Annex D

Report of the Sub-Committee on the Revised Management Procedure

Members: Bannister (Convenor), Allison, An, Baulch, Bjørge, Brandão, Brownell, Butterworth, Childerhouse, Chilvers, Cipriano, Collins, Cooke, Currey, De la Mare, De Moor, Diallo, Donovan, Double, Elvarsson, Fortuna, Funahashi, Goodman, Gunnlaugsson, Hakamada, Hammond, Hoelzel, Holloway, Iñíguez, Kanaji, Kanda, Kato, Kelly, Kim, H., Kishiro, Kitakado, Lang, Legorreta-Jaramillo, Marzari, Miyashita, Morishita, Murase, Nelson, Øien, Palacios, Palsbøll, Pampoulie, Park, J., Park, K., Pastene, Punt, Roel, Sakamoto, Santos, Simmonds, Skaug, Solvang, Víkingsson, Walløe, Williams, Witting, Yasokawa, Yoshida.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks
As Convenor, Bannister welcomed the participants.

1.2 Election of Chair and appointment of rapporteurs
Bannister was elected Chair. Punt acted as rapporteur.

1.3 Adoption of Agenda
The adopted Agenda is shown in Appendix 1.

1.4 Available documents
The documents considered by the sub-committee were SC/65a/RMP01-10, SC/65a/Rep05, SC/F13/SP06, SC/F13/SP17-19, SC/F13/SP20rev, and relevant extracts from past reports of the Committee.

2. REVISED MANAGEMENT PROCEDURE (RMP) – GENERAL ISSUES

2.1 Complete the MSY rates review
2.1.1 Report of the intersessional Workshop

Donovan introduced SC/65a/Rep05, the report of the fourth intersessional Workshop on the review of maximum sustainable yield rates (MSYR) in baleen whales. The Workshop was kindly hosted by the Southwest Fisheries Science Center in La Jolla, USA, from 26-28 March 2013.

Since 2007, the Committee has been discussing maximum sustainable yield rates (MSYR) in the context of a general reconsideration of the plausible range to be used in population models used for testing the *Catch Limit Algorithm* (*CLA*) of the RMP (IWC, 2008; 2009a; 2009b; 2010a; 2010b; 2010c; 2011a; 2011b; 2012a). The current range is 1% to 7%, in terms of the mature component of the population. At the 2012 Annual Meeting, the Committee had agreed that one more year be allocated for the MSYR review, but that if it could not be completed at the 2013 meeting, the current range of MSYR rates would be retained (IWC, 2013b; 2013c).

Donovan noted that the Workshop was primarily technical, and thus only a brief summary is provided here. Those interested in the details are referred to SC/65a/Rep05. He reported that the first part of the Workshop comprised a review of the present methods. In short, the approach agreed last year (IWC, 2013b) involves developing a posterior distribution for the quantity r_0/r_{max}, i.e. the ratio of the increase rate in the limit of zero population size to the maximum rate of increase of a whale stock which is demographically possible. Punt (2012) describes the model used to determine the extent of process error in r_0/r_{max} ('process error' is the variation in the true value for r_0/r_{max} caused by environmental variation). Considerably more detail is given in SC/65a/Rep05, including agreement to change the hyperpriors previously agreed such that they were in effect non-informative as was desired. The Workshop also received information on and endorsed intersessional refinements and additions: (1) to the population dynamics model used to calculate the extent of variation and temporal autocorrelation in the annual rate of increase; and (2) to update the software to allow for variation in natural mortality rather than fecundity.

The Workshop briefly reviewed the estimates of rates of increase to be used in the meta-analysis. These had been developed and refined over a number of years and are summarised in Table 1. Changes from previous agreements primarily centred around the need to limit the stocks included in the meta-analysis to those that had been depleted to 'low' levels (at least at the start of the data series) to approximate r_0 and to remove datasets that only referred to feeding aggregations given concerns about their relationship to the remainder of the stock.

The Workshop also agreed that following on from discussions in 2012 (IWC, 2013c), it would agree single estimates of demographic parameters for each species (Table 2). Table 3 summarises the input values for the reference case, where $\tilde{\sigma}_f$ and $\tilde{\rho}_f$ represent the standard deviation and temporal autocorrelation in fecundity (Brandon and Kitakado, 2011; Cooke, 2011).

Following on from discussions of Cooke (2011) last year, the Workshop focused on the question of correlation between variability in reproductive rates and in survival rates. It agreed that positive correlation between survival rate and reproduction was the most likely case, but agreed to include the cases of negative, zero and positive correlation in the meta-analysis as sensitivity checks, consistent with the view of the Scientific Committee (IWC, 2013c). Some potential additional work was specified to help determine the plausible range of variability in survival as summarised later. The Workshop agreed that if this was not successful, conclusions will continue to be based on sensitivity tests which assume that mortality and reproduction contribute in equal measure to the variation in the net recruitment rate.

The Workshop then discussed de la Mare (2013), which provided initial results from an individual-based model for a generic baleen whale population based on standard energetic relationships. It provided examples of relationships between the values of the annual births, which were subject to variation due to stochastic prey availability (as characterised here by $\tilde{\sigma}_f$), and additional deaths due to shortages of prey. Initial results also suggested a positive correlation between survival rate and birth-rate due to stochastic variability in prey abundance. In welcoming this new approach

Table 1

Estimates of rates of increase used as r_0 and the associated time periods over which they were estimated based upon the review provided in IWC (2010a) apart from for southern right whales which was based upon IWC (2013a). The main reference is given for each population but a fuller discussion of depletion and reliability can be found in the two reports. L=low; M=medium; H=high.

	Population level	Reliability of data	r_0 (%) (95% CI)	SE	Time period	Year span	References
Blue whale							
Central N Atlantic	L	H	9.0 (2.0, 17.0)	3.83	1987-2001	15	Pike *et al.* (2007)
Southern Hemisphere	L	H	8.2 (1.6, 14.8)	3.37	1978/79-2003/04	26	Branch (2007)
EN Pacific	L	H	3.2	1.4	1991-2005	16	Calambokidis *et al.* (2007)
Fin whale							
N Norway	L	H	5 (-13, 26)	9.95	1988-98	11	Víkingsson *et al.* (2007)
EN Pacific	L	H	4.8 (-1.6, 11.1)	3.24	1987-2003	15	Zerbini *et al.* (2006)
Humpback whale							
W Australia	L	H	10.1 (0.9, 19.3)	4.69	1982-94	13	Bannister and Hedley (2001)
E Australia	L	H	10.9 (10.5, 11.4)	0.23	1984-2007	24	Noad *et al.* (2008)
EN Pacific	L	H	6.4	0.9	1992-2003	12	Calambokidis and Barlow (2004)
Hawaii	L	H	10 (3-16)	3.32	1993-2000	18	Mizroch *et al.* (2004)
Bowhead whale							
B-C-B	M	H	3.9 (2.2, 5.5)	0.84	1978-2001	24	Zeh and Punt (2005)
Southern right whale							
SE Atlantic (S Africa)	L	H	6.8 (6.4, 7.2)	0.2	1979-2010	32	Brandão *et al.* (2011)
SW Atlantic (Argentina)	L	H	6.0 (5.5, 6.6)	0.28	1971-2010	40	Cooke *et al.* (2001)
SE Indian (Australia)	L	H	6.6 (3.8, 9.3)	1.40	1993-2010	18	Bannister (2011)

Table 2

Values of demographic parameters used to calculate r_{max} on a per-species basis. S is the annual adult survival rate, assumed to apply from age 1 and above; S_J is the survival rate for the first year of life which is assumed to equal S^2, a_{fp} is the age at first parturition, f is the highest fecundity considered possible, and r_{max} is the corresponding exponential growth rate in steady unexploited conditions.

	S	S_J	a_{fp}	f	r_{max}
Blue whale	0.98	0.96	5	0.5	0.114
Fin whale	0.98	0.96	5	0.5	0.114
Humpback whale	0.97	0.941	5	0.5	0.103
Bowhead whale	0.99	0.98	22	0.33	0.043
Southern right whale	0.99	0.98	8	0.33	0.076

the Workshop identified two approaches to using it to provide estimates that could be used in examining the effects on the meta-analysis arising from combined variability in births and deaths. This formed part of the proposed intersessional research discussed further below.

Given the absence of data to allow direct estimation of the extent of variability in survival, the Workshop **agreed** that analyses including such variability should be seen as providing robustness tests for the results of analyses taking account variability in reproduction alone.

The Workshop then considered estimates of the r_0/r_{max} distribution for the reference case based on the rate of increase data for the stocks in Table 3. The results are discussed fully in SC/65a/Rep05. They are not summarised here as these and the final analyses presented at the present meeting are discussed under Item 2.1.2 below and summarised in Table 4.

The Workshop considered a number of sensitivity analyses relating to:

(1) application of the environment model;
(2) data sets included in the meta-analysis;
(3) allowing for variation in natural mortality as well as fecundity; and
(4) higher and lower specifications for the values of r_{max}.

The results of the meta-analysis were generally insensitive to changing the assumptions upon which it is based, with a few exceptions (SC/65a/Rep05, fig. 3; Table 4). In particular, increasing the extent of variation and autocorrelation of fecundity leads to a posterior distribution for r_0/r_{max} which emphasises higher values for r_0/r_{max}. This is because higher environmental variation leads to higher overall variation (process and observation) for stocks with lower r_0/r_{max}. Consequently, the relative weight given to stocks for which the rate of increase is close to r_0 (especially the right whale stocks) becomes greater. The rates of increase for the right whale stocks are generally close to r_{max}).

The Workshop then focussed on the key matter of approaches to relate the r_0/r_{max} distribution to an appropriate MSYR range, the ultimate goal. The last discussion of this took place during the 2009 intersessional workshop on MSYR for baleen whales (IWC, 2010a), at which two views emerged. In the light of those discussions, and discussions at the Workshop, two proposals were put forward at the workshop: (1) $\text{MSYR}_{1+}=r_0/2$ (Butterworth and Best, 1990); $\text{MSYR}_{1+}= r_0/1.619$ as follows from the age-aggregated Pella-Tomlinson population model with MSYL=0.6K, which is used frequently in the Scientific Committee. However, the basis for these inferences was questioned on the grounds that they failed to take account of more recent work (Cooke, 2007; de la Mare, 2011) on the impacts on the shape of yield curves resulting from environmental stochasticity and predator-prey effects. As an interim approach, the Workshop had agreed to list results based on both assumptions and to revisit the matter at the Annual Meeting in the light of proposed intersessional work by Cooke (see below).

The Workshop agreed that while it had made considerable progress, it was not in a position to develop recommendations for the Scientific Committee on the appropriate range of MSYR rates. In the time available, the Workshop summarised the issues that must be explored more fully during the 2013 Scientific Committee meeting. In summary, these related to three major areas:

(1) the limitations of the modelling approach itself;
(2) the limitations within the approach (e.g. paucity of data); and
(3) the interpretation of the results in the context of the RMP.

Possible areas for further discussion at the Scientific Committee meeting included:

(a) the validity of the assumption that the distribution of r_0/r_{max} is independent of r_{max};
(b) the validity of extrapolating to species with a higher r_{max} than those included in the meta-analysis and how this should be done;
(c) the effect of the r_{max} constraint, uncertainty in r_0 and the variability in fecundity;
(d) sample size limitations;
(e) use within the RMP; and
(f) reference component of the population to which MSYR applies.

The Workshop finally noted four areas of work that, if able to be completed, would assist discussions at the 2013 Annual Meeting.

(1) Cooke agreed to explore further the plausible parameter space for the model in Cooke (2011), with a view to determining the plausible range of variability in survival.
(2) de la Mare agreed to investigate use of his individual based model (de la Mare, 2013) to examine the relationship between variability in reproduction and survivorship further.

Table 3

Summary of the values for the reference case to be used in the meta-analysis. The values in bold-underline typeface are taken from estimates pertain to the stock in question; other values are assigned from stocks of the same species listed in Table 2.

	r_0 (%) (SE)	Year-span	r_{max}	$\tilde{\sigma}_f$	$\tilde{\rho}_f$
Blue whale					
Central N Atlantic	9.0 (3.83)	15	0.114	0.380	-0.181
Southern Hemisphere	8.2 (3.37)	26	0.114	0.380	-0.181
EN Pacific	3.2 (1.4)	16	0.114	**0.380**	**-0.181**
Fin whale					
N Norway	5 (9.95)	11	0.114	0.765	0.636
EN Pacific	4.8 (3.24)	15	0.114	0.765	0.636
Humpback whale					
W Australia	10.1 (4.69)	13	0.103	0.135	0.320
E Australia	10.9 (0.23)	24	0.103	0.135	0.320
EN Pacific	6.4 (0.9)	12	0.103	**0.135**	**0.320**
Hawaii	10 (3.32)	18	0.103	0.135	0.320
Bowhead whale					
B-C-B	3.9 (0.84)	24	0.043	**0.995**	**0.065**
Southern right whale					
SE Atlantic (S African)	6.8 (0.2)	32	0.076	**0.042**	**0.169**
SW Atlantic (Argentinian)	6.0 (0.28)	40	0.076	**0.308**	**-0.074**
SE Indian (Australian)	6.6 (1.40)	18	0.076	0.042	0.169

Table 4

Outputs from the Bayesian meta-analysis.

Results are shown for the lower 5th and 10th percentiles of the posterior for r_0/r_{max}. For each percentile, results are shown are: (a) r_0/r_{max}, $r_0/r_{max}/2$; and (b) the product of r_{max} and $r_0/r_{max}/2$, for two choices for r_{max}. See SC/65a/Rep05 for the definitions of the sensitivity tests.

	Lower 5th percentile			Lower 10th percentage		
	r_0/r_{max}	$MSYR_{1+} \sim r_0/2$		r_0/r_{max}	$MSYR_{1+} \sim r_0/2$	
r_{max}		0.0426	0.114		0.0426	0.114
Reference	0.396	0.008	0.022	0.490	0.01	0.028
Case						
(a) Sensitivity tests to assumptions						
No environmental effects	0.386	0.008	0.022	0.481	0.010	0.027
common median $\tilde{\sigma}_f$ and $\tilde{\rho}_f$	0.395	0.008	0.022	0.488	0.010	0.028
75% $\tilde{\sigma}_f$ and $\tilde{\rho}_f$	0.431	0.009	0.024	0.524	0.011	0.03
95% $\tilde{\sigma}_f$ and $\tilde{\rho}_f$	0.621	0.013	0.035	0.688	0.015	0.039
No bowhead whale data	0.370	0.008	0.021	0.464	0.010	0.026
No fin whale data	0.412	0.009	0.023	0.506	0.011	0.029
Right whale data only	0.579	0.012	0.033	0.651	0.014	0.037
Independent *M* and *F*	0.414	0.009	0.024	0.508	0.011	0.029
Positive correlation *M* and *F*	0.391	0.008	0.022	0.485	0.010	0.028
Negative correlation *M* and *F**	0.406	0.009	0.023	0.500	0.011	0.028
Based on SC/65a/RMP09[&]	0.419	0.009	0.024	0.512	0.011	0.029
(b) Sensitivity to specifications for r_{max}						
20% higher fecundity	0.595	0.013	0.034	0.679	0.014	0.039
20% lower fecundity	0.335	0.007	0.019	0.42	0.009	0.024

*Ignoring the data for fin and bowhead whales because the populations do not persist given the assumed levels of variation of natural mortality and fecundity. [&]New sensitivity test for this meeting.

