Annex D
Report of the Sub-Committee on the Revised Management Procedure

Members: Hammond (Chair), Addison, Allison, Baker, Berggren, Borchers, Borodin, Born, Breiwick, Brownell, Buckland, Butterworth, Chen, Childerhouse, Clarke, Cooke, Donahue, Donovan, Ensor, Fujise, Givens, Goto, Gunnlaugsson, Hakamada, Hatanaka, Hester, Hiby, Innes, Kato, Kawachi, Kawahara, Kim, Kock, Komatsu, Leaper, Lens, Magnusson, Miyashita, Moronuki, Nakamura, Nishiwaki, Øien, Ohsumi, Okamoto, Okamura, Palka, Papastavrou, Pastene, Perrin, Pinedo, Polacheck, Punt, Schweder, Shimadzu, Skaug, Slooten, Smith, Stachowitsch, Tanaka, E., Tanaka, S., Tanakura, Thiele, Tomita, Wade, Walløe, Witting, Yagi, Yamamura, Zeh.

1. ELECTION OF CHAIRMAN AND APPOINTMENT OF RAPPORTEURS

Hammond was elected Chairman. Cooke, Palka, Punt and Smith acted as rapporteurs. Polacheck chaired Item 8.3.

2. ADOPTION OF AGENDA

The adopted agenda is given in Appendix 1.

3. *CLA* PROGRAM

3.1 Tuning

Last year the Committee requested the Secretariat to convert the MANAGE computer program, which calculates catch limits for the RMP, to use double precision arithmetic. The Committee also asked the Secretariat to use this modified program to determine a revised value for the tuning parameter that assures that the median final depletion for the D1 trial is 0.72K (accurately to 0.001K) (IWC, 1998a). Allison reported that the program had been successfully converted, but that it was too slow to allow her to achieve the level of precision specified by the Committee in the time available. The MANAGE program had been originally designed for quickly determining approximate catch limits in simulation trials and had then been adapted for implementation purposes. The numerical integration methods used cannot achieve the required precision because precision does not improve rapidly enough with decreasing integration step size.

The precision specified by the Committee is necessary, in the case of a population as large as one million animals, to guarantee the requirement in the RMP that calculated catch limits are accurate to one whale. It is recognised that this level of precision exceeds the precision of the biological input data. Rather, it ensures that exactly the same catch limit will be obtained regardless of the numerical integration methods used in any computer program that correctly implements the *Catch Limit Algorithm*.

A procedure for determining the tuning parameter was developed that the sub-committee believed was sufficient to ensure a unique value for the tuning parameter. The steps are as follows.

(a) Obtain a callable sub-program implementing the *CLA* that has been shown to calculate, for a given tuning parameter, catch limits accurate to within one whale in all the test scenarios described in Appendix 2, Adjunct 1 for tuning parameter values of 0.40 and 0.41.

(b) For the purpose of running the trials specified below (d), set the precision of the *CLA* sub-program to achieve a tuning accuracy in relative terms of 10^{-6} for each catch limit calculated (i.e. the cumulative probability of each catch limit calculated should be within 10^{-6} of the specified value of the tuning parameter)[1].

(c) Modify the control programmes (MANTST and MANRES) for the D1 trial to enable up to 50,000[2] replicates to be conducted, and to extend the random number seed file to 50,000 replicates.

(d) By iteration if necessary, determine a value of the tuning parameter which gives a median final depletion on the 50,000 replicates that lies within 10^{-5}K of 0.72K, and with 99% confidence limits on the median, calculated with the standard formula for confidence limits on a median, that lie within the range 0.719K to 0.721K, as previously agreed by the Committee (IWC, 1993b, p.225a).

(e) Round the value of the tuning parameter obtained by (d) to the nearest 0.0001. This would become the official new tuning parameter to replace the value of 0.4102 in the current RMP specification.

(f) All subsequent real implementations of the *CLA* should calculate the catch limit accurate to within one whale, conditional on the fixed value of the tuning parameter arising from step (e).

3.2 Revision of program

At last year's meeting (IWC, 1998, item 7.2.2), the Committee recommended that the Secretariat investigate methods to calculate catch limits under the *CLA* more efficiently. It noted that it would be desirable if the same

[1] It is necessary to specify this alternative level of precision because the population in the D1 trial is very small, with catch limits typically about 10; it is not intended to reflect absolute numbers of whales. A precision set to one whale accuracy is not sufficient for these trials.

[2] Note: Preliminary results from 40,000 trials indicate that 50,000 trials will almost certainly be sufficient to obtain 99% confidence limits that lie inside the range 0.719 to 0.721. Should this turn out not to be the case, steps (c) and (d) should be repeated using a larger number of trials.

computer program could be used for calculating catch limits and for simulation studies. The Committee also recommended that this work be completed before the 1998 meeting and that the Secretariat should consider contracting out this task. An intersessional Working Group was set up to facilitate this with membership Allison, Butterworth, Cooke, Givens, Hammond (Chair), Punt, Smith, Walløe.

During the intersessional period the Working Group finalised a specification for computer program structure, documentation, and performance, including specification of a set of test conditions. This is given as Appendix 2, and formed the basis of an invitation to bid for a contract to revise the program that implements the *CLA*. The invitation to bid was distributed to the members of the Working Group. One bid was received that substantially exceeded the amount allocated by the Secretariat. Recognising this and after some discussion, the sub-committee believed that these requirements could be met using a program previously presented by the Norwegian Computing Center (NCC) (Fenstad *et al.*, 1993). Noting that this program was shown during the last meeting to give the same answer as MANAGE when converted to double precision in at least one case, the sub-committee agreed that, suitably documented, it should meet the above needs.

The sub-committee **recommends** that the authors of the program be approached about completing the work that would be required to meet the most important requirements of Appendix 2, with the expectation that by using the previous coding and allocating some tasks to the Secretariat the costs might be more in line with the amount allocated last year.

The most important requirements of Appendix 2 for NCC to complete are:

(a) extract the subroutine that implements the *Catch Limit Algorithm* from the more general program described in Fenstad *et al.* (1993) ;
(b) **either** *[complete internal documentation of the code]* **or** *[complete sufficient internal documentation to allow Allison, in consultation with the authors, to finalise internal documentation]*;
(c) revise and expand Fenstad *et al.* (1993) to provide a complete description of the numerical analysis methods used, and how those methods are implemented.

The remaining aspects of Appendix 2 should be addressed by the Secretariat. This especially includes completing a User's Guide (including guidance on the use of control parameters for numerical precision), linking the subroutine into MANAGE, and evaluating the accuracy of the catch limits from the revised version of MANAGE. The latter would be done in two steps. First, exact comparisons to calculations using the existing double precision version of MANAGE with fine integration steps would be made for a small set of cases. Second, catch limits would be compared to those from double precision MANAGE with coarser integration steps for the several combinations of data input sets described in Appendix 2.

The task of adjusting this program for use in the tuning procedure, described under Item 3.1, would then be taken up by the Secretariat. In modifying the control programs under (c) of Item 3.1, the sub-committee agreed that a minor inconsistency should be rectified so that births derive from the current year's abundance. To demonstrate the expected result that this will have no appreciable affect on the results previously obtained, it was agreed that one or two trials should be repeated and compared.

4. ADDITIONAL VARIANCE

Some years ago the Committee specified that, to improve our basis for drawing inferences from trends from surveys, IDCR sighting data should be extracted on several spatial scales over the time series of the surveys. This task has yet to be completed. The sub-committee agreed that it was still important to complete the work. Borchers suggested that the data extraction may require up to two weeks using the DESS computer system. The sub-committee **recommends** that this task receive high priority during the intersessional period and that, if the Secretariat workload precludes accomplishing this, funds should be requested to see it to completion.

Smith believed that the general issue of additional variance should be further considered. Smith *et al.* (1997) concluded that additional or unmeasured variability was involved in many two-way and multi-way interactions in that study. The authors noted that there are many forms of unmeasured variability, and that the Committee has primarily considered the case where it increases when a population is more depleted. They suggest that the effects of other forms of unmeasured variability have not been explored sufficiently, and may be substantially different. Although, as some numbers suggested, this could be picked up in specific implementation trials, Smith argued that alternate formulations could usefully be considered in general. Schweder suggested that when unmeasured variability is modelled, care should be taken to specify the basis for the forms considered.

5. ABUNDANCE ESTIMATION - GENERAL ISSUES

5.1 Report of intersessional Working Group on statistical estimators

At last year's meeting an intersessional Working Group was re-established to test the performance of abundance estimation procedures over an appropriate range of sighting survey factors. The Working Group initiated a simulation experiment at that meeting in which two abundance estimation methods were applied to 25 replicates of 32 sets of data that simulated shipboard line transect two-platform surveys where there were different types of sighting heterogeneities and $g(0) < 1$. The results were reported to that meeting (IWC, 1998, item 7.1). During the intersessional period, two additional estimation methods (perpendicular distance implementation of the hazard probability model by Skaug and a radial distance implementation of the hazard probability model by Cooke) were applied to the simulation data sets. These results were presented to the sub-committee this year under Items 5.3 and 8.3.1.2. In addition, during the intersessional period more sets of simulated data sets with different conditions were created and more replicates of all the data sets were and continue to be created so that there will eventually be 100 replicates of each set of data.

The intersessional Working Group also began discussions about what topics should be addressed in the near future. It recognised that the remit was broad and so should focus on topics that are the most relevant to abundance estimates that are currently or will in the near future be submitted to the Committee. Priority topics identified were:

(1) condition simulated data sets on North Pacific sighting surveys for minke and/or Bryde's whales;
(2) test procedures that identify duplicates and correct for duplicate identification errors;

(3) test procedures that estimate abundance from multi-year surveys;
(4) increase the number of simulated data sets that have the characteristics already created, to allow better estimates of precision of the abundance estimation method that is being tested;
(5) create simulated data sets that have other characteristics, such as animal movement or errors in measurement and duplicate identification.

The sub-committee deferred discussion of these topics to Item 9.

The sub-committee re-established the intersessional Working Group under Palka (with membership listed in Annex Z) to continue its work testing the performance of abundance estimation procedures over an appropriate range of sighting survey factors.

5.2 IWC-DESS

Borchers reported that the work contracted to the University of St Andrews, described in last year's report (IWC, 1998d, annex O, appendix 1), had been completed and the relevant data files transferred to the Secretariat. Some problems were encountered during the transfer; Borchers reported that these were being addressed and would soon be resolved.

The sub-committee established a Working Group under Donovan to consider the future maintenance, support and development of the IWC-DESS. Its report is given as Appendix 3.

The report proposes that the best way for the Secretariat to ensure the appropriate maintenance, support and development of the DESS was to fund a part-time post at the RUWPA in St Andrews. This would have a number of advantages concerning the working environment, flexibility and continuity. The cost to the Secretariat was estimated at approximately £19,000 plus VAT per annum. Routine requests for data from accredited members of the Committee and international organisations would still be handled by the Secretariat. The intention under the proposal was that items 1-7 under existing relevant tasks in Appendix 3 would be completed as soon as possible and that items 1-3 under possible tasks in the near future in Appendix 3 would be considered in due course. Butterworth noted that some of these tasks would take a considerable amount of time.

The sub-committee **recommends** that the proposal described in Appendix 3 be adopted as a matter of priority.

5.3 Other

A number of papers dealing with new developments in abundance estimation methods were presented to the sub-committee.

SC/50/RMP2 described a new method to identify duplicate sightings for independent observer surveys where posterior probabilities were assigned to each candidate duplicate pair. All candidate pairs with posterior probabilities larger than a threshold value were judged as duplicate pairs. Two types of duplicate identification errors were defined and used in a method to correct the abundance estimate.

Concerns were raised that the posterior probabilities were subjectively chosen and that this could cause biases. It was suggested that certain animal behaviour and other factors may make some duplicates more obvious and be assigned a high probability; thus only certain types of duplicates would be included. Skaug pointed out that this could be true for most duplicate identification algorithms but with these procedures, because Type I and Type II errors were estimated and used to correct the abundance estimate, the abundance estimate would not contain such biases.

Part of SC/50/RMP22 reported the results of applying a duplicate identification rule to these data. The rule is explained in Cooke (1997). The rule is not subjective, applies to whale surfacing and not whale tracks, as in SC/50/RMP2, but also allows diagnostics to be calculated. It was suggested that, perhaps after modifications, this approach could supplement the methods proposed in SC/50/RMP2 to obtain better posterior probabilities.

Last year the Committee had noted that further analyses taking account of the heterogeneity among surveys and the spatial and temporal pattern of the surveys were required before the western North Pacific Bryde's whale abundance estimate would be appropriate for implementation of the RMP. SC/50/RMP16 described a preliminary GLM analysis that investigated the effects of potential heterogeneities due to year, month and type of vessel on sighting rates and density indices from several sighting surveys. The paper indicated that the effects of the differences between vessel types and the variation from year to year were statistically significant. However the influence of vessel types on the abundance estimate could be excluded if the effective search width was estimated separately for vessels with and without barrels.

The sub-committee welcomed this analysis and several comments were made. Concerns were expressed that the power of the analysis could be small because of the large SEs of the estimates of ship type effects, the low effort associated with at least one type of ship and the large influence that including the effective search width had on some estimates of ship type effects. It was suggested that a power analysis could provide information on the reliability of the results presented. Whether observer heterogeneity should be included in this analysis was also questioned.

SC/50/RMP19 described a model that enables the proportion of sighting records that are rounded to convenient radial distances and angles to be estimated as a function of the implicit pre-rounding estimate of distance and/or angle. When applied to radial distance and angle data for minke whales in the Northeast Atlantic, the model fitted the observed distribution of distances well, but the observed distribution of angles somewhat less well. Although the error due to rounding was found to make only a small contribution to the total mean square error of distance estimates, the rounding did have a strong influence on the plot of the goodness of fit between observed and predicted distributions.

The sub-committee welcomed this paper because it addressed a potential problem that could occur in all line transect sighting surveys. It was noted that for the type of detection function models used in this paper, the hazard probability with covariates, the Chi-squared test for the goodness of fit to radial distances and angles is only an approximation because the actual degrees of freedom are unknown. There is an unknown non-linear relationship between the degrees of freedom and the number of parameters used in this type of detection models. In this goodness of fit test and in those presented for other tests using the hazard probability models, a linear relationship was assumed. More work is needed to determine the actual degrees of freedom and the effects of the linear assumption on the results of the goodness of fit test.

SC/50/RMP20 described a study where the Cooke implementation of the hazard probability approach (Cooke, 1997) with covariates was applied to simulated data that emulated harbour porpoise type shipboard line transect surveys that use independent teams. Two variants of the method were tested: one which assigned duplicate sightings as those that were nearly simultaneously detected; and one where assigned duplicate sightings included not only simultaneous sightings but those that were delayed in time. For the simulated data sets where the two platforms were searching the same area of water, the agreement between true and estimated densities was generally good when the delayed duplicates were used, but there was a negative bias averaging about 12% in the density estimates when only the simultaneous duplicates were used.

The sub-committee noted that this type of analysis, where the statistical properties of an estimation method were tested using simulated data, had been recommended when testing the performance of abundance estimation procedures over an appropriate range of sighting factors.

The parts of SC/50/RMP19 and SC/50/RMP20 relevant to the application of methods to the northeast Atlantic minke whale abundance estimates, are discussed under Item 8.3.2.1.

Clarke presented the first part of SC/50/CAWS33 describing progress on the development of an unbiased abundance estimator based on generalised additive models (GAMs) with spatial covariates. Traditional abundance estimates from JARPA survey data are negatively biased because the use of closing mode with predetermined start-points for each day causes high density areas to be under-surveyed. Burt and Borchers (1997a; 1997b) proposed an estimator that compensates for the reduced effort using a raising factor based on the ratio of intended effort to actual effort but it had been suggested that this estimator may be positively biased. Model-based abundance estimation is in principle robust to the JARPA survey design. Following Hedley *et al.* (1997), the spatial distribution of density was modelled using 'waiting areas' (i.e. the effective area surveyed between sightings). Abundance estimates produced by this method are broadly similar to those obtained by Burt and Borchers (1997a) and in analyses of IDCR survey data. The work to date provides a good basis for future development of this methodology, using the simulation study described in the second part of the paper.

A concern raised last year about this estimation method was how to obtain unbiased variance estimates. Borchers reported that it was not planned to use the likelihood estimates of variance because these neglect spatial correlation. Instead, they planned to investigate using a parametric bootstrap method which attempts to account for spatial correlation.

The authors of SC/50/CAWS33 asked the sub-committee to comment on the proposed simulation study to be conducted before next year's meeting. The simulation study is designed to test and develop the GAM-based estimation methods. The sub-committee agreed that the re-established intersessional Working Group under Palka (see Item 5.1) should review the simulation design and provide comments.

