0	0	0	10	10	0	0
1904	0	0	0	0	0	0	6	15	238	210	0	0	0	0
1905	0	0	0	0	0	0	0	0	291	262	0	0	0	0
1906	0	0	0	0	0	0	0	0	101	121	0	0	0	0
1907	0	0	0	0	0	0	0	0	91	93	0	0	0	0
1908	0	0	0	0	0	0	0	0	428	416	0	0	0	0
1909	0	0	0	0	0	0	0	0	528	601	0	0	0	0
1910	0	0	0	0	0	0	10	11	474	507	0	0	0	0
1911	0	0	0	0	0	0	10	10	410	437	0	0	0	0
1912	0	0	0	0	0	0	0	0	209	225	0	0	0	0
1913	0	0	0	0	0	0	0	0	237	225	0	0	0	0
1914	0	0	0	0	0	0	10	10	283	231	0	0	0	0
1915	0	0	0	0	0	0	20	24	131	101	0	0	0	0
1916	0	0	0	0	0	0	0	0	48	39	0	0	0	0
1917	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1918	0	0	0	0	0	0	0	0	0	0	11	10	0	0
1919	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0	46	68	0	0	0	0
1921	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0	23	21	0	0	0	0
1923	0	0	0	0	0	0	0	0	55	41	32	29	0	0
1924	0	0	34	32	0	0	0	0	59	63	0	0	0	0
1925	0	0	0	0	0	0	0	0	114	110	165	167	16	8
1926	0	0	0	0	0	0	0	0	17	21	160	136	103	129
1927	92	96	0	6	0	0	0	0	168	163	190	143	83	89
1928	134	135	0	0	0	0	0	0	166	166	230	197	0	0
1929	164	169	0	4	0	0	0	0	89	144	137	143	0	0
1930	153	128	0	3	0	0	91	76	102	130	246	247	0	0
1931	0	0	154	132	0	0	1	7	0	0	130	103	0	0
1932	0	0	32	34	1	2	101	90	0	0	205	191	0	0
1933	0	0	13	11	25	23	159	130	52	43	211	181	0	0
1934	0	0	0	0	0	0	48	50	34	40	70	94	41	25
1935	44	53	9	14	0	0	0	0	36	38	45	58	0	0
1936	78	68	6	9	0	0	26	46	40	42	72	75	0	0
1937	0	0	2	7	6	2	185	160	91	83	173	182	0	0
1938	0	0	4	3	0	0	55	58	108	74	139	122	0	0
1939	62	56	1	2	0	0	66	43	73	80	134	148	0	0
1940	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1941	26	39	0	0	0	0	0	0	0	0	5	1	0	0
1942	30	32	0	0	0	0	0	0	0	0	33	25	0	0
1943	65	76	0	0	0	0	0	0	0	0	67	43	0	0
1944	115	116	0	0	0	0	0	0	0	0	55	57	0	0
1945	139	207	0	0	0	0	0	0	0	0	80	79	0	0
1946	280	222	26	21	0	0	0	0	53	39	207	185	0	0
1947	224	189	29	22	0	0	0	0	107	89	138	147	0	0
1948	374	295	10	11	0	0	92	103	112	111	133	127	21	25
1949	210	215	5	16	0	0	108	141	101	121	191	151	0	0
1950	195	213	18	18	0	0	96	130	228	179	185	156	45	37
1951	217	266	8	7	0	0	123	189	81	87	174	147	23	22
1952	0	1	4	12	0	0	100	124	15	5	193	181	6	6
1953	0	1	6	9	0	0	101	106	43	44	125	150	4	5
1954	0	0	17	5	0	0	70	107	6	11	137	132	6	6
1955	0	2	14	8	0	0	119	117	46	34	118	92	0	0
1956	3	4	17	11	0	0	114	151	22	21	62	70	0	0
1957	12	10	11	10	0	0	152	196	71	70	68	71	12	12

Cont.

Subarea:	EC	EC	WG	WG	EG	EG	WI	WI	EI/F	EI/F	N	N	Sp	Sp
Year	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
1958	37	18	2	6	0	0	141	148	7	9	58	65	10	15
1959	6	8	0	0	0	0	96	82	0	0	94	86	17	19
1960	1	0	0	0	0	0	82	78	0	0	62	66	22	17
1961	0	0	0	0	0	0	65	77	0	0	83	79	19	20
1962	0	0	0	0	0	0	164	139	5	1	80	65	1	2
1963	0	0	0	0	0	0	151	132	0	3	23	19	1	3
1964	20	36	0	0	0	0	111	106	4	9	18	20	30	11
1965	69	69	0	0	0	0	157	131	5	5	63	43	37	28
1966	188	235	0	0	0	0	161	149	2	1	23	31	58	49
1967	303	438	0	0	0	0	111	128	0	0	17	17	54	45
1968	312	388	0	0	0	0	101	101	4	2	39	37	60	46
1969	216	316	0	0	0	0	117	134	0	0	8	8	73	43
1970	288	288	0	0	14	5	140	132	0	0	17	27	97	84
1971	190	227	0	0	0	0	97	111	0	0	18	19	57	41
1972	177	183	0	0	0	0	122	116	0	0	0	0	41	56
1973	0	0	0	0	0	0	135	132	0	0	0	0	57	54
1974	0	0	0	0	0	0	142	143	0	0	0	0	65	55
1975	0	0	0	0	0	0	127	118	0	0	0	0	77	60
1976	0	0	0	0	0	0	132	143	0	0	0	0	113	121
1977	0	0	0	0	0	0	64	80	0	0	0	0	81	70
1978	0	0	1	0	0	0	104	132	5	2	0	0	253	207
1979	0	0	0	0	0	0	127	133	4	7	0	0	255	197
1980	0	0	0	0	0	0	117	119	0	0	0	0	113	105
1981	0	0	0	0	0	0	121	132	2	1	0	0	78	68
1982	0	0	0	0	0	0	96	98	1	2	0	0	58	91
1983	0	0	0	0	0	0	70	74	1	4	0	0	62	58
1984	0	0	0	0	0	0	66	100	2	0	0	0	33	69
1985	0	0	1	2	0	0	74	87	0	0	0	0	18	30
1986	0	0	2	1	0	0	27	49	0	0	0	0	0	0
1987	0	0	1	2	0	0	38	42	0	0	0	0	0	0
1988	0	0	4	5	0	0	31	37	0	0	0	0	0	0
1989	0	0	3	3	0	0	23	45	0	0	0	0	0	0
1990	0	0	9	6	0	0	0	0	0	0	0	0	0	0
1991	0	0	5	6	0	0	0	0	0	0	0	0	0	0
1992	0	0	4	9	0	0	0	0	0	0	0	0	0	0
1993	0	0	2	11	0	0	0	0	0	0	0	0	0	0
1994	0	0	10	10	0	0	0	0	0	0	0	0	0	0
1995	0	0	9	3	0	0	0	0	0	0	0	0	0	0
1996	0	0	8	10	0	0	0	0	0	0	0	0	0	0
1997	0	0	5	5	0	0	0	0	0	0	0	0	0	0
1998	0	0	1	8	0	0	0	0	0	0	0	0	0	0
1999	0	0	3	4	0	0	0	0	0	0	0	0	0	0
2000	0	0	3	3	0	0	0	0	0	0	0	0	0	0
2001	0	0	3	4	0	0	0	0	0	0	0	0	0	0
2002	0	0	5	8	0	0	0	0	0	0	0	0	0	0
2003	0	0	2	4	0	0	0	0	0	0	0	0	0	0
2004	0	0	5	6	0	0	0	0	0	0	0	0	0	0
2005	0	0	1	11	0	0	0	0	0	0	0	0	0	0
2006	0	0	2	6	0	0	3	4	0	0	0	0	0	0
2007	0	0	6	4	0	0	0	0	0	0	0	0	0	0
2008	0	0	8	3	0	0	0	0	0	0	0	0	0	0
2009	0	0	1	7	0	0	67	58	0	0	0	0	0	0
2010	0	0	0	5	0	0	74	68	0	0	0	0	0	0
2011	0	0	0	5	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	4	0	0	0	0	0	0	0	0	0	0
2013	0	0	3	5	0	0	58	71	0	0	0	0	0	0
M total:	4,424		529		46		5,375		5,669		5,136		2,200	
F total:		4,799		573		32		5,723		5,652		4,835		2,028

Adjunct 2

Survey abundance pro-rating

Rebecca Rademeyer

Some historical abundance estimates from the NASS surveys used in the North Atlantic fin trial conditioning do not cover the full sub-areas (East Greenland, West Iceland and East Iceland/Faroes). Robustness trials (NF-A3) have been included in which the data used in conditioning are pro-rated for these sub-areas only. The abundance indices have simply been pro-rated by assuming the same density in and out of the surveyed region.

Table 1 gives the NASS region estimates used to compute the final sub-areas estimates. The original and pro-rated estimates are given. Table 2 compares the final estimates used in the conditioning trials which are calculated as described in Wade (2009).

Table 1

The NASS region estimates used to compute the final sub-areas estimates (Pike and Gunnlaugsson, 2006; Pike *et al.*, 2008).

Year	Region	N	pro-rated N	Area covered	pro-rated by
East Greenland					
1987	B-West	1,750		82,331	
1989	B-West	2,329		82,331	
1995	B-West	7,812		77,682	
2001	B-West	7,736		88,694	
2007	B-West	7,185		101,893	
1989	A-West	3,274		263,980	1.00
1995	A-West	600	2,340	67,706	3.90
2001	A-West	3,970	6,489	161,551	1.63
2007	A-West	1,396	5,029	111,854	3.60
West Iceland					
1987	B-East	1,857		109,971	
1989	B-East	3,677		92,854	
1995	B-East	5,915		101,081	
2001	B-East	6,285		102,740	
2007	B-East	4,557		111,854	
1989	A-East	1,595		213,039	1.00
1995	A-East	885	1,448	130,217	1.64
2001	A-East	280	1,145	52,131	4.09
2007	A-East	2,781	3,561	135,878	1.28
East Iceland/Faroe Islands					
1987	EGI	1,050		145,783	
1995	EGI	4,145		127,219	
2001	EGI	5,405		254,076	
2007	EGI	981		125,767	
1987	WN-SPB	675		271,255	1.00
1995	WN-SPB	1,594	1,709	204,222	1.33
2001	WN-SPB	2,085	3,353	136,278	1.99
2007	WN-SPB	632	1,485	112,121	2.35

Table 2

The final estimates used in the conditioning trials which are calculated as described in Wade (2009).

East Greenland		
Year	N	pro-rated N
1988	5,269	5,269
1995	8,412	10,152
2001	11,706	14,225
2007	12,215	15,847
West Iceland		
Year	N	pro-rated N
1988	4,243	4,243
1995	6,800	7,363
2001	6,565	7,430
2007	8,118	8,898
East Iceland/Faroe Islands		
Year	N	pro-rated N
1987	5,261	5,261
1995	6,647	7,170
2001	7,490	9,555
2007	1,613	2,466

REFERENCES

Pike, D. and Gunnlaugsson, T. 2006. Regional estimates of density and abundance of fin whales (*Balaenoptera physalus*) from Icelandic and Faroese North Atlantic sightings surveys. Paper SC/M06/FW18 and SC/14/FW/18 presented to the joint IWC/NAMMCO workshop, 'Catch history, stock structure and abundance of North Atlantic fin whales', 23-26 March 2006, Reykjavik, Iceland (unpublished). 12pp. [Paper available from the Office of this Journal].

Pike, D.G., Gunnlaugsson, T., Víkingsson, G.A. and Mikkelsen, B. 2008. Estimates of the abundance of fin whales (*Balaenoptera physalus*) from the T-NASS Icelandic and Faroese ship surveys conducted in 2007 (revised). Paper SC/60/PFI13 (revised) presented to the IWC Scientific Committee, June 2008, Santiago, Chile (unpublished). 16pp. [Paper available from the Office of this Journal].

Wade, P. 2009. Report of the First Intersessional RMP Workshop on North Atlantic Fin Whales, 31 March to 4 April 2008, Greenland Representation, Copenhagen. Annex H. Compilation and calculation of North Atlantic fin whale abundance by sub-area. *J. Cetacean Res. Manage. (Suppl.)* 11: 448-50.

Adjunct 3

Catch at Age in the West Iceland (WI) catches

Table 1

Males known by age.

Age	1967	1969	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	2006	2009	2010
1	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
2	-	2	2	3	2	-	-	2	3	2	1	2	1	-	2	-	-	-	-	-	-	-	-
3	1	-	7	6	9	6	4	1	7	1	2	2	2	1	-	-	-	-	-	2	-	1	-
4	2	3	3	8	5	4	5	8	12	5	5	8	6	5	5	1	-	-	3	1	-	1	-
5	1	-	8	3	6	7	10	4	7	5	7	7	4	4	7	5	-	1	4	-	-	-	-
6	2	3	6	9	9	6	12	5	5	9	4	16	10	6	4	5	1	1	3	1	-	2	-
7	3	-	5	7	7	6	3	5	4	10	12	7	10	6	10	4	1	2	2	-	-	-	-
8	1	3	6	3	5	1	5	1	2	4	6	11	11	3	4	4	3	9	2	2	-	-	-
9	3	2	1	-	2	4	5	2	1	7	6	6	9	5	5	5	1	3	1	1	-	1	-
10	-	1	2	-	1	3	7	4	-	3	9	4	5	6	6	3	2	3	1	-	-	2	-
11	2	1	2	1	2	3	3	2	2	3	2	7	2	5	3	6	1	1	1	2	-	1	-
12	2	-	2	1	1	2	3	1	3	4	2	5	8	-	1	5	3	5	1	2	-	3	1
13	1	1	-	1	-	4	1	-	2	3	5	6	3	3	3	3	-	2	2	2	-	1	-
14	2	1	-	1	1	2	4	2	2	-	3	4	1	2	-	4	3	1	3	-	-	3	1
15	-	2	1	1	2	1	3	2	-	5	1	5	3	2	3	-	1	1	1	-	-	-	1
16	-	-	-	1	1	2	2	4	-	2	3	1	2	4	1	3	1	3	-	-	1	2	1
17	-	-	-	-	2	2	2	-	1	-	1	2	3	-	1	3	-	1	-	1	-	4	1
18	-	-	1	-	-	2	3	-	-	-	1	1	2	2	1	3	-	-	2	-	-	1	2
19	-	-	-	-	-	1	1	2	-	2	-	4	3	3	1	2	-	-	-	-	-	2	2
20	-	-	3	-	-	2	5	1	2	5	2	2	2	-	4	-	1	-	1	1	-	-	4
21	-	1	1	1	1	1	-	-	1	-	3	2	1	1	3	3	-	-	-	-	-	2	-
22	1	-	1	-	-	-	-	2	1	1	3	-	3	-	-	1	-	1	2	1	-	6	3
23	-	-	1	-	-	1	-	2	-	-	1	-	-	-	-	-	2	1	-	-	-	1	1
24	-	-	-	1	-	2	1	-	-	-	-	1	-	-	1	-	1	1	-	-	-	3	3
25	-	2	-	-	-	1	-	-	1	-	-	2	-	3	-	1	-	1	-	1	-	1	3
26	1	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	1	-	-	-	1	3	2
27	-	-	-	-	1	-	-	1	-	-	1	1	-	-	-	-	2	-	-	-	-	1	5
28	-	1	-	-	2	2	2	-	-	2	-	-	-	-	-	-	-	-	-	1	-	-	5
29	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	2
30	-	1	-	-	-	-	2	1	-	-	-	1	-	-	-	1	-	-	-	-	-	6	5
31	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	1	-	3	1
32	-	1	-	1	-	1	-	-	1	1	1	-	-	1	-	-	-	-	-	-	-	4	5
33	-	-	-	-	-	-	1	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	2
34	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	3
35	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1	-	-	-	-	-	2	-
36	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	6
38	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2
39	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-
40	1	-	-	1	-	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	2
41	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
43	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
44	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	1	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	2	1
47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
48	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
49	1	-	1	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
50	1	2	1	2	-	1	1	-	-	-	2	1	-	-	1	-	-	-	-	-	-	-	-
51	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	1
52	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
53	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-
55	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
58	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-
59	-	-	-	-	-	2	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
60	-	1	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-
61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
62	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
64	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
65	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
66	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
67	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-
68	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
70	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
73	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
74	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-
75	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-
83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-

Table 2

Females known by age.

Age	1967	1969	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	2006	2009	2010
1	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	1	4	4	2	4	1	1	-	-	-	4	1	-	-	-	-	-	2	-	-	-	-
3	4	1	9	4	7	6	8	1	2	2	2	7	6	6	1	3	-	-	-	1	-	-	-
4	1	1	8	4	5	4	10	6	5	6	3	9	4	1	11	1	2	-	2	2	-	1	-
5	3	3	5	5	10	9	10	7	5	7	7	9	6	4	2	6	3	-	2	3	-	-	-
6	2	3	12	5	5	5	6	7	10	5	6	7	6	3	10	3	-	1	3	2	-	-	-
7	2	4	5	4	5	1	5	10	9	12	4	16	11	8	11	8	5	2	2	3	-	1	-
8	1	2	6	5	5	3	3	6	3	5	10	7	11	8	6	3	1	3	1	4	-	1	1
9	2	2	4	4	10	7	5	2	6	9	7	7	3	6	5	5	7	3	4	4	-	-	-
10	2	3	-	3	2	2	1	2	1	4	10	14	2	3	2	11	3	3	2	-	-	2	-
11	3	3	1	1	2	3	3	2	7	5	3	8	5	2	5	1	1	6	-	2	-	-	-
12	-	1	1	2	2	-	4	3	3	4	4	3	6	4	3	1	2	-	-	5	1	-	-
13	-	3	5	1	-	-	2	3	1	4	7	9	4	2	5	2	2	3	1	3	-	1	-
14	-	3	-	3	2	3	4	1	3	3	2	3	5	1	3	4	1	4	2	1	-	2	-
15	1	-	-	-	1	2	2	1	-	4	1	3	2	1	5	2	2	4	-	-	-	2	1
16	1	-	-	1	2	2	1	3	1	3	6	3	2	3	3	9	3	-	-	-	-	2	-
17	-	-	3	-	1	1	3	-	-	2	1	4	3	2	1	2	5	2	1	-	-	-	-
18	-	-	1	1	-	1	1	1	2	-	3	-	2	2	4	1	-	1	-	-	-	4	4
19	-	-	1	-	-	1	1	-	-	1	2	1	1	2	2	3	1	-	1	3	-	6	1
20	-	-	-	-	1	3	2	3	2	3	2	5	1	-	-	1	-	2	-	1	1	2	3
21	-	1	-	-	-	1	1	3	2	1	1	3	2	-	1	1	1	-	2	2	-	4	-
22	-	1	3	-	-	-	3	1	-	3	1	1	-	2	-	4	-	-	-	-	-	3	1
23	-	1	-	1	-	-	-	-	-	1	3	-	1	-	1	-	-	-	2	-	-	2	1
24	-	1	-	-	-	-	1	-	1	-	1	-	-	-	-	-	1	1	1	3	-	1	5
25	1	-	-	-	-	-	3	-	1	1	1	-	-	3	2	1	-	2	-	-	-	2	1
26	2	-	-	-	1	-	1	1	-	-	-	1	1	-	1	1	1	-	-	1	-	1	4
27	-	-	-	1	1	-	-	-	1	-	-	2	-	1	-	-	1	-	-	-	-	1	3
28	1	-	-	-	-	-	-	-	-	2	-	-	1	-	-	2	-	1	-	-	-	2	2
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	-	2	2
30	-	-	-	-	2	-	1	-	-	3	1	-	-	-	-	-	-	-	-	-	-	2	7
31	-	-	-	-	-	-	-	1	-	-	1	-	1	-	-	-	-	-	-	-	1	-	2
32	-	2	-	1	-	1	1	-	-	1	-	-	-	-	-	1	-	-	-	-	-	2	8
33	-	2	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
34	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	1	2	5
35	1	-	-	1	-	-	2	1	1	-	-	-	1	-	-	-	1	1	-	-	-	1	-
36	-	-	-	-	-	-	1	1	-	-	1	-	-	1	-	-	-	-	1	-	-	1	6
37	-	-	-	-	-	-	-	1	1	-	1	1	-	-	-	-	-	1	-	-	-	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2	1
39	-	-	-	-	1	-	-	-	1	-	-	-	2	-	-	-	1	-	1	-	-	-	1
40	1	1	-	1	2	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2
41	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
42	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2
43	-	-	-	-	-	-	-	-	3	-	-	1	-	-	-	-	-	-	-	1	-	-	-
44	-	-	-	-	-	-	-	1	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-
45	1	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
46	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	-	1	-	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
51	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
55	-	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-
57	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
59	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	1	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-
61	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
65	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
77	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Adjunct 4

A comparison of the trial numbers used in these specifications with those used in the previous *Implementation* (IWC, 2010)

Trial no.	*Old no.*	Stock hypothesis	No. of Stocks	Trial description
Baseline				
NF-B1	NF01-1 etc.	I	4	Base case: 4 stocks, separate feeding areas
NF-B2	NF02-1 etc.	II	4	4 stocks; 'W' and 'E' feed in central sub-areas
NF-B3	NF03-1 etc.	III	4	4 stocks; 'C1', 'C2' and 'C3' feed in adjacent sub-areas
NF-B4	NF04-1 etc.	IV	4	4 stocks without sub-stock dispersion (i.e. no interchange) (revised to estimate γ_3)
NF-B5	NF05-1 etc.	V	4	4 stocks as in hypothesis I but stock 'S' in adjacent sub-areas
NF-B6	NF06-1 etc.	VI	3	3 stocks (no 'E' stock)
NF-B7	New	VII	4	4 stocks as in hypothesis III but WI/EG are combined; 2 'C' sub-stocks
NF-B8	New	VIII	4	4 stocks as in hypothesis IV but WI/EG are combined; 2 sub-stocks (no dispersal)
Other factors				
NF-H1	NF08-1 & -4	I	4	Hypothesis I; High historical catch series
NF-H3	NF09-1 & -4	III	4	Hypothesis III; High historical catch series
NF-H4	NF10-1 & -4	IV	4	Hypothesis IV; High historical catch series
NF-X3	NF13-1 & -4	III	4	N Iceland catch including in WI sub-area
NF-P3	NF14-1 & -4	III	4	Survey WI only with greater precision
NF-Q3	NF15-1 & -4	III	4	Future WI & EI/F surveys exc. strata S 60°N
NF-A3	NF16-1 & -4	III	4	Pro-rate abundance data for conditioning
NF-C3	NF17-1 & -4	III	4	Inc. CPUE data in the likelihood calculation
NF-T1	NF18-1 & -4	I	4	Tag loss =20% in year 1; 10%/year thereafter
NF-T3	NF19-1 & -4	III	4	Tag loss =20% in year 1; 10%/year thereafter
NF-T4	NF20-1 & -4	IV	4	Tag loss =20% in year 1; 10%/year thereafter
NF-U1	NF21-1 & -4	I	4	Selectivity decreases by 4%/year after age 8; M=0.04
NF-W1	NF22-1 & -4	I	4	Weight tag likelihood by factor of 10
NF-G1	NF23-1 & -4	I	4	C2 sub-stock enters EG beginning year 1985 (opt. a)
NF-G3	NF24-1 & -4	III	4	C2 sub-stock enters EG beginning year 1985 (opt. a)
NF-F1	NF25-1 & -4	I	4	C2 sub-stock enters EG 1985-2025 (opt. b)
NF-F3	NF26-1 & -4	III	4	C2 sub-stock enters EG 1985-2025 (opt. b)
NF-S3	New	III	4	Selectivity estimated for pre and post 2007
NF-S4	New	IV	4	Selectivity estimated for pre and post 2007
NF-Y3	New	III	4	8 year future survey interval
NF-Y4	New	IV	4	8 year future survey interval
NF-R3	New	III	4	Exclude Tags recaptured after one year
NF-R4	New	IV	4	Exclude Tags recaptured after one year
Trials not carried forward to the final version of the current *Implementation* (IWC, 2015)				
Alt. start				
NF-I1	New	I	4	Initialise the age-structure at the start of 1915
NF-I2	New	II	4	Initialise the age-structure at the start of 1915
NF-I3	New	III	4	Initialise the age-structure at the start of 1915
NF-I4	New	IV	4	Initialise the age-structure at the start of 1915
NF-I5	New	V	4	Initialise the age-structure at the start of 1915
NF-I6	New	VI	3	Initialise the age-structure at the start of 1915
NF-I7	New	VII	4	Initialise the age-structure at the start of 1915
NF-I8	New	VIII	4	Initialise the age-structure at the start of 1915
NF-J1	New	I	4	Initialise the age-structure at the start of 1960
NF-J2	New	II	4	Initialise the age-structure at the start of 1960
NF-J3	New	III	4	Initialise the age-structure at the start of 1960
NF-J4	New	IV	4	Initialise the age-structure at the start of 1960
NF-J5	New	V	4	Initialise the age-structure at the start of 1960
NF-J6	New	VI	3	Initialise the age-structure at the start of 1960
NF-J7	New	VII	4	Initialise the age-structure at the start of 1960
NF-J8	New	VIII	4	Initialise the age-structure at the start of 1960
Dispersal				
NF-D1	New	I	4	Density-dependent dispersal
NF-D2	New	II	4	Density-dependent dispersal
NF-D3	New	III	4	Density-dependent dispersal
NF-D5	New	V	4	Density-dependent dispersal
NF-D6	New	VI	3	Density-dependent dispersal
NF-D7	New	VII	4	Density-dependent dispersal
NF-E1	New	I	4	Bridging trial: Non density-dependent dispersal between sub-areas
NF-E2	New	II	4	Bridging trial: Non density-dependent dispersal between sub-areas
NF-E3	New	III	4	Bridging trial: Non density-dependent dispersal between sub-areas
NF-E5	New	V	4	Bridging trial: Non density-dependent dispersal between sub-areas
NF-E6	New	VI	3	Bridging trial: Non density-dependent dispersal between sub-areas
NF-E7	New	VII	4	Bridging trial: Non density-dependent dispersal between sub-areas
2010 Trials not carried forward to the current *Implementation*				
	NF07-1 -2 & -4	VII	2	2 stocks (no 'W' or 'E' stock)
	NF11-1 & -4	I	4	Hypothesis I; Low historic catch series
	NF12-1 & -4	III	4	Hypothesis III; Low historic catch series
	NF27-1 & -4	I	4	Fix Canada tag reporting rate = 1
	NF28-1 & -4	IV	4	Estimate rate of mixing of C1 in WI

REFERENCES

International Whaling Commission. 2010. Report of the 2nd Intersessional Workshop of the North Atlantic Fin Whale *Implementation*, 19-22 March 2009, Greenland Representation, Denmark. Annex B. The specifications for the *Implementation Simulation Trials* for North Atlantic fin whales. *J. Cetacean Res. Manage. (Suppl.)* 11(2):598-618.