(3) Cooke agreed to examine the relationship between $MSYR_{1+}$ and $MSYR_{mat}$ in the context of variability in net recruitment.
(4) Punt agreed to conduct a meta-analysis of r_0 values.

The sub-committee thanked Donovan for chairing the intersessional Workshop and the participants for their work during the Workshop and subsequently, without which it would not have been possible to conclude the MSYR review at this meeting.

2.1.2 Progress on intersessional work

As noted above, the Workshop had identified a number of areas of work that would assist discussions at the present meeting. However, given the short time between the Workshop and the present meeting, it was not possible for Cooke to explore further the plausible parameter space using the model of Cooke (2011) or to examine the relationship between $MSYR_{1+}$ and $MSYR_{mat}$ given variability in net recruitment.

SC/65a/RMP09 presented results from the energetic model presented to the MSYR Workshop in SC/F13/MSYR2. The model was used to predict variability in the realised rate of increase (r_0) in a generic depleted whale population given estimates of the variability and autocorrelation in birth-rates. The variability in the model's realised rates of increase is subject to the variability in death rates because the model links deathrates to birth-rates through the energetic requirements of the animals. The results are provided in the form used in the meta-analysis of (MSYR) according to the methods described in Punt (2012). Variability in births and deaths in a population is modelled as a consequence of a variable food supply. The realised rates of increase depend both on the average amount of food available and its variability. A wide range of variations in the food supply was modelled so as to produce a range of variations in birth-rates, deathrates and r_0. The results of the simulations are used in a linear model to predict the variability in r_0 conditioned on given values of variability in birth-rate (σ_f) and its autocorrelation (ρ_f). The procedure for the calculations starts with setting a number of scenarios for the prey population and running a single realisation of the population model for 1,500 years to stabilise the composition of the population so that it is at carrying capacity (K) and adapted to each particular prey scenario. The population is then reduced to about 1% of K over a 50 year period with a constant harvest rate. This provides a starting point from which the population is allowed to recover from a low level, but only a 10 year period is used so that the results remain consistent with the recovery rate of the stock at low abundance. The numbers of animals alive in each year is used to calculate the rate of increase and its inter-annual variability. The recovery period is repeated 200 times thus giving a total simulated time series of 2,000 years.

The sub-committee thanked de la Mare for conducting these analyses. It noted that the individual-based population dynamics model will be reviewed by the EM group. In discussion, de la Mare noted that variability in demographic rates tended to lead to lower values of MSYL than the 0.6 conventionally assumed in the Scientific Committee.

The sub-committee observed that none of the model runs conducted in SC/65a/RMP09 led to estimates of MSYL that were 0.6 or larger. In addition, Cooke (2007) showed that MSYL was closer to 0.5 than to 0.6 based on simulations in the context of a model with environmental effects for a wide range of parameter values. The Workshop had identified two scenarios for consideration with respect to the relationship between $MSYR_{1+}$ and r_0: $MSYR_{1+}=r_0/2$ and $MSYR_{1+}=r_0/1.619$. The latter scenario corresponds to $MSYL_{1+}=0.6$. Given the results in SC/65a/RMP09 and in Cooke (2007), the sub-committee **agreed** that $MSYR_{1+}= r_0/2$ was more appropriate for drawing inferences regarding the range of MSY rates for use in trials.

A key component of the work over the period of the review had been directed at a meta-analysis of observed rates of increase at low population size. SC/65a/RMP08 provided the results of a final sensitivity test for the Bayesian hierarchical meta-analysis using the data for rates of increase for the 13 baleen whale stocks selected in SC/65a/Rep05. The extent of environmental variation in r_0 as a function of r_0/r_{max} in SC/65a/RMP08 was determined from Equation 2 in SC/65a/RMP09. The lower 5% and 10% points of the posterior predictive distribution for r_0/r_{max} for an unknown stock for this sensitivity test were 0.419 and 0.512 respectively. SC/65a/RMP02 constructed a posterior predictive distribution for an unknown stock for r_0 rather than r_0/r_{max}. The lower 5% and 10% points of this posterior predictive distribution were 0.029 and 0.037 respectively.

2.1.3 Discussion and recommendations

The sub-committee recognised the considerable additional work that had been undertaken since the current range for MSYR of 1% to 7% in terms of the mature component of the population was selected in 1993 (IWC, 1994). In particular, since 2007, the Committee had *inter alia:*

(1) assembled and evaluated information on rates of increase for stocks at low population size;
(2) explored some of the impacts of environmental effects on r_0 relative to r_{max} and the shape of the yield curve for exploited baleen whales; and
(3) developed a meta-analysis framework to integrate this information, along with information on demographics to derive a probability distribution for r_0 and r_0/r_{max}.

Given the available information and knowledge, the Workshop had explored the sensitivity of the distribution for r_0/r_{max} to a number of factors, including choices of stocks from amongst those for which suitable data were available and to the potential effects of environmental variation on rates of increase (see Table 4). The sub-committee recognised that while the meta-analysis was an important advance, it was inevitably limited for a number of unavoidable reasons and uncertainty over a number of factors including:

(1) the assumption that the distribution of r_0/r_{max} is independent of r_{max};
(2) the effect of the r_{max} constraint;
(3) uncertainty about environmental impacts on r_0;
(4) sample size considerations, including the dependence of the results on estimated rates of increase for well-studied right whale populations and the over-representation of populations recovering in regions where most other large whale populations are also depleted and/or where there are limited, if any, effects from forage fisheries; and
(5) the lack of stocks from species of current interest for the RMP (e.g. minke, sei or Bryde's whales) apart from two fin whale stocks, which hardly contributed to the results because of the high variance of their trend estimates - the analysis thus relied almost exclusively on data from bowhead, right, blue and humpback whales.

In conclusion, despite these uncertainties, the sub-committee **agreed** that it had a better basis to select the range for MSYR for use in trials than when the 1% to 7%

choice had been made in 1993. In deciding to complete the review this year it recognised that this did not mean that additional work should not continue and be periodically reviewed by the Committee, both in a general sense and as part of *Implementations* and *Implementation Reviews*.

Given its importance in terms of meeting conservation objectives, the sub-committee then focused on the lower bound for MSYR for use in trials, based on the assumption MSYR~r_0/2. A number of options was considered when examining the results of the meta-analysis relating to choice of percentile (5% or 10%), the value for r_{max}, and whether the meta-analysis should be based on r_0 or r_0/r_{max}. A broad consideration of the full set of sensitivity tests in SC/65a/Rep05, SC/65a/RMP02 and SC/65a/RMP08, suggests a range of 1% to 2.5% for the lower bound for MSY rate expressed in terms of the age 1+ component of the population (during the RMP development process and to date, MSYR has been expressed in terms of the mature component of the population; the AWMP development process by contrast expresses MSYR in terms of the 1+ component).

Recognising the uncertainties in the meta-analysis and the need for precaution, the sub-committee **recommended** that $MSYR_{1+}$=1% be adopted as a pragmatic and precautionary lower bound for use in trials. The value corresponds to the lower of the two percentiles in table 5 of SC/65a/Rep05, and the lowest of the r_{max} values; all of the point estimates of r_0 used in the meta-analysis correspond to $MSYR_{1+}$ values larger than 1% under $MSYR_{1+}$~r_0/2. In essence, $MSYR_{1+}$=1% is roughly the equivalent of 1.5% $MSYR_{mat}$. This recommendation has the additional practical advantage of unifying the MSYR 'currencies' of the RMP and AWMP processes.

In making this practical recommendation, the sub-committee **recognised** that much remains to be learned regarding MSYR for baleen whales and that the issue of the appropriate range for MSYR should continue to be reviewed as new information becomes available. In particular, should data become available for more species and populations, the meta-analysis should be revisited with a view to making it more representative. The sub-committee **emphasised** in particular the need for information relating to stocks of species of interest for the RMP, including fin, sei, Bryde's and minke whales (although of course information on MSYR is important in assessing the status of all species within the Committee's work). Work should also continue to better understand the impact of environmental variation on MSYR and the biological and ecological processes leading to density-dependence, together with the shape of yield curves and hence the relationship between r_0 and $MSYR_{1+}$. As is already the case, consideration of MSYR for particular species and stocks should also occur during *Implementations* and *Implementation Reviews,* particularly where other information for the stock or species concerned suggests alternative plausible values to those discussed above.

The sub-committee **recommended** that the '*Requirements and Guidelines for Implementations under the RMP*' (IWC, 2012c) be updated as follows.

'**2. FIRST INTERSESSIONAL WORKSHOP**

Under the list of 6 items under 'Workshop discussions will include the items listed below' add a new number (2) and renumber the subsequent items.

(2) A review of any information relating to MSYR for the particular species and/or *Region* that might cause trials to be developed for $MSYR_{1+}$ outside the general range of $MSYR_{1+}$ 1% to 4% agreed at the 2013 Annual Meeting of the Committee (IWC, 2014 when published). In considering this, the Workshop will take into account the discussions and limitations noted in IWC (2014, pp. will be inserted when known) when this range was agreed, the full text of which will be part of the information supplied to the Workshop."

The sub-committee thanked Brandon, Butterworth, Cooke, de la Mare, Donovan, Kitakado and Punt, as well as other participants of the many intersessional meetings without whom it would not have been possible to complete the MSYR review. Above all, the sub-committee would like to acknowledge the contribution and dedication of the field researchers, whose data, particularly on bowhead, blue, right and humpback whales, collected over periods of up to 40 years, formed the backbone of the meta-analysis and the MSYR review.

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

The Committee agreed in 2006 that two steps needed to be completed. The first of these was the review of MSY rates, which was completed this year (see Item 2.1) and the second was specification of additional trials for testing the *CLA* and amendments to it. The latter related to modelling the effects of possible environmental degradation in addition to, or possibly replacing, the trials in which *K*, perhaps with MSYR, varies over time. This is because the current changing *K* trials have questionable behaviour when modelling population sizes above *K*. Last year, the sub-committee re-established a working group under Allison (members: Allison, Butterworth, Cooke, Donovan, Punt, Walløe) to develop and run such trials for consideration at this year's meeting. However, Allison reported that there had been insufficient time during the intersessional period to conduct the work.

The sub-committee noted that the EM Working Group had identified a set of possible issues to be addressed using individual-based simulation and other models (see Annex K1, item 3). These issues could form the basis for additional trials to further explore the behaviour of the RMP. The sub-committee re-established the working group under Allison (members: Allison, Butterworth, Cooke, de la Mare, Donovan, Punt, Walløe) to formulate and run trials related to environmental degradation, taking account of the discussions in EM, and report the results to the 2014 Annual Meeting.

2.3 Evaluate the Norwegian proposal for amending the *CLA*

The sub-committee noted that evaluation of this proposal required: (a) completion of the MSYR review; (b) review of the trials conducted in Aldrin and Huseby (2007); and (c) review of additional trials which explore the performance of the RMP given environmental degradation. This year, the sub-committee completed the MSYR review (see Item 2.1), but did not complete the trials related to environmental degradation. In addition, the sub-committee did not have time to review Cooke *et al.* (2007). The sub-committee **agreed** that: (a) Aldrin and Huseby (2007) should be a primary document for SC/65b; and (b) it would not be necessary to have all of the trials related to environmental degradation completed before a decision on amending the *CLA* could be made given the time required to parameterise trials based on individual-based models. It also **agreed** that the *Implementation Review* for North Atlantic minke whales could take place even though a decision had yet to be made regarding the Norwegian proposal to amend the *CLA*.

2.4 Modify the 'CatchLimit' program to allow for variance-covariance matrices

Last year it was noted that the Norwegian 'CatchLimit' program allows variance-covariance matrices for the abundance estimates to be specified. Allison was tasked last year to work with the Norwegian Computing Center during the interessional period to develop a final version of the program for use in trials and for actual application of the *CLA*. Allison reported that the Norwegian version of the *CLA* was used in the trials for western North Pacific minke whales. Some coding issues remain with the Norwegian version of the program. The sub-committee **recommended** that Allison contact the Norwegian Computing Center to attempt to resolve those issues.

2.5 Update requirements and guidelines for conducting surveys and *Implementations*

The RMP's *'Requirements and Guidelines for Conducting Surveys'* (IWC, 2012b) were written when the only realistic paradigm for planning and analysing good sighting surveys was the design-based approach. However, there is now potentially a legitimate alternative to design-based estimates: model-based estimates using spatial modelling (smoothers), which, unlike design-based approaches, also give some basis for limited spatial extrapolation. In addition, many surveys closely resemble design-based surveys, but do not strictly meet the design-based criterion. Last year, the sub-committee recommended that a review covering model-based abundance estimation in theory and practice, and its relation to the design-based approach, be conducted. The review was to provide draft text for inclusion in the *'Requirements and Guidelines for Conducting Surveys'* document. Hedley was contracted to conduct the review, but was unable to complete it on time. The sub-committee looks forward to receiving the review at the 2014 Annual Meeting.

2.6 Update the list of accepted abundance estimates to include western North Pacific common minke whales

The sub-committee **recommended** that the list of accepted abundance estimates be updated using the values provided by the western North Pacific minke whale Working Group (see Annex D1, item 10). However, that working group had been unable to finalise the estimates of abundance; final decisions are to be made at next year's meeting.

2.7 Other business

A number of issues arose during the 'second' western North Pacific common minke whale *Implementation Review* workshop that were of general relevance to the RMP process and require the attention of the Scientific Committee and the sub-committee on the RMP, as follows.

Imbalanced sex ratio in incidental catches

The Workshop confirmed that the RMP specification 3.5, which reduces the catch limit in a *Small Area* to the extent required to ensure that the intended catch of females is not exceeded, was only applicable to the commercial catch for the present trials (IWC, 2012a). However, the generic issue of how to deal with imbalanced sex ratios in incidental catches under the RMP needs to be examined by the Committee. The sub-committee **agreed** to consider this matter at the 2014 Annual Meeting and **encouraged** papers on this topic.

Review of abundance estimates in an RMP context

To avoid difficulties faced in reviewing estimates in the future, the Workshop recommended that the Scientific Committee consider including in its Requirements and Guidelines for *Implementations* and *Implementation Reviews*, a specified set of associated information to be provided along with abundance estimates:

(1) plots showing survey transects (excluding transit legs) with primary sighting positions, together with survey block boundaries, sub-area boundaries, and those parts of the area surveyed that are included when calculating the abundance estimates; and
(2) a table summarising: the number of primary sightings made; the distance searched on primary effort; the size of the open-ocean area included in the survey design; the mean school size and the effective search half-width inputs, together with population estimates output on a block-by-block basis for these surveys.

The sub-committee **endorsed** this recommendation.

Changing survey coverage in time-series of abundance estimates

It is conceivable that proportional coverage might increase in some future surveys. The Workshop agreed that such circumstances would trigger an *Implementation Review*, as it would not be acceptable to input such estimates automatically into the RMP because they would give the *CLA* a false impression of resource productivity that was too large. The sub-committee **agreed** to consider this matter at the 2014 Annual Meeting and **encouraged** papers on this topic.

Use of surveys carried out in different months in the Implementation *process and in actual implementation of the RMP*

The Workshop agreed to include surveys that occurred in different months in simulated applications of the candidate RMP variants (this is conservative in that if a variant is acceptable with these surveys included, it would be acceptable had they been excluded, and the purpose of the trials is purely to determine whether or not different variants are acceptable). The Workshop emphasised that this decision did not imply that such survey results would be acceptable for input in an actual application of the RMP, and recommended that the generic aspects of this matter be discussed by the Scientific Committee. The sub-committee **agreed** to consider this matter at the 2014 Annual Meeting and **encouraged** papers on this topic.

