Annex E

Report of the Standing Working Group on the Aboriginal Whaling Management Procedure (AWMP)

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1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks
Donovan welcomed the participants to Panama. He noted that the SWG had a considerable amount of work to do this year, including the completion of two *Implementation Reviews*.

1.2 Election of Chair
Donovan was elected Chair.

1.3 Appointment of rapporteurs
Butterworth, Givens and Punt acted as rapporteurs, with assistance from the Chair.

1.4 Adoption of agenda
The adopted agenda is given in Appendix 1.

1.5 Documents available
The new primary documents available to the SWG were SC/64/AWMP1-15, SC/64/BRG1, SC/64/BRG3, SC/64/BRG9 and SC/64/Rep3.

2. *IMPLEMENTATION REVIEW* OF GRAY WHALES WITH EMPHASIS ON THE PCFG

2.1 Summary of intersessional Workshop
Donovan briefly summarised the key conclusions of the intersessional Workshop held from 19-23 March 2012, kindly hosted by the Southwest Fisheries Science Center in La Jolla, California (SC/64/Rep3). With respect to gray whales, the Workshop focus was to build upon the work of the 2011 Annual Meeting to facilitate the completion of the *Implementation Review* with emphasis on the Pacific Coast Feeding Group (PCFG) at the 2012 Annual Meeting.

The Workshop was pleased to note that the code implementing the control programme and that producing summary statistics had been validated and it thanked Brandão and Punt for their hard work in this regard. A final set of *SLA* variants to be considered in the trials was agreed and these can be found in Appendix 2 of the present report. Considerable effort was put in after the 2011 Annual Meeting and at the Workshop to finalise the trial specifications and complete conditioning of the trials.

The Workshop undertook a thorough review of abundance estimates (Calambokidis *et al.*, 2012) and it agreed a final set of estimates based on the modified Jolly-Seber estimator developed at the 2011 Intersessional Workshop. These are given in Table 1 below. It was agreed that the 1998 estimate which was negatively biased to an appreciable extent for likely values of the detection probability for animals available to the surveys for the first time should be excluded. The Workshop also agreed that the operating model would be fitted to the abundance estimates for the NCA-NBC area (~41-52°N) while the *SLA*s would be based on the abundance estimates for the smaller OR-SVI area (Oregon to SVI ~42-49°N).

Table 1

JS1 abundance estimates (N) and standard errors in OR-SVI and NCA-NBC after exclusion of known calves from the year in which they were identified as calves.

Year	N	SE(N)
Region: OR-SVI		
1998	63	4.1
1999	78	8.4
2000	89	11.9
2001	117	8.9
2002	133	15
2003	151	13.7
2004	157	15.5
2005	162	15.7
2006	154	15.3
2007	152	14.5
2008	150	12.5
2009	146	14.9
2010	143	16.8
Region: NCA-NBC		
1998	101	6.2
1999	135	12
2000	141	13.2
2001	172	12.6
2002	189	9.2
2003	200	16.4
2004	206	14.9
2005	206	22.6
2006	190	18.8
2007	183	23.1
2008	191	16.1
2009	185	23.2
2010	186	18.7

The Workshop also welcomed the results of a simulation-based assessment of plausible levels of external recruitment into the PCFG stock (Lang and Martien, 2012). The generation of simulated datasets followed the steps outlined in TOSSM (IWC, 2007a). A number of suggestions were made for additional work and a revised paper for the 2012 Annual Meeting is discussed under Item 2.2 below. In addition, the Workshop strongly supported continued collection of genetic samples, particularly throughout the range of the northern stock.

In reviewing the intersessional results, a number of agreements were reached for modifications including:

(1) adult survival should be constrained to be <0.99 in future trials;
(2) the upper limit on maximum pregnancy rate of 0.6 should be retained;
(3) correction of an error in the previous trial specifications;
(4) incorporation of emigration as well as immigration in the trials; and
(5) incorporation of a revised value (0.3) of the proportion of whales classified as PCFG whales in the November-May period.

The Workshop also reviewed the requirements for graphical and tabular summaries to review results. These are not repeated here, but the agreed list can be seen in Appendix 2. The Workshop finalised the list of factors to be considered in the trials and these are given in Table 2.

The final set of *Evaluation* and *Robustness Trials* proposed by the Workshop can be found as Tables 3 and 4.

The Workshop agreed to a work plan for tasks to be undertaken prior to the 2012 Annual Meeting. The results of that work are detailed below.

In discussion, the SWG thanked the participants at the Workshop for their hard work and **endorsed** the report and its recommendations.

2.2 New information

2.2.1 Abundance

SC/64/AWMP10 provides an analysis of 13 years (1998-2010) of photo-id data for PCFG gray whales which were defined to be those whales present from 1 June to 30 November between 41°N to 52°N (northern California and northern British Columbia). Both closed and open population models were explored for abundance estimation. Closed models failed to accommodate transient behaviour of whales that were only seen in one year. Simulation showed that the standard Lincoln-Petersen (LP) estimator was biased high and even the trend was incorrect due to the transiency pattern. Instead of using LP, a limited LP estimator which removed transient whales by only using observations of whales in consecutive years that were also seen either before or after the consecutive years was used to construct the estimate. Various open Jolly-Seber type models were also fitted to the data. Those analyses demonstrated a relationship between minimum tenure (days between first and last sighting) and resighting probability in subsequent year and first-year apparent survival which includes permanent emigration. Post-first-year survival (excludes transients) for whales present in 1998 was 0.968 (SE=0.0093), but was only 0.881 (SE=0.0217) for whales first seen in 1999 or later which suggested some level of permanent emigration of whales that entered the PCFG during the 1999-2000 stranding event. The transients and minimum tenure preclude use of the standard Jolly-Seber abundance estimator. SC/64/AWMP10 considered two estimators (JS1 and JS2) that excluded the transients. JS1 assumed that all new whales in each year were seen and estimated the number of previously seen, and whales still in the population using the estimated resighting probability for each whale that was sighted. Simulation showed that it will underestimate the initial population size because all whales in the first year are 'new' but with the parameter values for these data, it provides the best current abundance estimate. The JS2 estimator was based on the resighting data after removing whales that were seen in only one year and is a parallel to the limited LP estimator. As expected, simulation showed that JS2 provides a better initial estimate of abundance but is biased low for the current abundance because any newly seen whales in the last year are excluded.

The SWG noted that bias identified in SC/64/AWMP10 is largest for 1998 and that this was a reason for excluding the estimate of abundance for 1998 when conditioning the trials.

2.2.2 Stock structure

SC/64/AWMP2 tested the assumption that individuals of the southern feeding group mate with the rest of population, and therefore that the eastern North Pacific gray whale represents one interbreeding population because this assumption is key to making appropriate management decisions given there is an interest by native groups in Washington and British Columbia to resume their traditional hunts. Such hunts could disproportionally affect whales of the PCFG, and

Table 2

Details of factors considered in trials.

Factors	Levels (reference levels shown bold and underlined)
$MSYR_{1+}$ (north)	**2%**, **4.5%**
$MSYR_{1+}$ (PCFG)	**1%**, **2%**, **4.5%**
Immigration rate (annual)	**0, 1, 2**, 4, 6
Pulse immigration (1999/2000)	**0**, 10, **20**, 30
Proportion of PCFG whales in PCFG area, ϕ_{fut}	0, **0.3**, 0.6, 1
Struck and lost rate (PCFG area)	0, **50%**, 75%
Northern need in final year (linear change from 150 in 2010)	**340**, 530
Historic survey bias	**None/Appendix 2, Table 6**, increasing between 1967 to 2002 from 0.5→1 (north only) 50% (PCFG only)
Future episodic events[1]	**None**, 3 events occur between yrs 1-75 (with at least 2 in yrs 1-50) in which 20% of the animals die. Events occur every 5 years in which 10% of the animals die[2]
Time dependence in *K*	**Constant**, halve linearly over 100yr; double linearly over 100yr
Time dependence in natural mortality, *M* *	**Constant**, double linearly over 100yr
Parameter correlations	Yes, **No**
Probability of mismatching north whales, p_2	0, **0.01**, 0.01-0.05
Probability of mismatching PCFG whales, p_1	**0**, 0.5
Frequency of PCFG surveys	**Annual**, 6-year
Incidental catch	**Reference**, double reference, half reference
Future sex ratio	**0.5:0.5**, 0.2:0.8 (M:F)
Episodic events with future pulse events[1]	**None**, 3 events occur between yrs 1-75 (with at least 2 in yrs 1-50) in which 20% of the north stock die and a pulse of 20 animals is added to the PCFG stock.

[1]The average value for adult survival needs to be adjusted to ensure the population is stable for these trials. [2]Selected to mimic the implications of stochasticity in the population dynamics.

Table 3

The *Evaluation Trials*. Values given in bold type show differences from the base case trial. The final three columns indicate which trials apply to which 'broad' hypotheses. For 'broad' hypotheses B and I, the number given is the plus in 1999/2000. Unless specified otherwise ϕ_{PCFG}=0.3, the struck and lost rate is 0.5, and there are no stochastic dynamics or episodic events.

Trial	Cond-ition	Description	$MSYR_{1+}$ North	$MSYR_{1+}$ PCFG	Final Need	Annual immigration	Survey freq.	Survey bias (north)	Hypothesis P	B	I
1A	Y	$MSYR_{1+}$=4.5%/4.5%	4.5%	4.5%	340/7	2	10/1	1	20	Y	10
1B	Y	$MSYR_{1+}$=4.5%/2%	4.5%	2%	340/7	2	10/1	1	20	Y	10
1C	Y	$MSYR_{1+}$=4.5%/1%	**4.5%**	**1%**	340/7	2	10/1	1	20	Y	10
1D	Y	$MSYR_{1+}$=2%/2%	**2%**	**2%**	340/7	2	10/1	**0.5→1**	20	Y	10
2A	Y	Immigration=0	4.5%	4.5%	340/7	**0**	10/1	1	20	Y	10
2B	Y	Immigration=0	4.5%	2%	340/7	**0**	10/1	1	20	Y	10
2C	Y	Immigration=0	**4.5%**	**1%**	340/7	**0**	10/1	1	20	Y	10
2D	Y	Immigration=0	**2%**	**2%**	340/7	**0**	10/1	**0.5→1**	20	Y	10
3A	Y	Immigration=1	4.5%	4.5%	340/7	**1**	10/1	1	20	Y	10
3B	Y	Immigration=1	4.5%	2%	340/7	**1**	10/1	1	20	Y	10
4A	Y	Immigration=4	4.5%	4.5%	340/7	**4**	10/1	1	20	Y	10
4B	Y	Immigration=4	4.5%	2%	340/7	**4**	10/1	1	20	Y	10
5A	Y	Immigration=6	4.5%	4.5%	340/7	**6**	10/1	1	20	Y	10
5B	Y	Immigration=6	4.5%	2%	340/7	**6**	10/1	1	20	Y	10
6A		High northern need	4.5%	4.5%	**530/7**	2	10/1	1	20	Y	
6B		High northern need	4.5%	2%	**530/7**	2	10/1	1	20	Y	
7A		3 episodic events	4.5%	4.5%	340/7	2	10/1	1	20	Y	
7B		3 episodic events	4.5%	2%	340/7	2	10/1	1	20	Y	
8A		Stochastic events 10% every 5 years	4.5%	4.5%	340/7	2	10/1	1	20	Y	
8B		Stochastic events 10% every 5 years	4.5%	2%	340/7	2	10/1	1	20	Y	
9A		Episodic events with future pulse events	4.5%	4.5%	340/7	2	10/1	1	20	Y	
9B		Episodic events with future pulse events	4.5%	2%	340/7	2	10/1	1	20	Y	
10A		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=0.6	4.5%	4.5%	340/7	2	10/1	1	20	Y	
10B		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=0.6	4.5%	2%	340/7	2	10/1	1	20	Y	
11A		Struck and lost (25%)	4.5%	4.5%	340/7	2	10/1	1	20	Y	
11B		Struck and lost (25%)	4.5%	2%	340/7	2	10/1	1	20	Y	
12A		Struck and lost (75%)	4.5%	4.5%	340/7	2	10/1	1	20	Y	
12B		Struck and lost (75%)	4.5%	2%	340/7	2	10/1	1	20	Y	
13A	Y	Higher 1999-2000 pulse	4.5%	4.5%	340/7	2	10/1	1	**30**		
13B	Y	Higher 1999-2000 pulse	4.5%	2%	340/7	2	10/1	1	**30**		
13C	Y	Higher 1999-2000 pulse	**4.5%**	**1%**	340/7	2	10/1	1	**30**		
14A	Y	Lower 1999-2000 pulse	4.5%	4.5%	340/7	2	10/1	1	**10**		
14B	Y	Lower 1999-2000 pulse	4.5%	2%	340/7	2	10/1	1	**10**		

Table 4

The *Robustness Trials*.

Trial	Condition	Description	$MSYR_{1+}$ north	$MSYR_{1+}$ PCFG	Survey freq.	Hypothesis P	B
1A		6 year surveys	4.5%	4.5%	10/6	20	Y
1B		6 year surveys	4.5%	2%	10/6	20	Y
2A		Linear decrease in K^{1+} [K halves over years 0-99]	4.5%	4.5%	10/1	20	Y
2B		Linear decrease in K^{1+} [K halves over years 0-99]	4.5%	2%	10/1	20	Y
3A		Linear decrease in PCFG K^{1+} [K halves over years 0-99]	4.5%	4.5%	10/1	20	Y
3B		Linear decrease in PCFG K^{1+} [K halves over years 0-99]	4.5%	2%	10/1	20	Y
4A		Linear increase in M [M halves over years 0-99]	4.5%	4.5%	10/1	20	Y
4B		Linear increase in M [M halves over years 0-99]	4.5%	2%	10/1	20	Y
5A		Linear increase in PCFG M [M halves over years 0-99]	4.5%	4.5%	10/1	20	Y
5B		Linear increase in PCFG M [M halves over years 0-99]	4.5%	2%	10/1	20	Y
6A		Perfect detection; p_1 =0; p_2=0.01-0.05	4.5%	4.5%	10/1	20	Y
6B		Perfect detection; p_1 =0; p_2=0.01-0.05	4.5%	2%	10/1	20	Y
7A		p_1 = 0.5	4.5%	4.5%	10/1	20	Y
7B		p_1 = 0.5	4.5%	2%	10/1	20	Y
8B	Y	Survey bias PCFG + p_1 = 0.5	4.5%	2%	10/1	20	Y
9B	Y	Correlation (draw for N; same quantile in the range for PCFG)	4.5%	2%	10/1	20	Y
10B	Y	Double incidental catches	4.5%	2%	10/1	20	Y
11B	Y	Halve incidental catches	4.5%	2%	10/1	20	Y
12A		Sex ratio = 0.2: 0.8	4.5%	4.5%	10/1	20	Y
12B		Sex ratio = 0.2: 0.8	4.5%	2%	10/1	20	Y
13A		Relative probability of harvesting a PCFG whale, ϕ_{PCFG} =1	4.5%	4.5%	10/1	20	Y
13B		Relative probability of harvesting a PCFG whale, ϕ_{PCFG} =1	4.5%	2%	10/1	20	Y

understanding how these whales are related to the rest of the population is necessary for properly managing such hunts. SC/64/AWMP2 analysed 15 nuclear microsatellite loci in 82 samples representing the PCFG and 51 samples from one of the calving lagoons – considered to be representative of the larger population – to test the hypothesis that the eastern North Pacific gray whale represents one interbreeding population. There was no indication of population substructuring based on the nuclear loci, suggesting that all sampled whales do indeed represent one interbreeding population. Combined with the results presented in Frasier *et al.* (2011), the mitochondrial and nuclear markers suggest one interbreeding population that is seasonally subdivided based on maternally-directed site fidelity to different feeding areas.

In discussion, the SWG questioned whether defining the larger population using samples from San Ignacio Bay, Mexico was appropriate because previous analyses had found differences between the Mexican lagoons using microsatellites (Alter *et al.*, 2009) and between animals inside lagoons and those sampled while feeding or migrating using mtDNA (Goerlitz *et al.*, 2003). It also noted that the sample sizes representing the larger eastern North Pacific population were very small, and the SWG was concerned about the reliability of genotyping given that gender could only be determined for 93 of the 133 samples. Finally, although the value for F_{ST} was low (0.0010), the uncertainty associated with this estimate may be large, implying that a wide range of migration rates may be comparable with the data. The SWG **recommended** that all estimates of F_{ST} be accompanied by confidence intervals.

Previous comparisons of the PCFG with whales feeding north of the Aleutians have revealed small but significant levels of mtDNA differentiation, which suggest that matrilineal fidelity is important in creating structure among feeding grounds. The relatively high levels of genetic diversity in the PCFG, however, suggest that some immigration into the group could also be occurring. In SC/64/AWMP4, a simulation-based approach was used to evaluate the plausible range of immigration into the PCFG. This work represents an update to the results presented in Lang and Martien (2012) and reflects modifications made in response to some of the recommendations from the intersessional Workshop (SC/64/Rep3, item 2.4.2.2). An individual-based population model was used to create simulated datasets that incorporate a post-whaling split of the PCFG from the larger ENP population. The scenarios simulated incorporated annual immigration ranging from 0 to 0.0008 (corresponding to between 0 and 16 immigrants/year when the larger ENP population reaches carrying capacity) both with and without additional pulse immigration. Comparison of mtDNA summary statistics (haplotype diversity, number of haplotypes, F_{ST} , and χ^2/df) generated from sampling of the simulated populations with those from empirical data suggest that immigration of less than two and more than eight animals per year (once the simulated larger ENP population has reached carrying capacity) are inconsistent with the empirical data, and that immigration of ~4 animals per year led to results that were most consistent with the empirical data. SC/64/AWMP4 also explored whether changes to the specifications of the model could result in a finding that no annual immigration into the PCFG is consistent with the empirical data. Most simulations were based on the PCFG splitting from the larger ENP in 1930 and on carrying capacity for the PCFG (K_{PCFG}) being set to 200 in accordance with recent abundance estimates. Additional simulations were performed that involved the PCFG splitting from the larger ENP population between 1940 and 1990. Results suggested that if the PCFG was colonised after 1950, and most plausibly between 1960 and 1980, a scenario with no annual immigration could lead to results similar to those found in the empirical data. In addition, simulations incorporating K_{PCFG} ranging from 500 to 5,000 were run; these simulations suggested that K_{PCFG} would need to be >500 and more plausibly between 2,000-3,000 animals for the simulations with no annual immigration to produce summary statistics consistent with those derived from the empirical data.

The SWG thanked Lang and Martien for providing this analysis which responded to several of the recommendations from the intersessional Workshop. Some discussion followed regarding how the mtDNA diversity in the simulated ENP population compared to measures based on the empirical data. As recommended at the intersessional Workshop, the mtDNA mutation rate parameter was tuned to produce simulated diversity values that more closely matched the observed data for the larger ENP population. After tuning, the median values of haplotype diversity and number of haplotypes were similar between the simulated and empirical data, but simulated values of nucleotide diversity were markedly higher than that found in the empirical data. The simulated datasets in SC/64/AWMP4 for the ENP stock yielded consistently higher nucleotide diversity estimates than observed. An alternative explanation could be that the simulated population size of the ENP stock is too high, as diversity scales with population size (at equilibrium). Tiedemann also noted that a higher-than-observed diversity in the simulated dataset will introduce a bias into the migration estimates towards a systematic underestimation.

Notwithstanding the difficulties, the SWG was pleased to see that the TOSSM framework was being used to address this complex issue. It **recommended** that future analyses consider a broader range of parameter choices to explore the robustness of the conclusions to uncertainty regarding these parameters.

Overall, SC/64/AWMP4 suggested that migration rates of greater than one or less than ten were most comparable with the genetics data. However, the SWG noted that fixing several parameters meant that the uncertainty associated with estimates of migration rates is higher than suggested by SC/64/AWMP4, and also that the population size trajectories for the PCFG in SC/64/AWMP4 are not comparable with the mark-recapture estimates of abundance for migration rates of roughly two and higher, and best for a zero migration rate. The *Implementation Trials* developed during the March 2012 intersessional Workshop cover migration rates from zero to six per year when the northern stock equals 20,000 animals. Given the assessment performed in SC/64/AWMP4, and the photo-identification work summarised by Calambokidis *et al*. (2012), Scordino considered that zero immigration should be allocated very low plausibility. The SWG **agreed** that the trials cover a plausible range of migration rates and that the information in SC/64/AWMP4 does not lead to a need to modify this range.