Hiby expressed a number of concerns about the hazard probability model currently used to estimate abundance of Northeast Atlantic minke whales. The first concern related to the vulnerability of the hazard probability (and cue counting) methods to distance estimation error or possible changes in surfacing behaviour in response to the vessel. His second concern related to the possibility that small sampling bias is not accounted for by the AIC selection criterion when using models that contain many covariates and their interactions.

With respect to the first concern, Hiby noted that the effective search area in the cue-counting method depended on the square of the estimated distance. Distance estimation errors could be highly influential and cause large biases. He believed that this also applied to the effective search width estimated by the hazard probability model, particularly as distances are estimated by eye. Schweder believed that the abundance estimate would be susceptible to distance estimation error in the same way as conventional line transect methods.

The sub-committee discussed whether reaction of whales to survey vessels could include a change in surfacing behaviour, how minke whales might react, and the question of data to address these questions. It is not known whether minke whales may react by either increasing dive times or increasing surfacing rates but the effects on hazard probability abundance estimates are very different. Cooke reviewed the results from a simulation study described in Cooke (1992). When half of the whales increased their dive time the resulting abundance estimate was only slightly negatively biased. However, when half of the whales surfaced prematurely at 0.2 n.miles from the ship, the resulting abundance estimate was positively biased by about 67%. It was suggested that simulation data similar to that produced in Cooke (1992) could be used to test the currently used hazard probability estimation methods to determine the potential effect of changes in surfacing behaviour. It was also suggested that a first step could be to collect surfacing behaviour data to determine if there is a change in surfacing rates in response to survey ships.

Several members commented that the Buckland-Turnock method of abundance estimation, in which the two teams survey at different distances ahead of the ship, would not be affected by changes in surfacing behaviour because it was designed to take responsive movement into account.

With respect to the second concern, Cooke indicated that he planned to investigate whether his method has been influenced by small sample bias. He noted that the number of duplicates in a cell is the influencing factor. The maximum likelihood and AIC could probably still be used to estimate and determine the covariates in the model; however, total abundance could be estimated using a summation of bias-corrected block abundance estimates.

There was no time available to discuss these issues further.

6. DOCUMENTATION OF RMP FOR INCORPORATION INTO SCHEDULE

At last year's meeting, an intersessional Working Group was established under Donovan to finalise documentation of the RMP for incorporation into the Schedule. This work had not been completed during the year. During the meeting, a finalised documentation was drafted and referred to plenary under Plenary Item 7.4.

7. STOCK IDENTITY

Pastene, Goto, Hatanaka and Kato suggested that it may be useful for the Committee to reconsider its definitions of the term stock. The importance of stock definition, or population subdivision for the purposes of management and conservation of whale resources by the IWC is obvious. For exploited species, an understanding of stock boundaries is critical for estimating abundance, setting catch limits and interpreting life-history parameters. For protected species, stock boundaries are important for assessing population trends, establishing territorial jurisdiction and identifying critical habitats (Baker *et al.*, 1994).

Under the New Management Procedure (NMP), the IWC managed the different whale species using specific 'management units' (see Donovan, 1991). An example of these 'management units' is the six management Areas in the Southern Hemisphere used by the IWC to manage the baleen whales species (except the Bryde's whale).

Under this scheme, the 'management stock' was defined as the group of whales occurring within a specific geographical boundary which is actively or potentially exploited by IWC member countries. These are the individual stocks whose status is assessed by the Committee (Hoelzel and Dover, 1989).

To date, most studies on stock identity of large whale species have attempted to test the hypothesis that IWC management units (management stocks) correspond to biologically defined entities (biological stocks). For that purpose, different techniques such as genetics, morphology, Discovery marks, ecological markers, sighting pattern and catch distribution have been used. In recent Committee discussions on the stock identity issue, however, the difficulty in interpreting genetic data has been evident.

There has been substantial development in techniques useful for determining stock structure in recent years, especially genetics based methods. The sub-committee agreed that, given this development, it would be useful to undertake a review with the goal of establishing more useful definitions of the term stock.

An *ad hoc* Working Group was established under DeMaster to develop terms of reference for such a review and to outline the tasks that it may be useful to address overall, including identifying specific steps that can be taken intersessionally in preparation for a more comprehensive discussion during the next meeting. The report of the Working Group is given as Appendix 4 and was considered directly by the plenary under Plenary Item 7.5.

In response to last year's recommendation by the Committee, SC/50/RMP6 presented a list of tissue samples of southern minke whales preserved at the National Research Institute of Far Seas Fisheries, which were collected under past commercial whaling. The sub-committee welcomed submission of the list but no time was available to review it.

8. PREPARATIONS FOR IMPLEMENTATION

8.1 Questions relating to implementation trials

Implementation Simulation Trials 'involve identifying the range of plausible hypotheses relevant to recommending an *Implementation* or *Implementation Review* for the RMP and formulating simulation models which conform with these hypotheses, (IWC, 1995, p.214). Appendix 5 provides a structured approach to the development of *Implementation Simulation Trials* in cases in which there is uncertainty about stock structure. Butterworth emphasised the need for addressing each of the issues in Appendix 5 sequentially because, for example, assumptions regarding choices of sub-areas depend on hypotheses about the number of stocks and how they migrate. The sub-committee thanked Butterworth for completing this task which it had requested at last year's meeting.

8.2 North Pacific minke whales

At its 1996 meeting, the Committee developed a set of *Implementation Simulation Trials* for North Pacific minke whales and recommended that the Secretariat develop a computer program to implement these trials and then conduct them (IWC, 1997a, p.70). The trials involve 13 sub-areas in the North Pacific and consider two hypotheses regarding the number of breeding stocks of minke whales in the North Pacific: (i) that there are three stocks, the J stock ('home' area - Sea of Japan and perhaps also the Yellow Sea and East China Sea), the O stock ('home' area - the Okhotsk Sea, the east coast of Japan) and the W stock (West Pacific); and (ii) that there are only the two stocks, J and O.

During its 1997 meeting, the Committee reviewed recent information on stock identity and catches and made some revisions to the trials.

8.2.1 Progress during intersessional period

Allison reported that she had developed most of the program to implement the trials. However, she had been unable to complete this task and conduct the trials because some of the specifications were incomplete. A Working Group under Alison was established to finalise the specifications for the trials, taking into account discussions under the remainder of Item 8.2. Its report is given in Appendix 6 and discussed under Item 8.2.4.

8.2.2 Uncertainty over catches

In 1994, the Revised Management Procedure for baleen whales (IWC, 1994, annex H, p.150) stated that 'known 'indirect' catches, e.g. whales killed through entanglement in fishing gear, should also be included in the catch history' in the RMP. *Implementation Simulation Trials* should include estimates of all non-natural removals. Some of the currently specified trials are used to examine the implications of alternative assumptions about catches. At last year's meeting, the Committee had agreed to modify the trials to include incidental catches of minke whales by Korea and Japan (IWC, 1998a).

In response to a request at last year's meeting, Kim presented new information about incidental catches of minke whales off Korea (Appendix 7). In response to a question, he indicated that the increase in incidental catches during 1996 was related to unusual environmental conditions that also led to substantially increased fish catches. Information about fishing effort and catches for the years before 1996 is not available due to the lack of a systematic recording system. Kim suggested that examination of further information including prices in the market could be used to provide estimates of earlier catches. He indicated that incidental catches off Korea had increased following the cessation of whaling in 1986 and suggested that this may be because of an increase in the abundance of minke whales in the inshore waters off Korea.

At last year's meeting, it had been agreed to include variants of the four base-case trials in which an incidental catch of 150 whales per annum is taken from sub-area 6. This means that the incidental catch does not respond to changes in abundance. The sub-committee agreed to retain these trials but also to include incidental catches off Korea (sub-area 6) in all the other trials. These incidental catches are assumed to be zero before 1989, to increase from 0 in 1988 to 78 in 1995, and to be 129 in 1996. The catches for the years from 1997 onwards are defined as 78 multiplied by the ratio of 1+ abundance to the 1+ abundance in 1997. The rationale for these specifications are the comments by Kim that minke whales returned inshore only gradually after the end of commercial whaling in 1986, that 1996 was environmentally abnormal resulting in an atypically high incidental catch that year, and the expectation that future incidental catches would be depend on the size of the population.

At last year's meeting, a Working Group was established to consider all the information on incidental catches in Japanese fisheries (estimated and observed) and to specify a time series of total incidental catches. Brownell reported that no agreement had been reached. He also noted that the incidental catches reported in the Japanese Progress Reports are notably lower than the estimates in Tobayama *et al.* (1992). While it is likely that the reported incidental catches are under-estimates, it is unclear whether the extrapolations made by Tobayama *et al.* (1992) are appropriate. Intersessionally, Brownell and Yagi had discussed the issues of what correction factors to apply to the reported estimates of incidental catch and how to collect better data in the future. Yagi reported that a project had been initiated to examine the first of these issues but it had not yet been completed. It was agreed that the completion of this work was necessary before the Commission could actually apply the RMP to this stock. In the meantime, it was also agreed that plausible scenarios on incidental catch should be used for the purpose of *Implementation Simulation Trials.*

The sub-committee agreed that two scenarios should be considered in trials: (a) that incidental catches are taken to be those in the Japanese Progress Reports, and (b) that incidental catches should be based on the values reported in Tobayama *et al.* (1992). Specifications incorporating these bycatches are given in Section D of Appendix 6. Further discussion is reported under Item 8.3.4.

Although it was generally agreed by the Commission last year that, as far as possible, the *CLA* should be used 'to determine the allowable removals and then take account of all known human-induced mortalities', other views were also expressed. The sub-committee therefore agreed that trials should be conducted in which (a) the incidental catches are taken over and above commercial catches as set by the RMP, and (b) in which the removals from each sub-area are the maxima of the incidental catches and the catches set by the RMP. This last case corresponds to the assumption that the RMP catch limits cover all non-natural removals.

8.2.3 Sightings survey planning

Smith described the intersessional work of the North Pacific Sighting Survey Steering Group (NPSSSG), noting that five tasks were identified (Appendix 8). The Steering Group was able to address several of these, and additional material was presented to the sub-committee relative to the remaining tasks. One important task was the development of review comments on an initial draft of the sighting survey proposal (SC/50/RMP4). Although comments were generated within the group, there was insufficient time for members to discuss the points raised. These comments were available for further discussion during this meeting. Several documents were also available to the meeting that addressed the outstanding issues.

Miyashita presented SC/50/RMP4, the revised version of the sighting survey plan addressed by the NPSSSG. He noted that this document included text in italics for convenience in determining how the recommendations of the NPSSG were accommodated. He also outlined the key features proposed for the conduct of the survey, and noted that the expected number of sightings, if the survey were conducted in the area proposed, would be 80.

In discussion, it was clarified that although this is a feasibility study it was intended that, if the survey is successful, estimates of abundance using the data were intended to be used in both implementation simulation trials and, potentially, in actual implementation of the RMP. It was suggested that because the applicability of the proposed methodology was not known, and because of concerns that some had raised about possible biases due to whale responsive movement (Item 5.3), it would be useful to include in the design the possibility of using an alternate estimation method. One possibility would be to use standard line transect analysis methods assuming $g(0) = 1$. The possibility of using the method used during the SCANS survey (Hammond *et al.*, 1995) due to Buckland and Turnock (1992) was also discussed. It was noted, however, that the latter two methods require different searching patterns, and that the observers would be required to adopt different search patterns so that the methods would not be compatible.

The sub-committee noted that the proposed determination of dive times using visual observations was not recommended as it is difficult to be confident about tracking individual animals and as some surfacings may be missed. The sub-committee **recommends** the use of other approaches such as monitoring diving using VHF telemetry. While it was noted that such monitoring would most desirably be made during the survey, as proposed for the visual observations, it would be acceptable if they were made at appropriate different times and even locations as was the case for abundance estimates in the northeast Atlantic (Schweder *et al.*, 1997). It was also suggested that if visual observations are attempted, they might be compared with VHF data or data from other more direct methods to determine the degree of bias in the visual observations.

The use of binoculars for searching and distance estimation was discussed. The sub-committee **recommends** that the experiments and testing of estimation of angles and distances should be conducted using the same methods used in the actual survey. The possibility of using binoculars for searching if the Buckland and Turnock method were adopted was noted.

Miyashita thanked the NPSSSG for its helpful assistance, and requested that it continue to function as the preparations for this survey and that for Bryde's whales (see Item 8.4.2). The sub-committee agreed and re-established the Steering Group under Smith with membership as listed in Annex Z.

The sub-committee considered the requirements for participation of a member of the Scientific Committee in this survey, as decided by the Committee last year. The sub-committee agreed that Scientific Committee representation on the planned surveys should take the form of participation of a scientist with active experience of surveys of the type proposed (hazard probability approach) and other methods that may be incorporated (such as the Buckland and Turnock method). The sub-committee noted that Miyashita (who has participated in Norwegian surveys using the hazard probability approach) would participate in the survey.

The sub-committee reiterated from last year its **strong recommendation** that the survey includes waters within the Russian EEZ in order to provide the necessary coverage. It **recommends** that the Commission requests the relevant authorities of the Russian Federation to grant permission for the vessels to operate in their EEZ. More generally, the sub-committee agreed that this recommendation should apply to all relevant countries in similar situations for all such surveys in the future.

8.2.4 Development of trials

The sub-committee considered the new information regarding stock structure for North Pacific minke whales in the context of whether it implied that changes had to be made to the specifications of the *Implementation Simulation Trials*.

SC/50/RMP7 presented the results of RFLP and sequencing analyses of the mtDNA control region for the examination of the population structure of North Pacific minke whales. In the first analysis, a total of 656 samples including 100 whales taken during the 1997 JARPN was examined. The pattern of genetic variation revealed by AMOVA in the 1997 JARPN samples was similar to that reported in a previous study (Goto and Pastene, 1997b). Haplotype frequencies in the samples from sub-areas 8 and 9 were not significantly different from those of the O stock. In the second analysis, a total of 153 samples was examined in a preliminary sequencing analysis. A consensus of 487 base pairs of the mtDNA control region was used. A total of 25 polymorphic sites discriminated 41 unique sequences (haplotypes) in the total sample of 153 individuals from sub-areas 6, 7 and 9. Nucleotide diversity was lower in sub-area 6 (0.0046 ± 0.0029) than in sub-areas 7 (0.0088 ± 0.0050) and 9 (0.0076 ± 0.0043). In general, nucleotide diversity in sub-areas 7 and 9 was similar to that for the eastern North Atlantic minke whale but lower than that for the Antarctic ordinary form minke whale. The results of the homogeneity test by AMOVA (PHI-st) showed a clear discrimination between minke whales from Korea (sub-area 6) and the eastern side of Japan (sub-areas 7 and 9) supporting previous results that used nuclear and mtDNA markers to investigate stock identity for these sub-areas. No significant heterogeneity was found in the comparison between sub-areas 7 and 9, though the probability was close to significant. Further sequencing analysis in sub-areas 7 and 9 was suggested.

SC/50/RMP8 presented the results of a microsatellite analysis to examine stock structure in western North Pacific minke whales based on a larger number of samples and loci than in a previous study (SC/49/NP12). Genotyping of three sub-areas (sub-area 6; $n=26$-28, sub-area 7; $n=184$-206, and sub-area 9; $n=177$-188) at six microsatellite loci revealed significant differences in the expected heterozygosity between sub-area 6 and sub-areas 7 and 9. Heterozygosity was significantly lower in the Korean samples of sub-area 6 than in the samples from sub-areas 7 and 9. Significant differences were also found between allele frequencies from samples from sub-area 6 and those from sub-areas 7-9. No significant differences in allele frequencies were found between the coastal (sub-area 7) and offshore (sub-area 9) sub-areas on the eastern side of Japan. In contrast to the previous study, no significant deviation from the expected Hardy-Weinberg proportions for sub-area 9 was found although significant deviations were still detected for sub-area 7.

SC/50/RMP12 examined the evidence for a W stock for North Pacific minke whales using data for the early period (early May to early June) of migration in sub-area 9 using the data from the 1997 JARPN survey. A high proportion of males (82.1-90.1%), high apparent pregnancy rate (100%), and relatively lower proportion of mature females (6.6-7.5%) were observed in samples in the early season and the summer season. Furthermore, whales taken in the early migration season, had almost the same peak of conception date as the sample in summer in sub-area 9 as well as the eastern side of sub-areas 7 and 8. Regarding other information such as the occurrence of anomalous testes of males, no difference was observed between the samples in the early season and summer. Overall, the results obtained from the 1997 JARPN samples provide no evidence to support the existence of a W stock in sub-area 9.