2.8 Work plan

The sub-committee **agreed** that its work plan before the 2014 Annual Meeting would be as follows:

(1) specify and run additional trials for testing the *CLA* and amendments to it (Item 2.2); and
(2) review issues related to model-based methods for abundance estimation (Item 2.5).

The sub-committee **agreed** that its work plan during the 2014 Annual Meeting would be as follows:

(1) finalise the approach for evaluating proposed amendments to the *CLA* (Item 2.2);
(2) evaluate the Norwegian proposal for amending the RMP (Item 2.3);
(3) update the requirements and guidelines for conducting surveys to reflect considerations related to model-based methods for abundance estimation (Item 2.5);
(4) specify how to deal with imbalanced sex ratios in incidental catches under the RMP (Item 2.7);
(5) develop guidelines for handling situations in which survey coverage in time-series of abundance estimates changes over time (Item 2.7); and
(6) consider the use of surveys carried out in different months in the *Implementation* process and in actual implementation of the RMP (Item 2.7).

3. RMP – *IMPLEMENTATION*-RELATED MATTERS

3.1 North Atlantic fin whales

3.1.1 Implementation Review

Appendix 2 provides the report of the pre-meeting to initiate the *Implementation Review*. The sub-committee reviewed the report and **endorsed** its conclusions, recommendations, and work plan. It established an intersessional group convened by Elvarsson (Allison, Butterworth, Donovan, Elvarsson, Gunnlaugsson, Punt, and Witting) to develop revised specifications for the trials.

3.2 North Atlantic minke whales

3.2.1 Review new information

The sub-committee received five papers which had been either been presented to the Special Permit Review or were revised versions of papers which were presented to the Review.

SC/F13/SP17 was first presented to the IWC Scientific Committee in 2008 (Pampoulie *et al.*, 2008). It presents genetic analyses based on samples collected during the Special Permit programme (2003-07) and historical samples (1981-85) collected in Icelandic waters, as well as samples collected off Greenland, in the Norwegian coastal region, in the Barents Sea, in the North Sea and off Spitsbergen, to allow comparisons with other geographical areas and IWC stock boundaries. None of the analyses revealed any pattern of genetic structure among feeding grounds. SC/F13/SP17 also compared geographical regions by pooling samples because Andersen *et al.* (2003) reported genetic differentiation at microsatellite loci for samples collected in four geographical-ecological regions (Iceland, West Greenland, Norway and the North Sea). A hierarchical analysis of molecular variance was performed and no genetic differentiation could be found, which contradicted the results of Andersen *et al.* (2003). Although the results for nuclear DNA markers in SC/F13/SP17 suggested no genetic structure among feeding grounds, two groups of mtDNA haplotypes were detected, but there was no geographical pattern to the groups. These results might suggest the existence of two putative breeding populations on the feeding grounds.

SC/F13/SP20rev used samples presented in SC/F13/SP17 and samples from Norway (2002-04) to perform relatedness analyses. SC/F13/SP20rev demonstrated a high rate of relatedness across the North Atlantic using relatedness analysis based on the likelihood odds score (LOD) and false discovery rate (FDR) methods, suggesting a high dispersal rate, and confirming the conclusion in SC/F13/SP17. The FDR procedure was calibrated to detect most mother-foetus pairs (where relationships were known), while at the same time limiting the number of false-positive determinations (calling two individuals related when they are actually unrelated). Although the combination of several datasets (Norway and Iceland), and the development of relatedness analyses seemed to be promising, SC/F13/SP20rev also reported on the value of access to additional biological information (such as age data) to understand the type of relationship observed, and to correct for false positives. However, additional analyses are needed as only parent-offspring LOD scores have been computed in SC/F13/SP20rev. The half-sibling and first-cousin relationships will be investigated in the current year.

The sub-committee welcomed the information in SC/F13/SP17 and SC/F13/SP20rev. It should be useful for the upcoming *Implementation Review,* and, in particular, the work of the joint AWMP/RMP Working Group on stock structure chaired by Palsbøll.

SC/F13/SP19 is an extension of Christensen *et al.* (1990) using morphometric data from 2003-09. Results from principal component analyses, multivariate analyses of variance, linear discriminant analyses and cluster analyses, suggest that morphometric data from five North Atlantic geographical areas ranging from West Greenland to Norway cannot be regarded as random samples drawn from one uniform distribution. However, the overlap between groups was too substantial to allow a firm conclusion to be drawn concerning the question of isolated breeding stocks versus a large common breeding pool. The Review Panel made several recommendations for revisions to these analyses and suggestions for new analyses. While there has not been time to complete these yet, the authors aim to present a revised paper during the 2014 *Implementation Review*.

SC/F13/SP18 reported that experiments were conducted to instrument and track the movements of common minke whales on their feeding grounds in Icelandic waters during 2001-10. Most of these constituted a part of the Icelandic research programme on minke whales (SC/65a/SP01). These experiments have led to the monitoring of the movements of six whales, of which three moved out of Icelandic waters during autumn. The start of the autumn migration occured over at least a month, somewhat later than previously assumed. The southbound migration appears to take place in the middle of the North Atlantic far from coastal areas. Signals were received from one minke whale off the west coast of Africa in early December 2004, 101 days after tagging and 3,700km from the tagging site off southwest Iceland. This study provides the first documentation of the autumn migration route and destination of common minke whales in the North Atlantic. It is noteworthy that none of the nearly 400 positions from eight whales received was outside the North Atlantic Central stock area.

The sub-committee recognised the value of the satellite tracking of minke whales for the development of *Implementation Simulation Trials*. It reiterated the recommendations of the the Special Permit Review that such tagging should continue, as much information as possible should be collected from each tagged individual, and that the results from the various stock definition methods should be integrated. Víkingsson and Pampoulie noted that attempts are made, and will continue to be made, to take biopsies from tagged animals, and that work is already underway to integrate multiple sources of information to resolve stock structure questions (SC/65a/SD02).

The sub-committee **agreed** that data from satellite tracking could be used in *Implementation Simulation Trials* both qualitatively (e.g. identification of breeding grounds and broad migration patterns) as well as quantitatively (e.g. estimation of movement and dispersal rates). The sub-committee noted there would be benefits to identifying the analysis methods to apply to data from satellite-tagged animals to determine the minimum number of animals needed for meaningful quanitative estimates and the point at which tagging additional animals leads to minimal additional information. If such analyses methods are developed, they should be reviewed by the Stock Definition group.

SC/F13/SP06 noted that the main objective of the aerial survey component of the Research program was to obtain a seasonal profile of relative abundance in coastal Icelandic waters with off-season survey effort. Mid-summer surveys in this area have been used to obtain absolute abundance estimates. Observers have to concentrate on the area closest to the plane during mid-summer surveys, but in some cases observer detection functions did not confirm that, or there were too few duplicates with the independent observer. This could result in large differences in the estimated abundance by observer. The number of sightings can be very low in the off-season surveys, and fitting a detection function to these sightings is not an option. Therefore, the consistency of the left and right observers and consistency in repeated coverage of the same area was first checked. It was found that the number of minke whales sighted was fairly consistent between repeats and observers. The detections of the smallest whales are more variable by observer, and inversely related to sightings of large whales. Consequently, an encounter rate with covariates for sightability was used for estimating relative abundance. Sightings in April-May were very few, but sightings in the autumn are still at about half the level of mid-summer surveys. Surveying later in the season was not considered feasible, and it was anticipated that trackings would provide more valuable information then. Surveys conducted after the off-season surveys have shown much greater variability in the encounter rate of minke whales in different areas and in the area as a whole than the earlier surveys. These recent surveys show a northward shift in the distribution of both minke whales and dolphins. This is in line with observed changes in the area and in the condition of the animals sampled. As the Panel mentions, these data will be revisited when it comes to application of a multispecies model. The recommendation of the Panel 'to model the detection function' does not have a clear benefit, because applying a detection function from a mid-summer survey to a spring survey is in effect just a function of the encounter rate.

3.2.1.1 NEW SURVEYS

SC/65a/RMP10 presented Norway's plans to conduct a new series of annual partial surveys over the period 2014-19 to collect data for a new estimate of minke whale abundance in the northeast Atlantic to be in accordance with the RMP requirements for the provision of abundance estimates at regular intervals. The survey and analytical methods will follow the same procedures as used in the previous survey cycles.

The sub-committee noted that the upcoming *Implementation Review* could lead to changes to the definitions of the *Small Areas*. Øien noted that the boundaries of the original *Small Areas* changed as a result of the 2003 *Implementation Review*, and that the survey strata had been modified to be in accord with the revised *Small Area* boundaries. The sub-committee noted the desire to achieve agreement between survey and *Small Area* boundaries, but **agreed** that an approach has been applied which can address changes in *Small Area* boundaries.

3.2.2 Prepare for 2014 Implementation Review

The sub-committee was informed that the joint AWMP/RMP group chaired by Palsbøll is coordinating discussions and analyses related to using genetics to examine stock structure for the North Atlantic minke whales. The sub-committee reviewed the report of the group (Appendix 3) and **endorsed** its recommendations. It reiterated its recommendation from last year that the work plan for the group (Donovan *et al.*, 2013) be completed, and supported holding an intersessional Workshop to consider stock structure hypotheses for North Atlantic minke whales. The sub-committee received and **supported** a proposal to conduct analyses to support the deliberations of the intersessional Workshop (Appendix 4).

3.2.3 Recommendations

The sub-committee **recommended** that a Steering Group (Walløe [Convenor], Butterworth, Donovan, Palsbøll, Punt, Víkingsson and Witting) be established to co-ordinate planning for the 2014 *Implementation Review*. It **recommended** that a three day pre-meeting be held prior to the 2014 Annual Meeting to ensure that sufficient progress is made on the *Implementation Review*, noting that this *Implementation Review* could be more complicated than previous *Implementation Reviews* because the original *Implementation* was not conducted under the current *'Requirements and Guidelines for Implementations'*.

3.3 North Atlantic sei whales

The decision whether to initiate an implementation is made by the Commission. However, last year the sub-committee established an intersessional group (Víkingsson [Convenor], Hammond, Øien, Palka, Palsbøll, Donovan) with Terms of Reference to review the available data for North Atlantic sei whales in the context of a *pre-Implementation assessment* and provide a report to the 2013 Annual Meeting. Unfortunately, insufficient progress was made during the intersessional period to warrant starting the *pre-Implementation assessment* at this year's meeting. The sub-committee therefore **recommended** that the intersessional group be re-established and progress evaluated at the 2014 Annual Meeting.

3.4 Western North Pacific's Bryde's whales

3.4.1 Prepare for 2016 Implementation Review

Miyashita provided the sub-committee with an update on progress and plans for the 2016 *Implementation Review*. A sighting survey was conducted between 30°N-40°N, 130°E-170°E (a part of sub-area 1 for the western North Pacific Bryde's whales) during 2012. 132 primary sightings of Bryde's whales were recorded and 42 Bryde's whales were biopsied. A sighting survey will be conducted in sub-areas 7 and 8 for the western North Pacific minke whales in 2013, and sightings of Bryde's whales will be recorded and biopsies obtained. POWER cruises will take place in 30°N-40°N, 160°W-135°W in 2013 and in 30°N-40°N, 170°W-160°W in 2014. Sightings data will be collected during these surveys and attempts will be made to biopsy Bryde's whales. Thirty-four genetic samples of Bryde's whales were collected during JARPN II cruises in 2012 and additional genetic samples will be collected during the 2013 JARPN II cruises.

3.5 Work plan

The sub-committee **agreed** that its work plan before the 2014 Annual Meeting would be as follows.

(1) Determine the final trial specifications for the northern Atlantic fin whales including framework and developing new trials (Item 3.1).
(2) Condition and run all the North Atlantic fin whale trials specified by the Steering Group, including all remaining original trials as well as new trials using the Norwegian version of the *CLA* (Item 3.1).
(3) Hold an intersessional meeting with objectives to review the results of conditioning and trials for the North Atlantic fin whales specified by the Steering Group, to modify the trial specifications if necessary, and determine an intersessional work plan to ensure that the *Implementation Review* can be completed at the 2014 Annual Meeting. There will be costs involved for travel and subsistence, estimated at £4,000 (Item 3.1).
(4) Evaluate the extent of dispersal needed to achieve management goals for North Atlantic minke whales given uncertainty in stock structure and relate this genetic sample sizes (Item 3.2).

(5) Hold an intersessional joint AWMP-RMP meeting on stock structure hypotheses for North Atlantic minke whales (see also IWC, 2013c, p.108). There will be costs involved for travel and subsistence, estimated at £10,000 (Item 3.2).

The sub-committee **agreed** that its work plan during the 2014 Annual Meeting would be as follows.

(1) Continue the *Implementation Review* for North Atlantic fin whales (Item 3.1).
(2) Begin preparations for a focused basin-wide stock structure study for North Atlantic fin whales to be completed in time to inform the next *Implementation Review* (Item 3.1).
(3) Start an *Implementation Review* for North Atlantic minke whales (Item 3.2) starting with a three day pre-meeting before SC/65b (Convenor: Walløe) (Item 3.2).
(4) Review the information available for North Atlantic sei whales in the context of a *pre-Implementation assessment* (Item 3.3).
(5) Review new information on western North Pacific Bryde's whales (Item 3.4).

4. CONSIDERATION OF CANDIDATES FOR CMP (CONSERVATION MANAGEMENT PLANS)

The sub-committee had no candidates for Conservation Management Plans.

5. ADOPTION OF REPORT

The Report was adopted at 14:01 on 11 June 2013. The sub-committee thanked Punt for his customarily indefatigable rapporteuring and Bannister for his excellent Chairmanship.

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Appendix 1

AGENDA

1. Introductory items
    - 1.1 Convenor's opening remarks
    - 1.2 Election of Chair and appointment of rapporteurs
    - 1.3 Adoption of Agenda
    - 1.4 Available documents
2. Revised Management Procedure (RMP) – general issues
    - 2.1 Complete the MSY rates review
        - 2.1.1 Report of the intersessional Workshop
        - 2.1.2 Progress on intersessional work
        - 2.1.3 Discussion and recommendation
    - 2.2 Finalise the approach for evaluating proposed amendments to the *CLA*
    - 2.3 Evaluate the Norwegian proposal for amending the *CLA*
    - 2.4 Modify the 'CatchLimit' program to allow for variance-covariance matrices
    - 2.5 Update the 'Requirements and Guidelines for Conducting Surveys and *Implementations*'
    - 2.6 Update the list of accepted abundance estimates to include western North Pacific common minke whales
    - 2.7 Other business
    - 2.8 Work plan
3. RMP – *Implementation*-related matters
    - 3.1 North Atlantic fin whales
        - 3.1.1 *Implementation Review*
    - 3.2 North Atlantic minke whales
        - 3.2.1 Review new information
            - 3.2.1.1 New surveys
        - 3.2.2 Prepare for 2014 *Implementation Review*
        - 3.2.3 Recommendations
    - 3.3 North Atlantic sei whales
    - 3.4 Western North Pacific's Bryde's whales
        - 3.4.1 Prepare for 2016 *Implementation Review*
    - 3.5 Work plan
4. Consideration of candidates for CMP (Conservation Management Plans)
5. Adoption of Report

Appendix 2

REPORT OF THE PRE-MEETING ON THE *IMPLEMENTATION REVIEW* FOR THE NORTH ATLANTIC FIN WHALES

1. INTRODUCTION

1.1 Opening remarks
Donovan welcomed the participants to Jeju and thanked the Government of Korea for providing excellent facilities. He noted that the purpose of the pre-meeting was to begin work on the *Implementation Review* for North Atlantic fin whales. The RMP states that:

> 'An *Implementation Review* for a species and *Region* should normally be scheduled no later than six years since the completion of the previous *Implementation (Review)*. In some cases an *Implementation (Review)* may require the specification and running of further *Implementation Simulation Trials*, especially when major changes to *Management Area* boundaries or the selection of different options for *Catch-capping* and/or *Catch-cascading* than those currently used is contemplated. In such cases the *Implementation Review* would probably not be completed at a single meeting.'