2.3 Progress with intersessional tasks

The SWG was pleased to note that the tasks identified in the work plan from the March 2012 intersessional Workshop had been completed and thanked those undertaking the work.

(1) The need to revise the scenarios regarding incidental catches was discussed by Punt, Scordino and Weller. However, these scenarios were not changed given that the magnitude of change with the updated incidental

take estimates was a fraction of a whale and not thought large enough to warrants changes to the structure of the operating models.

(2) All of the trials were reconditioned and provided to the Steering Group.
(3) Brandon, Punt and Scordino reviewed the results of the conditioning, and identified several trials for which the conditioning appears to have problems (see SC/64/AWMP11).
(4) Laake conducted further simulation analyses related to the plausibility of trials in which bias is varying (see Item 2.2).
(5) Lang and Martien conducted further TOSSM-based simulations to explore the plausibility of different levels of immigration into the PCFG (see Item 2.2).

Punt noted that all of the trials (see Tables 3 and 4 for a summary) had been run for the eleven *SLA*s (see Table 5 of Appendix 2). Software has been developed which produced the plots and tables identified by the March 2012 intersessional Workshop.

2.4 Finalise the specifications for the trials and presentation of results

The SWG **endorsed** the trial specifications, including the choice of *Evaluation* and *Robustness Trials*. The SWG selected a graphical format to summarise the results of the conditioning as well as those of projections based on different *SLA* variants, in addition to tables of the mandatory statistics (see Section F of Annex F of SC/64/Rep3 for details). The graphical summaries are based on those used previously to select the *Gray Whale SLA*, but with a focus on the PCFG. The full set of graphs and tables are available to members of the Scientific Committee through the Secretariat.

SC/64/AWMP11 presented an update on progress towards identifying a final set of trials for the ENP gray whale *Implementation Review*. Following the March 2012 intersessional Workshop, the proposed set of trials was conditioned and the authors of SC/64/AWMP11 evaluated the adequacy of this process for each trial. The primary factor assessed was the extent to which each trial was able to mimic the observed patterns in the time series of PCFG abundance estimates (all of the trials were able to mimic the abundance estimates for the northern stock). Only five of the 55 trials conditioned were identified as needing further scrutiny before being retained or dropped from the final set of trials. These trials (denoted by a first letter for the hypothesis, then the trial number and finally a last letter for the specifications for $MSYR_{1+}$ for each stock) were: B02C; IO2C; P05A; P14B, and P58B (robustness trial P08B).

Past practice in the SWG is only to drop trials from consideration if there is consensus to do so. Some members noted that trials P14B and P58B were sufficiently similar to the data to continue to be used for evaluating *SLA* variants. Consequently, only trials B02C, I02C, and P05A were dropped for further consideration given problems with conditioning.

2.5 Review results of trials

The SWG noted that its evaluation of *SLA*s was based on the objectives accepted by the Commission (IWC, 1983; 1995) which are to:

(a) ensure that the risks of extinction to individual stocks are not seriously increased by subsistence whaling;
(b) enable aboriginal people to harvest whales in perpetuity at levels appropriate to their cultural and nutritional requirements, subject to the other objectives; and
(c) maintain the status of stocks at or above the level giving the highest net recruitment and to ensure that stocks below that level are moved towards it, so far as the environment permits.

Highest priority is accorded to the objective of ensuring that the risk of extinction to individual stocks is not seriously increased by subsistence whaling.

2.5.1 Evaluation Trials

There were 75 *Evaluation Trials*, three of which were not considered further owing to problems conditioning them (see Item 2.4). The SWG adopted the following criteria (related to conservation performance) for identifying trials to examine in detail.

(1) The lower 5%ile of the final depletion distribution is lower than 0.6 (the MSYL level) and the lower 5%ile of the rescaled final depletion is lower than 0.6.
(2) The trial involved episodic events.
(3) The lower 5%ile of the trend in 1+ population size indicated a decline in population size of 5% or larger over the final 20 years of the 100-year projection period.

These criteria identified 16 trials (see Table 5). The SWG considered these trials in detail by reviewing the Zeh plots, the time-trajectories of 1+ population size for each *SLA* variant along with the median time-trajectory of 1+ population when there are no future catches and when there are only incidental catches (i.e. no aboriginal catches), and the median time-trajectories of 1+ population size for all *SLA* variants (see Appendix 3 for an example). Based on this review, the SWG identified the following features of the results.

- *SLA* variants 3, 6, 9, and 11 did not meet conservation objectives on trials with $MSYR_{1+}$ less than 4.5% and were not considered further.
- *SLA* variants 7 and 10 are most likely to lead to a declining trend in the lower 5%ile of 1+ population size.
- Most of the trials selected involve $MSYR_{1+}$=1% (trials P01C, B01C, I101C, P02C, P13C), episodic events, or no immigration from the north stock into the PCFG (trials P02B, B02B, I02B).
- All *SLA* variants lead to a declining trend in the lower 5%ile of 1+ population size for the trials based on $MSYR_{1+}$ = 1% when there is no immigration into the PCFG stock (trial P02C – this trial is the most challenging from a conservation viewpoint).
- *SLA* variant 5 leads to the best performance for the difficult trials. For example, only *SLA* variant 5 did not lead to a declining trend in the lower 5%ile of 1+ population size for trials B10B and P10B. However, this *SLA* variant also leads to the lowest landings and is hence 'inefficient' (lower landings without a correspondingly large increase in population size compared to some other *SLA* variants).
- The episodic events trials (e.g. P08B, P08B) show that episodic events can have a large impact on performance. The value for survival was adjusted for these trials so that the population persists, but this means that $MSYR_{1+}$ is effectively lower than 2% for these trials.
- The lower 5%ile of population size can drop below the initial levels in the trials with occasional large (20%) drops in abundance even though the overall trend in the lower 5%ile of 1+ population size is positive (e.g. B07B).

Table 5
Evaluation Trials which were considered in detail (see text).

Hypothesis		
P	B	I
01C	01C	01C
02B	02B	02B
02C	-	-
08B	08B	-
09B	09B	-
10A	10A	-
10B	10B	-
13C	-	-

2.5.2 Robustness Trials
The SWG applied the criteria used for the *Evaluation Trials* to select the following *Robustness Trials* for further consideration: P03A, P04A, P05A, P12A, P12B, P13A, P13B, B03A, B04B, B05B, B12B. Note that none of the *Robustness Trials* included episodic events. Based on the review of these trials, the SWG identified the following features of the results.

- Only *SLA* variants 1-3 reduce the strike limit for the trials in which abundance declines (e.g. *Robustness Trials* 05A and 05B).
- *SLA* variants 7 and 10 perform very poorly in terms of conservation performance for robustness test 13B compared to their performance for the other trials.
- The *SLA* variants perform adequately for the trials in which the sex ratio of future catches is female-biased (e.g. P12A). However, the sex ratio of the hunt should be monitored and considered in future *Implementation Reviews*.

The SWG thanked the small group which assembled the outputs (Brandon, Givens, Scordino); it would have been impossible to review the larger number of the trials without the ability to reduce the number of trials to a manageable number for full SWG review.

2.5.3 General comments and selection of SLAs
SC/64/Rep3, Annex D describes the hunting management plan proposed by the Makah Tribe. In order to minimise the risk of taking PCFG whales, the plan restricts the hunt both temporally (to the migratory season for gray whales, i.e. 1 December-31 May) and geographically (to the Pacific Ocean region). Some PCFG whales are present during the migratory season and thus the plan proposes an allowable PCFG limit (APL) during hunts that are targeting eastern North Pacific migrating whales, with the aim of ensuring that accidental takes of PCFG whales do not deplete the PCFG. The APL formula is provided in Appendix 2. The Tribe also recognises that whales struck in May might have a higher probability of being PCFG whales since they feed in this area in June. It thus proposes an additional requirement that all animals struck-and-lost in May are assumed to be PCFG whales (i.e. count against the APL), whereas whales struck between December and April are not.

Weather conditions and availability of whales makes it likely that most hunting will occur in May. However, there are insufficient data to assess the number of strikes by month. Consequently, it is not possible to reliably estimate the proportion of struck-and-lost whales that would count towards the APL. Given this uncertainty about how the plan would respond to failing to take into account struck-and-lost PCFG whales, the Tribe had proposed two *SLA* variants (1 and 2) that spanned the options as to when the hunt might occur.

SLA variant 1 proposes that struck-and-lost whales do not count towards the APL, i.e. there is no management response to PCFG whales struck but not landed. *SLA* variant 2 proposes that all struck-and-lost whales count towards the APL irrespective of hunting month, i.e. the number of whales counted towards the APL may exceed the actual number of PCFG whales struck. A number of other *SLA* variants were proposed by the Tribe to explore additional management options. However, none of the variants precisely mimicked the management plan proposed to the IWC.

The purpose of the trials is to provide information on those *SLA* variants that meet the Commission's objectives, with primary attention given to conservation performance.

After the initial examination of the trial results for each of the 11 *SLA* variants, the SWG **agreed**:

(1) *SLA* variants 1 and 2 were potentially satisfactory and performed well in nearly all 72 *Evaluation Trials* (see Appendix 4); and
(2) *SLA* variants 1 and 2 performed acceptably for all *Robustness Trials*.

Given this, the SWG focused on those few trials for which conservation performance required further consideration. It noted that the trials with 1% $MSYR_{1+}$ are the most challenging and that the conservation performance for some of these trials for both variants was not satisfactory (see Table 6). However, the SWG noted that given the available information for the eastern North Pacific population as a whole (the observed recovery rate from severe historical depletion, as well as the current recovery rate from the 1999/2000 mortality event), the most recent assessment (Punt and Wade, 2012) resulted in an estimated MSYR rate of 4.6% [90% posterior interval 2.2%, 6.4%]. Therefore, the $MSYR_{1+}$=1% trials were considered to be at the lower bounds of plausibility and that the conservation performance in these trials alone was not reason to preclude the conclusion that both variants have overall satisfactory conservation performance.

The SWG then focused on certain trials within the 2% $MSYR_{1+}$ set for which conservation performance might be considered questionable. Trial 08B (pulse and bias) involved 10% declines in abundance every five years as a proxy for random biological, environmental or anthropogenic events (e.g. disease or contamination). As noted above, these trials are in effect trials with lower $MSYR_{1+}$ than the nominal 2% of the trial. Given this, the SWG **agreed** that both variants 1 and 2 could be considered to have acceptable performance for these two trials.

Trial 10B (pulse and bias) involves an assumption that the relative probability of harvesting PCFG whales in the Makah U&A is double the observed ratio of PCFG whales to migrating whales observed in the available photo-identification studies. The conservation performance of *SLA* variant 2 was considered acceptable for this trial but that for variant 1 was considered marginal (Table 6). In discussing the results of this trial, the SWG noted that the ratio of PCFG whales to migrating whales could be monitored directly from data collected during the hunting period allowing this assumption to be evaluated.

In conclusion, the SWG **agreed**:

(1) *SLA* variant 2 performed acceptably and met the Commission's conservation objectives for conservation while allowing limited hunting; and
(2) *SLA* variant 1 performed acceptably for nearly all the trials and could be considered to meet the Commission's conservation objectives provided that it is accompanied

Table 6

Final depletion and rescaled final depletion statistics for *SLA*s 1 and 2 for the trials with $MSYR_{1+}$=1% and the trials with $MSYR_{1+}$=2% for which conservation performance might be considered to be questionable.

	SLA variant 1				*SLA* variant 2			
	Final depletion		Rescaled final depletion		Final depletion		Rescaled final depletion	
Trial	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median
$MSYR_{1+}$=1%								
GB01C	0.259	0.343	0.314	0.383	0.290	0.365	0.352	0.414
GP01C	0.382	0.461	0.400	0.472	0.438	0.515	0.460	0.528
GP02C	0.231	0.272	0.255	0.295	0.299	0.347	0.334	0.372
GI01C	0.378	0.446	0.399	0.459	0.434	0.497	0.457	0.513
$MSYR_{1+}$=2%								
GB08B	0.357	0.458	0.505	0.594	0.396	0.504	0.560	0.656
GB10B	0.492	0.556	0.492	0.557	0.575	0.633	0.576	0.635
GP08B	0.330	0.442	0.475	0.578	0.364	0.482	0.528	0.635
GP10B	0.475	0.536	0.476	0.538	0.556	0.619	0.557	0.621

by a photo-identification programme to monitor the relative probability of harvesting PCFG whales in the Makah U&A which is undertaken each year and the results presented to the Scientific Committee for evaluation.

The SWG **agreed** that the *Implementation Review* was completed.

Finally, the SWG noted that the *SLA* variants tested did not correspond exactly to the management plan proposed by the Makah to the US government. The SWG **agreed** to test such a variant intersessionally and present the results to the next Annual Meeting.

2.6 Other business

Spatial mixing between eastern and western North Pacific gray whale stocks along the Pacific coast of North America outside of the feeding season has been recently documented (IWC, 2012a). This raises issues about the population structure within the Sakhalin feeding area; see SC/64/BRG10 and IWC (2012a). The broad issue of stock structure of North Pacific gray whales is being addressed in the BRG sub-committee (Annex F) and through a basinwide research programme (IWC, 2012a). However, as noted last year, this finding raises concern about the possibility of whales feeding in the western North Pacific being subject to the proposed Makah Tribe hunt in northern Washington.

Last year (IWC, 2012a, p.15) the Committee had agreed that formally there was no need to modify the existing trials structure which had been designed to evaluate the *SLA*s for the northern and PCFG areas in the context of eastern gray whales. However, it had also noted that this structure does not incorporate conservation implications for western gray whales and the Committee had stressed three points.

(1) The new information on movements of gray whales highlighted the importance of further clarification of the stock structure of North Pacific gray whales. In particular, the matches of western gray whales with animals seen in the PCFG area and other areas along the west coast emphasised the need for efforts to estimate the probability of a western gray whale being taken in aboriginal hunts for Pacific gray whales (noting that this did not require incorporation of western gray whales into the *Implementation Review*).
(2) It had strongly endorsed the basinwide research programme, noting that the results of the research may require further trials for future *SLA* testing, but that this would certainly be a matter for consideration at the next *Implementation Review* if not before.
(3) The Committee will continue to monitor the situation and was willing to respond to any guidance or requests for further information from the Commission.

SC/64/BRG9 addressed point (1) above. It provided estimates for the probability of taking ≥1 western North Pacific whale during the hunt using five models from three model classes which vary depending on the type of data being used for estimation. Model set 1 makes use of abundance estimates for the western and eastern North Pacific populations. Model set 2 makes use of these abundance estimates, as well as sightings data from the proposed hunt area. Model set 3 makes use of the sightings data only. Within model sets 1 and 2, two models (A and B) differ depending on whether migrating eastern and western North Pacific whales are assumed to be equally available to the hunt per capita (A) or whether this assumption is relaxed somewhat (B). All models make the precautionary assumption that all western North Pacific whales migrate to the North American coast and are thus potentially available. The authors of SC/64/BRG9 considered Model 2B the most plausible because it made use of both available types of information and used a less restrictive assumption about the per capita strike probability on western relative to eastern North Pacific whales. Based on this model, the probability of taking one or more western gray whales in a single season ranged from 0.014 to 0.050, depending on whether the median or upper 97.5th percentile estimate was used and whether five or seven whales would be struck in a year (corresponding to two different types of strike limits in the Makah proposal; see SC/64/Rep3, Annex D). The probability of taking one or more western North Pacific whales once over five seasons, based on base case limits in the Makah plan (20 or 35), ranged from 0.056 to 0.225 across these same variables for Model 2B.

Moore stated that the estimates for the probability of taking one or more western gray whales based on the alternative scenario that total strikes *of non-PCFG whales* would equal three or four in a single year, and 15 or 20 over a 5-year period. The estimate of 3 non-PCFG strikes was informed by taking the average across all *Evaluation Trials* for *SLA* variant 1 (conditional on the bias hypothesis (B)), given the median estimated annual number of total strikes less the median estimated number of PCFG strikes; the estimate of four non-PCFG whales was calculated under the same scenarios, but taken as the average over the difference between the upper 95%ile of estimated annual total strikes and the lower 5%ile of such for PCFG strikes. The justification for considering these scenarios was that, given other management measures within the Makah Tribe's plan – most importantly the provision to cease the annual hunt if a certain number of PCFG whales are struck – it may be unlikely that the maximum strike limits of five or seven annually would be achieved. The additional estimates did not change the assessment presented in SC/64/BRG9, since, for the models considered most credible, the estimated parameters related to western gray whale strikes over the course of five years fell within the range of estimates presented in SC/64/BRG9.

The SWG welcomed this work. However, it **agreed** that the description of the methods was insufficient for a full review. It also noted that there are several categories of uncertainties that might need to be considered but that SC/64/BRG9 does not explain the choice of uncertainties addressed. The question was also raised that some of the results (such as the probability of encountering a western gray whale given a catch of five whales reported in the abstract) did not seem consistent with other information presented in SC/64/BRG9. The SWG also noted that additional sensitivity tests (e.g. to choices of priors) should be conducted, more information on convergence of the MCMC algorithm should be provided, and posteriors for model outputs should be presented.

The SWG **recommended** that a revised document be developed for further review at next year's meeting, noting its potential importance for the provision of management advice. It established an Advisory Group (Brandon, Givens, Punt, Scordino) to provide guidance to Moore and Weller.

3. *IMPLEMENTATION REVIEW* FOR BERING-CHUKCHI-BEAUFORT SEAS BOWHEAD WHALES

Donovan recalled the procedure and purpose of *Implementation Reviews* for aboriginal whaling *SLA*s, as summarised under Items 2.1 and 7. The SWG should assess whether there is any new information that would suggest that the range of trials used to evaluate the *Bowhead SLA* is no longer sufficient to ensure that it meets the Commission's conservation and user objectives.

3.1 Consideration of new information with a focus on whether this implies a need for new trials

SC/64/AWMP6 reviewed publications and information relevant to the Scientific Committee's 2012 *Implementation Review* of Bering-Chukchi-Beaufort Sea (B-C-B) bowhead whales and data that was provided under the Scientific Committee's Data Availability Agreement (DAA). Since the last *Implementation Review* in 2007, major studies ranging from molecular biology to broad-scale distribution/relative abundance have been conducted on B-C-B bowhead whales by the local, state, and federal government and the oil and gas industry in Alaska. Of particular relevance to the 2012 *Implementation Review* is the following: (i) the last abundance estimate accepted by the Scientific Committee is 12,631 with CV 0.2442 for the year 2004 (Koski *et al.*, 2010); (ii) subsistence harvest totals from recent years for US communities; and (iii) recent stock structure investigations. Also reviewed were selected publications relevant to the status of B-C-B bowhead whales (e.g. satellite telemetry, oil and gas, health status, etc.). The review did not identify any new information suggesting a concern with the current management scheme.

3.1.1 Stock structure

SC/64/BRG1 reported on a satellite telemetry study of 57 B-C-B bowhead whales tagged during 2006-11. The results elucidated the seasonal movements of bowheads in this stock throughout the entire annual cycle of migration. The paper was also considered by the Sub-Committee on Bowhead, Right and Gray Whales (Annex F) and so the presentation to the SWG focused on those results relevant to stock structure within the B-C-B stock. All tagged bowhead whales used the western Bering Sea during winter; the time period when mating occurs. All but one tagged whale migrated past Point Barrow in spring and went to Amundsen Gulf. The one exception migrated west along the Chukotka coast and summered in the Chukchi Sea. This whale was tagged near Barrow the previous August, but had not returned to Barrow before the tag stopped transmitting in August the following year. The movements of this whale indicate that individuals may not return to the same summer area in consecutive years. While most tagged whales summered within the Canadian Beaufort Sea, extensive summer movements included travel far to the north and northeast to overlap with at least one tagged bowhead whale from the eastern Canada stock. The two whales overlapped in space, but not in time, and each returned to its area of origin in the autumn. Other summer movements included complete transits from the Canadian Beaufort Sea to an area offshore of Barrow and back to the Canadian Beaufort Sea; and one whale travelled to the coast of Chukotka, Russia in July and spent the rest of the summer there. The autumn migration route across the Chukchi Sea was variable within and between years. The authors concluded that the movements and behaviour observed during this study support the hypothesis of a single stock of bowhead whales in the western Arctic. Further, they noted that satellite telemetry has proven to be a powerful new tool for determining the spatial and temporal distribution of B-C-B bowhead whales.

