Annex D

Report of the Sub-Committee on the Revised Management Procedure (RMP)

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1. INTRODUCTORY ITEMS

1.1 Pre-meeting meeting
Prior to the sub-committee meeting, a pre-meeting meeting was held over the two days 24-25 May. Chaired by Donovan, the pre-meeting agreed to address Items 2.1, 2.2, 3.1.1-3.1.3 of the sub-committee Agenda.

1.2 Election of Chair, appointment of rapporteurs
Bannister was elected Chair. Rapporteurial duties were undertaken by Butterworth, Donovan, Hammond, Perrin, Pike, Punt and Wade.

1.3 Adoption of Agenda
The adopted agenda is given in Appendix 1 (see also Item 1.1).

1.4 Review of documents
Documents available included SC/58/RMP1-8; PFI1-9; O21; Rep1.

2. REVISED MANAGEMENT PROCEDURE (RMP) – GENERAL ISSUES

2.1 Finalise the guidelines and requirements for implementing the RMP
2.1.1 Develop the thresholds for defining 'acceptable' and 'borderline' performance for classifying the performance of RMP variants for Implementation Simulation Trials (ISTs)

IWC (2005) developed a set of guidelines and requirements for the Scientific Committee when it attempts to Implement the RMP for a given species and Region. These guidelines relate to: (a) the information needed to initiate a *pre-Implementation assessment*; (b) the nature and outcomes from a *pre-Implementation assessment*; and (c) the steps when conducting an *Implementation*. An *Implementation* will normally be completed two years after the Scientific Committee recommends that the *pre-Implementation assessment* is complete and the *Implementation* can commence. The *Implementation* occurs over two intersessional workshops and two Annual meetings. The objective of the second of these intersessional workshops is to review the results of trials and develop recommendations to the Scientific Committee regarding management areas, RMP variants, operational constraints, future research to narrow the range of plausible hypotheses/eliminate some hypotheses, and 'less conservative' RMP variants (and their associated research programmes and duration).

The review of the results of the trials involves *inter alia* assessing conservation performance for each trial and RMP variant using pre-determined guidelines and hence classifying each combination of RMP variant and trial as 'acceptable', 'borderline' or 'unacceptable'. IWC (2005) developed some generic guidelines for evaluating performance, but did not specify the exact numerical values for the thresholds that define 'acceptable' and 'borderline'. It indicated that these values would be based on the values for the relevant performance measures for the single stock trials and that the values for 'acceptable' performance would be based on the results for the D1 and R1 base-case trials for the 0.72 tuning of the *Catch Limit Algorithm* (*CLA*), while those for 'borderline' performance would be based on the results for these trials for the 0.60 tuning of the *CLA*.

A previous attempt to calculate values for the thresholds that define 'acceptable', 'borderline' and 'unacceptable' conservation performance based on these specifications had not been completely successful (Punt, 2005). IWC (2006) therefore proposed the following way to determine the conservation performance of an RMP variant for each stock in an *IST* for which *MSYR*=1%.

(1) Construct a single stock trial, which is 'equivalent' to the *IST*. For example, if a particular *IST* involved carrying capacity halving over the 100-year projection period, the 'equivalent single stock trial' will also involve carrying capacity halving over the next 100 years;
(2) Conduct two sets of 100 simulations based on this single stock trial in which future catch limits are set by the *CLA*. The two sets of simulations correspond to the 0.6 and 0.72 tunings of the *CLA*. Rather than basing these calculations on a single initial depletion, the simulations for each stock to be conducted for the set of initial depletions for the stock concerned in the *IST*;

(3) The cumulative distributions for the final depletion and for the depletion ratio (the minimum over each of the 100 years of the ratio of the population size to that when there are only incidental catches) to be constructed for each tuning of the *CLA*;
(4) The lower 5%-ile of these distributions to form the basis for determining whether the performance of the RMP for the *ISTs* is 'acceptable', 'borderline' or 'unacceptable'.

At last year's meeting, the Committee requested that three analyses be conducted to evaluate the approach outlined above. The results of this work done intersessionally are reported in SC/58/RMP2 and given in Appendix 2.

The sub-committee **agreed** that the work completed intersessionally was sufficient to define the threshold levels for defining 'acceptable' and 'borderline' performance for classifying the performance of RMP variants for *ISTs*. An amendment to the Requirements and Guidelines for *Implementations* (IWC, 2005) is given in Appendix 3. The sub-committee **recommended** that this amended text be adopted.

2.1.2 Develop a list of agreed stock structure archetypes

Pastene presented SC/58/RMP3, which reviewed the process to define stocks during RMP *Implementations* of North Pacific (NP) common minke and Bryde's whales. The *Implementation* process was completed for NP common minke whales during the 2003 Scientific Committee meeting and an *Implementation Review* is scheduled for the 2008 meeting. The 'First Intersessional Workshop' for NP Bryde's whales was held in October 2005. Some general aspects of stock structure in these two NP assessment cases were summarised, namely: (1) the kind of data available and analyses conducted; and (2) how the information on stock structure was used in the *Implementation* process. SC/58/RMP3 identified some problematic issues inherent to the analysis and interpretation of stock structure, which made it difficult to reach agreement on this topic in the NP cases, particularly in the case of the common minke whale: (1) different views on how to define stocks; (2) stock delineation based on samples from migratory corridors or feeding grounds; and (3) use of novel and yet to be validated analytical techniques during assessments. Some suggestions were provided on how these issues can be addressed. The Committee has not agreed on a methodology to evaluate quantitatively the plausibility of different stock scenarios. It is argued in SC/58/RMP3 that all these issues, although complex, should not be over-emphasised and used as an argument to delay a reasonable agreement on stock structure scenarios. In reality, there is no way to address completely all of the issues listed above. Stock scenarios should be defined taking into account the best available scientific data recognising that these could be improved during the *Implementation Review*. Furthermore, SC/58/RMP3 argued that discussion on stock structure for different *Implementations* should be carried out on a consistent basis, as a scientific approach demands, and that the same criteria should be used to define stocks in different *Implementations*.

In discussion, the sub-committee **agreed** that peer-review of new methods for the analysis of genetic data was important and that this was best achieved through the Committee itself. It was desirable for this review to be done by a Working Group that was separate from the Working Group undertaking the *Implementation*. The sub-committee noted that the purpose of the Testing of Spatial Structure Models (TOSSM) project being developed under the Working Group on Stock Definition (see Annex I) was to test such methods; however, this will not be completed for a number of years.

In the absence of a framework such as TOSSM, the Committee has developed a number of stock structure hypotheses or archetypes in *Implementations* conducted to date. Details of these can be found for North Atlantic (IWC, 2004b), Southern Hemisphere (IWC, 1993a) and western NP minke whales (IWC, 2004a), western NP Bryde's whales (SC/58/Rep1) and North Atlantic fin whales (SC/58/Rep3).

2.2 Proposal for revision of the *CLA*

2.2.1 General approach to such considerations

IWC (1994, p.47) specifies the protocol for evaluating proposed amendments to the RMP. For a proposal for an amendment to be considered, there needs to be some evidence, in the form of simulation trial results or otherwise, that the proposed amendment would results in improved performance in at least some respect. The protocol consists of three steps.

(1) Adequate notice shall be given to the Commission and the Scientific Committee of any proposal for amendment to the RMP.
(2) Given the time it will take for the Committee to evaluate such proposals, suitable evidence shall be presented to indicate that the proposed amendment would indeed represent an improvement. In this context, an amended procedure that allowed higher catches or lower catch limit variability will only be considered an improvement by the Committee if it performs adequately on all risk-related performance statistics, and better than the current version of the RMP on at least some catch- or risk-related performance statistics. This evidence shall take the form of results from appropriate, fully specified and programmed simulation trials, a list of which needs to be developed by the Scientific Committee (based *inter alia* on table 3 in IWC, 1993b). These trials shall have been carried out by the proposer.
(3) The Committee may then specify further simulation trials and/or modification of trials already carried out along with criteria for the evaluation of the results. Advice to the Commission may then be given at its next Annual Meeting, subject to the completion of the work specified.

2.2.2 Consideration of the Norwegian proposal

In the notification given by Norway at the Sorrento meeting in 2004 four possible changes to the 'base-case' and robustness trial and to the *CLA* were indicated. Only two of these have been explored in SC/58/RMP7 as shown below. SC/58/RMP7 was introduced by Walløe.

(1) To run the simulations for more than a hundred years and until equilibrium abundance is reached. Exploratory simulations showed that equilibrium was nearly reached after 300 years, which was used as the period for all trials. The resulting long term (after 300 years) Depletion Level (DL) was chosen as the relevant parameter to characterise the trials instead of the Tuning Level (TL – depletion level after 100 years), which is usually wrongly interpreted as the long term depletion.
(2) The *MSYR* should refer to the 1+ component of the population instead of the mature component. The Committee has used the 1+ component and specific

choices of *MSYR* with $MSYR_{(1+)}$ = 1% as the minimum in its development of the *SLA* of the AWMP 'because it considered they more closely correspond to biological reality' (IWC 1998).

When the 'base case' simulations were run for 300 years for the three TL options of 0.60, 0.66 and 0.72, chosen when the *CLA* was developed in the late 1980s, the final depletion ends up at 0.73, 0.74 and 0.76, respectively. Three parameters in the *CLA* can potentially be used for tuning: PPROB, IPL and PSLOPE. PPROB was used as the tuning parameter in the original *CLA*. Values of PPROB = 0.4015, 0.4629 and 0.5222, gave TL = 0.72, 0.66 and 0.60, respectively, when IPL = 0.54 and PSLOPE = 3.0. However, it is not possible to obtain a DL lower than 0.70 by increasing PPROB. In addition, it is theoretically unwise to increase PPROB above 0.5.

In SC/58/RMP7, DL has been tuned to lower levels by increasing PSLOPE while keeping PPROB at 0.5 and IPL at 0.54. Two values of DL were chosen: 0.66 and 0.69. For these two DLs the six base case simulations and the 24 most difficult robustness simulation trials from the development around 1990 have been carried out. In addition three base case simulations have been carried out with $MSYR_{(mat)}$=1% for comparison. For each of the 33 simulation trials the results are displayed as depletion levels, lowest population, average catch, average annual variation in catch, average population as a function of time, 5% lowest population as a function of time, and average catch per year as a function of time. Three sample trajectories are also shown. The trial results clearly show that both new tunings give *CLA*s which perform adequately on all risk-related performance statistics, one somewhat better than the other, and that they both perform better than the current versions on catch-related performance statistics.

SC/58/RMP7 had used IWC (1993b) as a basis for the set of simulation trials conducted, on the interpretation that this was a list of trials developed by the Scientific Committee and thus satisfied point (2) under Item 2.2.1. The authors of SC/58/RMP7 noted that their table 3 lists robustness trials not performed. To run trials over 300 years takes considerable time and SC/58/RMP7 had concentrated on the more demanding trials. The T5 and T7 trials are not very challenging and the 'tent' model is difficult to implement in the age-structured model now used in all simulation trials so the T10 and T11 trials were also not conducted. The performance of the T13 trials, in which *MSYR* changes abruptly every 33 years, was deemed likely to be spanned by the corresponding *MSYR*=1% and *MSYR*=4% trials. The T14 trials are irrelevant because regular surveys are mandatory, and the T15 trials are not very relevant because surveys must be carried out every 5 years.

The sub-committee did not have time to fully review the results of SC/58/RMP7. The main point raised in discussion related to the behaviour exhibited in some cases in which catches initially increase and then decrease quite sharply followed by reduced catches in the long term to achieve acceptable final depletion levels after 300 years. The population trajectories show a corresponding strong initial dip followed by a long slow recovery. Some members pointed out that this was not a good generic feature of a procedure for sustainable management of a resource. The authors of SC/58/RMP7 pointed out that the current *CLA* exhibits similar properties in that relatively high catches are linked to an initial dip in the population trajectory and when there is no dip in the trajectory there are poor catches. They believed that making possible the highest continuing yield should be linked to the population achieving equilibrium in the long term.

As a note to the authors of SC/58/RMP7, it was suggested that the results of the episodic events trials appeared to show that an internal correction factor in the trials had not been recalculated to account for the change from $MSYR_{(mat)}$ to $MSYR_{(1+)}$.

Wade presented SC/58/RMP8, which briefly reviewed the process by which the Committee has previously agreed to specific calculations for the *CLA*, and discussed implications of changes to the *CLA* proposed by the Norwegian re-tuning in SC/58/RMP7. A number of candidate *CLA*s were considered when the Committee originally developed the *CLA* as part of the RMP. To compare these candidate *CLA*s in a fair manner, each candidate *CLA* was 'tuned' to achieve depletion levels of 0.60, 0.66, and 0.72*K* after 100 years from the start of the simulation. These depletion levels and the choice of 100 years were not considered specific management objectives – they were simply specified to cover a range of levels that were consistent with management goals, and allowed for the evaluation of the performance of the different candidate procedures in a consistent fashion. After the 'C' procedure was selected as the *CLA*, these different tunings were then additionally used to examine the tradeoffs between catch and risk within the 'C' procedure itself. The performance of the 'C' procedure for these three different tunings was presented to the Commission to provide a range of tradeoffs between catch and risk for the Commission to consider. When the Commission adopted the *CLA* it specified that the 0.72 tuning should be used in the *CLA*, as they considered that particular trade-off of catch and risk to be preferable.

SC/58/RMP8 noted that the authors of SC/58/RMP7 have run simulations to modify and 're-tune' the *CLA*. Specifically, the time horizon for examining final depletion level was changed from 100 to 300 years, two new lower target depletion levels were examined, and a higher population growth rate was used by changing $MSYR_{(mat)}$=1% to $MSYR_{(1+)}$=1%. Thus there are two separate items that have been changed in SC/58/RMP7. In addition to re-tuning the *CLA* to create new candidate *CLA*s, they also changed the trial scenarios used to evaluate candidate *CLA*s, and this makes it difficult to compare the performance of these new candidate *CLA*s with the existing *CLA* using the results presented in SC/58/RMP7. The guidelines for considering modifications to the *CLA* require that new candidate *CLA*s are demonstrated to perform better than the agreed *CLA* on the same performance trials. This is not possible given the trials run in SC/58/RMP8, which, with regards to performance, shows that, as expected, the two new re-tunings to lower depletion levels resulted in better performance on catch statistics, but poorer performance on risk statistics, illustrating the clear trade-off between catch and risk. SC/58/RMP8 suggests, therefore, that the two new lower depletion level tunings in SC/58/RMP7 do not appear to be acceptable on risk. With regard to *MSYR*, SC/58/RMP8 noted that the existing *CLA* had been previously examined in trials where $MSYR_{(mat)}$=4%, and its performance was found to be acceptable by the Committee. Further, the *CLA* includes a uniform prior distribution from 0% to 5% on $MSYR_{(1+)}$, and thus allows for higher growth rates.

Walløe responded that the performance on risk statistics of one of the new tuning levels (γ 0.69) in SC/58/RMP7 was very similar to the old TL of 0.60 if one considers $MSYR_{(1+)}$ an appropriate choice for a minimum *MSYR*, and that examination of the results of further simulation trials and response curve plots would be required to show if there really is a difference in risk-related performance.

The sub-committee briefly discussed the relevance of running simulations over 300 years vs the 100 years used during the development of the RMP. The sub-committee **agreed** that the acceptability of a proposed amended *CLA* would *inter alia* be judged on performance over 100 years. Further discussion on this point is recorded below.

During discussions of the proposals in SC/58/RMP7, a number of issues were raised concerning how the sub-committee should proceed in evaluating proposed amendments to the *CLA*. To avoid confusion when considering the steps that needed to be taken, the sub-committee recalled how the process by which the current *CLA* had been evaluated and selected.

(1) THE ROLE OF TUNING IN THE EVALUATION AND SELECTION OF THE *CLA*

When it came to recommending a single management procedure to the Commission for possible adoption, the Committee noted that comparison of alternative procedures is not entirely trivial, because they have to meet competing objectives. A procedure can always be modified to reduce the risk of depletion of stocks, but at the cost of allowing less catch. Likewise, higher catches can be achieved, but at the cost of a greater risk of depletion of the stock. The Committee recognised that in the presence of this trade-off, it could be difficult to compare the underlying performance of two candidate procedures if they are tuned to achieve different trade-offs between the two main objectives of catch and risk, and if only one tuning is presented. However, if results from several alternative tunings of each procedure are available, then it may be possible, by interpolating the results if necessary, to draw conclusions about the relative performance of the two procedures.

In 1990 (IWC, 1991) the Committee therefore requested developers to present results for a wide range of tunings to ensure that there would be at least some overlap in the range of risk-related performances of the different candidate procedures. In preparation for a final selection between procedures, the fourth and final Comprehensive Assessment Workshop on Management Procedures recommended that selection of a procedure be based on results for three specific tunings of each of the five candidate procedures. These three tunings should be such so as to achieve a median final depletion (ratio of current to unexploited population) of the mature female population after 100 years of 0.60, 0.66 and 0.72, in a specific reference trial. The reference trial chosen was the so-called D1 trial. 'The D1 trial was chosen because it reflected the greatest discrimination between the preferred tunings of the various developers; the highest and lowest final population values adopted for tuning purposes reflected the range covered by these preferred tunings' (IWC, 1992d, p.312).

A set of 12 trials was selected for performance comparison, in addition to a number of robustness trials for which it was merely required that a procedure perform 'acceptably'. Fourteen basic performance statistics were provided for each trial, but comparison between procedures was to be made on the basis of just 18 composite statistics calculated from the core set of 12 trials (IWC, 1992c). The Committee selected one of the five candidate procedures on this basis, for recommendation to the Commission (IWC, 1992e, p.55). The Commission accepted the recommendation and selected one of the three tunings presented, the 0.72 tuning (IWC, 1992a).

(2) DISTINCTION BETWEEN TUNING TARGETS AND PERFORMANCE CRITERIA

The denomination of the selected tuning in terms of a median final depletion to $0.72K$ in the D1 trial has caused considerable confusion within the secondary literature on the RMP. The tuning level of 0.72 has frequently been erroneously interpreted as a management target, when in fact it was only for comparative purposes for assessing the relative performance of alternative procedures. No special weight was placed by the Scientific Committee on either the D1 trial, nor on the median final depletion as a performance measure.

Of the eight risk-related performance measures used for management procedure selection, only two related to final depletion and six related to the lowest depletion over the 100-year period. The D1 trial was chosen because of the discrimination it offered between procedures, not because it was a typical, central or average trial in any sense. On the contrary, it was a relatively extreme trial in that it was based on the lower extreme of the range of *MSYRs* (1%, 4% and 7%) considered across the trials. For *MSYRs* in the middle of the range (i.e. the 4% trials), the median 100-year depletion was considerably higher.

The Committee based its selection of the current *CLA* on the consideration of a number of performance measures (18 in all). The actual final depletion level achieved by any catch limit algorithm, whether after 100 or 300 years, depends on the details of the specific trial. The current *CLA*, which has a nominal tuning level of 0.72, will only actually exhibit a median final depletion of 0.72 in the precise reference trial used for tuning purposes.

(3) IMPLICATIONS FOR EVALUATION OF AMENDMENTS TO THE *CLA*

The considerations outlined above have two implications for the evaluation of amendments to the *CLA*, such as proposed in SC/58/RMP7. First, achievement of a specific tuning level is not itself a measure of conservation performance. In comparing proposed amendments with the current *CLA*, performance should be compared across the full range of performance measures. Second, comparison of the performance of two procedures can only be validly evaluated their performance over the same trial. Whether or not *MSYR* is defined in terms of the recruited or mature population, and whether or not the tuning is to a given population size after 100 or 300 years are not very important provided that alternative procedures are evaluated over the same trials and the performance measures are appropriate.

The sub-committee highlighted three steps that should be taken to evaluate any amendment to the current *CLA*, including those presented in SC/58/RMP7:

(1) agreement on the range of *MSYRs* to be used in the trials;
(2) identification of an appropriate standard set of simulation trials;
(3) definition of an appropriate set of performance statistics to be used in evaluating alternative procedures.

There was some initial discussion of these steps. The sub-committee **agreed** that the development of proposed amendments to the *CLA* could proceed in parallel with consideration of these points.

RANGE OF MSY RATES TO INCLUDE IN TRIALS

The sub-committee established a Working Group under Cooke with terms of reference: (a) to make proposals on how to structure a review of the plausible range of *MSYRs* for use in management procedure evaluation; and (b) to determine what interim range of *MSYRs* should be used in trials pending the results of that review. The report of the Working Group is given in Appendix 4.

The sub-committee **agreed** to the report and accordingly **recommended**:

(1) The interim range of *MSYRs* to be used in further development of amendments to the *CLA*, pending review in 2007, shall be from $MSYR_{(mat)}$=1% to $MSYR_{(1+)}$=7%, corresponding approximately to the range 0.66-7% for $MSYR_{(1+)}$ or 1-10% for $MSYR_{(mat)}$.
(2) A review of *MSYRs* should be conducted at next year's meeting and completed by the 2008 Annual Meeting at the latest. The review should be limited to baleen whales.
(3) The review should not simply take published estimates of rates of increase or *MSYRs* but should examine them critically with respect to, *inter alia*, the nature of the data and the analysis methods used. Papers considered should be made available as For Information documents.
(4) Where relevant data exist but have not been analysed with respect to the question of *MSYRs*, relevant analyses of these data should be actively solicited. The attention of other sub-committees is drawn to this request.
(5) A list of cases to be considered in the review should be drawn up in advance, by the end of 2006. The list should include existing estimates and corresponding primary papers, analyses in preparation intended for submission to the review, and other relevant datasets of which analyses would be desirable.

The sub-committee received a brief presentation of SC/58/RMP6, which considered data on all landed minke whales from the northeastern Atlantic (small areas ES, EB, EW and EN) from 1952. The purpose is to construct a relative abundance series for the stock, and later to estimate productivity in the population. Due to changes in the management regime, with individual boat quotas from 1984 and a resumption of commercial whaling from 1993 under conditions rather different from in previous years, two unconnected series are constructed, one for 1952-1983 and one from 1993-2004. The simple and generally applicable net catcher day method of Cooke (1984) is employed, despite its shortcomings as discussed previously. The estimated relative change declines to 63% of its 1952 level in 1983, and increases to 186% of its 1993 level in 2004. Since autocorrelations have not been accounted for; the large estimated increase in recent years is rather uncertain.

In response to a question about how the decline in the CPUE series for the Lofoten area was handled in analysis, it was clarified that SC/58/RMP6 generated a CPUE series for the entire Norwegian fishery, including the Lofoten area. It was noted that spatial effects can be difficult to model in analyses of CPUE data, especially when there are closed areas into which results are extrapolated. These and other technical issues were important to consider in these types of analysis. There was insufficient time to discuss this paper in any detail. The sub-committee looked forward to receiving further results next year in the context of its review of *MSYRs*.

SET OF SIMULATION TRIALS FOR TESTING AMENDMENTS TO THE *CLA* AND PERFORMANCE STATISTICS TO BE USED

The sub-committee established another Working Group, under Allison, with terms of reference: (a) to review simulations trials conducted previously to evaluate catch limit algorithms and to specify a list of trials that should now be used to evaluate any proposed amendments to the *CLA*; (b) to revise the set of performance statistics to be used for comparison of catch limit algorithms; (c) to consider the specification of tuning levels for comparing catch limit algorithms.

The sub-committee thanked the Working Group for its work, the report of which is given in Appendix 5 in the form of a set of requirements for simulation trials to be conducted to evaluate proposed amendments to the *CLA*. The sub-committee **recommended** that these requirements be integrated into the RMP specification.

One topic discussed by the Working Group required further work. Additional trials that modelled possible environmental degradation should be developed in addition to or to replace the trials in which *K*, perhaps together with *MSYR*, varies over time. The current varying *K* trials have questionable behaviour when modelling population sizes above *K* and might better be modelled using an exponential model. Specification of these additional trials should be done before next year's meeting. The resulting trials will then be included in the full trial set in Appendix 5, but not in the list of those required to demonstrate an improvement in behaviour of a candidate procedure.

The sub-committee noted that some of the original trials used to test the *CLA* have been deleted from the list in Appendix 5. The tent model trials have been replaced by trials based on the Pella-Tomlinson recruitment function in which *MSYL* is varied; in addition, the trials proposed above to use an exponential model will address the requirement for a trial using a population model other than the standard age-structured model with a Pella-Tomlinson recruitment function. Trials that were designed to investigate minimum data standards (the T14-D1 and T14-R1 trials in which there was a survey in year 1 only and other trials with inter-survey intervals of 5, 7 and 10 years in combination with various factors) were deleted as the phase-out rule makes them unnecessary. In addition, the minimum data standards trials (IWC, 1994, p.47) are not included in the full set of trials because the response curves were considered sufficient in this regard.

2.3 Work plan

As its work plan for next year, the sub-committee referred to the work specified under Item 2.2.2 relating to the review of plausible *MSYRs* and the specification of additional trials for testing amendments to the *CLA*. Two Intersessional Working Groups were established to facilitate this work:

(1) to plan the review of *MSYRs*: Cooke (Convenor), Butterworth, Gunnlaugsson, Hatanaka, Polacheck, Punt, Schweder, Tanaka, Wade;
(2) to specify additional trials for testing amendments to the *CLA*: Allison (Convenor), Butterworth, Cooke, Donovan, Kawahara, Punt, Walløe.

The sub-committee noted that the review of *MSYRs* may take up considerable time at next year's meeting and that it may be prudent to plan for a pre-meeting workshop on this subject.