The purpose of such a review is therefore to examine any new information available (including catch and abundance) and determine whether the existing trials (and by extension hypotheses) are adequate, whether further trials are necessary or whether some existing trials are no longer required. The pre-meeting began on 1 June 2013 and continued into 2 June. The list of participants is given as Adjunct 1.

1.2 Election of Chair and appointment of rapporteurs
Donovan was elected Chair. Butterworth, Punt and Witting acted as rapporteurs, with assistance from the Chair.

1.3 Adoption of Agenda
The adopted agenda is given as Adjunct 2.

1.4 Documents available
The documents available to the meeting were SC/65a/RMP01, SC/65a/RMP03-05, together with relevant documents and extracts of the reports from past meetings.

2. SUMMARY OF THE RESULTS OF THE INITIAL *IMPLEMENTATION*
The original *Implementation* began in 2007 and was completed in 2009. Details of the final trials specifications can be found in IWC (2010). The final conclusions were developed at the 2009 Annual Meeting.

In summary, the Committee concluded that several variants (1, 3, 4, 5, 6) were all 'acceptable without research', but variant 2 had 'unacceptable' performance for some of the trials, all related to stock structure Hypothesis IV. In terms of catch-related performance, the Committee noted that variant 2 gave, by an appreciable margin, the best catch-related performance over the trials as a whole. Iceland indicated that they wished to pursue the option of presenting a research programme to the Committee that would allow variant 2 to be classified as 'acceptable with research'. Subsequent simulation runs had shown that this was acceptable in principle.

In 2010 however, comparison of results from different versions of the *CLA* revealed that variant 3 (which had the next best catch performance) did not have 'acceptable' performance for some of the trials and could no longer be considered to be acceptable without research, but was rather 'acceptable with research', when the 'Norwegian version' of the *CLA* code was used. The Committee had recommended that in future only the Norwegian version of the *CLA* should be used when conducting future trials; it had also been recommended that the existing trials should all be rerun using that version.

Subsequent to those discussions, Icelandic scientists worked simultaneously on developing a research programme and on examining existing marking data to investigate the validity of Hypothesis IV, including the running of additional trials. Discussion of this can be found in recent Committee reports and forms an important component of discussions under Item 3.3 below.

3. REVIEW OF NEW INFORMATION

3.1 Stock structure and movements
3.1.1 Existing hypotheses
The 2009 *Implementation* considered seven stock structure hypotheses and seven sub-areas (see Fig. 1). One of these (Hypothesis VII) was considered to be low plausibility, and trials based on this hypothesis were not used to select among RMP variants. The final stock structure hypotheses on which recommendations for RMP variants were based were:

(I) *Four stocks with separate feeding areas*. There are four 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 four 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-areas 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 four 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 interchange*. There are four stocks with the central stock divided into 3 sub-stocks, but there is no interchange 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 four 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 three 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.

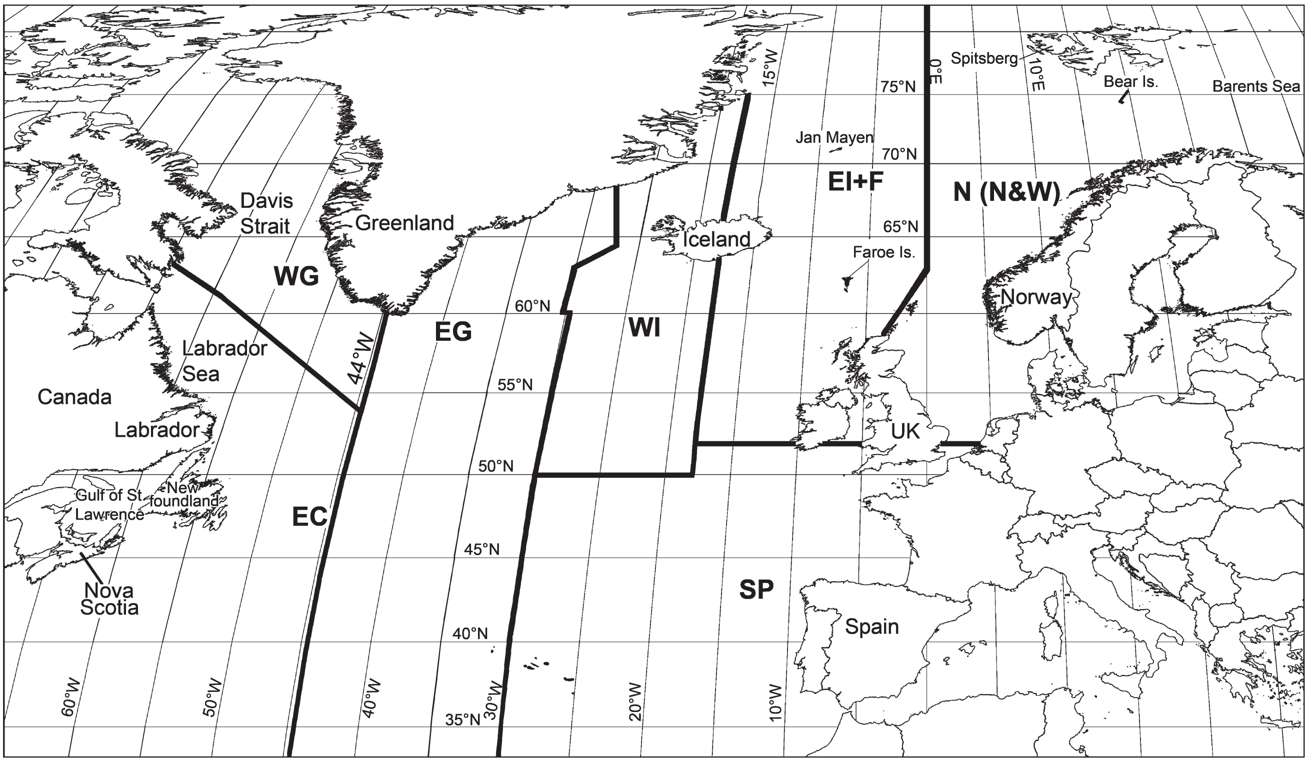


Fig. 1. Map of the North Atlantic showing the sub-areas defined for the North Atlantic fin whales.

Five of these stock structure hypotheses (I, II, III, V, and VI) included dispersal among the sub-stocks which mix in the EG, WI, and EI+F sub-areas (hypothesised sub-stocks[1] 'C1', 'C2' and 'C3'), while Hypothesis IV was based on the assumption that whales from the 'C1', 'C2', and 'C3' sub-stocks mix across the North Atlantic (except the Sp sub-area), but there is no dispersal among sub-stocks. Mixing, in the context of these trials, involves a fixed proportion of a stock (or sub-stock) feeding in a sub-area. While the proportion of a stock feeding in an area is assumed to be constant over time, the specific animals which feed in each sub-area are random from one year to the next. Dispersal between two stocks (or sub-stocks) involves permanent movement from one stock (or sub-stock) to another. It should be noted that dispersal is not the same as gene flow; it is possible for there to be gene flow between two stocks but with no animals moving permanently between the stocks. Dispersal can lead to a 'rescue effect' whereby a 'sub-stock' can be harvested in excess of its natural production, but sustained owing to dispersal into that sub-stock from other sub-stocks.

The extent of mixing had been pre-specified for Hypothesis IV during the *Implementation* primarily for the purposes of exploring behaviour, and the meeting **agreed** that the mixing rates should be estimated rather than being pre-specified if trials based on Hypothesis IV remain (see discussion below). Last year, Gunnlaugsson *et al.* (2012) compared Hypotheses III and IV using likelihood ratio tests and found that Hypothesis III was better supported by the data. However, Gunnlaugsson *et al.* (2012) fitted the operating model under the assumption of a Poisson distribution, rather than a negative binomial distribution, and the estimate of the tag reporting rate was larger than 1 when it was estimated for Hypothesis IV. Gunnlaugsson *et al.* (2012) proposed that their results were sufficient to reject Hypothesis IV and the Committee had referred further examination of this to the present *Implementation Review.* This matter is discussed further below.

3.1.2 New information

SC/65a/RMP01 presented a new method for genetic relatedness analysis based on a three-step procedure. First, LOD scores are computed for three kinds of relationships (half-siblings, parent-offspring, first cousins), *p*-values are then estimated, and finally a False Discovery Rate (FDR) procedure is applied. SC/65a/RMP01 applied this procedure and found relationships among 15 individuals caught during 2009 and 2010 in Icelandic waters (out of the 34,959 pair comparisons), exhibiting various relationships, from grandparent to grandchild, to parent and offspring and half-sibling. One female was found to be related to two other animals. This female was the mother of a male and half-sibling with another female. SC/65a/RMP01 suggested that this new three-step procedure supported by *p*-values should be applicable to additional stock structure issues, in terms of different levels of relationships observed among IWC 'stock boundaries'.

The meeting welcomed this new method and other close kin approaches. The paper was also discussed by the Working Group on Stock Definition and this is reported in Annex I. The meeting noted that parent-offspring relationships change over time and **recommended** further development and application of the method. The value of the method increases with sample size, and the meeting **recommended** that future analyses be based on data for the whole North Atlantic (see recommendation below).

SC/65a/RMP03 summarised the existing genetic stock structure studies performed on the North Atlantic fin whale using a table of information on structure based on allozymes, microsatellite loci and mtDNA. It emphasised the generally low levels of differentiation observed except at some

[1]Note that these sub-stocks are not based on observed genetic differences, but are rather a modelling device to approximate a genetic cline *in extremis*.

allozyme loci. However, Olsen *et al.* (In press) suggested that allozyme patterns at the two most informative loci (MPI and MDH-1) are not detected using DNA, which suggests that the observed patterns at these loci may not reflect genetic drift, migration or even selection. The results based on allozyme studies consequently should be interpreted with caution. SC/65a/RMP03 also summarised estimates of the number of migrants (gene flow) and LOD score, and emphasised the need to further develop these methods in the absence of large genetic differentiation. The authors of SC/65a/RMP03 also emphasised the need for more cooperative work and more effort to combine all available data/samples to better characterise the stock structure of the North Atlantic fin whales.

The meeting noted that in the longer term, new collaborative genetics studies could be used to refine understanding of population structure within the North Atlantic. It **recommended** that focused genetics studies take place based on samples from the entire North Atlantic. Recognising that this was a considerable task it **recommended** that a Steering Group be established (Convenor: Pampoulie, members to include at least Witting, Palsbøll, Skaug) to ensure that this work is developed and completed before the next *Implementation Review.* To improve sample size and geographical spread, it also **recommended** that:

(1) the possibility of obtaining historical samples (e.g. from Norway) should be explored;
(2) existing West Greenland samples should be analysed and samples should be collected from whales harvested off West Greenland wherever possible; and
(3) biopsy samples should be taken during sightings surveys throughout the North Atlantic whenever possible.

The meeting also noted that data on genetic relatedness could be used to estimate abundance. Gunnlaugsson advised that the estimate of abundance which can be inferred from the 11 parent-offspring pairs from the 1980s: 5,600; CV 0.37 (Gunnlaugsson, 2012) is comparable with estimates of abundance from shipboard surveys (although the estimate based on close-kin is less precise).

The meeting **agreed** that the genetics information alone did not warrant changing the existing stock structure hypotheses. It then went on to discuss a broader range of information with a focus on the plausibility of Hypothesis IV.

3.1.3 Stock Structure Hypothesis IV

The meeting noted that all of the stock structure hypotheses were necessarily caricatures of reality. In particular, Hypothesis IV can be considered to be the limit of low dispersal among sub-stocks. Genetic studies performed with microsatellite loci and mtDNA have not revealed any genetic structure among samples collected at several feeding grounds over a period of 20 years (Pampoulie *et al.*, 2008; SC/65a/RMP03). Genetic differences among samples would be expected if there were multiple independent stocks which mix on the feeding grounds in different proportions. However, it was noted that lack of genetic differences among areas would not be inconsistent with lack of permanent movement among stocks if gene flow, but not exchange of individuals, occurs between the stocks.

The breeding areas for fin whales in the North Atlantic are unknown. Hypothesis IV does not suggest where the breeding areas are, but assumes that there are three isolated breeding stocks ('C1', 'C2' and 'C3'). Gunnlaugsson commented that: (a) there were no observations indicating separation; and (b) the whales must be breeding in the deep waters of the open ocean with no geographic barriers and there are no suggestions of different breeding times for these 'sub-stocks'. In addition, he noted that there are no references or data to support a fixed proportional site fidelity in whales and he could not see how this could genetically arise and be maintained in this situation. Although calves are likely to follow their mothers it remains to be explained how they would learn such proportional preferences.

One consequence of a mixing rather than a dispersal hypothesis is that there is no 'rescue' effect whereby if, for example, sub-stock 'C2' was exterminated, there would be no density-dependent response in the proportion of whales moving to the feeding grounds of sub-stock 'C2'. The meeting **agreed** that it would be expected that areas which are depleted will eventually be rebuilt through changes in movement behaviour, but that the timescale over which that would take place, though unknown, would be large in the context of Hypothesis IV.

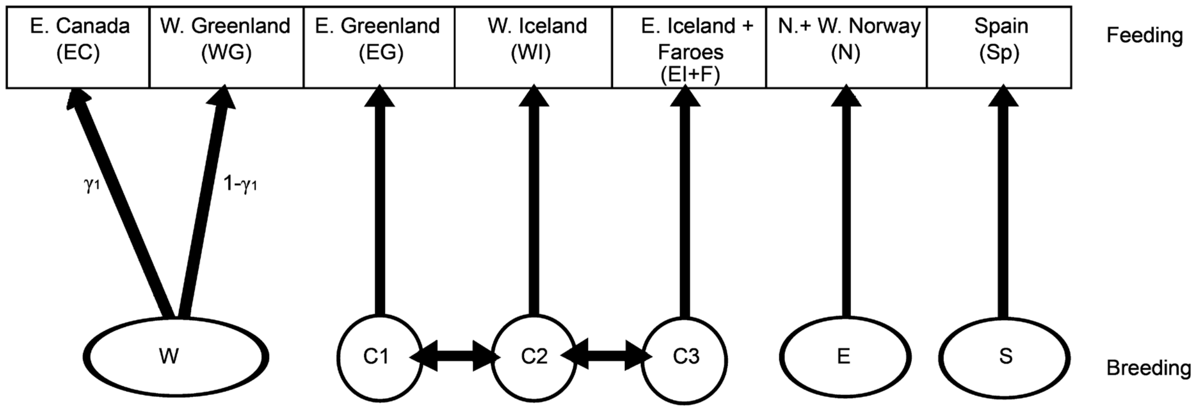
Whales are likely to be found close to where they were the previous year, but over time they would move randomly and gradually into other areas. Temporary site fidelity has been shown for whales in the WI sub-area (Víkingsson and Gunnlaugsson, 2006), consistent with generally gradual dispersal. It was noted that both Hypotheses III and IV relate the dynamics of populations, and neither are explicit about the behaviour of individuals at spatial scales smaller than sub-area. While of interest scientifically, there are likely too few data to enable a model at a fine spatial scale to be developed and parameterised. Gunnlaugsson commented that that by definition Hypothesis IV has no site fidelity across block boundaries and therefore site fidelity within a block would call for animal behaviour to obey arbitrarily drawn blocks.