During discussion of these findings, it was noted that when conception occurs (usually March), all the tagged animals are consolidated in the northern Bering Sea. This is further evidence that B-C-B bowhead whales constitute one breeding population.

The SWG commended the authors of SC/64/BRG1 for providing useful and relevant data on bowhead migration patterns, and recognised the cooperation of native hunters who were closely involved in all aspects of this study, and deployed most of the tags. It **agreed** that the tracking information provided no evidence to suggest that the trials evaluated during the previous *Implementation Review* (IWC, 2008b) did not adequately address stock structure concerns. The SWG **recommended** that such tagging and telemetry efforts continue.

SC/64/AWMP3 compared the use of SNPs and microsatellites for studying population structure, assignment and demographic analyses of bowhead whale populations in the Sea of Okhotsk, Bering-Chukchi-Beaufort Seas, and eastern Canada. The authors found that datasets of 42 linked and unlinked SNPs and 22 microsatellites provided similar power to detect low levels of population differentiation, but neither marker performed well for Bayesian analysis of population structure when the level of population differentiation was low. Microsatellites provided greater precision than this set of SNPs for estimating N_e and applying assignment tests. Using the microsatellites, SC/64/AWMP3 found small differences between B-C-B individuals estimated to have been born before 1949 and those born after 1979. However all analyses indicated that the B-C-B stock of bowhead whales represents a single population. The SWG noted that this paper was discussed primarily in the Stock Definition sub-committee (Annex I) since it evaluated of merits of studying different genetic markers.

The SWG concurred with SC/64/AWMP3 that the SNPs results were consistent with previous results from microsatellite analysis, and also noted that the use of SNPs has the advantage that the SNPs can be reproduced between labs and can be obtained from non-optimal tissues. With respect to conclusions about stock structure, the SWG **agreed** that the results provided no evidence to suggest that the trials evaluated during the previous *Implementation Review* (IWC, 2008b) did not adequately address stock structure concerns.

SC/64/AWMP9 presented sequences from three mtDNA genes from 350 bowhead whales from the B-C-B, eastern Canadian Arctic and the Sea of Okhotsk stocks, and discussed methods to calculate gene and site specific mutation rates. SC/64/AWMP9 used the data to demonstrate the improved resolution in phylogenetic analysis provided by increasing amounts of DNA sequence and in resolving recurrent substitutions. The mutation rate for the control region for bowhead whales was estimated as 2.8% per million years which is about half as fast as gray, humpback and minke whales reported in the literature and the time to most recent common ancestor of the mtDNA was estimated as 1.16 million years. Estimates of F_{ST} among the three bowhead stocks showed the Sea of Okhotsk stock to be significantly different from both B-C-B and Canada but Canada and the B-C-B do not differ significantly. The F_{ST} estimated between the Okhotsk and B-C-B stocks based upon the three gene mtDNA dataset was greater than a previous estimate in the literature calculated from control region alone. Tests of neutrality differed in their results for the control region compared to the two protein coding genes, with the latter both showing evidence for a population expansion that was not recovered from the control region sequence.

The SWG **agreed** that the results in SC/64/AWMP9 did not support the need for any additional trials for the *Bowhead SLA*. Consideration of the methodological issues raised in this paper were discussed by the Stock Definition Sub-Committee (see Annex I).

SC/64/AWMP1 investigated the demographic history the B-C-B population of bowhead whales using a variety of analytical methods, including approximate Bayesian computation and extended Bayesian skyline analysis, in addition to many classical bottleneck and demographic tests. The results support a pre-depletion ancestral population size of 10,000 to 20,000 individuals. However, uncertainty over mutation rate limited the precision of these estimations. This is the first genetic-based estimate of the pre-whaling population size of bowhead whales. In addition, the signal for a historical population expansion having begun approximately 75,000 years before present was supported by multiple analyses. A subsequent, non-anthropogenically driven, population reduction, that ensued about 15,000 years ago, was also detected. No genetic signature for the recent population depletion caused by commercial whaling was recovered through any analysis incorporating realistic mutation assumptions. The authors concluded that while bowhead whales have a dynamic demographic history, the reduction in population size caused by commercial whaling was of insufficient magnitude to contribute to this genetic history. From a biological perspective the bottleneck was of short duration in relation to the long generation time of the bowhead whale, which served as a buffer to minimise erosion of variability through genetic drift.

The SWG **agreed** that the new information presented provided no evidence to suggest that the trials evaluated during the previous *Implementation Review* (IWC, 2008b) did not adequately address stock structure concerns.

3.1.2 Abundance and rate of increase

A new agreed abundance estimate is not required for completion of the B-C-B bowhead whale *Implementation Review*. When a new estimate becomes available it can be incorporated into the *Bowhead SLA* calculations to provide management advice.

In SC/64/AWMP5, it was noted that George *et al.* (2004) fitted an exponential growth model to the 1978-2001 ice-based survey data of Zeh and Punt (2005) via generalised least squares, obtaining an estimated annual rate of increase (ROI) for B-C-B bowhead whales of 3.4% with a 95% confidence interval (CI) of 1.7% to 5%. SC/64/AWMP5 adds the 1985 and 2004 abundance estimates obtained from aerial photography survey data by Koski *et al.* (2010) to the ice-based survey data to obtain an updated ROI for 1978-2004. The resulting ROI value is 3.5% with 95% CI 2.2% to 4.8% (Fig. 1). Thus, the point estimate is almost identical, but the two added estimates improved precision. Photographic surveys can be carried out even in years when ice-based surveys are unsuccessful because of weather and/or ice conditions. When large numbers of photos are obtained, as in 1984-86, the resulting photographic survey estimate can be more precise than many of the ice-based survey estimates.

The SWG **recommends** that the Committee adopt this estimate (3.5% with 95% CI 2.2%, 4.8%) as the best available estimate of annual rate of increase for the B-C-B bowhead population. It also **agreed** that the best estimate of current abundance is 12,631 (95% bootstrap percentile CI 7,900 -19,700; 5% lower limit 8,400) for 2004 (Koski *et al.*, 2010).

The SWG was pleased to receive information from recent ice-based surveys that count whales migrating past Barrow, Alaska (SC/64/AWMP7). Full discussion of these surveys will occur in conjunction with the presentation of new abundance estimates within the next two years.

The 2009 visual survey was nearly a complete failure due to closed leads through the latter half of the season and was not discussed further. In 2010 and 2011, a primary perch and a second independent observer (IO) perch were used. The 2010 survey began with an unusually early (31 March)

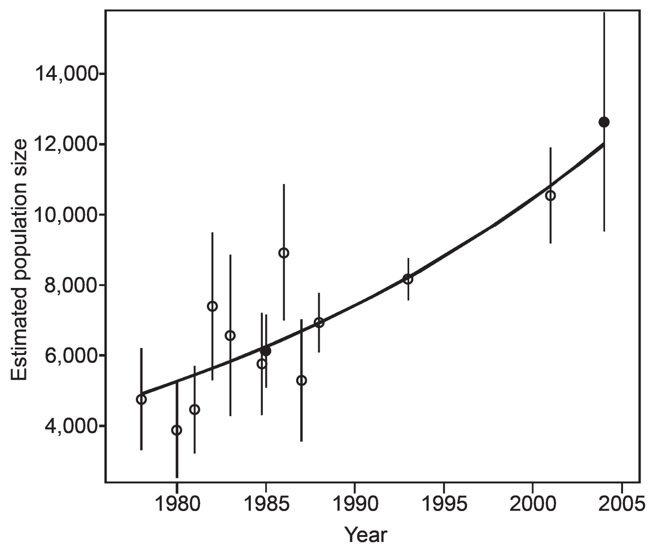

Fig.1. Estimated rate of increase for the B-C-B bowhead whales for the period 1978 to 2004 (from SC/64/AWMP5). The black dots indicate estimates based on photo mark-recapture techniques, the open dots are ice-based estimates.

pulse of bowheads that has not previously been documented (1978-present surveys). Field protocols were devised for operating the IO perches, and methods were developed for real-time and *post hoc* matching of whale sightings between perches. In 2010, a substantial portion (roughly 1/3) of the bowhead migration occurred during times when sightings were impossible due to closed near-shore leads while ice conditions rendered the acoustic data useless. Therefore, no abundance estimate was attempted for 2010, although the survey yielded a large amount of IO data from which estimates of detection probabilities were calculated.

By contrast, the 2011 survey conducted from 4 April to 5 June was extremely successful. Bowheads again arrived earlier than usual, with the first sightings on 9 April and a major pulse on 16 April; earlier sightings were made by whalers. Seven acoustic recorders were deployed of which six provided useful data. The survey resulted in one of the highest raw number of new whales seen. The same IO methods used in 2010 were applied in 2011, with the exception of the real-time matching. Total IO effort was about 180 hours in 2011. An aerial survey was conducted in spring 2011 near Point Barrow concurrent with the ice-based census. Some 4,594 photographs containing 6,801 bowhead whale images were obtained (not accounting for resightings). Thus, the 2011 season was exemplary in that full visual, acoustic and aerial photographic surveys were conducted in the same season. As a final note, first sighting data from 1978 to 2011 surveys were compiled which indicated an earlier arrival of bowheads at Barrow in recent years. This finding is consistent with observations of Barrow whale hunters who have independently reported earlier arrival of bowhead whales at Barrow.

In discussion, the earlier timing of the migration was emphasised and it was noted that there is age-structure within the northbound migration (Koski *et al.*, 2006). However, until the photographs have been analysed it is not known whether large whales were present in the 'early' animals. Rugh *et al.* (2004) found that the arrival times of well-marked whales varied among years, with some large whales (without calves) arriving early in the migration.

SC/64/BRG4 presented estimates of visual detection probabilities from the spring 2011 ice-based survey of bowhead whales migrating near Barrow, Alaska. The same methods will also be applied to similar data from the 2010 survey. These estimates are highly relevant to the AWMP SWG since they constitute one foundation upon which a future population abundance estimate will be calculated from the 2011 survey counts. This abundance estimate will then be used as input to the *Bowhead SLA*. The data for these analyses were produced by observer teams from two nearby ice perches who recorded sightings of whale groups independently, along with a wide variety of covariates. Then, the data were scrutinised *post hoc* to identify possible matches, i.e. whale groups seen from both perches. Whale groups seen from both perches constitute recaptures in the context of a capture-recapture analysis. However, standard capture-recapture model fitting methods are not directly applicable to the 2011 survey dataset for several reasons. First, a single perch may make multiple sightings of the same whale group, but these re-identifications and the links between them are uncertain. Second, the between-perch matches declared *post hoc* are also uncertain, and the analysts performing the matching task must rate each declared match with a confidence rating. Third, the group sizes recorded for multiple sightings both within and between perches are not always consistent, so it is necessary to estimate when or if extra group members belong to a partially unseen recaptured group or an independent individual that is not recaptured. Thus, bias correction methods are essential to produce accurate detection probability estimates. After developing and incorporating these corrections, the authors applied the general framework of Huggins (1989) and reported that detection probabilities depend on group size and the distance of the sighting from the perches. Specifically, group sizes of only one whale and increasing distance from the perch are associated with lower detection probabilities. For example, the detection probability estimates for a single whale at 3,000m and a group of whales at 1,000m are 0.377 and 0.645, respectively. The sample-weighted mean estimated detection probability is 0.495; most standard errors are less than 0.03. Thus, about half the bowheads migrating within the range of potential visual detection are not sighted by observers at the primary perch.

In discussion, the SWG noted that the independent observer (IO) method used in the 2010 and 2011 surveys is entirely different than the removal method protocol used in 1985 and previously to estimate detection probabilities (Zeh and Punt, 2005). Thus, the detection probability estimates from the two methodologies are not exchangeable. The authors of SC/64/BRG4 indicated their intent to estimate 2011 abundance using detection probability estimates based only on the new IO data, abandoning the irrelevant, older estimates. The SWG **endorsed** this approach, while also recognising that any possible implications of the shift to the superior IO method might merit future consideration. However, it was also noted that abundance estimates based on photo-identification have been added to the time series of abundance estimates (SC/64/AWMP5), and an abundance estimate from the new IO study would be another important contribution. The SWG and other Committee members interested in abundance estimation are **encouraged** to contact the authors of SC/64/BRG4 intersessionally with comments and suggestions so that the future abundance estimate for use in the *Bowhead SLA* could be based on an approved estimate of detection probabilities.

SC/64/BRG3 described an aerial photographic survey for B-C-B bowhead whales conducted from 19 April to 6 June 2011. The field season was very successful, both in terms of total flight days and the very large number of whale images (approximately 6,800) obtained during this time. These photographs are a significant contribution to the bowhead whale photographic catalogue. The SWG recognised the importance of this work as potentially providing an estimate of population abundance for use with the *Bowhead SLA*. This estimate would be entirely independent of the ice-based survey estimate described in SC/64/BRG4. Analyses of the photo-id data may also provide better precision in estimates of bowhead whale life-history parameters such as adult survival rate. A detailed discussion of this paper is provided in the BRG sub-committee report (Annex F).

3.1.2 Other

SC/64/AWMP8 provides a preliminary summary of the subsistence harvest of bowhead whales in Alaska from 1974 to 2011. Bowhead whales fill an important nutritional and cultural need for villages in northern and western Alaska. In total, 1,149 whales have been landed by 12 villages from 1974-2011, primarily during migration. The implementation of a quota in 1978 led to an abrupt drop in the number of whales harvested, but as more information became available about bowhead whales, the quota and the number of animals landed increased. The efficiency (no. landed/no. struck) of the hunt has also increased over this period. The average efficiency has reached a plateau at approximately 75% to 80%. In the past 5-10 years, not all strikes have been used. This is due in part to deteriorating ice conditions in the spring, which has made it very difficult for some villages to hunt and land whales. The total strike allocation has never exceeded what was allowed within a block quota based on the *Bowhead SLA*.

The SWG welcomed this information and noted that strikes have remained within the need envelope tested during development of the *Bowhead SLA*. It therefore **agreed** that no additional trials were warranted in this regard.

3.2 Discussion of new trials

In consideration of the evidence described in Item 3.1, the SWG **agreed** that there was no need for new trials or simulation testing of the *Bowhead SLA*.

3.3 Conclusions and recommendations

The SWG thanked the US scientists, the North Slope Borough, Alaska, and the native communities for continuing to provide a considerable body of high-quality scientific work which facilitated the SWG's *Implementation Review* process. The SWG **agreed** that the *Bowhead SLA* continues to be the most appropriate way for the Committee to provide management advice for the B-C-B population of bowhead whales. This completes the *Implementation Review* for the B-C-B bowhead whales.

4. CONSIDERATION OF WORK REQUIRED TO DEVELOP *SLA*S FOR ALL GREENLAND HUNTS

This topic had been advanced at the intersessional Workshop held in La Jolla in March 2012. Donovan summarised the discussions which had taken place at the Workshop (SC/64/Rep3), commenting on the different nature of the requirements for each of the four species (common minke whale, fin whale, humpback whale and bowhead whale) to be considered. He explained that separate *SLA*s would be considered for each species despite Greenlands request for a multi-species approach, as that would be too complex an exercise to undertake at this stage of the process.

The SWG referred to the benefits in previous *CLA* and *SLA* developments in the Committee of a co-operative competition amongst more than one *SLA* developer, and the Chair asked which groups might be interested in participating in such an exercise for the development of Greenland hunt *SLA*s: Witting, Butterworth and Givens (for the bowhead whale only) responded positively to this enquiry. He also drew attention to previous discussions within the SWG on the development of long-term *SLA*s. In particular, he noted the multi-species nature of the Greenland hunts and Greenland's desire for flexibility amongst species in meeting its subsistence needs. The SWG **reiterated** that its approach will first be to develop *SLA*s for individual species before considering whether and how to address multispecies considerations (IWC, 2010; 2011; 2012b).

4.1 Common minke whales

SC/64/AWMP15 had been submitted in response to a recommendation from the March intersessional Workshop in relation to common minke whales. This document dealt with stock structure issues, abundance estimates and aspects of simulation trial structure. The SWG thanked Witting for responding to this request. A summary of the information provided by Witting for each of the Greenland species is given as Appendix 5.

Donovan advised of a planned Workshop on the stock structure of this species in the North Atlantic, which is planned to inform the RMP *Implementation Review* process for common minke whales in the North Atlantic scheduled for 2014. The operating models developed in this process should (perhaps with minor adjustment to take account of focus on different populations) also serve for the *SLA* development process, which would accordingly be informed by expertise in RMP development for this species.

The SWG noted the need for a co-ordinated approach to the issue of stock structure and it **endorsed** the collaborative proposal given in Annex D, Appendix 6 that would culminate in a joint AWMP/RMP Workshop on stock structure in spring 2014.

4.2 Fin whales

SC/64/AWMP12 had been submitted in response to a recommendation from the March 2012 intersessional Workshop in relation to fin whales. This document dealt with stock structure and assessment issues, abundance data and aspects of simulation trial structure. The SWG thanked Witting for responding to this request.

The sub-committee noted that a pre-meeting for a North Atlantic fin whale RMP *Implementation Review* is scheduled before the 2013 Scientific Committee meeting. The stock structure discussions at this meeting would provide useful input to the fin whale *SLA* development process.

4.3 Humpbacks whales

SC/64/AWMP13 had been submitted in response to a recommendation from the March 2012 intersessional Workshop in relation to humpback whales. This document dealt with need envelopes, *SLA* development, stock structure and assessment issues, abundance data and aspects of simulation trial structure. The SWG thanked Witting for responding to this request.

Witting suggested that the ENP gray whale trial structure offered a framework around which trials for the single humpback stock involved could be developed. Punt supported this, commenting that this offered a process which should prove straightforward to implement.

4.4 Bowhead whales

SC/64/AWMP14 had been submitted in response to a recommendation from the March 2012 intersessional Workshop in relation to bowhead whales. This document dealt with stock structure, assessment and simulation trial issues. Here the earlier B-C-B bowhead trial structure may provide a helpful basis around which to design trials. The SWG thanked Witting for responding to this request.

4.5 Conclusions

The SWG **re-emphasised** the importance of developing long-term *SLA*s for the Greenlandic hunts as soon as possible and certainly before 2018. It **agreed** that it should be possible to develop appropriate trial structures and operating models for the humpback and bowhead whale hunts before the next Annual Meeting to enable potential *SLA*s to be evaluated in the future. It **endorsed** the proposal outlined in Appendix 6 to support this work.

It also **emphasised** the importance of developers beginning to consider the development of *SLA*s for fin whales and common minke whales in the context of the work being undertaken on stock structure with the RMP sub-committee especially the joint AWMP/RMP proposal for work on the stock structure of North Atlantic common minke whales (see

Annex D, Appendix 6). It noted that the development of an AWMP/RMP-lite program as outlined in Appendix 6 would also assist developers in beginning to investigate potential *SLA*s for common minke whales and fin whales.

In order to progress this essential *SLA* development work, the SWG **agreed** that an intersessional Workshop (to be held in winter 2012, probably in Copenhagen, at a cost of £8,000) was essential to maintain progress. As in previous years, maintenance of the AWMP Developer's Fund was also supported.

5. IMPLICATIONS OF NEW INFORMATION ON BROAD GRAY WHALE STOCK STRUCTURE (WITH BRG)

5.1 Summary of relevant BRG discussions

The SWG was informed that the sub-committee on BRG had received a number of interesting papers (see Annex F, item 4.1), but that at present its work on the basinwide review of gray whale stock structure was incomplete.

5.2 Conclusions with respect to *Implementation Review*

The SWG **agreed** that it was premature at this stage to consider whether the new information about western gray whales may warrant an *Implementation Review* (although see the discussion under Item 2).