3. RMP – PREPARATIONS FOR *IMPLEMENTATION*

3.1 Western North Pacific (WNP) Bryde's whales

3.1.1 Report from the first intersessional Implementation Workshop for western North Pacific Bryde's whales

Donovan introduced SC/58/Rep1, the Report of the Intersessional Workshop. The Workshop took place at the National Research Institute of Far Seas Fisheries, Shizuoka, Japan from 25-29 October 2005. The objective of the meeting was to develop an appropriate *ISTs* structure and to specify the associated conditioning so that it can be carried out before the following Annual Meeting. Full details can be found in the 'Requirements and Guidelines for *Implementations*' agreed by the Committee in 2004 (IWC, 2005).

A considerable part of the Workshop was dedicated to addressing issue related to stock structure hypotheses with emphasis on their role in specifying an appropriate trial structure. The Workshop reviewed the evidence for each of the five hypotheses agreed by the *pre-implementation assessment*. It noted and welcomed the considerable additional data that have become available since 1999. It noted that the assignment of plausibility in a trial context would not take place until the First Annual meeting in 2006. The Workshop considered information from several approaches, both genetic and non-genetic.

After considerable discussion, it agreed that four stock hypotheses were sufficient for the trials. These are given in Appendix 6, fig. 2.

Hypothesis 1: Only one stock of Bryde's whales is found in the area from 130°E to 160°W (excluding the area in which the East China Stock is found) and there are no sub-stocks.

Hypotheses 2 and 3: Different stocks in sub-areas 1 and 2. Hypothesis 3 differs from hypothesis 2 in that the stock found in sub-area 1 is also found in sub-area 2.

Hypothesis 4: Identical to hypothesis 2 but with two sub-stocks that mix in sub-area 1.

Most of the discussion at the Workshop focussed on hypothesis 4. It agreed that at this stage, a hypothesis that included sub-stocks was necessary to implement one of the possible explanations for the differences in the age distributions for JARPN II and for sub-areas 1E and 2, recognising that further work may eliminate this explanation by the next annual meeting. Results from a simple model filter analyses do not provide evidence for or against sub-stocks but suggest that *if* there is more than one sub-stock in sub-area 1, then there is likely to be considerable mixing.

It also considered a number of other issues related to trials structure and recommended that:

(1) all trials would assume that $g(0)=1$;
(2) there was insufficient information to develop an estimate of the lower bound for *MSYR*;
(3) alternative catch series be developed based on the agreements reached in SC/58/Rep1;
(4) experimental work be undertaken to try to determine whether observed differences in age distributions are: (a) related to age reading and/or sampling issues in the commercial data (this has implications for calculation of t_m and M); (b) real and reflect age-segregated distribution (this implies that trials should allow for smaller proportions of older animals in 1W than in 1E+2); or (c) differences are real and may indicate some degree of stock structure between sub-area 1W and 1E+2 (this has implications for stock structure hypothesis 4);
(5) the three previously agreed sub-areas be retained (see Appendix 6, fig. 2) but move the 1W/1E boundary to 165°E (and undertake sensitivity trials for 155°E);
(6) trials should assume an age at recruitment as applied to past coastal whaling (i.e. assuming no length limits) although it was agreed to investigate the implications of retaining or removing such limits;
(7) the trials structure given in SC/58/Rep1 (annex G) adequately captures the full range of uncertainty for the WNP Bryde's whales;
(8) a control program that implements these trials be developed and that the trials be conditioned and results reported to the 2006 Annual Meeting using values for abundance, biological parameters, *Small Area* definitions and management variants detailed in the report;
(9) the results be presented according to the manner described in SC/58/Rep1.

A number of recommendations were made to try to ensure that this work was completed before the 2006 meeting.

In discussion, the sub-committee thanked Donovan and the participants for their work. It endorsed the recommendations. Progress on the recommendations is discussed under the relevant Items below.

3.1.2 Objectives of the first Annual Meeting

The primary purpose of the first Annual Meeting is to review the results of conditioning and to finalise the IST*s*.

New analyses of data available up to the time of the previous workshop are acceptable but new data may **not** be introduced at this stage. After reviewing the results of the conditioning, the *t*rials themselves may be changed, but the overall structure can **not** be changed.

The primary output will be the detailed specifications of the final IST*s*. These will be determined on the basis of:

(1) final consideration of the plausibility of the various hypotheses and hence the weight assigned to each of the trials (the overall balance of the *ISTs* will be accounted for when weights are assigned);
(2) discussion of what data/research may reduce the number of hypotheses and possible time-frames for this research/data collection;
(3) updates/improvements to standard data sets (i.e. abundance, catches, bycatches) for use by the *CLA* in final trials and when evaluating the plausibility of hypotheses and hence assigning weights to trials (new data would not be used when conditioning the trials); and
(4) specification of operational features (geographical and temporal) and management variants.

The specification of final trials:

(1) may include trials to examine effects of using one RMP variant over an initial period (up to 10 years) followed, after a 5-year phase-out period, by a more conservative variant (see discussion below);
(2) will exclude potential 'low' weight trials (e.g. those where at least one factor is considered to have 'low' plausibility);
(3) will assign weights to the remaining trials of 'high', 'medium', or 'no agreement'.

A timetable for the remaining work (including circulation of trial results and format) will be developed – the timetable will be determined so that there is a reasonable expectation that the results of the trials will be available well before the second intersessional Workshop.

The Committee will also commence discussions related to defining the inputs for actual application of the *CLA* (catches, bycatches, estimates of abundance and projected future anthropogenic removals).

3.1.3 Review results of conditioning

Allison introduced the modifications to the trial specifications (SC/58/Rep1, annex G) that had been developed since the Workshop. The sub-committee **agreed** to the revised specifications in Appendix 6.

3.1.4 Updates to standard data sets

3.1.4.1 ABUNDANCE

The sub-committee **agreed** with the conclusions of the intersessional workshop. The pooled abundance estimates obtained for the complete survey area considered (blocks F-M: see fig. 1 of Annex H) was 21,826 (CV=0.295), to apply to 1995, with an additional standard deviation estimate of σ_A=0.673. These results (and corresponding estimates for smaller areas as reflected in Annex H) were adopted for use in the *ISTs*. It was noted that this estimate did not include contributions from blocks A-E (see fig. 1 of Annex H); this was not of concern for conditioning purposes because the 1998-2002 surveys indicated these contributions to be relatively small, but the methodology to be used to obtain abundance estimates for input on application of the RMP will need to take account of these blocks as well. With respect to using abundance estimates in the RMP, to avoid coding problems it was agreed that two separate estimates and their CVs should be used.

3.1.4.2 CATCHES AND OTHER ANTHROPOGENIC REMOVALS

SC/58/RMP1 provides a description of the Philippines commercial whaling operation for Bryde's whales in the 1980s. It confirmed, from official documents obtained in Manila, that the whaling was pelagic, not coastal, and that the whales were not taken in Philippine Exclusive Economic Zone (EEZ) waters but near the Ogasawara Islands and in Micronesia. Some of the whales taken in Micronesia may have been of the pygmy species (known currently as *Balaenoptera omurai* but as yet still included in the IWC list of recognised taxa with the 'ordinary' Bryde's whale under *B. edeni*). These points have been taken into consideration when constructing the final catch series and alternatives given as Appendix 7.

3.1.5 Final consideration of plausibility (including weighting of trials in terms of overall balance)

3.1.5.1 STOCK STRUCTURE HYPOTHESES

Pastene presented SC/58/PFI2 which provided an examination of the plausibility of the four stock structure hypotheses set out in the Report of the First Intersessional Workshop on the WNP Bryde's Whale *Implementation* (SC/58/Rep1). The paper considered information available from allozymes, mtDNA, microsatellites, sighting distributions, catch distributions, external body proportions, biological parameters, mark-recapture and age distributions of catches.

The sub-committee reviewed the information summarised in table 2 of SC/58/PFI2 regarding the plausibility of different stock structure hypothesis. After lengthy discussions, which included recognition of the importance of including a NIW (Not Inconsistent With) designation to cover cases where the absence of any identified signal in the available data precluded any distinction being drawn between the relative plausibilities of hypotheses. A summary of this information as provided in Table 1 was **agreed**. It was emphasised that the purpose of this table was not to provide a form of scoring system with 'totals' of some form dictating plausibility verdicts, but rather to provide an aid towards an integrative appraisal of all the potential sources of information.

The agreed process for interpreting the results from a set of RMP *ISTs* requires that a weight of either high, medium or low be accorded to each trial (in cases where there is wide range of views and hence no agreement, the weight of medium applies). It is important to recognise that where there are several hypotheses for a particular factor (such as stock structure) in the trials, the aim of the plausibility exercise is not to rank these hypotheses in order, but rather to classify them into one of these three broad categories. The sub-committee **recognised** that this necessitated some distinction between 'plausibility' and 'weight' of specific trials (for which the plausibility of several factors in combination has also to be addressed). While there might be differences in plausibility between certain hypotheses, the necessity that the RMP trials process provide an adequate check that a recommended RMP variant manifest robustness to uncertainty, means that it may be appropriate to have two hypotheses feature in, say, the high weight category, even though they differ somewhat in plausibility. There are only two weight designations (high and medium) that result in trials being retained in the testing process, which means that considerations of balance have also to be taken into account, with weights accorded also factoring in aspects of 'importance' in this overall context.

Following lengthy deliberation, the sub-committee developed the following views about the four stock structure hypotheses.

Hypothesis 1: There was general agreement that this had high plausibility (relative to the other hypotheses) and at baseline level should be accorded a high weight in trials.

Hypotheses 2 and 3: It was agreed that these two hypotheses could be treated equivalently for the purposes of plausibility and weight designation. There was agreement that the plausibility of these hypotheses was less than that of hypothesis 1, but there were varying views as to whether this difference was sufficient to warrant a medium plausibility ranking when only three categories were available for such designation. There was eventual agreement that a high-medium plausibility ranking was appropriate. In the context of weighting for trials, most members of the sub-committee were of the view that considerations of balance dictated that a high weight be accorded to the associated trials at the baseline level. However some members believed that according a medium weight would have been more appropriate.

Hypothesis 4: It was agreed that this hypothesis did not merit a high plausibility ranking. Some members considered that the ranking should be low. They noted the indications provided by genetic information in Table 1, and commented on the considerable amount of data and extent of associated analyses to support this viewpoint that had become available since the 1998 review (table 1 in SC/58/Rep1); they thus believed that this hypothesis should be ranked as of low plausibility. Others, while welcoming the provision of these extra data, noted that the absence of genetic evidence for distinction did not preclude the existence of some stock structure. They also referred to the unresolved reasons for apparent differences in age-structure in catches, and accordingly believed that the hypothesis should be accorded medium plausibility. Given this absence of agreement, at the baseline level trials based on this hypothesis would be accorded medium weight. It was agreed that once the investigations of the ageing data had been conducted, this decision should be revisited.

Table 1

General summary of the information useful to assess plausibility of alternative stock-structure hypotheses. A '+' indicates evidence in favour of a hypothesis, '-' indicates evidence against a hypothesis, '(+)' indicates weak evidence in favour of a hypothesis, '(-)' indicate weak evidence against a hypothesis, a (()) indicates very weak evidence, and 'NIW' indicates that the evidence is not inconsistent with the hypothesis. Note that the designation NIW often reflects the asymmetrical nature of information on stock structure (i.e., existence of differences can be viewed as positive evidence for multiple stocks, but absence of differences provides no information, and cannot be viewed as positive evidence for a single stock). Notations at the bottom of this table were extracted in part from the report of the 'First Intersessional Workshop' (SC/58/Rep1 published in this volume).

Evidence	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4
Allozymes	(+) [a]	(-)[a]	(-)[a]	(-)[a]
mtDNA	((+))[b]	NIW[c]	NIW[c]	-[d]
Microsatellites	NIW[b]	NIW[c]	NIW[c]	-[d]
Sighting distribution	NIW[e]	NIW[e]	NIW[e]	NIW[e]
Catch distribution	NIW[e]	NIW[e]	NIW[e]	NIW[e]
External body proportion	NIW[f]	NIW[f]	NIW[f]	NIW[f]
Biological parameters	NIW[f]	NIW[f]	NIW[f]	NIW[f]
Mark-recapture	NIW[g]	NIW[h]	NIW[h]	NIW[g]
Age distribution	NIW[i]	NIW[i]	NIW[i]	(+)/NIW[i,j]

[a]The sub-committee agreed that while the power to detect genetic structure might be considered to be low as only a single locus was analysed, the fact that this had been sufficient to detect structure in the Pacific Ocean suggest that if there are multiple stocks differentiated at a level similar to that between the western North stock and other stocks, examination of this single locus should be sufficient to detect this.

[b, c]Clustering and hypothesis testing analyses of mtDNA and microsatellites were conducted, and as noted by the sub-committee, none of these analyses revealed any significant heterogeneity within sub-area 1. Only 6 mtDNA samples are available from sub-area 2 – these provide very real evidence for hypothesis 1, but this is not sufficiently strong to be considered inconsistent with hypotheses 2 and 3.

[d]*Mixing of two sub-stocks*: There are no genetic data for the breeding grounds so the possibility of multiple sub-stocks cannot be excluded. Furthermore if two breeding stocks mix almost completely, it will be difficult to detect differences using, for example, genetics tests based on comparisons between data for the west and east of sub-area 1. However while complete mixing may lead to all methods of detecting stock structure having low power, the plausibility of this was considered fairly low given the behaviour of most large whales. Hypothesis tests based on comparisons for approximately the same area in sub-area 1 found no significant differences among years which suggest that if two sub-stocks mix in sub-area 1, there is little difference in the distribution proportion among years. Although the data set encompasses only four years, such a lack of variation in distribution proportions among years seems unlikely given the known behaviour of whales. In principle evidence for hypotheses 4 could be obtained by testing for deviation from Hardy-Weinberg equilibrium within sub-areas 1W and 1E because such deviations provide evidence of non-random mating as well as selection or migration, i.e. when genetically two different populations are being sampled. Analyses of nuclear markers for Bryde's whales in sub-area 1 have been conducted and these analyses provide no evidence for the significant deviations in Hardy-Weinberg equilibrium within sub-areas 1W and 1E which would provide support for multiple sub-stocks.

Statistical power: The Workshop received a paper, which evaluated the power to detect population structure using the chi-square test and Fisher Exact test under an island model in which population differentiation is controlled using a single parameter, F_{st}. Statistical power of the genetic analysis in sub-area 1 was found to be high for moderate sample sizes and quite small values for Fst, while it was higher for microsatellite data than for mtDNA.

[e]The sub-committee examined the sightings data and agreed that it revealed no evidence of a discontinuity in distribution within sub-areas 1 and 2. A similar conclusion was reached with respect to catch distribution. Discontinuity in the commercial catches identified in earlier meetings merely reflected operational constraints. Evidence of spatial discontinuity would be viewed as positive evidence for multiple stocks, but absence of discontinuity is viewed as neutral information, as there is no expectation that their prey would have a discontinuous distribution. Therefore, multiple stocks could exist without spatial discontinuity.

[f]External body proportion data (three features) and several biological parameters (body length, pregnancy rate, length at sexual maturity, seasonality in breeding) had been examined using data from past commercial whaling. Although operational differences (e.g. different minimum length limits for coastal and pelagic whaling) meant that some comparisons could not be made, the authors of these analyses concluded that there were no differences that could not be attributed to operational factors. Evidence of differences in biological parameters would be viewed as positive evidence for multiple stocks, but absence of differences does not provide positive evidence for a single stock, because it is not necessary for separate populations to diverge in their biological parameters, as these are often constrained by their ecology.

[g]Mark-recapture analysis revealed movement of animals within sub-area 1. A very limited number of marks were placed in sub-area 2 and while none has been recovered in sub-area 1, the sample sizes for this sub-area are sufficiently small that even if there is mixing between sub-areas 1 and 2, zero recaptures would not be highly unlikely.

[h]Mark-recapture data are available mainly for sub-area 1.

[i]One of the possible explanation for the differences observed in age distribution between sub-area 1W and 1E+2 is that these differences are real. Other possible explanations were geographical segregation by age or non-representativeness of the samples, perhaps as the result of unreadability of certain earplugs, inaccuracy in length determination, or inter-reader differences in ageing.

[j]There was no consensus on this verdict. The different views hinged on different interpretations on an appropriate entry given that there were alternative explanations for the observation in question.

3.1.5.2 OTHER (e.g. *MSYR*)

The sub-committee reviewed the *ISTs* specified in table 6 of SC/58/Rep1. All 22 trials were retained, and an additional six trials were specified. Four of these new trials used mixing matrix B (instead of D) in combination with the High catch series and with Additional process error (at both *MSYR* rates). It was agreed that the Additional process error would be specified using values from annex H of the Intersessional Workshop report. The final two additional trials will also use mixing matrix B with the High catch series in combination with Age-specific mixing (at both *MSYR* rates).

Each trial will be assigned a weight that is equal to the lowest plausibility of any component of that trial. The plausibility of the components of each trial was discussed and the sub-committee agreed to the following assignments.

MSYR: It was agreed that *MSYR*=4% would be given high plausibility and *MSYR*=1% would be given medium plausibility.

Age-dependent mixing: The age-dependent mixing accounts for the observations of different age distributions in different areas. It was agreed that both the inclusion of age-dependent mixing and the exclusion of it would be given high plausibility.

Additional process error: It was agreed that the inclusion of additional process error would be given high plausibility.

Stochastic mixing: It was agreed that stochastic mixing of two stocks in sub-area 1 would be given medium plausibility.

Alternative boundary: The default in trials is that the boundary between 1W and 1E is at the survey boundary. Alternative boundary allows for the stock boundary to be in locations other than the survey boundary. These alternative boundaries were all given medium plausibility.

Low and High catch series: The Low catch series and the High catch series are specified to account for uncertainty in the catch series, mainly due to uncertain species identification between Bryde's and sei whales, along with the possibility that the true catches are higher than the reported catches (Kasuya and Brownell, 2001). In discussion, it was suggested by Perrin that the High catch series was equally plausible as the reported catch series, and both should have high plausibility. As reported previously in IWC (2006), Kasuya and Brownell (2001) had noted the total actual catches off the Ogasawara Islands might be 1.6 times the reported catches but the original records have been lost and are not available. Therefore, it is not possible to examine this issue any further to elucidate which catch series is more likely, and consequently both catch records should be accorded high plausibility. This ensures that the performance of both catch series (Best and High) will be held to the same standards in trials. The sub-committee **agreed** that both the Best and High catch series would be given high plausibility.

3.1.6 Data/research to reduce hypotheses

Under this item the sub-committee noted its earlier discussions under Item 3.1.1, and in particular under Item 3.1.5.1, hypothesis 4.

3.1.7 Specification of operational features and management variants

The following four management options will be considered:

Management options based on calculating limits by *Small Area*:

(1) sub-areas 1W, 1E[1] and 2 are *Small Areas* and catch limits are set by *Small Area*;
(2) sub-area 2 is taken to be a *Small Area* and the complete sub-area 1 is treated as a *Small Area*. For this management option, all of the future catches in sub-area 1 are taken from sub-area 1W.

Management options based on applying catch cascading:

(3) sub-area 2 is taken to be a *Small Area* and sub-area 1 is taken to be a *Combination Area*. Sub-areas 1W and 1E are Small Areas, with *catch-cascading* applied;
(4) sub-areas I and 2 (combined) are taken to be a *Combination Area*, and sub-area 2 and sub-areas in 1W and 1E are *Small Areas*, with *catch-cascading* applied.

[1] Defined to be 140°E-165°E and 165°-180° irrespective of the true boundary used to define the structure of the populations in the operating model.

The simulation application of the RMP is based on using the 'best' catch series (see Table 2).

3.1.8 Specification and classification of final trials

The full list of specified trials, including the weights of each trial given by the lowest plausibility of any component, is found in Appendix 6, table 6.

3.1.9 Work plan

In accordance with the 'Requirements and Guidelines for *Implementations*' (IWC, 2005) plans were made for the second intersessional Workshop for the WNP Bryde's whale *Implementation*. Japan offered to host the meeting, as for the first intersessional Workshop, to be convened by Kawahara. The cost will be the same as for the first workshop.

3.2 North Atlantic fin whales

3.2.1 Report of the joint NAMMCO/IWC Scientific Workshop

Walløe presented the report of the Joint NAMMCO/IWC Scientific Workshop on the catch history, stock structure and abundance of North Atlantic fin whales (SC/58/Rep3). The main objective of the Workshop was to consider the available information on stock structure, catch history, biological parameters and abundance and trends in order to advance the fin whale assessments ongoing in the two organisations.

Several papers on stock structure, based on both genetic and non-genetic data, were presented at the Workshop. A number of key factors emerged that require further work before a full understanding of the contribution of the genetic work to the elaboration of stock structure in the North Atlantic fin whales can be completed, and these were given as recommendations for work to be completed before the IWC meeting in St. Kitts. The Workshop then went on to consider the hypotheses with respect to feeding areas, using the schematic figures of IWC (2005) as a guide. It is important to stress that the figures are schematic and the location of the 'breeding stocks' is not intended to suggest any specific geographical location. The Workshop considered each of the figures in turn and modified them where appropriate. The Workshop noted that in many cases the discriminatory evidence is weak. The results of these discussions are given in SC/58/Rep3, fig. 1. The Workshop agreed that pressures of time meant that it had not been possible to fully consider the need for possible further scenarios (e.g. incorporating possible north-south structure, alternative links and/or strength of links between breeding stocks and feeding areas, or finer structure within feeding areas).

The Workshop received a complete review of estimates of biological parameters for fin whales, including age and length at sexual maturity, asymptotic length, length at age five, age at recruitment, mortality rate, ovulation rate and interval and the proportion pregnant in the mature female catch. It was agreed that there was nothing in the review to necessitate change to the parameter values used previously by both the IWC (IWC, 1992b) and NAMMCO (NAMMCO, 2000; 2001; 2004) Scientific Committees.

A number of papers detailing catch series for the northeast and central Atlantic were presented to the Workshop. It was agreed that there was sufficient uncertainty in the catches, in particular in years when the fin whale catch was estimated from the total catch by species proportion and in years when the struck and lost rate was thought to be appreciable, to warrant development of alternative catch series. It was agreed that the information in the catch series will be used as a basis to develop a 'high' and a 'low' series containing the maximum and minimum catches, however this work could not be completed at the Workshop. In addition the Workshop considered papers detailing various Catch Per Unit Effort (CPUE) indices for the Icelandic, Norwegian and Faroese fin whaling operations, and provided a series of recommendations for improvement and better documentation of these indices. It was considered particularly important that papers proposing CPUE series provide adequate documentation of the rationale behind any assumptions made and values chosen and consideration of alternative values and assumptions to capture uncertainty/possible bias. It was recommended that priority be given to investigating whether appropriate CPUE series could be developed for the 'early' (pre-1915) Icelandic whaling operations and Faroese whaling after the 1st World War.

Several papers detailing abundance estimates from international and Norwegian surveys carried out in the northeast and central North Atlantic since 1987, as well as recent Canadian and Greenlandic surveys, were presented at the Workshop. The Workshop found the estimates from the North Atlantic Sighting Survey (NASS) and Norwegian surveys for the central and northeast Atlantic to be acceptable for use in assessments and agreed that for general purposes the best estimate of current abundance in the central North Atlantic (including the Faroes) is 25,800 (CV=0.125) for the year 2001. The best estimate for the eastern North Atlantic is 4,100 (CV=0.210) from the 1996-2001 survey series. These estimates are based on the assumption that $g(0)=1$. Estimates of $g(0)$ from recent NASS and Norwegian surveys were presented and fall in the range of 0.7 to 0.9 depending on whether the estimate is for the single or combined platforms. It was considered that for the purposes of assessment the assumption of $g(0)=1$ was adequate.

The Workshop noted that estimated abundance in the area west and southwest of Iceland increased at an annual rate of 10% (95% CI: 6% – 14%) between 1987 and 2001. This is the area where nearly all fin whaling has been conducted since 1915. Estimated abundance in the whole East Greenland/Iceland (EGI) area has increased at 3% (95% CI: −1% – 7%) per year, i.e. this rate of increase is not significant at the 5% level. There was no evidence of any trend in abundance in the eastern North Atlantic.

A new assessment model of the EGI fin whale population, modelled as four subpopulations with movement between areas was presented. The model is sex- and age-structured, and is fitted to CPUE, sightings survey abundance split by area, and mark-recapture data using both maximum likelihood and Bayesian approaches. For the base case and most sensitivity tests, the overall recruited population is increasing and above 80% (base case 84%) of pre-exploitation abundance. The Workshop could not draw firm conclusions from this modelling exercise, but noted that the more complex models involving two or more spatial components did fit the historical and modern CPUE and abundance data better than single homogeneous stock models.

The Workshop provided a series of recommendations for future work that are detailed in its report (SC/58/Rep3, item 10). It was agreed that all documents submitted to the respective Scientific Committees pertaining to the assessment of fin whales in the North Atlantic and the reports of the respective Committees, would be exchanged in the future. The first joint meeting between the NAMMCO and IWC Scientific Committees was considered successful, efficient and productive, and it was hoped that this level of cooperation on issues of common importance could be continued.