International Whaling Commission. 2015. Report of the AWMP Intersessional Workshop on the *Implementation Review* for North Atlantic fin whales, 6-8 January 2014, Copenhagen, Denmark. *J. Cetacean Res. Manage. (Suppl.)* 16:459-86.

Appendix 4

THE AWMP/RMP *IMPLEMENTATION SIMULATION TRIALS* FOR THE NORTH ATLANTIC MINKE WHALES

A. Basic concepts and stock-structure

The objective of these trials is to examine the performance of the RMP and AWMP when managing a fishery for North Atlantic minke whales. Allowance is made for both commercial and aboriginal subsistence catches. The underlying dynamics model allows for multiple stocks and sub-stocks, and is age- and sex-structured. The trials capture uncertainty regarding stock structure and MSYR, as well as uncertainty regarding selectivity.

The region to be managed (the Northern North Atlantic) is divided into 11 sub-areas (see Fig. 1). The term 'stock' refers to a group of whales from the same (putative) breeding ground. The 3-stock models assume there is western 'W' stock (which feeds at least in the 'WG' and 'WC' sub-areas), a central 'C' stock (which feeds at least in the 'CG', 'CIC', 'CIP', and 'CM' sub-areas), and an eastern 'E' stock (which feeds at least in the 'EN', 'EB', 'ESW', 'ESE', and 'EW' sub-areas). The 'E' and 'W' stocks are divided into sub-stocks for some of trials (sub-stocks 'E-1' and 'E-2' for the 'E' stock; sub-stocks 'W-1' and 'W-2' for the 'W' stock). There is no interchange between stocks, or sub-stocks. The rationale for the position of the sub-area boundaries is given in IWC (1993, p.194; 2004a, pp.12-13; 2009, p.138).

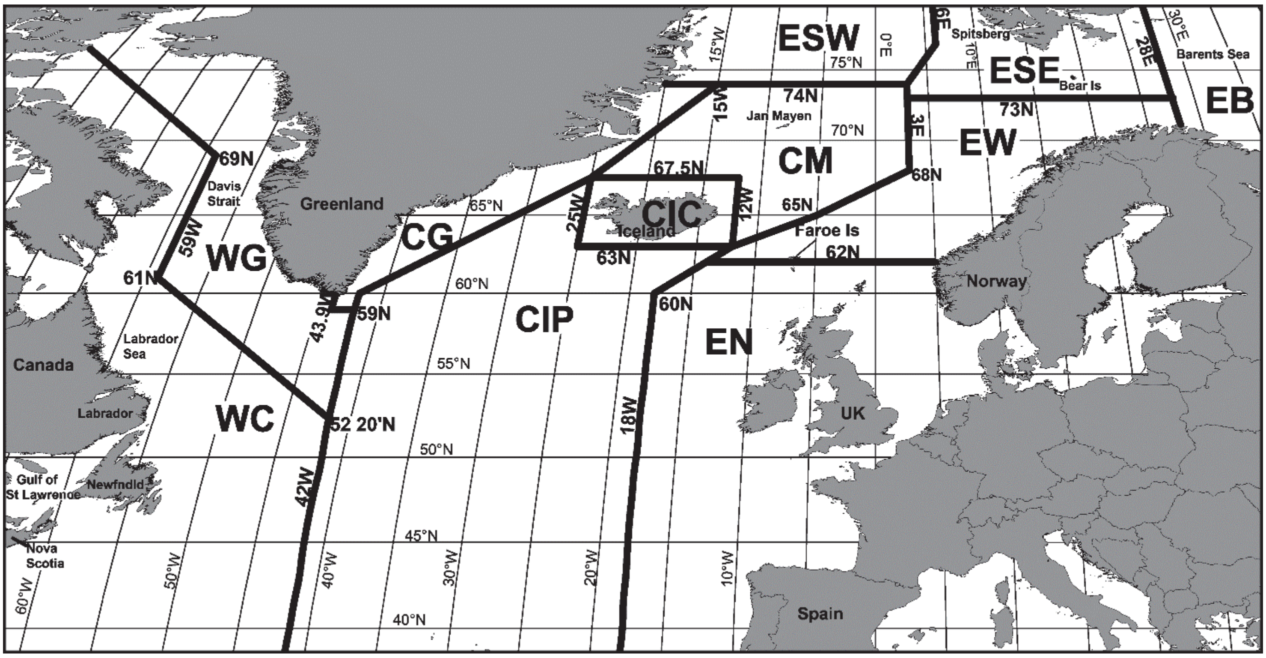


Fig. 1. Map of the North Atlantic showing the sub-areas defined for the North Atlantic minke whales.

There are three general hypotheses regarding stock structure (see IWC, 2015 for the rationale for these hypotheses) for the rationale for these hypotheses):

(I) *Three stocks*. There are three stocks 'W', 'C', and 'E'. The 'W' stock consists of two sub-stocks ('W-1' and 'W-2') and the 'E' stock consists of two sub-stocks ('E-1' and 'E-2').

(II) *Two stocks*. There are two stocks 'W*', and 'E'. The 'W*' stock consists of two sub-stocks ('W' and 'C*') where the C* stock is the same as the 'C' stock for stock hypothesis I, except that the whales that occur primarily in the 'WG' sub-area are also part of this stock. The 'E' stock is defined as for stock hypothesis I.

(III) *One stock*. There is only a single ('O') stock of minke whales in the North Atlantic.

(IV) *Two cryptic stocks*. There are two stocks ('O-1' and 'O-2') of minke whales in the North Atlantic. The two stocks are found in all 11 sub-areas[1].

The trials (see Section H) include variants of these general hypotheses to capture further aspects of uncertainty regarding stock structure. The trials also allow for the difference in the catch sex-ratios between the primary catching season (i.e. before July) and the time when surveys are conducted (July onwards) (see details in Section G).

[1]This stock structure hypothesis was discussed by the April 2014 joint AWMP/RMP North Atlantic minke whale stock structure Workshop, though it was not included in the final report of that meeting (IWC, 2015).

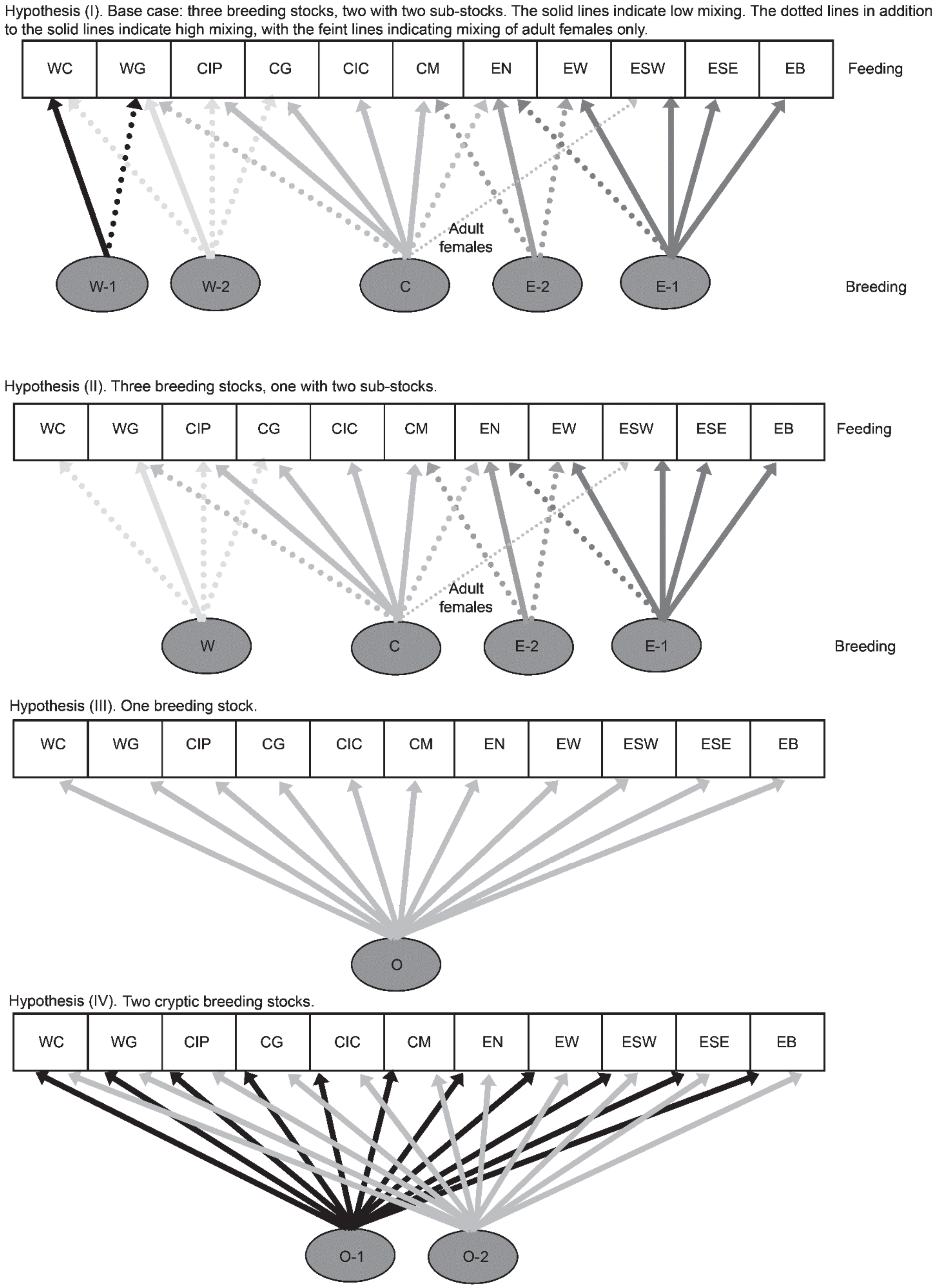


Fig. 1. Stock structure hypotheses for North Atlantic minke whales.

B. Basic dynamics

The dynamics of the animals in stock/sub-stock j are governed by equation B.1:

$$N^{g,j}_{t+1,a} = \begin{cases} 0.5 b^{j}_{t+1} & \text{if } a = 0 \\ (N^{g,j}_{t,a-1} - C^{g,j}_{t,a-1})\tilde{S}_{a-1} & \text{if } 1 \le a < x \\ (N^{g,j}_{t,x} - C^{g,j}_{t,x})\tilde{S}_{x} + (N^{g,j}_{t,x-1} - C^{g,j}_{t,x-1})\tilde{S}_{x-1} & \text{if } a = x \end{cases} \tag{B.1}$$

where:

$N^{g,j}_{t,a}$ is the number of animals of gender g and age a in stock/sub-stock j at the start of year t;

$C^{g,j}_{t,a}$ is the catch (in number) of animals of gender g and age a in stock/sub-stock j during year t (whaling is assumed to take place in a pulse at the start of each year);

b^{j}_{t} is the number of calves born to females from stock/sub-stock j at the start of year t;

$\tilde{S}_{a}$ is the survival rate = e^{-M_a} where M_a is the instantaneous rate of natural mortality (assumed to be independent of stock, time, and gender); and

x is the maximum age (treated as a plus-group);

Note that t=0, the year for which catch limits might first be set, corresponds to 2015.

C. Births

Density-dependence is assumed to act on the 1+ population. The convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition.

$$b^{j}_{t} = B^{j} N^{\mathrm{f},j}_{t} \{1 + A^{j}(1 - (N^{\mathrm{f},j}_{t} / K^{\mathrm{f},j})^{z^{j}})\} \tag{C.1}$$

where:

B^{j} is the average number of births (of both sexes) per year for a mature female in stock/sub-stock j in the pristine population;

A^{j} is the resilience parameter for stock/sub-stock j;

z^{j} is the degree of compensation for stock/sub-stock j;

$N^{\mathrm{f},j}_{t}$ is the number of 'mature' females in stock/sub-stock j at the start of year t:

$$N^{\mathrm{f},j}_{t} = \sum_{a=3}^{x} \beta_a N^{\mathrm{f},j}_{t,a} \tag{C.2}$$

β_a is the proportion of females of age a that have reached the age-at-first partition; and

$K^{\mathrm{f},j}$ is the number of mature females in stock/sub-stock j in the pristine (pre-exploitation, written as t=-∞) population:

$$K^{\mathrm{f},j} = \sum_{a=3}^{x} \beta_a N^{\mathrm{f},j}_{-\infty,a} \tag{C.3}$$

The values of the parameters A^{j} and z^{j} for each stock/sub-stock are calculated from the values for $MSYL^{j}$ and $MSYR^{j}$ (Punt, 1999). Their calculation assumes harvesting equal proportions of males and females.

D. Catches

The historical (pre-2013) catch series used is listed in Adjunct 1 and includes commercial, special permit and incidental catches. The numbers of incidental catches are small so these are not modelled into the future.

Catch limits are set by *Small Area*. It is assumed that whales are homogeneously distributed across a sub-area. The catch/strike limit for a sub-area is therefore allocated to stocks/sub-stocks by sex and age relative to their true density within that sub-area and a catch mixing matrix V.

The catch mixing matrix for these trials is based on the sightings mixing matrix, with the selectivity pattern by sex adjusted for each sub-area. Two fishing selectivity patterns are modelled in the WG sub-area to reflect the different sex ratio shown in different hunts: the recent aboriginal hunt in this area compared to that in the earlier commercial catches. All other sub-areas have just one hunt type and thus a single fishing selectivity per sub-area. Details of how the catch mixing matrix is set up is given in section G.

$$C^{g,j}_{t,a} = \sum_{k} \sum_{h \in k} F^{g,h}_{t} V^{g,j,k}_{t,a} \tilde{S}^{g,h}_{a} N^{g,j}_{t,a} \tag{D.1}$$

$$F^{g,h}_{t} = \frac{C^{g,h}_{t}}{\sum_{j'} \sum_{a'} V^{g,j',k}_{t,a'} \tilde{S}^{g,h}_{a'} N^{g,j'}_{t,a'}} \tag{D.2}$$

where:

$F_t^{g,h}$ is the exploitation rate in hunt *h* (within sub-area *k)* on fully recruited ($S_a^g \rightarrow 1$) whales of gender *g* during year *t*;

$V_{t,a}^{g,j,k}$ is the fraction of animals in stock/sub-stock *j* of gender *g* and age *a* that is in sub-area *k* during year *t*;

$\tilde{S}_a^{g,h}$ is the fishing selectivity on animals of gender *g* and age *a* by the hunt *h* (within sub-area *k*) which is based on the reference selectivity $R_a^{g,h}$ (see Equation G.5):

$C_t^{g,h}$ is the observed catch of animals of gender *g* in hunt *h* (within sub-area *k*) during year *t*. See adjunct 1 for the historical catches. Future catches are allocated to sex using the modelled fishery sex ratio $\hat{\lambda}^{2,h}$ (see equation G.7).

E. Mixing

The entries in the mixing matrix *V* are selected to model the distribution of each stock/sub-stock at the time when the catch is removed/when the surveys are conducted. Mixing is stochastic. For the two and three stock hypotheses, the mixing matrix for each year is selected at random from a matrix in which mixing is 'high' and in which it is 'low' (matrices A and B in Table 1). For the one stock and two cryptic stocks (Hypotheses III and IV), additional variance is added to the mixing matrices in table 1 to allow for stochastic mixing in projections only. The values for the parameters of the mixing matrix (just O-1 for trials NM04-1 and NM04-4) are generated as lognormal variables with means given by the estimated proportions and variance conditioned to the survey data. The variance parameters were estimated by maximum likelihood, treating the random perturbations about the expected proportions as random effects in the mixed model software TMB (Kristensen *et al.*, In press), to be: 0.504 (NM03-1), 0.505 (NM03-4), 0.709 (NM04-1) and 0.713 (NM04-4). The Norwegian abundance estimates were excluded from this conditioning because additional variance had already been included in these numbers and hence in how the pseudo abundance estimates are generated.

In Hypothesis IV, the ratio of the two pristine stocks is set equal to 4.

In the high mixing option for Hypotheses I and II, three sub-stocks (C, E-1 and E-2) are found in sub-area EN. There are no data on which to condition the proportions of these sub-stocks in the sub-area so the trials assume 50% of the whales in sub-area EN in the pristine state are from the E-2 sub-stock, with trials NM09 and NM10 testing sensitivity to this assumption.

Table 1

The mixing matrices. The γs and Ωs indicate that the entry concerned is estimated during the conditioning process. Note that the values for the γs and Ωs are the same for the high and low mixing matrices within each trial replicate.

	WC	WG	CIP	CG	CIC	CM	EN	EW	ESW	ESE	EB
Stock structure hypothesis I (matrix Ai) [high mixing]											
Adult females (ages 10+)											
W-1	0.5	0.5	-	-	-	-	-	-	-	-	-
W-2	0.2	0.45	0.15	0.2	-	-	-	-	-	-	-
C	-	0.1	γ_2	γ_3	0.5 γ_4	γ_5	0.05	-	γ_6	-	-
E-1	-	-	-	-	-	-	0.1	γ_7	0.1γ_6	γ_8	γ_9
E-2	-	-	-	-	-	0.1	0.8	0.1	-	-	-
Adult males (ages 10+) and juveniles											
W-1	0.5 Ω_{11}	0.5 Ω_{12}	-	-	-	-	-	-	-	-	-
W-2	0.2 Ω_{11}	0.45 Ω_{12}	0.15 Ω_{13}	0.2Ω_{14}	-	-	-	-	-	-	-
C	-	0.1 Ω_{12}	$\gamma_2\,\Omega_{13}$	$\gamma_3\,\Omega_{14}$	$\gamma_4\,\Omega_{15}$	$\gamma_5\,\Omega_{16}$	0.05 Ω_{17}	-	-	-	-
E-1	-	-	-	-	-	-	0.1 Ω_{17}	$\gamma_7\,\Omega_{18}$	0.1$\gamma_6\,\Omega_{19}$	$\gamma_8\,\Omega_{20}$	$\gamma_9\,\Omega_{21}$
E-2	-	-	-	-	-	0.1Ω_{16}	0.8 Ω_{17}	0.1 Ω_{18}	-	-	-
Stock structure hypothesis I (matrix Bi) [low mixing]											
Adult females (ages 10+)											
W-1	1	-	-	-	-	-	-	-	-	-	-
W-2	-	1	-	-	-	-	-	-	-	-	-
C	-	-	γ_2	γ_3	γ_4	γ_5	-	-	-	-	-
E-1	-	-	-	-	-	-	-	γ_7	5γ_6	5 γ_8	γ_9
E-2	-	-	-	-	-	-	1	-	-	-	-
Adult males (ages 10+) and juveniles											
W-1	1	-	-	-	-	-	-	-	-	-	-
W-2	-	1	-	-	-	-	-	-	-	-	-
C	-	-	$\gamma_2\,\Omega_{13}$	$\gamma_3\,\Omega_{14}$	2 $\gamma_4\,\Omega_{15}$	$\gamma_5\,\Omega_{16}$	-	-	-	-	-
E-1	-	-	-	-	-	-	-	$\gamma_7\,\Omega_{18}$	5$\gamma_6\,\Omega_{19}$	5 $\gamma_8\,\Omega_{20}$	$\gamma_9\,\Omega_{21}$
E-2	-	-	-	-	-	-	1	-	-	-	-
Stock structure hypothesis II (matrix Aii) [high mixing]											
Adult females (ages 10+)											
W	0.55	0.2	0.1	0.15	-	-	-	-	-	-	-
C	-	γ_1	γ_2	γ_3	0.5 γ_4	γ_5	0.05	-	γ_6	-	-
E-1	-	-	-	-	-	-	0.1	γ_7	0.1γ_6	γ_8	γ_9
E-2	-	-	-	-	-	0.1	0.8	0.1	-	-	-
Adult males (ages 10+) and juveniles											
W	0.2 Ω_{11}	Ω_{12}	0.1 Ω_{13}	0.2 Ω_{14}	-	-	-	-	-	-	-
C	-	0.1 $\gamma_1\Omega_{12}$	$\gamma_2\,\Omega_{13}$	$\gamma_3\,\Omega_{14}$	$\gamma_4\,\Omega_{15}$	$\gamma_5\,\Omega_{16}$	0.05 Ω_{17}	-	-	-	-
E-1	-	-	-	-	-	-	0.1 Ω_{17}	$\gamma_7\,\Omega_{18}$	0.1$\gamma_6\Omega_{19}$	$\gamma_8\,\Omega_{20}$	$\gamma_9\,\Omega_{21}$
E-2	-	-	-	-	-	0.1Ω_{16}	0.8 Ω_{17}	0.1 Ω_{18}	-	-	-

Cont.

Table 1 cont.

	WC	WG	CIP	CG	CIC	CM	EN	EW	ESW	ESE	EB
Stock structure hypothesis II (matrix Bii) [low mixing]											
Adult females (ages 10+)											
W	1	-	-	-	-	-	-	-	-	-	-
C	-	γ_1	γ_2	γ_3	γ_4	γ_5	-	-	-	-	-
E-1	-	-	-	-	-	-	-	γ_7	$5\gamma_6$	$5\ \gamma_8$	γ_9
E-2	-	-	-	-	-	-	1	-	-	-	-
Adult males (ages 10+) and juveniles											
W	1	-	-	-	-	-	-	-	-	-	-
C	-	$\gamma_1\ \Omega_{12}$	$\gamma_2\,\Omega_{13}$	$\gamma_3\ \Omega_{14}$	$2\ \gamma_4\,\Omega_{15}$	$\gamma_5\,\Omega_{16}$	-	-	-	-	-
E-1	-	-	-	-	-	-	-	$\gamma_7\ \Omega_{18}$	$5\gamma_6\ \Omega_{19}$	$5\ \gamma_8\ \Omega_{20}$	$\gamma_9\ \Omega_{21}$
E-2	-	-	-	-	-	-	1	-	-	-	-
Stock structure hypotheses III [high mixing]											
Adult females (ages 10+)											
O	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	γ_7	γ_8	γ_9	γ_{10}	1
Adult males (ages 10+) and juveniles											
O	$\gamma_1\ \Omega_{11}$	$\gamma_2\,\Omega_{12}$	$\gamma_3\,\Omega_{13}$	$\gamma_4\,\Omega_{14}$	$\gamma_5\,\Omega_{15}$	$\gamma_6\ \Omega_{16}$	$\gamma_7\ \Omega_{17}$	$\gamma_8\ \Omega_{18}$	$\gamma_9\ \Omega_{19}$	$\gamma_{10}\ \Omega_{20}$	Ω_{21}
Stock structure hypotheses IV [high mixing]											
Adult females (ages 10+)											
O-1	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	γ_7	γ_8	γ_9	γ_{10}	1
O-2	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	γ_7	γ_8	γ_9	γ_{10}	1
Adult males (ages 10+) and juveniles											
O-1	$\gamma_1\ \Omega_{11}$	$\gamma_2\,\Omega_{12}$	$\gamma_3\,\Omega_{13}$	$\gamma_4\,\Omega_{14}$	$\gamma_5\,\Omega_{15}$	$\gamma_6\ \Omega_{16}$	$\gamma_7\ \Omega_{17}$	$\gamma_8\ \Omega_{18}$	$\gamma_9\ \Omega_{19}$	$\gamma_{10}\ \Omega_{20}$	Ω_{21}
O-2	$\gamma_1\ \Omega_{11}$	$\gamma_2\,\Omega_{12}$	$\gamma_3\,\Omega_{13}$	$\gamma_4\,\Omega_{14}$	$\gamma_5\,\Omega_{15}$	$\gamma_6\ \Omega_{16}$	$\gamma_7\ \Omega_{17}$	$\gamma_8\ \Omega_{18}$	$\gamma_9\ \Omega_{19}$	$\gamma_{10}\ \Omega_{20}$	Ω_{21}
Stock structure hypothesis I, with no C stock in sub-area ESW (Trial NM05) (matrix A05) [high mixing]											
Adult females (ages 10+)											
W-1	0.5	0.5	-	-	-	-	-	-	-	-	-
W-2	0.2	0.45	0.15	0.2	-	-	-	-	-	-	-
C	-	0.1	γ_2	γ_3	$0.5\ \gamma_4$	γ_5	0.05	-	-	-	-
E-1	-	-	-	-	-	-	0.1	γ_7	$0.1\gamma_6$	γ_8	γ_9
E-2	-	-	-	-	-	0.1	0.8	0.1	-	-	-
Adult males (ages 10+) and juveniles											
W-1	$0.5\ \Omega_{11}$	$0.5\ \Omega_{12}$	-	-	-	-	-	-	-	-	-
W-2	$0.2\ \Omega_{11}$	$0.45\ \Omega_{12}$	$0.15\ \Omega_{13}$	$0.2\Omega_{14}$	-	-	-	-	-	-	-
C	-	$0.1\ \Omega_{12}$	$\gamma_2\ \Omega_{13}$	$\gamma_3\,\Omega_{14}$	$\gamma_4\,\Omega_{15}$	$\gamma_5\ \Omega_{16}$	$0.05\,\Omega_{17}$	-	-	-	-
E-1	-	-	-	-	-	-	$0.1\ \Omega_{17}$	$\gamma_7\ \Omega_{18}$	$0.1\gamma_6\ \Omega_{19}$	$\gamma_8\,\Omega_{20}$	$\gamma_9\,\Omega_{21}$
E-2	-	-	-	-	-	$0.1\Omega_{16}$	$0.8\ \Omega_{17}$	$0.1\ \Omega_{18}$	-	-	-
Stock structure hypothesis I (matrix Bi) [low mixing]											
Adult females (ages 10+)											
W-1	1	-	-	-	-	-	-	-	-	-	-
W-2	-	1	-	-	-	-	-	-	-	-	-
C	-	-	γ_2	γ_3	γ_4	γ_5	-	-	-	-	-
E-1	-	-	-	-	-	-	-	γ_7	$5\gamma_6$	$5\ \gamma_8$	γ_9
E-2	-	-	-	-	-	-	1	-	-	-	-
Adult males (ages 10+) and juveniles											
W-1	1	-	-	-	-	-	-	-	-	-	-
W-2	-	1	-	-	-	-	-	-	-	-	-
C	-	-	$\gamma_2\,\Omega_{13}$	$\gamma_3\ \Omega_{14}$	$2\ \gamma_4\ \ \Omega_{15}$	$\gamma_5\,\Omega_{16}$	-	-	-	-	-
E-1	-	-	-	-	-	-	-	$\gamma_7\,\Omega_{18}$	$5\gamma_6\ \Omega_{19}$	$5\ \gamma_8\ \Omega_{20}$	$\gamma_9\ \Omega_{21}$
E-2	-	-	-	-	-	-	1	-	-	-	-
Stock structure hypothesis II, with no C stock in sub-area ESW (Trial NM06) (matrix A06) [high mixing]											
Adult females (ages 10+)											
W	0.55	0.2	0.1	0.15	-	-	-	-	-	-	-
C	-	γ_1	γ_2	γ_3	$0.5\ \gamma_4$	γ_5	0.05	-	-	-	-
E-1	-	-	-	-	-	-	0.1	γ_7	$0.1\gamma_6$	γ_8	γ_9
E-2	-	-	-	-	-	0.1	0.8	0.1	-	-	-
Adult males (ages 10+) and juveniles											
W	$0.2\ \Omega_{11}$	Ω_{12}	$0.1\ \Omega_{13}$	$0.2\ \Omega_{14}$	-	-	-	-	-	-	-
C	-	$0.1\ \gamma_1\Omega_{12}$	$\gamma_2\ \Omega_{13}$	$\gamma_3\,\Omega_{14}$	$\gamma_4\,\Omega_{15}$	$\gamma_5\ \Omega_{16}$	$0.05\,\Omega_{17}$	-	-	-	-
E-1	-	-	-	-	-	-	$0.1\ \Omega_{17}$	$\gamma_7\ \Omega_{18}$	$0.1\gamma_6\Omega_{19}$	$\gamma_8\,\Omega_{20}$	$\gamma_9\,\Omega_{21}$
E-2	-	-	-	-	-	$0.1\Omega_{16}$	$0.8\ \Omega_{17}$	$0.1\ \Omega_{18}$	-	-	-
Stock structure hypothesis II (matrix Bii) [low mixing]											
Adult females (ages 10+)											
W	1	-	-	-	-	-	-	-	-	-	-
C	-	γ_1	γ_2	γ_3	γ_4	γ_5	-	-	-	-	-
E-1	-	-	-	-	-	-	-	γ_7	$5\gamma_6$	$5\ \gamma_8$	γ_9
E-2	-	-	-	-	-	-	1	-	-	-	-
Adult males (ages 10+) and juveniles											
W	1	-	-	-	-	-	-	-	-	-	-
C	-	$\gamma_1\ \Omega_{12}$	$\gamma_2\,\Omega_{13}$	$\gamma_3\ \Omega_{14}$	$2\ \gamma_4\,\Omega_{15}$	$\gamma_5\,\Omega_{16}$	-	-	-	-	-
E-1	-	-	-	-	-	-	-	$\gamma_7\ \Omega_{18}$	$5\gamma_6\ \Omega_{19}$	$5\ \gamma_8\ \Omega_{20}$	$\gamma_9\ \Omega_{21}$
E-2	-	-	-	-	-	-	1	-	-	-	-

Cont.