6. ANNUAL REVIEW OF MANAGEMENT ADVICE

6.1 Common minke whales off West Greenland

6.1.1 New information

In the 2011 season, 174 minke whales were landed in West Greenland and six were struck and lost (SC/64/ProgRep Denmark). Of the landed whales, there were 133 females, 39 males, and two whales of unreported sex. Genetic samples were obtained from 90 of these whales. The SWG **re-emphasised** the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP Workshop (see Item 4.1).

Witting noted that the next large whale survey off West Greenland is planned for 2015. The SWG agreed that next year it would review its best estimate of abundance in light of a slightly revised estimate provided in Heide-Jørgensen *et al.* (2010).

6.1.2 Management advice

In 2007, the Commission agreed that the number of common minke whales struck from this stock shall not exceed 200 in each of the years 2008-12, except that up to 15 strikes can be carried forward. In 2009, the Committee was for the first time ever able provide management advice for this stock based on a negatively biased estimate of abundance of 17,307 (95% CI 7,628-39,270) and the method for providing interim management advice which was confirmed by the Commission. Such advice can be used for up to two five year blocks whilst *SLA*s are being developed (IWC, 2009, p.16). Based on the application of the agreed approach, and the lower 5th percentile for the 2007 estimate of abundance, the SWG **repeats** its advice of last year that an annual strike limit of 178 will not harm the stock.

Table 7

Most recent abundance estimates for minke whales in the Central North Atlantic.

Small Area(s)	Year(s)	Abundance and CV
CM	2005	26,739 (CV=0.39)
CIC	2007	10,680 (CV=0.29)
CG	2007	1,048 (CV=0.60)
CIP	2007	1,350 (CV=0.38)

6.2 Common minke whales off East Greenland

6.2.1 New information

Nine common minke whales were struck (and landed) off East Greenland in 2011, and one was struck and lost (SC/64/ProgRepDenmark). All landed whales were females. The SWG noted that catches of minke whales off East Greenland are believed to come from the large Central stock of minke whales. No genetic samples were obtained from minke whales caught in East Greenland. The SWG **re-emphasised** the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP Workshop (see Item 4.1).

6.2.2 Management advice

In 2007, the Commission agreed to an annual quota of 12 minke whales from the stock off East Greenland for 2008-12, which the Committee stated was acceptable in 2007. The present strike limit represents a very small proportion of the Central stock (and see Item 4.1). The SWG **repeats** its advice of last year that the present strike limit would not harm the stock.

6.3 Fin whales off West Greenland

6.3.1 New information

A total of five fin whales (all females) were landed, and none were struck and lost, in West Greenland during 2011 (SC/64/ProgRepDenmark). No genetic samples were obtained from caught fin whales in 2011. The SWG **re-emphasised** the importance of collecting genetic samples from these whales, particularly in the light of the proposed work to develop a long-term *SLA* for this stock (see Item 4.2).

6.3.2 Management advice

In 2007, the Commission agreed to a quota (for the years 2008-12) of 19 fin whales struck off West Greenland. The Committee agreed an approach for providing interim management advice in 2008 and this was confirmed by the Commission. It had agreed that such advice could be used for up to two blocks whilst *SLA*s were being developed (IWC, 2009). Based on the agreed estimate of abundance for fin whales (4,539 95%CI 1,897-10,114), and using this approach, the SWG **repeats** its advice that an annual strike limit of 19 whales will not harm the stock.

6.4 Humpback whales off West Greenland

6.4.1 New information

A total of eight (three males; five females) humpback whales were landed (none were struck and lost) in West Greenland during 2011 (SC/64/ProgRepDenmark). Genetic samples were obtained from three of these whales. The SWG **re-emphasised** the importance of collecting genetic samples from these whales, particularly with respect to the YoNAH and MoNAH initiatives (Clapham, 2003; EC YoNAH, 2001).

6.4.2 Management advice

In 2007, the Committee agreed an approach for providing interim management advice and this was confirmed by the Commission. It had agreed that such advice could be used for up to two five year blocks whilst *SLA*s were being developed (IWC, 2009, p.16). Based on the agreed estimate of abundance for humpback whales (3,039, CV 0.45, annual rate of increase 0.0917 SE 0.0124) and using this approach, the SWG **agreed** that an annual strike limit of 10 whales will not harm the stock.

6.5 Humpback whales off St Vincent and The Grenadines

6.5.1 New information

Last year the SWG noted that it had received no catch data from St Vincent and The Grenadines for 2010-11. This year the Secretariat received information that a 35-foot whale was taken on 18 April 2011. It was reported that its girth was 18.6 feet, its flukes 9.7 feet and its 'tail length' was 17.9 feet. It also received information on a 33.75 foot female taken on 14 April 2012. Its girth was 18.25 feet. Genetic samples and photographs were taken.

Brownell reported that the USA and St Vincent and The Grenadines are discussing the transfer of tissue samples from this whale for analysis and storage at SWFSC (the IWC archive where *inter alia* SOWER samples are stored).

The SWG **welcomed** this information.

It also repeats its previous strong **recommendations** that St Vincent and The Grenadines:

(1) provide catch data, including the length of harvested animals, to the Scientific Committee; and
(2) that genetic samples be obtained for any harvested animals as well as fluke photographs, and that this information be submitted to appropriate catalogues and collections.

6.5.2 Management advice

The Committee has agreed that the animals found off St Vincent and The Grenadines are part of the large West Indies breeding population (11,570 95% CI 10,290-13,390). The Commission adopted a total block catch limit of 20 for the period 2008-12.

The SWG **repeats** its advice of last year that this block catch limit will not harm the stock.

6.6 Implications of possible move to biennial meetings with respect to length of block quotas

The Commission is considering a change from annual to biennial meetings. This has raised the issue within two Commission working groups as to whether there are any scientific implications for the Commission moving to setting block quotas for an even number of years rather than the present five-year intervals. This issue was addressed at the intersessional Workshop (see SC/64/Rep3).

The Workshop had recalled that trials for the B-C-B bowhead and Eastern North Pacific gray whale *SLA*s had shown satisfactory performance for surveys at intervals of 10 years (and even for some *Robustness Trials* for 15 years). The Workshop agreed that there are no scientific reasons for the Commission not to set catch limits for blocks of even numbers of years up to eight years for these stocks. However, it drew attention to its discussions of the AWS where it noted that despite the trial results it would not be appropriate for catches to be left unchanged if new abundance estimates were not available after 10 years (IWC, 2004 and see Item 7.2).

The Workshop had noted that this would not mean that the Committee would need to change its regular process of *Implementation Reviews* approximately every five years (with the provision for 'special' reviews should circumstances arise) or an annual examination of new information and provision of advice.

The Workshop had also noted that the interim safe *SLA* for the Greenland hunts (see Items 6.1-6.4 above) had also been tested for surveys at 10-year intervals and shown satisfactory performance and had been adopted by the Committee and the Commission in 2008. However, as noted at the time those tests had been for a restricted number of scenarios than the wider range of hypotheses customarily considered for such trials. It had thus been agreed that this *SLA* was appropriate for the provision of advice for up to two blocks (i.e. approximately 10 years) or to approximately 2018. The Workshop agreed that there were no scientific reasons why the next quota block for the Greenland hunts could not be for a six-year period, noting that the long-term *SLA*s will be available for implementation for the following block quota.

The SWG **endorsed** the views of the Workshop.

7. ABORIGINAL WHALING MANAGEMENT SCHEME

7.1 Draft guidelines for *Implementation Reviews*

An integral part of the AWMP process is the undertaking of regular or 'special' *Implementation Reviews*, as noted for example during the development process of the *Bowhead Whale SLA* (IWC, 2003b).

The first Bering-Chukchi-Beaufort Seas stock bowhead whale *Implementation Review* took place over two years and was completed in 2007 with most focus being on the issue of stock structure (IWC, 2007b; 2008a; 2008b; 2008c; 2008d). No changes needed to be made to the *Bowhead SLA* after the review. The first *Implementation Review* for gray whales was completed in 2010 and the *Gray Whale SLA* was not changed with respect to providing advice on the Russian hunt off Chukotka (IWC, 2011). However, as discussed above, during that review, information was received that led to the need to call for an immediate *Implementation Review* before providing advice for a potential hunt of gray whales by the Makah Tribe on the west coast of the USA.

The SWG had agreed that it would be useful to develop guidelines for *Implementation Reviews*, given the experience gained thus far. The adopted guidelines, which cover the issues outlined below, are provided in Appendix 7.

(1) Objectives.
(2) Timing of regular and special *Implementation Reviews.*
(3) Outcomes.
(4) Data availability.
(5) Computer programs.

The SWG **commends** these guidelines to the Committee.

7.2 Scientific aspects of an Aboriginal Whaling Scheme (AWS)

In 2002, the Committee strongly recommended that the Commission adopt the Aboriginal Subsistence Whaling Scheme (IWC, 2003a, pp.22-23). This covers a number of practical issues such as survey intervals, carryover, and guidelines for surveys. The Committee has stated in the past that the AWS provisions constitute an important and necessary component of safe management under AWMP *SLA*s and it **reaffirms** this view. It noted that discussions within the Commission of some aspects such as the 'grace period' are not yet complete.

8. PROGRESS ON FOLLOW-UP WORK ON CONVERSION FACTORS FOR THE GREENLANDIC HUNT

In 2009, the Commission appointed a small working group (comprising several Committee members) to visit Greenland and compile a report on the conversion factors used by species to translate the Greenlandic need request which is provided in tonnes of edible products to numbers of animals (Donovan *et al.*, 2010). At that time the group provided conversion factors based upon the best available data, noting that given the low sample sizes, the values for species other than common minke whales should be considered provisional. The group also recommended that a focused attempt to collect new data on edible products taken from species other than common minke whales be undertaken, to allow a review of the interim factors; and that data on both 'curved' and 'standard' measurements are obtained during the coming season for all species taken.

Last year the Committee had welcomed an initial report, recognising the logistical difficulty of collecting this kind of data. However, it had noted that considerably more detail is needed and requested that a detailed report be presented for consideration at the next meeting.

In particular, it had requested that the report should provide:

(1) a description of the field protocols and sampling strategy, including effort and likely sample sizes;
(2) a description of analysis methods and models; and
(3) presentation from results thus far, including from preliminary analyses with the available data.

It had noted that such information will assist the SWG in addressing issues such as appropriate sample size.

This year, the SWG received further information on the data collected thus far from the Greenlandic authorities which can be summarised as follows.

(1) Humpback whales (n=4). The average in kg $\pm$ SE:
  - meat: 4,823 $\pm$ 3,020;
  - mattak: 3,140 $\pm$ 1,282;
  - ventral grooves: 2,670 $\pm$ 454; and
  - total weight: 10,633 $\pm$ 4,217.

(2) Fin whales (n=2). The average in kg $\pm$ SE:
  - meat: 3,075 $\pm$ 955;
  - mattak: 1,998 $\pm$ 1,241;
  - ventral grooves: 1,238 $\pm$ 902; and
  - total weight: 6,311 $\pm$ 2,390.

(3) Bowhead whales (n=5). The average in kg $\pm$ SE:
  - total weight: 8,673 $\pm$ 2,127.

The SWG welcomed this information and the provision of data. It noted that a comparison of these values and the Recommended Conversion Factors Per Animal (RCPFA) from Donovan *et al.* (2010) showed reasonable agreement for humpback and bowhead whales (within 1 SD), but the yield for fin whales was lower than expected. It was not possible to examine this difference *inter alia* because no lengths of the animals included in the analysis were provided.

Although welcoming this information, the SWG expressed a number of concerns over the insufficient level of detail provided, the efficiency of the sampling regime (relatively poor sample sizes) and the extrapolation procedure in which only one meat tote or box is weighed.

In response to the concern over the lack of samples, Witting informed the SWG that the Greenland Institute of Natural Resources (GINR) has been asked to investigate this and is working with the hunters and authorities to improve the sample size in the future. The SWG greatly **encourages** this and looks forward to a report on progress made. It also encourages the GINR to develop improved protocols including weighing as many of the meat, mattak, and qiporaq bins as possible (i.e. not just 1 bin). Providing a breakdown of products from bowhead whales would be valuable both for conversion factors and biological information.

Given these concerns, the SWG **recommends**:

(1) the provision of a full scientific paper to the next Annual Meeting that details *inter alia* a full description of the field protocols and sampling strategy, analytical methods; and a presentation of the results thus far, including information on the sex and length of each of the animals for which weight data are available; and
(2) the collection and provision of data on Recommendation No. 2 of Donovan *et al.* (2010) comparing standard *vs.* curvilinear whale lengths. This should be done for all three species on as many whales as possible. Guidelines and protocols are suggested in Donovan *et al.* (2010).

9. WORK PLAN

The SWG draws attention to the following work identified in the report for completion intersessionally or at the 2013 Annual Meeting (note that item (7) was raised during review of report).

(1) Item 2.5.3. Present *Evaluation* and *Robustness Trial* results to the SWG of an *SLA* variant that corresponds exactly to the management plan proposed by the Makah Tribe to the US Government (co-ordinator: Brandon).
(2) Item 2.6. Present a revised document on the probability of a gray whale that regularly feeds in the western North Pacific being taken in a Makah hunt (Moore and Weller, with assistance from an advisory group comprising Brandon, Givens, Punt and Scordino).
(3) Item 4. Develop trial structures and operating models for the Greenland hunts of bowhead and humpback whales to be presented initially at an intersessional workshop (Punt – see Appendix 6).
(4) Item 4. Develop an AWMP/RMP-lite program to assist developers of *SLA*s for the Greenland hunts of fin and common minke whales (Punt – see Appendix 6).
(5) Item 4. Hold an intersessional Workshop to progress work on the development of *SLA*s for the Greenland hunts (estimated cost £8,000).
(6) Item 8. Present a full scientific paper on the work in Greenland related to the collection of information on conversion factors (co-ordinator: Witting; paper: Greenlandic authorities).
(7) Present a document that provides advice on the development of *SLA*s and their evaluation (co-ordinators: Donovan, Punt and Scordino).

10. ADOPTION OF REPORT

The Report was adopted at 18:00 on 19 June apart from Item 2.5.3 and Item 8 that were adopted by email at 09:15 on 20 June 2012. The Chair thanked the participants for their extremely hard work in completing a very full agenda, and especially Punt, Brandon, Butterworth, Givens and Scordino for their rapporteuring work and initial examination of trial results.

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Appendix 1

AGENDA

1. Introductory items
    - 1.1 Convenor's opening remarks
    - 1.2 Election of Chair
    - 1.3 Appointment of rapporteurs
    - 1.4 Adoption of agenda
    - 1.5 Documents available
2. *Implementation Review* of gray whales with emphasis on the PCFG
    - 2.1 Summary of intersessional Workshop
    - 2.2 New information
    - 2.3 Progress with intersessional tasks
    - 2.4 Finalise the specifications for the trials and presentation of results
    - 2.5 Review results of trials
        - 2.5.1 *Evaluation Trials*
        - 2.5.2 *Robustness Trials*
    - 2.6 Other business
3. *Implementation Review* for B-C-B bowhead whales
    - 3.1 Consideration of new information with a focus on whether this implies a need for new trials
        - 3.1.1 Stock structure
        - 3.1.2 Abundance and rate of increase
        - 3.1.2 Other
    - 3.2 Discussion of new trials
    - 3.3 Conclusions and recommendations
4. Consideration of work required to develop *SLA*s for all Greenland hunts before the end of the interim period
    - 4.1 Common minke whales
    - 4.2 Fin whales
    - 4.3 Humpback whales
    - 4.4 Bowhead whales
5. Implications of new information on broad gray whale stock structure (with BRG)
    - 5.1 Summary of relevant BRG discussions
    - 5.2 Conclusions with respect to *Implementation Review*
6. Annual review of management advice
    - 6.1 Common minke whales off West Greenland
        - 6.1.1 New information
        - 6.1.2 Management advice
    - 6.2 Common minke whales off East Greenland
        - 6.2.1 New information
        - 6.2.2 Management advice
    - 6.3 Fin whales off West Greenland
        - 6.3.1 New information
        - 6.3.2 Management advice
    - 6.4 Humpback whales off West Greenland
        - 6.4.1 New information
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    - 6.5 Humpback whales off St Vincent and The Grenadines
        - 6.5.1 New information
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    - 6.6 Implications of possible move to biennial meetings with respect to length of block quotas
7. Aboriginal Whaling Management Scheme
    - 7.1 Draft guidelines for *Implementation Reviews*
    - 7.2 Scientific aspects of an Aboriginal Whaling Scheme
8. Progress on follow-up work on conversion factors for the Greenlandic hunt
9. Work plan
10. Adoption of report

Appendix 2

TRIALS SPECIFICATIONS

This document outlines a set of trials to evaluate the performance of *SLA*s for hunting in the Pacific Northwest, with a primary focus on the PCFG (Pacific Coast Feeding Group). The operating model assumes the two groups (the 'north' group and the PCFG) are separate stocks, but with possible immigration of 'north' group animals into the PCFG group. The operating model considers four strata (north of 52°N, south of 41°N, PCFG December-May, and PCFG June-November) because the relative vulnerability of the two stocks to whaling and incidental mortality differs among these strata.

A. The population dynamics model

The underlying population dynamics model is deterministic, age- and sex-structured, and based on a two-stock version of the Baleen II model (Punt, 1999).

A.1 Basic dynamics

Equation A1.1 provides the underlying 1+ dynamics.

$$\begin{aligned}
R^{s,m/f}_{t+1,a+1} &= (R^{s,m/f}_{t,a} + I^{s,m/f}_{t,a} - C^{s,m/f}_{t,a})\,\tilde{S}^s_t\,S^s_a + U^{s,m/f}_{t,a}\,\tilde{S}^s_t\,S^s_a\,\delta_{a+1} && 0 \le a \le x-2 \\
R^{s,m/f}_{t+1,x} &= (R^{s,m/f}_{t,x} + I^{s,m/f}_{t,x} - C^{s,m/f}_{t,x})\,\tilde{S}^s_t\,S^s_x + (R^{s,m/f}_{t,x-1} + I^{s,m/f}_{t,x-1} - C^{s,m/f}_{t,x-1})\,\tilde{S}^s_t\,S^s_{x-1} && \\
U^{s,m/f}_{t+1,a+1} &= U^{s,m/f}_{t,a}\,\tilde{S}^s_t\,S^s_a\,(1-\delta_{a+1}) && 0 \le a \le x-2
\end{aligned} \qquad \text{(A1.1)}$$

$R^{s,m/f}_{t,a}$ is the number of recruited males/females of age a in stock s at the start of year t;

$U^{s,m/f}_{t,a}$ is the number of unrecruited males/females of age a in stock s at the start of year t;

$C^{s,m/f}_{t,a}$ is the catch of males/females of age a from stock s during year t (whaling is assumed to take place in a pulse at the start of each year);

δ_a is the fraction of unrecruited animals of age a-1 which recruit at age a (assumed to be independent of sex, time, and stock);

S^s_a is the annual survival rate of animals of stock s and age a in the absence of catastrophic mortality events (assumed to be the same for males and females):

$$S^s_a = \begin{cases} S^s_0 & \text{if } a = 0 \\ S^s_{1+} & \text{if } 1 < a \end{cases} \qquad \text{(A1.2)}$$

S^s_0 is the calf survival rate for animals of stock s;

S^s_{1+} is the survival rate for animals aged 1 and older for animals of stock s;

$\tilde{S}^s_t$ is the amount of catastrophic mortality (represented in the form of a survival rate) for stock s during year t (catastrophic events are assumed to occur at the start of the year before mortality due to whaling and natural causes; in general $\tilde{S}^s_t$=1, i.e. there is no catastrophic mortality);

$I^{s,m/f}_{t,a}$ is the net migration of female/male animals of age a into stock s during year t; and

x is the maximum (lumped) age-class (all animals in this and the x-1 class are assumed to be recruited and to have reached the age of first parturition). x is taken to be 15 for these trials.

Catastrophic mortality is assumed to be zero (i.e., $\tilde{S}^s_t$=1) except for the north stock for 1999 and 2000 when it is assumed to be equal to the parameter $\tilde{S}$. This assumption reflects the large number of dead ENP gray whales observed stranded along the coasts of Oregon and Washington during 1999 and 2000 relative to annual numbers stranding there historically (Brownell *et al.*, 2007; Gulland *et al.*, 2005). The mortality event is assumed to have only impacted the north stock because the abundance estimates for the PCFG stock increased when the mortality event occurred, in contrast to those for the north stock which declined substantially.