Baker summarised information in SC/50/RMP15 relating to the stock structure of North Pacific minke whales. From a forensic study conducted from 1993-97, 79 products were identified as northern minke whales using phylogenetic analysis of mtDNA control region sequences (Baker *et al.*, 1996). Variation within a highly variable 350 nucleotide segment of the control region resolved 26 unique sequences (i.e., haplotypes) among the northern minke whale products. It was assumed that the origin of the products from Japan was hunting, under scientific permit, of the O stock (IWC, 1997b, pp.203-26), primarily in sub-areas 7, 8, and 9 of the western North Pacific (to the east of Japan). It was assumed that the origin of products from Korea was coastal bycatch of the J stock (IWC, 1997b, pp.203-26) in the Sea of Japan/East China Sea (SC/50/ProgRep Korea). Contrary to expectations from previous genetic analysis (Goto and Pastene, 1997a), seven of the seventeen haplotypes in the Japanese samples were identical to Korean haplotypes. These shared, identical haplotypes accounted for 44% of the 25 Japanese products. A collection of 15 North Pacific minke whale products purchased in late 1997 and early 1998 showed a similar high proportion of shared, identical haplotypes with the Korean products (SC/50/O8). An analysis of variance modified for haplotype frequencies and molecular information (AMOVA) showed significant differences between the Korean and Japanese samples collected from 1993-97 (SC/50/RMP15). However, the magnitude of the genetic differentiation was 10-fold lower for the haplotype statistic and several-fold lower for the molecular distance statistic, compared to that of SC/50/RMP7 and Goto and Pastene (1997a).

The authors of SC/50/RMP15 and SC/50/O8 believed that this analysis raised two biological concerns relevant to the *Implementation Simulation Trials*. First, the currently accepted division between J and O stocks could be over-estimated due to the small and, perhaps, seasonally and geographically restricted sample used to represent the J stock in previous genetic analyses. Second, the current estimate of mixing between J and O stocks could have been underestimated. These are not mutually exclusive hypotheses.

Yagi recalled that, when similar forensic papers by Baker were presented last year to the Committee, 'some members noted that these reports did not provide information that could be used to evaluate stock structure as the geographic location of the samples referred to was unknown'. This year's documents SC/50/RMP15 and SC/50/O8 had exactly the same problem and he believed that they did not contain new information relevant to specifying *Implementation Simulation Trials*.

In discussion, Baker, Brownell and Wade noted that the analysis of mtDNA control region sequences in SC/50/RMP7 provided valuable new information on the question of stock differences or mixing between the J and O stocks. In particular, it allowed the comparative identification of previously defined RFLP haplotypes 2/5 using the direct sequencing methods of Baker *et al.* (1996) as applied specifically to the Japanese and Korean markets (SC/50/RMP15). The 2/5 types account for 76.7% of the samples representing the J stock (i.e., sub-area 6) and only about 4% of the 'O' stock (i.e., sub-areas 7, 8 and 9), except in sub-area 11 where seasonal mixing results in about 13.7% of types 2/5 (table 4 of SC/50/RMP7). However, the large majority of whaling since 1994 has been in sub-areas 8 and 9. Only 30 whales were killed in sub-area 11 (Pastene *et al.*, 1997) of the total of nearly 300 from 1994-97. For these reasons, the frequency of type 2/5 products, representing J stock whales, should be low in Japan, perhaps 6%.

Baker noted further that information in SC/50/RMP7 showed that a 'G' in position 298 of the control region identified all 21 of the type 5 sequences and one of the two type 2 sequences (table 8, SC/50/RMP7). Only one of the other 124 sequences from sub-area 7 and 9 was characterised by this 'G', suggesting a potential misclassification error of about 0.8% for non-type 2/5 sequences. Based on this information, a review of figs 1 and 2 of SC/50/RMP15 showed that 7 (28%) of the 25 Japanese North Pacific minke whale products purchased from 1993-97 were type 2/5. Baker noted that unpublished data also showed that 6 (40%) of the 15 North Pacific minke whale products purchased in late 1997 and early 1998 were type 2/5. Overall, type 2/5 products accounted for 32.5% of the 40 North Pacific minke whale products purchased in Japan from 1993-98. Baker believed that this is difficult to reconcile with the expectation of a small percentage of J stock whales in the Japanese markets and supports the need to address uncertainty about stock structure or mixing rates in the *Implementation Simulation Trials*.

Yagi stated that there was no reason to assume that the difference between 32.5% and 6% of the frequency of type 2/5 samples reflects uncertainty about stock structure or mixing rate. Rather the difference could be explained by the different nature of the two datasets: Baker's value of 32.5% was calculated using samples of unknown origin while the value of 6%, which was estimated using data from SC/50/RMP7, came from samples of known origin. Thus, he saw no reason to reconcile this difference.

The sub-committee noted that the location of the samples in SC/50/RMP15 and SC/50/O8 was unknown. Some members believed that because of this, SC/50/RMP15 and SC/50/O8 did not provide information that could be used to evaluate stock structure. Hatanaka noted that some of the animals could have been taken incidentally from the Sea of Japan, and that substantial quantities of frozen meat remained. Other members believed that the information in these papers was useful and might necessitate changes to the assumptions regarding stock structure and the values in the mixing matrices.

The sub-committee noted that the number of samples from sub-area 6 that had been genetically analysed in SC/50/RMP7 and previous papers was small (30) and had been collected from a limited area over a very short period (Sept.–Oct. 1982). It agreed that additional samples from animals stranded in Japan and from the incidental catches off Korea would further an understanding of stock structure in the Sea of Japan. Kim stated that he would contribute morphological and genetic samples from bycatches to improve understanding of stock structure in the region.

It was noted that the trials already allow for a small fraction of J stock animals to mix into sub-area 7 and some members suggested that increasing this fraction should be considered in the revised trials. Baker pointed out that if substantial quantities of J stock animals are found in sub-area 7, one of the possible explanations for the results in SC/50/RMP15, this was inconsistent with the results in SC/50/RMP8. However, Punt noted that this fraction was estimated as part of the conditioning process rather than being fixed. He also noted that because the revised trials would include incidental catches off Japan (including catches in the Sea of Japan) this would reduce the difference between the current set of trials and the apparently conflicting information in SC/50/RMP15.

It was agreed that an additional set of trials based on the four base-case trials would be developed that include the fraction of type 2/5 haplotypes in the Japanese market in the conditioning (Section F (g) of Appendix 6) assuming that the product available in the market each year is selected randomly from catches during that year. It was recognised that this last assumption was extreme because of the unknown locality of the market sample. The values for the coefficients in the mixing matrices (e.g. the fraction of J stock animals in sub-area 7) would be chosen to mimic this fraction as well as to be consistent with the other information used for conditioning.

It was agreed that this overall issue would be considered further when additional genetic samples from the incidental catches off Korea and from strandings and incidental catches in Japan are analysed.

Allison presented the revised specification for North Pacific minke whales *Implementation Simulation Trials* (Appendix 6). She drew attention to those aspects that had changed since the specification had last been published (IWC, 1997b, pp.216-225).

(i) The trials are amended to take into account, and to investigate the effect of different levels of, incidental catches off Japan. Two different options are to be tested: J(i) in which the catches are taken to be those reported in Japanese progress reports and which are assumed to continue at a similar level in the future (of 27 per year); and J(ii) in which an annual catch of 93 animals is assumed, as estimated by Tobayama *et al.* (1992). This level of catch is applied both since 1900 and continuing in the future.

    These trials include taking an incidental catch from sub-areas for which a catch limit is set by the *CLA*. The commercial catch taken is assumed to be equal to the catch limit less the incidental catch. Robustness trials will also be performed in which the commercial catch taken is equal to the catch limit, with the incidental catch being taken in addition.

(ii) The trials specified last year to test the effect of incidental catches off Korea are extended following information presented by Kim (Appendix 7). The base case assumes an incidental catch of 0 is taken in 1988 rising to 78 in 1995, followed in 1996-97 by the actual values reported by Kim. Future catches are assumed to be at a level proportional to the future population size in this sub-area. Four robustness trials are added to investigate the effect of a different level of incidental catch: a constant catch of 150 whales per annum since 1988 is assumed which continues into the future.

(iii) Trials will be run to test the effect of potentially different proportions of J whales in the catch taken by Japan. The effect of selecting the initial parameters (i.e. conditioning) to meet the requirement that 39.2% of the total catch (both commercial and incidental) off Japan are J stock whales is to be compared with results of trials where this condition is not met.

(iv) The conditioning process is amended to ensure that the entire historic catch can be taken from the pertinent sub-area. This may require the addition of extra parameters into the catch mixing matrices.

The sub-committee thanked Allison and the Working Group for their work. A number of points of clarification were raised and minor modifications were made. Polacheck queried whether there was an alternative to adding free parameters in the conditioning process when there were problems identified in ensuring that the entire historic catch can be taken from the pertinent sub-area. Allison and Butterworth responded that this would be investigated.

Several members expressed reservations about the plausibility of Option J(ii) in the trials concerning incidental catch in Japan as an independent review of this issue is ongoing. Nevertheless they accepted that this option should be included in the *Implementation Simulation Trials* at this time. Brownell expressed reservations about the plausibility of option J(i).

The sub-committee agreed the revised specification for North Pacific minke whale *Implementation Simulation Trials* as given in Appendix 6 and **recommends** as a high priority that the Secretariat conduct the trials during the intersessional period and report the results to next year's meeting.

Two years ago the sub-committee had established a Steering Group to consider and resolve any inconsistencies that remained when the trials were conditioned and run, and make decisions about the choices specified in Appendix 6. It re-established this Steering Group with membership Allison, Butterworth (Chair), Kawahara, Punt and Taylor. [Other members joined following plenary discussion under Plenary Item 8.2.4].

8.3 North Atlantic minke whales

8.3.1 Northeastern stock

8.3.1.1 PROGRESS DURING INTERSESSIONAL PERIOD

Polacheck reported on work completed by the intersessional Abundance Estimation Steering Group. He noted that at the 48th Annual Meeting it was agreed that additional analyses should be undertaken with respect to the estimates of abundance for eastern North Atlantic minke whales from the NASS 1989/90 and NILS-95 surveys. The identified analyses were (IWC, 1997a, p.76):

(1) additional simulation tests to more fully explore the statistical properties of the Norwegian Computing Center (NCC) estimator and for the purpose of further confirmation that software was adequately verified;
(2) to reconcile any differences between comparable estimates obtained from the NCC and Cooke implementations by identifying the main causes of any such differences;
(3) to further assess the implications, in terms of possible bias in the NCC estimates, of the lack of model fit to the Bernoulli data, with respect to the marginal distributions of radial distances.

In the interval between the 48th and 49th meetings an intersessional Steering Group was established to undertake the above analyses. While significant progress had been made by the Steering Group on the above issues and some additional progress had been made at the 49th annual meeting, definitive answers were not reached. Consequently, the Steering Group (Butterworth, Skaug, Schweder, Laake, Hammond, Palka, Polacheck (Chair), de la Mare, and Zeh) was asked to continue work on these issues intersessionally and to 'define and pursue a course of analysis that in its judgement would allow definitive answers to these questions to be available at the next annual meeting'. In order to facilitate this, Cooke agreed to join Steering Group.

After considering various options, the Steering Group agreed that there were two additional methods and implementations that could be used to analyse the NASS 1989/90 and NILS-95 survey data. One was the method presented by Skaug (1997) and the other was the implementation of the NCC approach that Cooke had been developing (Cooke, 1997). The group further agreed that it was the estimates that needed to be validated and not the estimator. It also noted that there were insufficient time and resources available to comprehensively address the statistical properties and lack of fit issues using the software implementation of Schweder *et al.* (1997), particularly given the short time period between the 49th and 50th Committee meetings. As such, the Steering Group agreed that the best approach was to produce independent estimates using these two other approaches. Skaug and Cooke agreed to undertake the analyses of the survey data using their respective approaches. If these two other approaches yielded estimates that were approximately the same as those in Schweder *et al.* (1997), the Steering Group agreed that this would provide sufficient validation of the estimates and that it would consider that the three issues had been resolved. If the different estimates did not agree, further analyses of the underlying source of the discrepancy might be required. However, the additional analyses that might be required could not be specified in advance.

Polacheck noted that the intention of the Steering Group was to have the results from analyses using these two approaches available with sufficient time for review prior to the 50th Committee meeting. Preliminary results were available from Skaug in February that indicated substantial agreement between the estimates from his approach and those in Schweder *et al.* (1997). Final results were not available until just shortly before the Committee meeting and yielded estimates that were about 30% greater than those in Schweder *et al.* (1997). An incomplete draft of a working paper which was intended for this year's meeting and which detailed some of Cooke's results was also made available to the Steering Group shortly before the meeting. At the same time, a copy of an intended working paper which Cooke had prepared too late for consideration by the Abundance Estimation sub-committee at last year's meeting was also circulated. The latter indicated close agreement between the abundance estimates from Cooke's implementation and the results in SC/47/NA1 for the NASS 1988/89 data, when no covariates were included. The time available in the period between when the Skaug and Cooke results became available and the start of this year's meeting was too short for the Steering Group to be able to review them. However, results from both approaches were to be presented in meeting documents to the 50th Scientific Committee meeting. The Steering Group considered that these result should provide the basis for the Committee to resolve the three outstanding issues.

8.3.1.2 REVIEW OF NEW INFORMATION

Papers that provided new information that could be used to address the three issues listed in Item 8.3.1.1 were SC/50/RMP1, 2, 3, 20, 21 and 22.

The portions of the results in SC/50/RMP1 that pertained to issues 1 and 2 were discussed. This paper presented an application of the perpendicular distance based hazard probability method (Skaug and Schweder, 1998) to the NILS-95 data. The application incorporated the approach described in SC/50/RMP2 for identifying duplicates in independent observer surveys, and for correcting for duplicate identification errors. The resulting estimate of abundance in SC/50/RMP1 was 114,916 without any covariates. When sea-state was included as a covariate, the estimate was 126,863. These estimates of abundance are approximately 30% higher than the corresponding estimates in Schweder *et al.* (1997). Possible reasons for this difference include the method for determining duplicates and possible bias in the estimator for some parameterisations of the logit hazard rate models for the detection process. The duplicate identification method was different from that in Schweder *et al.* (1997) as it was necessary to classify sightings into duplicate or non-duplicate whales in contrast to surfacings in Schweder *et al.* (1997). This classification was done subjectively, based on a careful examination of the data. This could be a source of bias in the estimates. However, in performing the subjective classification, a conservative approach was adopted when classifying possible duplicates as separate whales in order to prevent a positive bias in the estimates. Simulation results indicate that this perpendicular distance based method yielded positively biased estimates when applied to simulated data sets conditioned on observed radial sighting distance and angle distributions from harbour porpoise surveys. In one instance, the bias was as large as 30% suggesting that the current implementation of the model may not be robust to certain types of detection functions.

SC/50/RMP3 presented additional analyses concerning the apparent lack of model fit to the Bernoulli data with respect to the marginal distributions of radial distances in the NCC results. At last year's meeting, a test was performed that indicated that the lack of fit was statistically significant (IWC, 1998c, appendix 4). SC/50/RMP3 presented the results of applying this same test to estimates derived from 25 simulated data sets using the NCC analysis method and implementation. This was one approach that had been identified at last year's meeting. The test was found to provide a large number of significant results when applied to the estimated results from the simulated data sets. However, a similarly large number of significant results were found when the same test was applied to the simulated data sets when the 'true' underlying parameter values for the hazard probability function was used to calculate the expected proportion of successes to include in the test. These latter results indicate that the test statistic used was over-dispersed relative to a chi-squared distribution and, as such, was inappropriate.

After a discussion on the form and rationale underlying this test statistic, several reasons were identified that could have contributed to this over-dispersion.

(1) Measurement error: the expected probabilities were not calculated at the true positions due to measurement error;
(2) Duplication identification errors: the number of trials was not equal to the true number of trials due to a certain proportion of the outcomes being incorrectly classified;
(3) Link function: the link function used was that of Schweder *et al.* (1997); ideally, a new link function should have been calculated for the parameter values used the simulating data, so this may have caused a lack of fit for both the actual and observed values.

The sub-committee agreed that because of the large over-dispersion in the distribution of the test statistic in this case, the goodness of fit test presented in SC/50/RMP3 did not provide a reliable indication of significant lack of fit. In light of this, a reasonable approach was to use the simulated realisations of the values of the test statistic in table 1 of SC/50/RMP3 to obtain an empirical approximation to the distribution of the test statistic. This empirical approximation could then be used as a basis for testing goodness of fit. When this was done, the lack of fit to the simulated data was no longer significant. This indicates that the previous lack of fit identified (for test see IWC, 1998c, appendix 4) to the NILS 95 bernoulli data is not likely to be significant. However, the limited power of the statistical test in this case was noted.