Table 1 cont.

	WC	WG	CIP	CG	CIC	CM	EN	EW	ESW	ESE	EB
Stock structure hypothesis I, with no E-1 stock in sub-area ESW (Trial NM12) (matrix A12) [high mixing]											
Adult females (ages 10+)											
W-1	0.5	0.5	-	-	-	-	-	-	-	-	-
W-2	0.2	0.45	0.15	0.2	-	-	-	-	-	-	-
C	-	0.1	γ_2	γ_3	0.5 γ_4	γ_5	0.05	-	γ_6	-	-
E-1	-	-	-	-	-	-	0.1	γ_7	-	γ_8	γ_9
E-2	-	-	-	-	-	0.1	0.8	0.1	-	-	-
Adult males (ages 10+) and juveniles											
W-1	0.5 Ω_{11}	0.5 Ω_{12}	-	-	-	-	-	-	-	-	-
W-2	0.2 Ω_{11}	0.45 Ω_{12}	0.15 Ω_{13}	0.2Ω_{14}	-	-	-	-	-	-	-
C	-	0.1 Ω_{12}	γ_2 Ω_{13}	γ_3 Ω_{14}	γ_4 Ω_{15}	γ_5 Ω_{16}	0.05 Ω_{17}	-	γ_6 Ω_{19}	-	-
E-1	-	-	-	-	-	-	0.1 Ω_{17}	γ_7 Ω_{18}	-	γ_8 Ω_{20}	γ_9 Ω_{21}
E-2	-	-	-	-	-	0.1Ω_{16}	0.8 Ω_{17}	0.1 Ω_{18}	-	-	-
Stock structure hypothesis I, with no E-1 stock in sub-area ESW (Trial NM12) (matrix B12) [low mixing]											
Adult females (ages 10+)											
W-1	1	-	-	-	-	-	-	-	-	-	-
W-2	-	1	-	-	-	-	-	-	-	-	-
C	-	-	γ_2	γ_3	γ_4	γ_5	-	-	5γ_6	-	-
E-1	-	-	-	-	-	-	-	γ_7	-	5 γ_8	γ_9
E-2	-	-	-	-	-	-	1	-	-	-	-
Adult males (ages 10+) and juveniles											
W-1	1	-	-	-	-	-	-	-	-	-	-
W-2	-	1	-	-	-	-	-	-	-	-	-
C	-	-	γ_2 Ω_{13}	γ_3 Ω_{14}	2 γ_4 Ω_{15}	γ_5 Ω_{16}	-	-	5γ_6 Ω_{19}	-	-
E-1	-	-	-	-	-	-	-	γ_7 Ω_{18}	-	5 γ_8 Ω_{20}	γ_9 Ω_{21}
E-2	-	-	-	-	-	-	1	-	-	-	-
Stock structure hypothesis II, with no E-1 stock in sub-area ESW (Trial NM13) (matrix A13) [high mixing]											
Adult females (ages 10+)											
W	0.55	0.2	0.1	0.15	-	-	-	-	-	-	-
C	-	γ_1	γ_2	γ_3	0.5 γ_4	γ_5	0.05	-	γ_6	-	-
E-1	-	-	-	-	-	-	0.1	γ_7	-	γ_8	γ_9
E-2	-	-	-	-	-	0.1	0.8	0.1	-	-	-
Adult males (ages 10+) and juveniles											
W	0.2 Ω_{11}	Ω_{12}	0.1 Ω_{13}	0.2 Ω_{14}	-	-	-	-	-	-	-
C	-	0.1 $\gamma_1\Omega_{12}$	γ_2 Ω_{13}	γ_3 Ω_{14}	γ_4 Ω_{15}	γ_5 Ω_{16}	0.05 Ω_{17}	-	$\gamma_6\Omega_{19}$	-	-
E-1	-	-	-	-	-	-	0.1 Ω_{17}	γ_7 Ω_{18}	-	γ_8 Ω_{20}	γ_9 Ω_{21}
E-2	-	-	-	-	-	0.1Ω_{16}	0.8 Ω_{17}	0.1 Ω_{18}	-	-	-
Stock structure hypothesis II, with no E-1 stock in sub-area ESW (Trial NM13) (matrix B13) [low mixing]											
Adult females (ages 10+)											
W	1	-	-	-	-	-	-	-	-	-	-
C	-	γ_1	γ_2	γ_3	γ_4	γ_5	-	-	5γ_6	-	-
E-1	-	-	-	-	-	-	-	γ_7	-	5 γ_8	γ_9
E-2	-	-	-	-	-	-	1	-	-	-	-
Adult males (ages 10+) and juveniles											
W	1	-	-	-	-	-	-	-	-	-	-
C	-	γ_1 Ω_{12}	γ_2 Ω_{13}	γ_3 Ω_{14}	2 γ_4 Ω_{15}	γ_5 Ω_{16}	-	-	5γ_6 Ω_{19}	-	-
E-1	-	-	-	-	-	-	-	γ_7 Ω_{18}	-	5 γ_8 Ω_{20}	γ_9 Ω_{21}
E-2	-	-	-	-	-	-	1	-	-	-	-

F. Generation of Data

The actual historical estimates of absolute abundance (and their associated CVs) provided to the RMP are listed in Table 2. The proposed plan for future surveys is given in Table 3. The trials assume that it takes two years for the results of a sighting survey to become available for use by the RMP and *SLA*, e.g. a survey conducted in 2015 could first be used for setting the catch limit in 2017.

The future estimates of abundance for a survey area (a sub-area for these trials) (say survey area K) are generated using the formula (IWC, 1991).

$$\hat{P} = P\,Y\,w / \mu = P^{*}\,\beta^{2}\,Y\,w \tag{F.1}$$

where:

Y is a lognormal random variable $Y = e^{\varepsilon}$ where $\varepsilon \sim N(0;\sigma_{\varepsilon}^{2})$ and $\sigma_{\varepsilon}^{2} = \ell\text{n}(1+\alpha^{2})$;

w is a Poisson random variable with $E(w) = \text{var}(w) = \mu = (P/P^{*})/\beta^{2}$, Y and w are independent;

P is the current total (1+) population size in survey area K:

$$P = P_t^{K} = \sum_{k\in K}\sum_{j}\sum_{g}\sum_{a\ge 1} V_{t,a}^{g,j,k} N_{t,a}^{g,j} \tag{F.2}$$

P^* is the reference population level, and is equal to the total (1+) population size in the survey area prior to the commencement of exploitation in the area being surveyed; and

F is the set of sub-areas making up survey area K.

Note that under the approximation $CV^2(ab) = CV^2(a) + CV^2(b)$, $E(\hat{P}) = P$, and $CV^2(\hat{P}) = \alpha^2 + \beta^2 P^*/P$. For consistency with the first stage screening trials for a single stock (IWC, 1991, p.109; 1994, p.85), the ratio $\alpha^2 : \beta^2 = 0.12 : 0.025$, so that:

$$CV^2(\hat{P}) = \tau(0.12 + 0.025P^* / P) \quad \text{(F.3)}$$

The value of τ is calculated from the survey sampling CV's of earlier surveys in area K. If $\overline{CV^2}$ is the average value of CV^2 estimated for each of these surveys, and $\bar{P}$ is the average value of the total (1+) population sizes in area K in the years of these surveys, then:

$$\tau = \overline{CV^2} / \left(0.12 + 0.025P / \overline{P}\right) \quad \text{(F.4)}$$

Note therefore that:

$$\alpha^2 = 0.12\tau \qquad \beta^2 = 0.025\tau \quad \text{(F.5)}$$

The above equations apply in the absence of additional variance. If this is present with a CV of CV_{add}, then the following adjustment is made:

$$\sigma_\varepsilon^2 = \ell n\left(1 + \alpha^2 + CV_{add}^2\right) \quad \text{(F.6)}$$

An estimate of the CV is generated for each sighting survey estimate of abundance $\hat{P}$:

$$CV\left(\hat{P}\right)_{est}^2 = \sigma^2 \chi^2 / n \quad \text{(F.7)}$$

where $\sigma^2 = \ell n\left(1 + \alpha^2 + \beta^2 P^* / \hat{P}\right)$, and

χ^2 is a random number from a Chi-square distribution with n degrees of freedom, where n=10 as used in the North Pacific minke whale *Implementation* trials (IWC, 2004b).

Table 2
The estimates of abundance and their sampling standard errors.

Year	Sub-Area	Abundance	CV	Year	Sub-Area	Abundance	CV
2007	WC	20,741	0.3	1989	EN	8,318	0.25
1987	WG*	3,266	0.31	1995	EN	22,536	0.23
1993	WG*	8,371	0.43	1998	EN	13,673	0.25
2005	WG	10,792	0.59	2004	EN	6,246	0.47
2007	WG	16,609	0.428	2009	EN	6,891	0.31
1988	CIP	8,431	0.245	1989	EW	20,991	0.17
2001	CIP	3,391	0.82	1995	EW	34,986	0.12
2007	CIP	1,350	0.38	1996	EW	23,522	0.13
1995	CIP+CG*	4,854	0.27	2006	EW	27,152	0.218
1987	CG	1,555	0.26	2011	EW	21,218	0.32
2001	CG	7,349	0.31	1995	ESW	2,691	0.29
2007	CG	1,048	0.6	1999	ESW	1,932	0.68
1987	CIC	24,532	0.32	2008	ESW	5,009	0.29
2001	CIC	43,633	0.19	1989	ESE	13,370	0.19
2007	CIC	20,834	0.35	1995	ESE	23,278	0.11
2009	CIC	9,588	0.24	1999	ESE	16,241	0.25
1988	CM	4,732	0.23	2003	ESE	19,377	0.33
1995	CM	12,043	0.28	2008	ESE	22,281	0.18
1997	CM	26,718	0.14	1989	EB	21,868	0.21
2005	CM	26,739	0.39	1995	EB	29,712	0.18
2010	CM	10,991	0.36	2000	EB	25,885	0.24
				2007	EB	28,625	0.23
				2013	EB	34,125	0.34

*Only used when applying the *CLA* to *Small* or *Combination Areas* consisting of both CIP and CG, and not used for CIP or CG sub-areas separately (e.g. when allocating a catch limit for a *Combination Area* to its component *Small Areas*).

Table 3a

Sighting survey plan. The pattern of surveys from 2020-25 will be repeated every 6 years in the E areas, every seven years in the C areas and every 10 years in sub-area WG. The years when Assessments are run are also shown.

	Country			
Season	Norway	Iceland	Greenland	Assessment year
2014	ESW, ESE	-	-	-
2015	EW, CM*	CIC, CIP, CG	WG	Yes
2016	EB	-	-	-
2017	EN	-	-	-
2018	-	-	-	-
2019	-	-	-	-
2020	EW	-	-	-
2021	ESW, ESE	-	-	Yes
2022	EB	CIC, CIP, CG, CM	-	-
2023	EN	-	-	-
2024	-	-	-	-
2025	-	-	WG	-

**CM to be covered as a NAMMCO joint effort in TNASS-2015.*

Table 3b

List of past and planned sightings surveys and the constituents used in setting estimates for areas that are combinations of sub-areas. 0=No survey, 1=survey.

	CIP	CG	CIC	CM	CIP, CIC,CM	All C subareas	EN	EW	ESW	ESE	EB	EB, ESW, ESE, EW	EB, EW	ESW, ESE	All E subareas
1987	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1988	1	0	0	1	1=1987-8	1=1987-8	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	1	1	0	1	1	1=1989	1=1989	1=1989	1=1989
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	1*	1*	0	1	0	0	1	1	1	1	1	1=1995	1=1995	1=1995	1=1995
1996	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1997	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	1	1	0	0	0	1=1999	0
2000	0	0	0	0	0	0	0	0	0	0	1	1=1996-2000	1=1996-2000	0	1=1996-2000
2001	1	1	1	0	1=1995-2001	1=1995-2001	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	1	0	0	0	1=2003	0
2004	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2005	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2007	1	1	1	0	0	0	0	0	0	0	1	1=2003-7	1=2006-7	0	1=2003-7
2008	0	0	0	0	0	0	0	0	1	1	0	0	0	1=2008	0
2009	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
2010	0	0	0	1	1=2005-10	1=2005-10	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	1	1=2008-13	1=2011-13	0	1=2008-13
2014	0	0	0	0	0	0	0	0	1	1	0	0	0	1=2014	0
2015	1	1	1	1	1=2015	1=2015	0	1	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	1	1=2014-6	1=2015-6	0	0
2017	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1=2014-7
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	1	1	0	0	0	1=2021	0
2022	1	1	1	1	1=2022	1=2022	0	0	0	0	1	1=2020-22	1=2020-22	0	0
2023	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1=2020-23
2024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2026	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2027	0	0	0	0	0	0	0	0	1	1	0	0	0	1=2027	0
2028	0	0	0	0	0	0	0	0	0	0	1	1=2026-28	1=2026-28	0	0
2029	1	1	1	1	1=2029	1=2029	1	0	0	0	0	0	0	0	1=2026-29

*Only used when applying the *CLA* to *Small* or *Combination Areas* consisting of both CIP and CG, and not used for CIP or CG sub-areas separately.

G. Parameters and conditioning

The values for the biological and technological parameters are listed in Tables 4a and 4b.

Table 4a

The values for the biological parameters that are fixed.

Parameter	Value
Plus group age, x	20 years
Natural mortality, M	$M_a = \begin{cases} 0.085 & \text{if } a \leq 4 \\ 0.0775 + 0.001875a & \text{if } 4 < a < 20 \\ 0.115 & \text{if } a \geq 20 \end{cases}$
Maturity (first parturition), β_a	$a_{50} = 8$; $\delta = 1.2$
Maximum Sustainable Yield Level, *MSYL*	0.6 in terms of the 1+ population

Table 4b

The values for the selectivity parameters by area.

Parameter	Value
West *Medium Area* (commercial)	$a_{50}^{g,k} = 5; \delta^{g,k} = 1.2$
West Greenland (aboriginal)	$a_{50}^{g,k} = 1; \delta^{g,k} = 1.2$
Central *Medium Area*	$a_{50}^{g,k} = 4; \delta^{g,k} = 1.2$
Eastern *Medium Area*	$a_{50}^{g,k} = 5; \delta^{g,k} = 1.2$

The 'free' parameters of the operating model are the initial (pre-exploitation) sizes of each of the sub-stocks/stocks, the values that determine the mixing matrices (i.e. the γ and Ω parameters) and the hunt factors that allow for differences between survey and fishery selectivity (the ω^h parameters). The process used to select the values for these 'free' parameters is known as conditioning. The conditioning process involves first generating 100 sets of 'target' data as detailed in steps (a) and (b) below, and then fitting the population model to each (in the spirit of a bootstrap). The number of animals in sub-area k at the start of year t is calculated starting with guessed values of the initial population sizes and projecting the operating model forward to 2014 to obtain values of abundance and sex ratios by sub-area for comparison with the generated data.

The likelihood function used when fitting the model consists of three components. Equations G.2, G.3 and G.6 list the negative of the logarithm of the likelihood for each of these components so the objective function minimised is $L_1+L_2+L_3$. An additional penalty is added to the likelihood if the full historical catch is not removed.

(a) Abundance estimates

The 'target' values for the historical abundance by sub-area are generated using the formula:

$$P_t^k = O_t^k \exp[\mu_t^k - (\sigma_t^k)^2/2]; \ \mu_t^k \sim N[0;(\sigma_t^k)^2] \tag{G.1}$$

where:

P_t^k is the abundance for sub-area k in year t;

O_t^k is the actual survey estimate for sub-area k in year t (Table 2); and

σ_t^k is the CV of O_t^k.

The contribution to the likelihood from the abundance data is given by:

$$L_1 = 0.5 \sum_n \frac{1}{(\sigma_n)^2} \ell n \left(P_n / \hat{P}_n \right)^2 \tag{G.2}$$

where $\hat{P}_n$ is the model estimate of the 1+ abundance in the same year and sub-area as the n^{th} estimate of abundance P_n (the target abundances).

(b) Sex ratios

The parameters used to define the catch and the sightings mixing matrices are set up during the conditioning process. The data on catch sex-ratios by month (see Adjunct 2) for North Atlantic minke whales suggest that the relative proportion of males differs between the primary catching season (i.e. before July) and the time when surveys are conducted and thereafter (July onwards) for at least sub-areas ES and EB.

In principle, the entries of the catch and sightings mixing matrices can be estimated given information on the numbers of animals by sub-area and their age-/sex-structure when catching/sighting surveys take place. However, there is insufficient information to allow estimation in this case so the parameters are set as detailed below.

(I) SEX RATIO DURING SIGHTING SURVEYS

The sighting mixing matrix is used to calculate the number of animals in each sub-area by stock, sex and age in order to generate the sightings abundance estimates on which *SLA*s and the RMP are based (see equation F.2).

The 'observed' values for the pristine sex-ratios by sub-area are obtained by assigning sex ratios (the 'survey' sex ratios) to each sub-area. These 'survey' sex-ratios are not measured directly, so they have to be inferred (and hence are not strictly data in the customary meaning of the word). The operating models are conditioned to values intended to reflect such ratios at the time when whaling commenced. These values and their associated standard errors are estimated from catch-by-sex information for the earliest period of relatively substantial whaling in each sub-area for the month in which surveys take place (in September for WG and in July for all other areas). The details of the estimation process are given in Annex D of SC/66a/Rep05 and the data on which they are based are given in Adjunct 2. The conditioning uses the values as estimated for each area, but rounded values for their standard errors, which were agreed to be 0.05 for all sub-areas except that CIP and ESW (for which there is less past information because of fewer catches) which were agreed to be 0.1 (these values are somewhat larger than the averages of corresponding values in Annex D of SC/66a/Rep05 because the estimation process used there is negatively biased, for example because of overdispersion of the samples compared to the binomial variance assumption made). The proportions and the standard deviations used are listed in Table 5. The 'target' values ($\lambda^{1,k}$) are generated as normal variates of these values, bounded by 0.02 and 0.98.

Table 5

The proportion of females in the surveys (the 'observed' survey sex-ratios).

Sub-area (k)	WC	WG	CIP	CG	CIC	CM	EN	EW	ESW	ESE	EB
'Survey' sex ratio	0.527	0.556	0.276	0.429	0.399	0.584	0.403	0.446	0.562	0.481	0.437
SE	0.05	0.05	0.1	0.05	0.05	0.05	0.05	0.05	0.1	0.05	0.05

The contribution to the likelihood from the survey sex ratios is given by:

$$L_2 = 0.5\sum_k \left(\hat{\lambda}^{1,k} - \lambda^{1,k}\right)^2 / \left(\sigma^{1,k}\right)^2 \tag{G.3}$$

where:

$\lambda^{1,k}$ is the target sex-ratio (proportion of females) for sub-area k in the pristine population during the month in which surveys take place;

$\hat{\lambda}^{1,k}$ is the model-estimate of the sex-ratio for sub-area k in the pristine population:

$$\hat{\lambda}^{1,k} = \frac{\sum_a \sum_j V^{f,j,k}_{-\infty,a} S^{f,k}_a N^{f,j}_{-\infty,a}}{\sum_g \sum_{a'} \sum_{j'} V^{g,j',k}_{-\infty,a'} S^{g,k}_a N^{g,j'}_{-\infty,a'}} \tag{G.4}$$

$\sigma^{1,k}$ is the between-period variation in the sex-ratios for sub-area k during the month in which surveys take place (see Table 5).

$S^{g,k}_a$ is the survey selectivity for gender g in subarea k and is equal to the 'Reference' selectivity $R^{g,h\in k}_a$ where

$$R^{g,h}_a = (1 + e^{-(a - a^{g,h}_{50})/\delta^{g,h}})^{-1} \tag{G.5}$$

$a^{g,h}_{50}$, $\delta^{g,h}$ are the parameters of the (logistic) selectivity ogive for gender g and hunt h (see table 4b); and in sub-area WG (where there are two hunts), the survey selectivity is based on the reference selectivity of the commercial hunt ($R^{g,h=\text{WG-com}}_a$) rather than the aboriginal hunt (see Table 6 for the relationship between the 'Reference' selectivity and the survey selectivity values).

(II) FISHERY SEX RATIOS

The catch mixing matrix for these trials is based on the sightings mixing matrix, with the selectivity pattern by sex adjusted so that the split of the catch to sex in a sub-area matches that actually observed over a recent period if the whalers selected whales at random from those available. In the base-case, the most recent period (2008-13) is used to estimate the parameters by sub-area to adjust the selectivity pattern given that this period is likely to be best reflective of how future whaling operations will occur, and is trial-dependent. Trials NM07-1 and NM07-4 test the effect of using sex-ratios based on catches from the 2002-07 period.

These 'fishery' sex-ratios apply to the season as a whole. Since catch-by-sex data are available for all sub-areas/hunts and seasons for which future catches will be simulated (see Table 7), the fishery sex-selectivity parameter estimated for these sub-areas/hunts provides the flexibility for an exact fit by the model to this information.

Two fishing selectivity patterns are modelled in the WG sub-area to reflect the different sex ratio shown in different hunts: the recent aboriginal hunt in this area compared to that in the earlier commercial catches. All other sub-areas have just one hunt type and thus a single fishing selectivity per sub-area.

The 'target' values ($\lambda^{1,k}$) for the fishery sex ratios are generated as normal variates from the estimated proportion of females over a recent period bounded by 0.02 and 0.98. The estimated female proportions are given in Table 7; details of the estimation process is given in Annex D of SC/66a/Rep05, and the data on which they are based are given in Adjunct 2.

Table 6

Relationship between hunts, sub-areas and the selectivity arrays.

Hunt (h)	WC	WG-com	WG-ab	CIP	CG	CIC	CM	EN	EW	ESW	ESE	EB
Sub-area (k)	WC	WG	-	CIP	CG	CIC	CM	EN	EW	ESW	ESE	EB
Parameters used in setting the Reference selectivity $R_a^{g,h}$ (see equation G.5):												
$a_{50}^{g,h}$	5	5	1	4	4	4	4	5	5	5	5	5
$\delta^{g,h}$	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
The survey selectivity												
$S_a^{g,k}$ =	$R_a^{g,h}$	$R_a^{g,h=\text{WG-com}}$	-	$R_a^{g,h}$	$R_a^{g,h}$	$R_a^{g,h}$	$R_a^{g,h}$	$R_a^{g,h}$	$R_a^{g,h}$	$R_a^{g,h}$	$R_a^{g,h}$	$R_a^{g,h}$
Fishing selectivity parameters (see equation G.8)												
ω^h	1	1	Est.	1	Est.	Est.	1	Est.	Est.	1	Est.	Est.

Table 7

The proportion of females in recent catches (the 'observed' fishery sex-ratios and their standard errors).