In the sub-committee's discussion of the joint Workshop report, Aguilar noted that most evidence suggested that Mediterranean fin whales were a separate population with little or no exchange with other North Atlantic groups. Records from past whaling operations as well as more recent studies indicate that fin whale densities in the Strait of Gibraltar area were low historically and are so now. Nevertheless evidence from satellite tagging and stable isotope ratios (Guinet *et al.*, 2005) indicates that some exchange between the Mediterranean and the Atlantic through the Strait does occur.

3.2.2 Report of the intersessional Working Group

Víkingsson reported on the work of the Intersessional Working Group on North Atlantic Fin Whales. The Working Group met briefly in St Kitts, but Víkingsson reported mainly on a meeting held in connection with the Joint NAMMCO/IWC Scientific Workshop (see Item 3.2.1). The conclusions of the Intersessional Working Group are included where relevant under Item 3.2.3 below.

3.2.3 Progress on completion of the pre-implementation assessment

3.2.3.1 PLAUSIBLE STOCK STRUCTURE HYPOTHESES

The sub-committee noted that plausible stock hypotheses need only to be specified in broad detail at this stage, that they should be consistent with the data and inclusive enough that it is deemed unlikely that new data collected during the *Implementation* process will suggest a major new hypothesis. New analyses conducted subsequent to the Joint Workshop are detailed below.

SC/58/PFI6 presented results from the population genetic structure analysis of two datasets that were calibrated and combined by Bérubé and Daníelsdóttir and contain genetic data of six microsatellite loci (genotypes) and one mtDNA locus (control region sequences). The main objective of this study was to assess further the population genetic structure of North Atlantic fin whales at their feeding locations by combining datasets and therefore enlarge the dataset presented in Bérubé *et al.* (1998). The sample sizes were increased for West Greenland, Iceland and Spain and the geographical coverage was extended by adding new locations, such as Norway and the Faroe Islands. The combined datasets consist of a total of 649 samples from eight North Atlantic fin whale feeding locations: Gulf of Maine (n=31); Gulf of St. Lawrence (n=109); West Greenland (n=56); Iceland (n=129); Faroe Islands (19); Norway (38); Spain (n=92); and the Mediterranean Sea (n=74) and in addition as reference samples, samples from the Sea of Cortez (n=75), in the Gulf of California and the North Pacific Ocean (n=13). The combined samples from the North Atlantic and the Mediterranean Sea as well as the combined samples from the North Atlantic (excluding the Mediterranean Sea for the microsatellite loci), deviated significantly from Hardy-Weinberg genotypic proportions due to heterozygote deficiency. Deviations were also observed among the samples collected in the Gulf of St. Lawrence and off the Faroe Islands but they were not statistically significant after applying the sequential Bonferroni test. The Slatkin linearised F_{ST} homogeneity tests, based on the microsatellite loci data within and among the North Atlantic and Mediterranean Sea samples, revealed significant between the different sample years of the Faroe Islands samples, but it should be noted that sample sizes were low. The Faroe Islands samples were the most divergent samples from the remaining North Atlantic Ocean sampling localities (estimates of F_{ST} ranged from 0.005 to 0.113 among the North Atlantic localities). One possible explanation may be some level of pod structure in fin whales, but each pod would have to have large geographic ranges to explain the overall low level of genetic structure across the North Atlantic. The Faroe Island samples differ from the samples collected in other areas by being collected more or less at the same position in and in a very short time (over a few hours). In all other areas only one or two samples may have been collected at the same time and place. Future data analyses and sample collection need take this possibility into consideration. Significant heterogeneity was also detected between sampling localities in the North Atlantic and Mediterranean Sea against the Sea of Cortez (estimates of F_{ST} ranged from 0.325 to 0.528). The *BayesAss* estimation (Wilson and Rannala, 2003) that was undertaken as the rate of current dispersal may be of more immediate management concern than the average rate of gene flow over evolutionary time. The probability that an individual was an immigrant indicated that between 17% and 33% of the individuals in each population are immigrants which suggested large amounts of gene flow among all putative populations/stocks. The amount of migration rates between locations suggested that movement of animals between locations were predominantly unidirectional. The point estimates revealed that 20 percent or more of individuals in a single area are immigrants. Such exchange rates are in a range where populations are likely to be demographically correlated, and perhaps should not be viewed as demographically or genetically independent populations. A total of 35 polymorphic sites were detected defining 78 haplotypes of the mtDNA control region sequence data. The estimates of the nucleotide diversity at all North Atlantic sampling localities were all within the same range (0.012-0.014). The nucleotide diversity observed in the Mediterranean Sea and in the North Pacific Ocean samples were significantly lower than any of the observed values at North Atlantic sampling localities. In addition, the nucleotide diversity of 0.001 estimated in the samples from the Sea of Cortez was exceptionally low, and significantly lower than in any other sampling localities. Based on the mtDNA data, significant levels of heterogeneity were detected among some of the North Atlantic samples and also between the Mediterranean Sea and all North Atlantic samples. Significant levels of heterogeneity were detected between Sea of Cortez and all the North Atlantic/Mediterranean Sea sampling localities as well as between North Pacific and all the North Atlantic/Mediterranean Sea sampling localities. However, estimates of genetic divergence among the North Atlantic (and Mediterranean Sea) sampling localities were all very low and [as for nuclear DNA] suggesting high levels of exchange between sampling areas.

SC/58/PFI6 concluded that the genetic analyses based upon nuclear as well as mitochondrial loci all suggested high levels of gene flow among all North Atlantic sampling areas; although both allele and haplotype frequencies were statistically different among the majority of the sampling areas, the actual level of divergence is *very* low. The estimated migration rates were in a range where populations are likely to be demographically correlated, and perhaps should not be viewed as demographically or genetically independent populations. The analyses ignored the signal of exponential population expansions detected in the North Atlantic samples by Bérubé *et al.* (1998). Hence, the high degree of genetic similarity among the North Atlantic sampling areas may be due to recent divergence rather than high gene flow. However, the *BayesAss* analyses suggest differently. The number of migrants estimated from the F_{st} estimates is on the order of 30 migrants per generation. While this rate may initially seem much lower, it should be kept in mind that the estimate is an estimate of the effective number of migrants and hence should be related to the effective population size, which may be lower than the census population size. In addition, the ~30 migrants per generation is between each pair of populations, which results in a much larger number of immigrants once summed for all connected populations.

In discussion the sub-committee noted that the methodology used in the *BayesAss* software is relatively new and has not been tested on a wide range of scenarios, particularly ones where the level of differentiation is as low as that found in North Atlantic fin whales. The estimated levels of immigration may be upwardly biased under this circumstance. Donovan noted that this program is being tested with simulated datasets under the TOSSM project.

All samples came from feeding grounds, not from the breeding grounds, the location of which is uncertain. A degree of mixing of different stocks on the feeding grounds might be expected and is indicated by other genetic analyses. The methodology used in *BayesAss* has not been tested under these circumstances, and it was therefore not clear if dispersal between feeding areas or alternatively the degree of mixing of discrete stocks on the feeding areas was being estimated. Samples from the breeding grounds would be useful in this regard but are not yet available.

SC/58/PFI7 presented results of the genetic analyses of two fin whale datasets that aimed to study further the temporal and micro- and macrogeographical population structure of North Atlantic fin whales sampled at different feeding grounds. At the joint Workshop the interpretation of P-values, when values of F_{ST} were very small, was discussed. The Workshop agreed that this topic required further investigation and discussion and referred the matter to a working group consisting of Skaug, Kitakado and Butterworth, in consultation with Palsbøll, Daníelsdóttir and Pastene. In particular it noted that it was important when presenting results of F_{ST} values that CI be calculated (e.g. using bootstrapping) for new and previously published data where significant differences have been reported (Árnason *et al.*, 1992; Danielsdóttir *et al.*, 2006; 1991; 1992; 2005). The first dataset was on the genetic variation at nine microsatellite loci in 1,022 fin whales sampled at five North Atlantic areas; i.e. West off Iceland (n=900), Spain (n=39), Norway (n=54), West off Greenland (n=16) and East off Canada (n=13). The data were based on further statistical analysis of data presented in Daníelsdóttir *et al.* (Danielsdóttir *et al.*, 2006; 2005). The new statistical programs applied included CI's of F_{ST} (as suggested at the joint Workshop), number of migrants per generation (N_m) and graphical illustration of potential 'populations' as in Waples and Gaggiotti (2006). There was significant heterogeneity within all samples, except the West Greenland samples, all due to heterozygote deficiency. Various genetic analyses resulted in significant genetic heterogeneity among the Icelandic samples, revealing temporal and seasonal differences in the samples from the years 1981-89. The level of genetic differentiation was low among the 13 samples

(F_{ST}~0.004, p<0.05). As before, greatest significant differences were observed between the Newfoundland Canadian samples and the other locations. The CIs of the pairwise F_{ST} comparisons varied considerably. When looking at the lower value of the 95% CI of the F_{ST} values, it reduced the number of the significant pairwise comparisons down from 26 to 10 of 78 comparisons made, two were comparisons between Icelandic sample years and eight were involving the Newfoundland Canadian and Icelandic samples. However, if the higher value was considered, all comparisons were significant. According to the graphical illustration of potential 'populations' as in Waples and Gaggiotti (2006) the number of groups should be five. The first consisting of Icelandic sample years (Iceland 1982, 1984-88), Norway, Spain and West Greenland. Then each of IC81, IC83, IC89 and Newfoundland Canada as separate groups. As previously suggested, there might be variations in herds at feeding locations in the different sample years from Iceland, contributing to the heterogeneity within and among years and feeding locations or there could be disproportional mixing of different breeding units at the feeding grounds both in time and space.

The second dataset is on the microsatellite genetic variation in 226 fin whales sampled in five North Atlantic areas; i.e. off West Iceland, Norway, Spain and West Greenland, a total of: 129, 54, 39 and 16 samples, respectively. The analyses are based on genotypes at 16 microsatellite loci. More number of samples is to be screened so only preliminary statistical analysis of this dataset was presented.

The sub-committee noted in discussion that the significant heterogeneity between sampling years seen at Iceland and the Faroes suggested either temporal variation in the summer distribution of stocks and/or that different proportional mixtures of stocks were being sampled on the feeding grounds. Such year to year differences may exist in other areas as well but the temporal resolution of the sampling is not sufficient to detect them. The situation at the Faroes was exceptional in that the samples were collected in single events over a short period of time. Therefore it is possible that single 'herds' of related individuals may have been sampled in each event.

There was some discussion over the issue of the use of simple P values *vs* bootstrap confidence intervals for pairwise F_{ST} comparisons. Although it was generally agreed that providing confidence intervals for F_{ST} values is to be encouraged, it was pointed out that the P value from a standard test of heterogeneity provides a more direct test of the null hypothesis that all samples have been drawn from the same population.

SC/58/PFI8 presented results of new statistical analyses of three old fin whale allozyme and carbonic anhydrase datasets previously published in Árnason *et al.* (1992) Daníelsdóttir *et al.* (1991; 1992). At the joint NAMMCO/IWC Scientific Workshop the interpretation of P-values, when values of F_{ST} were very small, was discussed. The first dataset is on the genetic variation at 11 variable allozyme loci in 328 fin whales sampled in two North Atlantic areas; i.e. off West Iceland and Spain, a total of: 283 (Iceland 1985-88) and 46 (Spain 1985) samples, respectively. The data is based on further analysis of genotypes at 11 allozyme loci: *Ada, Ak-1, Gpd, Ldh-A, Mdh-S, Mpi-1, Pep-A, Pgm-1, Pgi and Sod-A*. The new statistical programs applied included F_{ST}, CIs of F_{ST}, N_m, PCA, multidimensional scaling (MDS), *STRUCTURE* and graphical illustration of potential 'populations' as in Waples and Gaggiotti (2006). There was significant heterogeneity within each sample and overall samples, all due to heterozygote deficiency. Various genetic analyses on the dataset resulted in high significant genetic heterogeneity among the Icelandic and Spanish samples, and temporal differences in the Icelandic samples from the years 1981-88 (F_{ST}~0.078, p<0.0001) as well as differences between Icelandic and Spanish samples (F_{ST}~0.094, p<0.0001). Divergence between Icelandic sample years was less than between Icelandic and Spanish samples. The Spanish samples were overall the most divergent of the samples and with lower N_m than among the Icelandic sample years. The CIs of the pairwise F_{ST} varied considerably and were larger in comparisons of larger F_{ST} (i.e. between Icelandic and Spanish samples than between Icelandic sample years). This could indicate that the observed level genetic divergence between groups is less than concluded before from the previous results of high F_{ST} and significance between groups, however when considering the lower CI values, all comparisons remained significant. Based on Nei's (1978) genetic distances, multidimensional scaling (MDS) analysis revealed genetic divergence with a stress value of 0.0229 between axes 1 and 2. The *STRUCTURE* analysis indicated two groups among the samples. As previously suggested, there might be variations in herds at feeding locations in the different sample years of Iceland, contributing to the heterogeneity within and among years and feeding locations. The genetic heterogeneity within and between temporal Icelandic samples and geographical samples, in addition to the likelihood of number of breeding units estimated in *STRUCTURE*, are both in agreement with the hypothesis that the North Atlantic fin whale is genetically structured on the feeding grounds and different breeding units might mix disproportionally at the feeding grounds both in time and space. The heterogeneity among Icelandic samples years could therefore also be disproportional mixing of two breeding units represented in the different years.

The second dataset (II) is on the genetic variation at five allozyme loci (*Ak-2*, *Est*, *Ldh-A*, *Mdh-S* and *Pgi*) of 67 fin whales from three North Atlantic areas; i.e. Newfoundland Canada (n=24), Norway (n=19) and off West Iceland (n=24). There were statistical significant heterogeneity within the pooled samples and genetic divergences were found among Newfoundland Canadian, Norwegian and Icelandic samples (F_{ST}~0.343, P<0.0001). All three F_{ST} pair-wise comparisons varied considerably in their CIs indicating variation in the estimation of significant comparisons from two to all significant comparisons of three made and reducing the earlier level of observed genetic differentiation. The *STRUCTURE* analysis indicated three clusters among the samples. The results from this study based on allozyme loci indicate that the fin whale samples from the feeding grounds off Iceland, Norway, Spain and Newfoundland Canada are significantly heterogenous, but genetic divergence is high between groups. The genetic heterogeneity within and between the samples in addition with the likelihood of number of breeding units estimated in *STRUCTURE* both are in agreement with the hypothesis that the North Atlantic fin whale is genetically structured on the feeding grounds and different breeding units might mix disproportionally at the feeding grounds.

The level of genetic differentiation was higher for the allozyme than the microsatellite data (Bérubé *et al.*, 1998; Danielsdóttir *et al.*, 2005; 2006; Sigurjónsson and Gunnlaugsson, 2006; SC/58/PFI6). To better estimate the true unbiased geneflow among the samples, further analyses need to include estimation on effective population size (N_e) to have a better estimate of effective number of migrants per generation (N_m), *BayesAss* to estimate current migration rates and *MIGRATE* to estimate historical migration rates.

The third dataset (III) is on the *Ca* locus genotype variation in 1.159 fin whales sampled in two North Atlantic areas; i.e. off Spain (1983 and 1984) and West Iceland (1971 and 1981-89), a total of 26 and 1,133 samples, respectively. There was heterogeneity in two Icelandic sample years, but no overall significant heterogeneity was observed at this locus within or among samples (F_{ST}~0.003, P>0.05). The Spanish 1983 samples showed greatest overall F_{ST} values compared to all other locations and the least number of migrants, N_m.

Skaug presented SC/58/PFI9 which detailed the screening of a dataset consisting of 15 microsatellite loci from 226 fin whales from several North Atlantic locations for closely related individuals. Five pairs of individuals were identified as being closely related, four of which were consistent with a parent-offspring relationship. Two of these parent-offspring pairs had been conjectured to be mother-calf pairs when the biopsies were obtained. Of the two pairs that were not sampled at the same location, one showed a linkage between North Norway and the area west of Svalbard, and the other between North Norway and West Iceland.

The sub-committee agreed that this method shows promise for identifying relatives in genetic samples and can assist in the interpretation of analyses related to stock boundaries and degree of mixing among areas. It was noted that the number of matches of closely related individuals would increase with sample size, and the certainty of detection with the number of microsatellite loci included in the analysis. In response to a query, Skaug noted that it would be possible to determine if the number of related individuals in a sample was greater or less than expected given the assumption of random mixing.

Kitakado presented the results of a preliminary analysis using a new method aimed at simultaneous estimation of mixing proportions and genetic differentiation for stocks for North Atlantic fin whales. The method uses individual genotypes at multiple loci and does not require the presence of baseline stocks. An integrated likelihood function with elimination of nuisance parameters was employed to estimate the parameters, and then the maximum values under one and two stock scenarios were compared to determine the likely number of stocks. To investigate model performance, a simulation study was conducted under the one stock scenario and with two simulated stocks with F_{ST} = 0.1. The model successfully discriminated the 1 and 2 stock situations. For analysis for fin whales, the same data were used as in SC/58/PFI7 (226 individual's genotypes at 17 microsatellite loci). The result was consistent with one stock in the area. Kitakado emphasised the preliminary nature of this analysis and that further investigations are required.

In response to a query, Kitakado noted that while the method is similar to *STRUCTURE* in that it estimates the number of genetic stocks present in a sample without reference to sample origin, the estimation methods employed are different. In addition this method provides explicit parameters for mixing proportions of the putative stocks identified.

The F_{ST} used in the simulation study was much higher than that commonly observed between fin whale sampling areas. The ability of the model to detect population structure when the populations are so weakly differentiated has not been tested. The sub-committee considered this method promising and **recommended** that Kitakado continue simulation testing of the model under levels of differentiation observed in whale populations. In addition the method should be applied to other species and stocks for which stock structure is better known, such as bowhead and gray whales.

Conclusions

The Report of the Joint NAMMCO/IWC Scientific Workshop (SC/58/Rep3) provided a range of stock hypotheses and recommendations for further genetic work to refine or suggest new ones. The sub-committee was gratified to see that much of this work had been accomplished and thanked the authors of SC/58/PFI6-8 and the members of the intersessional Working Group for their hard work in fulfilling these recommendations in the short period since the joint Workshop. Considering the new information brought forward, the sub-committee found no reason to modify any of the existing stock hypotheses, or to suggest new ones.

3.2.3.2 PRELIMINARY INVESTIGATION OF EXPERIMENTAL WAYS TO DISTINGUISH AMONG COMPETING HYPOTHESES

It was noted that recommendations for further analytical work to distinguish among competing stock hypotheses should be provided at this meeting so that the work could be carried out in time for the first intersessional meeting for the *Implementation Assessment*, if it proceeds.

Photo-id work was identified as a potentially useful method, but it was noted that there are only two catalogues available, for the Gulf of Maine and the Mediterranean. Robbins agreed to compile all information on photo-identification for the sub-committee.

The sub-committee agreed that obtaining samples for genetic analysis from the breeding grounds would be very valuable for identifying fin whale stocks, which might then be distinguishable on the feeding grounds. However the location(s) of the breeding grounds are presently unknown. Satellite tags applied late in the season on the feeding ground might be very useful in identifying fin whale breeding areas. In addition such applications could provide information on migration routes and movements between feeding areas. However it was recognised that the rate of success in fin whale tagging, in terms of tag functioning and duration, had been low in previous attempts, and that these issues must be resolved before tagging could proceed on a large scale.

The new analytical methods for genetic data used in SC/58/PFI6 (*BayesAss*), SC/58/PFI7 and SC/58/PFI8 (*STRUCTURE*), and in the report of the intersessional Workshop, were considered promising, but in all cases they should be tested using simulated datasets showing similar levels of genetic variation to that observed in fin whales. It was hoped that this might occur under the TOSSM project but the sub-committee recognised that the results might not be available for the prospective *Implementation Assessment*.

3.2.3.3 DISPERSAL RATES

F_{ST} values and other data provided by genetic studies will need to be used to produce realistic ranges of dispersal rates for input into trials. The sub-committee noted that dispersal rates refer to permanent movement of individuals between breeding stocks and differ from mixing proportions which refer to situations where more than one breeding stock feeds in a particular area; trials need estimates of both these quantities. This work requires careful consideration and must be completed before the first intersessional Workshop once an *Implementation* has begun. The issue was referred to an intersessional Working Group consisting of Palsbøll, Skaug and Waples.

3.2.3.4 ABUNDANCE ESTIMATES (INCLUDING *g*(0) ISSUES AND PLANS FOR FUTURE SURVEYS)

Víkingsson confirmed that all survey data will become available in the IWC database as per the data availability guidelines. It was concluded that these were of sufficient temporal and spatial resolution to calculate abundance estimates both on the scale of the sub-areas that would be likely to be used in conditioning simulation trials and for use in the *CLA*.

It had been noted at the Joint Workshop (SC/58/Rep3) that no recent abundance data are available for the American coastline. However Palka informed the intersessional Working Group that there are estimates available for the Gulf of Maine-Bay of Fundy region and that these could be made available to the Scientific Committee.

Abundance estimates from the 1987, 1989, 1995 and 2001 NASS as well as the 1996-2001 Norwegian surveys were reviewed by the Joint Workshop and found to be of sufficient quality for use in simulation trials and in the *CLA*. The issue of $g(0)$ for fin whale ship surveys was also examined by the joint Workshop, which concluded that $g(0)$ was close to 1 and the assumption of $g(0)=1$ would be sufficient for trials.

The sub-committee **concurred** with these conclusions of the Joint Workshop.

Víkingsson informed the sub-committee that a new survey would be carried out in 2007 and that Iceland planned to continue large-scale surveys at 5-6 year intervals. Plans for the Trans North Atlantic Sightings Survey (TNASS, see Item 4.2), which will cover a large part of the northern North Atlantic and includes the participation of Norway, the Faroe Islands, the Russian Federation, Iceland, Greenland and Canada, were provided in SC/58/O21. A synoptic redfish survey will take place in 2007, coordinated by the ICES Study Group on Redfish Stocks, with international participation from several countries including Iceland. The Icelandic vessel will be used as a cetacean survey platform. The sub-committee **endorsed** this collaborative effort and **recommended** that the Commission encourage the relevant governments participating in the international redfish survey to include a cetacean component in the survey.

3.2.3.5 CATCH DATA (INCLUDING ALTERNATIVE SERIES)

Allison confirmed that the catch history for North Atlantic fin whales was sufficiently well known to allow a catch series to be developed for use in trials, and that work on this task was in progress. This compilation will include notations on data quality and available ancillary information. There are sufficient uncertainties in the catch series (allocation of catches between species, catch location, struck and lost) to anticipate the use of alternative catch series, and the compilation of catch data will be used to develop such alternative series.

SC/58/PFI4 presented CPUE series for fin whales during the early modern whaling operation in Iceland (1883-1915) that have been revised from Sigurjónsson and Gunnlaugsson (1988), based on the recommendations drawn up at the joint Workshop. The series are split by the west (Vestfjord) and East coast operation. The FpBM (fin whales per boat month) series for the East coast is based on individual catch records from 1904 to 1913 restricted to the period 14th May to 11th August. This series might be used only from 1907 when fin whale catches exceeded 50% of the total. Individual catch records are too limited for the Vestfjord operation so total fin whale catch per boat (FpB) has to be used. Fin whale catches exceed 50% continuously from 1902, which is considered a reasonable starting point in this case. The operational range expanded over time and in particular in the last year in 1915 when a large part of the catches were taken on the Greenland side of the Iceland-Greenland midline, which suggests that this year should not be included. Two alternatives in correcting for handling times are given for both series. The season length is generally not known in the Vestfjord operation, but is needed for this correction and is assumed to have been four months based on all information available. An uncorrected catch per boat series (CpB) is also presented and is considered a reasonable index for the Vestfjord operation although not accounting for handling times dampens the trend therein. Operational changes over time and limitations of the data are believed to be more likely to mask the real trend in the population.

The sub-committee thanked the authors for their work in responding to the recommendations of the joint Workshop.

3.2.3.6 FUTURE WHALING OPERATIONS

This RMP *Implementation* is requested by Iceland, and the only likely commercial whaling operation in the near future at least is on the traditional fin whaling grounds off west Iceland. The operational factors in this fishery have been described by Sigurjónsson (1988). Since the ban on whaling was imposed by the Icelandic parliament in 1915, Icelandic whaling for large whales has been limited to a single land station in Hvalfjörður, Faxaflói in West Iceland apart from limited catches from a single whaling station in northwest Iceland during 1935-1939. The whaling station in Hvalfjörður operated during 1948-89 and has been maintained so that future large whaling operations are likely to be restricted to this station. Company regulations restricted the whaling operation in various ways. Thus, the processing capacity of the factory limited the number of whaling vessels, operating at any one time to four and further restrictions on catch rates were imposed temporarily during busy periods (Rørvik *et al.*, 1976). The Hvalfjörður whaling station is the only one in Iceland and there are no plans to build whaling stations in other parts of Iceland. It can therefore be assumed that future whaling will only be conducted from this single land station and that the operating area of the whaling vessels will be restricted to the same area as during the commercial whaling 1948-85. The whaling area off Iceland during 1951-73 is shown in fig. 2 of SC/58/PFI5. Some of the catches were taken west of the present 200 n.miles EEZ for Iceland, but any future catches would likely be within this 200 n.miles limit. The whaling seasons from the whaling station in Hvalfjörður usually began in the latter half of May and ended near the end of September. Since 1968 the whaling season began in the first half of June (Read *et al.*, 2004). Future catches under the RMP would likely be confined to the period June-September.