SC/50/RMP22 presented results of an alternative implementation of the hazard probability method to the NILS95 data. The basic method for strip width estimation is described in Cooke (1997) and was extended to allow for inclusion of covariates as recommended by the Committee. The extensions to the method to allow the fitting of covariates were specified in SC/50/RMP21. The Akaike Information Criterion (AIC) was used to select covariates for inclusion in the model. A preliminary analysis was first performed to choose a suitable form for the hazard probability function. A sequence of environmental covariates were then fitted: sea state (Beaufort), weather (cloud cover), and meteorological visibility were selected in both the level and the radial components of the hazard rate function on the basis of AIC, but glare was not selected. Observer covariates were then fitted as variance components (sources of heterogeneity). Team effects in the level and radial components of the hazard rate, and in the recorded distance bias all gave substantial reductions in the AIC. Although the AIC indicated that estimating a separate dispersion parameter (where the dispersion is the variance/mean ratio of the number of whales encountered) for each survey block was preferred over estimating a common dispersion parameter, it was clear from the results that the block-specific dispersion rates were not well estimated, and that this aspect of the methodology needed to be improved. A comparison of the observed and predicted distribution of radial distances to initial sightings (which accounted for rounding errors in the manner specified in SC/50/RMP19) indicated an acceptable fit to the data. The fit of observed and predicted duplicate proportions by radial distance was also acceptable, but the distribution of angles indicated significant lack of fit, which the authors attributed to a failure of the rounding model of SC/50/RMP19 to adequately correct for rounding beyond 45°.

Extensive discussion on this paper resulted in a number of suggestions and concerns. These included:

(1) There was concern that the model was over-parameterised, particularly with respect to the heterogeneity between vessels, blocks and observers, all of which are inter-related. It was suggested that the dispersion between blocks should be investigated in order to determine if the dispersion parameter should be allowed to vary for every block or instead for groups of blocks (particularly those with low sample sizes). In addition, it was suggested that team heterogeneity should be investigated to determine if it was in fact as high as the results implied. Because of small sample sizes for some teams, the number of duplicates could be very small and thus cause a bias. It was suggested that consideration be given to pooling data across some teams to alleviate this problem.
(2) The measure of dispersion used for estimating the variances does not appear adequate. An alternative measure should be considered that is less sensitive to cells with small sample sizes.
(3) For presentation purposes and comparison of the standard error of the model parameter estimates, the level of a factor that is set as the aliasing baseline should be a level that has the largest or at least an adequate sample size. This may not be the last level of a factor, as is often the default in statistical packages.

(4) It was suggested that the number of duplicates at the block level be presented in tabled results in order to allow a more complete evaluation of the estimates between blocks.

Additional discussion concerning (1) and (2) focussed on comparing estimates from the NCC and Cooke implementations found in Schweder *et al.* (1997) and SC/50/RMP21, respectively. Comparison of abundance estimates resulting from the NILS95 data for models without any covariates indicated that the Cooke estimate was similar but less than that from the NCC implementation (77,500 compared to approximately 82,000 - this NCC estimate was reduced by approximately 4,000 to account for estimated abundance in blocks NVN and JMC which are not included in the Cooke estimate). It should be noted that exact agreement should not be expected because different parameterisations of the logit model for the hazard probability function were used in the two implementations. The sub-committee considered the closeness of the two estimates as an indication of the robustness of the estimator to the specific parameterisation.

Comparison of the abundance estimates for the two implementations for their respective best fit that included covariates indicated a larger difference between the two. The abundance estimates for the complete model was 112,000 for the NCC implementation and 141,500 for the Cooke implementation. It was noted that the Cooke implementation contained substantially larger numbers of covariates and, as such, it was not surprising that the Cooke estimate was larger. The sub-committee considered the *eshw* estimates for the different blocks from the two implementations. However, these were defined and calculated differently in the tabled results. As such, the estimates were not directly comparable. It was noted the the relative magnitude of the abundance estimates by survey block for the full covariate model for the two different implementations exhibited considerable variability. This same level of variability was not seen in the comparison of the NCC estimates with those based on the perpendicular based method in SC/50/RMP1.

In conclusion, the sub-committee noted that the abundance estimates obtained in SC/50/RMP21 without the inclusion of environmental and observer covariates were reasonably close to the estimate without covariates obtained by Schweder *et al.* (1997). Furthermore, the range of estimates obtained with covariates fitted spanned the range of estimates obtained by Schweder *et al.* (1997) with covariates, although there were differences in the underlying functional form of the hazard rate and the way in which covariates were included in the model. The sub-committee concluded that this comparison adequately addressed item (2) of the tasks identified at its 1996 meeting (IWC, 1997a, p.76), namely the reconciliation of any differences between comparable estimates between the two different implementations of the hazard probability method. The sub-committee noted that the results of SC/50/RMP21 were also relevant to item (3) of these tasks in that there was no indication of a lack of fit to the Bernoulli data by radial distance interval in this implementation. As such, the model fit appeared to be acceptable in this regard.

The sub-committee noted the substantial amount of work involved in producing the abundance estimates in SC/50/RMP21. It thanked Cooke for his sustained effort and considered that SC/50/RMP20 and 21 represented important contributions to the science of line transect abundance estimation in addition to their value in helping to resolve the specific issues being addressed under this Agenda Item.

SC/50/RMP20 presented results for two sets of simulation studies of the version of the hazard probability method described by Cooke (1997), as modified to account for covariates in the way specified in SC/50/RMP21. The first set used simulated data generated with a view to emulating the surveys of minke whales in the eastern North Atlantic (SC/A96/AE20). The results showed that strip width estimates based on a simple logit model for the hazard probability seemed to agree well with the 'true' strip width, although most of the data sets were too small for the latter to be known precisely, hence a precise comparison was possible in only four of the data sets. The results from fitting a product logit model were less satisfactory. The second set used simulated data generated with a view to emulating surveys of harbour porpoise (Palka and Polacheck, 1997). The agreement between estimated and 'true' densities was good in all scenarios when delayed duplicates (cases where a pod is sighted by both platforms, but one sees it before the other) were used, but there was a 10-15% bias in estimated density when only simultaneous duplicates were used. It was noted that these latter results may not be directly relevant to the evaluation of the estimator used with the NASS-87/88 and NILS-95 survey data for eastern North Atlantic minke whales.

8.3.1.3 CONCLUSIONS

The sub-committee agreed that the large amount of new information available at this meeting provided a sufficient basis for resolving the three outstanding issues with respect to the Schweder *et al.* (1997) abundance estimates for northeast Atlantic minke whales from the NASS 1989/90 and NILS1995 surveys. The sub-committee agreed with the advice from the intersessional Steering Group that it was the estimates that needed to be validated and not the estimator. The sub-committee also agreed with the approach taken by the Steering Group to compare the estimates from the NCC implementation with estimates produced by the implementation and methods in SC/50/RMP1 and SC/50/RMP22 as a sufficient basis for validating the NCC estimates with respect to the above three issues. The sub-committee noted that the comparable estimates from these alternative approaches were either quite similar or, when the discrepancies were greater, the NCC estimate was always the smaller. In these latter cases, potential reasons had been identified that could be introducing positive biases in the alternative implementations. The sub-committee noted that in terms of implementation within the RMP the primary concern is to avoid positively biased estimates. In this context, the comparative results provide no indication of a positive bias in the NCC estimates.

The sub-committee further recognised that the new information available this year contained results which dealt directly with each of the three outstanding issues. With respect to the first issue, the additional simulation results in SC/50/RMP20 provided additional information on the statistical properties of the general hazard probability approach and indicated general agreement between the estimated *eshw* using this approach and the 'true' value within the simulated data sets. The sub-committee noted that the issue of software verification had been resolved at last year's meeting. With respect to the second issue, the results in SC/50/RMP22 provided comparable estimates from the NCC and Cooke implementations which provided no indication of any positive bias in the NCC estimates. With respect to the third issue, reconsideration of the statistical test performed at last year's meeting suggests that the test, as performed, was inappropriate. The test in SC/50/RMP3 appeared not to indicate a significant lack of fit to the Bernoulli data in the NCC implementation, although the sub-committee noted that the power of this test is limited. SC/50/RMP22 also found no lack of fit in its implementation and SC/50/RMP19 indicates that the apparent lack of fit in the NCC implementation could be the result of not having taken into account rounding error. Taking all of these factors into consideration, the sub-committee agreed that the model fit appeared to be acceptable.

Overall, the sub-committee agreed that the comparative results from the different implementations combined with the other additional new information meant that the task of undertaking additional analyses with respect to the NCC estimates of abundance for eastern North Atlantic minke whales from the NASS-89/90 and NILS-95 survey as defined at the 48th Annual Meeting had now been completed. The sub-committee further agreed that the results from these analyses did not indicate any problem with the estimates in terms of the issues that had been raised at the 48th Annual Meeting and supported the Committee's previous conclusion that the abundance estimates in Schweder *et al.* (1997) are adequate for use in the RMP.

8.3.2 Central Stock

8.3.2.1 RECONSIDERATION OF EARLIER ESTIMATES

CIC Small Area. Last year, the Abundance Estimation sub-committee had noted an apparent discrepancy between the previously accepted abundance estimate for the NASS87 Icelandic aerial survey block (Hiby *et al.*, 1989) and a recent reanalysis of these data (Borchers *et al.*, 1997).

SC/50/RMP14 reported an investigation into the source of this discrepancy. The effective search area estimated by Borchers *et al.* (1997) was about half that estimated by Hiby *et al.* (1989). There was some slight difference in the data used, probably due to different truncation choices, but the major discrepancy resulted from the use of a peaked detection function, without correction for error in distances estimation, by Borchers *et al.* (1997) versus a detection function with a wider shoulder, in combination with correction for error in distance estimation, by Hiby *et al.* (1989). The error in distance estimation was apparent from comparison of distance estimates to duplicate cues seen by the two observers during the duplicate sightings experiment. In particular, one observer tended to round the angles of declination heavily. If the true detection function is flat at short distances, then error in distance estimates will tend to make the predicted distribution peaked at short distances, whereas if the true detection function is already peaked, error in distance estimation has less effect.

In discussion, it was noted that these data alone are insufficient to distinguish between detection functions which are peaked or flat near the origin. There was some inconclusive discussion as to whether a peaked or flat detection function might be expected *a priori*. It was noted that the detection function fitted to the data recorded during the West Greenland NASS87 aerial survey, for which distance estimation error was far smaller, had a shoulder extending well beyond the first distance interval (Hiby *et al.*, 1989). Assumption of a peaked detection function would yield a higher abundance estimate. However, other options suggested in the discussion, such as repeating the analysis without using the distance estimates from the observer who rounded heavily, could yield a lower estimate.

In conclusion, the sub-committee considered that the previously accepted estimate should remain so, pending resolution of the matters raised above. The sub-committee noted that the data from this survey had been provided to the Committee for use during the current meeting. However, no arrangements were in place for continuing access. The sub-committee considered that if the estimate is to be used in the implementation of the RMP then the data would need to be available to the Committee on a continuing basis in accordance with the Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme (IWC, 1997c, pp.227-28). This was considered critical in order that issues such as those raised in the discussion could be examined further if necessary whenever they arise (see Item 8.3.2.2).

CM Small Area. The Committee had previously calculated an abundance estimate from the NASS-87 data for this area from an *ad hoc* proration of the estimates from Norwegian and Icelandic surveys, based on the number of sightings in the area (IWC, 1993a, p.66).

SC/50/RMP17 presented a reanalysis of the NASS-87 data for this area. While the southern parts of the CM area received a reasonable coverage by Icelandic vessels, the northern parts covered by Norwegian vessels received a low coverage. The data from Icelandic and Norwegian vessels were pooled, resulting in a total of 25 primary sightings. A detection function was fitted to the pooled data, giving an effective search half-width of 0.122 n.miles (CV 0.336). Encounter rates and school sizes were estimated separately by original survey stratum. The total estimate of minke of minke whale abundance for the CM *Small Area* in 1987 was 11,969 whales (CV = 0.445).

In discussion, three concerns were raised about the analysis presented in SC/50/RMP17. First, no smearing of the line transect data had been carried out. The fitted detection function had a very narrow shoulder (approx. 0.025 n.miles) and a steep fall-off, which is suggestive of angles rounded to zero. Second, data were pooled across Icelandic and Norwegian vessels. Previous analysis has suggested that the effective strip width for minke whales was appreciably wider for the Norwegian vessels. Although the number of sightings from Icelandic and Norwegian vessels was about the same, the population size estimates obtained from Norwegian data alone accounted for roughly 80% of the total abundance estimate. Hence, downward bias in the estimated effective strip width for the Norwegian vessel may have led to substantial upward bias in the population estimate, which will not have been compensated for by an opposite bias from the Icelandic data. Third, survey block B2 contributed over 50% to the total abundance estimate, yet survey coverage in this block was very low. All but one detection came from a single transect line. There was no search effort in the northwest portion of the block. It was suggested that it would be more appropriate to treat this portion as not having been covered by the survey. It was further suggested that, instead of analysing these relatively small sets of data in isolation, they should be analysed in the context of the full Norwegian and Icelandic data sets from the NASS-87 surveys.

The authors of SC/50/RMP17 indicated that they would undertake to reanalyse the data to address the concerns raised. The sub-committee noted that the data from this survey were also available to the Committee only during the current annual meeting. The sub-committee emphasised that if the abundance estimates from these data are to be used as input to RMP implementation, the data will need to be available to the Committee on a continuing basis (see Item 8.3.2.2).

SC/50/RMP10 analysed minke whale sightings data collected in the NVS stratum of the CM *Small Area* from

Icelandic vessels in the NASS-95 survey. An estimate of 5,869 minke whales (CV = 0.427) was obtained using standard line transect methodology assuming $g(0) = 1$. It is likely that $g(0)$ was in fact less than unity so that this abundance estimate is negatively biased. Evidence for $g(0) < 1$ include: a paucity of detections near the trackline together with reports that observers may not have 'guarded' the trackline; the omission of sightings first detected behind the abeam line in the analysis; evidence from analyses of Norwegian surveys, in which $g(0)$ for north Atlantic minke whales was estimated to be substantially less than one (Schweder *et al.*, 1997). The estimate for the NVS stratum was added to estimates for the NVN and JMC strata of the CM *Small Area* obtained from the NILS-95 survey using different methodology (Schweder *et al.*, 1997) to yield a total abundance estimate of 12,043 minke whales (CV = 0.277) for the whole CM area in 1995.

The sub-committee had a number of questions concerning the conduct of the survey and the field protocols followed, such as whether there had been experiments to test distance estimation and how duplicate sightings had been identified. The authors of SC/50/RMP10 reported that there had been no independent observer counts, and that there had usually been one observer in the barrel, which had a standing height of 12-13m, while the remaining observers were on the bridge, the height of which was 9m. Some observers had used reticule binoculars and some had used distance sticks to estimate distances. Initial distance estimates were sometimes revised following a resighting of the whale and sometimes the recorded distance estimate was a consensus estimate reached by two or more observers. Experiments were conducted to test observers' ability to determine sight distances and angles, but documentation of these experiments was not available. The sub-committee's attention was also drawn to NAMMCO document SC/4/18 (Sigurjónsson *et al.*, 1996) which contained some of the information requested.

Since this survey had been conducted recently, the sub-committee considered that it was important to consider the extent to which it had met the requirements and guidelines for conducting surveys under the RMP. To facilitate this, a checklist (Appendix 9) was developed summarising the extent to which these were met. This checklist and possible implications for future use of estimates from these data in implementing the RMP are discussed under Item 8.3.2.2.

Data access for the Icelandic survey component described in SC/50/RMP10 was similar to that for the other surveys of the Central area reviewed under this item; i.e. the data had been supplied by Iceland for use only until the end of the current meeting. The sub-committee expressed its appreciation to Iceland for making available all of these datasets during the current meeting. However, the sub-committee once again noted that if the estimates were to be used in an implementation of the RMP, then the data would need to be made permanently available to the Committee.

8.3.2.2 DATA AVAILABILITY

Last year the Committee posed four general questions (IWC, 1998a, item 8.2.2) arising out of specific discussion about the availability of sighting survey data for estimates that it might review for suitability under the RMP. These questions arose out of the specific issue of the suitability of abundance estimates from the CM area that were based in part on data collected by a non-member state and for which the Committee did not have access to the primary data. The sub-committee had extensive discussion on these four questions. It noted that these questions arose out of the requirements and guidelines for surveys under the RMP (IWC, 1996, p.211) and that these requirements pertain strictly to data for estimates to be used in an implementation of the RMP. Requirements for data used by the Committee to address other issues do not fall under these same requirements.

The sub-committee considered that availability meant that the data needed to be lodged with the Secretariat and that they were freely available to all accredited members of the Scientific Committee without restriction. Data availability in this context does not extend to public access nor does it allow for further redistribution of the data by members of the Scientific Committee.