Immigration only occurs from the north stock to the PCFG stock and only animals aged 1+ immigrate. The annual number of animals immigrating is either $\bar{I}_t = I\, N^{\text{north},1+}_t/20{,}000$ where $\bar{I}$ is the hypothesized recent average number of individuals recruiting into the PCFG from the north stock (i.e., 2, 4 or 6) or a fixed level (0, 10, 20 or 30). The annual number of immigrants by age and sex is given by:

$$I^{s,m/f}_{t,a} = I_t \frac{(R^{\text{north,m/f}}_{t,a} + U^{\text{north,m/f}}_{t,a})}{N^{\text{north},1+}_t} \qquad \text{(A1.3)}$$

Emigration from the PCFG stock is modelled by implementing an extra survival rate, S after 1930 (immigration or emigration are ignored when carrying capacity and the parameters which determine the productivity of the population are calculated). Owing to the different sizes of the two stocks, emigrants from the PCFG stock are assumed to die rather than join the north stock. The value of $\tilde{\tilde{S}}$ is set so that at carrying capacity immigration and emigration are balanced, i.e.:

$$\overline{I}\, K_{1+}^{\text{north}} = K_{0+}^{\text{PCFG}}(1-\tilde{\tilde{S}}) \tag{A1.4}$$

A.2 Births

The number of births to stock s at the start of year t+1, B^s_{t+1}, is given by:

$$B_{t+1}^{s} = b_{t+1}^{s}\, N_{t+1}^{s,f} \tag{A2.1}$$

$N_t^{s,f}$ is the number of mature females in stock s at the start of year t:

$$N_t^{s,f} = \sum_{a=a_m}^{x} (R_{t,a}^{s,f} + U_{t,a}^{s,f}) \tag{A2.2}$$

a_{m} is the age-at-maturity (the convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition);

b_{t+1}^{s} is the probability of birth/calf survival for mature females:

$$b_{t+1}^{s} = b_{-\infty}^{s}\{1 + A^s(1-(D_{t+1}^{s}/D_{-\infty}^{s})^{z^s})\} \tag{A2.3}$$

$b_{-\infty}^{s}$ is the average number of live births per year per mature female in the pristine (pre-exploitation) population for stock s;

A^s is the resilience parameter for stock s;

z^s is the degree of compensation for stock s;

D_t^s is the size of the component of stock s in year t upon which the density-dependence is assumed to act; and

$D_{-\infty}^{s}$ is the pristine size of the component of stock s upon which the density-dependence is assumed to act.

The number of female births, $B_t^{s,f}$, is computed from the total number of the births during year t according to the equation:

$$B_t^{s,f} = 0.5\, B_t^s \tag{A2.4}$$

The numbers of recruited/unrecruited calves is given by:

$$\begin{aligned} R_t^{s,f} &= \pi_0\, B_t^{s,f} & R_t^{s,m} &= \pi_0\,(B_t^s - B_t^{s,f}) \\ U_t^{s,f} &= (1-\pi_0)\, B_t^{s,f} & U_t^{s,m} &= (1-\pi_0)(B_t^s - B_t^{s,f}) \end{aligned} \tag{A2.5}$$

π_0 is the proportion of animals of age 0 which are recruited (0 for these trials).

For the trials $D_t^s = N_t^{s,1+}$ and $D^s_{-\infty} = K^s_{1+}$ because density-dependence is assumed to act on the 1+ component of the population and affects fecundity and infant survival. $N_t^{s,1+}$ and K^s_{1+} are defined according to the equations:

$$N_t^{s,1+} = \sum_{a=1}^{x}(R_{t,a}^{s,\text{f}} + U_{t,a}^{s,\text{f}} + R_{t,a}^{s,\text{m}} + U_{t,a}^{s,\text{m}}) \qquad K_{1+}^{s} = \sum_{a=1}^{x}(R_{-\infty,a}^{s,\text{f}} + U_{-\infty,a}^{s,\text{f}} + R_{-\infty,a}^{s,\text{m}} + U_{-\infty,a}^{s,\text{m}}) \tag{A2.6}$$

A.3 Catches

The historical (t<2010) catches by stratum (north, south, PCFG December-May, and PCFG June-November) are taken to be equal to the reported catches (Table 1). The historical catches are allocated to stocks in fixed proportions as follows:

- North area catches: all north animals;
- PCFG area catches in December-May: PCFG animals with probability ϕ_{PCFG} - base-case value 0.3, as determined by the photo-ID data (Calambokidis *et al.*, 2012);
- PCFG area catches in June-November: all PCFG animals; and
- South area catches: PCFG animals with probability ϕ_{south} (base-case value 0.01, as determined by relative abundance).

Table 1
Historical catches of eastern north Pacific gray whales.

	South			PCFG Jun.-Nov.			PCFG Dec.-May			North			Total		
Year	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
1930	0	0	0	0	0	0	0	0	0	23	24	47	23	24	47
1931	0	0	0	0	0	0	0	0	0	5	5	10	5	5	10
1932	5	5	10	0	0	0	0	0	0	5	5	10	10	10	20
1933	30	30	60	0	0	0	0	0	0	8	7	15	38	37	75
1934	30	30	60	0	0	0	0	0	0	36	30	66	66	60	126
1935	55	55	110	0	0	0	0	0	0	16	28	44	71	83	154
1936	43	43	86	0	0	0	0	0	0	50	62	112	93	105	198
1937	0	0	0	0	0	0	0	0	0	12	12	24	12	12	24
1938	0	0	0	0	0	0	0	0	0	32	32	64	32	32	64
1939	0	0	0	0	0	0	0	0	0	19	20	39	19	20	39
1940	0	0	0	0	0	0	0	0	0	56	69	125	56	69	125
1941	0	0	0	0	0	0	0	0	0	38	39	77	38	39	77
1942	0	0	0	0	0	0	0	0	0	60	61	121	60	61	121
1943	0	0	0	0	0	0	0	0	0	59	60	119	59	60	119
1944	0	0	0	0	0	0	0	0	0	3	3	6	3	3	6
1945	0	0	0	0	0	0	0	0	0	25	33	58	25	33	58
1946	0	0	0	0	0	0	0	0	0	14	16	30	14	16	30
1947	0	0	0	0	0	0	0	0	0	11	20	31	11	20	31
1948	0	0	0	0	0	0	0	0	0	7	12	19	7	12	19
1949	0	0	0	0	0	0	0	0	0	10	16	26	10	16	26
1950	0	0	0	0	0	0	0	0	0	4	7	11	4	7	11
1951	0	0	0	0	0	0	1	0	1	5	8	13	6	8	14
1952	0	0	0	0	0	0	0	0	0	17	27	44	17	27	44
1953	0	0	0	0	0	0	6	4	10	15	23	38	21	27	48
1954	0	0	0	0	0	0	0	0	0	14	25	39	14	25	39
1955	0	0	0	0	0	0	0	0	0	22	37	59	22	37	59
1956	0	0	0	0	0	0	0	0	0	45	77	122	45	77	122
1957	0	0	0	0	0	0	0	0	0	36	60	96	36	60	96
1958	0	0	0	0	0	0	0	0	0	55	93	148	55	93	148
1959	1	1	2	0	0	0	0	0	0	73	121	194	74	122	196
1960	0	0	0	0	0	0	0	0	0	58	98	156	58	98	156
1961	0	0	0	0	0	0	0	0	0	77	131	208	77	131	208
1962	4	0	4	0	0	0	0	0	0	55	92	147	59	92	151
1963	0	0	0	0	0	0	0	0	0	68	112	180	68	112	180
1964	15	5	20	0	0	0	0	0	0	75	124	199	90	129	219
1965	0	0	0	0	0	0	0	0	0	71	110	181	71	110	181
1966	15	11	26	0	0	0	0	0	0	80	114	194	95	125	220
1967	52	73	125	0	0	0	0	0	0	109	140	249	161	213	374
1968	41	25	66	0	0	0	0	0	0	48	87	135	89	112	201
1969	39	35	74	0	0	0	0	0	0	50	90	140	89	125	214
1970	0	0	0	0	0	0	0	0	0	71	80	151	71	80	151
1971	0	0	0	0	0	0	0	0	0	57	96	153	57	96	153
1972	0	0	0	0	0	0	0	0	0	61	121	182	61	121	182
1973	0	0	0	0	0	0	0	0	0	97	81	178	97	81	178
1974	0	0	0	0	0	0	0	0	0	94	90	184	94	90	184
1975	0	0	0	0	0	0	0	0	0	58	113	171	58	113	171
1976	0	0	0	0	0	0	0	0	0	69	96	165	69	96	165
1977	0	0	0	0	0	0	0	0	0	87	100	187	87	100	187
1978	0	0	0	0	0	0	0	0	0	94	90	184	94	90	184
1979	0	0	0	0	0	0	0	0	0	58	125	183	58	125	183
1980	0	0	0	0	0	0	0	0	0	53	129	182	53	129	182
1981	0	0	0	0	0	0	0	0	0	36	100	136	36	100	136
1982	0	0	0	0	0	0	0	0	0	57	111	168	57	111	168
1983	0	0	0	0	0	0	0	0	0	46	125	171	46	125	171
1984	0	0	0	0	0	0	0	0	0	59	110	169	59	110	169
1985	0	0	0	0	0	0	0	0	0	54	116	170	54	116	170
1986	0	0	0	0	0	0	0	0	0	46	125	171	46	125	171
1987	0	0	0	0	0	0	0	0	0	48	111	159	48	111	159
1988	0	0	0	0	0	0	0	0	0	43	108	151	43	108	151
1989	0	0	0	0	0	0	0	0	0	61	119	180	61	119	180
1990	0	0	0	0	0	0	0	0	0	67	95	162	67	95	162
1991	0	0	0	0	0	0	0	0	0	67	102	169	67	102	169
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	21	23	44	21	23	44
1995	0	0	0	0	0	0	0	0	0	48	44	92	48	44	92
1998	0	0	0	0	0	0	0	0	0	64	61	125	64	61	125
1999	0	0	0	0	0	0	0	1	1	69	54	123	69	55	124
2000	0	0	0	0	0	0	0	0	0	63	52	115	63	52	115

Cont.

	South			PCFG Jun.-Nov.			PCFG Dec.-May			North			Total		
Year	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
Table 1 cont.															
1996	0	0	0	0	0	0	0	0	0	18	25	43	18	25	43
1997	0	0	0	0	0	0	0	0	0	48	31	79	48	31	79
2001	0	0	0	0	0	0	0	0	0	62	50	112	62	50	112
2002	0	0	0	0	0	0	0	0	0	80	51	131	80	51	131
2003	0	0	0	0	0	0	0	0	0	71	57	128	71	57	128
2004	0	0	0	0	0	0	0	0	0	43	68	111	43	68	111
2005	0	0	0	0	0	0	0	0	0	49	75	124	49	75	124
2006	0	0	0	0	0	0	0	0	0	57	77	134	57	77	134
2007	0	0	0	0	1	1	0	0	0	50	81	131	50	82	132
2008	0	0	0	0	0	0	0	0	0	64	66	130	64	66	130
2009	0	0	0	0	0	0	0	0	0	59	57	116	59	57	116
2010	0	0	0	0	0	0	0	0	0	57	61	118	57	61	118

The future catches by stratum are incidental catches and the catches arising from application of the *SLA*s. Subsistence catches are only assumed to occur in the north and the PCFG area from December-May. The sex-ratio of future catches is assumed to be 50:50 except for a sub-set of the robustness trials. The catches are allocated to stock as outlined above, except that the subsistence catches from the PCFG area in June-November are modelled individually. Thus, the catch from the PCFG area is allocated to the PCFG stock based on Bernoulli trials with probability:

$$\frac{\sum_{\text{m/f}}\sum_{a'} R_{y,a'}^{\text{PCFG,m/f}}}{\delta\sum_{\text{m/f}}\sum_{a''} R_{y,a''}^{\text{north,m/f}} + \sum_{\text{m/f}}\sum_{a''} R_{y,a''}^{\text{PCFG,m/f}}} \tag{A3.1}$$

where δ is the relative probability of harvesting a PCFG versus a north animal had the sizes of the two populations been the same. δ is calculated from ϕ under the assumption that the number of PCFG animals is 200 and north animals is 20,000, i.e.:

$$\delta=(200 / \phi) - 200 / 20{,}000 \tag{A3.2}$$

The incidental catches by stratum for the historical period are computed using the equation:

$$C_y^{\text{I}/s} = 0.5\begin{cases}\left\{1-\frac{0.5}{69}[1999-y]\right\}\bar{C}^I & \text{if } y \le 1999\\ \bar{C}^I N_y^{1+} / \bar{N}^{1+} & \text{otherwise}\end{cases} \tag{A3.3}$$

$C_y^{\text{I}/s}$ is the incidental catch of animals of sex s during year y;
$\bar{C}^I$ is the mean catch in the stratum (see Table 2); and
$\bar{N}^{1+}$ is the mean 1+ abundance (in the stratum concerned from 2000-09).

The catches from the PCFG and north stocks are then allocated to age and size using the formula:

$$C_{t,a}^{s,m} = C_t^{s,m} R_{y,a}^{s,m} / \sum_{a''} R_{y,a''}^{s,m};\quad C_{t,a}^{s,\text{f}} = C_t^{s,\text{f}} R_{y,a}^{s,\text{f}} / \sum_{a''} R_{y,a''}^{s,\text{f}}; \tag{A3.4}$$

The probability of not identifying a PCFG whale as such, is p_2, (base-case value 0) while the probability of incorrectly identifying a north whale as a PCFG whale is p_1 (base-case 0.01). If the survey frequency for the PCFG area is not annual, p_2 is defined as:

$$p_{2,t} = 1-\frac{\sum_{a\ge SF}(R_{t,a}^{\text{north,m}} + R_{t,a}^{\text{north,f}} + U_{t,a}^{\text{north,m}} + U_{t,a}^{\text{north,f}})}{\sum_{a\ge 1}(R_{t,a}^{\text{north,m}} + R_{t,a}^{\text{north,f}} + U_{t,a}^{\text{north,m}} + U_{t,a}^{\text{north,f}})} \tag{A3.5}$$

where *SF* is the survey frequency for the PCFG area.

Stratum	Average incidental catch
North	0[1]
PCFG [Dec.-May]	2
PCFG [Jun.-Nov.]	1.4[2]
South	3.4

[1]Obviously not actually zero, but will be small relative to population size.
[2]Includes southern whales during June-November as these whales are almost certainly PCFG animals.

A.4 Recruitment

The proportion of animals of age *a* that would be recruited if the population was pristine is a knife-edged function of age at age 0, i.e.:

$$\pi_a = \begin{cases} 0 & \text{if} \quad a = 0 \\ 1 & \text{otherwise} \end{cases} \tag{A4.1}$$

The (expected) number of unrecruited animals of age *a* that survive to age *a*+1 is $U^{s,m/f}_{t,a}\ S_a$. The fraction of these that then recruit is:

$$\delta_{a+1} = \begin{cases} [\pi_{a+1} - \pi_a]/[1-\pi_a] & \text{if } 0 \le \pi_a < 1 \\ 1 & \text{otherwise} \end{cases} \tag{A4.2}$$

A.5 Maturity

Maturity is assumed to be a knife-edged function of age at age a_m.

A.6 Initialising the population vector

The numbers at age in the pristine population are given by:

$$\begin{aligned} R^{s,\mathrm{m/f}}_{-\infty,a} &= 0.5\ \ N^s_{-\infty,0}\ \ \pi_a \prod_{a'=0}^{a-1} S^s_{a'} && \text{if} \quad 0 \le a < x \\ U^{s,\mathrm{m/f}}_{-\infty,a} &= 0.5\ \ N^s_{-\infty,0}\ \ (1-\pi_a) \prod_{a'=0}^{a-1} S^s_{a'} && \text{if} \quad 0 \le a < x \\ R^{s,\mathrm{m/f}}_{-\infty,x} &= 0.5\ \ N^s_{-\infty,0} \prod_{a'=0}^{x-1} \frac{S^s_{a'}}{(1-S_x)} && \text{if} \quad a = x \end{aligned} \tag{A6.1}$$

$R^{s,\mathrm{m/f}}_{-\infty,a}$ is the number of animals of stock *s* of age *a* that would be recruited in the pristine population;

$U^{s,\mathrm{m/f}}_{-\infty,a}$ is the number of animals of stock *s* of age *a* that would be unrecruited in the pristine population; and

$N^s_{-\infty,0}$ is the total number of animals of stock *s* of age 0 in the pristine population.

The value for $N^s_{-\infty,0}$ is determined from the value for the pre-exploitation size of the 1+ component of the population using the equation:

$$N^s_{-\infty,0} = K^s_{1+} \Bigg/ \left(\sum_{a'=1}^{x-1} \prod_{a'=1}^{a-1} S^s_a + \frac{1}{1-S_x} \prod_{a'=0}^{x-1} S^s_{a'} \right) \tag{A6.2}$$

It is well-known that it is not possible to make a simple density-dependent population dynamics model consistent with the abundance estimates for the eastern north Pacific stock of gray whales (Butterworth *et al.*, 2002; Cooke, 1986; Lankester and Beddington, 1986; Reilly, 1981; 1984). This is why recent assessments of this stock (Punt and Wade, 2012) have been based on starting population projections from a more recent year (denoted as τ) than that in which the first recorded catch occurred. The trials are therefore based on the assumption that the age-structure at the start of τ=1930 is stable rather than that the population was at its pre-exploitation equilibrium size at the start of 1600, the first year for which catch estimates are available. The choice of 1930 for the first year of the simulation is motivated by the fact that the key assessment results are not sensitive to a choice for this year from 1930-68 (Punt and Butterworth, 2002; Punt and Wade, 2012). Note that even though the operating model ignores the catch data for 1600-1929, these catches are nevertheless provided to the *SLA* for the north area.

The determination of the age-structure at the start of 1930 involves specifying the effective 'rate of increase', γ, that applies to each age-class. There are two components contributing to γ, one relating to the overall population rate of increase (γ^+) and the other to the exploitation rate. Under the assumption of knife-edge recruitment to the fishery at age 1, only the γ^+ component (assumed to be zero following Punt and Butterworth, 2002) applies to ages a of age 0. The number of animals of age a at the start of τ=1930 relative to the number of calves at that time, $N^{s,*}_{\tau,a}$, is therefore given by the equation:

$$N^{s,*}_{\tau,a} = \begin{cases} 1 & \text{if } a = 0 \\ N^{s,*}_{\tau,0}\, S^s_0 & \text{if } a \le 1 \\ N^{s,*}_{\tau,a-1}\, S^s_{a-1}\,(1-\gamma^+) & \text{if } 1 < a < x \\ N^{s,*}_{\tau,x-1}\, S^s_{x-1}(1-\gamma^+)/(1-S^s_x(1-\gamma^+)) & \text{if } a = x \end{cases} \tag{A6.3}$$

B^s_τ is the number of calves in year τ (=1930) and is derived directly from equations A2.1 and A2.3 (for further details see Punt, 1999):

$$B^s_\tau = \left(1 - \left[1/(N^{s,f}_\tau b^s_{-\infty}) - 1\right]/A^s\right)^{1/z^s} \frac{D^s_{-\infty}}{D^{s,*}_\tau} \tag{A6.4}$$

$D^{s,*}_\tau$ is the number of animals in the density-dependent component of the population relative to the number of births at that time (see equation A2.6).

The effective rate of increase, γ^s, is selected so that if the population dynamics model is projected from 1930 to 1968, the size of the 1+ component of the population (both stocks) in 1968 equals a pre-specified value, P^s_{1968}.

A.7 z and A

A^s, z^s and S^s_0, are obtained by solving the system of equations that relate $MSYL^s_{1+}$, $MSYR^s_{1+}$, S^s_0, S_{1+}, $f_{\max}$ a_m, A^s and z^s, where $f_{\max}$ is the maximum theoretical pregnancy rate (Punt, 1999).