The sub-committee noted that there are no plans to initiate commercial whaling for fin whales by other nations that caught fin whales in the North Atlantic prior to the onset of the moratorium such as Spain, the Faroes, Norway and Canada. The possibility of a very limited catch (5-10 animals) for scientific purposes off Norway and the Faroes in the medium future cannot be precluded and might thus be included as a sensitivity test (Bjarni Mikkelsen and Lars Walløe, pers. comm.).

3.2.3.7 OTHER ANTHROPOGENIC REMOVALS

SC/58/PFI5 summarised non-natural mortality of fin whales, other than direct catch, as compiled from National Progress Reports covering the period 1997-2004 (*www.iwcoffice.org/sci_com/scprogress.htm*). During this eight year period a total of 11 fin whales was reported killed from fisheries interactions, four in the North Atlantic and two in the Mediterranean (see table 1 of SC/58/PFI5). In the same period nine fin whales were reported killed or likely killed by ship strikes. Eight of these were in the North Atlantic.

Read *et al.* (2006) used bycatch statistics from the USA to make crude extrapolations to estimate global bycatch of large cetaceans. Of 201 reported bycatches in US waters during 1990-99, six were fin whales.

The sub-committee noted that since systematic monitoring of cetaceans was initiated in Iceland around 1980 there have been no reported bycatches of fin whales off Iceland, in contrast to many other species of cetaceans in this area. Only one stranding of a fin whale is reported for this period, a calf that stranded near a small boat harbour in 1994. The animal had wounds on the head that might have been caused by a ship strike (Marine Research Institute, Reykjavik, unpublished information). This is the only known example for fin whales off Iceland of anthropogenic mortality other than direct catch. Apart from a single bycatch off Ireland and a ship strike in the mid North Atlantic, it is the only example for the whole Northeastern Atlantic (east of West Greenland). Somewhat higher rates in the Western North Atlantic may be due to the apparently more coastal distribution of the species in this region.

Berggren informed the sub-committee that the sub-committee on estimation of bycatch and other human induced mortality had received some new information on ship strikes of fin whales in the Mediterranean (Anonymous, 2005; 1991) and the Strait of Gibraltar (SC/58/BC5) this year, which indicates that this source of mortality may be greater in this area than in others. However he emphasised that rate of reporting may be low in all areas. There is no information to suggest a high rate of lethal bycatch of fin whales in the North Atlantic.

The sub-committee recognised that although the efficiency of reporting schemes is difficult to evaluate with precision, it can be concluded from the available evidence that non-natural mortality of fin whales in the North Atlantic (outside the Mediterranean) is insignificant compared to abundance. The sub-committee concluded that there is no need to model incidental catches in the *ISTs*.

3.2.3.8 CONDITIONING (INCLUDING BIOLOGICAL PARAMETERS)

SC/58/PFI3 presented some new investigations of life history parameters based on data from biological samples of fin whales caught off Iceland from 1967-85 and scientific catches from 1986-89, originally presented in Lockyer and Sigurjónsson (2006). The classification of animals with respect to maturity and pregnancy stage when foetuses and/or ovaries were lost or damaged, that then had to be based on other measurements, is validated. Samples were collected only for different parts of the season in the first years and in two years appear selective with respect to size. The scientific catches show some differences from the commercial catches. The proportion pregnant changes over the season and with age, so the imbalance in the samples needs to be considered in estimates of pregnancy rate. The changes in fecundity with age are best demonstrated by comparing females with a different number of ovarian corpora. After the first pregnancy the females are estimated to rest for 1.64yr. Of these the younger animals appear to rest for longer which indicates that early maturity may come at some cost. The resting period decreases to 1.37yr after 10-15 ovulations but then increases again to 1.74yr in animals after 21 or more ovulations, indicating reproductive senescence (also reported by Konrádsson *et al.*, 1991). In addition, no foetuses were found in the oldest animals that appeared to be pregnant from inspection of the ovaries. Fewer of the younger females caught were in the later stages of pregnancy, which implies that they need a longer time feeding to build up the energy required for pregnancy and lactation. The earlier findings of changes in the age at maturity based on the proportion mature and proportion of first ovulators, are confirmed and are in line with estimates based on transition phase readings in the ear plugs (IWC, 2005). Estimates of mortality are derived based on an assumption of constant cohort size. The estimate of natural mortality is 0-0.07. It is suggested that a high proportion of maturing animals in the most recent catches and changes in the age distribution of the catch can best be explained by an influx of immature animals.

The sub-committee thanked the authors for this compilation and noted that it will be of use in the *Implementation* process. It was agreed that the available biological data, including estimates of relevant biological parameters, was sufficient for *ISTs*.

3.2.4 Work plan

The sub-committee concluded that the only outstanding item to be completed before proceeding towards an *Implementation* was the development of a list of catches with associated ancillary information that would allow the development of a best and alternative catch series for use in simulation trials. Considerable progress towards this had been made at the joint Workshop and it was anticipated that this could be completed in time to begin an *Implementation* this year. However, it was considered impractical to begin the *Implementation* this year because of a lack of resources and the high workload of the Committee, which must complete the NP Bryde's whale *Implementation* as a priority. Therefore the sub-committee proposed that the *Implementation* for North Atlantic fin whales be initiated in 2007. It was emphasised that this delay in initiation of the *Implementation* was due to the priorities and workload of the Scientific Committee rather than a lack of sufficient preparation on the part of the initiating Member Government, Iceland.

In the interim period the sub-committee **recommended** the following priorities for further research:

(1) completion of a comprehensive list of catches as noted above;
(2) refinement and extension of genetic and other analyses to discriminate between existing stock hypotheses and to estimate mixing proportions and dispersal rates.

4. CONSIDERATION OF SURVEYS UNDER THE GUIDELINES AND REQUIREMENTS

4.1 Norwegian surveys

Walløe presented results from SC/58/RMP4, which was a report of a Norwegian 2005 survey for minke whales in *Small Management Area* CM around Jan Mayen. As part of a six-year programme over the period 2002-07 with the aim to get a new estimate of minke whale abundance in the Northeast Atlantic, the area around Jan Mayen in the Greenland Sea, the *Small Management Area* CM, was surveyed with two vessels during the summer 2005. There were three planned blocks with a planned basic coverage of about 2,000 n.miles. In total about 2,100 n.miles were searched with primary effort. The most common species sighted were minke whales (67 groups seen from the primary platform), humpback whales (33 groups), fin whales (27 groups) and sperm whales (18 groups). In addition sightings were made of killer whales, Northern bottlenose whales, blue whales and unspecified dolphins. Opportunistic collections were made of biopsy samples from one minke whale and two fin whales, and photographs were collected from 16 humpback whales.

The sub-committee welcomed the report of this new cruise. Polacheck raised the issue of whether new information on dive time had been collected, and noted that this issue had been raised in the past. The sub-committee **recommended** that new data on dive time should be collected during future surveys. Such data had been requested in the past, and it had been stated in cruise plans that such data would be collected. Walløe indicated that dive time data would be collected in 2006. With regards to review of the 2005 survey, Walløe suggested that the results of these new surveys do not need to be reviewed now, as full results, including data analysis, will be presented in 2008, and that would be the appropriate time to review and consider approval of these surveys for the RMP. Official Scientific Committee oversight for the 2006 Norwegian survey was designated to Øien.

4.2 Other

Víkingsson raised the issue of planning for a joint survey in late June 2007. It was noted that any part of a survey planned to provide data for use in the RMP needed to have its cruise plans submitted to the Scientific Committee for consideration prior to the survey being carried out. The sub-committee **agreed** it would review in detail the cruise plans for this survey in 2007. The planners of the survey were reminded that there are specific guidelines to be followed in submitting cruise plans for survey data to be used in an RMP *Implementation*.

The next North Atlantic Sighting Survey (NASS) will be conducted in the summer of 2007. To date four NASS have been conducted, in 1987, 1989, 1995 and 2001. It is hoped that by participation of Greenland and Canada in addition to Iceland, Faroes and Norway and coordination with a simultaneous survey planned off the western coast of Europe, this survey will cover a larger area than any of the earlier surveys (SC/58/O21). The first planning meeting for the 2007 survey (TNASS) was held in Reykjavík in March 2006. The sub-committee noted that the NASS have used standard methodology (line-transect and cue counting) and covered large areas of the central and eastern North Atlantic. The methodology is in accordance with the requirements and guidelines for conducting surveys and analysing data within the RMP and abundance estimates from NASS for common minke whales and fin whales have been accepted for use in the RMP. Official Scientific Committee oversight for the 2007 survey was designated to Hammond and Donovan.

5. OTHER BUSINESS

No items were raised under this Item.

6. ADOPTION OF REPORT

The report was adopted at 08:35hr, 3 June 2006. The sub-committee expressed its appreciation of the work of the rapporteurs and Chair.

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Appendix 1

AGENDA

1. Introductory Items
   - 1.1 Pre-meeting meeting
   - 1.2 Election of Chair, appointment of rapporteurs
   - 1.3 Adoption of Agenda
   - 1.4 Review of documents

2. Revised management procedure (RMP) – general issues
   - 2.1 Finalise the guidelines and requirements for implementing the RMP
     - 2.1.1 Develop the thresholds for defining 'acceptable' and 'borderline' performance for classifying the performance of RMP variants for *Implementation Simulation Trials* (*ISTs*)
     - 2.1.2 Develop a list of agreed stock structure archetypes
   - 2.2 Proposal for revision of the *CLA*
     - 2.2.1 General approach to such considerations
     - 2.2.2 Consideration of the Norwegian proposal
   - 2.3 Work plan

3. RMP – preparations for *Implementation*
   - 3.1 Western North Pacific (WNP) Bryde's whales
     - 3.1.1 Report from the first intersessional *Implementation* Workshop for western North Pacific Bryde's whales
     - 3.1.2 Objectives of first Annual Meeting
     - 3.1.3 Review results of conditioning
     - 3.1.4 Updates to standard data sets
       - 3.1.4.1 Abundance
       - 3.1.4.2 Catches and other anthropogenic removals
     - 3.1.5 Final consideration of plausibility (including weighting of trials in terms of overall balance)
       - 3.1.5.1 Stock structure hypotheses
       - 3.1.5.2 Other (e.g. *MSYR*)
     - 3.1.6 Data/research to reduce hypotheses
     - 3.1.7 Specification of operational features and management variants
     - 3.1.8 Specification and classification of final trials
     - 3.1.9 Work plan
   - 3.2 North Atlantic fin whales
     - 3.2.1 Report of the joint NAMMCO/IWC Workshop
     - 3.2.2 Report of the intersessional Working Group
     - 3.2.3 Progress on completion of the pre-implementation assessment
       - 3.2.3.1 Plausible stock structure hypotheses

3.2.3.2 Preliminary investigation of experimental ways to distinguish among competing hypotheses
3.2.3.3 Dispersal rates
3.2.3.4 Abundance estimates (including *g*(0) issues and plans for future surveys)
3.2.3.5 Catch data (including alternative series)
3.2.3.6 Future whaling operations
3.2.3.7 Other anthropogenic removals
3.2.3.8 Conditioning (including biological parameters)
3.2.4 Work plan
4. Consideration of surveys under the guidelines and requirements
4.1 Norwegian surveys
4.2 Other
5. Other business
6. Adoption of report

Appendix 2

EVALUATING CRITERIA FOR DEFINING CONSERVATION PERFORMANCE FOR *IMPLEMENTATION SIMULATION TRIALS* (*ISTs*)

Andre E. Punt and Cherry Allison

IWC (2006) proposed the following steps to determine the conservation performance of an RMP variant for each stock in an *IST* for which *MSYR*=1%.

(1) Construct a single stock trial, which is 'equivalent' to the *Implementation Simulation Trial*. For example, if a particular *IST* involved carrying capacity halving over the 100-year projection period, the 'equivalent single stock trial' will also involve carrying capacity halving over the next 100 years.
(2) Conduct two sets of 100 simulations based on this single stock trial in which future catch limits are set by the Catch Limit Algorithm (*CLA*). The two sets of simulations correspond to the 0.6 and 0.72 tunings of the *CLA*. Rather than basing these calculations on a single initial depletion, the simulations for each stock to be conducted for the set of initial depletions for the stock concerned in the *ISTs*.
(3) The cumulative distributions for the final depletion and for the depletion ratio (the minimum over each of the 100 years of the ratio of the population size to that when there are only incidental catches) to be constructed for each tuning of the *CLA*.

The lower 5%ile of these distributions to form the basis for determining whether the performance of the RMP for the *IST* is 'acceptable', 'borderline' or 'unacceptable'.

Fig. 1 outlines these steps for a hypothetical case. Fig. 1(a) shows the cumulative distribution of the initial depletion in the *IST*. Figs 1(b) and (c) show cumulative distributions for the final depletion and the depletion ratio. These figures are constructed by running single-stock trials where the initial depletions are set to those values on which Fig. 1(a) was based. The horizontal lines in Figs 1(b) and (1c) are used to compute the thresholds that define 'acceptable', 'borderline' or 'unacceptable' performance. Note that the performance of an RMP variant for a specific *IST* is 'acceptable' if either the final depletion or the depletion ratio satisfies the criteria for 'acceptable', and similarly for 'borderline' (Table 1).

At its 2005 meeting, the Committee requested that three analyses be conducted to evaluate the approach outlined above. The results of this work done intersessionally are reported in SC/58/RMP2 and described below.

CUMULATIVE DISTRIBUTIONS FOR SINGLE-STOCK TRIALS

Fig. 2 shows cumulative distributions for the initial depletion, the final depletion, and the depletion ratio for six initial depletion distributions (two cases for mean initial depletions of 0.3, 0.5 and 0.7) to illustrate the sensitivity of the thresholds. The difference between the two cases is the inter-simulation variation in the initial depletion (standard deviations of 0 and 0.05; 0.05 was chosen because it is large enough to differ from 0 and small enough that the impact of the mean initial depletion is still evident). Table 2 lists the values for the thresholds. Note that the initial depletion for the trial in which there is only a single initial depletion is set equal to the mean of the initial depletions for the trial in which initial depletion varied among simulations.

The values for the thresholds that define 'acceptable' and 'borderline' performance for the two performance statistics are, as expected, most sensitive to the initial depletion level. However, the values of these thresholds are fairly insensitive to variation in the initial depletion, except when the initial depletion is low (~0.3). This result is not unexpected given that the standard deviation of the initial depletion distribution was pre-specified when constructing the trials for which results are reported in Fig. 2 and Table 2.

APPLICATION TO *ISTs* DEVELOPED FOR NORTH ATLANTIC MINKE WHALES

Table 3 lists the initial depletions for all the stocks in all the North Atlantic minke whale trials for which *MSYR*=1%, the resulting thresholds for the final depletion and depletion ratio statistics, the lower 5th percentiles for the final depletion and depletion ratio based on the actual trials, and the net result of using the criteria developed by IWC (2006) to evaluate conservation performance. The catch limits for the North Atlantic minke whale trials are set by catch-cascading over the central and eastern *Medium Areas* (IWC, 1994). These results of the North Atlantic minke trials are not identical to those in IWC (1993) because, for consistency with the single-stock trials, all of the calculations are based on the *CATCHLIMIT* program. IWC (2006) agreed that this program would be used in simulation trials owing to improvements in computing speed. However, for completeness, the results based on the old *CLA* program are included in parentheses in Table 3. As expected, differences between the results based on the old *CLA* program and on *CATCHLIMIT* are small.

The results in Table 3 indicate that the conservation performance of the RMP variant selected for the North Atlantic minke whales would be classified as 'acceptable' for the *ISTs* considered in Table 3 (the conservation performance of a trial is taken to be that for the stock for which conservation performance is evaluated to be poorest). There were two cases in which performance on one of the two performance statistics was below the threshold that defines 'acceptable' performance, but overall performance was 'acceptable'.

APPLICATION TO *ISTs* DEVELOPED FOR NORTH PACIFIC MINKE WHALES

IWC (2006) suggested calculating the thresholds for the four baseline trials for the North Pacific minke whales (IWC, 2003). Table 4 lists the initial depletions for the 'J', 'O' and 'W' stocks, the resulting thresholds for the final depletion and depletion ratio statistics, the lower 5th percentiles for the final depletion and depletion ratio based on the actual trials, and the net result of using the criteria developed by IWC (2006) to evaluate conservation performance. Note that 'zero catch' trajectories on which the depletion ratio is based assume no RMP catches, although there are incidental catches, as specified for the trials concerned. The catch limits for the North Pacific minke whales are set by treating sub-areas 1, 2, 3, 4, 5, 6, 9N, 10 and 13 as *Residual Areas*, and sub-areas 7+8+11+12 and sub-area 9 as combination areas with catch limits cascaded to sub-areas within each combination area. The results for the *ISTs* differ from those reported in IWC (2003) because they are based on the *CATCHLIMIT* program. However, for completeness, the results based on the old *CLA* program are included in a parenthesis in Table 4. As expected, there are few differences between the results based on old *CLA* program and on *CATCHLIMIT*.

The results in Table 4 indicate that the conservation performance of the RMP variant selected for North Pacific minke whales would be classified as 'acceptable' for the baseline trials based on stock structure hypotheses A and B and 'borderline' for the baseline trials based on stock structure hypotheses C and D. The conservation performance for the 'J' stock is 'acceptable' even though the final depletion is low. This is because there are few RMP catches from this stock so that depletion ratio is close to 1 (i.e. the population trajectory with RMP catches is similar to that without RMP catches). The primary reason for the low final depletion values for the 'J' stock in Table 4 is that the thresholds are calculated from single stock trials that do not include bycatch, whereas the multi-stock trials do include bycatch. It is not clear how to include bycatch in the single stock trials because bycatch is taken from multiple stocks but the use of the depletion ratio as a performance measure obviates the need for further consideration of this.

CONCLUSION

The sub-committee noted that there is still a fair amount of inter-simulation variability in the values for the thresholds. It may be appropriate therefore to conduct more than one simulation for each initial depletion when initial depletion varies among simulations in a trial. The sub-committee also noted, while conducting these calculations, the authors had discovered that *MSYR* had been specified in several different ways in previous *ISTs*. Standardising this to specifications that are already implemented in the single-stock control program would reduce the workload needed to apply the criteria for evaluating conservation performance.

Table 1

Categories of conservation performance.

Acceptable	Borderline	Unacceptable
Either:	Either:	Anything that cannot be classified as 'acceptable' or 'borderline'
lower *v*%-ile of final depletion >αK;	lower *w*%-ile of final depletion >βK;	
and/or	and/or	
the lower x%-ile of the minimum over each of the 100 years of the ratio of the population size to that in the same scenario but there are only incidental catches, remains >γ.	the lower *y*%-ile of the minimum over each of the 100 years of the ratio of the population size to that in the same scenario but there are only incidental catches, remains >δ.	

Table 2

Values for the thresholds that define 'borderline' and 'acceptable' performance for three average initial depletion levels and two values for the standard deviation of the initial depletion level. 'Borderline' thresholds are calculated using the 0.6 tuning of the *CLA*, 'Acceptable' thresholds are calculated using the 0.72 tuning of the *CLA*. *MSYR*=1% for all trials.

Average initial depletion	SD initial depletion	'Borderline' thresholds: Lower 5%ile Final depletion	'Borderline' thresholds: Depletion ratio	'Acceptable' thresholds: Lower 5%ile Final depletion	'Acceptable' thresholds: Depletion ratio
0.3019	0	0.425	0.607	0.547	0.795
0.3019	0.05	0.388	0.578	0.436	0.763
0.5018	0	0.437	0.500	0.606	0.693
0.5018	0.05	0.435	0.500	0.601	0.682
0.7051	0	0.448	0.468	0.621	0.649
0.7051	0.05	0.439	0.466	0.617	0.641

Table 3

Summary of the application of the performance criteria for the North Atlantic minke trials. The two numbers for each threshold are respectively those based on the 0.6 and 0.72 tunings of the *CLA*. The values in parenthesis in the 'Lower 5%ile' columns are the results based on the using the *CLA* program on which the actual trials were based. Values indicated in bold-underline are not 'acceptable' for one of the two performance statistics.

		Final depletion		Depletion ratio		
Trials/stock	Initial depletion	Thresholds	Lower 5%ile	Thresholds	Lower 5%ile	Conservation performance
Trial NO-1						
CIC	0.7628	0.396/0.562	0.642 (0.642)	0.418/0.593	0.685 (0.685)	Acceptable
CM	0.8195	0.403/0.560	0.622 (0.623)	0.417/0.582	0.664 (0.664)	Acceptable
EN	0.5269	0.383/0.543	0.574 (0.592)	0.459/0.653	0.741 (0.763)	Acceptable
EC	0.5009	0.385/0.541	0.543 (0.569)	0.469/0.665	0.666 (0.681)	Acceptable
ES	0.4690	0.383/0.536	0.585 (0.598)	0.483/0.679	0.754 (0.771)	Acceptable
EB	0.4759	0.385/0.536	0.583 (0.597)	0.480/0.676	0.751 (0.771)	Acceptable
Trial NO-3						
EN	0.4442	0.385/0.530	0.542 (0.560)	0.500/0.691	0.793 (0.817)	Acceptable
EC	0.4168	0.386/0.523	0.523 (0.545)	0.510/0.704	0.736 (0.759)	Acceptable
ES	0.3809	0.380/0.515	0.546 (0.561)	0.534/0.727	0.799 (0.820)	Acceptable
EB	0.3877	0.383/0.512	0.545 (0.563)	0.529/0.721	0.797 (0.822)	Acceptable
Trial NO-4						
CIC	0.7858	0.400/0.564	0.627 (0.627)	0.419/0.591	0.672 (0.672)	Acceptable
CM	0.8084	0.403/0.564	0.616 (0.620)	0.417/0.586	0.658 (0.662)	Acceptable
Trial NO-5						
EN	0.6102	0.384/0.550	0.596 (0.605)	0.434/0.623	0.704 (0.715)	Acceptable
EC	0.5865	0.381/0.549	0.552 (0.564)	0.437/0.631	<u>**0.602**</u> (0.616)	Acceptable
ES	0.5595	0.383/0.545	0.610 (0.619)	0.448/0.638	0.720 (0.731)	Acceptable
EB	0.5659	0.383/0.546	0.606 (0.615)	0.446/0.636	0.716 (0.727)	Acceptable
Trial NO-6						
CIC	0.7271	0.393/0.561	0.611 (0.616)	0.420/0.600	0.654 (0.658)	Acceptable
CM	0.8090	0.404/0.564	<u>**0.561**</u> (0.567)	0.417/0.587	0.591 (0.585)	Acceptable

Table 4

Summary of the application of the performance criteria for the four baseline trials for North Pacific minke trials. The two numbers for each threshold are respectively those based on the 0.6 ('borderline') and 0.72 ('acceptable') tunings of the *CLA*. Thresholds are calculated using single stock trials, which do not include bycatch. The values in parenthesis in the 'Lower 5%ile' columns are the results based on using the *CLA* program on which the actual trials were based. Values indicated in bold-underline are not 'acceptable' for one of the two performance statistics.

		Final depletion		Depletion ratio		
Case/stock	Initial depletion (median)	Thresholds	Lower 5%ile	Thresholds	Lower 5%ile	Conservation performance
Baseline A						
J	0.300	0.354/0.462	<u>**0.111**</u> (0.111)	0.587/0.764	0.964 (0.964)	Acceptable
O	0.704	0.391/0.555	0.719 (0.723)	0.407/0.593	0.751 (0.744)	Acceptable
W	0.993	0.423/0.558	0.919 (0.920)	0.409/0.554	0.908 (0.907)	Acceptable
Baseline B						
J	0.300	0.354/0.462	<u>**0.111**</u> (0.111)	0.587/0.764	0.964 (0.964)	Acceptable
O	0.728	0.394/0.557	0.728 (0.729)	0.409/0.589	0.752 (0.757)	Acceptable
Baseline C						
J	0.300	0.354/0.462	<u>**0.108**</u> (0.108)	0.587/0.764	0.968 (0.967)	Acceptable
Ow	0.253	0.347/0.457	<u>**0.430**</u> (0.427)	0.554/0.740	<u>**0.693**</u> (0.696)	Borderline
Oe	0.662	0.387/0.555	0.571 (0.565)	0.406/0.595	0.723 (0.731)	Acceptable
W	0.990	0.408/0.555	0.819 (0.824)	0.398/0.552	0.817 (0.822)	Acceptable
Baseline D						
J	0.300	0.354/0.462	<u>**0.109**</u> (0.109)	0.587/0.764	0.969 (0.969)	Acceptable
O	0.290	0.356/0.482	<u>**0.381**</u> (0.385)	0.510/0.699	<u>**0.692**</u> (0.688)	Borderline
W	0.987	0.408/0.554	0.804 (0.806)	0.398/0.554	0.797 (0.800)	Acceptable

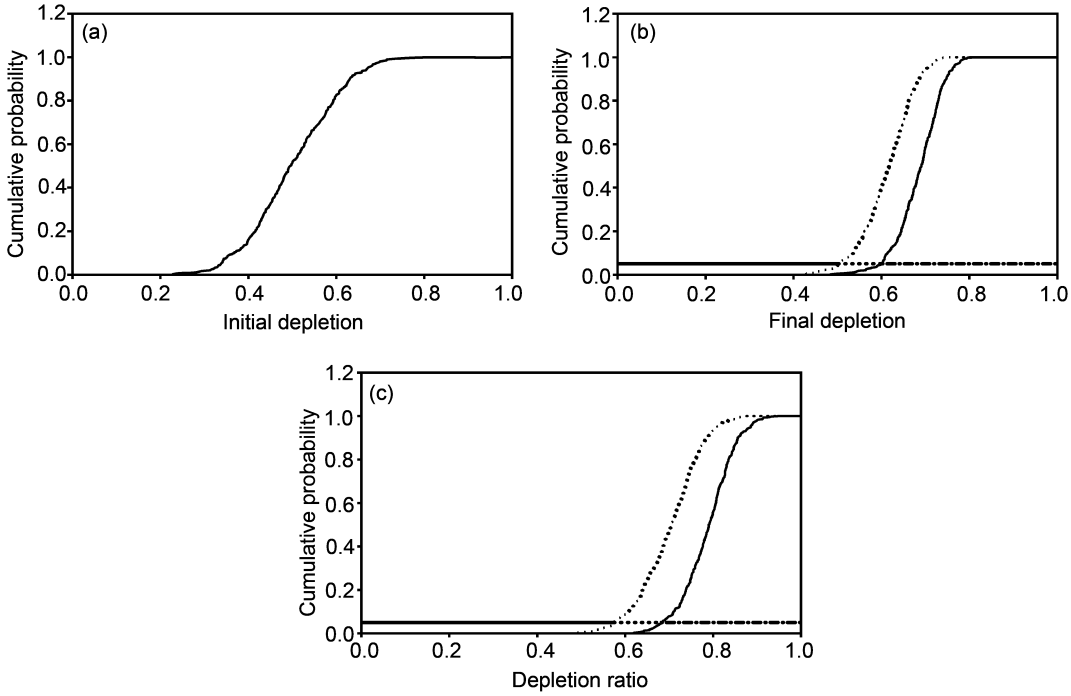

Fig. 1. Application of the performance criteria evaluated in this paper to a hypothetical *IST*. Panel (a) plots the distribution for the initial depletions in the trial. The solid and dotted lines in panels (b) and (c) denote the cumulative distributions for the 0.72 and 0.60 tunings of the *CLA*. The solid, dotted and dashed horizontal lines denote the ranges for the two performance statistics for which performance would be considered to be 'unacceptable', 'borderline' and 'acceptable' respectively.