Hunt	WG-ab	CG	CIC	EN	EW	ESE	EB
Baseline Fishery sex ratio (using years 2008-13)	0.722	0.436	0.267	0.738	0.434	0.926	0.662
SE $\sigma^{2,h}$	0.023	0.12	0.058	0.096	0.023	0.014	0.071
Fishery sex ratio in Trial 07 (using years 2002-07)	0.747	0.665	0.502	0.506	0.496	0.944	0.691
SE	0.015	0.156	0.051	0.042	0.018	0.016	0.094

The contribution to the likelihood from the fishery sex ratios is given by:

$$L_3 = 0.5\sum_h \left(\hat{\lambda}^{2,h} - \lambda^{2,h}\right)^2 / \left(\sigma^{2,h}\right)^2 \tag{G.6}$$

where:

$\lambda^{2,h}$ is the target fishery sex-ratio (proportion of females) for hunt h (see above);

$\hat{\lambda}^{2,h}$ is the model-estimate of the sex-ratio for hunt h:

$$\hat{\lambda}^{2,h} = \sum_t \left\{ \left(C_t^{\mathrm{m},h} + C_t^{\mathrm{f},h}\right) \frac{\sum_a \sum_j \sum_{k\in h} V_{t,a}^{\mathrm{f},j,k} \tilde{S}_a^{\mathrm{f},h} N_{t,a}^{f,j}}{\sum_g \sum_{a'} \sum_{j'} \sum_{k\in h} V_{t,a'}^{g,j',k} \tilde{S}_{a'}^{g,h} N_{t,a'}^{f,j'}} \right\} / \sum_{t'} \left(C_{t'}^{\mathrm{m},h} + C_{t'}^{\mathrm{f},h}\right) \tag{G.7}$$

$\tilde{S}_a^{g,h}$ is the fishing selectivity on animals of gender g and age a by the hunt h (within sub-area k) which is based on the reference selectivity $R_a^{g,h}$ (see Equation G.5 and Table 6):

$$\tilde{S}_a^{\mathrm{m},h} = \omega^h R_a^{\mathrm{m},h} \quad \text{and} \quad \tilde{S}_a^{\mathrm{f},h} = R_a^{\mathrm{f},h} \tag{G.8}$$

ω^h is the difference in male selectivity in the catches over the year compared to the value at the time of the survey in hunts h for which a future catch is set (and is set to 1 in other hunts); and

$\sigma^{2,h}$ is the between-period variation in the catch sex-ratios for hunt h; (see Table 7).

H. Trials

The *Implementation Simulation Trials* for the North Atlantic minke whales are listed in Table 8. All trials are based on the assumption that $g(0)$=1. The majority of the sensitivity tests are based on stock structure hypothesis I because this hypothesis is likely to be the most challenging from a conservation standpoint.

Table 8

The *Implementation Simulation Trials* for North Atlantic minke whales (Trial NM08 was deleted and so is not shown here).

Trial No.	Stock hypothesis	*MSYR*	No. of Stocks	Boundaries	Catch sex-ratio for selectivity	Trial weight	Notes
NM01-1	I	1%[1]	3	Baseline	2008-13		3 stocks, E and W with sub-stocks
NM01-4	I	4%[2]	3	Baseline	2008-13		3 stocks, E and W with sub-stocks
NM02-1	II	1%[1]	2	Baseline	2008-13		2 stocks, E with sub-stocks
NM02-4	II	4%[2]	2	Baseline	2008-13		2 stocks, E with sub-stocks
NM03-1	III	1%[1]	1	Baseline	2008-13		1 stock
NM03-4	III	4%[2]	1	Baseline	2008-13		1 stock
NM04-1	IV	1%[1]	2	Baseline	2008-13		2 cryptic stocks
NM04-4	IV	4%[2]	2	Baseline	2008-13		2 cryptic stocks
NM05-1	I	1%[1]	3	Stock C not in ESW	2008-13		3 stocks, E and W with sub-stocks
NM05-4	I	4%[2]	3	Stock C not in ESW	2008-13		3 stocks, E and W with sub-stocks
NM06-1	II	1%[1]	2	Stock C not in ESW	2008-13		2 stocks, E with sub-stocks
NM06-4	II	4%[2]	2	Stock C not in ESW	2008-13		2 stocks, E with sub-stocks
NM07-1	I	1%[1]	3	Baseline	**2002-07**		Alternative years to adjust selectivity-at-age
NM07-4	I	4%[2]	3	Baseline	**2002-07**		Alternative years to adjust selectivity-at-age
NM09-1	I	1%	3	Baseline	2008-13		E-2 stock in EN 10%
NM09-4	I	4%	3	Baseline	2008-13		E-2 stock in EN 10%
NM10-1	I	1%	3	Baseline	2008-13		E-2 stock in EN 90%
NM10-4	I	4%	3	Baseline	2008-13		E-2 stock in EN 90%
~~NM11-1~~	~~I~~	~~1%~~	~~3~~	~~Baseline~~	~~2008-13~~		~~Force fit to EN survey sex ratio~~
NM12-1	I	1%[1]	3	Stock E1 not in ESW	2008-13		3 stocks, E and W with sub-stocks
NM12-4	I	4%[2]	3	Stock E1 not in ESW	2008-13		3 stocks, E and W with sub-stocks
NM13-1	II	1%[1]	2	Stock E1 not in ESW	2008-13		2 stocks, E with sub-stocks
NM13-4	II	4%[2]	2	Stock E1 not in ESW	2008-13		2 stocks, E with sub-stocks

1 – 1+; 2 –mature.

I. Management options

All the Management variants are based on applying catch cascading from the C and E *Combination areas* (which are identical to the C and E *Medium areas*). In all cases catch limits for sub-areas WG and CG are based on an *SLA*[2] and WC is a residual area. The following management variants will be considered:

V1 Sub-areas CIC, CM, CG, CIP, EN, EB, ESW+ESE and EW are *Small Areas*, with the catch limits for these *Small Areas* based on catch cascading from the C and E *Combination Areas*. The catch from the ESW+ESE *Small Area* is all taken in the ESE sub-area. The catch limits set for the CM, CG and CIP *Small Areas* are not taken (except that the Aboriginal catch is taken from CG);

V2 Sub-areas CIC, CM, CG, CIP, EN and EB+ESW+ESE+EW are *Small Areas*, with the catch limits for these *Small Areas* based on catch cascading from the C and E *Combination Areas*. The catch from the EB+ ESW+ESE +EW *Small Area* is all taken in the EW sub-area. The catch limits set for the CM, CG and CIP *Small Areas* are not taken (except that the Aboriginal catch is taken from CG);

V3 Sub-areas CIC, CM, CG, CIP, EN, ESW+ESE, and EB+EW are *Small Areas*, with the catch limits for these *Small Areas* based on catch cascading from the C and E *Combination Areas*. The catch from the EB+ EW *Small Area* is all taken in the EW sub-area and the catch from the ESW+ESE *Small Area* is taken in the ESE sub-area. The catch limits set for the CM, CG and CIP *Small Areas* are not taken (except that the Aboriginal catch is taken from CG);

V4 As for V1, except that sub-areas CIC+CIP+CM are a single *Small Area* and all of the catches from this *Small Area* are taken in the CIC sub-area. The catch limits set for the CG *Small Area* are not taken (except that the Aboriginal catch is taken); and

V5 Sub-areas CIP+CIC+CG+CM, EN, EB, ESW+ESE and EW are *Small Areas*, with the catch limits for the E *Small Areas* based on catch cascading from the E *Combination Area*. All the catches from CIP+CIC+CG+CM *Small* Area are taken in the CIC sub-area (after taking the Aboriginal catch from CG) and those for the ESW+ESE *Small Area* are taken in the ESE sub-area.

If the RMP catch limit for the *Combination Area* or *Small Area* containing the CG sub-area is

(i) ≤ the aboriginal strike limit, the catch limit for that *Combination Area* or *Small Area* is set to zero and the aboriginal catch is equal to the strike limit; or

(ii) > the aboriginal strike limit, the RMP catch limits are set as usual.

J. Output statistics

The population-size statistics are produced for each feeding ground and stock, while the catch-related statistics are for each sub-area.

(1) Total catch (TC) distribution: (a) median; (b) 5th value; (c) 95th value.

(2) Initial mature female population size (P_{initial}) distribution: (a) median; (b) 5th value; (c) 95th value.

(3) Final mature female population size (P_{final} distribution: (a) median; (b) 5th value; (c) 95th value.

(4) Lowest mature female population size (P_{lowest}) distribution: (a) median; (b) 5th value; (c) 95th value.

(5) Average catch by sub-area over the first ten years of the 100 year management period: (a) median; (b) 5th value; (c) 95th value.

(6) Average catch by sub-area over the last ten years of the 100 year management period: (a) median; (b) 5th value; (c) 95th value.

K. References

International Whaling Commission. 1991. Report of the Sub-Committee on Management Procedures, Appendix 4. Report of the *ad-hoc* trials subgroup. *Rep. int. Whal. Commn.* 41:108-12.

International Whaling Commission. 1993. Report of the Scientific Committee, Annex I. Report of the Working Group on Implementation Trials. *Rep. int. Whal. Commn.* 43:153-96.

International Whaling Commission. 1994. Report of the Scientific Committee, Annex D. Report of the Sub-Committee on Management Procedures, Appendix 2. Minimum Standards Trials. *Rep. int. Whal. Commn.* 44:85-88.

International Whaling Commission. 2004a. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 6:1-60.

International Whaling Commission. 2004b. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 10. North Pacific minke whale *Implementation Simulation Trial* specifications. *J. Cetacean Res. Manage. (Suppl.)* 6:118-29.

International Whaling Commission. 2009. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure (RMP). *J. Cetacean Res. Manage. (Suppl.)* 11:91-144.

International Whaling Commission. 2015. Report of the AWMP/RMP Joint Workshop on the Stock Structure of North Atlantic Common Minke Whales, 14-17 April 2014, Copenhagen, Denmark. *J. Cetacean Res. Manage. (Suppl.)* 16:543-58.

Kristensen, K., Nielsen, A., Berg, C.W., Skaug, H. and Bell, B. In press. TMB: Automatic differentiation and Laplace approximation. *Journal of Statistical Software*.

Punt, A.E. 1999. Report of the Scientific Committee. Annex R. A full description of the standard BALEEN II model and some variants thereof. *J. Cetacean Res. Manage. (Suppl.)* 1: 267-76.

Adjunct 1

The Catch Series

C. Allison

The catch series used in the trials is given in Table 1 and includes all known direct and indirect catches. Details of the sources of the direct catch data are given in Allison (2015) and of the indirect catches in IWC (2015, p.118). The two known catches prior to 1900 are ignored. The Faroes catches (125 whales) are allocated to the EW sub-area as they were all taken from land stations in the north of the Faroes. The Norwegian catch data from 1938 on includes detailed positions except for 16 records; these have been allocated to sub-area in accordance with the ratio of other catches in the same year. Table 2 lists the catches known by sex and sub-area/hunt. The average sex ratio for the hunt is assumed for all other catches.

Table 1

The 'Best' catch series.

Year	WC	WG-comm.	WG-aborgl.	CIP	CG	CIC	CM	EN	EW	ESW	ESE	EB	Total
1914	0	0	0	0	0	1	0	0	0	0	0	0	1
1915	0	0	0	0	0	10	0	0	0	0	0	0	10
1916	0	0	0	0	0	6	0	0	0	0	0	0	6
1917	0	0	0	0	0	6	0	0	0	0	0	0	6
1918	0	0	0	0	0	6	0	1	0	0	0	0	7
1919	0	0	0	0	0	6	0	5	3	0	0	0	14
1920	0	0	0	0	0	6	0	0	0	0	0	0	6
1921	0	0	0	0	0	20	0	0	0	0	0	0	20
1922	0	0	0	0	0	20	0	0	0	0	0	0	20
1923	0	0	0	0	0	20	0	0	0	0	0	0	20
1924	0	0	0	0	0	20	0	0	0	0	0	0	20
1925	0	0	0	0	0	20	0	0	0	0	0	0	20
1926	0	0	0	0	0	9	0	0	4	0	0	0	13
1927	0	0	0	0	0	9	0	0	4	0	0	0	13
1928	0	0	0	0	0	9	0	0	0	0	0	0	9
1929	0	0	0	0	0	9	0	2	4	0	0	0	15
1930	0	0	0	0	0	9	0	28	10	0	0	0	47
1931	0	0	0	0	0	7	0	0	175	0	0	0	182
1932	0	0	0	0	0	5	0	0	350	0	0	0	355
1933	0	0	0	0	0	10	0	0	525	0	0	0	535
1934	0	0	0	0	0	4	0	30	670	0	0	0	704
1935	0	0	0	0	0	2	0	50	828	0	0	0	880

Cont.

Year	WC	WG-comm.	WG-aborgl.	CIP	CG	CIC	CM	EN	EW	ESW	ESE	EB	Total
1936	0	0	0	0	0	1	0	84	909	0	30	30	1,054
1937	0	0	0	0	0	1	0	125	996	0	60	50	1,232
1938	0	0	0	0	0	1	0	266	907	0	112	68	1,354
1939	0	0	0	0	0	1	0	137	762	1	12	6	919
1940	0	0	0	0	0	1	0	35	503	0	1	13	553
1941	0	0	0	0	0	5	0	186	1,914	0	4	6	2,115
1942	1	0	0	0	0	18	0	158	1,976	0	0	0	2,153
1943	0	0	0	0	0	16	0	158	1,455	0	0	0	1,629
1944	0	0	0	0	0	15	0	97	1,252	0	0	0	1,364
1945	0	0	0	0	0	16	0	165	1,611	0	0	10	1,802
1946	0	0	0	0	0	34	0	305	1,337	0	140	101	1,917
1947	16	0	0	0	0	34	0	373	1,810	0	136	237	2,606
1948	38	0	4	0	0	102	0	358	2,035	0	559	535	3,631
1949	38	0	5	0	0	106	7	241	1,206	0	701	1,693	3,997
1950	3	0	9	0	0	80	0	106	1,173	0	274	437	2,082
1951	55	0	16	0	0	63	0	89	1,836	0	155	672	2,886
1952	17	0	32	0	0	64	0	122	1,273	0	101	1,829	3,438
1953	0	0	32	0	0	79	0	63	1,231	0	62	1,079	2,546
1954	0	0	22	0	0	54	0	359	1,508	0	88	1,544	3,575
1955	13	0	22	0	6	57	1	435	2,138	1	56	1,679	4,408
1956	57	0	22	0	0	21	3	441	1,611	10	483	1,111	3,759
1957	37	0	24	1	0	37	0	593	1,417	12	612	1,000	3,733
1958	42	0	30	0	0	36	0	639	1,658	3	498	1,543	4,449
1959	18	0	55	0	14	35	2	575	900	15	495	1,091	3,200
1960	11	0	56	4	12	82	0	628	1,039	14	369	1,223	3,438
1961	22	0	35	1	3	108	72	377	1,322	13	208	1,187	3,348
1962	50	0	72	0	3	134	158	400	1,302	22	113	1,225	3,479
1963	18	0	166	5	10	115	80	340	1,043	5	324	1,355	3,461
1964	54	0	162	1	8	153	151	400	1,057	10	233	769	2,998
1965	41	0	196	3	0	147	255	268	1,062	5	534	253	2,764
1966	11	0	225	15	87	123	88	330	633	1	288	671	2,472
1967	40	0	244	44	143	193	66	181	901	91	536	118	2,557
1968	0	20	315	62	211	409	45	355	893	90	656	114	3,170
1969	60	165	269	22	94	214	21	479	667	22	397	467	2,877
1970	88	126	207	8	159	222	13	350	632	20	628	282	2,735
1971	84	263	196	38	29	228	17	410	385	0	524	483	2,657
1972	214	123	156	32	139	199	0	319	231	0	158	1,467	3,038
1973	3	221	276	24	222	147	0	200	267	3	253	839	2,455
1974	3	252	217	12	102	127	15	172	291	0	26	931	2,148
1975	4	102	222	15	217	193	0	186	269	0	324	651	2,183
1976	3	187	191	3	81	216	0	186	148	0	365	1,190	2,570
1977	1	75	285	0	1	194	0	118	281	0	749	551	2,255
1978	2	75	180	0	130	199	3	83	312	0	162	826	1,972
1979	9	75	250	0	119	198	1	76	446	0	62	1,202	2,438
1980	10	78	258	0	119	202	0	67	259	0	477	1,004	2,474
1981	8	61	204	0	45	201	0	62	385	0	714	610	2,290
1982	4	66	250	0	109	212	0	60	344	0	655	723	2,423
1983	4	68	268	0	98	204	15	36	158	0	623	871	2,345
1984	6	70	235	0	25	178	90	19	219	0	183	209	1,234
1985	7	52	222	0	44	145	55	23	171	0	209	231	1,159
1986	4	0	145	0	2	0	50	33	129	0	128	39	530
1987	8	0	86	0	4	0	50	34	92	0	157	40	471
1988	9	0	109	0	10	0	0	0	29	0	0	0	157
1989	10	0	63	0	10	0	0	0	1	0	16	0	100
1990	11	0	89	0	6	0	0	0	5	0	0	0	111
1991	5	0	109	0	10	0	0	0	1	0	0	0	125
1992	8	0	110	0	11	0	0	0	37	0	36	22	224
1993	5	0	113	0	9	0	13	8	120	0	51	34	353
1994	5	0	104	0	5	0	41	9	94	0	31	105	394
1995	7	0	155	0	9	0	42	3	38	0	46	89	389
1996	0	0	170	0	13	0	40	24	75	0	112	137	571
1997	2	0	148	0	14	0	20	40	74	0	129	240	667
1998	5	0	169	0	10	0	57	137	85	0	129	217	809
1999	9	0	172	0	14	0	58	122	158	0	112	141	786
2000	1	0	147	0	10	0	57	65	192	0	103	70	645
2001	10	0	139	0	17	0	31	104	247	0	120	50	718
2002	9	0	140	0	10	2	35	74	253	0	146	126	795
2003	6	0	185	0	14	37	21	98	157	0	150	221	889
2004	8	0	179	0	11	25	17	93	199	0	113	125	770
2005	6	0	176	0	4	41	5	9	244	0	99	284	868
2006	2	0	181	0	3	62	0	34	373	0	118	23	796
2007	7	0	167	0	2	45	0	99	176	0	295	28	819
2008	6	0	154	0	1	38	31	98	160	0	230	22	740
2009	0	0	165	0	4	81	0	50	182	0	250	4	736
2010	5	0	187	0	9	60	1	35	145	0	270	18	730
2011	4	0	179	0	10	58	0	14	218	0	201	100	784
2012	0	0	148	0	4	52	0	14	200	0	244	6	668
2013	0	0	175	0	6	35	0	2	242	0	282	68	810
2014	0	0	146	0	11	137	0	20	231	0	377	108	1,030
Total	1,244	2,079	9,840	290	2,473	6,507	1,727	13,570	54,865	338	18294	36,503	146,700

Table 2

Catches known by sex.

	WC		WG-com		WG-ab		CIP		CG		CIC		CM		EN		EW		ESW		ESE		EB	
Year	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1914	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1915	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1916	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1917	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1918	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1919	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1921	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	1	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	13	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	143	98	463	386	0	0	50	50	47	19
1939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	63	70	383	323	1	0	5	7	4	2
1940	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	25	257	207	0	0	0	0	9	4
1941	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	78	1,003	863	0	0	2	2	3	3
1942	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94	64	1,112	853	0	0	0	0	0	0
1943	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88	69	844	592	0	0	0	0	0	0
1944	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45	52	658	585	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0	0	0	104	55	891	705	0	0	0	0	7	3
1946	0	0	0	0	0	0	0	0	0	0	0	0	0	0	190	114	737	588	0	0	58	78	65	35
1947	0	0	0	0	0	0	0	0	0	0	9	3	0	0	202	166	1,013	779	0	0	47	89	162	72
1948	24	14	0	0	0	0	0	0	0	0	38	28	0	0	207	148	1,100	905	0	0	234	317	321	200
1949	24	14	0	0	0	0	0	0	0	0	38	33	3	4	141	99	652	542	0	0	250	446	841	826
1950	2	1	0	0	0	0	0	0	0	0	0	0	0	0	61	44	649	510	0	0	62	212	179	254
1951	26	29	0	0	0	0	0	0	0	0	0	0	0	0	68	20	1,030	791	0	0	68	87	243	428
1952	10	7	0	0	0	0	0	0	0	0	1	1	0	0	75	46	704	561	0	0	59	42	632	1,185
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	26	721	504	0	0	37	24	436	642
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	204	149	795	702	0	0	54	34	688	852
1955	5	8	0	0	7	8	0	0	1	5	4	9	0	1	244	181	1,156	972	1	0	18	37	620	,1053
1956	27	27	0	0	5	15	0	0	0	0	0	0	3	0	288	149	906	694	4	6	159	323	451	659
1957	6	12	0	0	6	18	1	0	0	0	1	0	0	0	380	210	772	634	1	11	151	457	347	651
1958	0	0	0	0	5	6	0	0	0	0	0	0	0	0	412	225	950	704	2	1	152	346	470	1,052
1959	6	12	0	0	2	17	0	0	9	5	1	0	0	2	423	149	483	414	1	14	121	373	594	480
1960	5	6	0	0	3	15	3	1	4	8	7	2	0	0	436	187	531	482	2	12	114	253	443	779
1961	8	14	0	0	7	9	1	0	3	0	42	8	45	27	236	140	779	530	9	4	65	143	349	821
1962	0	0	0	0	18	43	0	0	3	0	48	24	82	75	261	137	704	583	8	14	34	79	364	839
1963	2	16	0	0	32	47	3	2	9	1	40	28	33	47	214	126	592	450	2	3	115	209	517	836
1964	12	42	0	0	26	37	1	0	5	3	85	22	88	63	278	121	549	500	4	6	65	168	289	478
1965	7	4	0	0	19	30	2	1	0	0	51	36	112	143	175	93	583	477	3	2	151	381	112	137
1966	0	0	0	0	24	49	13	2	69	18	31	28	12	76	218	111	362	249	1	0	96	192	171	498
1967	15	25	0	0	7	42	31	13	108	35	78	38	42	24	125	53	553	338	31	60	154	381	59	59
1968	0	0	7	13	10	47	33	29	106	104	163	157	32	13	233	117	528	329	51	39	346	304	59	54
1969	33	27	119	46	14	42	11	11	64	30	37	17	6	15	300	173	444	221	12	10	80	317	177	289
1970	22	66	74	52	12	20	4	4	91	68	56	32	6	7	197	148	383	245	7	13	239	389	62	218
1971	20	63	86	177	6	25	2	4	23	6	47	34	6	11	281	115	212	166	0	0	177	345	183	299
1972	84	130	32	91	6	40	16	16	74	65	42	23	0	0	189	126	116	111	0	0	39	119	446	1,014
1973	0	0	67	154	8	39	17	6	159	62	13	7	0	0	109	90	149	117	0	3	54	199	334	503
1974	1	0	43	209	6	34	7	4	73	28	60	62	1	14	89	81	144	136	0	0	3	23	290	636
1975	0	0	11	91	1	17	7	8	84	132	89	80	0	0	131	55	156	109	0	0	66	257	246	405
1976	0	1	38	149	2	20	3	0	57	23	114	87	0	0	115	71	64	74	0	0	85	279	351	839
1977	0	0	21	54	15	39	0	0	0	0	103	86	0	0	70	48	186	90	0	0	231	517	223	328
1978	0	0	10	65	2	13	0	0	72	58	85	113	3	0	54	29	152	159	0	0	13	148	251	574
1979	0	1	31	44	0	1	0	0	75	43	111	87	1	0	41	32	296	148	0	0	14	48	409	783
1980	2	2	14	64	0	0	0	0	77	39	120	81	0	0	54	12	182	73	0	0	155	320	388	604
1981	0	0	15	46	1	1	0	0	10	35	113	77	0	0	36	25	209	168	0	0	257	454	256	354
1982	0	0	24	42	0	0	0	0	84	24	127	85	0	0	44	16	168	174	0	0	184	471	233	476
1983	0	0	25	42	0	0	0	0	51	38	117	87	1	14	23	13	88	67	0	0	182	440	315	543
1984	0	0	20	49	0	0	0	0	6	9	91	71	28	62	17	2	164	54	0	0	65	118	89	119
1985	0	0	28	24	0	0	0	0	15	15	92	50	3	52	19	2	142	28	0	0	56	153	103	126
1986	0	0	0	0	0	0	0	0	0	0	0	0	6	44	24	9	109	19	0	0	66	62	27	12
1987	0	0	0	0	14	29	0	0	0	4	0	0	12	38	20	14	46	46	0	0	61	96	27	13
1988	0	0	0	0	5	35	0	0	1	4	0	0	0	0	0	0	21	8	0	0	0	0	0	0
1989	0	0	0	0	16	34	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	15	0	0
1990	0	0	0	0	14	62	0	0	0	5	0	0	0	0	0	0	4	1	0	0	0	0	0	0
1991	0	0	0	0	19	63	0	0	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	1	0	0	18	75	0	0	0	8	0	0	0	0	0	0	22	13	0	0	15	20	14	8
1993	1	0	0	0	25	71	0	0	0	2	0	0	5	8	1	7	79	36	0	0	4	45	6	26
1994	0	0	0	0	20	77	0	0	0	5	0	0	3	38	5	3	61	29	0	0	5	25	57	47
1995	0	1	0	0	46	105	0	0	0	2	0	0	4	38	1	2	14	23	0	0	2	43	13	76

Cont.