A.8 Conditioning

The method for conditioning the trials (i.e. selecting the 100 sets of values for the parameters a_m, S^s_0, S_{1+}, S, K^{north}_{1+}, K^{PCFG}_{1+}, A^{north}, A^{PCFG}, z^{north}, and z^{PCFG}) is based on a Bayesian assessment of the eastern North Pacific stock of gray whales (Punt and Butterworth, 2002; Punt and Wade, 2012; Wade, 2002). The algorithm for conducting the Bayesian assessment is as follows:

Draw values for the parameters S_{1+}, $f_{\max}$, a_m, K^{north}_{1+}, K^{PCFG}_{1+}, P^{north}_{1968}, P^{PCFG}_{1968}, $\tilde{S}$, CV^{north}_{add} (the additional variance for the estimates of 1+ abundance at Carmel, California in 1968), CV^{PCFG}_{add} (the additional variance for the estimates of 1+ abundance from northern California to southeast Alaska in 1968, had such a survey taken place) from the priors in Table 3. It is not necessary to draw values for $MSYL^s_{1+}$ and $MSYR^s_{1+}$ because the values for these quantities are pre-specified rather than being determined during the conditioning process.

Solve the system of equations that relate $MSYL^s_{1+}$, $MSYR^s_{1+}$, S^s_0, S_{1+}, $f_{\max}$, a_m, A^s and z^s to find values for S^s_0, A^s and z^s.

Calculate the likelihood of the projection for each area, given by[1]:

$$-\ell nL = 0.5\ell n\,|\mathbf{V}+\Omega| + 0.5\sum_i\sum_j (\ell n N^{\text{obs}}_i - \ell n\hat{P}^{1+}_i)[(\mathbf{V}+\Omega)^{-1}]_{i,j}(\ell n N^{\text{obs}}_j - \ell n\hat{P}^{1+}_j) \tag{A8.1}$$

N^{obs}_i is the i^{th} estimate of abundance[2] (Tables 4a, 4b),

$\hat{P}^{1+}_i$ is the model-estimate corresponding to N^{obs}_i,

$\mathbf{V}$ is the variance-covariance matrix for the abundance estimates, and

Ω is a diagonal matrix with elements given by $E(CV^2_{add,t})$:

$$E(CV^2_{add,t}) = CV^2_{add}\,\frac{0.1 + 0.013P^*/\hat{P}_t}{0.1 + 0.013P^*/\hat{P}_{1968}} \tag{A8.2}$$

Steps (a)-(c) are repeated a large number (typically 1,000,000) of times.

[1]This formulation assumes that the observed data relate to the medians of sampling distributions for the data. Alternative assumptions (such as that the observed data relate to the means of the sampling distribution) will be inconsequential given the extent of uncertainty associated with the estimates of abundance.

[2]The shore-based abundance estimate for year y/y+1 is assumed to pertain to abundance at the start of year y+1.

100 sets of parameters vectors are selected randomly from those generated using steps (a)-(c), assigning a probability of selecting a particular vector proportional to its likelihood. The number of times steps (a)-(c) are repeated is chosen to ensure that each of the 100 parameter vectors are unique.

The expected value for the estimate of abundance of the north area is taken to the total 1+ abundance (PCFG and north stocks combined) while the abundance estimates for the PCFG area are assumed to pertain to the PCFG stock only.

Table 3

The prior distributions for the eastern north Pacific stock of gray whales.

Parameter	Prior distribution
Non-calf survival rate, S_{1+}	U[0.95, 0.99]
Age-at-maturity, a_m	U[6, 12]
K_{1+}^{north}	U[16,000, 70,000]
K_{1+}^{PCFG}	U[100, 500]
Maximum pregnancy rate, f_{max}	U[0.3, 0.6]
Additional variation (population estimates) CV_{add}, in 1968	U[0, 0.35]
1968 abundance, P_{1968}^{north}	U[8,000, 16,000]
1968 abundance, P_{1968}^{PCFG}	U[50, 300]
Catastrophic mortality, $\tilde{S}$	U[0.5,1.0]

B. Data generation

B.1 Absolute abundance estimates

The historic (t<2011) abundance estimates (and their CVs) are provided to the *SLA*s and are taken to be those in Tables 4a, 4c. Future estimates of absolute abundance (and their estimated CVs) are generated and provided to the *SLA* once every F years during the management period (starting in year 2011 where the default values for F are 10 for the northern area and F=1 for the PCFG area). The CV of the abundance estimate (CV_{true}) may differ from the CV provided to the *SLA* (further details are provided below).

The survey estimate, $\hat{S}$, may be written as:

$$\hat{S} = B_A P Y w / \mu = B_A P^* \beta^2 Y w \tag{B1.1}$$

B_A is the bias (the bias for the bulk of the simulations for the north area is 1 while the bias for PCFG area is generated from $\ell n B_A \sim N(-0.305, 0.108)$ – this bias reflects the difference between the abundance estimates on which the ABL is based [which pertain to Oregon to Southern Vancouver Island] and the abundance of the entire stock];

P is the current total 1+ population size ($= N_t^{1+}$); (B1.2)

Y is a lognormal random variable: $Y = e^{\phi}$ where: $\phi \sim N[0; \sigma_\phi^2]$ and $\sigma_\phi^2 = \ell n(1+\alpha^2)$ (B1.3)

w is a Poisson random variable, independent of Y, with $E(w) = \text{var}(w) = \mu = (P / P^*) / \beta^2$; and (B1.4)

P^* is the reference population level (the pristine 1+ population, $= K^{1+}$).

The steps used in the program to generate the abundance estimates and their CVs are given below[3].

The *SLA* is provided with estimates of CV_{est} (the estimation error associated with factors considered historically) for each future sightings estimate. The estimate of $CV_{est,t}$ is given by:

$$\hat{C}V_{est,t} = \sqrt{\sigma_t^2 (\chi_n^2 / n)} \qquad \sigma_t^2 = \ell n(1+E(CV_{est,t}^2)) \tag{B1.5}$$

$E(CV_{est,t}^2)$ is the sum of the squares of the actual CVs due to estimation error:

$$E(CV_{est,t}^2) = \theta^2 (a^2 + b^2 / w\beta^2) \tag{B1.6}$$

[3]The steps used to generate estimates of abundance and their CVs are as follows (steps (i)-(iii) are part of the conditioning process).

(i) Read in CV_{est}. Generate values of CV^2_{add} for 1968.

(ii) Set η using equation B1.6b and the value of CV_{add} generated in step (i).

(iii) Set θ^2 using equation B1.7a and the values for CV_{est} from step (i) and $w\beta^2 = P/P^* = P_{1968} / P^*$. Set α^2 and β^2 using equation B1.8.

(iv) Generate w (Poisson random variable – see equation B1.4) and ϕ (lognormal random variable – see equation B1.3).

(v) Set abundance estimate $\hat{S}$ using equation B1.1.

(vi) Set $E(CV^2_{est,t})$ using eqn B1.6a.

(vii) Generate $CV_{est,t}$ from χ^2_n distribution using equation B1.5.

χ^2_n is a random number from a χ^2 distribution with n (=19; the value assumed for the single stock trials for the RMP) degrees of freedom;

a^2, b^2 are constants and equal to 0.02 and 0.012 respectively;

The relationship between CV_{est} and CV_{true} is given by:

$$\eta = [E(CV^2_{true}) - E(CV^2_{est})] / (0.1 + 0.013P^* / P) \quad \text{(B1.7a)}$$

where η is a constant known as the additional variance factor. The value of η is based on the population size and CVs for 1968 (for consistency with the way the CV for P_{1968} is generated in Table 3):

$$\eta = CV^2_{add} / (0.1 + 0.013P^* / P_{1968}) \quad \text{(B1.7b)}$$

The values of α and β are then computed as:

$$\alpha^2 = \theta^2 a^2 + \eta\, 0.1\,, \qquad \beta^2 = \theta^2 b^2 + \eta\, 0.013 \quad \text{(B1.8)}$$

Table 4a

Estimates of absolute abundance (with associated standard errors) for the eastern north Pacific stock of gray whales based on shore counts (source: table 9 in Laake *et al.*, 2012).

Year	Estimate	CV	Year	Estimate	CV
1967/68	13,426	0.094	1979/80	19,763	0.083
1968/69	14,548	0.080	1984/85	23,499	0.089
1969/70	14,553	0.083	1985/86	22,921	0.081
1970/71	12,771	0.081	1987/88	26,916	0.058
1971/72	11,079	0.092	1992/93	15,762	0.067
1972/73	17,365	0.079	1993/94	20,103	0.055
1973/74	17,375	0.082	1995/96	20,944	0.061
1974/75	15,290	0.084	1997/98	21,135	0.068
1975/76	17,564	0.086	2000/01	16,369	0.061
1976/77	18,377	0.080	2001/02	16,033	0.069
1977/78	19,538	0.088	2006/07	19,126	0.071
1978/79	15,384	0.080			

Table 4b

Estimates of absolute abundance (with associated CVs) for 41°-52°N (source: J. Laake, pers. commn).

Year	Estimate	CV	Year	Estimate	CV
1998	101	0.062	2005	206	0.109
1999	135	0.089	2006	190	0.099
2000	141	0.093	2007	183	0.126
2001	172	0.073	2008	191	0.084
2002	189	0.048	2009	185	0.125
2003	200	0.082	2010	186	0.100
2004	206	0.072			

Table 4c

Estimates of absolute abundance (with associated CVs) for the Oregon to Southern Vancouver Island (source: J. Laake, pers. commn).

Year	Estimate	CV	Year	Estimate	CV
1998	63	0.066	2005	162	0.097
1999	78	0.107	2006	154	0.099
2000	89	0.133	2007	152	0.095
2001	117	0.076	2008	150	0.083
2002	133	0.113	2009	146	0.102
2003	151	0.090	2010	143	0.116
2004	157	0.098			

C. Need

The level of need in each year, Q_t, will be supplied to the *SLA*s. The need is given by $Q_t = Q_{2011} + \frac{t - 2011}{100}(Q_{2111} - Q_{2011})$ where Q_{2011} (=150 for the north area and =7 for the PCFG area) is the need at the start of the first year in which the AWMP is applied and Q_{2111} is the value 100 years later.

D. Implementing the Makah harvest regime

The overall application of the Makah management regime is as follows:

- compute the ABL (Allowable Bycatch Limit of PCFG whales);
- strike an animal;
- if the animal is struck and lost in December-April[4]:
  - o if the total number of struck and lost animals is 3, stop the hunt;
  - o if the total number of struck animals equals the need of 7 stop the hunt;

If the animal is struck-and lost in May:

- add one to the number of whales counted towards the ABL;
- if the ABL is reached; stop the hunt;
- if the total number of struck and lost animals is 3, stop the hunt;
- if the total number of struck animals equals the need of 7; stop the hunt;

If the animal is landed and is matched against the catalogue[5]:

- add one to the number of whales counted towards the ABL;
- if the ABL is reached; stop the hunt;
- if the total number of landed whales equals 5; stop the hunt;
- if the total number of struck animals equals the need of 7; stop the hunt;
- if the number of landed whales for the current five-year block equals 20; stop the hunt;

If the animal is landed and does not match any whale in the catalogue:

- if the total number of landed whales equals 5; stop the hunt;
- if the total number of struck animals equals the need of 7; stop the hunt;
- if the number of landed whales for the current five-year block equals 20; stop the hunt;

The base-case and the 10 alternative variants are listed in Table 5.

Table 5

The Makah Tribe's proposed hunt and suggested Variants for evaluation noting which management measure is altered as compared to the Makah Tribe's proposed management plan.

Variant number	Bycatch limit	Modelled time period of hunt	Availability of PCFG
Makah proposal	ABL formula	December to April	Trial specified
2	ABL formula	May only	Trial specified
3	ABL formula	May only	PCFG=100%
4	1	December to April	Trial specified
5	1	May only	Trial specified
6	1	May only	PCFG=100%
7	2	December to April	Trial specified
8	2	May only	Trial specified
9	2	May only	PCFG=100%
10	No limit	December to May	Trial specified
11	No limit	May only	PCFG=100%

E. Trials

There three 'broad' hypotheses to capture possible reasons for the trend in the abundance data for the PCFG area:

- The 1998 abundance estimate is biased due to 'discovery', and 20 whales immigrated into the PCFG stock from the northern stock in each of 1999 and 2000 (hypothesis 'P').
- There has been no pulse immigration into the PCFG stock; rather the abundance estimates are subject to time-varying bias (Table 6) (hypothesis 'B').
- Ten whales immigrated into the PCFG stock from the northern stock in each of 1999 and 2000 and the abundance estimates are subject to time-varying bias (but not the extent as for hypothesis P; Table 6) (hypothesis 'I').

Table 6

Bias for the 'B' and 'I' hypotheses.

Year	Hypothesis B	Hypothesis I
1998	0.513	0.7565
1999	0.631	0.8155
2000	0.750	0.8750
2001	0.869	0.9345
2002	0.988	0.9940
2003+	1.000	1.0000

[4]Whether a whale is struck and lost is determined from a Bernoulli trial with probability 0.5 (base-case).

[5]PCFG whales are mismatched as north stock whales with probability p_2 while north stock whales are matched to the catalogue with probability p_1.

Table 7 lists all of the factors considered in the trials. Table 8 summarises the trials. Note that some trials do not apply to some of the 'broad' hypotheses. Table 8 also indicates which trials need to be conditioned.

Table 7

Details of factors considered in trials.

Factors	Levels (reference levels shown bold and underlined)
MSYR $_{1+}$ (north)	**2%**, **4.5%**
MSYR $_{1+}$ (PCFG)	**1%**, **2%**, **4.5%**
Immigration rate (annual)	**0, 1, 2**, 4, 6
Pulse immigration (1999/2000)	**0**, 10, **20**, 30
Proportion of PCFG whales in PCFG area, ϕ_{fut}	0, **0.3**, 0.6, 1
Struck and lost rate (PCFG area)	0, **50%**, 75%
Northern need in final year (linear change from 150 in 2010)	**340**, 530
Historic survey bias	**None/Appendix 2, Table 6**, increasing between 1967 to 2002 from 0.5→1 (north only) 50% (PCFG only)
Future episodic events[1]	**None**, 3 events occur between yrs 1-75 (with at least 2 in yrs 1-50) in which 20% of the animals die. Events occur every 5 years in which 10% of the animals die[2]
Time dependence in *K*	**Constant**, halve linearly over 100yr; double linearly over 100yr
Time dependence in natural mortality, *M* *	**Constant**, double linearly over 100yr
Parameter correlations	Yes, **No**
Probability of mismatching north whales, p_2	0, **0.01**, 0.01-0.05
Probability of mismatching PCFG whales, p_1	**0**, 0.5
Frequency of PCFG surveys	**Annual**, 6-year
Incidental catch	**Reference**, double reference, half reference
Future sex ratio	**0.5:0.5**, 0.2:0.8 (M:F)
Episodic events with future pulse events[1]	**None**, 3 events occur between yrs 1-75 (with at least 2 in yrs 1-50) in which 20% of the north stock die and a pulse of 20 animals is added to the PCFG stock.

[1]The average value for adult survival needs to be adjusted to ensure the population is stable for these trials. [2]Selected to mimic the implications of stochasticity in the population dynamics.

Table 8a

The *Evaluation Trials*. Values given in bold type show differences from the base case trial. The final three columns indicate which trials apply to which 'broad' hypotheses. For 'broad' hypotheses B and I, the number given is the plus in 1999/2000. Unless specified otherwise ϕ_{PCFG}=0.3, the struck and lost rate is 0.5, and there are no stochastic dynamics or episodic events.

Trial	Condition	Description	$MSYR_{1+}$ North	$MSYR_{1+}$ PCFG	Final Need	Annual immigration	Survey freq.	Survey bias (north)	Hypothesis P	B	I
1A	Y	$MSYR_{1+}$=4.5%/4.5%	4.5%	4.5%	340/7	2	10/1	1	20	Y	10
1B	Y	$MSYR_{1+}$=4.5%/2%	4.5%	2%	340/7	2	10/1	1	20	Y	10
1C	Y	$MSYR_{1+}$=4.5%/1%	**4.5%**	**1%**	340/7	2	10/1	1	20	Y	10
1D	Y	$MSYR_{1+}$=2%/2%	**2%**	**2%**	340/7	2	10/1	**0.5→1**	20	Y	10
2A	Y	Immigration=0	4.5%	4.5%	340/7	**0**	10/1	1	20	Y	10
2B	Y	Immigration=0	4.5%	2%	340/7	**0**	10/1	1	20	Y	10
2C	Y	Immigration=0	**4.5%**	**1%**	340/7	**0**	10/1	1	20	Y	10
2D	Y	Immigration=0	**2%**	**2%**	340/7	**0**	10/1	**0.5→1**	20	Y	10
3A	Y	Immigration=1	4.5%	4.5%	340/7	**1**	10/1	1	20	Y	10
3B	Y	Immigration=1	4.5%	2%	340/7	**1**	10/1	1	20	Y	10
4A	Y	Immigration=4	4.5%	4.5%	340/7	**4**	10/1	1	20	Y	10
4B	Y	Immigration=4	4.5%	2%	340/7	**4**	10/1	1	20	Y	10
5A	Y	Immigration=6	4.5%	4.5%	340/7	**6**	10/1	1	20	Y	10
5B	Y	Immigration=6	4.5%	2%	340/7	**6**	10/1	1	20	Y	10
6A		High northern need	4.5%	4.5%	**530/7**	2	10/1	1	20	Y	
6B		High northern need	4.5%	2%	**530/7**	2	10/1	1	20	Y	
7A		3 episodic events	4.5%	4.5%	340/7	2	10/1	1	20	Y	
7B		3 episodic events	4.5%	2%	340/7	2	10/1	1	20	Y	
8A		Stochastic events 10% every 5 years	4.5%	4.5%	340/7	2	10/1	1	20	Y	
8B		Stochastic events 10% every 5 years	4.5%	2%	340/7	2	10/1	1	20	Y	
9A		Episodic events with future pulse events	4.5%	4.5%	340/7	2	10/1	1	20	Y	
9B		Episodic events with future pulse events	4.5%	2%	340/7	2	10/1	1	20	Y	
10A		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=0.6	4.5%	4.5%	340/7	2	10/1	1	20	Y	
10B		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=0.6	4.5%	2%	340/7	2	10/1	1	20	Y	
11A		Struck and lost (25%)	4.5%	4.5%	340/7	2	10/1	1	20	Y	
11B		Struck and lost (25%)	4.5%	2%	340/7	2	10/1	1	20	Y	
12A		Struck and lost (75%)	4.5%	4.5%	340/7	2	10/1	1	20	Y	
12B		Struck and lost (75%)	4.5%	2%	340/7	2	10/1	1	20	Y	
13A	Y	Higher 1999-2000 pulse	4.5%	4.5%	340/7	2	10/1	1	**30**		
13B	Y	Higher 1999-2000 pulse	4.5%	2%	340/7	2	10/1	1	**30**		
13C	Y	Higher 1999-2000 pulse	**4.5%**	**1%**	340/7	2	10/1	1	**30**		
14A	Y	Lower 1999-2000 pulse	4.5%	4.5%	340/7	2	10/1	1	**10**		
14B	Y	Lower 1999-2000 pulse	4.5%	2%	340/7	2	10/1	1	**10**		

Table 8b

The *Robustness Trials*.