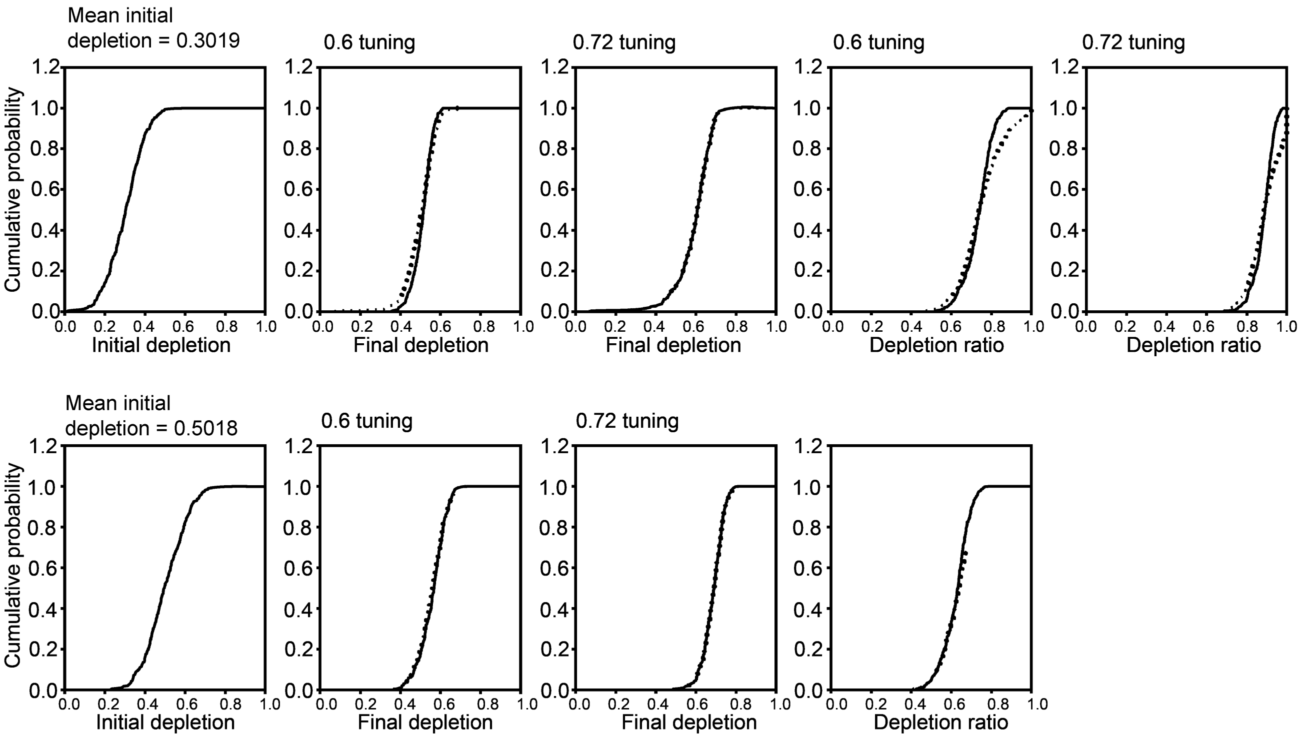

Fig. 2. Initial depletion distribution, distributions for the final depletion and the depletion ratio for the 0.6 tuning of *CLA*, and distributions for the final depletion and the depletion ratio for the 0.72 tuning of *CLA*. Results are shown for three mean initial depletions. The solid and dotted lines in columns 2-4 denote respectively results when there is no inter-simulation variation in the initial depletion and when the inter-simulation standard deviation of the initial depletion is 0.05.

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Appendix 3

AMENDMENT TO THE REQUIREMENTS AND GUIDELINES FOR *IMPLEMENTATIONS*

The Requirements and Guidelines for *Implementations* are given in IWC (2005).

The following amendments are proposed (note that 'variant' refers to RMP variants, i.e. specifications or *Small Areas*, *Catch cascading*, etc).

Page 87, Item 4.1

Replace the first sentence under point (1) with the following text:

The conservation performance (given the highest priority by the Commission) for each trial and variant shall be examined using the following guidelines to determine whether each combination of variant and trial will be classified as 'acceptable', 'borderline' or 'unacceptable' (see box 1 of Fig. 2).

For each stock in an *Implementation Simulation Trial* (*IST*) for which *MSYR*=1%:

(1) construct a single stock trial, which is 'equivalent' to the *IST*. For example, if a particular *IST* involved carrying capacity halving over the 100-year projection period, the 'equivalent single stock trial' will also involve carrying capacity halving over the next 100 years;

(2) conduct two sets of 100 simulations based on this single stock trial in which future catch limits are set by the *CLA*. The two sets of simulations correspond to the 0.60 and 0.72 tunings of the *CLA*. Rather than basing these calculations on a single initial depletion, the simulations for each stock shall be conducted for the set of initial depletions for the stock concerned in the *Implementation Simulation Trial* under consideration;

(3) the cumulative distributions for the final depletion and for the depletion ratio (the minimum over each of the 100 year projection of a trial of the ratio of the population size to that when there are only incidental catches) shall be constructed for each of these two tunings of the *CLA*;

(4) the lower 5%-ile of these distributions shall form the basis for determining whether the performance of the RMP for the *IST* is 'acceptable', 'borderline' or 'unacceptable';

(5) if the 5%-ile of the final depletion or the 5%-ile of the depletion ratio for the *IST* that shows better performance is less than for the equivalent single stock trial with 0.60 tuning of the *CLA*, the performance of the RMP shall be classified as 'unacceptable';

(6) if the 5%-ile of the final depletion or the 5%-ile of the depletion ratio for the *IST* that shows better performance is greater than for the equivalent single stock trial with 0.60 tuning of the *CLA* but less than for the equivalent single stock trial with 0.72 tuning of the *CLA*, the performance of the RMP shall be classified as 'borderline';

(7) if the 5%-ile of the final depletion or the 5%-ile of the depletion ratio for the *IST* that shows better performance is greater than for the equivalent single stock trial with 0.72 tuning of the *CLA*, the performance of the RMP shall be classified as 'acceptable'.

Appendix 2, fig. 1 outlines these steps for a hypothetical case and the reader should refer to this appendix for full details.

Page 88

Delete Table 1.

Pages 88 and 89

Renumber Figs 1 and 2 as Figs 2 and 3, respectively.

REFERENCE

International Whaling Commission. 2005. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 2. Requirements and guidelines for *Implementation*. *J. Cetacean Res. Manage. (Suppl.)* 7:84-92.

Appendix 4

REPORT OF SUB-GROUP ON REVIEW OF MAXIMUM SUSTAINABLE YIELD (MSY) RATES

Members: Cooke, Butterworth, Gunnlaugsson, Hatanaka, Polacheck, Schweder, Tanaka, Wade.

The group had two terms of reference:

(i) determine what interim range of MSY rates should be used in trials in the meantime pending a review of the range of plausible MSY rates;

(ii) make proposals for how to structure a review of the plausible range of MSY rates for use in management procedure evaluation.

1. Interim range of MSY rates

The group agreed that if further work on RMP variants is conducted before completion of the review described below, the full range of MSY rates used to date should be used in trials, namely from 1% (mature) to 7% (1+). This corresponds roughly to the range 0.66-7% for $MSYR_{(1+)}$, or 1-10% for $MSYR_{(mat)}$. This range will be revisited following the review.

2. Review of the plausible range of MSY rates

The last comprehensive review by the Scientific Committee of the plausible range of MSY rates for baleen whales was conducted in 1993 (IWC, 1994). At the time the Committee concluded that there was no need to change the plausible range of MSY rates from the range of 1-7% (mature) that had been used in the RMP trials until then.

The group considered that sufficient new information had become available since 1993 to justify a new review, which should be conducted at the 2007 Annual Meeting. It should be completed by the 2008 Annual Meeting at the latest. The group recommended that review be limited to baleen whales.

2.1 Structure of the review

The structure of the review can be based on that of the 1993 review. The items are:

(1) estimates from recovering populations;
(2) estimates from changes in biological parameters;
(3) estimates from population dynamic models of exploited populations;
(4) estimates from catch at age data;
(5) estimates from interspecific comparisons;
(6) generic issues, specifically the issue of yield curve shapes, and the effects of changing environments.

2.2 New information since 1993

Considerable new information is available or is expected to become available under each of these headings.

(1) Not only are there data from more recovering stocks, but some may already be near or above MSY so that not merely an estimate of the maximum growth rate at low population sizes, is available but potentially also on the changes in growth rates as the populations increase. There is information from, for example, gray and right whales and North Atlantic humpbacks which should also be used. Information from Southern Hemisphere (SH) humpback whales should arise from the current Comprehensive Assessment.
(2) There is new information on changes in biological parameters at least of gray and northern humpback whales with increasing population level. The 1997 JARPA review resulted in revised estimates of changes in southern hemisphere minke whale parameters.
(3) Schweder reported the intention to use the CPUE series developed in SC/58/RMP6 to fit a population model to determine confidence bounds for *MSYR* for Northeastern Atlantic minke whales. Similar analyses on fin whales were submitted to the joint IWC/NAMMCO meeting. The group encourages further submissions of this kind on other stocks where possible.
(4) The extensive analyses on JARPA catch-at-age potentially provided information on MSY rates for SH minke whales. It was noted that changes in *K* or other parameters are needed to explain these data.
(5) Some comparison tables of biological parameters and their changes for cetaceans have been published and should be made available as For Information papers but the group felt that the Committee would probably want to construct its own comparison table based on its review of the information.
(6) The ubiquity of environmental changes has become more apparent since the last review. In addition to the SH minke data mentioned above, variability in parameters was evident in other data sets such as for right and gray whales and fin whales off Iceland. An important issue is how to define and measure *MSYR* in the context time-varying parameters.

2.3 Collation and use of the available information

The group recommended that the review not simply used published estimates of increase rates or MSY rates, but would want to categorise them at least according to the nature of data used and the analysis method. For an estimate to be considered in the review, the relevant primary paper or manuscript should be made available.

Where relevant data exist, but have not been analysed with respect to the question of MSY rates, relevant analyses of these data should be actively solicited. The attention of other sub-committees should be drawn to this request.

The group recommended that a list of the cases to be considered in the review be drawn up in advance, say by the end of 2006. This should list:

(1) existing estimates and the corresponding primary papers;
(2) analyses in preparation which are intended for submission to the review;
(3) other relevant data sets of which analyses would be desirable.

3. Other matters

The group identified but did not discuss the following issues that may need to be addressed in addition to the review:

(1) revision of the standard set of simulation trials;
(2) revision of the set of performance statistics to be used for comparison (some of those used for selecting the first versions of the RMP are based on syntheses of results across a range of *MSYRs*);
(3) implications of a change in the plausible range of *MSYR* for tuning of the RMP or variants thereof.

REFERENCE

International Whaling Commission. 1994. Report of the Scientific Committee, Annex M. Report of the Working Group on MSY rates. *Rep. int. Whal. Commn* 44:181-89.

Appendix 5

REPORT OF *CATCH LIMIT ALGORITHM* (*CLA*) TRIALS GROUP

Members: Allison, Butterworth, Cooke, Donovan, Kawahara, Walløe.

1. Trials required to demonstrate the candidate procedure may be an improvement over the current version

The Group agreed the trials listed in Table 1 be required to be run for any candidates to replace the current version of the RMP. The trials were selected as being those which would be expected to highlight differences in performance of procedures, and trials which model issues of particular concern. Trials were added with $MSYR_{(mat)}$=1.5%, which are approximately equivalent to trials with $MSYR_{(1+)}$=1.0%, to ensure all necessary risk-related trials are run pending the Scientific Committee decision on choice of MSY rates. It was also agreed that 400 simulations should be run for each trial (previously the 1% base case trials included 400 simulations, but other trials used only 100).

Table 1

Description		Trial		
$MSYR_{mat}$	1%	1.5%	4%	7%
T1. Age structured model, maturity 7yr	T1-D1	T1-D1.5	T1-D4	T1-D7
D=Development (initial population 0.99*K*)				
R=Rehabilitation (initial population 0.3*K*)	T1-R1	T1-R1.5	T1-R4	T1-R7
S = Sustainable (initial population 0.6*K*)	T1-S1	T1-S1.5		
T2. Survey Bias 0.5	T2-D1	T2-D1.5		
	T2-R1	T2-R1.5		
T3. Survey Bias 1.5	T3-D1	T3-D1.5		
	T3-R1	T3-R1.5		
	T3-S1	T3-S1.5		
T4. Initial population size P_0 = .05*K*	T4-R1	T4-R1.5		
T6. Historic catch in error (1/2 true catch)	T6-R1	T6-R1.5	T6-R4	
T9. Episodic events: 2% chance each year that population is halved	T9-D1	T9-D1.5	T9-D4	
	T9-R1	T9-R1.5	T9-R4	
T12A. *K* doubles over management period	T12A-D1	T12A-D1.5	T12A-D4	
	T12A-R1	T12A-R1.5	T12A-R4	
T12B. *K* halves over management period	T12B-D1	T12B-D1.5	T12B-D4	
	T12B-R1	T12B-R1.5	T12B-R4	

Table 2

Description	Trials				
T1. Age structured model, maturity 7yr	T1-D10				
D=Development (initial population 0.99*K*)					
R=Rehabilitation (initial population 0.3*K*)	T1-R10				
S = Sustainable (initial population 0.6*K*)	T1-S4	T1-S7	T1-S10		
T5. 25 years protection prior to management	T5-R1	T5-R1.5	T5-R4		
T7. Age at maturity = 10yr	T7-D1	T7-D1.5	T7-D4		
	T7-R1	T7-R1.5	T7-R4		
T8. Random parameters	T8				
T10. *MSYL*=40%[1]	T10-D1	T10-D1.5	T10-D4		
	T10-R1	T10-R1.5	T10-R4		
T11. *MSYL*=80%[1]	T11-D1	T11-D1.5	T11-D4		
	T11-R1	T11-R1.5	T11-R4		
T13. 33year cycle in *MSYR* (141)	T13-D1	T13-R1			
T13. 33year cycle in *MSYR* (414)	T13-D4	T13-R4			
T15. Survey every 10 years	T15-D1	T15-D1.5	T15-D4	T15-D7	
	T15-R1	T15-R1.5	T15-R4	T15-R7	
T1. Initial population 0.20*K*	T1-T1	T1-T1.5	T1-T2.5	T1-T4	T1-T7
T1. Initial population 0.4*K*	T1-F1	T1-F1.5	T1-F2.5	T1-F4	T1-F7
	T1-R2.5				
	T1-R7				
T16. *MSYR* declines linearly to half its initial value	T16-D1	T16-D1.5	T16-D4		
T17. *K* & *MSYR* decline linearly to half initial values	T17-D1	T17-D1.5	T17-D4		

[1]Formerly Tent model with *MSYL*=40%; replaced by standard age structured model with PT recruitment function.

In addition the following response curve plots should be produced for MSY rates of 1%, 1.5% and 4% and initial depletion levels of 0.3*K* (*R* trials), 0.6*K* (*S* trials) and 0.99*K* (*D* trials). Fig. 1 shows an example of a response curve. Other parameters are kept at their base case values.

Initial depletion level
(a) (low depletion set) 0.05*K*; 0.1*K*; 0.2*K*; 0.3*K**; 0.4*K*; 0.5*K*
(b) (full depletion range) 0.05*K*; 0.2*K*; 0.4*K*; 0.6*K**; 0.80*K*; 0.99*K**
Unreported catch level: Reported catch = 100% C_t*; 80% C_t ; 60% C_t ; 40% C_t ; 20% C_t ; 1% C_t where C_t is the true historic catch
Positive bias: (constant) No bias (1.0)*; 1.2; 1.4; 1.6; 1.8; 2.0

*=base case trial

2. The full set of trials

The Group agreed that the full set of trials comprised the further trials listed in Table 2 in addition to those in Table 1. The full set would need to be run on a candidate procedure if the Scientific Committee considers the candidate procedure likely to be an improvement over the current version.

In addition the following response curve plots should be produced for MSY rates of 1%, 1.5% and 4% and initial depletion levels of 0.3*K* (*R* trials), 0.6*K* (*S* trials) and 0.99*K* (*D* trials). Fig. 1 shows an example of a response curve. Other parameters are kept at their base case values.

Biological parameters and models

Parameter	Values
MSYL level	0.3*K*; 0.45*K*; 0.6*K**; 0.75*K*; 0.9*K*
MSYR level	0.5% 1%*; 2.5%; 4%*; 7%*
Varying *MSYR*	(a) 1%*; 14yr steps 1-4-1; 14yr steps 4-1-4; 33yr steps 1-4-1; 33yr steps 4-1-4; 4%*
	(b) Constant 1%*; increases linearly[1] from 1-2%; 1-4%; decreases linearly[1] from 4-2%; 4-1%; Constant 4%*

Other recruitment models	Pella-Tomlinson (PT) (40% *MSYL* with lower bound on recruitment); PT (60% *MSYL*); PT (80% *MSYL*);
Other models	Base case*; Age of maturity = 10; Standard PT; PT + maximum recruitment limitation; PT + 25yr recruitment delay
Stock condition and historic catches	
Period of historic catch	10; 30*; 50
Period of protection	None*; 15yr; 30yr
Environmental impacts	
K and *MSYR* decrease[1]	Constant*; decrease to: 80%; 60%; 40%; 20%; 1% of initial values
Varying K	Doubles linearly; constant*; halves linearly[1]; cyclic, starting min; cyclic, starting max
Survey-related	
Varying bias	0.5 constant; linear increasing[1] 0.5-1.0; No bias (1.0)*; linear decreasing[1] 1.5-1.0; 1.5 constant
CV_{obs}	0.1 2; 0.2*; 0.4; 0.6; 0.8; 1.0 (The corresponding values of $CV_{(true)}$ are 0.36; 0.40; 0.53; 0.69; 0.87; 1.06)
Level of process error	Process error factor η=0; 0.5; 1*; 2; 3; 4 (CV_{obs}=0.2 in these trials) (The corresponding values of $CV_{(true)}$ are 0.2; 0.32 0.40; 0.53; 0.64; 0.73)
Survey frequency	2yr; 5yr*; 7yr; 10yr; 20yr; determined by forecast quota
Surveys cease	after 0yr (i.e. initial survey only); 20yr; 40yr; 60yr; 80yr; continuous*

[1] The parameter(s) vary linearly over the 100 years of management (and are constant prior to management).

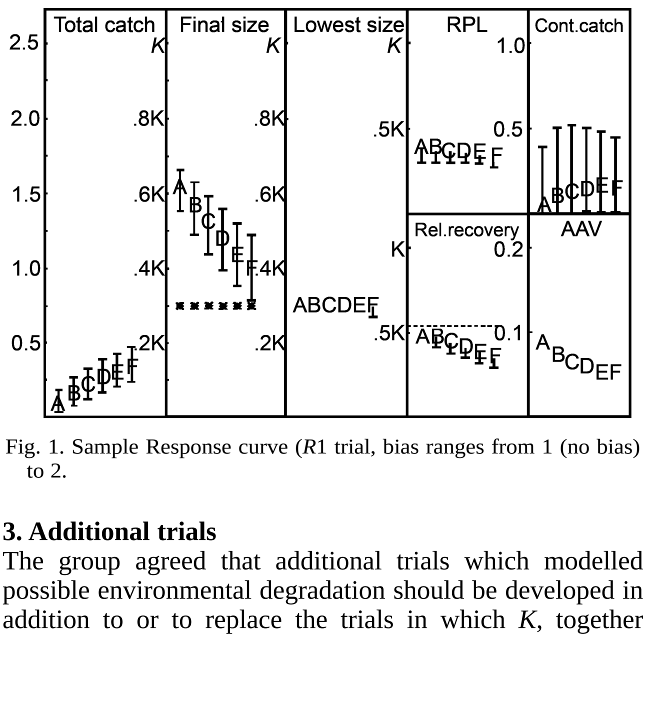


Fig. 1. Sample Response curve (*R*1 trial, bias ranges from 1 (no bias) to 2.

3. Additional trials

The group agreed that additional trials which modelled possible environmental degradation should be developed in addition to or to replace the trials in which *K*, together perhaps with *MSYR*, varies over time. The current varying *K* trials have questionable behaviour when modelling population sizes above *K* and might better be modelled using an exponential model. The group suggested that specification of these additional trials required further work and recommends this be done before the next Scientific Committee meeting. The resulting trials would be included in the full trial set, but not in the list of those required to demonstrate an improvement in behaviour of a candidate procedure.

4. Trials not required

The tent model trials have been replaced by trials based on the PT recruitment function in which *MSYL* is varied; in addition, the trials suggested above to use an exponential model will address the requirement for a trial using a population model other than the standard age structured model with a PT recruitment function.

Trials which were designed to investigate minimum data standards (the T14-D1 and T14-R1 trials in which there was a survey in year 1 only, and other trials with inter survey intervals of 5, 7 and 10 years in combination with various factors) were deleted as the phaseout rule makes them unnecessary. In addition the minimum data standards trials (IWC, 1994) are not included in the full set of trials, as the response curves were considered sufficient in this regard.

5. Tuning Level

The group agreed that the current *CLA* which is tuned to 72% final depletion after 100 years, together with the 66% and 60% tunings provide a set of procedures with which to compare any candidate procedure. Hence it is unnecessary for any new procedure to be tuned to a particular level, as its performance will be compared to the existing (tuned) *CLA* by considering the full set of performance statistics.

This being the case, it is unnecessary to change the summary statistics (and in particular the continuing catch statistic which is defined over the years 90 to 99) or the time period of the trials. It is, however, open to developers to investigate properties of their procedure over longer time periods, if they so wish.

6. Summary statistics

Scaling: Catches are scaled by the initial carrying capacity. Population sizes are scaled by the carrying capacity except in trials where *K* varies. In these cases P_f and $P_{\min}$ are scaled by the population size resulting if no catch is taken in the management period.

(1) TOTAL CATCH (TC) DISTRIBUTION

(a) median of the 400 simulations (i.e. average of 200th and 201st values); (b) 5th %ile (20th); (c) 96th %ile (381st); (d) mean.

(2) FINAL POPULATION SIZE (P_F) DISTRIBUTION

(a) median (b) 5th %ile (c) 96th %ile

(3) LOWEST MINIMUM POPULATION OVER 100 YEARS DISTRIBUTION

(a) median (b) 5th %ile (c) 1st (i.e. lowest) value

(4) AVERAGE ANNUAL CATCH VARIATION (AAV)

$$\text{AAV} = \left\{ \sum_{i=1}^{100} \sum_{t=0}^{98} | C_{i,t+1} - C_{i,t} | \right\} \cdot \left\{ \sum_{i=1}^{100} \sum_{t=0}^{98} C_{i,t} \right\}^{-1}$$

(5) CONTINUING CATCH (C_C) DISTRIBUTION, AS DEFINED BELOW

(a) median (b) 5th %ile (c) 96th %ile

The 'sustainable yield' as a function of population size, $S_Y(P)$ is defined as:

$$S_Y(P) = \begin{cases} \text{MSY} & \text{for } P > MSYL \\ \text{long-term equilibrium } RY & \text{for } P < MSYL \end{cases}$$

The 'continuing yield' realised by a catch, C, is defined as:

$$C_Y = \begin{cases} C & \text{for } C < S_Y \\ S_Y & \text{for } C > S_Y \end{cases}$$

The 'continuing yield' or 'continuing catch' statistic (C_c) is the median over simulations of:

$$\frac{1}{10}\sum_{t=90}^{99} C_{Y,t}$$

The statistic is computed by calculating $S_Y(P)$ for population sizes at fixed intervals from P=0 to P=$MSYL$, for each set of trials, and storing the results in an array. The statistic is calculated by interpolation from this array.