	WC		WG-com		WG-ab		CIP		CG		CIC		CM		EN		EW		ESW		ESE		EB	
Year	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1996	0	0	0	0	37	126	0	0	1	12	0	0	1	39	5	18	18	56	0	0	2	110	27	107
1997	0	0	0	0	42	102	0	0	1	10	0	0	0	19	9	29	33	41	0	0	1	126	70	168
1998	1	0	0	0	41	124	0	0	1	9	0	0	8	49	50	82	31	53	0	0	2	125	37	177
1999	0	3	0	0	35	133	0	0	1	13	0	0	9	46	47	69	67	81	0	0	2	104	37	95
2000	0	0	0	0	37	103	0	0	2	8	0	0	23	33	25	39	101	85	0	0	1	96	24	43
2001	0	0	0	0	32	91	0	0	0	14	0	0	4	27	31	71	150	92	0	0	0	116	11	39
2002	0	2	0	0	33	97	0	0	0	10	1	1	6	29	37	33	140	111	0	0	21	114	22	102
2003	2	2	0	0	57	118	0	0	1	11	23	13	1	19	45	48	73	82	0	0	5	135	89	127
2004	0	3	0	0	44	129	0	0	4	7	10	15	0	17	35	55	95	102	0	0	2	109	23	100
2005	1	0	0	0	34	135	0	0	3	1	20	15	4	1	6	3	108	133	0	0	5	92	31	249
2006	0	0	0	0	44	127	0	0	2	0	31	28	0	0	11	21	200	166	0	0	9	108	0	22
2007	0	1	0	0	38	121	0	0	0	1	14	28	0	0	52	44	86	88	0	0	12	271	20	8
2008	0	1	0	0	55	87	0	0	0	1	28	7	5	26	44	50	99	55	0	0	9	220	12	10
2009	0	0	0	0	47	107	0	0	3	1	64	14	0	0	29	21	83	98	0	0	13	237	1	3
2010	1	0	0	0	54	122	0	0	4	2	47	12	0	1	5	29	80	65	0	0	11	256	6	12
2011	0	0	0	0	39	133	0	0	0	9	45	13	0	0	1	13	121	95	0	0	26	173	15	83
2012	0	0	0	0	34	108	0	0	0	4	38	11	0	0	1	13	113	84	0	0	26	214	4	2
2013	0	0	0	0	37	127	0	0	1	3	13	22	0	0	1	0	144	94	0	0	28	253	21	47
2014	0	0	0	0	27	115	0	0	1	9	80	54	0	0	7	11	122	108	0	0	79	297	28	79
Total	347	535	665	1,412	1,188	3,430	155	101	1,360	1,015	2,468	1,729	598	1,122	8,033	5,057	27,951	21,763	140	198	4,975	13,093	13,460	22,686

REFERENCES

Allison, C. 2015. IWC Summary catch database version 5.5.

International Whaling Commission. 2015. Report of the Scientific Committee. Annex D. Report of the Sub-committee on the Revised Management Procedure. Appendix 5. *Implementation Review* for North Atlantic common minke whales. *J. Cetacean Res. Manage. (Suppl.)* 16: 112-136.

Adjunct 2

Data used to estimate the survey and fishery sex ratios (see Appendix 4, Tables 5 and 7)

C. Allison

The sex ratios in the catches of North Atlantic minke whales have been shown to be both spatially and seasonally variable (see IWC, 2015, pp.120-122). The trials allow for the difference in the catch sex-ratios between the primary catching season (i.e. before July) and the time when surveys are conducted (July onwards) and thereafter (see details in Section G of Appendix 4).

'Survey' sex-ratio data

The 'Survey' sex-ratios are intended to reflect such ratios at the time when whaling commenced, and are estimated from catch-by-sex information for the earliest period of relatively substantial whaling in each sub-area for the month in which surveys take place (in September for WG and in July for all other areas). The data used are listed in Table 1. In areas where the catches in the survey month are relatively small, the 'survey' sex ratios are estimated using data from all years (see Table 1). Catches in the CIC area from the 1986-92 period are excluded as they were primarily taken during a scientific whaling program and hence may be more widely distributed across the area than commercial catches and have a different sex ratio. Bycatch data are omitted.

Table 1

Catches used to estimate 'survey' sex ratios by sub-area.

Month:	July		September		July		July		July		July		July	
Years:	All		<1986		All		All		All		All		All	
Sub-area:	WC		WG		CIP		CG		CIC		CM		ESW	
Year	M	F	M	F	M	F	M	F	M	F	M	F		
1948	10	5	-	-	-	-	-	-	16	10	-	-	M	F
1949	15	6	-	-	-	-	-	-	21	18	3	4	-	-
1950	0	1	-	-	-	-	-	-	-	-	-	-	-	-
1951	8	4	-	-	-	-	-	-	-	-	-	-	-	-
1952	2	2	-	-	-	-	-	-	1	1	-	-	-	-
1953	5	3	-	-	-	-	-	-	-	-	-	-	-	-
1954	9	14	-	-	-	-	-	-	-	-	-	-	-	-
1955	2	1	-	-	-	-	-	-	3	7	0	1	-	-
1956	8	6	-	-	-	-	-	-	-	-	3	0	-	-
1957	4	8	-	-	-	-	-	-	-	-	-	-	-	-
1959	3	7	-	-	-	-	-	-	-	-	-	-	-	-
1960	4	2	0	1	-	-	-	-	1	1	-	-	-	-
1961	4	7	1	2	-	-	3	0	20	3	10	5	-	-
1962	0	0	6	11	-	-	0	0	6	3	42	41	6	10
1963	0	0	-	-	-	-	1	0	3	3	11	25	0	0
1964	0	2	-	-	-	-	1	3	6	4	29	25	1	2
1965	5	3	-	-	-	-	0	0	22	18	50	29	0	0
1966	1	3	-	-	6	1	0	0	6	4	1	3	0	0

Cont.

Month:	July		September		July		July		July		July		July	
Years:	All		<1986		All		All		All		All		All	
Sub-area:	WC		WG		CIP		CG		CIC		CM		ESW	
Year	M	F	M	F	M	F	M	F	M	F	M	F		
1967	3	11	-	-	6	3	52	14	39	27	32	1	0	0
1968	0	0	0	0	0	0	7	11	22	17	14	3	8	7
1969	9	12	0	0	0	1	3	1	0	0	3	7	1	0
1970	4	12	11	13	3	2	30	24	31	15	2	3	0	3
1971	3	4	11	16	0	0	1	1	20	26	5	11	-	-
1972	22	22	1	0	2	1	7	4	29	16	-	-	-	-
1973	-	-	0	0	10	3	26	16	5	1	-	-	-	-
1974	-	-	0	1	1	0	9	6	6	4	-	-	-	-
1975	-	-	0	0	1	2	25	55	24	18	-	-	-	-
1976	-	-	0	0	-	-	22	6	25	21	-	-	-	-
1977	-	-	0	0	-	-	0	0	44	28	-	-	-	-
1978	-	-	0	0	-	-	55	36	51	39	-	-	-	-
1979	-	-	6	4	-	-	43	28	37	25	1	0	-	-
1980	-	-	0	0	-	-	17	8	63	32	-	-	-	-
1981	-	-	1	0	-	-	-	-	26	32	-	-	-	-
1982	-	-	2	2	-	-	-	-	30	19	-	-	-	-
1983	-	-	8	6	-	-	-	-	30	28	1	5	-	-
1984	-	-	7	15	-	-	-	-	40	22	25	52	-	-
1985	-	-	5	2	-	-	6	14	31	21	0	10	-	-
1986	-	-	-	-	-	-	-	-	-	-	4	29	-	-
1987	-	-	3	1	-	-	-	-	-	-	9	12	-	-
1988	-	-	1	6	-	-	-	-	-	-	-	-	-	-
1989	-	-	3	7	-	-	-	-	-	-	-	-	-	-
1990	-	-	4	12	-	-	-	-	-	-	-	-	-	-
1991	-	-	4	14	-	-	-	-	-	-	-	-	-	-
1992	-	-	3	13	-	-	-	-	-	-	-	-	-	-
1993	-	-	8	10	-	-	-	-	-	-	3	4	-	-
1994	-	-	7	10	-	-	-	-	-	-	0	7	-	-
1995	-	-	9	16	-	-	-	-	-	-	1	4	-	-
1996	-	-	11	22	-	-	-	-	-	-	0	16	-	-
1997	-	-	14	18	-	-	-	-	-	-	0	1	-	-
1998	-	-	4	30	-	-	-	-	-	-	1	0	-	-
1999	-	-	7	33	-	-	-	-	-	-	0	1	-	-
2000	-	-	2	11	-	-	-	-	-	-	2	12	-	-
2001	-	-	5	15	-	-	-	-	-	-	0	0	-	-
2002	-	-	9	13	-	-	-	-	-	-	1	2	-	-
2003	-	-	7	20	-	-	-	-	-	-	0	5	-	-
2004	-	-	8	23	-	-	-	-	3	6	-	-	-	-
2005	-	-	11	26	-	-	-	-	11	7	-	-	-	-
2006	-	-	15	32	-	-	-	-	8	17	-	-	-	-
2007	-	-	4	10	-	-	-	-	3	2	-	-	-	-
2008	-	-	11	14	-	-	-	-	12	0	5	25	-	-
2009	-	-	7	16	-	-	-	-	20	6	-	-	-	-
2010	-	-	7	17	-	-	-	-	10	3	-	-	-	-
2011	-	-	13	28	-	-	-	-	18	2	-	-	-	-
2012	-	-	5	14	-	-	-	-	6	4	-	-	-	-
2013	-	-	-	-	-	-	-	-	6	5	-	-	-	-

Month:	July		July		July		July	
Years:	< 1960		< 1960		< 1960		< 1960	
Area:	EN		EW		ESE		EB	
Year	M	F	M	F	M	F	M	F
1927	0	0	1	2	0	0	0	0
1929	2	0	1	1	0	0	0	0
1930	6	6	0	0	0	0	0	0
1938	70	34	128	104	20	19	21	7
1939	14	12	138	105	0	0	0	0
1940	2	9	91	59	0	0	6	1
1941	29	24	334	268	2	2	2	2
1942	27	12	292	233	0	0	0	0
1943	23	14	146	124	0	0	0	0
1944	7	9	186	147	0	0	0	0
1945	26	13	280	205	0	0	5	0
1946	58	36	232	172	29	35	56	28
1947	54	37	228	196	1	2	134	61
1948	56	45	464	375	104	86	162	89
1949	33	23	172	136	39	41	354	369
1950	11	6	87	95	8	7	24	26
1951	7	0	133	102	8	4	16	37
1952	9	3	104	63	0	0	87	142
1953	0	1	90	75	0	0	7	9
1954	14	15	96	96	0	0	116	118
1955	45	47	225	211	0	0	0	0
1956	20	13	185	137	0	0	0	0
1957	97	62	152	127	0	0	0	0
1958	66	38	195	152	0	0	21	22
1959	50	22	98	79	0	0	76	27

‘Fishery’ sex-ratio data

The ‘Fishery’ sex ratios are estimated for all future hunts and are based on recent catches as this is likely to be best reflective of how future whaling operations will occur. In the base case all catches from the 2008-13 period are used (except any by-catches) and for trials NM07-1 and NM07-4 the 2002-07 period is used. The data are listed in Table 2.

Table 2

Catches used to estimate ‘fishery’ sex ratios (for all future hunts).

	WG-ab	WG-ab	CG	CG	CIC	CIC	CM	CM	EN	EN	EW	EW	ESE	ESE	EB	EB
Year	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
2002	33	97	0	10	0	0	6	29	37	33	140	111	21	114	22	102
2003	57	118	1	11	23	13	1	19	45	48	73	82	5	135	89	127
2004	44	129	4	7	10	15	0	17	35	53	95	102	2	109	23	100
2005	34	135	3	1	20	14	4	1	6	1	108	133	5	92	31	249
2006	44	127	2	0	31	28	0	0	10	20	200	166	9	108	0	22
2007	38	121	0	1	14	28	0	0	52	44	86	88	12	271	20	8
2008	55	87	0	1	28	7	5	25	43	48	99	55	9	220	12	10
2009	47	107	3	1	64	14	0	0	28	21	83	98	13	237	1	3
2010	54	122	4	2	47	12	0	1	4	29	80	65	11	256	6	12
2011	39	133	0	9	45	13	0	0	1	13	121	95	26	173	15	83
2012	34	108	0	4	38	11	0	0	1	13	113	84	26	214	4	2
2013	37	127	1	3	13	22	0	0	1	0	144	94	28	253	21	47

REFERENCE

International Whaling Commission. 2015. Report of the Scientific Committee. Annex D. Report of the Sub-committee on the Revised Management Procedure. Appendix 5. *Implementation Review* for North Atlantic common minke whales. *J. Cetacean Res. Manage. (Suppl.)* 16: 112-136.

Appendix 5

CONDITIONING RESULTS FOR NORTH ATLANTIC MINKE WHALES *IMPLEMENTATION SIMULATION TRIALS*

C. Allison and C. de Moor

The following example results of conditioning for trials NM01 and NM02 (MSYR=1% and 4%) are given:

(i) median and 90%ile 1+ population trajectories by sub-area plus the deterministic trajectory (in grey). The abundance estimates used in conditioning are also shown:

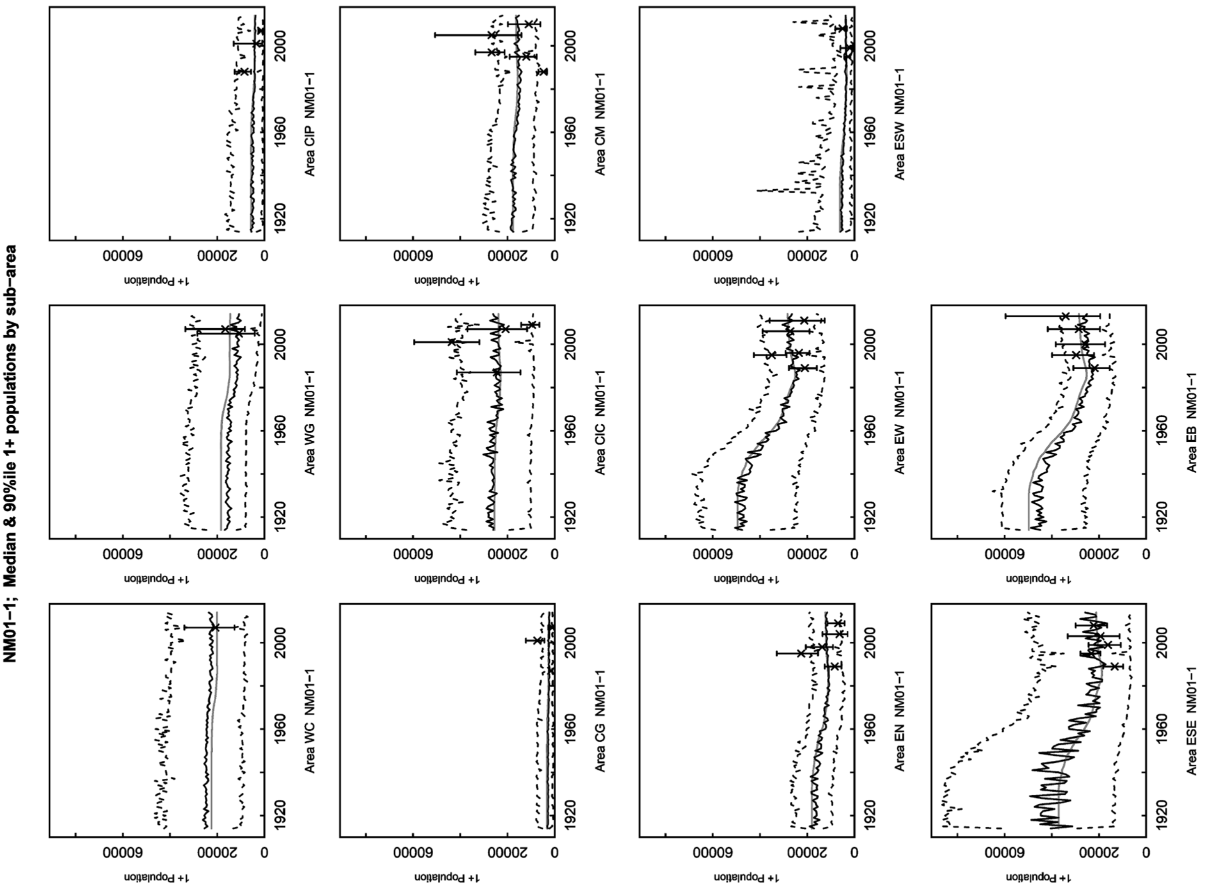
(ii) as for plot (i) but using the same scale for all sub-areas;

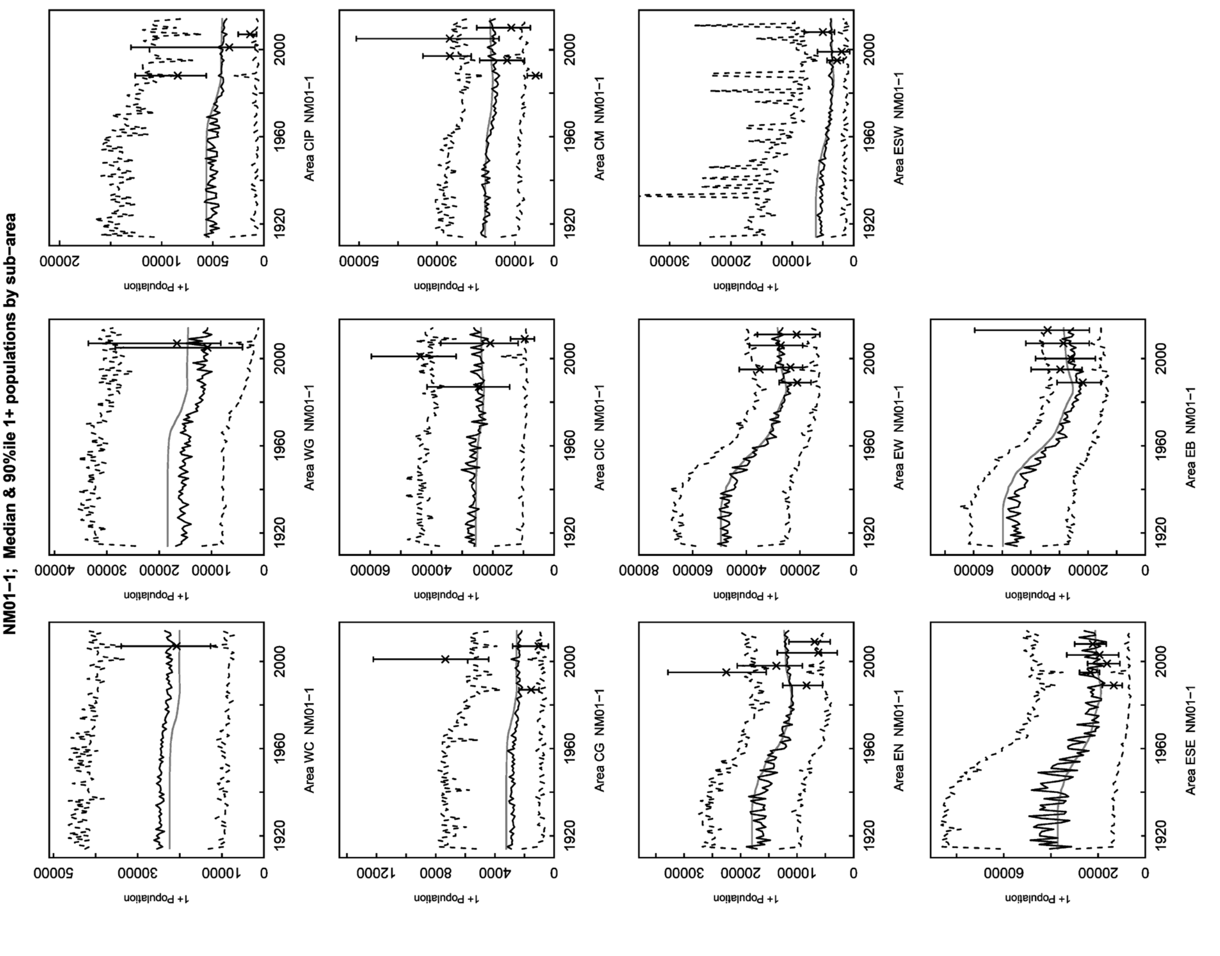
(iii) median and 90%ile mature female population trajectories by sub-stock;

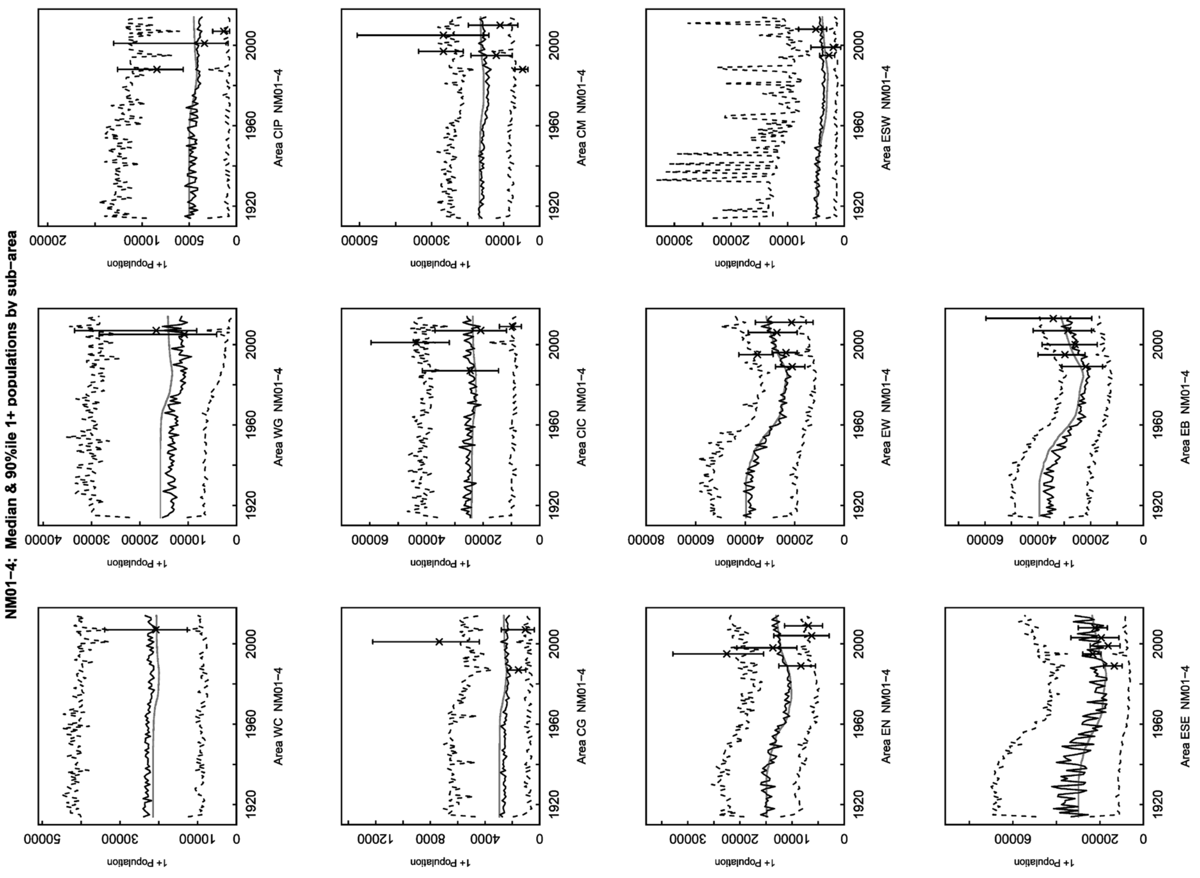
(iv) as for plot (iii) but using the same scale for all sub-stocks;

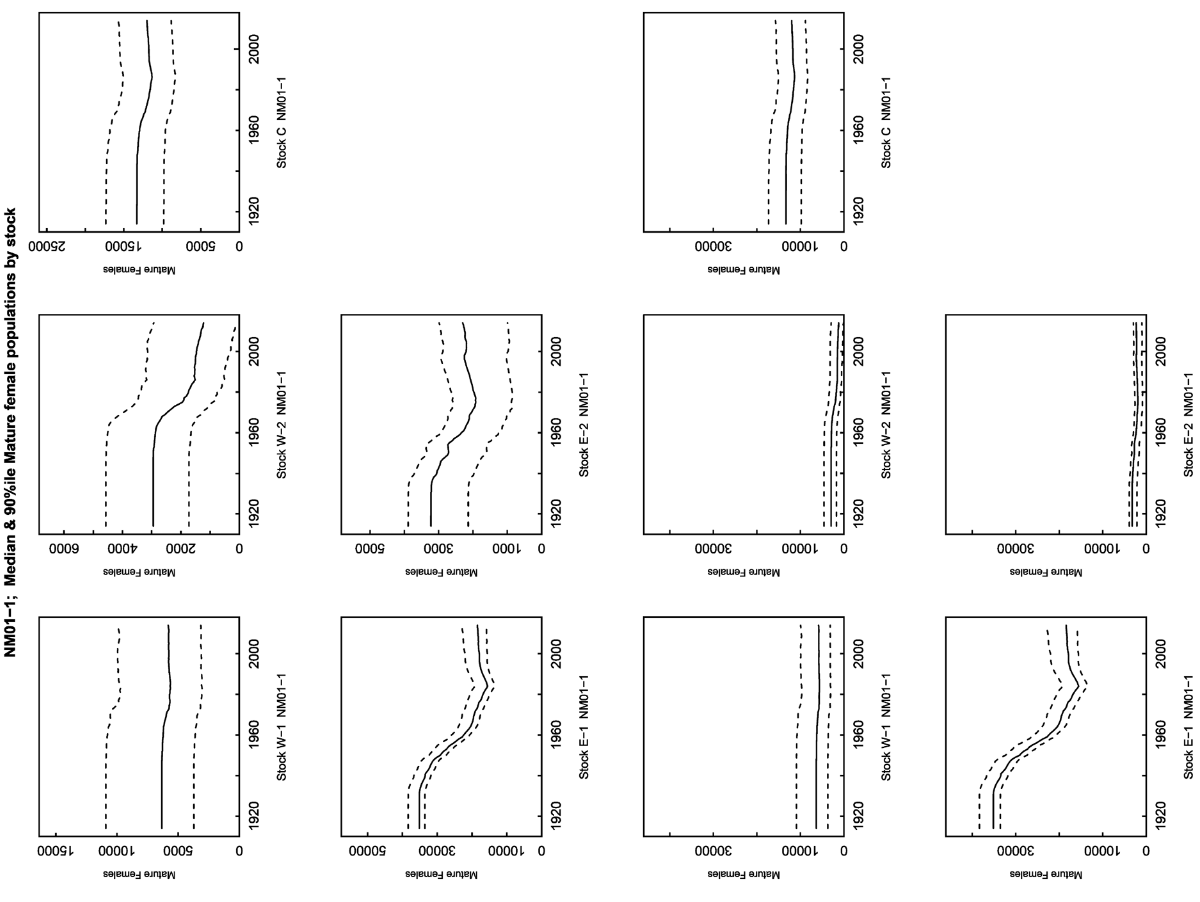
(v) median and 90%ile pristine proportions of females by sub-area; and

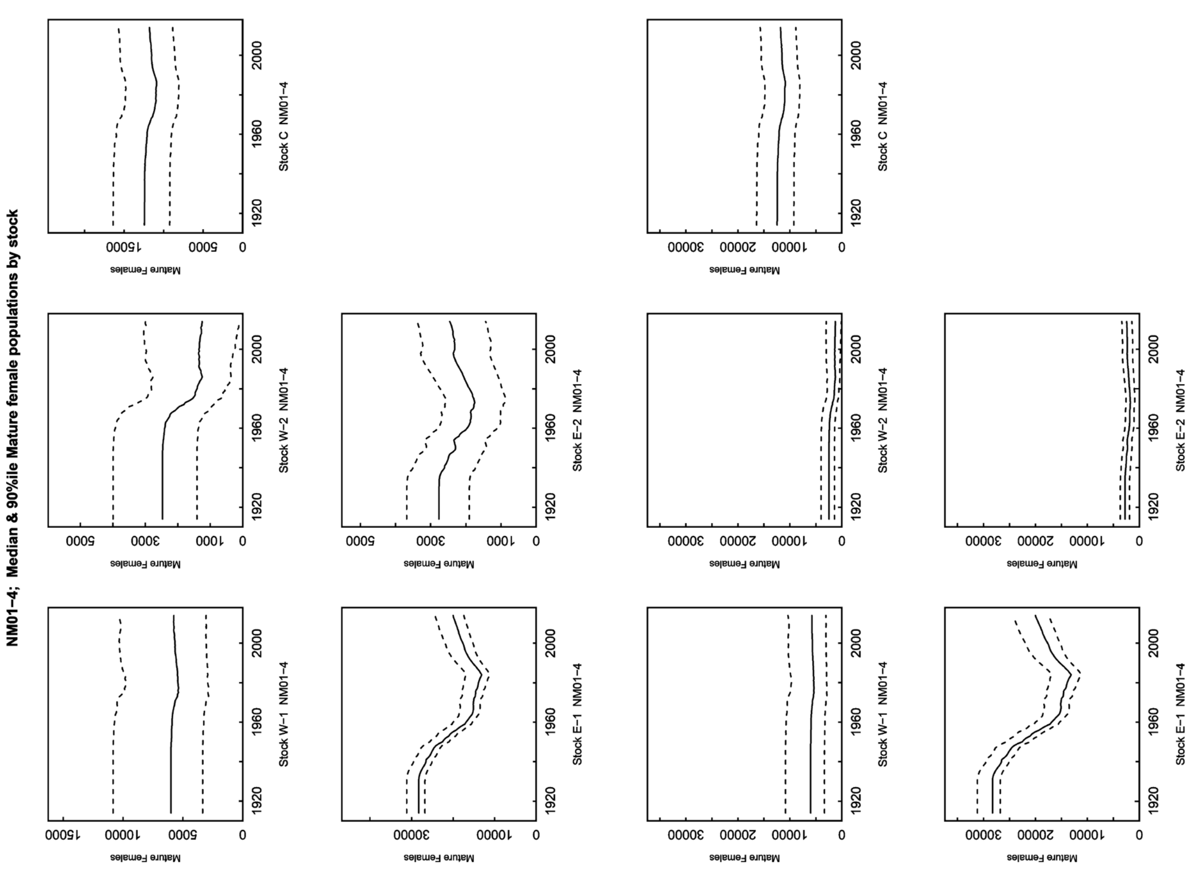
(vi) median and 90%ile fishery proportions of females by sub-area.