In discussing this issue, the sub-committee noted the desirability of having access to data from abundance surveys for stocks of interest to the Commission that were conducted by non-members states. The sub-committee **recommends** that the Commission request non-member states to cooperate in the work of the Committee by providing information on abundance surveys that they conduct on stocks of interest to the Commission and to make the data from such surveys available.

The sub-committee recognised that results from various other analyses (both inside and outside of the context of the RMP) were used to provide management advice to the Commission for which the data were not available to the Committee. Some members of the sub-committee considered that the question of data availability from these other analyses needed to be addressed by the Committee. However, the general question of data availability was considered beyond the scope of this item. The sub-committee agreed that this more general issue should be referred to the full Committee for its consideration,

The sub-committee discussion focused on the four questions posed last year by the Committee.

(1) REQUIREMENTS FOR CONTINUING AVAILABILITY OF DATA FROM ABUNDANCE SURVEYS

The sub-committee noted the critical importance of having continued access to data from abundance surveys. The need for such access is essential in order to be able to verify estimates when questions arise and to update previous analyses in response to methodological improvements and developments. In addition, a key component of the RMP is the requirement to periodically review the definition of *Small Areas* used in any particular implementation and to redefine these areas in light of additional information. Unless the data used to estimate abundance are available, it would not be possible to re-calculate appropriate abundance estimates that corresponded to redefined *Small Areas*.

The sub-committee **recommends** the requirement that data from abundance surveys be available on a continuing basis as an absolute minimum requirement if an abundance estimate from such a survey were to be used in an implementation of the RMP.

The sub-committee further **recommends** that the Committee should not review such estimates under the terms of the RMP unless there were assurances of such access.

(2) ACCESS TO DATA SUPPLIED BY A COUNTRY SUBSEQUENTLY LEAVING THE COMMISSION

The sub-committee noted the discussion above about the necessity to ensure continued availability of data for abundance estimates when such estimates are for use in the RMP. If data access were lost in the event that a member state subsequently left the Commission then the continued implementation of the RMP could be compromised. As such, the sub-committee **recommends** that the Commission develop appropriate provisions that ensure that any data supplied by a member country for use under the RMP remains available to the Scientific Committee in the event that a member country withdraws from the Commission.

(3) POSSIBILITY OF ALLOWING 'SLIGHTLY MORE LIMITED RESTRICTIONS' WHERE DATA OF GREAT INTEREST TO THE COMMITTEE ARE OWNED BY A NON-MEMBER NATION

Last year the Committee agreed 'that it would be useful to attempt to make an estimate for the entire CM area for 1995.' At this year's meeting abundance estimates for the CM area that incorporated data collected by Iceland were referred to this sub-committee. These data were made available to the Committee during its current meeting, but no arrangements had been made for continuing access. The sub-committee recognised that Iceland was not currently a member of the IWC and as such was under no obligation to supply data or meet other requirements and guidelines when conducting surveys. The sub-committee also recognised that the Committee may have interest in having data available to it from abundance surveys conducted by non-member states with respect to other aspects of its work.

The sub-committee recognised that in both the case of the use of an estimate under the RMP and the use of an estimate to address other issues of interest to the Committee, limitations on the use of such data for analyses beyond that required for the RMP or the issue for which they were supplied might be considered. Such restrictions might include ensuring safeguarding the rights of collectors for the first use of the data for their own purposes. Such restrictions might be included as a part of the conditions under which the data would be provided to the IWC. The sub-committee considered that such restrictions should not necessarily preclude the use of abundance estimates from such data as long as there was adequate access to the data for use in the RMP. The sub-committee stressed that within the RMP context such data would need to be available without restriction to accredited scientists. However, the publication of results of analyses not clearly and directly related to implementation issues, without the agreement and/or collaboration with the data collectors, could be forbidden.

The sub-committee **recommends** that a set of guidelines be developed for the types of availability restrictions that it would consider acceptable if a non-member country, individual scientists or international organisation were to provide data for use in the RMP. In developing such guidelines, consideration should be given both to the needs for ensuring continuing adequate implementation of the RMP and the limitations on data uses that would facilitate and encourage the provision of such data.

(4) COMMITTEE POLICY ON REVIEWING PUBLISHED ESTIMATES IF THE RAW DATA ARE NOT AVAILABLE

The sub-committee **recommends** that the Committee should not review estimates for use in an application of the RMP based on data that it judges do not adequately meet its requirements and guidelines. However, the sub-committee **recommends** that the Committee should consider the specifics of any data set in terms of its requirements and guidelines. It should evaluate the degree to which the data are adequate for use in the RMP and should judge the relative importance in terms of the behaviour of the RMP in those areas where the requirements were not met and guidelines were not followed. In particular, some aspects of the guidelines dealing with prior notification and timing of data provision, etc. may be inappropriate or irrelevant depending upon the situation under which the survey was conducted by a non-member country.

In the case of the 1995 Icelandic data for the CM area, Appendix 9 provides an evaluation of these data in terms of the RMP requirements and guidelines. It was noted that the several members of the Committee had participated in the planning meeting in Tromsø for this survey. In addition, the methodology and procedures were similar to those used in the previous NASS-87 and 89 surveys. Moreover, results of analyses in SC/50/RMP10 suggested that if a standard line transect estimator was used with these data the resulting estimate would be negatively biased. With the exception of the issue of data availability, the sub-committee did not identify any issues in its review of SC/50/RMP10 and the supplementary information provided to the sub-committee in Sigurjónsson *et al.* (1996) that would have precluded the use of the abundance estimate in SC/50/RMP10 for use within the RMP. However, members of the Committee may wish to conduct additional analyses to verify the acceptability of the estimate for use in the RMP if the data become permanently available.

8.4 Western North Pacific Bryde's whales

8.4.1 Specification of Implementation Simulation Trials

The Scientific Committee completed the Comprehensive Assessment of North Pacific Bryde's whales at its 1996 meeting and recommended development of *Implementation Simulation Trials.* At last year's meeting, the Committee considered information about stock identity and historical catches of North Pacific Bryde's whales. It identified seven tasks which, if completed during the intersessional period, would assist in the development of *Implementation Simulation Trials.* An intersessional e-mail correspondence group chaired by Punt was established to facilitate completion of these tasks.

8.4.1.1 PROGRESS DURING INTERSESSIONAL PERIOD

Punt presented the report of the intersessional Correspondence Group on the Specification of *Implementation Simulation Trials* for the Western North Pacific Bryde's Whales (Appendix 10).

8.4.1.2 DEVELOPMENT OF TRIALS

The sub-committee considered the new information regarding stock structure for North Pacific Bryde's whales.

Pastene presented document SC/50/RMP9. The nucleotide sequence of the mitochondrial DNA (mtDNA) control region was determined to examine the pattern of genetic variation within and between ocean basins in the ordinary form Bryde's whale. A total of 221 samples were examined, 150 from the western North Pacific, 24 from the western South Pacific (south Fijian), 24 from the eastern South Pacific (Peruvian) and 23 from the eastern Indian Ocean (south Javan). For comparison, sequences of seven local form animals from the Solomon Islands and Kochi were used.

A consensus 358 base pairs segment of the control region was used. A total of 50 unique sequences (haplotypes) was identified, 48 in the ordinary form and two in the local form. The overall nucleotide diversity in the ordinary form was 1.10%. The western North Pacific sample was divided into two longitudinal sectors, Gr-A (10°N-35°N; 130°E-155°E, $n = 79$) and Gr-B (10°N-40°N; 155°E-180°, $n = 71$). Homogeneity tests were conducted using the chi-squared test of independence, the haplotype (Hst) statistic and the sequence (Kst*) statistic. No significant differences in mtDNA composition were found between the two longitudinal sectors in the western North Pacific. In contrast significant genetic differences were found among the western North Pacific, western South Pacific, eastern South Pacific and eastern Indian Ocean regions supporting the view that independent genetic populations of the ordinary form Bryde's whales occur in these oceanic regions. The study provided no evidence to support the occurrence of more than one population of the ordinary form in the western North Pacific.

The range of sequence divergence among ordinary form individuals was 0.28-3.74%. These values were much lower than the divergence calculated between ordinary form and local form whales (6.71-16.96%). At the population level, genetic distances among ordinary form populations were well correlated with their geographical locations. A negative value for the net inter-population distance was found between the two sectors in the western North Pacific. Among Pacific Ocean populations, the range was 0.11-0.60% while that between the Pacific and Indian Ocean populations was 0.74-1.09%. Genetic distances between ordinary form populations and the animals from Kochi ranged from 7.41% to 9.25% while those between ordinary form populations and the animals from the Solomon Islands ranged from 14.34% to 15.58%.

In discussion, Baker noted that the second most common haplotype for Bryde's whales in the Western North Pacific was the most common haplotype found in the Western South Pacific and raised the possibility of movement from the North to the South Pacific. Polacheck noted that the results of one test for differences between the Gr-A and Gr-B sectors were very close to significant ($P = 0.0520$). Pastene responded that because the other two statistics were far from significant and the net genetic distance was very low (zero) he would disregard the near-significant results for the Hst statistic.

Perrin presented SC/50/RMP13 which summarised available information on distribution relative to water depth of Bryde's whales in the Philippines. The information was requested by the sub-committee last year because of the suggested possibility of using a depth contour (the 1000-m isobath was mentioned) as the offshore limit of distribution of the local form Bryde's whales in the western Pacific. There are only six confirmed records. Five were in inner waters of about 250-1,000m depth; these were presumably of the local form. One sighting (unidentified but presumably of the ordinary form) was made off the eastern coast of Mindanao, in water some 5km deep. There are no records between 1km and 5km. Catch positions within the Philippines EEZ for 96 whales taken during Philippine commercial whaling in 1983-85 are thought to have been falsified; there is some evidence that the whales were captured outside the EEZ to the east and northeast. The limited data indicate that the 1,000m isobath would not be suitable to delimit the offshore distribution of the local form because more information (from sightings cruises) is needed on distribution over intermediate depths (1,000-5,000m) in the region.

Hatanaka queried the interpretation that water depth limits the distribution of animals, and he suggested the alternative interpretation that animals are distributed mainly in the water between islands.

Since the accuracy of the positions of the commercial catch is suspect, the sub-committee agreed that these data could not be used to make inferences about stock structure or distribution.

SC/50/CAWS6 summarised the information on stock identity and distribution for Bryde's whales in the eastern South Pacific. The Bryde's whale has been difficult to study in this region due to its similarity with the sei whale. Whaling stations continued to confuse both species until 1973 in Peru and 1981 in Chile. Bryde's whales are found in this region from the Equator to 37°S. Morphometric and genetic studies have separated Bryde's whales from Peru from animals from the western South and North Pacific and from animals from the Indian Ocean. No firm evidence exists to support additional stock structure in the eastern South Pacific. Most of the whaling operations and assessment of Bryde's whales in Peru were carried out in square H34 (0°-10°S; 80°W-90°W). Bryde's whales seem to occur in most months of the year in this square but especially during the austral summer. On the other hand, Bryde's whales in Chile seem to occur mainly in the central area (35°S-37°S) in spring-summer associated with a seasonal upwelling event. Relationships between Peruvian and Chilean Bryde's whales are unknown.

Best introduced a review of the distribution and population separation of Bryde's whales off southern Africa (SC/50/CAWS13), as requested last year. Available catch, sightings and biological data suggest that there are three stocks in the region. An inshore population (the South African Inshore Stock) occurs over the continental shelf of South Africa south of about 30°S, and appears to be non-migratory, although it may move up the west coast in winter. A pelagic population (the Southeast Atlantic Ocean Stock) occurs on the west coast of southern Africa, ranging from equatorial regions to about 34°S, and appears to migrate north in autumn and south in spring. A third (pelagic) population (the Southwest Indian Ocean Stock) occurs south of Madagascar northwards. Whales from the Southeast Atlantic Ocean Stock are larger than those from the other two stocks, and differ in scarring, baleen shape, diet, fecundity and seasonality of reproduction from those in the South African Inshore Stock. Circumstantial evidence suggests that the individual from Durban regarded as 'abnormal' may have been from the Southwest Indian Ocean Stock.

SC/50/RMP18 summarised the mark-recapture data for Western North Pacific Bryde's whales by 5° square using all available information (51 animals). The mark-recapture data indicate that: (a) the animals found in the whaling grounds in summer come from a wide latitudinal band from 5°S to 30°N where they are found in winter, and (b) intermingling of animals is observed from 5°S to 40°N and 130°E to 180°. The movements of 16 animals from or to the 5° squares including islands showed that all were connected to the offshore squares without islands. It was believed that this implies that the mark-recapture data do not support the existence the local form around the islands.

It was noted that the interpretation of the information in SC/50/RMP18 needed to account for the historical distribution of effort. For example, the lack of recaptures in the southern longitudinal bands was not surprising owing to the lack of historical effort in this area. Polacheck commented that there did not appear to be much longitudinal movement of animals marked north of 20ºN. He noted that only one animal had been recaptured more than 20º longitude away from where it was marked, although this may also be a consequence of the distribution of effort.

On the basis of inferences from where the local form has been shown to occur, historical commercial catches, sightings from research surveys and observations based on whalewatching as described in Appendix 11. Hatanaka argued that any Bryde's whales around the Hawaiian Islands, Midway Island, the Kiribati Group, the Caroline Islands, and the Northern Marianas should be considered to be of the ordinary form. Perrin disagreed, noting that no surveys had been conducted near the Hawaiian Leeward Islands and that just because ordinary form Bryde's whales are found near an island does not imply that the local form cannot also occur there. Brownell commented that the situation for Midway Island and the Hawaiian Islands may be quite different from that for the islands in Indo-Pacific including the other island groups noted by Hatanaka.

Hatanaka presented SC/50/RMP11 which proposed three hypotheses regarding stock structure for western North Pacific Bryde's whales based on the results of 1996 Comprehensive Assessment, the outcomes of the intersessional e-mail correspondence group and other available information. These are: (1) only the ordinary form is found in stock division b (SC/50/RMP11, fig. 2), (2) animals of the local form are found around oceanic islands within this division, and (3) Southern Hemisphere Bryde's whales move into division b occasionally. SC/50/RMP11 suggested that the first of these hypotheses was supported by several sources of information, while no information negating it exists. The author believed that there is no information to support the second and third hypotheses. SC/50/RMP11 proposed three options for *Implementation Simulation Trials* based on these hypotheses (and their relative plausibility). These are: (1) a single stock scenario (the base case trial), (2) a 'two forms' scenario related to the second hypothesis, and (3) an intermediate scenario in which those island blocks from which mark-recapture and genetic samples were taken are allocated to the ordinary form.

In response to SC/50/RMP11, Perrin introduced Appendix 12 which raises several concerns with the assumption that the local form is not found around oceanic islands and that Southern Hemisphere Bryde's whales never migrate into the North Pacific. Kato noted that previous whaling operations around the Bonin Islands mainly occurred some 150-200 n.miles east of the islands. He further noted that although information from whalewatching can never be equivalent to a systematic survey, the whalewatching association of the Bonin Islands (OWA) has conducted seasonal surveys, which were organised more systematically than most whalewatching operations, in cooperation with the National Research Institute of Far Seas Fisheries. Whalewatching effort now extends to summer and autumn for sperm whales in addition to that in spring for humpback whales. However, no Bryde's whales had ever been seen around the coast of the Bonin Islands during surveys or whalewatching operations.

Appendix 13 summarises the existing information on sightings and sightings effort in the Western North Pacific and gives revised abundance estimates.

There was insufficient time to finalise discussion of the plausibility of the three hypotheses presented in SC/50/RMP11 or, therefore, to finalise agreement on how to model the structure of inshore and offshore Bryde's whales in and around major island groups.

The sub-committee then discussed plausible stock structure hypotheses for offshore Bryde's whales from a starting point of the stock area proposed by the Comprehensive Assessment and modified to exclude the area south of 10ºN (Appendix 10, Adjunct 1).

Smith and Polacheck expressed a number of concerns based on the available information on catch distribution, and genetic and marking data. First, they queried why there was a gap in the catch distribution between 150° and 160°E. Second, they noted that there were large areas of ocean to the east of the proposed stock area in which there were no data. Third, having examined changes in catches over time in the area of pelagic whaling, they pointed out that downward trends in catches had occurred at a small spatial scale (5° × 5° block) over short (up to 5 year) periods of time. This raised concerns about local depletion and the possible desirability of incorporating within-stock spatial structure in the trials.

Hatanaka responded to these three issues. First, he pointed out that the gap in catch distribution between 150° and 160°E was a result of catch regulations; the western boundary to pelagic whaling set by the Government of Japan at that time was 159°E and the eastern extent of coastal whaling was restricted by distance from the land station. Second, he noted that although there were no genetic or marking data in the area to the east of 170°E, there were large catches and analyses of biological data had indicated no difference between whales taken by coastal and pelagic whaling. Third, he believed that it was clear from all the available data that there was no within stock spatial structure latitudinally or longitudinally. Ohsumi added that the observed trends in catches identified by Smith and Polacheck were a result of operational factors such as changes in the range of pelagic whaling grounds and catch quotas.