Tag recoveries in sub-areas EG and WI, as well as in the Canadian marking areas show signs of gradual spatial dispersal (Gunnlaugsson *et al.*, 2012). Gunnlaugsson (2011) presented data on the time trend in the Discovery marking data. The Committee agreed in 2011 that while the patterns in the Discovery marking data were suggestive that Hypothesis IV could be rejected, and recommended further analysis based on *Implementation Simulation Trials*. Gunnlaugsson *et al.* (2012) subsequently showed that the fit of Hypothesis IV was significantly worse than that of Hypothesis III, even then mixing rate parameter in Hypothesis IV was estimated rather than being assumed to be 5%.

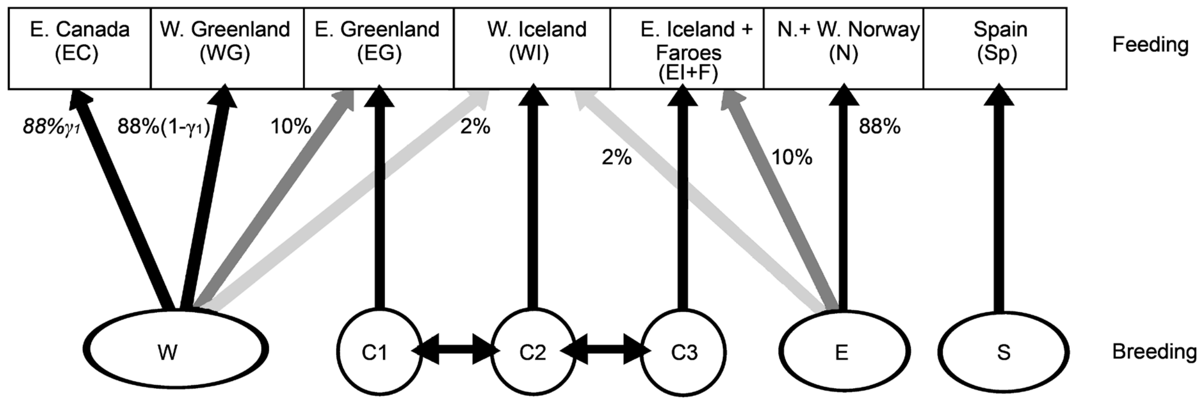
The meeting explored how well Hypotheses III and IV fit the abundance and tagging data when $MSYR_{mat}$ is set to 1%. In contrast to Gunnlaugsson *et al.* (2012), the analysis was based on the assumption of a negative binomial rather than a Poisson recapture process to match the structure of the existing trials. The deviance for Hypothesis III is 10.46 units lower than that for Hypothesis IV, which is statistically significant given that the Hypothesis III model has only one more parameter than the Hypothesis IV model. The mixing proportion for Hypothesis IV is estimated to be 8.4%. Figs. 2 and 3 show the fits to the abundance and tagging data. Although the fits of Hypothesis III are nominally statistically significant better than those of Hypothesis IV at p=0.05, the probable lack of independence of the data means that this is not sufficient to allow Hypothesis IV to be rejected. Hypothesis III fits the data for releases and recaptures in sub-area WI better than Hypothesis III. The reporting rate would be higher than 1 for Hypothesis IV if it was estimated.

Although the results in Figs 2 and 3 indicate a preference for Hypothesis III over Hypothesis IV, most members **agreed** that they are not sufficient alone to reject Hypothesis IV. It was

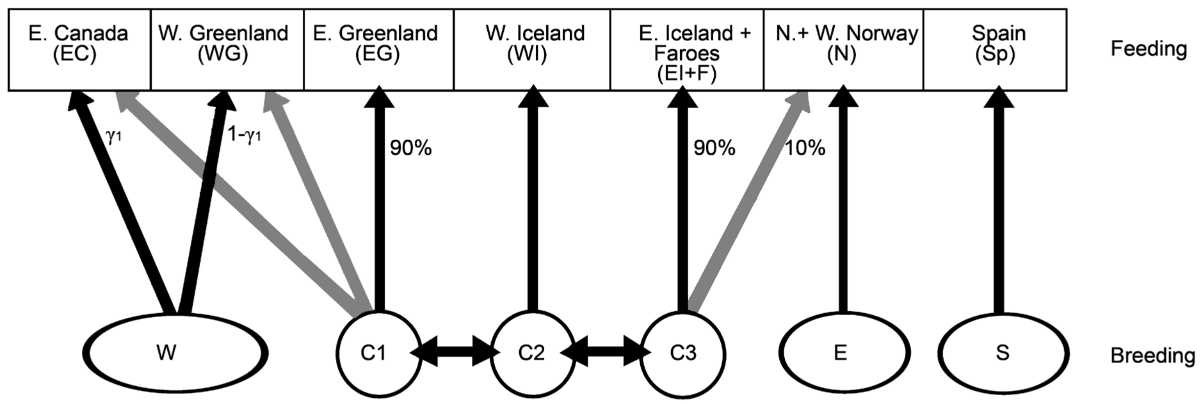
Hypothesis (I). Base case: 4 breeding stocks with separate feeding sub-areas



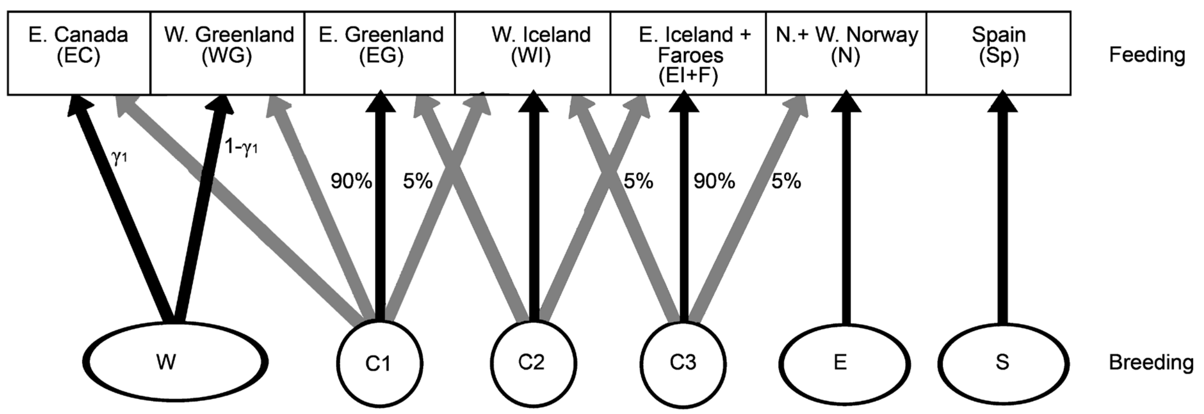
Hypothesis (II). 4 breeding stocks with the W and E stocks also feeding in the central sub-area



Hypothesis (III). 4 breeding stocks with the C stock feeding in adjacent sub-areas



Hypothesis (IV). 4 breeding stocks but without interchange between the C sub-stocks



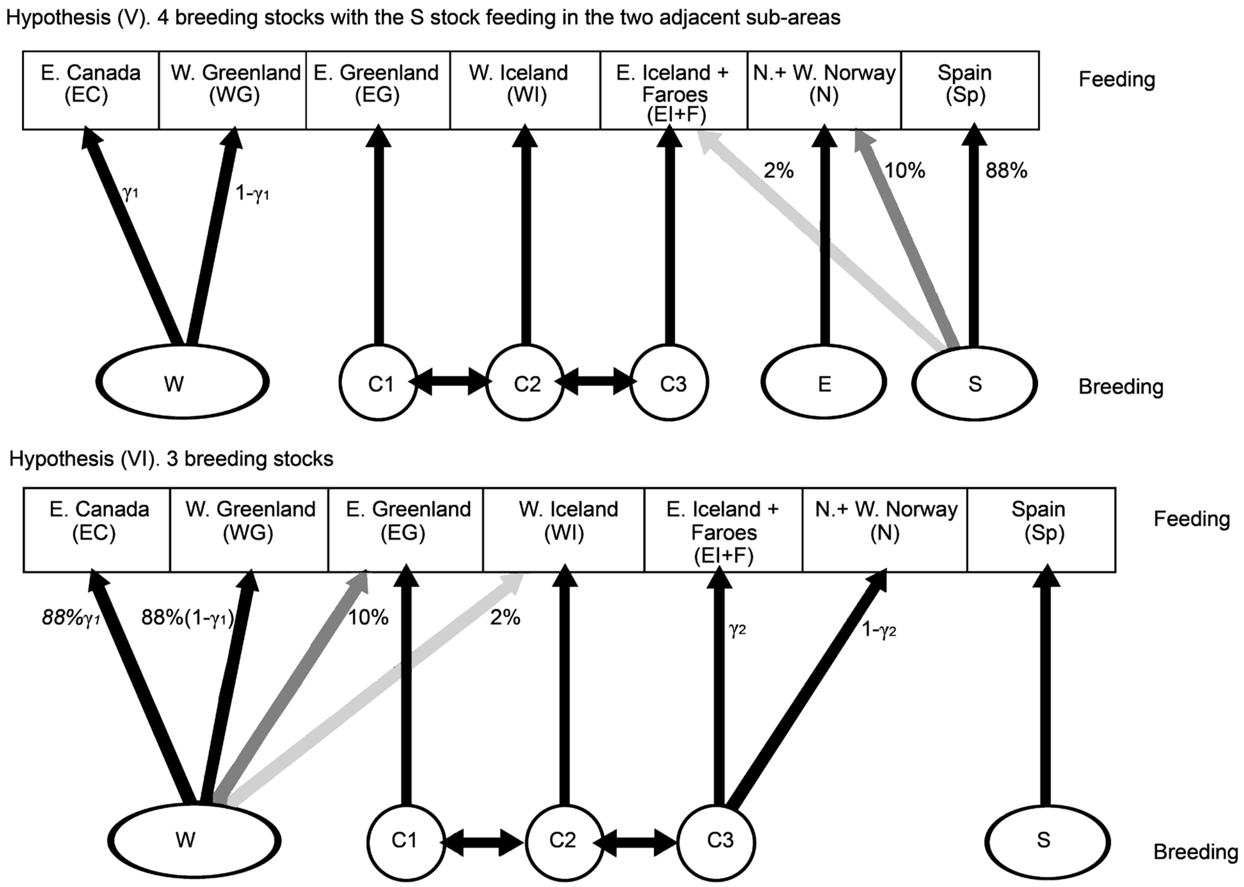


Fig. 2. Stock structure hypotheses for North Atlantic fin whales.

Table 1

Agreed North Atlantic fin whale abundance estimates.

	Variant 6								Variant 2	
	EG+WI+EI/F		WI		EG		EI/F		EG+WI	
Year	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV
1988	14,773	0.1424	4,243	0.229	5,269	0.221	5,261	0.277	9,512	0.1594
1995	21,859	0.1567	6,800	0.218	8,412	0.288	6,647	0.288	15,212	0.1867
2001	25,761	0.1253	6,565	0.194	11,706	0.194	7,490	0.255	18,271	0.1425
2007	21,946	0.1483	8,118	0.260	12,215	0.20	1,613	0.260	20,333	0.1588

noted that during the *Implementation,* all stock hypotheses had been considered 'high' (apart from one hypothesis). The meeting **agreed** that this discussion showed that 'medium' plausibility for Hypotheses IV was appropriate, compared to 'high' for Hypothesis III. However, it noted that in practice this would not change the overall overview of trial results since all trials with $MSYR_{mat}$=1% had been assigned 'medium' plausibility.

3.2 Abundance

The agreed North Atlantic fin whale abundance estimates were compiled in Annex D last year and are summarised in Table 1.

The most recent survey had been carried out in 2007. Regarding future surveys, Víkingsson advised that Iceland's intention was to maintain a six-year cycle as assumed in the *Implementation.* Nevertheless, a decision had been made to conduct the next set of surveys in 2015 rather than 2013. This had been a compromise to fit in with the availability of survey vessels to other states in the North Atlantic so as to be able to carry out a synoptic survey of the whole region.

The meeting recognised the advantage of synoptic surveys. However, it noted that this means that a new abundance estimate (time-stamped 2015) would not be available until 2016. In addition to the phase-out rule implications for catch limits set under the RMP, it was noted that similar circumstances might result in delays in the future. The implications of this for the specification of future *IST*s is discussed under Item 4.

3.3 Catches

Table 2 lists the catches by sub-area and sex from 1864 to 2012.

3.4 Other

SC/65a/RMP04 considered data that had become available following the resumption of whaling on fin whales west of Iceland, which provided an opportunity to compare estimated biological parameters of the stock after three decades without whaling on the stock that followed continuous whaling for over four decades which had ended in four years of extensively studied scientific permit catches.

The comparison showed some large changes. As expected there were more large whales after the pause in whaling, but these whales had a lower pregnancy rate and a higher age at maturity. The predominant sex in the catch had changed from female to male, and there were few young whales in the recent catch together with indications of stunted growth. This implied that there had already been a density-dependant response in the stock. The authors concluded that this would not be expected if the stock was severely depleted with a low MSYR, as assumed in some *IST* scenarios.

The meeting noted that it was important to examine whether the estimated changes were real or perhaps the result of operational changes (e.g. selectivity) or the tempero-geographical differences in the hunt or the animals. Adjunct 3 summarises information on abundance and distribution over recent decades, which Víkingsson developed at the meeting's request. This information points to an expansion of the fin whale distribution west of Iceland into deeper waters over the most recent years, and also to the different estimated rates of increase in different areas, with a higher rate in the West Iceland/East Greenland region compared to the East Iceland/Faroes and Norwegian areas. The Icelandic scientists noted that it was unlikely that operational changes could explain the differences since the operational strategies were largely the same even for the period of special permit whaling.

As an initial basis to assist in the interpretation of the recent estimated changes, particularly with respect to the catch-at-length distributions, reported in SC/65a/RMP04, the meeting requested certain data extractions. The spatial distributions of catches by month over various periods of harvest are shown in Fig. 3. The meeting considered that these did not give evidence of any major changes.

Inspection of the data revealed no indication of differential age-readability by length. The age distributions (see Fig. 4) showed a distinct difference for the most recent period, reflecting a comparatively lower proportion of smaller whales. The meeting agreed that the interpretation of this needed to await the provision of statistics on the implied age distributions of catches from trials under the existing stock structure hypotheses, but also recognised that refinement of the trials might be necessary to be able to reflect these recent estimated changes.