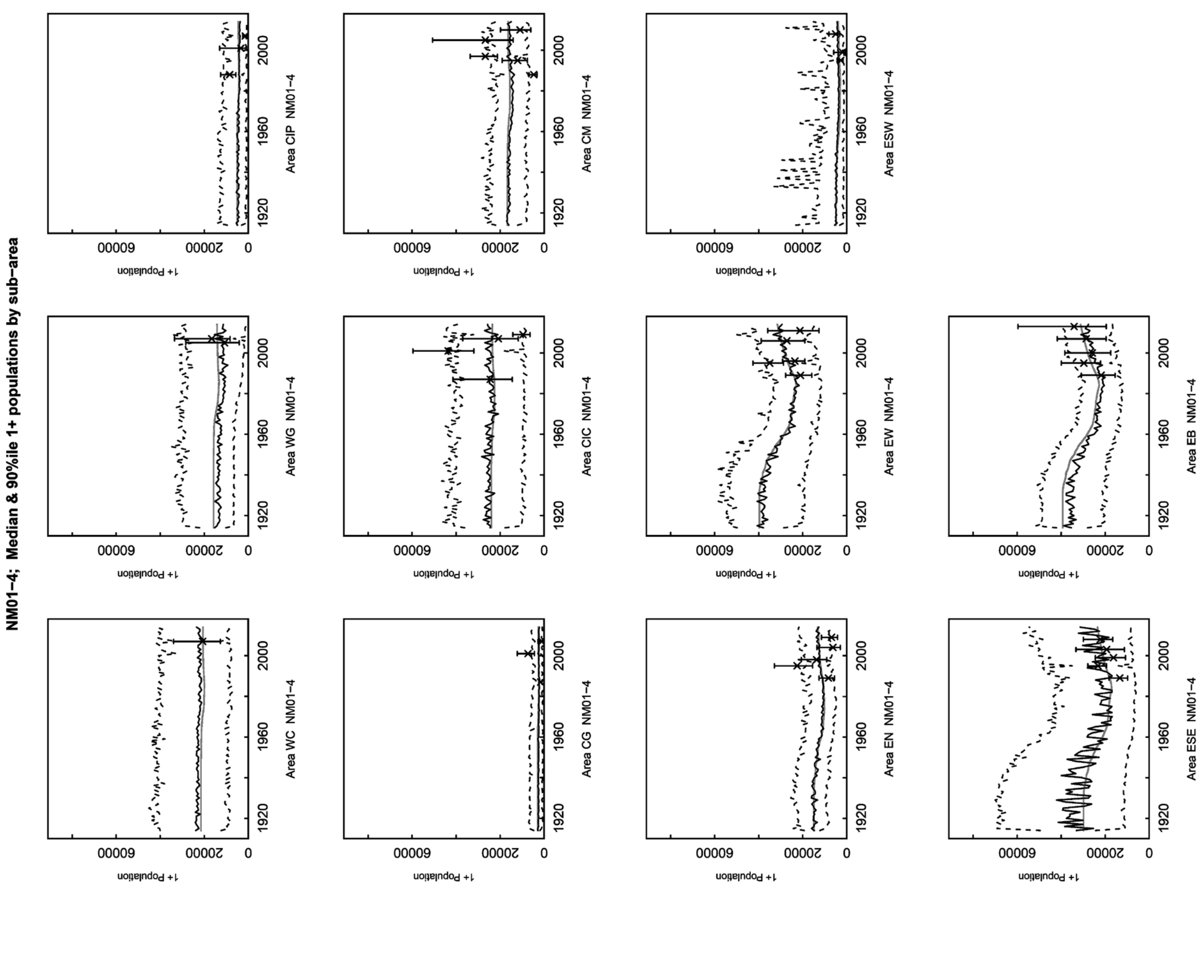

NM01–1; Median & 90%ile 1+ populations by sub-area
Area WC NM01–1
Area WG NM01–1
Area CIP NM01–1
Area CG NM01–1
Area CIC NM01–1
Area CM NM01–1
Area EN NM01–1
Area EW NM01–1
Area ESW NM01–1
Area ESE NM01–1
Area EB NM01–1
1+ Population
1920
1960
2000

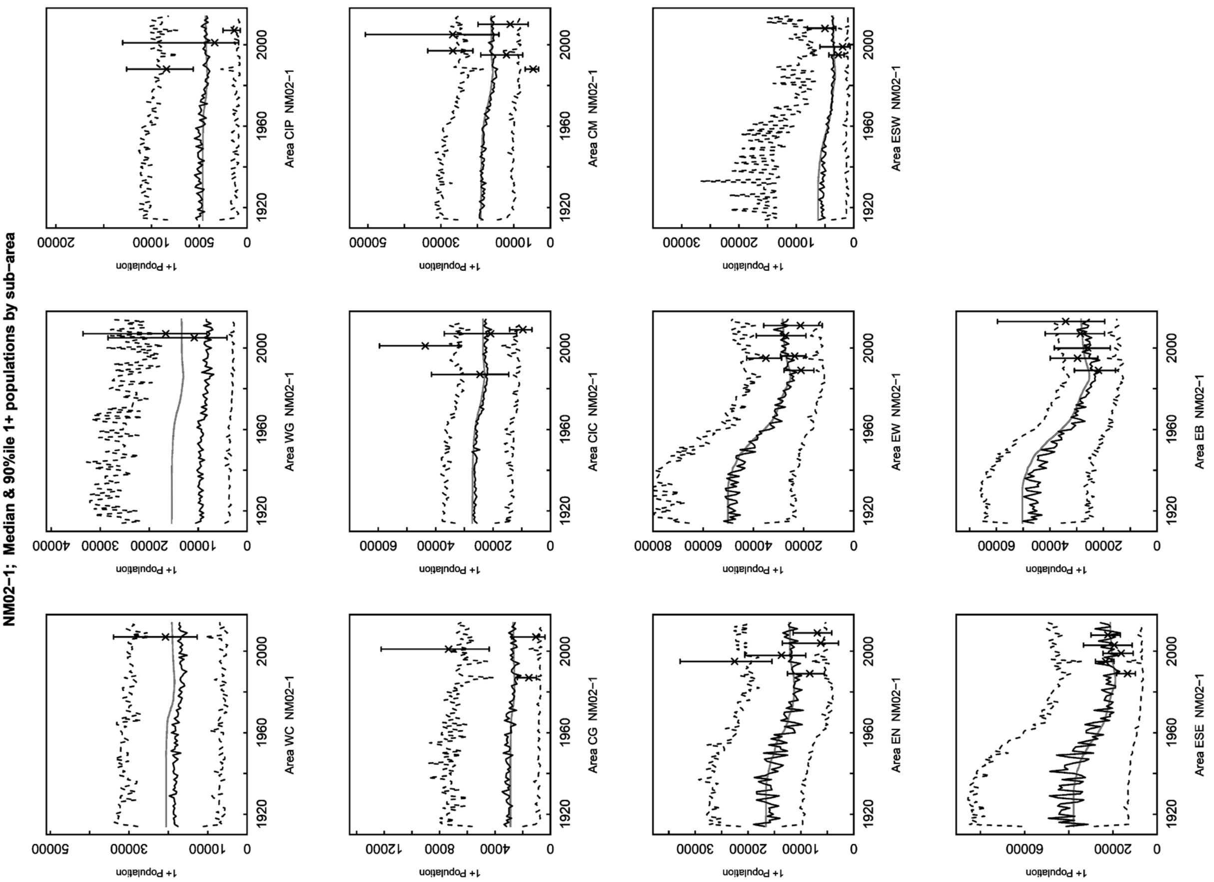

NM01–1; Median & 90%ile 1+ populations by sub-area
Area WC NM01–1
Area WG NM01–1
Area CIP NM01–1
Area CG NM01–1
Area CIC NM01–1
Area CM NM01–1
Area EN NM01–1
Area EW NM01–1
Area ESW NM01–1
Area ESE NM01–1
Area EB NM01–1
1+ Population
1920
1960
2000

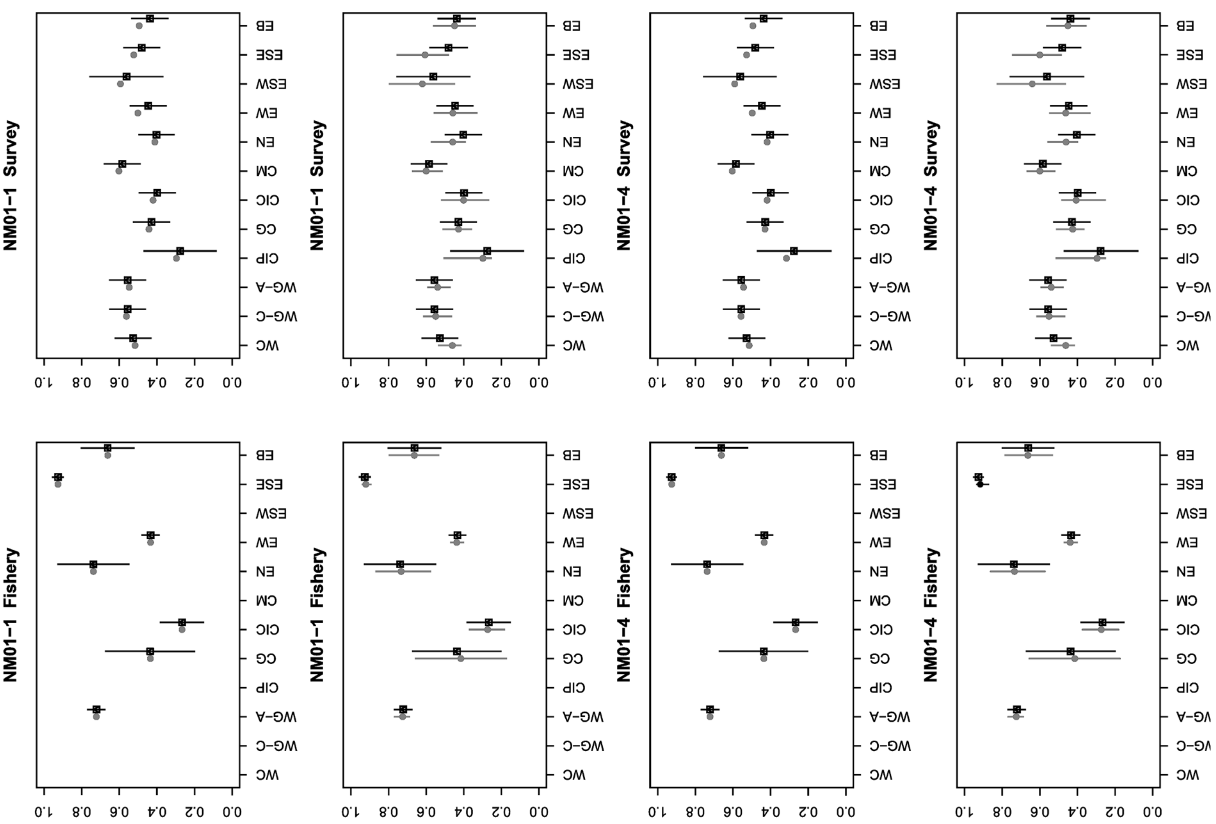

NM01–4: Median & 90%ile 1+ populations by sub-area
Area WC NM01–4
Area WG NM01–4
Area CIP NM01–4
Area CG NM01–4
Area CIC NM01–4
Area CM NM01–4
Area EN NM01–4
Area EW NM01–4
Area ESW NM01–4
Area ESE NM01–4
Area EB NM01–4
1+ Population

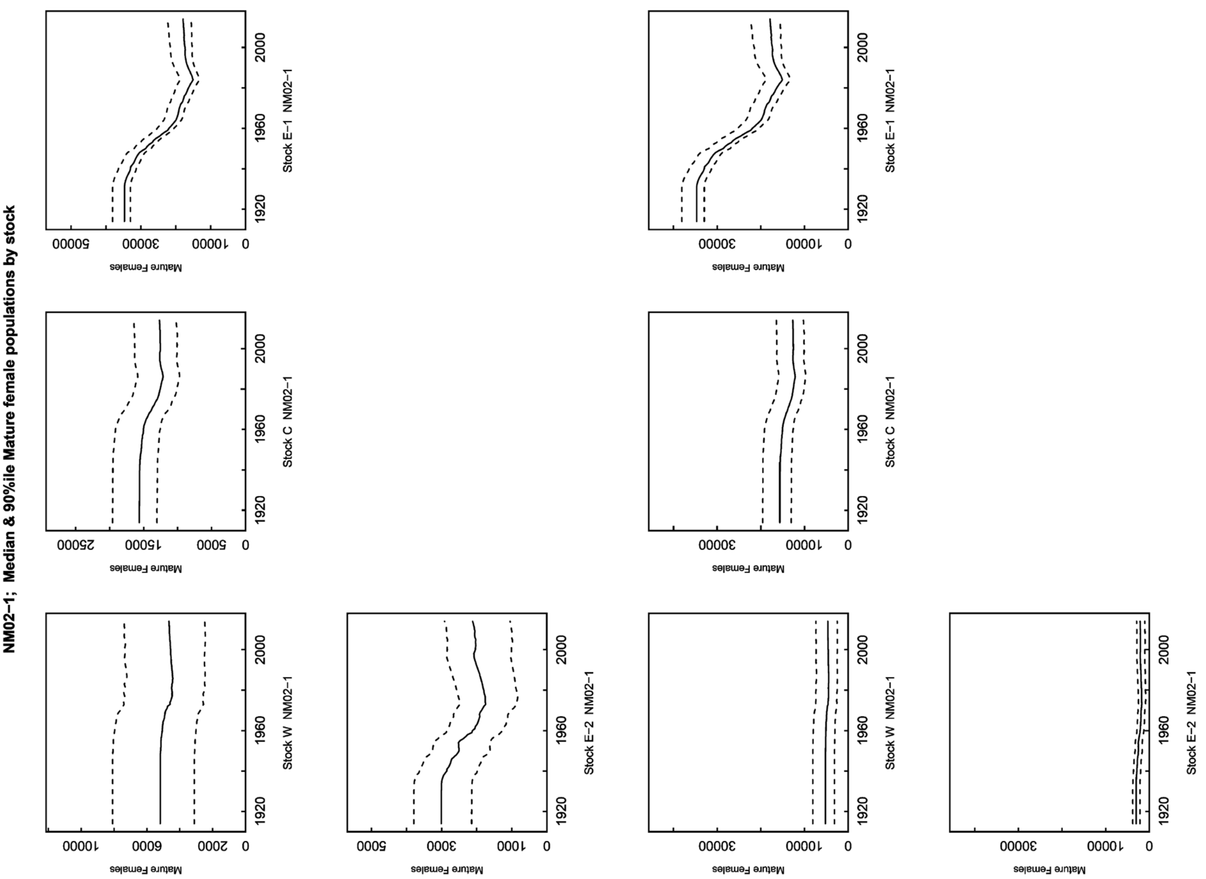

NM01–1; Median & 90%ile Mature female populations by stock
Stock W–1 NM01–1
Stock W–2 NM01–1
Stock C NM01–1
Stock E–1 NM01–1
Stock E–2 NM01–1
Mature Females

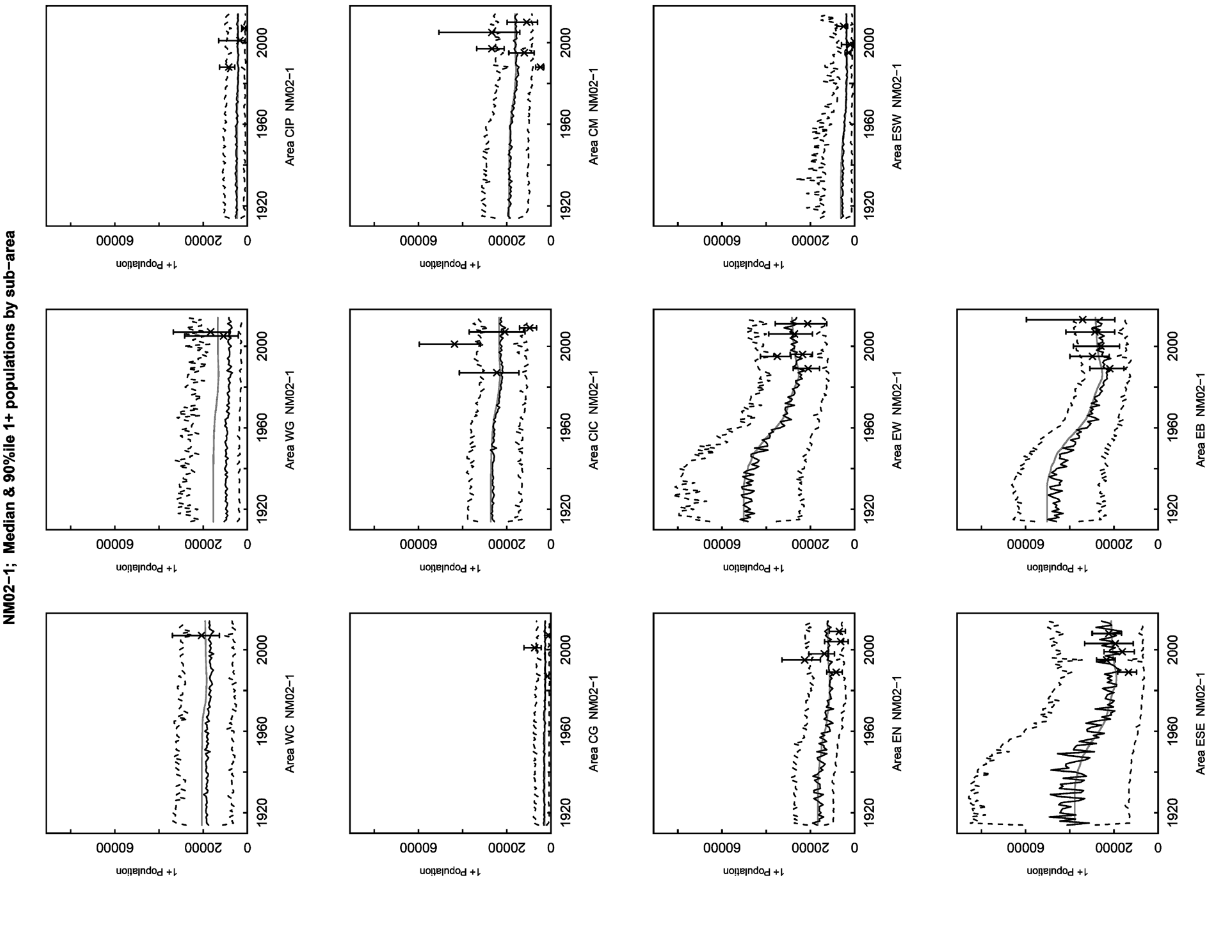

NM01–4; Median & 90%ile Mature female populations by stock
Mature Females
Stock C NM01–4
Stock W–1 NM01–4
Stock W–2 NM01–4
Stock E–1 NM01–4
Stock E–2 NM01–4

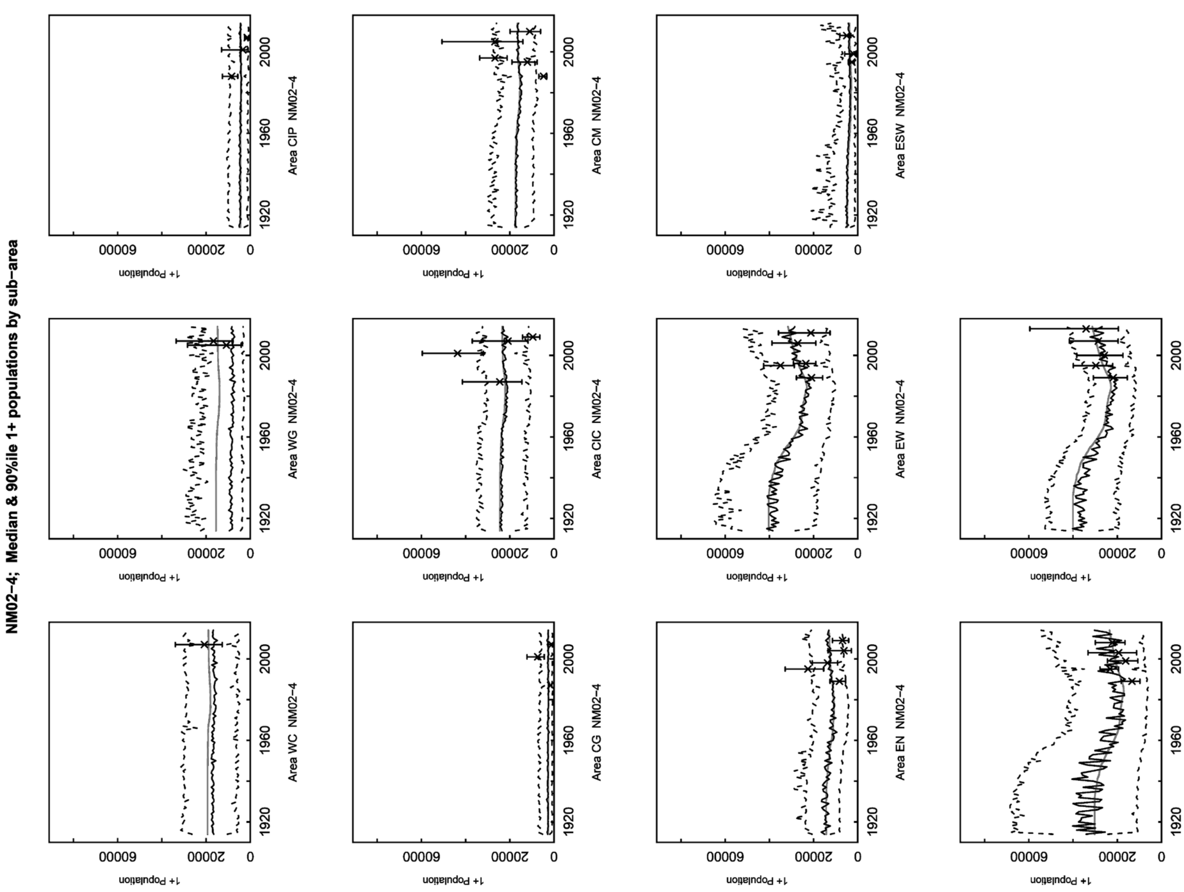

NM01–4; Median & 90%ile 1+ populations by sub-area
1+ Population
Area WC NM01–4
Area WG NM01–4
Area CIP NM01–4
Area CG NM01–4
Area CIC NM01–4
Area CM NM01–4
Area EN NM01–4
Area EW NM01–4
Area ESW NM01–4
Area ESE NM01–4
Area EB NM01–4