After considerable discussion of the available data and the areas to which they pertained (summarised in Appendix 14), the sub-committee agreed that an appropriate boundary to the western stock of North Pacific Bryde's whales for the purposes of the RMP was as described in Appendix 14. This specifically excluded the area to the south of the Hawaiian Islands and east of 180° from which there were no data. The sub-committee further agreed that there should be two sub-areas in this stock area divided by 180° which would allow the testing of two alternative stock hypotheses:

(1) there is only one stock of offshore Bryde's whales in the western stock area;
(2) there are two offshore stocks present in the sub-area to the east (sub-area 2 in Appendix 14), the western stock and an eastern stock.

The sub-committee noted that it was planned for future sightings surveys to cover the entire western stock area as defined over a four year period.

Key questions concerning stock structure that remained include: how to model the interchange between inshore and offshore Bryde's whales in the areas around islands; whether or not operational factors can explain the observed trends in catches at small spatial scales, and if not whether within-stock spatial structure needed to be considered.

Concerning catch data, a key issue is resolution of the disagreement last year about how to treat Soviet catches in the trials (IWC, 1998b). This would need to be resolved after sub-areas had been fully defined.

To address these and other questions relating to the specification of the simulation trials, the intersessional Working Group from last year was re-established under Punt to work by e-mail and to report to next year's meeting. Hatanaka further proposed that to ensure good progress a workshop should be held before next year's meeting. This had been considered last year but no workshop had been held. The sub-committee agreed that the detailed work of specifying trials was best conducted at a separate meeting but recognised that the priority given to any such meeting would need to be decided by the Committee during plenary discussions.

8.4.2 Sightings survey planning

Smith described the work of the North Pacific Sighting Survey Steering Group (NPSSSG), noting that nine tasks were identified (Appendix 8). The Steering Group was able to address several of these, and additional material was presented to the sub-committee relative to the remaining tasks. One important task was the development of review comments on an initial draft of the sighting survey proposal (SC/50/RMP4). Although comments were generated within the group, there was insufficient time for members to discuss the points raised. These comments were available for further discussion during this meeting. Several documents were also available to the meeting that addressed the outstanding issues.

Miyashita presented SC/50/RMP5, the revised version of the four year sighting survey plan addressed by the NPSSSG. He noted that this document included text in italics for convenience in determining how the several recommendations of the NPSSG were accommodated. He also outlined the key features proposed for the conduct of the survey, noting that there will be three vessels used and that the expected number of sightings was 30 per vessel. One of the vessels will have the capability of an independent observer platform, which will be used as a feasibility study to determine if $g(0)$ is close to one or not.

In discussion, it was clarified that the data being collected are intended for use in both implementation simulation trials and implementation of the RMP for North Pacific Bryde's whales. It was suggested that the initial estimate of school size, at the time of sighting, be recorded as well as the actual estimate after closing in order to obtain data to correct school size estimates during passing mode. Although previous experience with this approach for Southern Hemisphere minke whales was noted to have been unsatisfactory, an attempt under these situations was suggested by some as being worthwhile. Covering an entire latitudinal band in one year was noted to be a good approach.

The sub-committee considered the requirements for participation of a member of the Scientific Committee in this survey, as decided by the Committee last year.

The sub-committee agreed that Scientific Committee representation on the planned survey should take the form of participation of a scientist with active experience of surveys of the type. The sub-committee noted that Shimada would participate in the survey.

The sub-committee **strongly recommends** that the surveys include waters within the EEZs of the Federated states of Micronesia, the Republic of the Marshall Islands and the USA in order to provide the necessary coverage. It **recommends** that the Commission requests the relevant authorities of the Federated States of Micronesia, the Republic of the Marshall Islands and the USA to grant permission for the vessels to operate in their EEZs.

9. LONGER TERM PRIORITIES AND DIRECTIONS

The sub-committee discussed priorities and directions under the following items: (a) issues relating to the RMP, (b) specifying, conditioning and conducting implementations and implementation reviews, and (c) reviewing and overseeing surveys plans and abundance estimates that are used in implementation trials and could be used in the implementation of the RMP.

(a) Priorities related to the RMP include:
 (1) revise *CLA* program (see Item 3.2);
 (2) tune the *CLA* to the accuracy needed (see Item 3.1).

(b) Long-term priorities related to specifying implementation trials include:
 (1) finalise specification and conduct implementation trials for North Pacific minke whales;
 (2) specify and conduct implementation trials for North Pacific Bryde's whales;
 (3) review and, as appropriate, re-specify the currently agreed implementation for northeast Atlantic minke whales (see below).

(c) There are long and short-term priorities related to reviewing and overseeing survey plans and abundance estimates.

Long-term high priority topics include:
 (1) review plans for surveys and, as appropriate, suggest ways to obtain better data so that complicated analytical methods are not needed;
 (2) review abundance estimates from surveys intended for use in the RMP, specifically estimates from surveys for North Pacific minke and Bryde's whales and northeast Atlantic minke whales;
 (3) create and maintain a sufficient number of replicates of simulated data sets that have a variety of characteristics, particularly those that are similar to sighting surveys that have recently or will be conducted in the near future, e.g. in addition to those already simulated, include characteristics such as animal movement, errors in measurement, and duplication identification (see below);
 (4) analyse the above simulated data sets using estimation methods that might be used in the above mentioned surveys;
 (5) test existing abundance estimators for situations where ship avoidance is manifested by animals changing their surfacing patterns in response to survey vessels (e.g. Cooke, 1992).

Short-term high priority topics include:
 (1) review of Clarke and Borcher's simulation study to test the properties of the GAM-based estimators of abundance, in general and as applied to JARPA data (SC/50/CAWS33) - this started during the meeting and will continue intersessionally;
 (2) test abundance estimation procedures that estimate abundance and trends from multi-year surveys (applicable to IDCR, Northeast Atlantic minke whales and North Pacific Bryde's and minke whale surveys);
 (3) test procedures that identify duplicates and correct for duplication identification errors (applicable to Northeast Atlantic minke whales and North Pacific minke whale surveys).

For North Atlantic minke whales, catches have been taken by Norway under objection and substantial new information is available on abundance estimates. In addition, the methods used for specifying implementation trials have improved significantly since 1992. The sub-committee noted, therefore, that it may be appropriate to consider an *Implementation Review* for minke whales in this region in the near future.

The project to create and maintain simulated data sets is important not only to the work of this sub-committee but also to all other sub-committees. The sub-committee agreed, therefore, that this project should continue for at least the next few years. There are two options available to accomplish this. The first is to award a contract to support a part-time position in CSIRO; the second is to spread out the work to a number of investigators but maintain the central data base of simulation files on a ftp site. These are not mutually exclusive. However, it was noted that a substantial sum would be required to accomplish this, significantly more than the few thousand pounds requested last year.

10. ADOPTION OF REPORT

The report was adopted as amended at 10:30 on 6 May 1998. The sub-committee expressed appreciation of the chairmanship of Hammond and Polacheck.

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Appendix 1

AGENDA

1. Election of Chairman and appointment of rapporteurs
2. Adoption of agenda
3. *CLA* program
   - 3.1 Tuning
   - 3.2 Revision of program
4. Additional variance
5. Abundance estimation - general issues
   - 5.1 report of intersessional group on statistical estimators
   - 5.2 IWC-DESS
   - 5.3 Other
6. Documentation of RMP for incorporation into Schedule
7. Stock identity
8. Preparations for implementation
   - 8.1 Questions relating to implementation trials
   - 8.2 North Pacific minke whales
     - 8.2.1 Progress during intersessional period
     - 8.2.2 Uncertainty over catches
     - 8.2.3 Sightings survey planning
     - 8.2.4 Development of trials
   - 8.3 North Atlantic minke whales
     - 8.3.1 Northeastern stock
       - 8.3.1.1 Progress during intersessional period
       - 8.3.1.2 Review new information
       - 8.3.1.3 Conclusions
     - 8.3.2 Central stock
       - 8.3.2.1 Reconsideration of earlier estimates
       - 8.3.2.2 Data availability
   - 8.4 Western North Pacific Bryde's whales
     - 8.4.1 Specification of implementation simulation trials
       - 8.4.1.1 Progress during intersessional period
       - 8.4.1.2 Development of trials
     - 8.4.2 Sightings survey planning
9. Longer term priorities and directions
10. Adoption of report

Appendix 2

PROGRESS ON REVISION OF THE *CLA* PROGRAM

P.S. Hammond

At last year's meeting (IWC, 1998, item 7.2.2), the Committee recommended that the Secretariat investigate methods to calculate catch limits under the *CLA* more efficiently. It noted that it would be desirable if the same computer program could be used for calculating catch limits and for simulation studies. The Committee also recommended that this work be completed before the 1998 meeting and that the Secretariat should consider contracting out this task. An intersessional Working Group was set up to facilitate this with membership Allison, Butterworth, Cooke, Givens, Hammond (Chair), Punt, Smith, Walløe.

During the intersessional period the Working Group finalised a specification for computer program structure, documentation, and performance, including specification of a set of test conditions. This is given as Adjunct 1 and formed the basis of an invitation to bid for a contract to revise the program that implements the *CLA*. The invitation to bid was distributed to the members of the Working Group. One bid to do the work was received from the Norwegian Computing Center but at a price that was about ten times greater than the sum allocated by the Secretariat. It was agreed that this matter required further discussion at this meeting.

During intersessional discussions, Cooke described another program (MANAGE2) that he had written, based on MANAGE. He indicated that it gives the same catch limit for the E area as reported in Helgeland *et al.* (1997) using the Norwegian program, RMP, to two decimal places, and that it runs at roughly the same speed as that program.

Tuning

Although not included in the terms of reference of the Working Group, during the intersessional period, Allison identified problems with obtaining a revised tuning parameter at the level of precision specified by the Scientific Committee using the existing program, MANAGE, changed to double precision (IWC, 1998, item 7.2.2). This was confirmed by Cooke, who noted that the MANAGE programme was designed for low-precision work and the precision does not substantially improve as the step sizes are reduced. Cooke proposed a procedure for accomplishing this task (Adjunct 2) to be followed once a revised program to implement the *CLA* had been completed.

Adjunct 1. Specification for Computer Programs Required

A sub-routine and a calling program that implements the IWC's Catch Limit Algorithm is required. The callable Fortran subroutine must implement the *CLA* for a single stock as defined in IWC (1994a, pp.145-152). This should be written in Fortran 77 in a transparent manner consistent with modern programming principles.

A short main program should read in data (catch, abundance, variance/covariance matrix) and values of control parameters (tuning, phase out, required precision in units of whales), pass these inputs to the subroutine defined above, and return catch limits for the next five years and both calculated absolute (units of whales) and relative upper and lower error bounds of the limits resulting from the precision of the numerical integration.

All subprograms used must be open access and must not use library routines for which the code is unavailable. The subroutine must be readily used with both real data for individual calculations and in simulation trials for repeated calculations. The programs must be compilable and implemental on microcomputers. The precision of the calculation (and hence the time required to execute) must be controllable with a single control parameter setting.

Complete internal documentation is required within the computer code itself. A complete technical description of both the calling program and the subroutine, using modern computer program documentation procedures, with at least the level of detail of IWC (1994b, pp.153-167) is also required.

An overview description of the numerical analysis techniques used in the programs and a User's Guide, to include description of program use and guidance on control parameter values, are required.

The programs and documentation will become the property of the IWC.

The *CLA* sub-routine must be able to compute a catch limit accurate to one whale for a fixed tuning parameter for ranges of input data as follows, although less precise (and hence quicker) calculations must also be possible. The submitted program and documentation will be tested by comparing the calculated catch limits for selected combinations of data to the results obtained using other implementations of the *Catch Limit Algorithm*.

A. Abundance estimates: 1,000 to 1,000,000.
B. Coefficients of Variation of abundance estimates: 0.05 to 1.0.
C. Number of abundance estimates: 1 to 60.
D. Spacing of multiple abundance estimates: consecutive years and up to 10 years apart.
E. Length of catch history: 1 to 300 years.
F. Annual catches (number per year): 1 to 10,000.
G. Distribution of catches: uniform over time up to 90% in first or last half of catch history.
H. Covariance between abundance estimates: 0 to 0.5.

Specific deliverables

1. Fortran 77 subroutine implementing the *Catch Limit Algorithm*, internally documented.
2. Main program that calls sub-routine, internally documented.
3. Technical documentation of both the sub-routine and the calling program.
4. Description of numerical analysis methods used.
5. Users Guide.

Adjunct 2. Draft Specifications for Procedure to be used for Tuning

(a) Calculate (roughly) a number of trials aimed at achieving a 99% confidence interval in the D1 trial that lies within 0.719 to 0.721K, say 50,000 (err on the safe side – see (c) below).

(b) Conditional on this specific number of trials and on Allison's 'standard' random number seeds, calculate the tuning, to the nearest 10^{-5}K, that achieves a median final depletion of exactly 0.72K for this given set of trials.

(c) Calculate the 99% confidence interval for the median final depletion (there is a standard textbook formula for this) and confirm that it lies entirely within the range 0.719 to 0.721. If not, go back to (a) and increase the number of trials (by erring on the high side in the initial choice of the number of trials, it is expected that no iteration will be necessary).

(d) Round the result of (b) to the nearest 0.0001. This would become to the official new value of the tuning parameter to replace the value of 0.4102 in the current RMP specification.

(e) All subsequent real implementations of the *CLA* should calculate the catch limit to within one whale, conditional on the tuning parameter value arising from step (d).

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Appendix 3

REPORT OF THE RMP *AD HOC* GROUP TO CONSIDER FUTURE MAINTENANCE, SUPPORT AND DEVELOPMENT OF DESS

Members: Allison, Borchers, Buckland, Butterworth, Donovan (Convenor)

Background

The initial development of the IWC Database and Estimation Software System (DESS) by the Research Unit for Wildlife Population Assessment at the University of St Andrews (RUWPA) is now virtually complete. DESS is a complex piece of software and specialised programming skills are required to maintain and develop it further. The present IWC staff do not possess these skills and it would be difficult even after training to quickly acquire the same level of understanding as held by the developers (see Continuity below).

A related issue is the level of statistical competence required to perform even routine statistical analyses such as abundance estimation from SOWER surveys, using DESS. In addition to automating the process of extracting and plotting data by any geographic block, sighting type, species, etc., DESS automates standard distance analyses to a large degree. However, nobody in the Secretariat with a sufficient level of expertise to carry out even standard analyses has time available. One obvious option therefore would be for an appropriate additional member of staff to be employed at the Secretariat. However the *ad hoc* group noted that there are disadvantages in employing an additional staff member with the necessary skills.

For example, even if the new staff member took responsibility for routine data analyses as well as support and development of DESS, this work is unlikely to be sufficient for a full-time post. In addition, given that the Secretariat is not primarily a scientific body, that the work will to some extent become largely routine, and that there is little scope for promotion, past experience suggests that such a scientist would not remain in the post for long.

Proposal

The *ad hoc* group felt that an arrangement by which the IWC retains access to the programming and statistical expertise within RUWPA would be preferable to acquiring the expertise within the Secretariat. This being the case, the *ad hoc* group suggests that future maintenance and support for DESS and routine statistical analyses of DESS data could best be effected by the IWC funding part of a post within RUWPA.

The advantages of this arrangement include the following:

1. Working environment

The postholder would already hold much of the necessary expertise and would be working in a group with very relevant experience and expertise, which is active in developing software and methods for assessing wildlife populations.

2. Flexibility

There will probably not be enough regular additional computing and analysis work to justify a regular full-time post.

An arrangement by which the IWC funded around half a post at RUWPA annually, with the option of funding additional work by agreement with RUWPA if and when necessary, could provide both continuity and more flexibility than would normally be possible were the IWC to employ someone directly. RUWPA would make up the balance of the annual post costs from other sources, and the postholder would work on other projects for the remainder of the year. This might also put the IWC in a better position to respond to unanticipated computing and analysis tasks which arose at short notice.

3. Continuity

While substantial documentation has been created for DESS, much of the inner workings of the software cannot realistically be documented. It would be daunting for someone new to maintain and develop DESS. The arrangement suggested above has the advantage of retaining the experience and expertise already developed at RUWPA. In addition, Buckland's and Borchers' familiarity with IWC datasets and analysis methods will ensure consistency of future analyses with IWC methods and conventions.

Some existing tasks which the postholder would be in a good position to perform or assist with are listed below, together with some tasks which are likely to arise in the near future.

The full cost (including salary and office overheads but not travel between St Andrews and Cambridge) of the IWC funding half a post in RUWPA would be approximately £19,000 plus VAT per annum.