(6) RPL = REALISED PROTECTION LEVEL = LOWEST STOCK SIZE FOR WHICH A CATCH IS SET (MEDIAN AND 5%ILE) (IWC, 1993, P.222)

(7) RR = RELATIVE RECOVERY = STOCK LEVEL IN THE YEAR WHEN THE ZERO CATCH TRAJECTORY REACHES 54% (MEDIAN AND 5%ILE)

Graphical presentation (IWC, 1990, p.114)

Graphs showing the following are required (a sample of the graphs is given in Fig. 2):

(i) the mean population trajectory over the 400 simulations;
(ii) the set of 5th and 96th %iles of the distribution of population sizes reached each year in the 400 simulations, on the same plot as (i);
(iii) the mean catch trajectory over the 400 simulations; and
(iv) the catches taken in the first two stochastic simulations, preferably on the same plot as (iii).

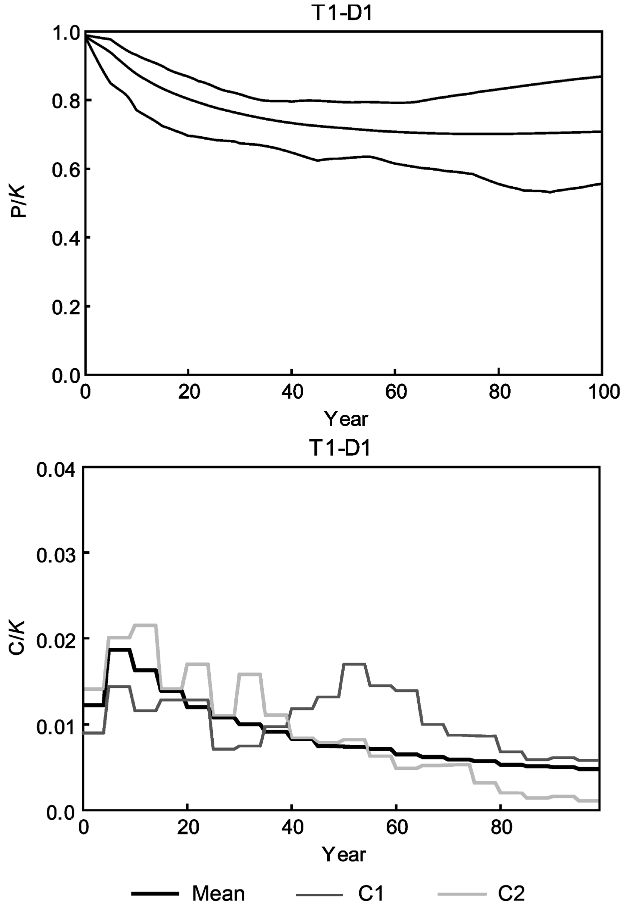


Fig. 2. Sample plots.

REFERENCES

International Whaling Commission. 1990. Report of the sub-committee on management procedures, Appendix 6. Report of the subgroup set up to reconsider the statistics presented for each trial, to revise specifications of existing second stage screening trials and to detail new trials. *Rep. int. Whal. Commn* 40:112-18.

International Whaling Commission. 1993. Special Meeting of the Scientific Committee on the Revised Management Procedure. *Rep. int. Whal. Commn* 43:221-28.

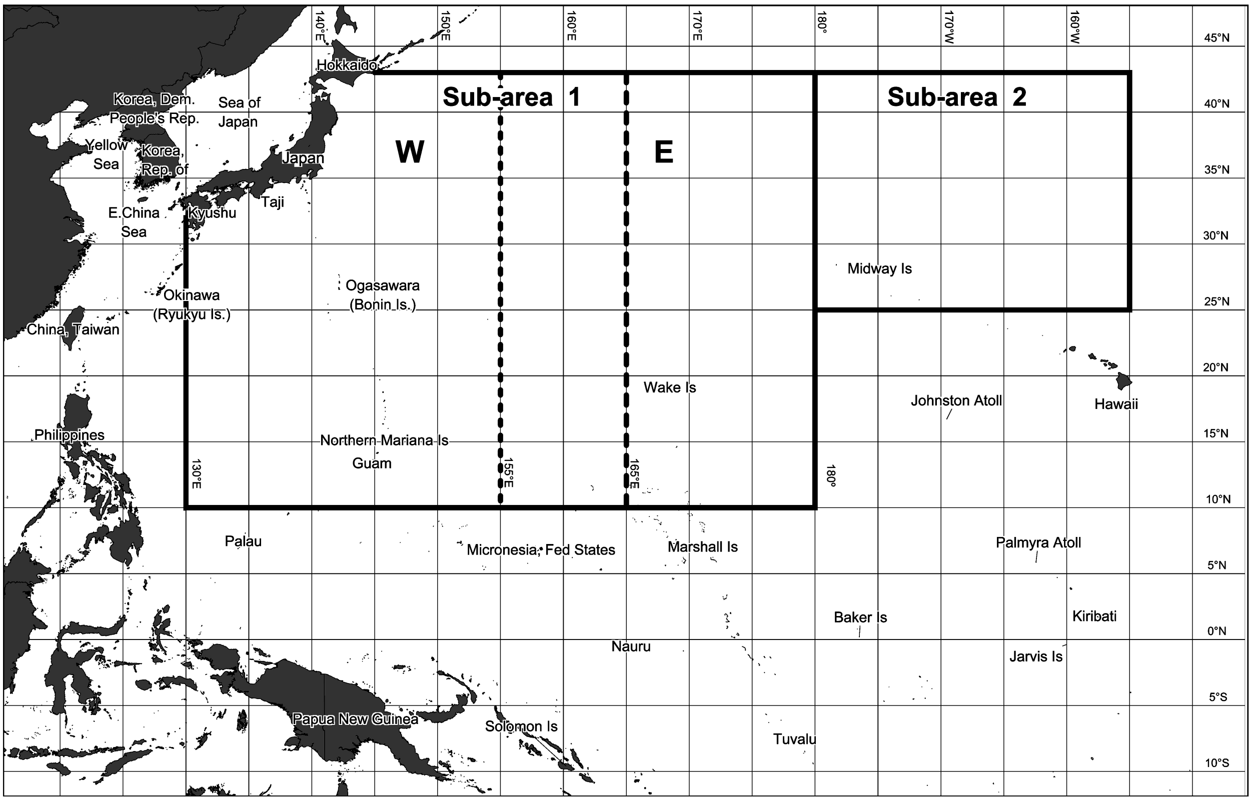
International Whaling Commission. 1994. Report of the Scientific Committee, Annex D. Report of the Sub-Committee on Management Procedures, Appendix 2. Minimum Standards Trials. *Rep. int. Whal. Commn* 44:85-88.

Appendix 6

THE SPECIFICATIONS FOR THE *IMPLEMENTATION SIMULATION TRIALS* FOR WESTERN NORTH PACIFIC BRYDE'S WHALES

A. Basic concepts and stock-structure

The trials outlined below consider the implications of alternative variants of the RMP for Bryde's whales in sub-areas 1 and 2 of the western North Pacific (Fig. 1). Sub-area 1 is further sub-divided into sub-areas 1W and 1E at 1650E for the bulk of the trials although sensitivity is explored to alternative placements of the boundary in some of the trials. The trials consider up to two *stocks* of Bryde's whales in the western North Pacific, one of which (Stock 1) could consist of two *sub-stocks* that mix across sub-area 1 and perhaps also sub-area 2. Sub-stocks are modelled as stocks (i.e. there is no permanent transfer of animals among sub-stocks) for ease of *Implementation*, because it should provide a more stringent test of the RMP variants, and because there are no data to estimate rates of dispersal among putative sub-stocks nor any way to estimate dispersal rates.



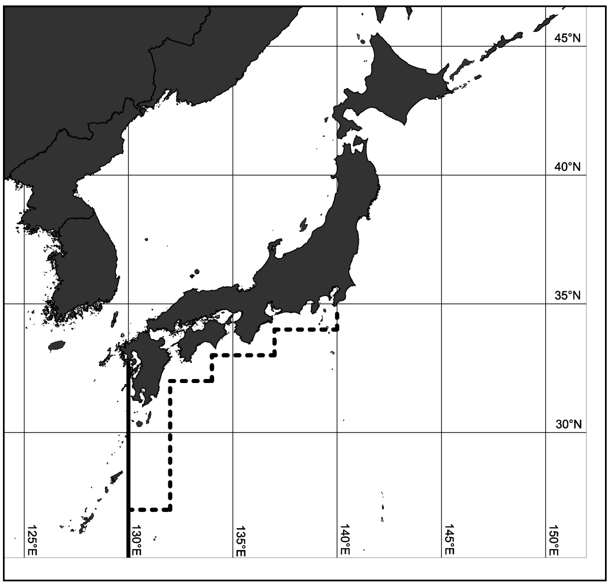


Fig. 1. Map of the western North Pacific showing the sub-areas defined for the western North Pacific Bryde's whales. Note: The boundary between the 1W and 1E subareas is now set at 165°E.

There are four general hypotheses regarding stock structure:

(1) there is only one stock of Bryde's whales in sub-areas 1 and 2;
(2) there are two stocks of Bryde's whales in sub-areas 1 and 2. One stock is found in sub-area 1 and the other is found in sub-area 2;
(3) there are two stocks of Bryde's whales in sub-areas 1 and 2. One stock is found in sub-areas 1 and 2, and the other is found in sub-area 2 only;
(4) there are two stocks of Bryde's whales in sub-areas 1 and 2. One stock is found in sub-area 1 and the other is found in sub-area 2. Stock 1 consists of two sub-stocks that mix in sub-areas 1W and 1E.

B. Basic dynamics

The dynamics of the animals in stock/sub-stock j are governed by the equations:

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

where

$N^{g,j}_{t,a}$ is the number of animals of gender g and age a in stock/sub-stock j at the start of year t;
$C^{g,j}_{t,a}$ is the catch (in number) of animals of gender g and age a in stock/sub-stock j during year t (whaling is assumed to take place in a pulse at the start of each year)
b^{j}_{t} is the number of calves born to females from stock/sub-stock j at the start of year t;
M is the instantaneous rate of natural mortality; and
x is the maximum age (treated as a plus-group).

C. Births

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

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

where

B^{j} is the average number of births (of both sexes) per year for a mature female in stock/sub-stock j in the pristine population;
A^{j} is the resilience parameter for stock/sub-stock j;
z^{j} is the degree of compensation for stock/sub-stock j;
$N^{\mathrm{f},j}_{t}$ is the number of 'mature' females in stock/sub-stock j at the start of year t:

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

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

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

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

D. Catches

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

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

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

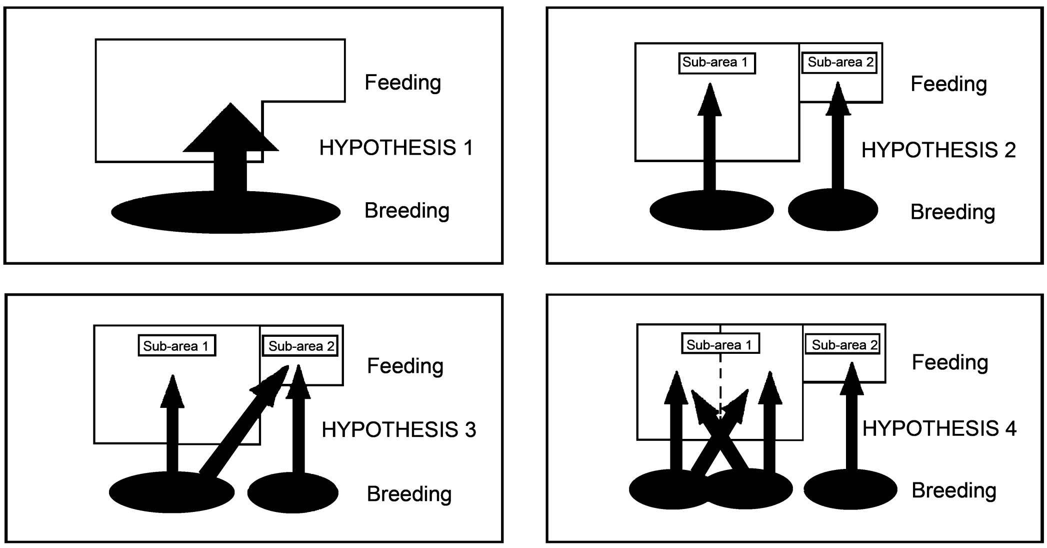


Fig. 2. Stock structure hypotheses selected by the Workshop on the *pre-implementation assessment* of the western North Pacific Bryde's whales.

where

$F_t^{g,k}$ is the exploitation rate in sub-area k on recruited animals of sex g during year t;

$S_{t,a}^{k}$ is the selectivity on animals of age a in sub-area k during year t;

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

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

Most trials assume that the mixing matrix does not depend on age. The exceptions are trials Br11 and Br12 in which there is age-dependency in the distribution across sub-area 1. In these trials the values for the entries in the mixing matrix are set using the following equation:

$$\begin{aligned} V_{t,a}^{j,1W} &= V_{t,0}^{j,1W}(1-\lambda a) \\ V_{t,a}^{j,1E} &= (1-V_{t,a}^{j,1W}) \end{aligned} \qquad \text{(D.3)}$$

where λ is a parameter which determines the extent to which the mixing matrix depends on age. The value of λ is determined during conditioning (see section G(d)).

The catches by sub-area and year are either set to the historical (pre-2005) values (Table 2); or, in the future, are determined using the RMP. The sex ratio for future catches is assumed to be 50:50.

E. Mixing

The entries in the mixing matrix *V* are selected to model the distribution of each stock/sub-stock at the time when the catch is removed. Mixing can be deterministic or stochastic. If mixing is stochastic, the mixing matrix is selected at random from two possibilities. Table 1 lists the mixing matrices for each of the stock structure hypotheses. Mixing is stochastic for the trials in which Stock 1 or Sub-stock 1E is found in sub-area 2 (Br6 and 7, hypothesis 3). A random number, u, is selected from U[0,1] for each year. If $u \leq 0.5$, Stock 1/Sub-stock 1E mixes into sub-area 2 otherwise no mixing takes place. A similar scheme is used to model stochastic mixing of Sub-stocks 1W and 1E in sub-areas 1W and 1E for trials Br13 and Br14, with the 1W and 1E substocks assumed to move in phase in order to minimise or maximise the overlap (i.e. a single random number is selected and applied to both substocks).

In most trials, the boundary between sub-areas 1W and 1E used when modelling the true population dynamics is the same as that used when applying the RMP (and is at 165°E). However, for some of trials based on stock structure hypothesis 4, a different boundary is used.

Consider the case in which the true boundary between the sub-stocks on which the trials are based and to which the mark-recapture data pertain (trials-sub-areas) is at 155°E and that between the sub-areas for which catches are reported and survey abundance estimates are available (observation-sub-areas) is 165°E (Fig. 3). The mixing matrix for either of the sub-stocks can conveniently be expressed as the vector (1, φ) where a fraction of φ/(1+φ) of the animals from the stock are found to the east of 155°E and 1/(1+φ) are found west of 155°E. Now assume that a fraction δ of the animals in the sub-area east of 155°E are located between 155°E and 165°E. The split of the stock among the three sectors: 140°E-155°E; 155°E-165°E;165°E-180° is therefore 1/(1+φ), δφ/(1+φ), and (1-δ)φ/(1+φ).

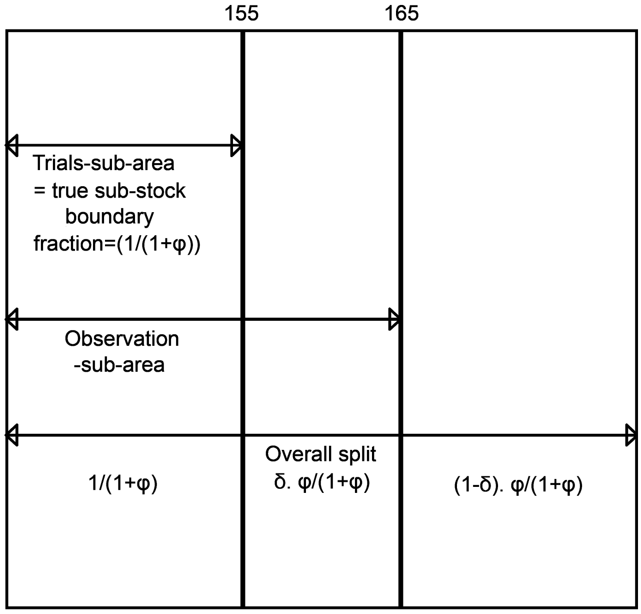


Fig. 3. Illustration of how trials sub-areas and observation sub-areas operate for trials in which trials sub-areas and observation sub-areas differ.

The value of δ is set assuming that a stock (or sub-stock) is uniformly distributed across the area in which it is found. Thus, δ=2/5 when the stock boundary is at 155°E and the RMP boundary is at 165°E. (Note: the boundary used by the RMP is always the same as the true boundary in trials when mixing is age dependent.)

Note that the tagging data are assigned to stocks/ sub-stocks (and reported) according the trials-sub-areas and not the observation sub-areas.

F. Generation of data

The actual estimates of absolute abundance (and their associated CVs) for 1995 (Table 3) are provided to the RMP. These abundance estimates exclude the areas identified in table 3 of IWC (2000). The future surveys are assumed to cover each of sub-areas 1W, 1E and 2 in their entirety in a single survey. This is a slight simplification of reality; the entire area will actually be covered in four years (see Table 4 for the proposed survey plan), but the westernmost part of sub-area 1W contains very few Bryde's whales so the two surveys in sub-area 1W are treated as one for the purposes of trials. The trials assume that it takes two years for the results of a sighting survey to become available to be used by the management procedure, i.e. a survey conducted in 2006 could first be used for setting the catch limit in 2008.

The future estimates of abundance for a survey area (a sub-area for these trials) (say survey area E) are generated using the formula:

$$\hat{P} = P\,Y\,w/\mu = P^*\,\beta^2\,Y\,w \qquad \text{(F.1)}$$

where

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

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

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

$$P = P_t^E = \sum_{k\in F}\sum_j V_t^{j,k}\sum_g\sum_{a\geq 1} N_{t,a}^{g,j} \qquad \text{(F.2)}$$

P^* is the reference population level, and is equal to the expected total (1+) population size in the survey area prior to the commencement of exploitation in the area being surveyed (where the expectation is taken with respect to inter-annual variation in the mixing matrix); and

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

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

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

An estimate of the CV, X, is generated for each sightings estimate:

$$X = \sigma\sqrt{(CHISQ/n)} \tag{F.4}$$

where $\sigma^2 = \ell n(1 + CV^2_{est})$ and CHISQ is a random number from a Chi-square distribution with n degrees of freedom (where n is 10 (as for the North Pacific minke trials)) and $CV^2_{est} = \theta^2(a^2 + b^2/w\beta^2)$ where a^2 and b^2 are constants and equal 0.02 and 0.012 respectively. Note that under the approximation $E(1/w) = 1/E(w) = 1/[(P/P^*)/\beta^2] = \beta^2 P^*/P$, this gives:

$$CV^2_{est} = \theta^2(a^2 + b^2 P^*/P) \tag{F.5}$$

The equation used to compute θ^2 for a given sub-area is:

$$\theta^2 = CV^2_{\tilde{P}}/(0.02 + 0.012P^*/\tilde{P}) \tag{F.6}$$

where $CV_{\tilde{P}}$ is the observed CV (excluding additional variance) corresponding to some model population size $\tilde{P}$. The extent of additional variance, σ^2_p, is defined as the additional variance at $P = \tilde{P}$, i.e.:

$$CV^2(\tilde{P}) = CV^2_{est}(\tilde{P}) + \sigma^2_p \tag{F.7}$$

The value for τ (and hence those for α^2 and β^2) can be computed from values for θ^2, σ^2_p, and Equations (F.5), (F.6), and (F.7) as follows:

$$\tau = \frac{CV^2_{\tilde{P}} + \sigma^2_p}{0.12 + 0.025P^*/\tilde{P}} \tag{F.8}$$

Adjunct 1 lists the values for $CV_{\tilde{P}}$ and σ^2_p by sub-area.

G. Parameters and conditioning

The values for the biological and technological parameters are listed in Table 5. In relation to selectivity, a 35ft (10.7m) legal minimum size limit applies to coastal whaling and a 40ft (12m) limit applies to pelagic operations. These limits correspond to ages of five and nine years respectively (Ohsumi, 1977). These limits can be implemented by making selectivity depend on sub-area. Historically, pelagic whaling occurred in sub-areas 1E and 2, and coastal whaling in sub-area 1W. Therefore, selectivity is assumed to be knife-edged at age five for sub-area 1W, while selectivity for sub-areas 1E and 2 is assumed to be knife-edged at age nine. All future catches are assumed to be based on pelagic whaling with knife-edged selectivity at age five.

The 'free' parameters of the above model are the initial (pre-exploitation) sizes of each of the sub-stocks/stocks and the values that determine the mixing matrices. The conditioning process involves first generating 100 sets of 'target' data, detailed in steps (a) to (d) below, and then fitting the population model to each (in the spirit of a bootstrap). Note that each replicate involves different realizations for the random variables that determine the mixing matrices.

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

$$P^k_t = O^k_t \exp[\mu^k_t - (\sigma^k_t)^2/2];\ \mu^k_t \sim N[0;(\sigma^k_t)^2] \tag{G.1}$$

where

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

O^k_t is the actual survey estimate for sub-area k in year t (Table 3); and

σ^k_t is the CV is O^k_t.

(b) A 'target' for the numbers of animals tagged in sub-areas 1 and 2 during 1972–85 and recaptured by the Japanese fleets is generated by selecting records with replacement from the tag-recapture data (see Tables 7 and 8). The objective function used to include the tagging data when conditioning is given in Adjunct 3. The tag recapture data are assumed to be negative binomially (rather than Poisson) distributed to account for possible non-randomness in the tagging/recapture process.

(c) A target for the ratio of the number of 1+ animals from Stock 2 in sub-area 2 to those from Stock 1 in sub-area 2 (for trials that involve mixing of Stocks 1 and 2 in sub-area 2 only, i.e. hypothesis 3) at pre-exploitation equilibrium – assumed to be 0.5.

(d) For the trials in which there is age-dependency across sub-area 1, estimates of total mortality are generated for sub-areas 1W and 1E+2 (N(0.864, 0.027^2) and (N(0.894, 0.006^2) respectively in the years 1971-79 + 2000-03) and the fit to these data included in the objective function used when conditioning the operating model. The model estimate of the survival rate is based on applying the Chapman-Robson estimator to animals aged 15+ for consistency with the way the above normal distributed were derived. The model estimates of the total mortality for sub-areas 1W and 1E+2 are obtained by averaging total mortality by year over year, weighting the yearly estimates by the number of animals aged, i.e.:

$$\hat{M}^A = \sum_y Q^A_y \bar{M}^A_y / \sum_{y'} Q^A_{y'} \tag{G.2}$$

where

Q^A_y is the number of animals aged in region A (either 1W or 1E+2) during year y as given in Table 9, and

$\bar{M}^A_y$ is the total mortality for region A and year y.

The total mortality for area A and year y is computed using the Chapman-Robson estimator, i.e.:

$$\bar{M}^A_y = (1 + 1/\tilde{a}^A_y)^{-1} \tag{G.3}$$

where

$\tilde{a}^A_y$ is the amount by which the average age of the catch during year y in region A exceeds the age-at-recruitment, i.e.:

$$\tilde{a}^A_y = \sum_a a(C^{m,A}_{y,a} + C^{f,A}_{y,a}) / \sum_{a'} (C^{m,A}_{y,a'} + C^{f,A}_{y,a'}) \tag{G.4}$$

H. Trials

The *Implementation Simulation Trials* for the western North Pacific Bryde's whales are listed in Table 6. All of trials are based on the assumption $g(0)=1$. Mixing is stochastic (see section E) for the trials in which Stock 1 or Sub-stock 1E is found in sub-area 2. A similar scheme is used to model stochastic mixing of Sub-stocks 1W and 1E in sub-areas 1W and 1E for trials Br13 and Br14.

I. Management Options

The following four management options will be considered.

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

(1) Sub-areas 1W, 1E[1] and 2 are *Small Areas* and catch limits are set by *Small Area*.
(2) Sub-area 2 is taken to be a *Small Area* and the complete sub-area 1 is treated as a *Small Area*. For this management option, all of the future catches in sub-area 1 are taken from sub-area 1W.

Management options based on applying *catch cascading*:

(3) Sub-area 2 is taken to be a *Small Area* and sub-area 1 is taken to be a *Combination Area*. Sub-areas 1W and 1E are *Small Areas*, with *catch-cascading* applied.
(4) Sub-areas 1 and 2 (combined) are taken to be a *Combination Area*, and sub-area 2 and sub-areas in 1W and 1E are *Small Areas*, with *catch-cascading* applied.

The simulation application of the RMP is based on using the 'best' catch series (see Table 2).

J. Output statistics

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

[1] Defined to be 140°E-165°E and 165°-180° irrespective of the true boundary used to define the structure of the populations in the operating model.