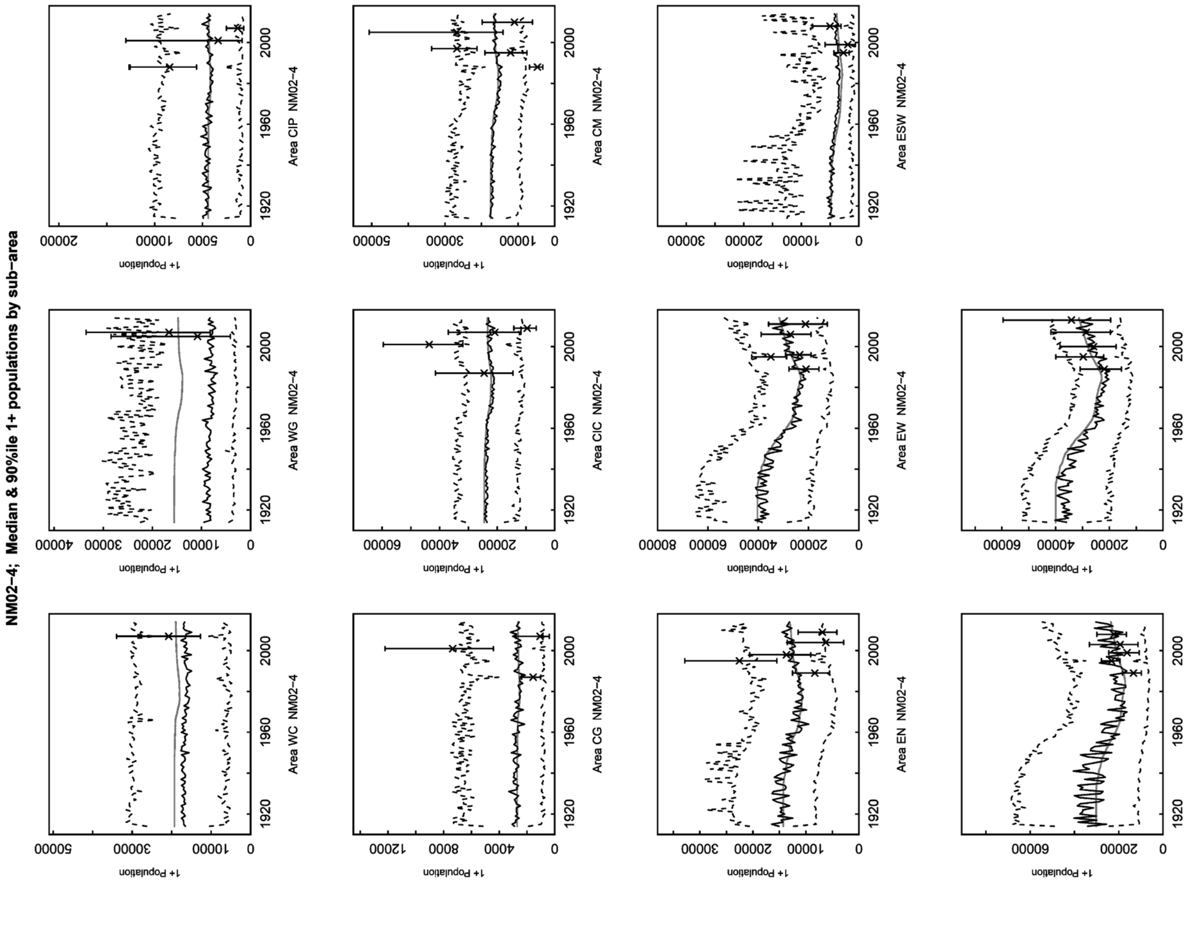

NM02–1; Median & 90%ile 1+ populations by sub-area
Area WC NM02–1
Area WG NM02–1
Area CIP NM02–1
Area CG NM02–1
Area CIC NM02–1
Area CM NM02–1
Area EN NM02–1
Area EW NM02–1
Area ESW NM02–1
Area ESE NM02–1
Area EB NM02–1
1+ Population

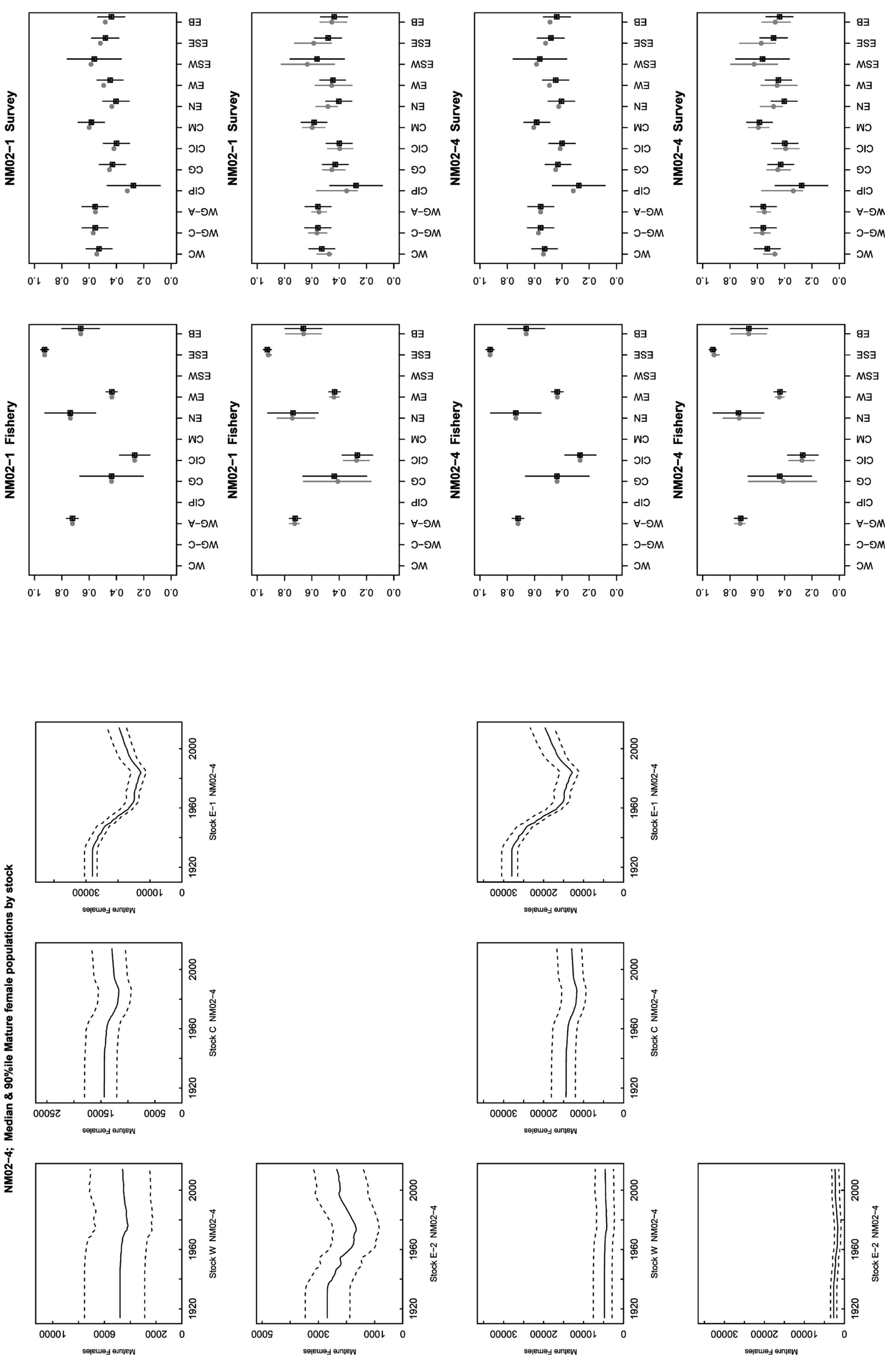

NM01–1 Fishery
NM01–1 Survey
NM01–1 Fishery
NM01–1 Survey
NM01–4 Fishery
NM01–4 Survey
NM01–4 Fishery
NM01–4 Survey
WC
WG-C
WG-A
CIP
CG
CIC
CM
EN
EW
ESW
ESE
EB


NM02–1; Median & 90%ile Mature female populations by stock
Stock W NM02–1
Stock C NM02–1
Stock E–1 NM02–1
Stock E–2 NM02–1
Stock W NM02–1
Stock C NM02–1
Stock E–1 NM02–1
Stock E–2 NM02–1
Mature Females


NM02–1; Median & 90%ile 1+ populations by sub-area
Area WC NM02–1
Area WG NM02–1
Area CIP NM02–1
Area CG NM02–1
Area CIC NM02–1
Area CM NM02–1
Area EN NM02–1
Area EW NM02–1
Area ESW NM02–1
Area ESE NM02–1
Area EB NM02–1
1+ Population


NM02-4; Median & 90%ile 1+ populations by sub-area
Area WC NM02-4
Area WG NM02-4
Area CIP NM02-4
Area CG NM02-4
Area CIC NM02-4
Area CM NM02-4
Area EN NM02-4
Area EW NM02-4
Area ESW NM02-4
Area ESE NM02-4
Area EB NM02-4
1+ Population


NM02-4; Median & 90%ile 1+ populations by sub-area
Area WC NM02-4
Area WG NM02-4
Area CIP NM02-4
Area CG NM02-4
Area CIC NM02-4
Area CM NM02-4
Area EN NM02-4
Area EW NM02-4
Area ESW NM02-4
Area ESE NM02-4
Area EB NM02-4
1+ Population


NM02–1 Survey
NM02–1 Fishery
NM02–4 Survey
NM02–4 Fishery
WC
WG–C
WG–A
CIP
CG
CIC
CM
EN
EW
ESW
ESE
EB
NM02–4; Median & 90%ile Mature female populations by stock
Mature Females
Stock W NM02–4
Stock C NM02–4
Stock E–1 NM02–4
Stock E–2 NM02–4

Appendix 6

LIST OF ACCEPTED ABUNDANCE ESTIMATES

List of accepted abundance estimates used in the RMP context for: (i) North Atlantic fin whales; (ii) North Atlantic minke whales; (iii) western North Pacific minke whales; and (iv) North Pacific Bryde's whales. The abundance estimates are provided not for populations but the sub-areas given consideration of existing multiple stock structure hypotheses.

Abbreviations used

Category

(1) Acceptable for use in in-depth assessments or for providing management advice;
(2) underestimate - suitable for 'conservative' management but not reflective of general abundance; or
(3) while not acceptable for use in (1), adequate to provide a general indication of abundance.

Evaluation extent

'1': the estimate was examined in detail by the sub-group;
'C' and 'C_{min}': used in the conditioning as an absolute and minimum abundance, respectively; and
'T': used in the trials but further analysis needs to be considered before use in an actual *CLA* calculation.

Status

'I' agreed to be suitable for use in a real *Implementation*;
'C' and 'C_{min}': used in the conditioning as an absolute and minimum abundance, respectively;
'CP': provisional estimate suitable for use in conditioning but further analysis needs to be considered before use in an actual *CLA* calculation; and
'T': used in the trials but further analysis needs to be considered before use in an actual *CLA* calculation.

Method

'DS' distance-sampling;
'MR' mark-recapture;
'SM' spatial modelling; and
'PA' population assessment, 1+.

Corrected

Indicates if corrected for availability (A) and/or perception (P) bias.

Table 1a

North Atlantic minke whales.

Sub-area	Cat.	Eval. ext.	Status	Year	Method	Correctn	Estimate	CV	Approx. 95% CI	Reference	Note
EB	1	1	CI	1989	DS	A+P	21,868	0.21	14,600-32,700	Bøthun and Øien (2011); IWC (2011, p.95)	
EB	1	1	CI	1995	DS	A+P	29,712	0.18	20,800-42,400	Bøthun and Øien (2011); IWC (2011, p.95)	
EB	1	1	CI	2000	DS	A+P	25,885	0.24	16,200-41,500	Bøthun and Øien (2011); IWC (2011, p.95)	
EB	1	1	CI	2007	DS	A+P	28,625	0.23	18,100-45,300	Bøthun and Øien (2011); IWC (2011, p.95)	a
EB	1	1	CI	2013	DS	A+P	34,125	0.34	17,500-66,400	SC/66a/RMP08	
EN	1	1	CI	1989	DS	A+P	8,318	0.25	5,100-13,700	Bøthun and Øien (2011); IWC (2011, p.95)	
EN	1	1	CI	1995	DS	A+P	22,536	0.23	14,300-35,600	Bøthun and Øien (2011); IWC (2011, p.95)	
EN	1	1	CI	1998	DS	A+P	13,673	0.25	8,300-22,500	Bøthun and Øien (2011); IWC (2011, p.95)	
EN	1	1	CI	2004	DS	A+P	6,246	0.47	2,500-15,600	Bøthun and Øien (2011); IWC (2011, p.95)	a
EN	1	1	CI	2009	DS	A+P	6,891	0.31	3,800-12,700	SC/66a/RMP08	
ES	1	1	CI	1989	DS	A+P	13,070	0.13	10,100-16,900	Bøthun and Øien (2011); IWC (2011, p.95)	
ES	1	1	CI	1995	DS	A+P	24,891	0.10	20,600-30,000	Bøthun and Øien (2011); IWC (2011, p.95)	
ES	1	1	CI	1999	DS	A+P	17,406	0.14	13,200-22,900	Bøthun and Øien (2011); IWC (2011, p.95)	
ES	1	1	CI	2003	DS	A+P	19,377	0.28	11,300-33,200	Bøthun and Øien (2011); IWC (2011, p.95)	a
ES	1	1	CI	2008	DS	A+P	27,390	0.29	15,500-48,400	SC/66a/RMP08	
EW	1	1	CI	1989	DS	A+P	20,991	0.17	15,100-29,200	Bøthun and Øien (2011); IWC (2011, p.95)	
EW	1	1	CI	1995	DS	A+P	34,986	0.12	27,900-43,900	Bøthun and Øien (2011); IWC (2011, p.95)	
EW	1	1	CI	1996	DS	A+P	23,522	0.13	18,300-30,200	Bøthun and Øien (2011); IWC (2011, p.95)	
EW	1	1	CI	2006	DS	A+P	27,152	0.218	17,700-41,600	Bøthun *et al.* (2009); Bøthun and Øien (2011); IWC (2011, p.95)	
EW	1	1	CI	2011	DS	A+P	21,218	0.320	11,300-39,700	SC/66a/RMP08	
CM	1	1	CI	1988	DS	-	4,732	0.23	3,000-7,400	IWC (2009, p.135)	b
CM	2	1	-	1995	DS	-	[6,174]	0.36	-	Bøthun and Øien (2011) and IWC (2009, p.135) from Schweder *et al.* (1997)	c
CM	1	1	CI	1995	DS	-	12,043	0.28	7,000-20,800	IWC (2009, p.135) from Borchers *et al.* (1998)	d
CM	1	1	CI	1997	DS	A+P	26,718	0.14	20,300-35,200	Bøthun and Øien (2011); IWC (2009, p.135) from Skaug *et al.* (2004)	

Cont.

Sub-area	Cat.	Eval. ext.	Status	Year	Method	Correctn	Estimate	CV	Approx. 95% CI	Reference	Note
CM	1	1	CI	2005	DS	A+P	26,739	0.39	12,500-57,400	Bøthun and Øien (2011); Bøthun *et al.* (2009)	e
CM	3		CI	2010	DS	A+P	10,991	0.36	5,400-22,300	SC/66a/RMP08	
CIC	1	1	CI	1987	DS	A+P	24,532	0.32	13,000-46,300	IWC (2009, p.135); Bøthun *et al.* (2009)	
CIC	2		-	1995	DS	A+P				Not estimated. Borchers *et al.* (1997)	
CIC	1	1	CI	2001	DS	A+P	43,633	0.19	30,100-63,300	IWC (2009, p.135); Borchers *et al.* (2009)	
CIC	1	1	CI	2007	DS	A+P	20,834	0.35	10,500-41,400	IWC (2015, pp.117-19); Pike *et al.* (2011)	f
CIC	1	1	CI	2009	DS	A+P	9,588	0.24	6,000-15,300	IWC (2015, pp.117-19); Pike *et al.* (2011)	
CIP	1	1	CI	1987-9	DS	-	8,431	0.245	5,200-13,600	IWC (1993, pp.66, 128-29)	g
CIP	1	1	CI	2001	DS	-	3,391	0.82	700-16,900	Gunnlaugsson *et al.* (2003)	g, h
CIP	1	1	CI	2007	DS	-	1,350	0.38	600-2,800	SC2009 (TNASS); IWC (2011, p.95)	
CG	1	1	CI	1987	DS	-	1,555	0.26	900-2,600	IWC (1993, p.66, pp.128-29)	g
CG+CIP	1	1	CI	1995	DS	-	4,854	0.27	2,900-8,200	Pike *et al.* (2003)	g
CG	1	1	CI	2001	DS	-	7,349	0.31	4,000-13,500	Gunnlaugsson *et al.* (2003) (blocks Bx and Wx)	g, h
CG	1	1	CI	2007	DS	-	1,048	0.60	300-3,400	SC2009 (TNASS), IWC (2011, p.95)	
WG	2	1	C_{min}	1987-8	DS	-	3,266	0.31	1,800-6,000	IWC (2009, p.135); IWC (1990, p.43)	j
WG	2	-	C_{min}	1993	DS	A	8,371	0.43	3,600-19,400	IWC (2009, p.135); Larsen (1995)	k, l
WG	2	-	C_{min}	2005	DS	A+P	10,792	0.59	3,600-32,400	IWC (2008, p.126); Heide-Jørgensen *et al.* (2008)	k
WG	2	-	C_{min}	2007	DS	A+P	16,609	0.428	7,200-38,500	IWC (2012, p.130); Heide-Jørgensen *et al.* (2010)	k, m
WC		-	C	2007	DS	A+P	20,741	0.30	11,500-37,300	Lawson and Gosselin (2009)	

(a) Bøthun and Øien (2011), recalculated the 1989 and 1995 estimates and associated CVs for the revised sub-areas; the CVs for the 2003-07 period were also recalculated using the same method and so are used here as they are comparable with those from earlier years. They differ from those in Bøthun *et al.* (2009) which were calculated using a simulation approach.
(b) Combination of estimates for 1987: 5,609, CV=0.26 (Øien, 2000) and 1988-89: 2,650, CV=0.48 (Schweder *et al.*, 1997, no NVS). See IWC (2009, p.135).
(c) No NVS. The 12,043 estimate had better areal coverage.
(d) Combined Norway and Iceland.
(e) This is an update to the estimate in IWC (2009, p.135) (24,890, CV=0.45).
(f) Replaces estimate that was agreed IWC (2009, p.135) (10,680, CV=0.29).
(g) Used as a minimum estimate: no $g(0)$ correction
(h) IWC (2009, p.135) shows a combined estimate for CG+CIP in 2001 as 23,592. This should be 10,740 (=3,391+7,349).
(j) Partial coverage of area.
(k) Known not to cover all of population.
(l) Reanalysed by Hedley *et al.* (1997): 6,385, CV=0.411 or 6,342, CV=0.35 in IWC (2009, p.135). Discrepancy unexplained.
(m) See IWC (2010, pp.138-39) for discussion of method (17,307 estimate was revised for publication).

References

Borchers, D., Pike, D., Gunnlaugsson, H. and Víkingsson, G. 2009. Minke whale abundance estimation from the NASS 1987 and 2001 aerial cue-counting surveys taking appropriate account of distance estimation errors. *NAAMCO Sci. Publ.* 7: 95-110.

Borchers, D.L., McCracken, M., Gunnlaugsson, T. and Burt, M.L. 1997. Estimates of minke whale abundance from the 1987 and 1995 NASS aerial surveys. Working paper SC/5/AE/2 for the NAMMCO Scientific Committee Working group on Abundance Estimates. [Available from: *www.nammco.no*].

Borchers, D.L., Øien, N., Gunnlaugsson, T. and Burt, M.L. 1998. Minke whale abundance in the NVS stratum of the CM Management Area from NASS95. Paper SC/50/RMP10 presented to the IWC Scientific Committee, April 1998 (unpublished). 9pp. [Paper available from the Office of this Journal].

Bøthun, G. and Øien, N. 2011. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 7. Estimates used for catch limit calculations in northeast Atlantic minke whales. *J. Cetacean Res. Manage. (Suppl.)* 12: 107-10.

Bøthun, G., Skaug, H.J. and Øien, N. 2009. Abundance of minke whales in the northeast Atlantic based on survey data collected over the period of 2002-2007. Paper SC/61/RMP2 presented to the IWC Scientific Committee, June 2009, Madeira, Portugal (unpublished) 13pp. [Paper available from the Office of this Journal].

Gunnlaugsson, T., Pike, D.G., Víkingsson, G.A., Desportes, G. and Mikkelson, B. 2003. An estimate of the abundance of minke whales (*Balaenoptera acutorostrata*) from the NASS-2001 shipboard survey. Paper originally submitted to NAMMCO as document NAMMCO/SC/11/AE/6. [Available from: *www.nammco.no*].

Hedley, S., Barner Neve, P. and Borchers, D.L. 1997. Abundance of minke whales off West Greenland, 1993. Paper SC/49/NA7 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 11pp. [Available from the Office of this Journal].

Heide-Jørgensen, M.P., Borchers, D.L., Witting, L., Laidre, K.L., Simon, M.J., Rosing-Asvid, A. and Pike, D.G. 2008. Estimates of large whale abundance in West Greenland waters from an aerial survey in 2005. *J. Cetacean Res. Manage.* 10(2): 119-30.

Heide-Jørgensen, M.P., Witting, L., Laidre, K.L., Hansen, R.G. and Rasmussen, M.H. 2010. Fully corrected estimates of minke whale abundance in West Greenland in 2007. *J. Cetacean Res. Manage.* 11(2): 75-82.

International Whaling Commission. 1990. Report of the Scientific Committee. *Rep. int. Whal. Commn* 40:39-79.

International Whaling Commission. 1993. Report of the Scientific Committee. *Rep. int. Whal. Commn.* 43:55-92.

International Whaling Commission. 2008. Report of the Scientific Committee. Annex E. Report of the Standing Working Group on the Development of an Aboriginal Subsistence Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 10:121-49.

International Whaling Commission. 2009. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure (RMP). *J. Cetacean Res. Manage. (Suppl.)* 11:91-144.

International Whaling Commission. 2010. Report of the Scientific Committee. Annex E. Report of the Standing Working Group on the Aboriginal Whaling Management Procedure. *J. Cetacean Res. Manage (Suppl.)* 11(2):135-53.

International Whaling Commission. 2011. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 12:89-116.

International Whaling Commission. 2012. Report of the Scientific Committee. Annex E. Report of the Standing Working Group on an Aboriginal Subsistence Whaling Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 13:130-53.

International Whaling Commission. 2015. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure (RMP). *J. Cetacean Res. Manage. (Suppl.)* 16:100-43.

Larsen, F. 1995. Abundance of minke and fin whales off West Greenland, 1993. *Rep. int. Whal. Commn.* 45: 365-70.

Lawson, J.W. and Gosselin, J.-F. 2009. Distribution and preliminary abundance estimates for cetaceans seen during Canada's Marine Megafauna Survey - a component of the 2007 TNASS. *Can. Sci. Advisory Sec. Res. Doc.* 2009/031: 33pp.

Øien, N. 2000. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 8. NASS-87 abundance of minke whales in the CM Management Area. *J. Cetacean Res. Manage. (Suppl.)* 2: 123-24.

Pike, D.G., Gunnlaugsson, T. and Víkingsson, G. 2011. Icelandic aerial survey 2009: survey report and a preliminary abundance estimate for minke whales (revised). Paper SC/18/AESP/15 presented to the NAMMCO Scientific Committee. 35pp. [Available from: *www.nammco.no*].

Pike, D.G., Gunnlaugsson, T. and Víkingsson, G.A. 2003. A reanalysis of minke whale (*Balaenoptera acutorostrata*) abundance from Icelandic NASS-95 shipboard data. Submitted to NAMMCO as SC/10/AE/6. [Available from: *www.nammco.no*].

Schweder, T., Skaug, H.J., Dimakos, X.K., Langaas, M. and Øien, N. 1997. Abundance of northeastern Atlantic minke whales, estimates for 1989 and 1995. *Rep. int. Whal. Commn.* 47: 453-84.

Skaug, H.J., Øien, N., Schweder, T. and Bothun, G. 2004. Abundance of minke whales (*Balaenoptera acutorostrata*) in the northeastern Atlantic; variability in time and space. *Can. J. Fish Aquat. Sci.* 61(6): 870-86.

Table 1b

North Pacific fin whales.

North Atlantic fin whale abundance estimates from shipboard surveys in 1988 (Buckland *et al.*, 1992a), 1995 (Borchers and Burt, 1997), 2001 (Pike *et al.*, 2003) and 2007 (Pike *et al.*, 2008) were discussed and summarised in Wade (2009) and IWC (2010).