Trial	Condition	Description	$MSYR_{1+}$ north	$MSYR_{1+}$ PCFG	Survey freq.	Hypothesis P	Hypothesis B
1A		6 year surveys	4.5%	4.5%	10/6	20	Y
1B		6 year surveys	4.5%	2%	10/6	20	Y
2A		Linear decrease in K^{1+} [K halves over years 0-99]	4.5%	4.5%	10/1	20	Y
2B		Linear decrease in K^{1+} [K halves over years 0-99]	4.5%	2%	10/1	20	Y
3A		Linear decrease in PCFG K^{1+} [K halves over years 0-99]	4.5%	4.5%	10/1	20	Y
3B		Linear decrease in PCFG K^{1+} [K halves over years 0-99]	4.5%	2%	10/1	20	Y
4A		Linear increase in M [M halves over years 0-99]	4.5%	4.5%	10/1	20	Y
4B		Linear increase in M [M halves over years 0-99]	4.5%	2%	10/1	20	Y
5A		Linear increase in PCFG M [M halves over years 0-99]	4.5%	4.5%	10/1	20	Y
5B		Linear increase in PCFG M [M halves over years 0-99]	4.5%	2%	10/1	20	Y
6A		Perfect detection; p_1 =0; p_2=0.01-0.05	4.5%	4.5%	10/1	20	Y
6B		Perfect detection; p_1 =0; p_2=0.01-0.05	4.5%	2%	10/1	20	Y
7A		p_1 = 0.5	4.5%	4.5%	10/1	20	Y
7B		p_1 = 0.5	4.5%	2%	10/1	20	Y
8B	Y	Survey bias PCFG + p_1 = 0.5	4.5%	2%	10/1	20	Y
9B	Y	Correlation (draw for N; same quantile in the range for PCFG)	4.5%	2%	10/1	20	Y
10B	Y	Double incidental catches	4.5%	2%	10/1	20	Y
11B	Y	Halve incidental catches	4.5%	2%	10/1	20	Y
12A		Sex ratio = 0.2: 0.8	4.5%	4.5%	10/1	20	Y
12B		Sex ratio = 0.2: 0.8	4.5%	2%	10/1	20	Y
13A		Relative probability of harvesting a PCFG whale, ϕ_{PCFG} =1	4.5%	4.5%	10/1	20	Y
13B		Relative probability of harvesting a PCFG whale, ϕ_{PCFG} =1	4.5%	2%	10/1	20	Y

F. Statistics

The risk- and recovery-related performance statistics are computed for the mature female and for the total (1+) population sizes (i.e. P_t is either the size of the mature female component of the population, N_t^f, or the size of the total (1+) population, N_t^{1+}). P_t^* is the population size in year t under a scenario of zero strikes in the northern and PCFG area (but allowing for incidental catches) over the years $t \geq 2011$ (defined as t=0 below), P_t^{**} is the population size in year t under a scenario of zero strikes in the PCFG area (but allowing for incidental catches and strikes in the north area) over the years $t \geq 2011$ (defined as t=0 below), and K_t^* is the population size in year t if there had never been any harvest.

The trials are based on a 100-year time horizon, but a final decision regarding the time horizon will depend *inter alia* on interactions between the Committee and the Commission regarding need envelopes and on the period over which recovery might occur. To allow for this, results are calculated for T=20 and 100 (T^* denotes the number of blocks for a given T; for the PCFG area T^* is 19 and 99 respectively for T=20 and T=100 while for the north area T^* is 3 and 19 respectively for T=20 and T=100).

Statistics marked in bold face have previously been considered the more important. Note that the statistic identification numbers have not been altered for reasons of consistency. Hence, there are gaps in the numbers where some statistics have been deleted.

E.1 Risk

D1. Final depletion: P_T/K. In trials with varying K this statistic is defined as P_T/K_t^*.

D2. Lowest depletion: $\min(P_t/K)$:t=0,1,…,T. In trials with varying K this statistic is defined as $\min(P_t/K_t^*)$:t=0,1,…,T.

D6. Plots for simulations 1-100 of $\{P_t: t = 0,1,..,T\}$, $\{P_t^*: t = 0,1,..,T\}$, $\{P_t^{**}: t = 0,1,..,T\}$.

D7. Plots of $\left\{P_{t[x]}: t = 0,1,...,T\right\}\left\{P^*_{t[x]}: t = 0,1,...,T\right\}$ and $\{P^{**}_{t[x]}: t = 0,1,..,T\}$ where $P_{t[x]}$ is the xth percentile of the distribution of P_t. Results are presented for x = 5 and x = 50.

D8. Rescaled final population: P_T / P_T^* and P_T / P_T^{**}.

D9. Minimum population level in terms of mature females, $\min(P_t)$: t = 0,1,…,T.

D10. Relative increase P_T/P_0.

E.2 Need

N1. Total need satisfaction: $\sum_{t=0}^{T-1} C_t / \sum_{t=0}^{T-1} Q_t$

N2. Length of shortfall = (negative of the greatest number of consecutive blocks in which $C_t < Q_t$) / T^*

N4. Fraction of blocks in which $C_t = Q_t$

N7. Plot of $\{V_{t[x]}$: $t = 0,1,T^*$ -1$\}$ where $V_{t[x]}$ is the xth percentile of the distribution of $V_t = C_t/Q_t$ [catch for the PCFG area].

N8. Plots of V_t for simulations 1-100.

N9. Average need satisfaction: $\frac{1}{T}\sum_{t=0}^{T-1}\frac{C_t}{Q_t}$

N10. AAV (Average Annual Variation): $\sum_{b=0}^{T^*-1} |C_{b+1} - C_b| \,/\, \sum_{t=0}^{T^*-1} C_b$ where C_b is the catch in block *b*.

N11. Anti-curvature: $\frac{1}{T^*-1} \sum_{b=0}^{T^*-2} \left| \frac{C_b - M_b}{\max(10, M_b)} \right|$ where $M_b = \left(C_{b+1} + C_{b-1}\right) / 2$.

N12. Mean downstep (or modified AAV): $\sum_{t=-1}^{T^*-1} \left|\min\left(C_{b+1} - C_b, 0\right)\right| \,/\, \sum_{t=-1}^{T^*-2} C_b$.

N13. Average annual number of animals landed.

N14. Average annual number of animals struck and lost.

The following key plots are to be produced for each trial:

Time-trajectories of 1+ population size (northern and PCFG stock) in absolute terms and relative to carrying capacity, along with the fits to the abundance estimates. This plot allows an evaluation of whether conditioning has been achieved satisfactorily.

Histograms of the 100 parameter vectors for each trial. This plot allows an evaluation of whether and how conditioning has impacted the priors for these parameters.

Individual time-trajectories of 1+ population size for the northern and PCFG stocks, individual time-trajectories of strikes for the northern and PCFG area, a summary (median and 95% intervals) for the depletion of the PCFG stock, and a summary (median and 95% intervals) for the time-trajectories of 1+ population size when: (a) there are no future catches; (b) there are only incidental catches; and (c) there are incidental catches and catches due to hunts in the PCFG and northern area.

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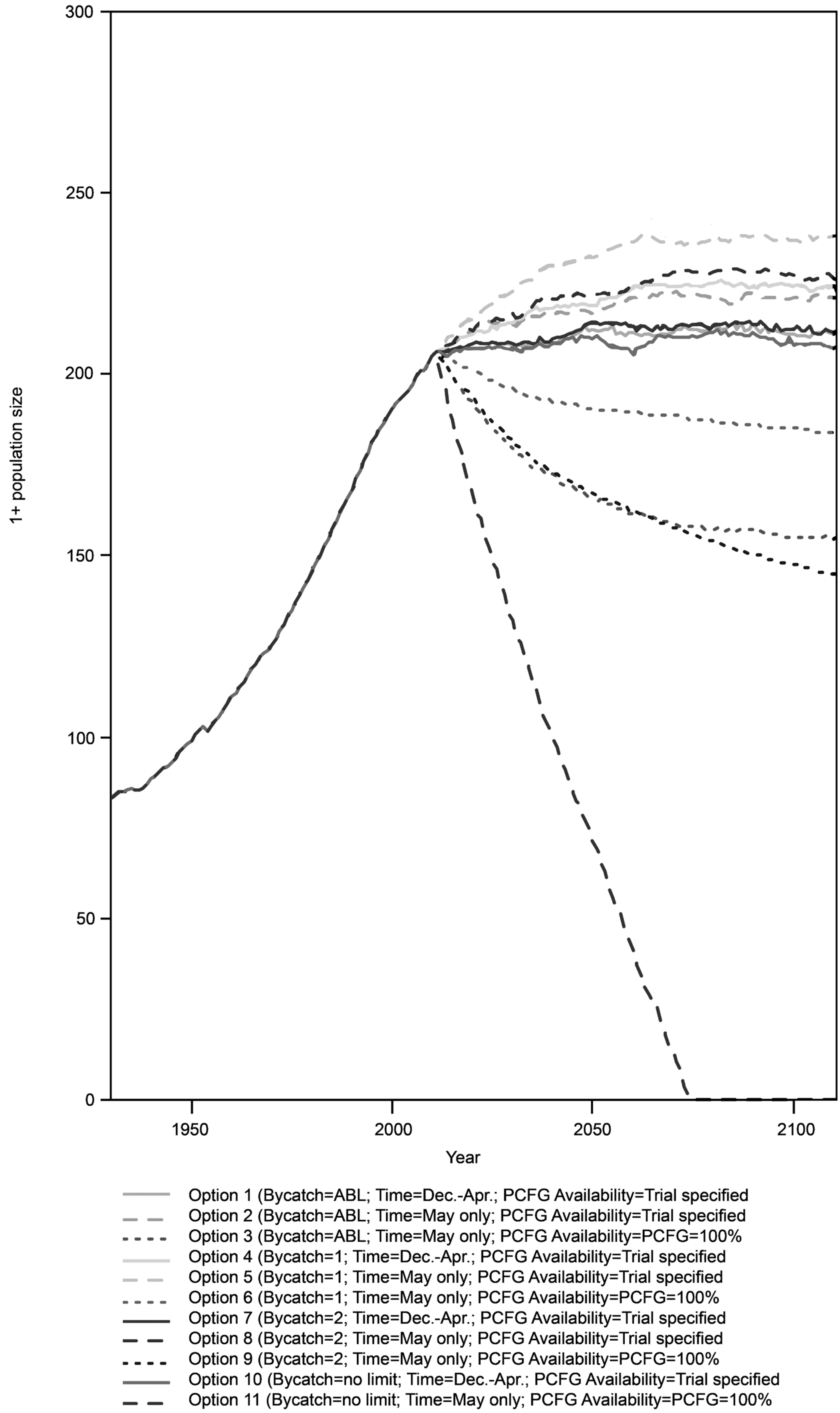
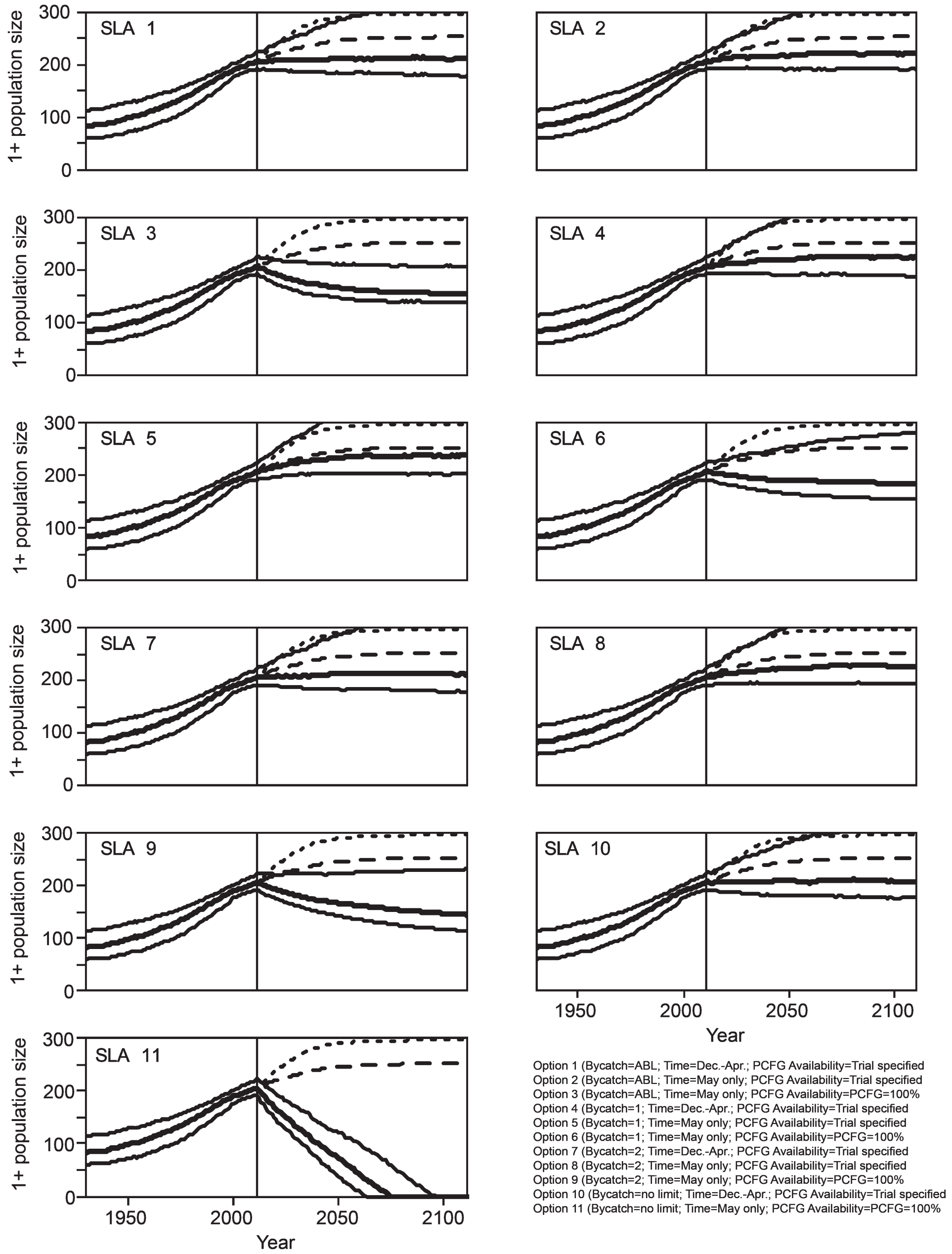
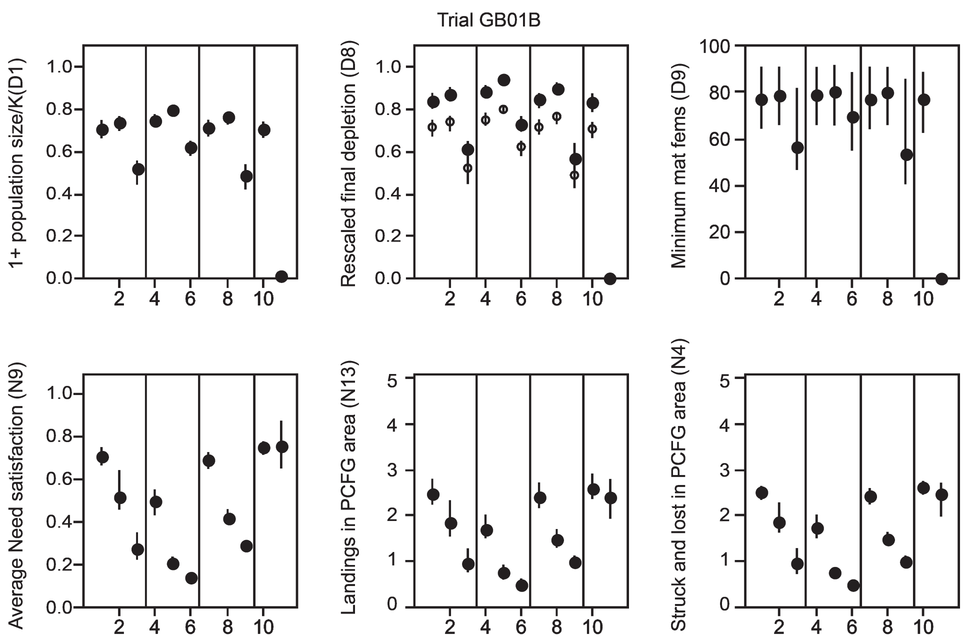
Appendix 3

EXAMPLE PLOTS USED WHEN REVIEWING THE RESULTS OF THE *EVALUATION TRIALS*




SLA 1
SLA 2
SLA 3
SLA 4
SLA 5
SLA 6
SLA 7
SLA 8
SLA 9
SLA 10
SLA 11
1+ population size
Year
Option 1 (Bycatch=ABL; Time=Dec.-Apr.; PCFG Availability=Trial specified
Option 2 (Bycatch=ABL; Time=May only; PCFG Availability=Trial specified
Option 3 (Bycatch=ABL; Time=May only; PCFG Availability=PCFG=100%
Option 4 (Bycatch=1; Time=Dec.-Apr.; PCFG Availability=Trial specified
Option 5 (Bycatch=1; Time=May only; PCFG Availability=Trial specified
Option 6 (Bycatch=1; Time=May only; PCFG Availability=PCFG=100%
Option 7 (Bycatch=2; Time=Dec.-Apr.; PCFG Availability=Trial specified
Option 8 (Bycatch=2; Time=May only; PCFG Availability=Trial specified
Option 9 (Bycatch=2; Time=May only; PCFG Availability=PCFG=100%
Option 10 (Bycatch=no limit; Time=Dec.-Apr.; PCFG Availability=Trial specified
Option 11 (Bycatch=no limit; Time=May only; PCFG Availability=PCFG=100%


Trial GB01B
1+ population size/K(D1)
Rescaled final depletion (D8)
Minimum mat fems (D9)
Average Need satisfaction (N9)
Landings in PCFG area (N13)
Struck and lost in PCFG area (N4)

Appendix 4

SUMMARY OF CONSERVATION PERFORMANCE AND LANDINGS FOR *SLA* VARIANTS 1 AND 2 FOR THE *EVALUATION TRIALS*

Table 1

Trials indicated with an asterisk selected for detailed examination.
Underlined trials fail to leave either final depletion or rescaled final depletion at 0.6 or above.