Existing relevant tasks* taken from table 5 of IWC (1998), and IWC (1997, p.152):

(1) calculation of Antarctic minke whale estimates south of a common northern boundary, by 10º, 20º, 30º and 60º longitude sectors and estimation of additional variance;
(2) verify North Pacific Bryde's whale abundance data;
(3) analysis of IDCR/SOWER IO data;
(4) development of objective duplicate identification methods for IDCR Antarctic minke survey data;
(5) estimation of trends in abundance using the IDCR Antarctic minke survey data;
(6) development of methods for combining survey data collected over different years;

* Items that were earmarked at a previous IWC Scientific Committee meeting to be performed by Butterworth and Brown have been omitted.

(7) incorporation of 'before/after' IDCR survey data and 'Dedicated survey' data into DESS.

Possible tasks in the near future:

(1) DESS maintenance, support and development, including addition of new datasets;

(2) Incorporation into DESS and analysis of 1997/98 (and any future) SOWER sighting survey dàta;

(3) SOWER2000 Survey. Some or all of: sightings data form preparation; data validation programs; data entry into DESS (including modifications to DESS); assistance in analyses of sightings survey data.

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Appendix 4

A RECOMMENDATION BY THE RMP WORKING GROUP ON STOCK DEFINITION TO ESTABLISH A WORKING GROUP OF THE SCIENTIFIC COMMITTEE ON STOCK DEFINITION

Members: DeMaster (Chair), Baker, Born, Brownell, Chen, Clapham, Cooke, Hester, Donahue, Donovan, Friday, Fujise, Goto, Hatanaka, Innes, Kasuya, Kato, Kawahara, Kim, Miyashita, Moronuki, Øien, Okamoto, Okamura, Pastene, Perrin, Pinedo, Rojas Bracho, Shimadzu, Slooten, Smith, Tanaka, E., Van Waerebeek, Wade, Walløe, Witting.

To date, most studies on stock identity of large whale species have attempted to test the hypothesis that existing IWC management units correspond to biologically distinct populations or to try to allow such units to be geographically, or sometimes temporally, defined. For this purpose, a suite of techniques have been used (e.g., sequence divergence, haplotypic frequency, morphological characters, presence/absence of parasites, pollutant loads, distribution, etc.). However, our ability to determine what constitutes a 'distinct' population, and indeed the need to do so in the traditional way, has recently been questioned. Rather, an approach that continues to emphasise management at the subspecific level, but which also allows for low levels (i.e., demographically negligible) of exchange between separate management units, has been proposed (see Taylor, 1997).

Several members of the Scientific Committee have commented that to move forward with such an approach, recently developed genetic techniques, as well as more traditional techniques, could be used to define what is meant by the term 'stock' in the context of managing large whales. It is therefore the recommendation of the RMP Working Group on Stock Definition (WGSD) that the Scientific Committee establish a Working Group for the purpose of developing one or more operational definitions of stock, which are better suited to the types of data currently available to evaluate stock structure and which are based on the management context in which they are to be used. Terms of reference for this group are reported below. In addition, the process by which the IWC's current definition of stock would be modified is outlined.

1. Background

At the recent Workshop on Right Whales (SC/50/Rep4), the following generic description of what a stock is, was reported: a stock is the 'unit that is be conserved. Such a unit is generally termed a 'management stock' and in ideal circumstances would normally be based on a true biological population, although it may be based on smaller groupings (Donovan, 1991).' An example of a smaller grouping would be a stock definition based on distinct feeding aggregations. At this same workshop, it was noted that recently developed genetic techniques for the purpose of stock identification have increased substantially over the last decade (e.g., see Dizon *et al.*, 1996).

However, the difficulty in interpreting genetic and other data regarding stock structure has also been noted during discussions of the Scientific Committee. In particular, the lack of a detected genetic difference cannot be assumed to prove the existence of a single stock. Three examples are summarised here for the purpose of describing the types of problems that are to be addressed by the WGSD.

During the meeting of the Working Group on North Pacific Minke Whale Trials the issue of the stock identify in the western North Pacific minke whale was discussed (IWC, 1997). For minke whales in this area several techniques, including genetics, were used to evaluate stock structure. While these techniques were successful in differentiating between putative stocks of minke whales distributed around the Korean Peninsula (J stock) and the eastern side of Japan (O stock), they did not resolve the issue regarding minke whale stock structure between animals in coastal waters along the eastern side of Japan and those from offshore waters east of Japan. As noted during the Working Group meeting, 'finding no significant differences does not in itself allow the hypothesis of two stocks to be abandoned.' In this case, the problem becomes one of how much additional data and analyses are needed prior to concluding those whales from coastal and offshore areas belong to a single stock. Working Group participants recognised the merit of having a prior agreement as to the level of genetic diversity sufficient to conclude that two putative stocks should be managed as separate stocks.

A second example of difficulties in the interpretation of data regarding the management of large whales concerns Southern Hemisphere minke whales. In this case, a considerable degree of heterogeneity in mtDNA between whales from Areas IV and V has been reported (IWC, 1998a). However, it was also reported that the expected degree of genetic differentiation between two putative stocks (referred to as the effect size) of Antarctic minke whales was very small, given the current sampling regime. Therefore, studies designed to evaluate stock identity for this species in this area require large sample sizes to obtain statistically reliable results. During recent discussion of the Scientific Committee it was suggested that 'genetic data can be best analysed in this particular case if analysts know the level of differentiation (i.e., effect size) they are looking for' (IWC, 1998b).

A third example concerns problems due to basing stock definitions solely upon genetic data and is illustrated by the North Atlantic population of the humpback whale. Population structure for North Atlantic humpback whales has been divided into several relatively discrete feeding stocks, fidelity to which is determined matrilineally. This fidelity appears to persist over an evolutionary time scale for feeding stocks off Iceland and Norway, where mtDNA work has shown that animals from these two areas are genetically distinct from each other and from the four other feeding grounds in the western North Atlantic (i.e., West Greenland, Newfoundland/Labrador, Gulf of St Lawrence and the Gulf of Maine). However, animals from different feeding grounds in the western North Atlantic cannot be distinguished with mtDNA. As a result, from a purely genetic standpoint, these animals would not be managed as separate management units. In contrast, the rate of exchange of animals between areas is known from photo-identification data to be very low. Therefore, there is no assurance that a feeding subpopulation which was extirpated would be readily repopulated by immigration from other nearby regions. If one of the goals of management is to maintain the extant range over which large whales occur, the use of all available information on stock structure is necessary to avoid or at least lower the likelihood of mismanagement.

2. Terms of reference

It is recommended that a Working Group on Stock Definition be established by the Scientific Committee and charged with the following duties:

(1a) Review the published literature regarding the current usage of the stock concept in managing renewable resources, with special emphasis on long-lived, highly mobile species;

(1b) Prepare a report summarizing the results of the review, particularly in the context of the RMP and any future AWMP;

(2a) Review case studies of management advice for large whales, with special emphasis on the extent to which the definition of a stock used in the assessment contributed to or detracted from the success of the assessment, with particular reference to the level and nature of the available data;

(2b) Prepare a report summarising the results of the review;

(3) Assess the results of studies using suitable spatially explicit population simulation models for the purpose of evaluating the relationships among population size, various rates of movement between putative stocks, methods of analysis, effect size and experimental design, taking into account the approaches presently used in developing Implementation Simulation Trials in the RMP and possible approaches used in developing future AWMP's;

(4) Endeavour to refine existing stock definitions on the basis of the above mentioned reports and activities; and

(5) Assess the desirability and means of considering multiple lines of evidence, including evidence from studies on movement patterns, morphology, and ecology, as well as genetics, in developing definitions of stocks.

It is recommended that the latter two tasks (and possibly task 3) be undertaken at an intersessional meeting sponsored by the Scientific Committee.

3. Proposed assignments for an Intersessional Meeting of the WGSD and the next Scientific Committee Meeting (1999)

An intersessional meeting of the WGSD should be scheduled upon the completion of the tasks identified in the previous paragraph. If this is to be accomplished prior to the 1999 meeting of the Scientific Committee, assignments will have to be agreed at this year's (1998) meeting of the Scientific Committee. Finally, to avoid unnecessary delays and to ensure the efficient development of appropriate stock definitions for the purpose of managing stocks of large whales, it is recommended that a Steering Group be identified and charged with the responsibility for making assignments as necessary to complete the activities described above and for the development of a final agenda for the intersessional meeting. That Group will also determine if sufficient progress has been made to warrant an intersessional meeting prior to the 1999 meeting of the Scientific Committee.

The financial implications of holding intersessional meetings were recognized by members of the RMP working group. Due to the importance of stock definition in the assessment and management of large whales, the RMP working group recommends that this activity be considered a high priority for the Scientific Committee over the next few years.

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Appendix 5

QUESTIONS THAT NEED TO BE ADDRESSED WHEN SPECIFYING *IMPLEMENTATION SIMULATION TRIALS*

D.S. Butterworth

Introduction

What is the primary purpose of Implementation Simulation Trials?
Implementation of the RMP in a particular situation involves a choice between a number of variants, such as '*catch capping*' and '*catch cascading*'. The results of the trials provide a basis upon which to make this choice.

Since the RMP has already been heavily simulation-tested, why are the additional trials needed?
The tests of the RMP were primarily tests of the *Catch Limit Algorithm* (*CLA*), which is identical to the RMP in the extreme situation where it is clear that only one breeding stock is involved. Although some tests of multi-stock situations were carried out on a generic basis, totally comprehensive testing of the multi-stock situation in this way is not practical. Therefore, the primary purpose of the *Implementation Simulation Trials* is to capture the range of uncertainties regarding stock structure and mixing which may pertain to a particular case.

While the RMP variant to be proposed needs to be robust across a plausible range of such and other uncertainties, there is no need to require robustness against circumstances that are known not to apply in a particular case. Hence the process of developing *Implementation Simulation Trials* involves 'conditioning' these trials on existing data; essentially this process amounts to restricting trials to ones which are not inconsistent with what is known from the data already available for the resource in question.

What do Implementation Simulation Trials involve?
A summary has already been developed by the Scientific Committee at its 1994 meeting (IWC, 1995, pp.117-9). This document therefore endeavours not to repeat that material, but rather to amplify it by casting it in the form of a 'check-list'.

A check-list for developing *Implementation Simulation Trials* (*ISTs*)

Framework
(1) Split the *Region* under consideration into '*Sub-Areas*'. Such areas must be sufficiently small that any catches from them cannot distinguish amongst the various breeding stocks which may be represented, i.e. the catch taken from each breeding stock present will be in proportion to the abundance of that breeding stock in that *Sub-Area*.

(2) Clarify whether there is sex- or age-dependence in migration patterns. If so, the models underlying the *ISTs* must incorporate the necessary level of disaggregation by sex and age.

Stock structure hypotheses
(3) Clarify the number of discrete breeding stocks present for each of the hypotheses put forward.

(4) The 'migration pattern' of each such stock through the year must be clarified for each such hypothesis, at least in so far as specifying the fraction of each breeding stock (disaggregated as under (2) if necessary) present in each *Sub-Area* in each time unit when catching or sighting surveys take place. These proportions, for a specific hypothesis, are collected in forms termed 'catch mixing matrices' or 'sighting mixing matrices'. Note that these matrices are not necessarily time-invariant; they can show trends and incorporate random components (all of which must be specified).

Stock dynamics
(5) Models for the dynamics of each breeding stock must be specified. Normally the age- (and possibly sex-) disaggregated BALEEN II model serves as the basis to develop such models.

Information used for conditioning
(6) Conditioning typically involves the computations of distributions of initial (pre-exploitation) size for the various breeding stocks for each of the hypotheses under consideration. This requires the following historic data:

(a) past catches, allocated by *Sub-Area* by year (season), and by shorter time-steps within seasons where relevant;
(b) past sighting survey estimates with their CVs (or more generally if pertinent, variance-covariance matrices) and timings, ideally by *Sub-Area*, but a wider spatial scale for such results can be accommodated;
(c) information from, for example, genetic analyses which provide estimates of the proportions of the number of whales in a *Sub-Area* at a particular time which belong to each breeding stock; and
(d) other information, such as CPUE series for example, which may be acceptable to the Scientific Committee as sufficiently reliable to contribute towards the estimation of pre-exploitation population size distributions.

(7) The values of certain parameters of the stock dynamics model about which there is uncertainty (e.g. *MSYR*) have to be specified for each trial before the conditioning process can proceed.

The future
(8) The variety of management options to be considered in the *ISTs* must be specified. This includes decisions upon:

(a) what combinations of *Sub-Areas* should be treated as *Small Areas* (and if such combination involves more than one *Sub-Area*, how are future catches allocated to that *Small Area* to be split amongst its constituent *Sub-Areas*); and

(b) how such *Small Areas* might be combined for the purpose of implementing some *catch cascading* or *catch capping* options (the last-mentioned also requires specification of which of the constituent *Small Areas* will be undercaught, and by how much, in years when it is applied).

(9) Options for the timing, coverage extent, and anticipated CVs for future surveys must be specified.

(10) The output statistics to be used to compare the performances of the RMP variants considered over the set of robustness trials applied must be defined.

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Appendix 6

SPECIFICATIONS OF THE NORTH PACIFIC MINKE WHALING TRIALS

A. Basic concepts and stock structure

The objective of these trials is to examine the performance of the RMP in scenarios which relate to the actual problem of managing a likely fishery for minke whales in the North Pacific. They attempt to bound the range of plausible hypotheses regarding the number of minke whale stocks in the North Pacific, how they feed (by sex and age) and recruit, and how surveys index them. The underlying dynamics model is age- and sex-structured and allows for multiple stocks. Note that these trials do not take account of 'leakage' (transference of animals) between putative stocks because previous results suggest that unintended stock depletion becomes less likely when leakage occurs (IWC, 1993).

The region to be managed (the western North Pacific) is divided into 13 sub-areas (see Fig. 1). Future surveys are unlikely to cover sub-areas 1, 2, 3, 4, 5, 6, 10 and 13 (see Table 1) so for these trials, these sub-areas are taken to be *Residual Areas* (although allowance is made for future incidental catches from some of these sub-areas – see section D). The term 'stock' refers to a group of whales from the same breeding ground where the number of animals dispersing between breeding grounds is sufficiently small to have no impact on the population dynamics. The model considers two hypotheses in this regard: (1) that there are three stocks, the J stock ('home' area - Sea of Japan and perhaps also the Yellow Sea and East China Sea), the O Stock ('home' area - the Okhotsk Sea, the east coast of Japan) and the W Stock (West Pacific); (2) that there are only the J and O stocks. The reason for considering the W stock is that, by unintentionally counting whales from such a stock during surveys, catch limits may be set which lead to over-exploitation of a coastal O stock.

The main differences from the trials specified by IWC (1997a) are:

(a) addition of trials with differing levels of incidental catch off Korea and Japan (section D); and
(b) addition of trials to condition on the proportion of animals of each stock in catches off Japan (section F, item (g)).