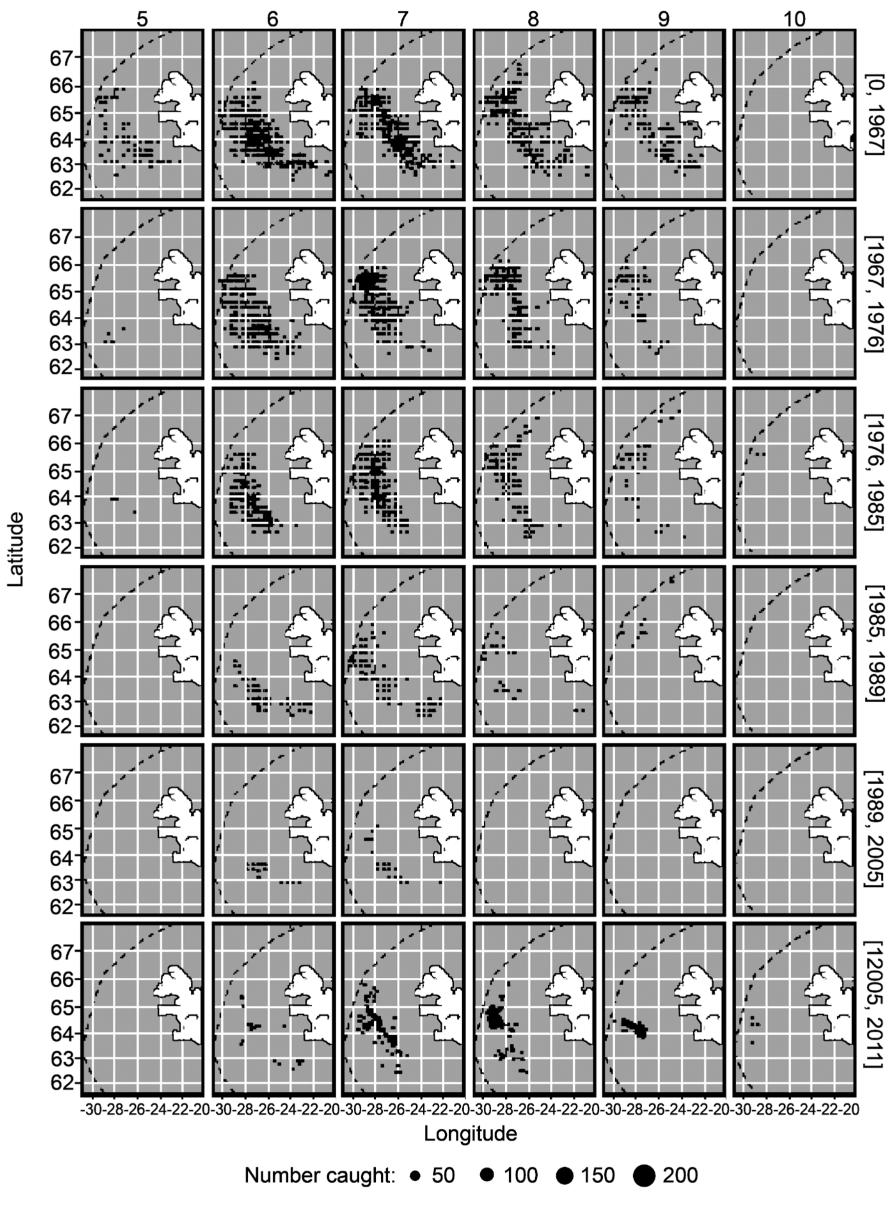


Fig. 3 Spatial distribution of the catch by period.

Table 2
Catches of North Atlantic fin whales by sex and sub-area (the 'Best' series). A ratio of 50:50 males:females is assumed for catches of unknown sex.

Subarea:	EC	EC	EC	WG	WG	WG	EG	EG	EG	WI	WI	WI	EI/F	EI/F	EI/F	N	N	N	Sp	Sp	Sp
Year	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?
1864	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
1865	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
1866	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0
1867	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	1	0	0	0
1868	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	10	0	0	0
1869	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0
1870	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	0
1871	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	20	0	0	0
1872	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0
1873	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0
1874	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0
1875	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0
1876	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
1877	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0
1878	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0
1879	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52	0	0	0
1880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	0	0
1881	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68	0	0	0
1882	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	366	0	0	0
1883	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	316	0	0	0
1884	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	338	0	0	0
1885	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	12	8	592	0	0	0
1886	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	15	22	830	0	0	0
1887	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	6	14	607	0	0	0
1888	0	0	0	0	0	0	0	0	0	0	0	47	0	0	0	11	10	488	0	0	0
1889	0	0	0	0	0	0	0	0	0	0	0	86	0	0	0	10	7	492	0	0	0
1890	0	0	0	0	0	0	0	0	0	0	0	105	0	0	0	17	19	449	0	0	0
1891	0	0	0	0	0	0	0	0	0	0	0	119	0	0	0	9	21	365	0	0	0
1892	0	0	0	0	0	0	0	0	0	0	0	164	0	0	5	22	22	486	0	0	0
1893	0	0	0	0	0	0	0	0	0	0	0	403	0	0	4	20	9	706	0	0	0
1894	0	0	0	0	0	0	0	0	0	0	0	273	0	0	18	10	12	688	0	0	0
1895	0	0	0	0	0	0	0	0	0	0	0	372	0	0	10	1	4	587	0	0	0
1896	0	0	0	0	0	0	0	0	0	0	0	235	0	0	26	20	16	1015	0	0	0
1897	0	0	0	0	0	0	0	0	0	0	0	329	0	0	33	8	5	595	0	0	0
1898	0	0	103	0	0	0	0	0	0	0	0	249	0	0	49	10	11	649	0	0	0
1899	0	0	116	0	0	0	0	0	0	0	0	389	0	0	61	4	4	371	0	0	0
1900	0	0	99	0	0	0	0	0	0	0	0	425	0	0	86	1	2	385	0	0	0
1901	0	0	135	0	0	0	0	0	0	0	0	532	0	0	204	13	10	474	0	0	0
1902	0	0	235	0	0	0	0	0	0	0	0	485	0	0	295	13	7	620	0	0	0
1903	0	0	449	0	0	0	0	0	0	0	0	322	0	0	835	10	10	217	0	0	0
1904	0	0	897	0	0	0	0	0	0	6	15	234	238	210	770	0	0	318	0	0	0
1905	0	0	598	0	0	0	0	0	0	0	0	202	291	262	930	0	0	329	0	0	0
1906	0	0	354	0	0	0	0	0	0	0	0	151	101	121	743	0	0	132	0	0	0
1907	0	0	466	0	0	0	0	0	0	0	0	131	91	93	1404	0	0	170	0	0	0
1908	0	0	449	0	0	0	0	0	0	0	0	138	428	416	552	0	0	76	0	0	0
1909	0	0	524	0	0	0	0	0	0	0	0	261	528	601	538	0	0	58	0	0	0
1910	0	0	384	0	0	0	0	0	0	10	11	177	474	507	377	0	0	149	0	0	0
1911	0	0	371	0	0	0	0	0	0	10	10	133	410	437	444	0	0	131	0	0	0
1912	0	0	336	0	0	0	0	0	0	0	0	97	209	225	241	0	0	81	0	0	0
1913	0	0	293	0	0	0	0	0	0	0	0	49	237	225	190	0	0	42	0	0	0
1914	0	0	252	0	0	0	0	0	0	10	10	6	283	231	154	0	0	0	0	0	0
1915	0	0	171	0	0	0	0	0	0	20	24	15	131	101	114	0	0	0	0	0	0
1916	0	0	50	0	0	0	0	0	0	0	0	0	48	39	121	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
1918	0	0	84	0	0	0	0	0	0	0	0	0	0	0	0	11	10	586	0	0	0
1919	0	0	34	0	0	0	0	0	0	0	0	22	0	0	0	0	0	477	0	0	0
1920	0	0	0	0	0	0	0	0	0	0	0	36	46	68	567	0	0	165	0	0	0
1921	0	0	0	0	0	0	0	0	0	0	0	0	0	0	174	0	0	37	0	0	323
1922	0	0	0	0	0	14	0	0	0	0	0	0	23	21	393	0	0	117	0	0	571
1923	0	0	66	0	0	20	0	0	0	0	0	0	55	41	409	32	29	86	0	0	1,080
1924	0	0	144	34	32	28	0	0	0	0	0	0	59	63	624	0	0	272	0	0	1,218
1925	0	0	270	0	0	30	0	0	0	0	0	0	114	110	316	165	167	0	16	8	1,568
1926	0	0	329	0	0	24	0	0	0	0	0	0	17	21	518	160	136	104	103	129	1,080
1927	92	96	61	0	6	16	0	0	0	0	0	0	168	163	103	190	143	44	83	89	197
1928	134	135	89	0	0	24	0	0	0	0	0	0	166	166	87	230	197	0	0	0	0
1929	164	169	0	0	4	20	0	0	0	0	0	0	89	144	0	137	143	60	0	0	0
1930	153	128	0	0	3	24	0	0	0	91	76	0	102	130	6	246	247	18	0	0	0
1931	0	0	0	154	132	15	0	0	0	1	7	0	0	0	0	130	103	0	0	0	0
1932	0	0	0	32	34	0	1	2	0	101	90	0	0	0	0	205	191	2	0	0	0
1933	0	0	0	13	11	0	25	23	9	159	130	1	52	43	0	211	181	4	0	0	0
1934	0	0	0	0	0	23	0	0	0	48	50	0	34	40	0	70	94	0	41	25	0
1935	44	53	59	9	14	0	0	0	0	0	0	25	36	38	1	45	58	3	0	0	0
1936	78	68	0	6	9	0	0	0	0	26	46	0	40	42	0	72	75	0	0	0	0
1937	0	0	439	2	7	0	6	2	0	185	160	1	91	83	0	173	182	0	0	0	0
1938	0	0	0	4	3	0	0	0	0	55	58	0	108	74	1	139	122	0	0	0	0
1939	62	56	0	1	2	0	0	0	0	66	43	0	73	80	0	134	148	0	0	0	0

Cont.

Subarea:	EC	EC	EC	WG	WG	WG	EG	EG	EG	WI	WI	WI	EI/F	EI/F	EI/F	N	N	N	Sp	Sp	Sp
Year	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?
1940	0	0	64	0	0	0	0	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	0	0	0	0	0	5	1	0	0	0	0
1942	30	32	0	0	0	0	0	0	0	0	0	0	0	0	0	33	25	0	0	0	0
1943	65	76	0	0	0	0	0	0	0	0	0	0	0	0	0	67	43	0	0	0	0
1944	115	116	0	0	0	0	0	0	0	0	0	0	0	0	0	55	57	0	0	0	38
1945	139	207	0	0	0	0	0	0	0	0	0	0	0	0	30	80	79	0	0	0	36
1946	280	222	0	26	21	0	0	0	0	0	0	0	53	39	2	207	185	0	0	0	42
1947	224	189	0	29	22	0	0	0	0	0	0	0	107	89	0	138	147	0	0	0	111
1948	374	295	1	10	11	0	0	0	0	92	103	0	112	111	0	133	127	0	21	25	132
1949	210	215	0	5	16	0	0	0	0	108	141	0	101	121	0	191	151	0	0	0	69
1950	195	213	0	18	18	0	0	0	0	96	130	0	228	179	2	185	156	1	45	37	0
1951	217	266	0	8	7	0	0	0	0	123	189	0	81	87	1	174	147	0	23	22	27
1952	0	1	0	4	12	0	0	0	0	100	124	0	15	5	0	193	181	0	6	6	129
1953	0	1	0	6	9	0	0	0	0	101	106	0	43	44	0	125	150	0	4	5	49
1954	0	0	0	17	5	0	0	0	0	70	107	0	6	11	0	137	132	1	6	6	114
1955	0	2	0	14	8	0	0	0	0	119	117	0	46	34	0	118	92	0	0	0	134
1956	3	4	0	17	11	0	0	0	0	114	151	0	22	21	0	62	70	0	0	0	34
1957	12	10	1	11	10	0	0	0	0	152	196	0	71	70	0	68	71	0	12	12	39
1958	37	18	0	2	6	0	0	0	0	141	148	0	7	9	0	58	65	0	10	15	12
1959	6	8	0	0	0	0	0	0	0	96	82	0	0	0	0	94	86	0	17	19	18
1960	1	0	0	0	0	0	0	0	0	82	78	0	0	0	0	62	66	0	22	17	85
1961	0	0	0	0	0	0	0	0	0	65	77	0	0	0	0	83	79	0	19	20	120
1962	0	0	0	0	0	0	0	0	0	164	139	0	5	1	0	80	65	0	1	2	47
1963	0	0	0	0	0	0	0	0	0	151	132	0	0	3	0	23	19	0	1	3	15
1964	20	36	1	0	0	1	0	0	0	111	106	0	4	9	0	18	20	0	30	11	18
1965	69	69	3	0	0	1	0	0	0	157	131	0	5	5	0	63	43	0	37	28	90
1966	188	235	4	0	0	0	0	0	0	161	149	0	2	1	1	23	31	0	58	49	0
1967	303	438	4	0	0	0	0	0	0	111	128	0	0	0	0	17	17	0	54	45	0
1968	312	388	0	0	0	3	0	0	0	101	101	0	4	2	0	39	37	0	60	46	0
1969	216	316	1	0	0	0	0	0	0	117	134	0	0	0	0	8	8	0	73	43	0
1970	288	288	2	0	0	0	14	5	0	140	132	0	0	0	0	17	27	0	97	84	0
1971	190	227	1	0	0	0	0	0	0	97	111	0	0	0	0	18	19	0	57	41	0
1972	177	183	0	0	0	1	0	0	0	122	116	0	0	0	0	0	0	0	41	56	0
1973	0	0	0	0	0	2	0	0	0	135	132	0	0	0	0	0	0	0	57	54	1
1974	0	0	0	0	0	5	0	0	0	142	143	0	0	0	0	0	0	0	65	55	0
1975	0	0	0	0	0	1	0	0	0	127	118	0	0	0	0	0	0	0	77	60	0
1976	0	0	0	0	0	9	0	0	0	132	143	0	0	0	0	0	0	0	113	121	0
1977	0	0	0	0	0	13	0	0	0	64	80	0	0	0	0	0	0	0	81	70	0
1978	0	0	0	1	0	7	0	0	0	104	132	0	5	2	0	0	0	0	253	207	208
1979	0	0	0	0	0	7	0	0	0	127	133	0	4	7	0	0	0	0	255	197	110
1980	0	0	0	0	0	13	0	0	0	117	119	1	0	0	0	0	0	0	113	105	0
1981	0	0	0	0	0	7	0	0	0	121	132	1	2	1	0	0	0	0	78	68	0
1982	0	0	0	0	0	9	0	0	0	96	98	0	1	2	0	0	0	0	58	91	1
1983	0	0	0	0	0	8	0	0	0	70	74	0	1	4	0	0	0	0	62	58	0
1984	0	0	0	0	0	10	0	0	0	66	100	1	2	0	0	0	0	0	33	69	0
1985	0	0	0	1	2	6	0	0	0	74	87	0	0	0	0	0	0	0	18	30	0
1986	0	0	0	2	1	6	0	0	0	27	49	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	1	2	6	0	0	0	38	42	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	4	5	0	0	0	0	31	37	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	3	3	8	0	0	0	23	45	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	9	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	5	6	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	4	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	2	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	10	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	8	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	5	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	1	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	3	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	3	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	5	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	2	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	5	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	1	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	2	6	2	0	0	1	3	4	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	6	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	8	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	1	7	2	0	0	0	67	58	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	5	1	0	0	0	74	68	6	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