	SLA 1					*SLA* 2				
	Final depletion		Rescaled final depletion		Annual landings	Final depletion		Rescaled final depletion		Annual landings
Trial	Low 5%	Median	Low 5%	Median	Median	Low 5%	Median	Low 5%	Median	Median
GB01A	0.856	0.880	0.857	0.881	2.42	0.881	0.893	0.884	0.895	1.63
GB01B	0.669	0.711	0.671	0.713	2.47	0.700	0.743	0.702	0.745	1.84
GB01C*	0.259	0.343	0.314	0.383	2.47	0.290	0.365	0.352	0.414	1.98
GB01D	0.685	0.722	0.685	0.724	2.48	0.705	0.747	0.707	0.749	1.80
GB02A	0.856	0.881	0.856	0.881	2.41	0.884	0.896	0.884	0.896	1.62
GB02B*	0.623	0.666	0.623	0.666	2.47	0.662	0.704	0.662	0.705	1.90
GB02D	0.651	0.683	0.651	0.684	2.49	0.681	0.715	0.681	0.715	1.96
GB03A	0.859	0.879	0.859	0.879	2.42	0.879	0.897	0.879	0.898	1.63
GB03B	0.660	0.693	0.660	0.693	2.47	0.695	0.728	0.696	0.728	1.85
GB04A	0.857	0.880	0.861	0.882	2.43	0.878	0.893	0.881	0.896	1.69
GB04B	0.710	0.746	0.713	0.750	2.49	0.729	0.765	0.731	0.770	1.85
GB05A	0.855	0.874	0.858	0.879	2.43	0.873	0.888	0.879	0.894	1.68
GB05B	0.731	0.763	0.736	0.770	2.47	0.754	0.779	0.759	0.786	1.85
GB06A	0.849	0.871	0.849	0.871	2.41	0.872	0.887	0.874	0.888	1.61
GB06B	0.657	0.696	0.659	0.697	2.46	0.692	0.728	0.694	0.729	1.83
GB07A	0.982	1.000	0.686	0.907	2.45	0.991	1.009	0.696	0.916	1.73
GB07B	0.886	0.954	0.728	0.812	2.48	0.910	0.969	0.761	0.821	2.00
GB08A*	0.741	0.769	0.830	0.854	2.38	0.769	0.788	0.859	0.874	1.53
GB08B*	0.357	0.458	0.505	0.594	2.28	0.396	0.504	0.560	0.656	1.49
GB09A*	0.927	0.952	0.698	0.895	2.43	0.942	0.961	0.705	0.907	1.78
GB09B*	0.807	0.852	0.730	0.780	2.52	0.818	0.868	0.743	0.793	2.14
GB10A*	0.792	0.812	0.793	0.813	2.04	0.837	0.849	0.837	0.850	1.32
GB10B*	0.492	0.556	0.492	0.557	2.06	0.575	0.633	0.576	0.635	1.38
GB11A	0.857	0.879	0.859	0.879	3.76	0.873	0.887	0.873	0.888	2.93
GB11B	0.670	0.711	0.672	0.711	3.79	0.693	0.728	0.696	0.730	3.23
GB12A	0.873	0.890	0.876	0.892	0.97	0.885	0.902	0.885	0.902	0.66
GB12B	0.705	0.739	0.707	0.741	0.98	0.726	0.759	0.727	0.759	0.77
GP01A	0.859	0.877	0.859	0.879	2.43	0.877	0.893	0.878	0.894	1.75
GP01B	0.663	0.702	0.663	0.703	2.48	0.684	0.732	0.685	0.734	1.88
GP01C*	0.382	0.461	0.400	0.472	2.34	0.438	0.515	0.460	0.528	1.57
GP01D	0.669	0.709	0.671	0.712	2.49	0.683	0.732	0.686	0.734	1.95
GP02A	0.858	0.876	0.860	0.876	2.40	0.880	0.893	0.880	0.894	1.61
GP02B*	0.592	0.642	0.593	0.643	2.46	0.635	0.684	0.635	0.684	1.90
GP02C	0.231	0.272	0.255	0.295	2.17	0.299	0.347	0.334	0.372	1.31
GP02D	0.631	0.678	0.633	0.678	2.46	0.661	0.711	0.663	0.711	1.83
GP03A	0.857	0.876	0.860	0.876	2.43	0.878	0.892	0.879	0.892	1.69
GP03B	0.635	0.682	0.635	0.682	2.47	0.664	0.710	0.666	0.710	1.90
GP04A	0.853	0.873	0.857	0.877	2.39	0.874	0.888	0.878	0.892	1.57
GP04B	0.696	0.731	0.699	0.735	2.49	0.719	0.749	0.720	0.753	2.07
GP05B	0.712	0.747	0.716	0.753	2.49	0.738	0.764	0.744	0.771	1.95
GP06A	0.848	0.867	0.848	0.869	2.43	0.870	0.885	0.872	0.886	1.74
GP06B	0.643	0.684	0.645	0.685	2.46	0.670	0.718	0.671	0.719	1.88
GP07A	0.974	0.996	0.756	0.908	2.47	0.978	1.005	0.765	0.916	1.84
GP07B	0.876	0.941	0.750	0.798	2.49	0.885	0.955	0.752	0.810	2.00
GP08A*	0.728	0.762	0.824	0.847	2.42	0.750	0.782	0.844	0.870	1.61
GP08B*	0.330	0.442	0.475	0.578	2.28	0.364	0.482	0.528	0.635	1.49
GP09A*	0.925	0.946	0.739	0.893	2.46	0.932	0.955	0.735	0.904	1.90
GP09B*	0.786	0.845	0.720	0.770	2.52	0.790	0.854	0.741	0.784	2.13
GP10A*	0.781	0.806	0.781	0.809	2.10	0.825	0.841	0.827	0.843	1.38
GP10B*	0.475	0.536	0.476	0.538	2.02	0.556	0.619	0.557	0.621	1.42
GP11A	0.858	0.875	0.859	0.877	3.77	0.870	0.884	0.870	0.885	3.05
GP11B	0.663	0.699	0.665	0.701	3.78	0.678	0.716	0.679	0.718	3.24
GP12A	0.866	0.887	0.869	0.890	0.98	0.880	0.899	0.881	0.900	0.71
GP12B	0.697	0.729	0.699	0.731	0.97	0.705	0.747	0.706	0.749	0.77
GP13A	0.856	0.876	0.856	0.876	2.43	0.877	0.892	0.879	0.893	1.62
GP13B	0.675	0.709	0.677	0.710	2.44	0.699	0.741	0.699	0.744	1.78
GP13C*	0.392	0.464	0.409	0.476	2.36	0.442	0.520	0.464	0.533	1.59
GP14A	0.860	0.877	0.861	0.877	2.48	0.875	0.888	0.876	0.889	1.82
GP14B	0.666	0.699	0.667	0.700	2.49	0.678	0.720	0.679	0.722	1.97
GI01A	0.860	0.877	0.861	0.877	2.48	0.875	0.888	0.876	0.889	1.82
GI01B	0.666	0.699	0.667	0.700	2.49	0.678	0.720	0.679	0.722	1.97
GI01C*	0.378	0.446	0.399	0.459	2.38	0.434	0.497	0.457	0.513	1.64
GI01D	0.669	0.708	0.671	0.710	2.49	0.691	0.725	0.693	0.728	2.07
GI02A	0.853	0.876	0.853	0.876	2.46	0.873	0.891	0.873	0.892	1.78
GI02B*	0.606	0.643	0.607	0.644	2.46	0.631	0.685	0.632	0.686	1.89
GI02D	0.614	0.671	0.615	0.673	2.46	0.652	0.702	0.653	0.702	1.98
GI03A	0.853	0.876	0.853	0.876	2.48	0.872	0.890	0.872	0.890	1.77
GI03B	0.639	0.680	0.639	0.681	2.47	0.663	0.706	0.664	0.706	1.95
GI04A	0.852	0.875	0.856	0.876	2.42	0.873	0.886	0.875	0.890	1.65
GI04B	0.692	0.727	0.694	0.730	2.49	0.709	0.741	0.710	0.744	2.09
GI05A	0.851	0.870	0.859	0.877	2.38	0.870	0.885	0.877	0.892	1.60
GI05B	0.720	0.749	0.725	0.753	2.49	0.733	0.764	0.736	0.770	2.06

Appendix 5

BIOLOGICAL INFORMATION RELATING TO *SLA* DEVELOPMENT FOR THE LARGE WHALE HUNTS IN WEST GREENLAND

Lars Witting

Humpback whale

Agreed abundance estimates for West Greenland humpback whales are listed in Table 1. Other information include a 2007 estimate of 4,365 (CV:0.20) humpback whales in Canadian waters (NAMMCO, 2010; 2011).

The latest assessment paper is Witting (2011) that use an age- and sex-structured population model to examine if the long-term dynamics of West Greenland humpback whales is best described by density regulated growth or by selection-delayed dynamics (earlier referred to as inertia dynamics). Discussion of the results of this exercise and implications for the operating model(s) for *SLA* development will form part of the development process.

There is no estimate of the age of the first reproductive event (a_m) for humpback whales in West Greenland. There are, however, several estimates from other areas (Clapham, 1992; Gabriele *et al.*, 2007; Ramp, 2008; Robbins, 2007). For North Atlantic humpback whales, Ramp (2008) estimated a_m to exceed 12 years in the Gulf of St. Lawrence, Clapham (1992) estimated it to a range from five to seven years for humpback whales in the Gulf of Maine, and a later estimate from this area obtained an average estimate of seven years, ranging from five to 13 (Robbins, 2007).

There is no estimate of the birth rate for humpback females in West Greenland, but estimates exist for other areas. Gabriele *et al.* (2007) found that adult females in Alaska typically give birth every second to third year, with a documented range from one to six, and a mode every second year. Robbins (2007) found a comparable range for humpback whales in the Gulf of Maine, with a mean estimated annual birth rate of 0.57 and a process variance of 0.042 for 201 adult in the south-west of the area. The assessment model (Witting, 2011) used the latter estimate as an informative beta prior on the birth rate (a=2.741, b=2.111). As for a_m, for density-regulated growth and selection-delayed dynamics, the prior on the birth rate should reflect the expected range for the average birth rate among the individuals in a population that increases at its maximum growth rate. As West Greenland humpbacks are estimated to increase at a rate faster than humpbacks in the Gulf of Maine (Clapham *et al.*, 2003; Heide-Jørgensen *et al.*, 2008c), the applied prior may be in the lower range of the true value.

Larsen and Hammond (2004) estimated an annual survival rate (p) of 0.957 (SE=0.028) for humpback whales off West Greenland. This is similar to estimates of 0.951 (SE=0.010) and 0.960 (SE=0.008) for the Gulf of Maine feeding aggregation of humpbacks (Barlow and Clapham, 1997; Buckland, 1990), and an estimate of 0.963 (95% CI:0.944-0.978) for humpbacks in the central North Pacific (Mizroch *et al.*, 2004). In the Gulf of Maine, calf survival was estimated at 0.664 (95% CI:0.517-0.784), and yearly adult survival at 0.991 (95% CI:0.919-0.999) when excluding animals younger than five years of age (Robbins, 2007). From age zero to five, yearly survival was found to increase by an approximate straight line.

Table 1

Abundance estimates for West Greenland humpback whales with CV in parenthesis (given in %). I_a is an index series from aerial surveys. I_b is an index series of mark-recapture estimates, and N a fully corrected line transect survey from 2007. Data from Larsen and Hammond (2004), Heide-Jørgensen *et al.* (2008c).

Year	I_a	I_b	N
1984	138 (54)	-	-
1988	231 (70)	357 (16)	-
1989	-	355 (12)	-
1991	-	376 (19)	-
1992	-	348 (12)	-
1993	873 (53)	-	-
2005	1,218 (38)	-	-
2007	-	-	3,270 (50)

Bowhead whale

Abundance estimates for EA-WG bowhead whales are listed in Table 2. Abundance estimates that relate to the two stock hypothesis are 6,340 (CV: 0.38) for Baffin Bay-Davis Strait in 2002 and 1,350 (CV: 0.78) for Foxe Basin-Hudson Bay in 2003 (Givens *et al.*, 2009; IWC, 2009).

Table 2

Abundance estimates for bowhead whale N_{bd} is an agree estimate from 2002 for Baffin Bay and Davis Strait (1+ component), with CV in % in parenthesis. N_{wg} is (†) a fully corrected line-transect and (‡) a mark-recapture estimate from West Greenland (mainly mature animals), with CV in parenthesis. I_{wg} is sighting rates (number/km) from aerial surveys in West Greenland (mature animals), with the total number of sightings given in parenthesis. Data from Heide-Jørgensen *et al.* (2007; 2008b), Givens *et al.* (2009), IWC (2009) and Wiig *et al.* (2011).

Year	N_{bd}	N_{wg}	I_{wg}
1981	-	-	0.0011 (1)
1982	-	-	0.0004 (1)
1990	-	-	0.0017 (1)
1991	-	-	0.0028 (3)
1993	-	-	0.0000 (0)
1994	-	-	0.0000 (0)
1998	-	-	0.0042 (5)
1999	-	-	0.0000 (0)
2002	6,340 (38)	-	-
2006	-	1,229† (47)	0.0109 (18)
2010	-	1,410‡ (23)	-

Under the two stock hypothesis there appears to be no stock structure uncertainty associated with the allocation of the West Greenland catches, which in this case will be allocated to the Baffin Bay-Davis Strait stock. While the assumed Foxe Basin-Hudson Bay and the Baffin Bay-Davis Strait stocks may mix on the wintering ground at the northern Labrador coast and the entrance to Hudson Strait, in spring, Foxe Basin-Hudson Bay animals would have to migrate in the opposite direction of the Baffin Bay-Davis Strait animals that migrate to West Greenland (Heide-Jørgensen *et al.*, 2006; Heide-Jørgensen *et al.*, 2010a).

Fin whale

Agreed abundance estimates for West Greenland fin whales are listed in Table 3. Other abundance information includes a 2007 estimate of 1,716 (CV:0.40) fin whales in Canadian waters (NAMMCO, 2010; 2011).

To examine annual growth rates and life-histories in North Atlantic fin whales, an age- and sex-structured

Table 3

Abundance estimates for North Atlantic fin whales with CV in parenthesis (given in %). WG estimates from IWC (1992), Heide-Jørgensen *et al.* (2008a) and pro-rated estimates for EG, WI and EI from IWC (2010).

Year	N_{WG}	N_{EG}	N_{WI}	N_{EI}
1987	-	-	-	5,260 (28)
1988	1,100 (35)	5,270 (22)	4,240 (23)	-
1995	-	10,200 (29)	7,360 (22)	7,170 (29)
2001	-	14,200 (19)	7,430 (19)	9,550 (26)
2005	3,230 (44)	-	-	-
2007	4,360 (45)	15,800 (20)	8,900 (26)	-

Table 4

Abundance estimates for West Greenland minke whales with CV in parenthesis (given in %). *N* absolute estimates; 1987/88, 1993 and 2005 cue count estimates; 2007: fully corrected line-transect estimate. *I* time series of relative abundance. Data from Larsen (1995), Heide-Jørgensen and Laidre (2008), Heide-Jørgensen *et al.* (2008a; 2010b).

Year	*N*	*I*
1984	-	446 (36)
1985	-	198 (38)
1987	-	297 (31)
1988	-	1,841 (37)
1987/8	3,266 (31)	-
1989	-	636 (37)
1993	8,371 (43)	1,055 (86)
2005	10,792 (59)	663 (33)
2007	16,610 (43)	1,365 (25)

population model with exponential growth was fitted to recent abundance estimates (Table 3) for the West Greenland (WG), East Greenland (EG), West Iceland (WI) and East Iceland/Faroese (EI) summer aggregations of North Atlantic fin whales. Discussion of the results of this exercise and implications for the operating model(s) for *SLA* development will form part of the development process.

Minke whale

Abundance estimates for West Greenland minke whales are listed in Table 4. Other abundance information include a 2007 estimate of 5,675 (CV:0.24) minke whales in Canadian waters (NAMMCO, 2010; 2011).

SC/64/AWMP15 also presented a model for sex and density dependent dispersal between summer aggregations of minke whales. Discussion of the results of this exercise and implications for the operating model(s) for *SLA* development will form part of the development process.

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Appendix 6

DEVELOPMENT OF AN OPERATING MODEL FOR WEST GREENLAND HUMPBACK AND BOWHEAD WHALES

1. Relevant Agenda item (no. and title)
Annex E, Item 4

2. Brief description of project and why it is necessary to your sub-committee
The Committee developed interim *Strike Limit Algorithms* (*SLA*s) for the minke, fin, humpback and bowhead whales off West Greenland. These *SLA*s need to be reviewed and perhaps revised, ideally by the 2017 Annual Meeting. Development of *SLA*s for the hunts of minke and fin whales can be co-ordinated with the *Implementation Reviews* for these whales which are being conducted by the RMP sub-committee. In contrast, the situations for humpback and bowhead whales are relatively straightforward (essentially single-stock situations), but without a fully-specified and coded operating model progress on these cases will be limited. The first step in the process of developing *SLA*s is constructing an operating model and associated trials, and this project aims to make sufficient progress that an AWMP Workshop (in late 2012) could finalise trials and initiate testing.

The key activities covered by the proposal are as follows.

(1) Extend the single-stock gray whale trials so that trials can be conducted for humpback and bowhead whales.
(2) Outline a set of *Evaluation* and *Robustness Trials* which could form the basis for the evaluation of *SLA*s for these two groups of whales.
(3) Present the trial specifications and results for: (a) the interim *SLA*s; and (b) an alternative *SLA* at an intersessional AWMP Workshop.
(4) Develop an AWMP/RMP-lite to assist developers of *SLA*s for the cases of fin whales and common minke whales.

3. Timetable
(1) Obtain the latest version of the gray whale trials from the Secretariat (July-August 2012).
(2) Update the trials as needed: (a) update the catch streams; (b) add the ability to condition to existing data for West Greenland; and (c) add the ability to test user-specified *SLA*s (before the AWMP Workshop).
(3) Draft full technical specifications for the proposed trials (before the AWMP Workshop).

4. Researchers name
André Punt (University of Washington).

5. Estimated total cost with breakdown as needed
Total budget: £5,000.

Appendix 7

DRAFT GUIDELINES FOR AWMP *IMPLEMENTATION REVIEWS*

1. Objectives of *Implementation Reviews*
The primary objectives of an *Implementation Review* are to:
(1) review the available information (including biological data, abundance estimates and data relevant to stock structure issues) to ascertain whether the present situation is as expected (i.e. within the space tested during the development of a *Strike Limit Algorithm* (*SLA*)) and determine whether new simulation trials are required to ensure that the *SLA* still meets the Commission's objectives; and
(2) to review information required for the *SLA*, i.e. catch data and, when available at the time of the *Review*, new abundance estimates (note that this can also occur outside an *Implementation Review* at an Annual Meeting).

2. Timing of *Implementation Reviews*
Regular Implementation Reviews
Implementation Reviews are undertaken regularly, normally every five years. This does not have to coincide with the renewal of catch/strike limits in the Commission. For logistical and resource reasons, only one major *Implementation Review* shall be undertaken at a time. The Committee shall begin planning for the *Review* at the Annual Meeting at least two years before the Annual Meeting at which the *Review* is expected to be finished. This is to enable the Committee to schedule additional work or Workshops if it believes that new information or analyses are likely to be presented that will necessitate the development of new simulation trials. Early planning will enhance the likelihood that the Committee will complete an *Implementation Review* on schedule. It is not expected that every *Implementation Review* will entail a large amount of work.

Special Implementation Reviews
In addition to regular *Implementation Reviews*, under exceptional circumstances the Committee may decide to call for special *Implementation Reviews,* should information be presented to suggest that this is necessary and especially if there is a possibility that the Commission's conservation objectives may not be met.

Calling such a *Review* does not necessarily mean revising the Committee's advice to the Commission, although it may do so. The Committee has not tried to compile a formal comprehensive list of what factors might 'trigger' such an early review, which implies unexpected/unpredictable factors. However, the following list is provided to give examples of some possible factors.

(1) Major mortality events (e.g. suggested by large numbers of stranded animals).
(2) Major changes in whale habitat (e.g. the occurrence of natural or anthropogenic disasters or changes, an oil spill, dramatic change in sea-ice, development of a major oil/gas field, etc.).
(3) Major ecological changes resulting in major long-term changes in habitat or biological parameters.
(4) A dramatically lower abundance estimate (although the *SLA* has been tested and found to be robust to large sudden drops in abundance, the Committee would review the potential causes of unexpected very low estimates).
(5) Information from the harvest and hunters (this might include very poor harvest results, reports of low abundance despite good conditions, reports of large numbers of unhealthy animals).
(6) Changes in biological parameters that may result in changes to management advice (e.g. reproduction, survivorship).
(7) If there are cases when need is not being satisfied, strong information that might narrow the plausibility range and allow an increase in block limits.
(8) A new harvest regime (e.g. the potential hunt of gray whales by the Makah Tribe on the west coast of the USA).

3. Outcomes of *Implementation Reviews*

There are a number of possible conclusions of *Implementation Reviews:*

(1) there is no need to run additional trials and that the existing *SLA* is acceptable;
(2) the results from the additional trials developed and run reveal that the existing *SLA* is acceptable;
(3) there is no need for any immediate additional trials or changes to management advice but work is identified that is required for consideration at the next *Implementation Review*; or
(4) the results of the additional trials require the development of a new (or modified and then retested) *SLA* in which case management advice will have to be reconsidered until that work is complete.

4. Data availability

Implementation Reviews fall under the Committee's Data Availability Agreement Procedure A (IWC, 2004). By the time of the Annual Meeting prior to that at which the *Implementation Review* is expected to be completed, the scientists from the country or countries undertaking the hunts, or others intending to submit relevant analyses, shall develop a document or documents that explains the data that will/could be used for the *Implementation Review*. Such a document will:

(a) outline the data that will be available, including by broad data type (e.g. sighting data, catch data, biological data): the years for which the data are available; the fields within the database; and the sample sizes.
(b) provide references to data collection and validation protocols[1] and any associated information needed to understand the datasets or to explain gaps or limitations; and
(c) where available, provide references to documents and publications of previous analyses undertaken of data.

The data themselves shall be available in electronic format one month after the close of that Annual Meeting.

In the case of complex *Implementation Reviews* that may last more than one year and involve one or more workshops, new data can be submitted, provided that the data are described and made available at least nine months before the Annual Meeting at which the *Implementation Review* is expected to be completed.

5. Computer programs

All non-standard programs used in analyses submitted to the *Implementation Review* shall be lodged with the Secretariat at least at the same time (in accordance with the time schedule provided in DAA Procedure A) as the submission of the papers to which they pertain. The Committee may decide that the programmes need independent validation.

All final trial runs shall be undertaken by the Secretariat using validated programmes.

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[1]Genetic data must follow the quality control guidelines developed by the Scientific Committee in 2008 (IWC, 2009).