Sub-area	Cat.	Eval. ext.	Status	Year	Method	Cor.	Estimate	CV	Approx. 95% CI	Reference	Notes
EC	-		-	1965-72	MR	-	10,818	0.36	5,340-21,900	IWC (1992a, p.600); Cooke (1992)	-
EC	-	-	C	2006	-	-	2,269	0.37	1,090-4,680	Wade (2009); IWC (2009, p.12); Waring *et al.* (2007)	S Gulf of Maine - upper Bay of Fundy - Gulf of St Lawrence. Not used in fin trials as only part of sub-area included.
EC	3	-	C	2007	-	-	10,105	0.4	4,610-22,130	Lawson (2006)	Lawson's estimate for Newfoundland waters is used. However NOAA reports list 3,522, CV=0.27 for this survey.
WG	-	-	C	1987/8	CC	-	1,096	0.35	560-2,130	IWC (1992a, p.606); IWC (1993, p.75)	Revised from IWC (1992b, p.70, p.200) and Hiby *et al.* (1989) to use revised blow rate estimate.
WG	1	1	C	2005	LT	P	3,234	0.44	1,400-7,400	Heide-Jørgensen *et al.* (2008); IWC (2008, p.125-26)	Revised from value of 3,218 CV=0.43 in Heide-Jørgensen *et al.* (2007). Potential -ve bias as no adjustment for availability bias.
WG	1	1	I,C	2007	LT	-	4,359	0.45	1,900-10,100	Heide-Jørgensen *et al.* (2010); IWC (2010, p.23)	Negatively biased (no correction for submerged whales). See IWC (2009, p.12) for status.
EG	1	1	I,C	1987-9	LT	-	5,269	0.221	3,410-8,120	Pike and Gunnlaugsson (2006); Buckland *et al.* (1992a); Wade (2009)	Weighted average of 1987 and 1989 B-West estimates + 1989 estimate for A-West.
EG	1	1	I,C	1995	LT	-	8,412	0.288	4,780-14,790	Pike and Gunnlaugsson (2006)	Sum of A-West (low coverage) and B-West.
EG	1	1	I,C	2001	LT	-	11,706	0.194	8,000-17,120	Pike and Gunnlaugsson (2006)	Sum of A-West and B-West.
EG	1	1	I,C	2007	LT	-	12,215	0.2	8,250-18,070	Pike *et al.* (2008)	-
WI	1	1	I,C	1988	LT	-	4,243	0.229	2,700-6,640	Pike and Gunnlaugsson (2006); Buckland *et al.* (1992a); Wade (2009)	Averaged value using 1987 and 1989 estimates.
WI	1	1	I,C	1995	LT	-	6,800	0.218	4,430-10,420	Pike and Gunnlaugsson (2006)	Sum of A-East (low coverage) and B-East.
WI	1	1	I,C	2001	LT	-	6,565	0.194	4,480-9,600	Pike and Gunnlaugsson (2006)	Sum of A-East and B-East.
WI	1	1	I,C	2007	LT	-	8,118	0.26	4,870-13,510	Pike *et al.* (2008)	-
EI/F	1	1	I,C	1987/8	LT	-	5,261	0.277	3,050-9,050	Christensen *et al.* (1992); Øien (1990); Pike and Gunnlaugsson (2006); Wade (2009)	Sum of blocks W of 0° (1987 and 1988 average), EGI and WN-SPB blocks.
EI/F	-	-	-	1989	-	-	-	-	-	Christensen *et al.* (1992)	Not used: survey did not go N of Iceland.
EI/F	1	1	I,C	1995	LT	-	6,647	0.288	3,770-11,680	Øien (2003); Pike and Gunnlaugsson (2006); Wade (2009)	Sum of EGI, WN-SPB, NVN and JMC blocks.
EI/F	1	1	I,C	2001	LT	-	7,490	0.255	4,540-12,340	Pike and Gunnlaugsson (2006); Wade (2009)	Sum of EGI and WN-SPB blocks. WN-SPB coverage went less far south than previously.
EI/F	1	1	I,C	2007	LT	-	1,613	0.26	960-2,680	Pike *et al.* (2008)	Not used in fin trials - see Feb 2015 Workshop report (SC/66a/Rep04).
N	-	-	-	1988	-	-	-	-	-	-	Estimates require further analysis.
N	-	-	C	1995	LT	-	3,964	0.21	2,620-5,980	Wade (2009)	Skaug based on Øien (2003).
N	-	-	C	1999	LT	-	3,749	0.24	2,340-6,000	Wade (2009)	Skaug based on Øien (2003).

Cont.

Sub-area	Cat.	Eval. ext.	Status	Year	Method	Cor.	Estimate	CV	Approx. 95% CI	Reference	Notes
Sp	-	-	-	1982	-	-	1,696	0.27	990-2,870	Mizroch and Sanpera (1984)	Not used in RMP trials as covered a smaller area than in 1989.
Sp	-	-	-	1987	-	-	4,617	0.098	3,800-5,600	IWC (1992a, p.600); Buckland *et al.* (1992b)	Revised from Sanpera and Jover (1989). Not used in RMP trials as covered a smaller area than in 1989.
Sp	-	-	C	1989	-	-	17,355	0.265	10,400-28,900	IWC (1992a, p.606); IWC (1993, p.67); Buckland *et al.* (1992b)	42-52°S, extending out to 25°W.
Sp	-	-	-	1993	-	-	7,507	0.15	5,600-10,100	Goujon *et al.* (1995)	Survey primarily for small cetaceans; not used in RMP trials as thought to cover a small area.
Med	-	-	-	1991	LT	-	3,583	0.27	2,100-6,000	Forcada *et al.* (1996); Notarbartolo di Sciara *et al.* (2003)	Estimate for the western basin portion of the Mediterranean, where most of the population is found.

References

Borchers, D.L. and Burt, M.L. 1997. Sei and fin whale abundance in the North Atlantic estimated from NASS-95 shipboard survey data. NAMMCO Scientific Committee Working Group Document SC/5/AE/1 (unpublished). [Available from *nammco-sec@nammco.no*].

Buckland, S.T., Cattanach, K.L. and Gunnlaugsson, T. 1992a. Fin whale abundance in the North Atlantic, estimated from Icelandic and Faroese NASS-87 and NASS-89 data. *Rep. int. Whal. Commn.* 42: 645-51.

Buckland, S.T., Cattanach, K.L. and Lens, S. 1992b. Fin whale abundance in the eastern North Atlantic, estimated from Spanish NASS-89 data. *Rep. int. Whal. Commn.* 42: 457-60.

Christensen, I., Haug, T. and Øien, N. 1992. Seasonal distribution, exploitation and present abundance of stocks of large baleen whales (Mysticeti) and sperm whales (*Physeter macrocephalus*) in Norwegian and adjacent waters. *ICES. J. Mar. Sci* 49(3): 341-55.

Cooke, J. 1992. Report of the Comprehensive Assessment Special Meeting on North Atlantic Fin Whales, Annex E. Matters concerning abundance and trends, E3: mark-recapture analyses. *Rep. int. Whal. Commn.* 42: 616.

Forcada, J., Aguilar, A., Hammond, P., Pastor, X. and Aguilar, R. 1996. Distribution and abundance of fin whales (*Balaenoptera physalus*) in the western Mediterranean sea during the summer. *J. Zool.* 238: 23-34.

Goujon, M., Forcada, J. and Desportes, G. 1995. Fin whale abundance in the eastern temperate North Atlantic for 1993. *Rep. int. Whal. Commn.* 45: 287-90.

Heide-Jørgensen, M.P., Borchers, D.L., Witting, L., Laidre, K.L., Simon, M.J., Rosing-Asvid, A. and Pike, D.G. 2007. Final estimates of large whale abundance in West Greenland waters from are areial survey in 2005. Paper SC/59/AWMP7 presented to the IWC Scientific Committee, Anchorage, Alaska, USA (unpublished). 28pp. [Paper available from the Office of this Journal].

Heide-Jørgensen, M.P., Borchers, D.L., Witting, L., Laidre, K.L., Simon, M.J., Rosing-Asvid, A. and Pike, D.G. 2008. Estimates of large whale abundance in West Greenland waters from an aerial survey in 2005. *J. Cetacean Res. Manage.* 10(2): 119-30.

Heide-Jørgensen, M.P., Laidre, K., Simon, M., Burt, M.L., Borchers, D.L. and Rasmussen, M.H. 2010. Abundance of fin whales in West Greenland in 2007. *J. Cetacean Res. Manage.* 11(2): 83-88.

Hiby, A.R., Ward, A. and Lovell, P. 1989. Analysis of the North Atlantic Sightings Survey 1987: aerial survey results. *Rep. int. Whal. Commn.* 39: 447-55.

International Whaling Commission. 1992a. Report of the Comprehensive Assessment Special Meeting on North Atlantic Fin Whales, Reykjavík, 25 February-1 March 1991. *Rep. int. Whal. Commn.* 42:595-644.

International Whaling Commission. 1992b. Report of the Scientific Committee. *Rep. int. Whal. Commn.* 42:51-86.

International Whaling Commission. 1993. Report of the Scientific Committee. *Rep. int. Whal. Commn.* 43:55-92.

International Whaling Commission. 2008. Report of the Scientific Committee. Annex E. Report of the Standing Working Group on the Development of an Aboriginal Subsistence Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 10:121-49.

International Whaling Commission. 2009. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 11:1-74.

International Whaling Commission. 2010. Report of the Scientific Committee. *J. Cetacean Res. Manage (Suppl.)* 11(2):1-98.

Lawson, J. 2006. Preliminary information on distribution and abundance of fin whales (*Balaenoptera physalus*) in Newfoundland and Labrador, Canada. Paper SC/M06/FW21 and SC/14/FW/21 presented to the joint IWC/NAMMCO workshop, 'Catch history, stock structure and abundance of North Atlantic fin whales', 23-26 March 2006, Reykjavik, Iceland (unpublished). 13pp. [Paper available from the Office of this Journal].

Mizroch, S.A. and Sanpera, C. 1984. A preliminary estimate of abundance of fin whales in Atlantic waters near Spain. *Rep. int. Whal. Commn.* 34: 395-97.

Notarbartolo di Sciara, G., Zanardelli, M., Jahoda, M., Panigada, S. and Airoldi, S. 2003. The fin whale, *Balaenoptera physalus* (L., 1758) in the Mediterranean Sea. *Mammal Rev.* 33(2): 105-50.

Øien, N. 1990. Sightings surveys in the northeast Atlantic in July 1988: distribution and abundance of cetaceans. *Rep. int. Whal. Commn.* 40: 499-511.

Øien, N. 2003. Distribution and abundance of large whales in the northeast Atlantic. Document SC/11/MF/10 presented to the NAMMCO Scientific Committee Working Group on North Atlantic Minke and Fin Whales, 20-22 November 2003, Copenhagen, Denmark. [Available from: *www.nammco.no*].

Pike, D. and Gunnlaugsson, T. 2006. Regional estimates of density and abundance of fin whales (*Balaenoptera physalus*) from Icelandic and Faroese North Atlantic sightings surveys. Paper SC/M06/FW18 and SC/14/FW/18 presented to the joint IWC/NAMMCO workshop, 'Catch history, stock structure and abundance of North Atlantic fin whales', 23-26 March 2006, Reykjavik, Iceland (unpublished). 12pp. [Paper available from the Office of this Journal].

Pike, D.G., Gunnlaugsson, T., Víkingsson, G.A., Desportes, G., Mikkelsen, B. and Bloch, D. 2003. Fin whale abundance in the North Atlantic, from Icelandic and Faroese NASS-2001 shipboard surveys: slightly revised estimates. Paper SC/10/AE/8 submitted to the NAMMCO Scientific Committee as SC/10/AE/8. [Available from *nammco-sec@nammco.no*].

Pike, D.G., Gunnlaugsson, T., Víkingsson, G.A. and Mikkelsen, B. 2008. Estimates of the abundance of fin whales (*Balaenoptera physalus*) from the T-NASS Icelandic and Faroese ship surveys conducted in 2007 (revised). Paper SC/60/PFI13 (revised) presented to the IWC Scientific Committee, June 2008, Santiago, Chile (unpublished). 16pp. [Paper available from the Office of this Journal].

Sanpera, C. and Jover, L. 1989. Density estimate of fin whales in the North Atlantic from NASS-87 Spanish cruise data. *Rep. int. Whal. Commn.* 39: 427-29.

Wade, P. 2009. Report of the First Intersessional RMP Workshop on North Atlantic Fin Whales, 31 March to 4 April 2008, Greenland Representation, Copenhagen. Annex H. Compilation and calculation of North Atlantic fin whale abundance by sub-area. *J. Cetacean Res. Manage. (Suppl.)* 11: 448-50.

Waring, G.T., Josephson, E., Fairfield-Walsh, C.P. and Maze-Foley, K. 2007. US Atlantic and Gulf of Mexico marine mammal stock assessments - 2007. *NOAA Technical Memorandum* NMFS-NE-194: 453pp. [Available at: *http://www.nefsc.noaa.gov/nefsc/publications/tm/tm194*].

Table 1c

Western North Pacific Bryde's whales.

Area	Category	Evaluatn extent	Status	Year (date stamp)	Range of years	Method	Correctn	Estimate	CV	Approx. 95% CI	Reference
1W	1	1	I, C	2000	1998-2002	LT	-	4,957	0.398	2,270-10,810	IWC (2009, pp.6-7); Kitakado *et al.* (2008); Shimada *et al.* (2008)
1E	1	1	I, C	1999	1998-2002	LT	-	11,213	0.498	4,220-29,750	As for 1W
2	1	1	I, C	2002	1998-2002	LT	-	4,331	0.553	1,460-12,800	As for 1W

References

International Whaling Commission. 2009. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 11:1-74.

Kitakado, T., Shimada, H., Okamura, H. and Miyashita, T. 2008. CLA abundance estimates for western North Pacific Bryde's whales and their associated CVs with taking the additional variance into account. Paper SC/60/PFI3 presented to the IWC Scientific Committee, June 2008, Santiago, Chile (unpublished). 27pp. [Paper available from the Office of this Journal].

Shimada, H., Okamura, H., Kitakado, T. and Miyashita, T. 2008. Abundance estimate of western North Pacific Bryde's whales for the estimation of additional variance and CLA application. Paper SC/60/PFI2 presented to the IWC Scientific Committee, June 2008, Santiago, Chile (unpublished). 34pp. [Paper available from the Office of this Journal].

Table 1d

Western North Pacific minke whales.

If not otherwise stated, the abundance estimates are given under the assumption of $g(0)=1$. Additional estimates are available but it was agreed they would not be used in the 2013 trials so they are not included here (for details see IWC (2012, p.422-23, 451-53).

Sub-area	Category	Evaluation extent	Year	Method	Corr-ected	Estimate and approx. 95% CI or equivalent	IWC reference	Original reference	Comments
Population: Western North Pacific									
6E	1	1	2003	DS	P	940 (470-1,840)	IWC (2014b)	Miyashita *et al.* (2009)	-
6E	1	1	2004	DS	P	730 (360-1,470)	IWC (2014b)	Miyashita *et al.* (2009)	-
10W	1	1	2006	DS	P	2,480 (1,360-4,500)	IWC (2014b)	Miyashita and Okamura (2011)	$g(0)$-corrected estimate 3,400 (2,600-4,400); Okamura *et al.* (2010)
10E	1	1	2002	DS	P	820 (250-2,640)	IWC (2014b)	Miyashita *et al.* (2009)	-
10E	1	1	2003	DS	P	410 (140-1,140)	IWC (2014b)	Miyashita *et al.* (2009)	-
10E	1	1	2005	DS	P	600 (260-1,370)	IWC (2014b)	IWC (2014a, p504-06)	-
7WR	1	1	2004	DS	P	860 (270-2,750)	IWC (2014b)	Hakamada and Kitakado (2010rev)	-
7E	1	1	2004	DS	P	440 (110-1,700)	IWC (2014b)	Hakamada and Kitakado (2010rev)	-
7E	1	1	2006	DS	P	250 (60-1,110)	IWC (2014b)	Hakamada and Kitakado (2010rev)	-
8	1	1	1990	DS	P	1,060 (300-3,680)	IWC (2014b)	IWC (2004, p.124); IWC (1997, p.203)	-
8	1	1	2002	DS	P	0	IWC (2014b)	Hakamada and Kitakado (2010rev)	-
8	1	1	2004	DS	P	1,090 (380-3,120)	IWC (2014b)	Hakamada and Kitakado (2010rev)	-
8	1	1	2006	DS	P	310 (90-1,030)	IWC (2014b)	Hakamada and Kitakado (2010rev)	-
9	1	1	1990	DS	P	8,300 (3,900-17,500)	IWC (2014b)	IWC (2004, p.124); IWC (1997, p.203, p.211).	-
9	1	1	2003	DS	P	2,550 (1,500-4,330)	IWC (2014b)	Hakamada and Kitakado (2010rev)	-
9N	1	1	2005	DS	P	420 (90-2,070)	IWC (2014b)	Miyashita and Okamura (2011)	$g(0)$-corrected estimate 2,080 (1,600-2,600) for SA 8+9+12, Okamura *et al.* (2010)
11	1	1	1990	DS	P	2,120 (920-4,910)	IWC (2014b)	IWC (2004, p.124); IWC (1997, p.203, p.211)	-
11	1	1	1999	DS	P	1,460 (520-4,090)	IWC (2014b)	IWC (2004, p.124); IWC (2003, p.470-72)	-
5	2	1 [C_{min} & T]	2001	DS	P	1,530 (590-4,020)	IWC (2014b)	An *et al.* (2010)	13% area coverage
5	2	1 [C_{min} & T]	2004	DS	P	800 (430-1,480)	IWC (2014b)	An *et al.* (2010)	13% area coverage
5	2	1 [C_{min} & T]	2008	DS	P	680 (340-1,380)	IWC (2014b)	An *et al.* (2010)	13% area coverage
5	2	1 [T]	2011	DS	P	590 (270-1,260)	IWC (2014b)	Park *et al.* (2012)	13% area coverage
6W	2	1 [C_{min} & T]	2000	DS	P	550 (250-1,210)	IWC (2014b)	An *et al.* (2010)	14% area coverage
6W	2	1 [C_{min} & T]	2002	DS	P	390 (130-1,180)	IWC (2014b)	An *et al.* (2010)	14% area coverage
6W	2	1 [C_{min} & T]	2003	DS	P	490 (250-930)	IWC (2014b)	An *et al.* (2010)	14% area coverage
6W	2	1 [C_{min} & T]	2005	DS	P	340 (180-620)	IWC (2014b)	An *et al.* (2010)	14% area coverage
6W	2	1 [C_{min} & T]	2006	DS	P	460 (180-1,190)	IWC (2014b)	An *et al.* (2010)	14% area coverage
6W	2	1 [C_{min} & T]	2007	DS	P	570 (250-1,300)	IWC (2014b)	An *et al.* (2010)	14% area coverage
6W	2	1 [C_{min} & T]	2009	DS	P	880 (510-1,530)	IWC (2014b)	An *et al.* (2010)	14% area coverage

Cont.

Sub-area	Category	Evaluation extent	Year	Method	Corr-ected	Estimate and approx. 95% CI or equivalent	IWC reference	Original reference	Comments
6W	2	1 [T]	2010	DS	P	1,010 (480-2,150)	IWC (2014b)	An *et al.* (2011)	14% area coverage
6E	2	1 [C&T]	2002	DS	P	890 (300-2,670)	IWC (2014b)	Miyashita *et al.* (2009)	Poor coverage and analysis difficulties
7CS	2	1 [T]	1991	DS	P	0	IWC (2014b)	Butterworth and Miyashita (2014)	-
7CS	2	1 [C&T]	2004	DS	P	500 (290-880)	IWC (2014b)	IWC (2014a, pp.492-96; pp.504-06)	-
7CS	2	1 [C&T]	2006	DS	P	3,700 (600-23,500)	IWC (2014b)	Hakamada and Kitakado (2010rev)	Non-random start
7CS	2	1 [T]	2012	DS	P	890 (420-1,870)	IWC (2014b)	Hakamada *et al.* (2013)	-
7CN	2	1 [T]	1991	DS	P	850 (550-1,330)	IWC (2014b)	Butterworth and Miyashita (2014)	-
7CN	2	1 [T]	2012	DS	P	300 (130-710)	IWC (2014b)	Hakamada *et al.* (2013)	-
7CN	2	1 [T]	2012	DS	P	400 (160-1,020)	IWC (2014b)	Hakamada *et al.* (2013)	-
7WR	2	1 [T]	1991	DS	P	310 (200-490)	IWC (2014b)	Butterworth and Miyashita (2014)	-
7WR	2	1 [C_{min}&T]	2003	DS	P	270 (80-920)	IWC (2014b)	IWC (2014a, pp.496-6; 504-6)	27% coverage
7WR	2	1 [C&T]	2007	DS	P	550 (110-2,640)	IWC (2014b)	Hakamada and Kitakado (2010rev)	Non-random start
7E	2	1 [C&T]	2007	DS	P	0	IWC (2014b)	Hakamada and Kitakado (2010rev)	Non-random start etc.
8	2	1 [C&T]	2005	DS	P	130 (24-710)	IWC (2014b)	Hakamada and Kitakado (2010rev)	Non-random start etc.
8	2	1 [C&T]	2007	DS	P	390 (80-2,030)	IWC (2014b)	Hakamada and Kitakado (2010rev)	Non-random start etc.
11	2	1 [C&T]	2003	DS	P	880 (220-3,600)	IWC (2014b)	Miyashita and Okamura (2011)	*g*(0)-corrected estimate 42,100 (32,700-54,200) in SA 11+12SW+12NE Okamura *et al.* (2010)
11	2	1 [C_{min}&T]	2007	DS	P	380 (180-790)	IWC (2014b)	Miyashita and Okamura (2011)	20% coverage. *g*(0)-corrected estimate 500 (250-1,000) in SA11. Okamura *et al.* (2010)
12SW	2	1 [C&T]	1990	DS	P	5,240 (1,300-21,000)	IWC (2014b)	IWC (2004, p.124)	-
12SW	2	1 [C&T]	2003	DS	P	3,400(1,570-7,350)	IWC (2014b)	Miyashita and Okamura (2011)	*g*(0)-corrected estimate 42,100 (32,700-54,200) in SA 11+12SW+12NE Okamura *et al.* (2010)
12NE	2	1 [C&T]	1990	DS	P	10,400 (5,200-20,800)	IWC (2014b)	IWC (2004, p.124)	-
12NE	2	1 [C&T]	1992	DS	P	11,500 (5,620-23,700)	IWC (2014b)	IWC (2004, p.124)	-
12NE	2	1 [T]	1999	DS	P	5,100 (2,500-10,400)	IWC (2014b)	IWC (2014a, pp.492-6, 504-6)	-
12NE	2	1 [C&T]	2003	DS	P	13,100 (7,500-22,700)	IWC (2014b)	Miyashita and Okamura (2011)	*g*(0)-corrected estimate 42,100 (32,700-54,200) in SA 11+12SW+12NE Okamura *et al.* (2010)
10E	3	1 [C]	2004	DS	P	470 (180-1,270)	IWC (2014b)	Miyashita *et al.* (2009)	Design questioned
10E	3	1 [C]	2007	DS	P	580 (310-1,070)	IWC (2014b)	Miyashita *et al.* (2009)	-
7CN	3	1 [C]	2003	DS	P	180 (50-740)	IWC (2014b)	Hakamada and Kitakado (2010rev)	Problem in coverage
7E	3	1	1990	DS	P	790 (70-8,620)	IWC (2014b)	IWC (2004, p.124)	CV too high to be meaningful

References

An, Y.-R., Choi, S.-G., Moon, D.-Y. and Park, K.-J. 2010. A review of abundance estimates of common minke whales using the sighting surveys conducted in subareas 5 and 6 by Korea from 2000 to 2009. Paper SC/62/NPM16rev presented to the IWC Scientific Committee, June 2010, Agadir, Morocco (unpublished). 5pp. [Paper available from the Office of this Journal].

An, Y.-R., Park, K.-Y., Choi, S.-G., Kim, H.-W. and Moon, D.-Y. 2011. Abundance estimation of western North Pacific minke whales using the Korean sighting survey in 2010. Paper SC/63/RMP28 presented to the IWC Scientific Committee, June 2011, Tromsø, Norway (unpublished). 4pp. [Paper available from the Office of this Journal].

Butterworth, D. and Miyashita, T. 2014. Report of the 'Second' Intersessional Workshop on the *Implementation Review* for western North Pacific Common Minke Whales, 19-23 March 2013, La Jolla, California, USA. Annex F. Derivation of revised estimate for sub-area 7 in 1991 and aero abundance estimates. *J. Cetacean Res. Manage. (Suppl.)* 15: 502-03.

Hakamada, T. and Kitakado, T. 2010. Summary of the information on dedicated sighting surveys for abundance estimation in JARPN and JARPN II. Paper SC/D10/NPM12rev presented to the First Intersessional Workshop for Western North Pacific Common Minke Whales, 14-17 December 2010, Pusan, Republic of Korea (unpublished). [Paper available from the Office of this Journal].

Hakamada, T., Matsuoka, K. and Miyashita, T. 2013. Abundance estimate of western North Pacific minke whales using JARPNII dedicated sighting survey data obtained in 2012. Paper SC/M13/NPM3rev presented to the IWC Scientific Committee Second Intersessional Workshop on the Implementation Review for Western North Pacific Common Minke Whales, 19-23 March 2013, La Jolla, California, USA (unpublished). 7pp. [Paper available from the Office of this Journal].

International Whaling Commission. 1997. Report of the Scientific Committee, Annex J. Report of the Working Group on North Pacific minke whale trials. *Rep. int. Whal. Commn.* 47:203-26.

International Whaling Commission. 2003. Report of the Scientific Committee. Report of the Workshop on north Pacific common minke whale. Annex C. Report of the small working group on abundance estimates for use in conditioning the *Implementation Simulation Trials*. *J. Cetacean Res. Manage. (Suppl.)* 5:470-72.

International Whaling Commission. 2004. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 10. North Pacific minke whale *Implementation Simulation Trial* specifications. *J. Cetacean Res. Manage. (Suppl.)* 6:118-29.

International Whaling Commission. 2012. Report of the first RMP intersessional workshop for western North Pacific common minke whales. *J. Cetacean Res. Manage. (Suppl.)* 13:411-60.

International Whaling Commission. 2014a. Report of the 'Second' Intersessional Workshop on the *Implementation Review* for western North Pacific Common Minke Whales, 19-23 March 2013, La Jolla, California, USA. *J. Cetacean Res. Manage. (Suppl.)* 15:489-506.

International Whaling Commission. 2014b. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 15:87-111.

Miyashita, T. and Okamura, H. 2011. Abundance estimates of common minke whales using the Japanese dedicated sighting survey data for RMP *Implementation* and CLA - Sea of Japan and Sea of Okhotsk. Paper SC/63/RMP11 presented to the IWC Scientific Committee, June 2011, Tromsø, Norway (unpublished). 34pp. [Paper available from the Office of this Journal].

Miyashita, T., Okamura, H. and Kitakado, T. 2009. Abundance of J-stock common minke whales in the Sea of Japan using the Japanese sighting data with $g(0)=1$. Paper SC/61/NPM7 presented to the IWC Scientific Committee, June 2009, Madeira, Portugal (unpublished). 10pp. [Paper available from the Office of this Journal].

Okamura, H., Miyashita, T. and Kitakado, T. 2010. $g(0)$ estimates for western North Pacific common minke whales. Paper SC/62/NPM9 presented to the IWC Scientific Committee, June 2010, Agadir, Morocco (unpublished). 7pp. [Paper available from the Office of this Journal].

Park, K.J., An, Y.R., Kim, H.W., Kim, D.N., Sohn, H.S. and An, D.H. 2012. Abundance estimation of common minke whales in the Yellow Sea using the Korean sighting data in 2011. Paper SC/64/NPM7 presented to the IWC Scientific Committee, June 2012, Panama City (unpublished). 4pp. [Paper available from the Office of this Journal].