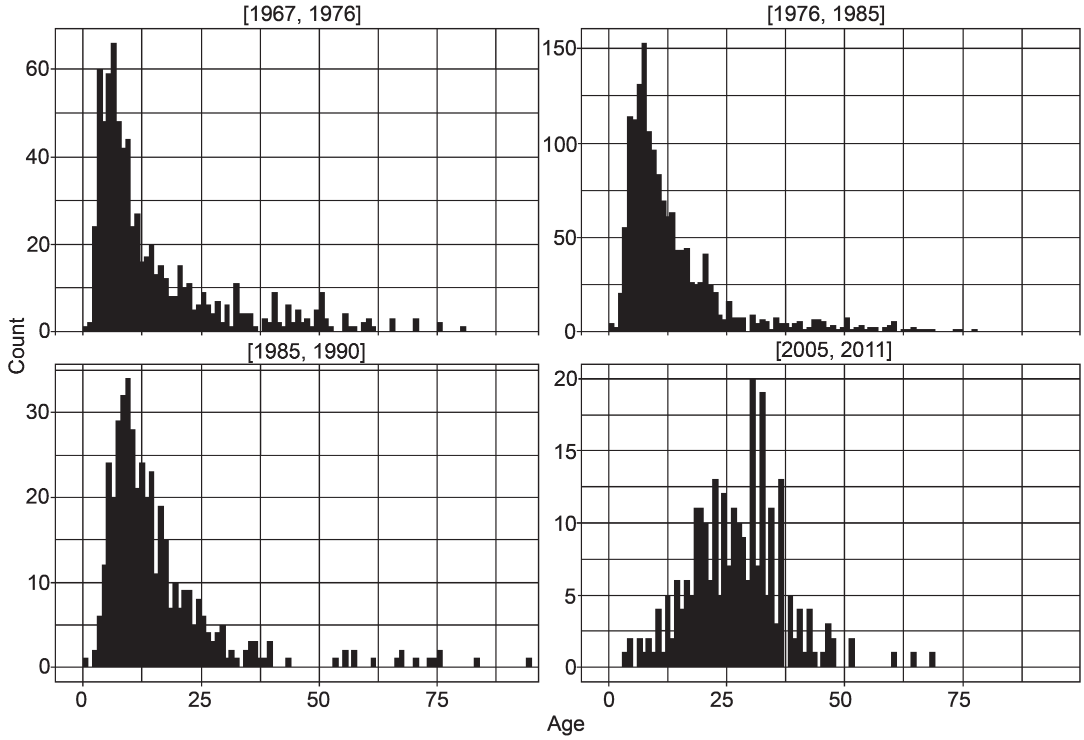


Fig. 4. Age distributions by period.

4. CONSIDERATION OF THE NEED FOR NEW TRIALS (AND THE NEED TO RERUN EXISTING TRIALS)

SC/65a/RMP05 provides the specifications for the most recent version of RMP/AWMP-lite. RMP/AWMP-lite is a platform written in R which implements a framework for evaluating the performance of catch and strike limit algorithms. This framework can be used to evaluate management schemes where multiple stocks of whales are exploited by a combination of commercial and aboriginal whaling operations. The operating models can be conditioned to the actual data to allow an evaluation of whether stock structure assumptions and other hypotheses are comparable with the available data. SC/65a/RMP05 applies the framework for illustrative purposes to data for fin whales in the North Atlantic.

The meeting **agreed** that the set of trials need to be refined as follows.

(1) The mixing rates in trials based on stock structure Hypothesis IV should be estimated rather than being assumed to be 5%.
(2) The operating model should be initialised in a year other than 1864 with a non-equilibrium age-structure.
(3) Allowance should be made for time-dependent movement among sub-areas to better fit the abundance estimates for sub-areas WG and EG (see Fig. 5 of SC/65a/RMP05).
(4) The catch age-composition from the operating model should be output and compared with the observed data. This comparison may suggest that some stock structure hypotheses or choices for $MSYR_{mat}$ are implausible.
(5) Trials should be developed which condition the operating model on the catch age-composition data.
(6) Trials should be developed in which sub-areas EG and WI are combined into a single sub-area given the continuous distribution of sightings between Iceland and East Greenland (see Adjunct 3). Operating models which pool these sub-areas may also fit the recent abundance data better.
(7) Trials which relate to an 8-year survey period.

The meeting established a small group under Elvarsson to begin to develop revised specifications based on the above factors. Progress was made but it was agreed that this work has an iterative component and would need to continue. An intersessional group convened by Elvarsson (Allison, Butterworth, Donovan, Elvarsson, Gunnlaugsson, Punt, and Witting) to develop revised specifications for the trials. The meeting also **agreed** that the trials would need to be reconditioned given that the control program which implemented the earlier trials has been shown to converge to local minima (Elvarsson, 2011). The RMP variants should be implemented using the Norwegian version of the *CLA* code in future trials as previously recommended by the Committee.

The meeting noted that it did not address several issues which are relevant to developing and running trials: (1) the values for $MSYR_{mat}$ – these may be refined as a consequence of the MSYR review; and (2) the need envelope and candidate strike limit algorithms for West Greenland – these will be specified by the SWG on the AWMP.

5. CONCLUSIONS AND WORK PLAN

The meeting **agreed** that the progress made during this meeting should allow the *Implementation Review* to be completed at the next Annual Meeting provided an intersessional Workshop is held. The meeting noted that cost savings could be made if the Workshop was held in conjunction with a proposed intersessional Workshop of the AWMP (see Annex E), given the overlap in some key personnel.

The Workshop proposed the following timetable:

Item	Task	Responsible persons	Date
4	Finalise trial specifications including framework and developing new trials.	Steering Group via email and Skype	Mid-Jul. 2013
2, 4	Condition and run all trials specified by the Steering Group including remaining original trials as well as new trials using Norwegian code.	Allison with assistance from Steering Group	Mid Dec. 2013
4	Review results of conditioning and trials specified by the Steering Group, modify if necessary and determine intersessional work plan to ensure that the *Implementation Review* can be completed at the 2014 Annual Meeting.	2-day intersessional Workshop	Early Jan.
3.1.2	Begin preparations for a focused basin-wide stock structure study to be completed in time to inform the next *Implementation Review* expected around 2020.	Steering Group	2014 Annual Meeting

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Adjunct 1

Participants

Iceland
Bjarki Elvarsson
Thorvaldur Gunnlaugsson
Christophe Pampoulie
Gisli Víkingsson

Denmark
Lars Witting

Secretariat
Cherry Allison
Greg Donovan

Invited Participants
Doug Butterworth
André Punt

Japan
Toshihide Kitakado
Naohisa Kanda

Adjunct 2

Agenda

1. Introduction
    1.1 Opening remarks
    1.2 Election of Chair and appointment of rapporteurs
    1.3 Adoption of Agenda
    1.4 Documents available
2. Summary of the results of the initial *Implementation*
3. Review of new information
    3.1 Stock structure and movements
    3.2 Abundance
    3.3 Catches
    3.4 Other
        3.1.1 Existing hypotheses
        3.1.2 New information
        3.1.3 Stock structure Hypothesis IV
4. Consideration of the need for new trials (and the need to rerun existing trials)
5. Conclusions and work plan

Adjunct 3

Distribution and abundance of fin whales in the Irminger Sea and adjacent areas 1987-2007

Gísli A. Víkingsson

Fin whale distribution and abundance in Icelandic and adjacent waters has been monitored since 1987 throughout the NASS surveys. During 1987-2001 abundance has increased by 4% p.a. in the EGI area as a whole (see Table 1). Most of this increase has been in the Irminger Sea between Iceland and E-Greenland (the whaling grounds and adjacent areas) where the rate of increase has been 10% (Table 1). The distribution of fin whales in this area has also changed during this period. During 1987 and 1989 distribution was largely confined to the continental shelf areas off W Iceland and E Greenland with low densities in the deep waters between. However, fin whale densities have increased markedly in this deep water area from 1995, so that in the 2001 and 2007 surveys, the area between Iceland and Greenland has been characterised by uniformly high densities (Figs. 1 and 2). Concomitantly sea temperature has increased in this area (Fig. 1) which may have triggered the increase and distribution changes of fin whales (e.g. through increased krill production?).

The abundance estimate from 2007 (TNASS) was slightly lower than the 2001 estimate, albeit not significantly different (Pike *et al.*, 2008). This might indicate that the population expansion/increase has come to an end, perhaps as the stock approached carrying capacity although further monitoring is obviously necessary to confirm that. The observed decrease in APR (Apparent Pregnancy Rates) (SC/65a/RMP04) would be consistent with such a theory.

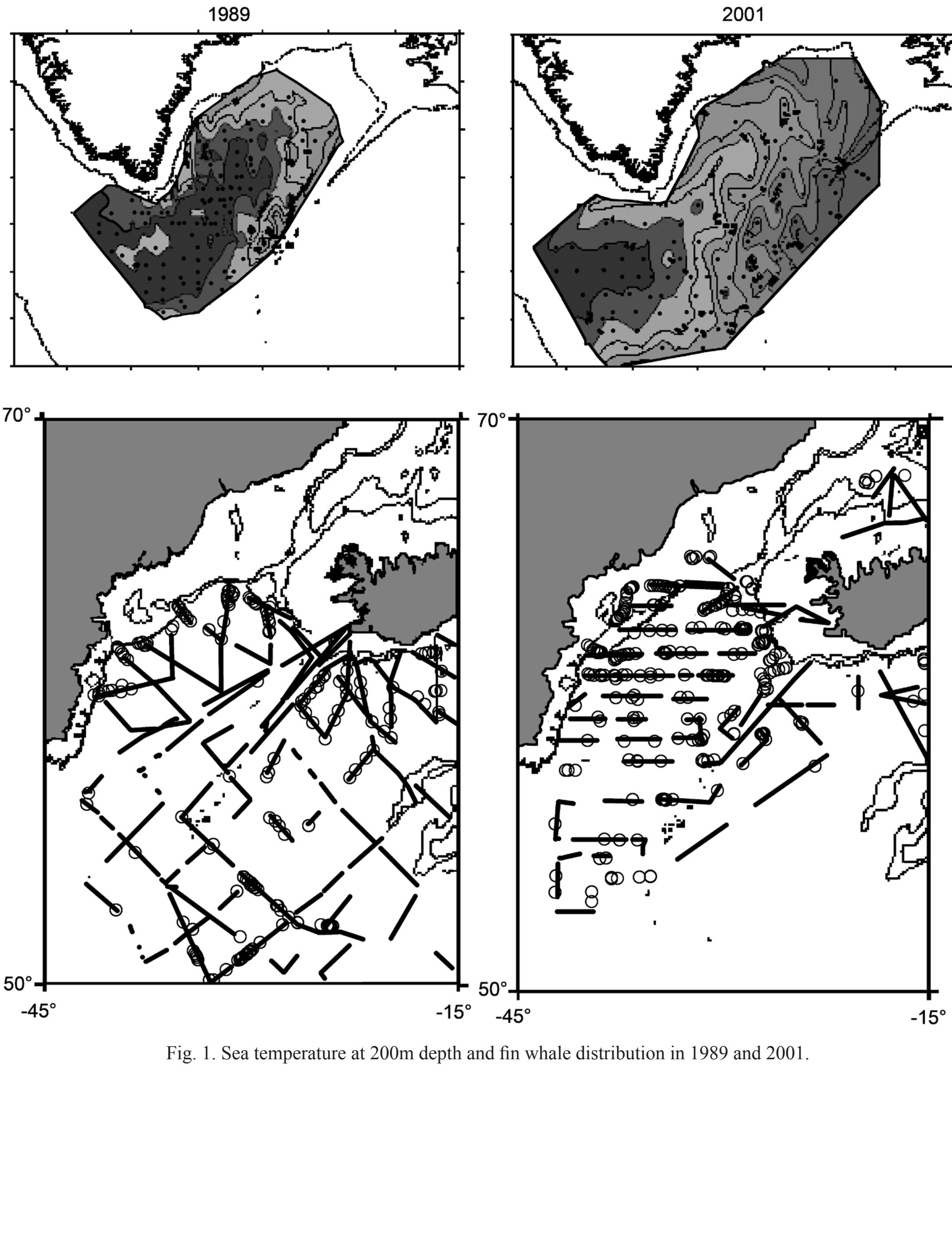

Fig. 1. Sea temperature at 200m depth and fin whale distribution in 1989 and 2001.

Table 1

Abundance estimates and rates of increase for fin whales 1987-2001 (from Víkingsson *et al.*, 2009). *A*=surface area (n.mile^2); *N*=abundance; *D*=density (no./n.mile^2); CV=coefficient of variation for *N* and *D*; *L*, *U*=lower and upper 95% confidence intervals for *N*.

Year	Region	*A*	*N*	*D*	CV	*L*	*U*	Comments
1987	West	192,302	3,607	0.0188	0.18	2,537	5,132	
1989	West	175,185	6,006	0.0343	0.25	3,468	10,401	
1995	West	178,763	13,726	0.0768	0.23	8,667	21,740	
2001	West	191,434	14,021	0.0732	0.18	9,550	20,586	
Growth rate			0.1			0.06	0.14	
1988	EGI	908,077	15,237	0.0168	0.22	9,990	23,239	Includes components of 1987 and 1989 surveys
1995	EGI	623,605	20,262	0.0325	0.21	13,464	30,492	Norwegian – Øien (2003)
2001	EGI	659,192	23,676	0.0359	0.13	18,024	31,101	
Growth rate			0.03			-0.01	0.07	
1988	NOR	231,195	1,242	0.0054	0.38	512	3,009	Øien and Bøthun (2005)
1989	NOR	231,195	1,106	0.0048	0.43	464	2,637	Øien and Bøthun (2005)
1995	NOR	231,195	1,806	0.0078	0.51	576	5,668	Øien and Bøthun (2005)
1998	NOR	231,195	1,723	0.0075	1.09	201	14,734	Øien and Bøthun (2005)
Growth rate			0.05			-0.13	0.26	
1988	Total	1,982,281	17,482	0.0088	0.19	11,981	25,508	Includes components of 1987 and 1989 surveys
1995	Total	1,768,393	26,343	0.0149	0.17	18,754	37,004	Norwegian – Øien (2003)
2001	Total	1,703,020	29,891	0.0176	0.11	24,040	37,167	Norwegian – Øien (2004)
Growth rate			0.04			0.01	0.08	