(1) Total catch (TC) distribution: (a) median; (b) 5th value; (c) 95th value.
(2) Initial mature female population size (P_{initial}) distribution: (a) median; (b) 5th value; (c) 95th value.
(3) Final mature female population size (P_{final}) distribution: (a) median; (b) 5th value; (c) 95th value.
(4) Lowest mature female population size (P_{lowest}) distribution: (a) median; (b) 5th value; (c) 95th value.
(5) Average catch by sub-area over the first ten years of the 100 year management period: (a) median; (b) 5th value; (c) 95th value.
(6) Average catch by sub-area over the last ten years of the 100 year management period: (a) median; (b) 5th value; (c) 95th value.

Table 1

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

	Stock 1	Sub-stock 1A	Sub-stock 1B	Stock 2
Single stock hypothesis (matrix A)				
Sub-area 1W	1	-	-	N/A
Sub-area 1E	γ_1	-	-	N/A
Sub-area 2	γ_2	-	-	N/A
Two stock hypothesis (matrix B)				
Sub-area 1W	1	-	-	0
Sub-area 1E	γ_2	-	-	0
Sub-area 2	0	-	-	1
Two stock hypothesis (matrix C1)				
[note: mixing is stochastic in this trial]				
Sub-area 1W	1	-	-	0
Sub-area 1E	γ_3	-	-	0
Sub-area 2	γ_3*	-	-	1
	Matrix C2			
Sub-area 1W	1	-	-	0
Sub-area 1E	γ_3	-	-	0
Sub-area 2	0	-	-	1
Two stock hypothesis (matrix D)				
Sub-area 1W	-	1	γ_6	0
Sub-area 1E	-	γ_5	1	0
Sub-area 2	-	0	0	1

*Selected so that the split of the population size at pre-exploitation equilibrium between Sub-stock 1B and Stock 2 in sub-area 2 is 50:50.

Table 2

The Catch Series used in the trials (L=low, B=best, H=high).

Sub area	IW	IW	IW	IW	IW	IW	IW	IW	IW	IW	IW	IW	IW	IW	1E	1E	1E	1E	1E	1E	2	2
Sex:	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Boundary	155	155	155	155	155	155	160	160	165	165	165	165	165	165	155	155	160	160	165	165		
Series	B	B	H	H	L	L	B	B	B	B	H	H	L	L	All	All	All	All	All	All	All	All
1906	6	7	9	11	4	3	6	7	6	7	9	11	4	3	0	0	0	0	0	0	0	0
1907	17	18	24	28	10	9	17	18	17	18	24	28	10	9	0	0	0	0	0	0	0	0
1908	39	42	57	67	24	22	39	42	39	42	57	67	24	22	0	0	0	0	0	0	0	0
1909	23	24	33	39	14	13	23	24	23	24	33	39	14	13	0	0	0	0	0	0	0	0
1910	24	26	35	41	15	13	24	26	24	26	35	41	15	13	0	0	0	0	0	0	0	0
1911	75	81	109	128	46	42	75	81	75	81	109	128	46	42	0	0	0	0	0	0	0	0
1912	38	43	61	75	18	16	38	43	38	43	61	75	18	16	0	0	0	0	0	0	0	0
1913	58	66	94	115	28	25	58	66	58	66	94	115	28	25	0	0	0	0	0	0	0	0
1914	24	32	51	68	2	2	24	32	24	32	51	68	2	2	0	0	0	0	0	0	0	0
1915	72	97	154	208	3	3	72	97	72	97	154	208	3	3	0	0	0	0	0	0	0	0
1916	45	60	94	126	4	4	45	60	45	60	94	126	4	4	0	0	0	0	0	0	0	0
1917	88	93	124	142	57	52	88	93	88	93	124	142	57	52	0	0	0	0	0	0	0	0
1918	69	79	112	138	32	29	69	79	69	79	112	138	32	29	0	0	0	0	0	0	0	0
1919	77	84	113	132	47	43	77	84	77	84	113	132	47	43	0	0	0	0	0	0	0	0
1920	41	51	78	101	10	9	41	51	41	51	78	101	10	9	0	0	0	0	0	0	0	0
1921	40	49	72	93	13	12	40	49	40	49	72	93	13	12	0	0	0	0	0	0	0	0
1922	37	44	66	84	12	11	37	44	37	44	66	84	12	11	0	0	0	0	0	0	0	0
1923	32	43	68	92	2	2	32	43	32	43	68	92	2	2	0	0	0	0	0	0	0	0
1924	48	63	100	134	4	4	48	63	48	63	100	134	4	4	0	0	0	0	0	0	0	0
1925	55	64	93	115	23	21	55	64	55	64	93	115	23	21	0	0	0	0	0	0	0	0
1926	60	73	114	143	18	16	60	73	60	73	114	143	18	16	0	0	0	0	0	0	0	0
1927	53	65	97	122	18	17	53	65	53	65	97	122	18	17	0	0	0	0	0	0	0	0
1928	36	44	65	83	12	11	36	44	36	44	65	83	12	11	0	0	0	0	0	0	0	0
1929	29	34	49	61	12	11	29	34	29	34	49	61	12	11	0	0	0	0	0	0	0	0
1930	27	35	59	75	4	4	27	35	27	35	59	75	4	4	0	0	0	0	0	0	0	0
1931	64	71	97	115	37	34	64	71	64	71	97	115	37	34	0	0	0	0	0	0	0	0
1932	51	53	69	78	35	33	51	53	51	53	69	78	35	33	0	0	0	0	0	0	0	0
1933	37	47	79	97	9	8	37	47	37	47	79	97	9	8	0	0	0	0	0	0	0	0
1934	45	48	65	73	31	28	45	48	45	48	65	73	31	28	0	0	0	0	0	0	0	0
1935	46	46	64	64	37	34	46	46	46	46	64	64	37	34	0	0	0	0	0	0	0	0
1936	40	48	86	100	8	8	40	48	40	48	86	100	8	8	0	0	0	0	0	0	0	0
1937	59	64	122	123	29	27	59	64	59	64	122	123	29	27	0	0	0	0	0	0	0	0
1938	77	83	129	143	40	36	77	83	77	83	129	143	40	36	0	0	0	0	0	0	0	0
1939	87	105	175	211	25	23	87	105	87	105	175	211	25	23	0	0	0	0	0	0	0	0
1940	49	61	106	128	9	9	49	61	49	61	106	128	9	9	0	0	0	0	0	0	0	0
1941	64	80	145	176	3	3	64	80	64	80	145	176	3	3	0	0	0	0	0	0	0	0
1942	9	12	25	26	3	3	9	12	9	12	25	26	3	3	0	0	0	0	0	0	0	0
1943	17	12	57	35	3	3	17	12	17	12	57	35	3	3	0	0	0	0	0	0	0	0
1944	37	37	139	111	1	2	37	37	37	37	139	111	1	2	0	0	0	0	0	0	0	0
1945	5	7	11	15	0	0	5	7	5	7	11	15	0	0	0	0	0	0	0	0	0	0
1946	52	74	110	154	1	1	52	74	52	74	110	154	1	1	0	0	0	0	0	0	0	0
1947	48	58	80	99	0	1	48	58	48	58	80	99	0	1	0	0	0	0	0	0	0	0
1948	58	77	111	148	0	1	58	77	58	77	111	148	0	1	0	0	0	0	0	0	0	0
1949	101	97	152	169	15	16	101	97	101	97	152	169	15	16	0	0	0	0	0	0	0	0
1950	132	156	146	175	120	139	132	156	132	156	146	175	120	139	0	0	0	0	0	0	0	0
1951	166	141	178	157	156	127	166	141	166	141	178	157	156	127	0	0	0	0	0	0	0	0
1952	303	188	341	239	271	144	303	188	303	188	341	239	271	144	0	0	0	0	0	0	0	0
1953	25	36	54	75	1	3	25	36	25	36	54	75	1	3	0	0	0	0	0	0	0	0
1954	31	44	66	91	2	4	31	44	31	44	66	91	2	4	0	0	0	0	0	0	0	0
1955	34	60	34	60	34	60	34	60	34	60	34	60	34	60	0	0	0	0	0	0	0	0
1956	12	12	12	12	12	12	12	12	12	12	12	12	12	12	0	0	0	0	0	0	0	0
1957	12	27	12	27	12	27	12	27	12	27	12	27	12	27	0	0	0	0	0	0	0	0
1958	113	141	113	141	113	141	113	141	113	141	113	141	113	141	0	0	0	0	0	0	0	0
1959	153	110	153	110	153	110	153	110	153	110	153	110	153	110	0	0	0	0	0	0	0	0
1960	188	216	188	216	188	216	188	216	188	216	188	216	188	216	0	0	0	0	0	0	0	0
1961	83	84	83	84	83	84	83	84	83	84	83	84	83	84	0	0	0	0	0	0	0	0
1962	209	295	209	295	209	295	209	295	209	295	209	295	209	295	0	0	0	0	0	0	0	0
1963	100	110	100	110	100	110	100	110	100	110	100	110	100	110	0	0	0	0	0	0	0	0
1964	25	43	25	43	25	43	25	43	25	43	25	43	25	43	0	0	0	0	0	0	0	0
1965	1	7	1	7	1	7	1	7	1	7	1	7	1	7	0	0	0	0	0	0	0	0
1966	19	36	19	36	19	36	19	36	19	36	19	36	19	36	0	0	0	0	0	0	0	0
1967	17	28	17	28	17	28	17	28	17	28	17	28	17	28	0	0	0	0	0	0	0	0
1968	70	101	70	101	70	101	70	101	70	101	70	101	70	101	0	0	0	0	0	0	0	0
1969	34	55	34	55	34	55	34	55	34	55	34	55	34	55	0	0	0	0	0	0	0	0
1970	36	37	36	37	36	37	36	37	36	37	36	37	36	37	16	24	16	24	16	24	11	15
1971	80	92	80	92	80	92	102	133	102	133	102	133	102	133	201	305	179	264	179	264	101	140

Cont.

Table 2 cont.

Sub area	IW	IW	IW	IW	IW	IW	IW	IW	IW	IW	IW	IW	IW	IW	1E	1E	1E	1E	1E	1E	2	2
Sex:	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Boundary	155	155	155	155	155	155	160	160	165	165	165	165	165	165	155	155	160	160	165	165		
Series	B	B	H	H	L	L	B	B	B	B	H	H	L	L	All	All	All	All	All	All	All	All
1972	38	46	38	46	38	46	38	46	38	46	38	46	38	46	22	41	22	41	22	41	4	9
1973	179	381	179	381	179	381	185	391	190	402	190	402	190	402	31	52	25	42	20	31	20	36
1974	210	349	210	349	210	349	282	418	287	422	287	422	287	422	197	259	125	190	120	186	147	161
1975	334	307	334	307	334	307	349	331	358	343	358	343	358	343	153	203	138	179	129	167	227	208
1976	371	423	371	423	371	423	379	446	390	461	390	461	390	461	389	245	381	222	370	207	25	6
1977	164	165	164	165	164	165	182	192	416	371	416	371	416	371	330	278	312	251	78	72	2	7
1978	236	194	304	258	168	130	252	203	274	216	342	280	206	152	205	148	189	139	167	126	8	5
1979	570	499	604	531	537	466	589	517	670	570	704	602	637	537	123	87	104	69	23	16	0	2
1980	401	354	401	354	335	292	401	354	401	354	401	354	335	292	0	0	0	0	0	0	0	0
1981	249	236	324	298	249	236	249	236	249	236	324	298	249	236	0	0	0	0	0	0	0	0
1982	275	207	409	300	275	207	275	207	275	207	409	300	275	207	0	0	0	0	0	0	0	0
1983	403	142	462	161	398	138	403	142	403	142	462	161	398	138	0	0	0	0	0	0	0	0
1984	353	175	542	262	328	153	353	175	353	175	542	262	328	153	0	0	0	0	0	0	0	0
1985	249	108	428	178	225	92	249	108	249	108	428	178	225	92	0	0	0	0	0	0	0	0
1986	217	100	426	196	217	100	217	100	217	100	426	196	217	100	0	0	0	0	0	0	0	0
1987	256	61	444	104	256	61	256	61	256	61	444	104	256	61	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	20	23	20	23	20	23	20	23	20	23	20	23	20	23	0	0	0	0	0	0	0	0
2001	17	33	17	33	17	33	17	33	17	33	17	33	17	33	0	0	0	0	0	0	0	0
2002	17	19	17	19	17	19	25	25	25	25	25	25	25	25	8	6	0	0	0	0	0	0
2003	16	21	16	21	16	21	18	28	19	31	19	31	19	31	3	10	1	3	0	0	0	0
2004	0	0	0	0	0	0	14	24	18	26	18	26	18	26	19	32	5	8	1	6	0	0
2005	21	25	21	25	21	25	21	26	21	29	21	29	21	29	0	4	0	3	0	0	0	0

Table 3

The estimates of abundance and their sampling *CV*s.

Sub-areas	Year	Estimate	Sampling *CV*
1W (165 boundary)	1995	8,152	0.329
1E (165 boundary)	1995	10,814	0.342
2	1995	2,860	0.372

Table 4

Sighting survey plan for the WNP Bryde's whales. Note: the results from any surveys in the westernmost part of sub-area 1W are ignored in the trials (see section F).

Season	Sector			
	130°E-145°E	145°E-165°E	165°E-180°	180°-160°W
2006		Yes		
2007			Yes	
2008	Yes			
2009				Yes
2010		Yes		
2011			Yes	
2012	Yes			
2013				Yes
2014		Yes		
2015			Yes	
2016	Yes			
2017				Yes
2018		Yes		
2019			Yes	
2020	Yes			
2021				Yes

Table 5

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

Parameter	Value
Plus group age, x	50 yr
Natural mortality, M	$0.08 yr^{-1}$
Age-at-first-parturition, a_m	7 years (Adjunct 2)
Selectivity (historical)	
Sub-area 1W:	Knife-edged at age 5 (IWC, 2000; 2005)
Sub-areas 1E & 2:	Knife-edged at age 9 (IWC, 2000; 2005)
Selectivity (future)	Knife-edged at age 5 (Item 3.2)
MSYL	0.6 in terms of mature female component of the population

Table 6

The *ISTs* for the WNP Bryde's whales.

Trial no.	Stocks	Sub-stocks	$MSYR_{mat}$	Mixing matrix	Process error	Stochastic mixing in 1W/1E	Catch series	Age-dependent mixing?	1W/1E boundary	Comment	Trial weight
Br1	1	No	1	A	Baseline	No	Best	No	165°E	Stock structure hypothesis 1	M
Br2	1	No	4	A	Baseline	No	Best	No	165°E	Stock structure hypothesis 1	**H**
Br3	2	No	1	B	Baseline	No	Best	No	165°E	Stock structure hypothesis 2	M
Br4	2	No	4	B	Baseline	No	Best	No	165°E	Stock structure hypothesis 2	**H**
Br5	2	No	1	C	Baseline	No	Best	No	165°E	Stock structure hypothesis 3	M
Br6	2	No	4	C	Baseline	No	Best	No	165°E	Stock structure hypothesis 3	**H**
Br7	2	Yes	1	D	Baseline	No	Best	No	155°E	Stock structure hypothesis 4	M
Br8	2	Yes	4	D	Baseline	No	Best	No	155°E	Stock structure hypothesis 4	M
Br9	2	No	1	B	Baseline	No	Best	**Yes**	165°E	B + Age-dependent mixing	M
Br10	2	No	4	B	Baseline	No	Best	**Yes**	165°E	B + Age-dependent mixing	**H**
Br11	2	Yes	1	D	σ_p=0.9	No	Best	No	155°E	D + Additional process error	M
Br12	2	Yes	4	D	σ_p=0.9	No	Best	No	155°E	D + Additional process error	M
Br13	2	Yes	1	D	Baseline	**Yes**	Best	No	155°E	Stochastic mixing	M
Br14	2	Yes	4	D	Baseline	**Yes**	Best	No	155°E	Stochastic mixing	M
Br15	2	Yes	1	D	Baseline	No	Best	No	**160°E**	Alternative Boundary 1	M
Br16	2	Yes	4	D	Baseline	No	Best	No	**160°E**	Alternative Boundary 1	M
Br17	2	Yes	1	D	Baseline	No	Best	No	**165°E**	Alternative Boundary 2	M
Br18	2	Yes	4	D	Baseline	No	Best	No	**165°E**	Alternative Boundary 2	M
Br19	2	Yes	1	D	Baseline	No	**Low**	No	155°E	D + Low catch series	M
Br20	2	Yes	4	D	Baseline	No	**Low**	No	155°E	D + Low catch series	M
Br21	2	Yes	1	D	Baseline	No	**High**	No	155°E	D + High catch series	M
Br22	2	Yes	4	D	Baseline	No	**High**	No	155°E	D + High catch series	M
Br23	2	No	1	B	Baseline	No	**High**	No	165°E	B + High catch series	M
Br24	2	No	4	B	Baseline	No	**High**	No	165°E	B + High catch series	**H**
Br25	2	No	1	B	σ_p=0.9	No	Best	No	165°E	B + Additional process error	M
Br26	2	No	4	B	σ_p=0.9	No	Best	No	165°E	B + Additional process error	**H**
Br27	2	No	1	B	Baseline	No	**High**	**Yes**	165°E	B + Age-dep.mixing+high catch	M
Br28	2	No	4	B	Baseline	No	**High**	**Yes**	165°E	B + Age-dep.mixing+high catch	**H**

Table 7

Summary of Bryde's whales marked in the western North Pacific. This table ignores 94 animals that were marked outside of sub-areas 1 and 2.

Sub-area (Boundary):	1W (155°)	1E (155°)	1W (160°)	1E (160°)	1W (165°)	1E (165°)	2
1972	3	0	3	0	3	0	0
1973	2	7	6	3	8	1	0
1974	0	8	0	8	0	8	2
1975	9	6	9	6	9	6	14
1976	0	2	0	2	0	2	1
1977	0	0	0	0	0	0	1
1978	42	7	45	4	46	3	0
1979	72	5	77	0	77	0	0
1980	36	18	54	0	54	0	1
1981	25	7	31	1	32	0	0
1982	31	9	40	0	40	0	0
1983	28	24	43	9	48	4	0
1984	36	34	54	16	55	15	0
1985	13	0	13	0	13	0	0
Total	297	127	375	49	385	39	19

Table 8

Marks recovered from Japanese whaling fleets within sub-areas 1W, 1E and 2.

Mark no.	Date marked	Date recovered	Position marked	Position recovered	Sex	Length (m)
12065	12 Feb 1972	2 May 1982	24°48N,142°3E	24°25N,144°16E	M	12.6
12198	16 Mar 1973	10 Jun 1976	23°58N,156°40E	29°19N,166°45E	F	14.3
33017	15 May 1978	30 Apr 1981	25°12N,145°11E	29°51N,138°20E	M	13.3
33552	28 Jun 1979	11 May 1980	27°55N,147°46E	32°12N,137°21E	F	13.4
33565	28 Jun 1979	19 Apr 1986	27°57N,147°43E	24°13N,143°46E	M	12.8
33528	28 Jun 1979	10 Jun 1986	27°59N,147°21E	26°29N,143°13E	M	12.9
14622	11 Jun 1980	2 Jun 1981	24°55N,141°43E	25°9N,141°56E	F	12.7
14711	26 Jun 1980	28 Apr 1984	30°6N,152°36E	25°41N,144°19E	M	12.7
14725	28 Jun 1980	1 May 1986	27°18N,157°46E	25°36N,143°54E	F	12.6
14741	29 Jun 1980	21 Jun 1981	25°52N,159°14E	31°35N,142°53E	F	12.9
14776	16 Jun 1981	29 Apr 1984	26°15N,159°55E	25°55N,143°18E	F	12.2
14799	20 Jun 1981	7 Jun 1985	27°29N,150°00E	27°38N,143°17E	F	13.3
37319	21 Jun 1981	18 Apr 1982	27°39N,146°43E	25°17N,142°13E	F	11.5
37322	21 Jun 1981	12 Jun 1985	27°38N,146°34E	26°38N,143°4E	M	12.2
14380	12 Jun 1982	26 Apr 1986	25°3N,149°58E	25°14N,144°11E	M	11.9
14408	18 Jun 1982	21 Apr 1985	27°34N,156°32E	25°19N,143°50E	M	12.4
14476	18 Jun 1983	26 Apr 1986	23°5N,134°0E	25°32N,144°39E	M	12.4
14491	24 Jun 1983	12 Jul 1985	20°1N,139°24E	26°10N,144°57E	F	11.5
14801	28 Jun 1983	9 May 1984	25°28N,144°50E	26°50N,142°56E	M	11.5
14807	30 Jun 1983	14 Jun 1984	23°58N,148°25E	24°33N,142°15E	M	12.4
14994	30 Jun 1984	4 Aug 1985	26°34N,147°31E	26°59N,144°19E	F	12.3
15098	30 Jul 1984	21 Apr 1985	35°9N,146°18E	25°43N,143°34E	M	13.4

Table 9

Sample sizes of aged whales used to calculate mortality rates (data using 165° boundary).

Year	Subarea 1W	Subarea 1E	Subarea 2
Commercial catches			
1971	0	12	0
1972	0	0	0
1973	0	1	0
1974	0	29	76
1975	0	86	128
1976	0	87	5
1977	0	12	0
1978	0	31	0
1979	0	15	1
Scientific permit catches			
2000	9	0	0
2001	8	0	0
2002	11	0	0
2003	11	0	0

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Ohsumi, S. 1977. Further assessment of population of Bryde's whales in the North Pacific. *Rep. int. Whal. Commn* 27:156-60.

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

Adjunct 1

Approximate calculation of Sub-area level additional CVs based on revised abundance estimates for conditioning of *ISTs*

H. Okamura, T. Kitakado and D.S. Butterworth

Sub-area level CVs are calculated based on the method in SC/58/Rep1. CVs based on sampling errors were calculated by Tables 2 and 3 (Case 2) of Kitakado *et al.* (2005). For example, the sampling CV for block F, $CV_S(N_F)$, is

$$CV_S(N_F) = \frac{\sqrt{(N_{F,\text{closing}}/R)^2\{CV_S^2(N_{F,\text{closing}}) + CV^2(R)\} + N_{F,\text{passing}}^2 CV_S^2(N_{F,\text{passing}})}}{N_{F,\text{closing}}/R + N_{F,\text{passing}}}.$$

where R = 0.727 ($CV(R)$ = 36.4%) (SC/58/Rep1, annex H). We ignored a correlation for simplicity.

Then, $\text{var}_S(N_F) = \{CV_S(N_F)\exp(\mu_F + \sigma_F^2/2)\}^2$ where μ_F and σ_F are extracted from table 1 of SC/58/Rep1, annex H.

Total $CV_T(N_F) = \sqrt{CV_S^2(N_F) + \sigma_A^2}$ for each block, and $\text{var}_T(N_F) = \{CV_T(N_F)\exp(\mu_F + \sigma_F^2/2)\}^2$.

For Sub-area 1W = F+G+H, the Sub-area level CVs are calculated as follows:

$$CV_S(N_{FGH}) = \frac{\sqrt{\text{var}_S(N_F) + \text{var}_S(N_G) + \text{var}_S(N_H)}}{N_{FGH}},$$

$$CV_T(N_{FGH}) = \frac{\sqrt{\text{var}_T(N_F) + \text{var}_T(N_G) + \text{var}_T(N_H)}}{N_{FGH}},$$

$$CV_{Add}(N_{FGH}) = \sqrt{CV_T^2(N_{FGH}) - CV_S^2(N_{FGH})}.$$

Table 1

Summary of the sub-area CVs.

	Sub-area 1W (blocks FGH)	Sub-area 1E (blocks IJK)	Sub-area 2 (blocks LM)
N	8,152	10,814	2,860
$CV_{(\text{sampling})}$ %	25.43	24.45	32.80
σ_p=0.673			
$CV_{(\text{Total})}$ %	46.68	51.59	58.29
$CV_{(\text{add})}$ %	39.15	45.42	48.19
σ_p=0.9			
$CV_{(\text{Total})}$ %	58.20	65.48	72.31
$CV_{(\text{add})}$ %	52.36	60.75	64.44

REFERENCE

Kitakado, T., Shimada, H., Okamura, H. and Miyashita, T. 2005. Update of additional variance estimate for the western North Pacific stock of Bryde's whales. Paper SC/O05/BWI6 presented at the Bryde's whale *Implementation* workshop, Tokyo, 25-29 October 2005. 16pp. [Paper available at the Office of this Journal].

Adjunct 2

Estimation of age-at-maturity for female Bryde's whales

A.E. Punt

Four models were fitted to the data on the maturity-at-age for female Bryde's whales sampled during JARPN II (table 1 of Bando *et al.*, 2005). The four models are special cases of the following general model:

$$P_a = \left[\frac{\alpha}{1+\exp[-(a-a_{50})/\delta]}\right]^{\beta} \qquad (1)$$

where

- P_a is the proportion of animals of age a which are mature;
- a_{50} is the age-at-50%-maturity (if α=1 and β=1);
- δ is the parameter that determines the width of the maturity ogive;
- α is asymptotic fraction of animals which are mature; and
- β is a shape parameter.

The model is fitted using a binomial likelihood under the assumption that age and maturity determination are exact (i.e. no measurement error).

Table 1 lists the values for the parameters of Equation (1) for each of the four models and the true age-at-50%-maturity (the age at which a proportion of α/2 animals are mature). Fig. 1 shows the fit of the four models to the available data.