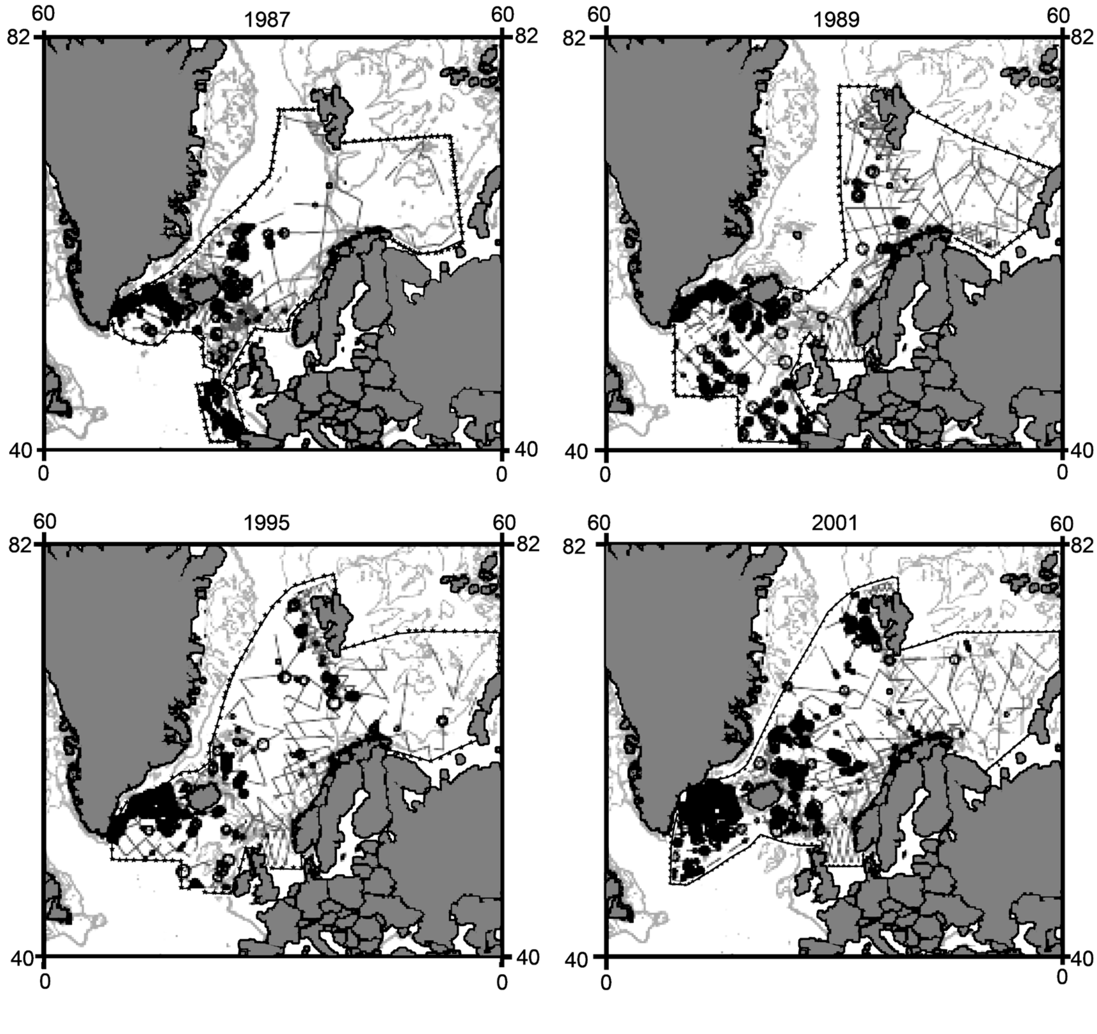

Fig.2. Realised survey effort and sightings of fin whales in NASS ship surveys, 1987 to 2001. Symbol size is proportional to group size from 1 to 4+. The Norwegian sector of the 2001 survey was surveyed from 1996-2001.

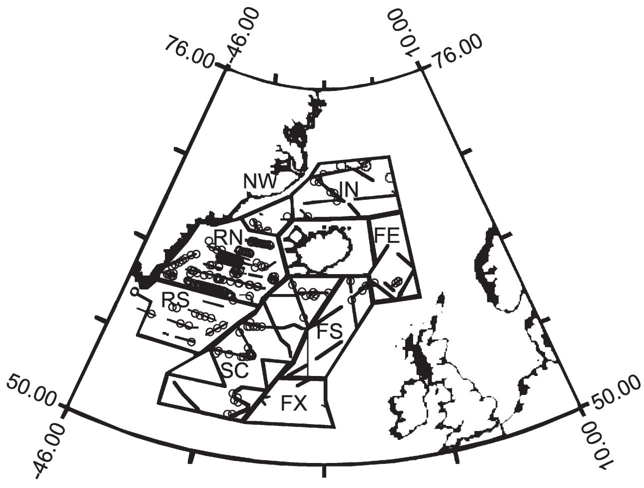

Fig. 3. Sightings of fin whales (High-Medium confidence identification) in the T-NASS Faroese and Icelandic ship surveys. Symbol size is proportinal to group size is proportional to group size in the range 1 to 5.

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Appendix 3

REPORT OF THE NORTH ATLANTIC MINKE WHALE STOCK DEFINITION SMALL WORKING GROUP

Members: Donovan, Gaggiotti, Hoelzel, Pampoulie, Palsbøll, Punt, Skaug, Solvang, Tiedemann, Øien, Víkingsson, Waples and Witting.

The small working group met twice during SC/65a to draft an overall plan to organise and direct the stock structure analyses for the North Atlantic minke whale *Implementation Review*. Four specific items were discussed: (i) designing a simulation experiment to assess data needs for genetic stock identification analyses; (ii) coordinating the generation of new genetic data; (iii) deciding on possible additional non-genetic data generation; and (iv) setting a timetable for simulation experiment, data inventory and generation of genetic data.

1. Simulation experiment to assess expected level of resolution and corresponding data needs for genetic stock analyses

Over the years it has been brought up at multiple occasions during Scientific Committee meetings and inter-sessional workshop and reviews, that identifying stocks from genetic analyses often yield ambiguous results because the values of key parameters at which management recommendations change are not defined. Realising that such 'tipping points' are likely to be case specific it was suggested to use the North Atlantic minke whale as a case study. Such an *in silico* pre-assessment will help the IWC Scientific Committee in two ways; (a) determine which stock hypothesis may be resolved by feasible genetic analyses; and (b) provide an approximate estimate of the amount of genetic data necessary to achieve the required precision. The process consists of two steps.

(1) Conduct demographic simulations for a reasonable range of stock hypotheses and management scenarios to determine the dispersal rates such that management performance is acceptable from a conservation point. After a general discussion a small group (Punt, Skaug, Witting and Pampoulie) outlined the demographic simulations (Appendix I). This first step is anticipated to be completed by the beginning of October, 2013 when a proof-of-concept set of simulations should be made available to a Steering Group.

(2) The second step is to conduct genetic simulations to assess the ability of genetic clustering methods to robustly determine the number of breeding populations and assign individuals to a breeding population. Such simulations will build upon the results from the demographic simulations and require that the critical dispersal rates and population sizes reported by the demographic simulations are converted into the corresponding population genetic entities, typically effective population size (N_e) and gene flow (mN_e). An outline of such genetic simulations is presented in Appendix II. One key issue discussed by the group is linkage among genetic markers. If large numbers of new markers are developed, it will become increasingly untenable to continue to assume that all markers are unlinked. Therefore, it will be necessary to explicitly consider linkage relationships among the markers, although it was noted that for one recommended method (DAPC, Jombart *et al.*, 2010), linkage is accounted for. Provided that initial genetic simulations reveal that some stock structure hypotheses may be addressed by genetic analyses, additional genetic simulations should be undertaken to assess the potential biases due to linkage. The genetic simulations are anticipated to be completed late January 2014.

2. Coordinate the generation of genetic data

During the 2012 Annual Meeting the group decided to aim for a standardised data set consisting of 16 microsatellite loci, mitochondrial (mt) control region DNA sequences and sex for each sample. Work is underway to ensure this level of data in a geographically representative set of genetic samples The Norwegian samples have only been analysed at 10 STR loci, but a small subset (samples from 2003-06) has been genotyped at all 16 loci. The effect of collecting 16 loci for a larger subset of the Norwegian samples will be investigated as part of the genetic simulations.

The group discussed the expected power of this agreed-upon data set in terms of resolving the number of North Atlantic minke whale breeding populations. The data analyses reported so far (based upon 10-16 microsatellite loci and mt control region DNA sequences) have failed to identify more than a single breeding population using both standard statistical tests and genetic clustering methods (i.e. STRUCTURE, Pritchard *et al.*, 2000). However, the applied analytical methods are known to perform poorly when the genetic divergence is below a F_{ST} at 0.03-0.02.

Consequently, *if* the demographic simulations, mentioned above, reveal that the critical dispersal rates are at a level that is likely to yield genetic divergence below 0.02-0.03 then the agreed upon genetic data are likely to be insufficient. As a result the group discussed, in great lengths, the possibility of applying a more recent SNP genotyping method known as ddRAD (double digest Restriction-site Associated DNA, Peterson *et al.*, 2012) sequencing, which is expected to yield approximately 4,000-5,000 SNPs (single nucleotide polymorphisms) genotypes in each analysed sample. Work in model species, such as humans, and in non-model species (orange roughy, Hoelzel, unpublished results) has demonstrated the considerable elevated statistical power of this number of markers. At this level of genotypes per individual many loci will be linked and potentially bias the clustering or the very least the level of statistical confidence of the assessment under some models (i.e. those implemented in STRUCTURE, Pritchard *et al.*, 2000) but not in others (e.g. DAPC, Jombart *et al.*, 2010). Accordingly, as described above and in Appendix II, simulations will assess the impact of linkage.

3. Decide on possible additional non-genetic data generation

The group discussed relatively briefly the use of other, non-genetic, data for stock definition. The group **agreed** that such data, while often insufficient on their own add support to groupings defined by other means. One added complication is that different North Atlantic regions collected different kinds of samples (i.e. lethal versus biopsy sampling), Even for comparable samples, different institutions have collected different data. The group **concluded** that while such data are valuable, generation and standardisation of genetic data should be the primary objective. Non-genetic data should be compiled and made available for the implementation review but the group **agreed** that allocating additional resources to generating new non-genetic data was unlikely to be fruitful.

4. Set a timetable for simulation experiment, data inventory and genetic data generation

The group **agreed** upon the following time table, and point persons.

Demographic simulations
- Point person: Punt.
- Deadline: Beginning of October, 2013.

Genetic simulations
- Point person: Palsbøll (with input from Waples and Gaggiotti).
- Deadline: Late January, 2014.

Generation of genetic data
- 16 STR, mtCR and sex.
- Point persons: Hoelzel, Pampoulie (with Tiedemann), Skaug, Palsbøll and Witting.
- Deadline: late January, 2014.

ddRAD sequencing (provided funding) in 200 samples across the North Atlantic
- Point persons: Hoelzel, Skaug/Glover, Pampoulie/Tiedemann and Palsbøll.
- Deadline: SC/66.

Inventory of available samples and non-genetic data by region, year and type
- Point persons: Øien, Witting, Víkingsson/Pampoulie, Palsbøll and Hoelzel.
- Deadline: October 2013.

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Adjunct 1

Strawperson simulations to evaluate [demographic] dispersal rates

Andre Punt, Christophe Pampoulie, Hans Skaug, Lars Witting

Objective

Identify the levels of dispersal between putative breeding stocks which overcomes uncertainty regarding stock structure uncertainty given management based on the RMP.

Approach

(1) Identify stock structure hypotheses (numbers of stocks [W, C, E] and sub-stocks [??]) and where they are located spatially (including their rates of mixing on the feeding groups when surveys are conducted/catches are taken).
(2) Implement RMP/AWMP-lite based on the sub-areas already specified for the NA minke whales – the involves fitting to time-series of abundance estimates for stock structure hypotheses.
(3) Postulate management scenarios based on possible RMP variants (catch cascading, small areas, including bizarre ones such as 'the E Medium Area is a Small Area and all catches comes from sub-area EB').
(4) Identify a management goal (e.g. final depletion above 0.66*K* for all stocks/sub-stocks).
(5) Repeat steps 2-4 for various levels of dispersal among stocks.
(6) Summarise the results in terms of the relationship between dispersal rate and management scenario.

Workload

(1) Obtain catch and survey time series by sub-area.
(2) Set up AWMP/RMP-lite to match the situation for the NA fin whales.
(3) Condition on existing data (for pre-specified rates of dispersal).
(4) Run the management scenarios.

Adjunct 2

Strawperson simulations to evaluate power and precision of genetic clustering at critical [demographic] dispersal rates

Per Palsbøll, Oscar Gaggiotti, Rus Hoelzel, Robin Waples

Objective

Identify the amount of genetic data necessary to determine the number of breeding population and mixing proportions in management areas at critical demographic rates.

Approach

(1) Rank stock hypotheses based on the output from the demographic simulations (Appendix I) in order of expected difficulty in terms of resolving stocks from genetic analyses.
(2) Convert demographic parameter values (breeding population sizes and annual dispersal rates) into corresponding population genetic parameter values (e.g. effective population sizes and migration rates per generation).
(3) Generate microsatellite (16 loci), mt control region DNA sequence and SNP (up to 5,000 loci) data using coalescent simulations for each specific stock hypothesis starting with the least challenging hypothesis.
(4) Apply clustering method (DAPC) to simulated data.
(5) Repeat steps 2-4 for increasingly challenging stock hypotheses until maximum feasible level of data (e.g. 4,000-5,000 SNPs) and samples is unable to resolve the number of breeding populations.
(6) For stock hypotheses requiring large data sets where linkage among loci is likely, repeat steps 2-4 with explicit modeling of linkage among loci to assess bias (e.g. on genetic estimates and precision).
(7) Summarise and report the results in relation to individual stock hypotheses in terms of data, samples as well as relative proportions of breeding population in each management and the genetic divergence between management areas.

Workload

(1) Decide on conversion factors for census versus effective population size as well as dispersal and gene flow.
(2) Code and set up simulation pipeline.
(3) Run simulations for each stock hypothesis using critical values from demographic simulations.

Appendix 4

PREPARING FOR THE 2014 *IMPLEMENTATION REVIEW*

RELEVANT AGENDA ITEM (NO. AND TITLE)

RMP 3.2.2: Prepare for 2014 *Implementation Review.*

BRIEF DESCRIPTION OF PROJECT AND WHY IT IS NECESSARY TO YOUR SUB-COMMITTEE

Over the years it has been brought up at multiple occasions during Scientific Committee meetings, intersessional Workshops and reviews, that identifying stocks from genetic analyses often yield ambiguous results because the values of key parameters at which management recommendations change are not defined. Realising that such 'tipping points' are likely to be case specific it was suggested to use the North Atlantic minke whale as a case study. Conducting an *in silico* pre-assessment will help the IWC SC in two ways; (a) determine which stock hypothesis may be resolved by feasible genetic analyses; and (b) provide an approximate estimate of the amount of genetic data necessary to achieve the required precision. The proposed process consists of two steps.

(1) Conduct demographic simulations under reasonable range of stock hypotheses and management scenarios to determine the dispersal rates such that management performance is acceptable from a conservation point, outlined in Adjunct I of Appendix 3. This first step is anticipated to be completed by the beginning of October, 2013 when a proof-of-concept set of simulations should be made available to a Steering Group.
(2) The second step is to conduct genetic simulations to assess the ability of genetic clustering methods to robustly determine the number of breeding populations and assign individuals to a breeding population. Such simulations will build upon the results from the demographic simulations and require that the critical dispersal rates and population sizes reported by the demographic simulations are converted into the corresponding population genetic entities, typically effective population size (N_e) and gene flow ($_mN_e$). An outline of the genetic simulations is given in Adjunct 2 of Appendix 3.

While the proposed assessment is specific to the North Atlantic minke whale, the general approach (and software developed) is applicable to all stock hypotheses. Two key advantages of the proposed approach are: (i) identification of stock hypotheses which cannot be resolved with current feasible genetic data and analyses; and (ii) resolve one-stock hypotheses, which is impossible without defining a threshold value for dispersal.

TIMETABLE

Demographic simulations finalised by beginning of October 2013. Genetic simulations by beginning of February 2014.

RESEARCHERS' NAMES

Punt and Palsbøll.

ESTIMATED TOTAL COST WITH BREAKDOWN AS NEEDED (E.G. SALARY, EQUIPMENT)

Salary contributions (Punt and Palsbøll) for period up to 2014 Scientific Committee meeting: £15,000 (incl. benefits and OHs).