Although the model in which α (but not β) is treated as an estimable parameter provides the most parsimonious representation of the data, the age-at-50%-maturity is robustly estimated to be 6 years. The age-at-first-parturition corresponding to this age-at-maturity is 7 years.

a_{50}	δ	α	β	No. of parameters	$-\ell nL$	Age-at-50%-maturity
5.93	2.07	1	1	2	21.042	5.93 (0.89)
6.21	0.915	0.978	1	3	15.662	6.21 (0.55)
-23.40	2.33	1	212031	3	19.640	5.99 (N/A)
-7.42	1.25	0.999	30066	4	15.619	5.90 (0.51)

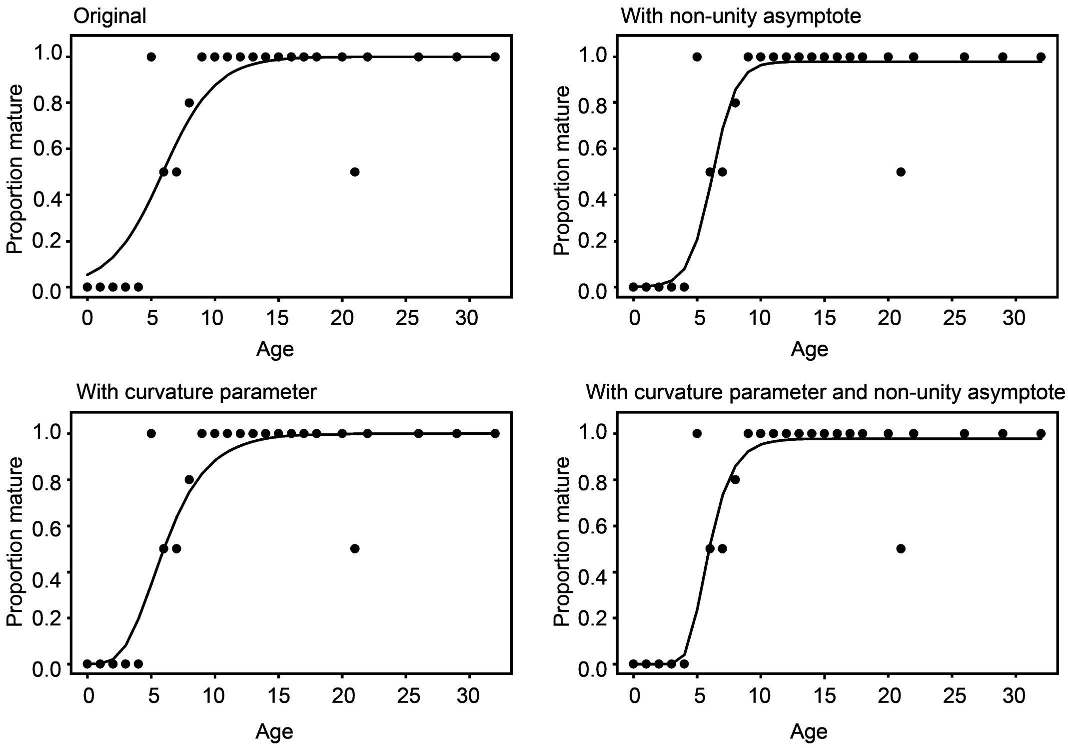

Fig. 1. Fits of the four models to the data on maturity-at-age.

REFERENCE

Bando, T., Kishiro, T., Ohsumi, S., Zenitani, R. and Kato, H. 2005. Estimation of some biological parameters of western North Pacific Bryde's whales by age distribution. Paper SC/O05/BWI7 presented at the Bryde's whale *Implementation* workshop, Tokyo, 25-29 October 2005. 10pp. [Paper available at the Office of this Journal].

Adjunct 3

The dynamics of tagged animals

The dynamics of tagged animals are essentially the same as those of untagged animals, except that account needs to be taken of tagging. The following equation is used to determine the number of tagged animals of age a (for ages less than x) and sex g in stock/sub-stock j at the start of year t+1 originally tagged in sub-area k, $T_{t+1,a}^{g,j,k}$ (tagging is assumed to take place halfway through the fishing season):

$$T_{t+1,a}^{g,j,k} = [(T_{t,a-1}^{g,j,k}(1-\sum_{k'} V_{t,a}^{j,k'} S_{t,a-1}^{k'} F_t^{g,k'}) + Q_{t,a-1}^{g,j,k}(1-S_{t,a-1}^{k'} F_t^{g,k}/2)]\, e^{-M}\tilde{S} \quad (1)$$

where

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

$$Q_{t,a}^{g,j,k} = \frac{Q_t^k C_t^{g,k}}{C_t^{\mathrm{f},k} + C_t^{\mathrm{m},k}} \frac{V_{t,a}^{j,k} N_{t,a}^{g,j}}{\sum_{j'} \sum_{a'} V_{t,a'}^{j',k} N_{t,a'}^{g,j'}} \quad (2)$$

Q_t^k is the actual number of releases during year t in sub-area k; and

$\tilde{S}$ is the rate of tag-loss (assumed to be unity for the baseline analyses).

The number of 'recruits' by age, sex and sub-stock to the tagged population therefore depends on the actual number tagged, assuming that an animal to be tagged is selected at random from the catch. Account is taken in Equation (1) of mortality (both natural and fishing) from the time of tagging until the end of the year.

The observed number of animals recaptured by the Japanese fleets during year t in sub-area k that were originally tagged in sub-area k', $U_t^{k,k'}$ is given by:

$$U_t^{k,k'} = \Psi\left(\sum_g \sum_j \frac{J_t^{g,k}}{C_t^{g,k}} \sum_a \left[T_{t,a}^{g,j,k'} F_t^{g,k} S_{t,a}^{k} V_{t,a}^{j,k} + \tfrac{1}{2} F_t^{g,k'} S_{t,a}^{k'} Q_{t,a}^{g,j,k'}\right]\right) \quad (3)$$

where

Ψ is the reporting rate parameter (assumed to be independent of sub-area) whose value is estimated during conditioning; and

$J_t^{g,k}$ is the catch of animals of sex g in sub-area k during year t by the Japanese fleets.

The second term in Equation (3) only applies in the case $k = k'$.

Appendix 7

CATCH SERIES FOR WESTERN NORTH PACIFIC BRYDE'S WHALES

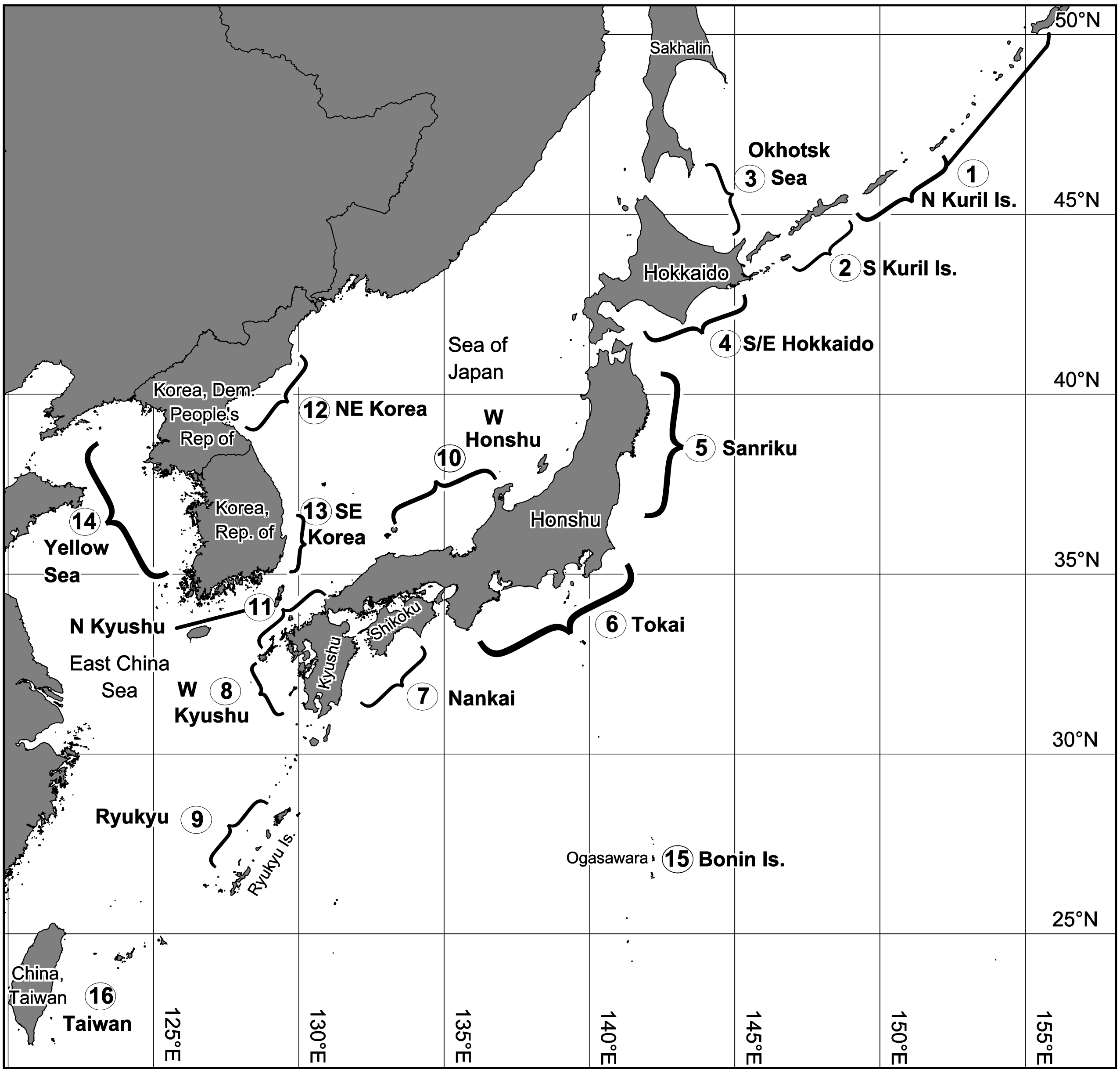

Fig. 1. The 16 areas used in Japanese historic catch records.

Japanese coastal whaling

Historic catch data from Japanese coastal land stations has been collected by area using 16 areas as illustrated in Fig. 1. The composition of the catches in the 16 areas is summarised in Table 1.

Japanese coastal whaling 1899-1954

Norwegian-style whaling by Japan began in 1899 on the eastern side of Korea in the Sea of Japan (Ohsumi, 2005). Operations gradually extended to other areas and reached the eastern side of Japan in 1906 when land stations were built at Tateyama and Choishi (Chiba Prefecture) and Ayukawa (Miyagai Prefecture) (see Fig. 1). Hence catches prior to 1906 do not include any Western North Pacific Bryde's whales.

The total catch from Eastern Japan in 1909 and 1910 is estimated by proration using the mean ratio of the catches in 1906-1908+1911 (the range of years for which the operational range is thought to be most similar).

The catch of sei/Bryde's whales in Areas 5 and 6 in 1906-1910 is then estimated from the total catches in Eastern Japan, prorated using data from 1911 (Kasahara, 1950).

Catches are known by species and area in the period 1911-54, but do not differentiate between sei and Bryde's whales. There are some discrepancies in the total annual catches of sei whales as reported by different sources. The agreed 'best' catch series uses numbers for 1920-39 from Tønnessen and Johnson (1982) as these were described as revised numbers from the Whales Research Institute, Tokyo. For other years the numbers have been taken from International Whaling Statistics.

Table 1

The 16 areas used in Japanese historic catch records. Areas in which Western North Pacific Bryde's whales are found are shown in bold.

Area		Composition of Sei/Bryde's catch
1	N Kuril Is.	All sei whales
2	S Kuril Is.	All sei whales
3	Okhotsk Sea	All sei whales
4	**S & E Hokkaido**	**Catches include Sei and Bryde's whales**
5	**Sanriku (NE Honshu)**	**Catches include Sei and Bryde's whales**
6	**Tokai (Central S Honshu)**	**All Bryde's whales**
7	Nankai (S/E Kysushu & Shikoku)	All Bryde's whales, assumed to be from E China Sea stock
8	W Kyushu (inc. Goto Is.)	All Bryde's whales, assumed to be from E China Sea stock
9	Ryukyu Is.	All assumed to be from E China Sea stock (2 whales only)
10	W Honshu	No sei/Bryde's whales recorded in catch
11	N Kyushu	E China Sea stock
12	NE Korea	No sei/Bryde's whales recorded in catch
13	SE Korea	E China Sea stock (2 whales only taken)
14	Yellow Sea	E China Sea stock
15	**Bonin Is.**	**Catches include Sei and Bryde's whales**
16	Taiwan	Catches all of local inshore form

The annual sei/Bryde's catch by area is be taken to be the 'best' total described above, prorated to area in using the data from the relevant year from Kasahara (1950), or if there are no data, using the mean catch by area from the adjacent year. (The IWC individual database includes the date and sex of catches in 1929 and 1946-54 but as the data do not differentiate between sei and Bryde's whales the method used to prorate these data is the same as for the other years).

The historic catch of Bryde's whales by sex is estimated by prorating the number sei/Bryde's whales by Area and year, using the data from years 1953-72, which were taken from the NP1 forms for 1955-67 and from the IWC database for 1968 on. Data from 1973 on was not included in the proration because separate sei and Bryde's whale quotas were set from this time, so the data cannot be taken as a reflection of the proportion of each species in the area. Two alternative catch series will be considered for which the pre 1955 catches from Area 5 (Sanriku) will be allocated using the upper and lower 5%iles of the proportion of known Bryde's whale catches 1953-72.

Japanese coastal whaling 1955-present

The catch data since 1955 differentiate between sei and Bryde's whales and are summarised in Table 2.

Kondo and Kasuya (2002) report data from 1965-76 by Nihon Hogei which differs from the official catch series. However, for Bryde's whales, the new total catch of Bryde's whales is less than the official catch data, so the revised data has not been used in the catch series.

Whaling by Japan in the Bonin Islands

The catch in the Bonin Islands since 1951 has been identified to be 100% Bryde's whales. Before 1945, whaling in the Bonin Islands was conducted from December to May with a peak in March (Mizue, 1950).

Omura and Fujino (1954) show that the catch from the Bonin Islands in 1935-36, which was taken in the period Nov-Apr, was exclusively of sei whales (with the exception of one animal which could not be classified), in comparison with the catch in 1952 which was taken in the period May-Jun and was exclusively of Bryde's whales. They state that sei whales are found in the vicinity of the Bonin Islands in the period from December to the middle of April, after which they go north. Bryde's whales arrive in the middle or end of April.

An analysis of length data from the 1946-52 catch in the Bonin Islands (Ohsumi, pers. comm.) confirms that the length distribution in February and March is similar to that of the sei whale, while that for May and June is similar to that of the Bryde's whale. The data in April is mixed.

From the above data the 'best' catch series is constructed by assuming that for the pre-1946 data: (i) 2/3 of the historic catch of sei/Bryde's whales in April and May is Bryde's whales; and (ii) that the fraction caught in April/May is the same as that for the catch of all species. For the years 1946-49, the catch in April is allocated as for the pre 1946 data while the catch in May is assumed to be all Bryde's whales.

The uncertainties in the classification of the Bonin Island catches are such that two other catch series are used in the trials. The 'Low' catch series assumes that the historic catches in the Bonin Islands prior to 1945 do not include any Bryde's whales while the 'High' catch series assumes the catch to be 100% Bryde's whales. This will ensure that the full range of uncertainty is covered.

Kondo (2001) and Kasuya and Brownell (2001) report data from 1981-87 in the Bonin Islands which differs from the official catch series. The Kondo and Kasuya data will be used in the 'high' catch series.

Republic of China (Taiwan)

The estimates of the catch by Republic of China (Taiwan) are taken from Brownell (1981). Whaling ceased in 1981 (IWC, 1986). The 'low' catch series will use the minimum values for the years 1978-80 given in Brownell and the 'high' series will use the maximum values.

Philippines

The official catches were all listed as taken close to Homonhon and hence would be of the inshore form Bryde's whale. The numbers are tabled below. The official sex ratio is 41% female. (This compares with a sex ratio of 28% females in the Japan Bonin Island catch in the same three years).

Perrin and Dolar (1998) provides information showing the catch was taken in more distant and deeper waters, possibly as far as the Bonin Islands. More recent information from Perrin (pers. comm.) confirms this and further shows that some catches were taken in the vicinity of

Table 2

Table of catches. Components of the different catch series are shown in the columns on the left and the totals on the right).

By:	Japan	Japan	Japan	USSR	R. China	Philipne	All	All	All	Japan	Japan	All	All	All	All	All
Sub area	1W	1E	2	All	1W	1W	1W	1E	2	1W	1W	1W	1W	All	All	All
B'dry	165	165					165	165		165	165	165	165			
Series	Best	Best	Best	All	Best	B and H	Best	All	All	Low	High	Low	High	Low	Best	High
1906	13	0	0	0	0	0	13	0	0	7	20	7	20	7	13	20
1907	34	0	0	0	0	0	34	0	0	19	52	19	52	19	34	52
1908	82	0	0	0	0	0	82	0	0	46	124	46	124	46	82	124
1909	47	0	0	0	0	0	47	0	0	26	71	26	71	26	47	71
1910	51	0	0	0	0	0	51	0	0	28	77	28	77	28	51	77
1911	156	0	0	0	0	0	156	0	0	87	237	87	237	87	156	237
1912	81	0	0	0	0	0	81	0	0	35	137	35	137	35	81	137
1913	125	0	0	0	0	0	125	0	0	53	209	53	209	53	125	209
1914	56	0	0	0	0	0	56	0	0	3	119	3	119	3	56	119
1915	169	0	0	0	0	0	169	0	0	6	362	6	362	6	169	362
1916	105	0	0	0	0	0	105	0	0	9	219	9	219	9	105	219
1917	181	0	0	0	0	0	181	0	0	109	266	109	266	109	181	266
1918	148	0	0	0	0	0	148	0	0	62	249	62	249	62	148	249
1919	161	0	0	0	0	0	161	0	0	90	245	90	245	90	161	245
1920	92	0	0	0	0	0	92	0	0	19	179	19	179	19	92	179
1921	89	0	0	0	0	0	89	0	0	24	165	24	165	24	89	165
1922	81	0	0	0	0	0	81	0	0	23	149	23	149	23	81	149
1923	75	0	0	0	0	0	75	0	0	3	160	3	160	3	75	160
1924	111	0	0	0	0	0	111	0	0	8	234	8	234	8	111	234
1925	118	0	0	0	0	0	118	0	0	44	208	44	208	44	118	208
1926	134	0	0	0	0	0	134	0	0	34	257	34	257	34	134	257
1927	118	0	0	0	0	0	118	0	0	35	219	35	219	35	118	219
1928	80	0	0	0	0	0	80	0	0	23	148	23	148	23	80	148
1929	63	0	0	0	0	0	63	0	0	24	110	24	110	24	63	110
1930	62	0	0	0	0	0	62	0	0	8	134	8	134	8	62	134
1931	135	0	0	0	0	0	135	0	0	71	211	71	211	71	135	211
1932	104	0	0	0	0	0	104	0	0	68	146	68	146	68	104	146
1933	84	0	0	0	0	0	84	0	0	17	176	17	176	17	84	176
1934	93	0	0	0	0	0	93	0	0	58	137	58	137	58	93	137
1935	92	0	0	0	0	0	92	0	0	71	129	71	129	71	92	129
1936	87	0	0	0	0	0	87	0	0	16	186	16	186	16	87	186
1937	122	0	0	0	0	0	122	0	0	56	245	56	245	56	122	245
1938	160	0	0	0	0	0	160	0	0	76	273	76	273	76	160	273
1939	193	0	0	0	0	0	193	0	0	48	386	48	386	48	193	386
1940	110	0	0	0	0	0	110	0	0	18	233	18	233	18	110	233
1941	144	0	0	0	0	0	144	0	0	6	321	6	321	6	144	321
1942	21	0	0	0	0	0	21	0	0	6	52	6	52	6	21	52
1943	29	0	0	0	0	0	29	0	0	7	92	7	92	7	29	92
1944	74	0	0	0	0	0	74	0	0	4	250	4	250	4	74	250
1945	12	0	0	0	0	0	12	0	0	0	25	0	25	0	12	25
1946	126	0	0	0	0	0	126	0	0	3	263	3	263	3	126	263
1947	106	0	0	0	0	0	106	0	0	2	179	2	179	2	106	179
1948	134	0	0	0	0	0	134	0	0	2	258	2	258	2	134	258
1949	199	0	0	0	0	0	199	0	0	31	321	31	321	31	199	321
1950	288	0	0	0	0	0	288	0	0	260	321	260	321	260	288	321
1951	307	0	0	0	0	0	307	0	0	283	335	283	335	283	307	335
1952	491	0	0	0	0	0	491	0	0	415	580	415	580	415	491	580
1953	61	0	0	0	0	0	61	0	0	3	128	3	128	3	61	128
1954	75	0	0	0	0	0	75	0	0	6	157	6	157	6	75	157
1955	94	0	0	0	0	0	94	0	0	94	94	94	94	94	94	94
1956	24	0	0	0	0	0	24	0	0	24	24	24	24	24	24	24
1957	39	0	0	0	0	0	39	0	0	39	39	39	39	39	39	39
1958	254	0	0	0	0	0	254	0	0	254	254	254	254	254	254	254
1959	263	0	0	0	0	0	263	0	0	263	263	263	263	263	263	263
1960	404	0	0	0	0	0	404	0	0	404	404	404	404	404	404	404
1961	167	0	0	0	0	0	167	0	0	167	167	167	167	167	167	167
1962	504	0	0	0	0	0	504	0	0	504	504	504	504	504	504	504
1963	210	0	0	0	0	0	210	0	0	210	210	210	210	210	210	210
1964	68	0	0	0	0	0	68	0	0	68	68	68	68	68	68	68
1965	8	0	0	0	0	0	8	0	0	8	8	8	8	8	8	8
1966	55	0	0	0	0	0	55	0	0	55	55	55	55	55	55	55
1967	45	0	0	0	0	0	45	0	0	45	45	45	45	45	45	45
1968	171	0	0	0	0	0	171	0	0	171	171	171	171	171	171	171
1969	89	0	0	0	0	0	89	0	0	89	89	89	89	89	89	89
1970	73	0	0	66	0	0	73	40	26	73	73	73	73	139	139	139
1971	172	109	0	638	0	0	235	443	241	172	172	235	235	856	919	919

Cont.

Table 2 cont.

By:	Japan	Japan	Japan	USSR	R. China	Philipne	All	All	All	Japan	Japan	All	All	All	All	All
Subarea	1W	1E	2	All	1W	1W	1W	1E	2	1W	1W	1W	1W	All	All	All
B'dry	165	165					165	165		165	165	165	165			
Series	Best	Best	Best	All	Best	B and H	Best	All	All	Low	High	Low	High	Low	Best	High
1972	84	5	0	71	0	0	84	63	13	84	84	84	84	160	160	160
1973	40	2	0	657	0	0	592	51	56	40	40	592	592	147	699	699
1974	147	250	272	654	0	0	709	306	308	147	147	709	709	761	1,323	1,323
1975	116	263	424	629	0	0	701	296	435	116	116	701	701	847	1,432	1,432
1976	83	547	31	679	119	0	851	577	31	83	83	851	851	691	1,459	1,459
1977	437	63	0	275	171	0	787	150	9	437	437	787	787	596	946	946
1978	67	195	0	216	318	0	490	293	13	67	67	358	622	373	796	928
1979	195	30	2	227	827	0	1,240	39	2	195	195	1,174	1,306	236	1,281	1,347
1980	307	0	0	0	448	0	755	0	0	307	307	627	755	307	755	755
1981	485	0	0	0	0	0	485	0	0	485	622	485	622	485	485	622
1982	482	0	0	0	0	0	482	0	0	482	709	482	709	482	482	709
1983	536	0	0	0	0	9	545	0	0	536	614	536	623	536	545	623
1984	481	0	0	0	0	47	528	0	0	481	757	481	804	481	528	804
1985	317	0	0	0	0	40	357	0	0	317	566	317	606	317	357	606
1986	317	0	0	0	0	0	317	0	0	317	622	317	622	317	317	622
1987	317	0	0	0	0	0	317	0	0	317	548	317	548	317	317	548
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	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	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	1	0	0	0	0	0	1	0	0	1	1	1	1	1	1	1
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	43	0	0	0	0	0	43	0	0	43	43	43	43	43	43	43
2001	50	0	0	0	0	0	50	0	0	50	50	50	50	50	50	50
2002	50	0	0	0	0	0	50	0	0	50	50	50	50	50	50	50
2003	50	0	0	0	0	0	50	0	0	50	50	50	50	50	50	50
2004	44	7	0	0	0	0	44	7	0	44	44	44	44	51	51	51
2005	50	0	0	0	0	0	50	0	0	50	50	50	50	50	50	50

the Caroline Islands and so may not have been taken from the Western North Pacific stock but rather from the Bryde's like pygmy species.

The official Philippines catch series will be used, but assuming the catches were taken from the Western North Pacific Stock. The 'Low' catch series will assume 50% were taken from the Western North Pacific Stock (the remainder assumed to have been taken from another stock or species).

Pelagic catch data

It was shown that the revised data from 1970 to 1979 do not differ significantly from the officially reported data, and the latter data are by individual whale, it was agreed to use the official data.

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