B. Basic dynamics

Further details of the underlying age-structured model and its parameters can be found in IWC (1991, pp. 112-112A), although note that the model has now been extended to take sex-structure into account. The 1+ population of a stock is governed by the equations:

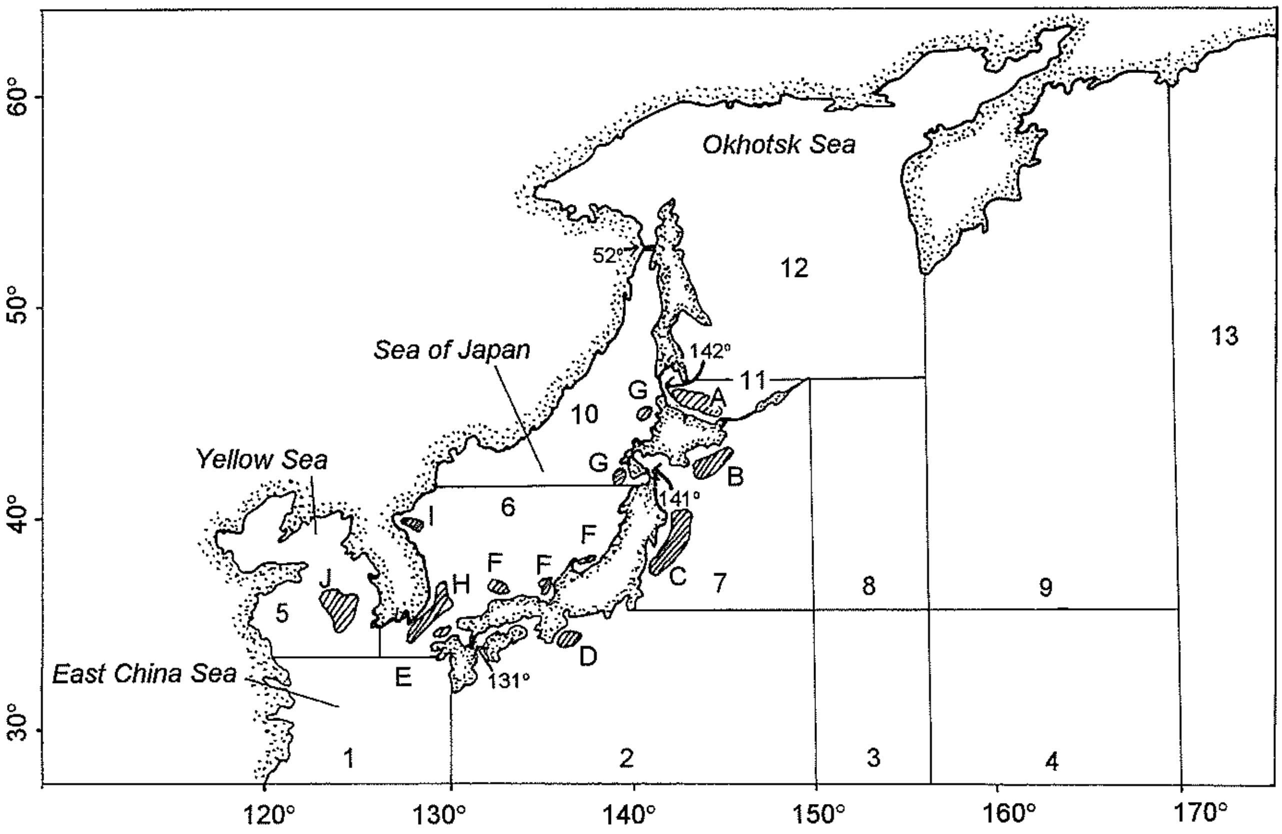

Fig. 1. Whaling grounds and the 13 sub-areas used for the *Implementation Simulation Trials* for the North Pacific minke whales (IWC, 1997c, p.204).

Table 1

Plan for future sighting surveys of minke whales in the western North Pacific.

	Sub-Area				
Season	7	8	9	11	12
1998				Aug.-Sep.	Aug.-Sep.
1999			Aug.-Sep.		
2000	Aug.-Sep.	Aug.-Sep.			
2001				Aug.-Sep.	Aug.-Sep.
2002			Aug.-Sep.		
2003	Aug.-Sep.	Aug.-Sep.			
2004				Aug.-Sep.	Aug.-Sep.
2005			Aug.-Sep.		
2006	Aug.-Sep.	Aug.-Sep.			
2007			Continuing in this pattern		

$$R^{m/f,s}_{t+1,a+1} = (R^{m/f,s}_{t,a} - C^{m/f,s}_{t,a})S_a + U^{m/f,s}_{t,a} S_a \delta_{a+1} \quad 0 \le a \le x-2$$
$$R^{m/f,s}_{t+1,x} = (R^{m/f,s}_{t,x} - C^{m/f,s}_{t,x})S_x + (R^{m/f,s}_{t,x-1} - C^{m/f,s}_{t,x-1})S_{x-1} \quad (1)$$
$$U^{m/f,s}_{t+1,a+1} = U^{m/f,s}_{t,a} S_a (1-\delta_{a+1}) \quad 0 \le a \le x-2$$

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

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

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

S_a is the instantaneous survival rate of animals of age a, and is equal to exp($-Ma$) where Ma is the instantaneous natural mortality rate for animals of age a (assumed to be independent of stock, sex and whether or not an animal is recruited),

$C^{m/f,s}_{t,a}$ is the catch of males/females of age a from stock s during year t, and

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

Note that year $t=0$, for which catch limits might first be set, corresponds to 1998.

For computational ease, the numbers-at-age and by sex are updated at the end of each year only, even though catching is assumed to occur from April to September. This simplification is unlikely to affect the results substantially for two reasons: (1) catches are at most only a few percent of the size of the recruited stock; and (2) sightings survey estimates are subject to high variability so that the resultant slight positive bias in abundance estimates is almost certainly inconsequential.

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.

$$U^{m/f,s}_{t,0} = 0.5(1 - a_0)B^s N^{f,s}_t\{1 + A^s(1 - (N^{f,s}_t/K^{f,s})^{z^s})]$$
$$R^{m/f,s}_{t,0} = 0.5a_0 B^s N^{f,s}_t \{1 + A^s (1 - (N^{f,s}_t/K^{f,s})^{z^s})\} \quad (2)$$

B^s is the average number of live births (both sexes) per year for mature females in stock s in the pristine population,

A^s is the resilience parameter for stock s,

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

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

$$N^{f,s}_t = \sum_{a=1}^{x} \beta_a (R^{f,s}_{t,a} + U^{f,s}_{t,a}) \quad (3)$$

a_0 is the proportion of animals of age 0 which are recruited, and $=0$ in this version,

b_a is the proportion of females of age a which are mature (assumed to be independent of stock, year and whether or not an animal is recruited), and

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

$$K^{f,s} = \sum_{a=1}^{x} \beta_a (R^{f,s}_{-\infty,a} + U^{f,s}_{-\infty,a}) \quad (4)$$

The values of the parameters A^s and z^s for each stock are calculated from the values of $MSYL^s$ and $MSYR^s$ as detailed in IWC (1991, pp.112-112A). Their calculation assumes harvesting equal proportions of males and females.

D. Catches

The operating model considers two sources for non-natural mortality (incidental catches and commercial catches). In future ($t \ge 1998$), the former are pre-specified, while the latter are set by the RMP. In cases in which the catch limit set by the RMP is less than the (pre-specified) level of incidental catch, the total removals are taken to be the incidental catch only, whereas if the RMP catch limit exceeds the incidental catch, the level of the commercial removals is taken to be the difference between the RMP catch limit and the incidental catch.

Catch limits are set by *Small Area*. (Catches are always reported by *Small Area*, i.e. the RMP is not provided with catches by sub-area for cases in which sub-areas are smaller than *Small Areas*.) As it is assumed that whales are homogeneously distributed across a sub-area, the catch limit for a sub-area is allocated to stocks by sex and age relative to their true density within that sub-area, and a catch mixing matrix V which depends on sex, age and the time of the year, and may also depend on year, i.e.:

$$C^{m/f,s}_{t,a} = \sum_k \sum_q C^{m/f,s,k,q}_{t,a}$$
$$C^{m/f,s,k,q}_{t,a} = C^{m/f,k,q}_t \{V^{m/f,s,k,q}_{t,a} R^{m/f,s}_{t,a} / \sum_j \sum_{a'=1}^{x} V^{m/f,j,k,q}_{t,a'} R^{m/f,j}_{t,a'}\} \quad (5)$$

$C^{m/f,s,k,q}_{t,a}$ is the catch of males/females of age a from stock s in sub-area k during month q of year t, where $t \ge 1998$, and

$C^{m/f,k,q}_t$ is the catch of males/females from sub-area k during month q of year t.

Each entry in the catch mixing matrix $V^{m/f,s,k,q}_{t,a}$, is the fraction of males/females of age a from stock s which are found in sub-area k during month q of year t. The catch mixing matrix is different for each month to reflect the effects of migration between the breeding and the feeding grounds. Table 2 gives the catch mixing matrices considered. The rationale for the values used is given in (IWC, 1997d). The catch mixing matrices give the relative fraction of an age-class in each of the sub-areas during the months April-September. Once the values of the mixing rate parameters γ_1 - γ_{11} are specified (these are estimated separately for each trial in the conditioning process), the catch mixing matrices can be

Table 2

The catch mixing matrices (the sightings mixing matrix is calculated from the catch mixing matrices for August and September). Differences from the base-case matrices (A, B, F and K) are in **bold** type. The rationale for the values used is given in IWC (1997d).
J Stock (Option C) is identical to Option A except there are no J stock whales in sub-Area 5 (i.e. the sub-Area 5 column is replaced with zeros and historic catches from sub-Area 5 are assumed to have been taken from another, unmodelled, stock). J Stock (Option D) is identical to Opion B except there are no J stock whales in sub-Area 5 (i.e. the sub-Area 5 column is replaced with zeros and historic catches from sub-Area 5 are assumed to have been taken from another, unmodelled, stock). J Stock (Option E) is identical to Option B except there are no J stock whales in sub-Area 7 (i.e. the sub-Area 7 column is replaced with zeros). W Stock (Option L) is identical to Option K except there are no W stock whales in sub-Area 8 (i.e. the sub-Area 8 column is replaced with zeros).

Month/ Age-class	Sub-Area 1	2	3	4	5	6	7	8	9	10	11	12
J Stock (Option A)												
Age 4												
Apr.	1	0	0	0	1	1	0	0	0	1	γ_1	0
May	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jun.	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jul.	0	0	0	0	1	1	0	0	0	1	γ_2	0
Aug.	0	0	0	0	1	1	0	0	0	1	X^1	0
Sep.	1	0	0	0	1	2	0	0	0	1	0	0
Age 10 - Female												
Apr.	1	0	0	0	1	1	0	0	0	1	$2\gamma_1$	0
May	0	0	0	0	1	1	0	0	0	2	$2\gamma_2$	0
Jun.	0	0	0	0	1	1	0	0	0	2	$2\gamma_2$	0
Jul.	0	0	0	0	1	1	0	0	0	1	$2\gamma_2$	0
Aug.	0	0	0	0	1	1	0	0	0	1	γ_2	0
Sep.	1	0	0	0	1	2	0	0	0	1	0	0
Age 10 - Male												
Apr.	1	0	0	0	1	1	0	0	0	1	γ_1	0
May	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jun.	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jul.	0	0	0	0	1	1	0	0	0	1	γ_2	0
Aug.	0	0	0	0	1	1	0	0	0	1	γ_{11}	0
Sep.	1	0	0	0	1	2	0	0	0	1	0	0
J Stock (Option B) some animals in sub-Area 7 in Aug./Sep. and in sub-Area 12 in May-Aug.												
Age 4												
Apr.	1	0	0	0	1	1	0	0	0	1	γ_1	0
May	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jun.	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jul.	0	0	0	0	1	1	0	0	0	1	γ_2	0
Aug.	0	0	0	0	1	1	$2\gamma_4$	0	0	1	X^1	0
Sep.	1	0	0	0	1	2	$2\gamma_4$	0	0	1	0	0
Age 10 - Female												
Apr.	1	0	0	0	1	1	0	0	0	1	$2\gamma_1$	0
May	0	0	0	0	1	1	0	0	0	2	$2\gamma_2$	γ_3
Jun.	0	0	0	0	1	1	0	0	0	2	$2\gamma_2$	γ_3
Jul.	0	0	0	0	1	1	0	0	0	1	$2\gamma_2$	γ_5
Aug.	0	0	0	0	1	1	γ_4	0	0	1	γ_2	γ_5
Sep.	1	0	0	0	1	2	γ_4	0	0	1	0	0
Age 10 - Male												
Apr.	1	0	0	0	1	1	0	0	0	1	γ_1	0
May	0	0	0	0	1	1	0	0	0	2	γ_2	γ_3
Jun.	0	0	0	0	1	1	0	0	0	2	γ_2	γ_3
Jul.	0	0	0	0	1	1	0	0	0	1	γ_2	γ_5
Aug.	0	0	0	0	1	1	$5\gamma_4$	0	0	1	γ_{11}	γ_5
Sep.	1	0	0	0	1	2	$5\gamma_4$	0	0	1	0	0
O Stock (Option F) for trials with O and W stocks												
Age 4												
Apr.	0	2	0	0	0	0	4	0	0	0	γ_7	0
May	0	1	0	0	0	0	4	0	0	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	0	0	0	γ_7	0
Age 10 - Female												
Apr.	0	2	0	0	0	0	4	0	0	0	$2\gamma_7$	$2\gamma_6$
May	0	1	0	0	0	0	2	0	0	0	$2\gamma_7$	$3\gamma_6$
Jun.	0	0	0	0	0	0	1	0	0	0	$2\gamma_7$	$3\gamma_6$
Age 10 – Female cont.												
Jul.	0	0	0	0	0	0	1	0	0	0	$2\gamma_7$	$3\gamma_6$
Aug.	0	0	0	0	0	0	1	0	0	0	γ_7	$2\gamma_6$
Sep.	0	0	0	0	0	0	1	0	0	0	γ_7	γ_6
Age 10 - Male												
Apr.	0	2	0	0	0	0	4	0	0	0	γ_7	γ_6
May	0	1	0	0	0	0	4	0	0	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
O Stock (Option G) for trials with an O stock only												
Age 4												
Apr.	0	2	2	2	0	0	4	1	0	0	γ_7	0
May	0	1	1	1	0	0	4	1	0	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	1	0	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	1	0	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	1	0	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	1	0	0	γ_7	0
Age 10 - Female												
Apr.	0	2	2	2	0	0	4	1	4	0	$2\gamma_7$	$2\gamma_6$
May	0	1	1	1	0	0	2	1	2	0	$2\gamma_7$	$3\gamma_6$
Jun.	0	0	0	0	0	0	1	1	1	0	$2\gamma_7$	$3\gamma_6$
Jul.	0	0	0	0	0	0	1	1	1	0	$2\gamma_7$	$3\gamma_6$
Aug.	0	0	0	0	0	0	1	1	1	0	γ_7	$2\gamma_6$
Sep.	0	0	0	0	0	0	1	1	1	0	γ_7	γ_6
Age 10 - Male												
Apr.	0	2	2	2	0	0	4	2	4	0	γ_7	γ_6
May	0	1	1	1	0	0	4	2	2	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	2	2	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	2	2	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	2	2	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	2	2	0	γ_7	γ_6
O Stock (Option H) for trials with O and W stocks (Some O stock animals in sub-Area 10, compared to Option F)												
Age 4												
Apr.	0	2	0	0	0	0	4	0	0	**0**	γ_7	0
May	0	1	0	0	0	0	4	0	0	**γ_8**	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	0	0	**γ_8**	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	0	0	**γ_8**	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	0	0	**0**	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	0	0	**0**	γ_7	0
Age 10 - Female												
Apr.	0	2	0	0	0	0	4	0	0	**0**	$2\gamma_7$	$2\gamma_6$
May	0	1	0	0	0	0	2	0	0	**$2\gamma_8$**	$2\gamma_7$	$3\gamma_6$
Jun.	0	0	0	0	0	0	1	0	0	**$2\gamma_8$**	$2\gamma_7$	$3\gamma_6$
Jul.	0	0	0	0	0	0	1	0	0	**$2\gamma_8$**	$2\gamma_7$	$3\gamma_6$
Aug.	0	0	0	0	0	0	1	0	0	**0**	γ_7	$2\gamma_6$
Sep.	0	0	0	0	0	0	1	0	0	**0**	γ_7	γ_6
Age 10 - Male												
Apr.	0	2	0	0	0	0	4	0	0	**0**	γ_7	γ_6
May	0	1	0	0	0	0	4	0	0	**γ_8**	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	0	0	**γ_8**	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	0	0	**γ_8**	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	0	0	**0**	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	0	0	**0**	γ_7	γ_6

cont…

Table 2 continued.

Month/ Age-class	Sub-Area 1	2	3	4	5	6	7	8	9	10	11	12
O Stock (Option I) for trials with an O stock only (Some O stock animals in sub-Area 10, compared to Option G)												
Age 4												
Apr.	0	2	2	2	0	0	4	1	0	**0**	γ_7	0
May	0	1	1	1	0	0	4	1	0	γ_8	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	1	0	γ_8	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	1	0	γ_8	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	1	0	**0**	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	1	0	**0**	γ_7	0
Age 10 - Female												
Apr.	0	2	2	2	0	0	4	1	4	**0**	$2\gamma_7$	$2\gamma_6$
May	0	1	1	1	0	0	2	1	2	$2\gamma_8$	$2\gamma_7$	$3\gamma_6$
Jun.	0	0	0	0	0	0	1	1	1	$2\gamma_8$	$2\gamma_7$	$3\gamma_6$
Jul.	0	0	0	0	0	0	1	1	1	$2\gamma_8$	$2\gamma_7$	$3\gamma_6$
Aug.	0	0	0	0	0	0	1	1	1	**0**	γ_7	$2\gamma_6$
Sep.	0	0	0	0	0	0	1	1	1	**0**	γ_7	γ_6
Age 10 - Male												
Apr.	0	2	2	2	0	0	4	2	4	**0**	γ_7	γ_6
May	0	1	1	1	0	0	4	2	2	γ_8	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	2	2	γ_8	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	2	2	γ_8	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	2	2	**0**	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	2	2	**0**	γ_7	γ_6
O Stock (Option J) for trials with O and W stocks (Some O stock animals in sub-Area 8, compared to Option F)												
Age 4												
Apr.	0	2	0	0	0	0	4	γ_9	0	0	γ_7	0
May	0	1	0	0	0	0	4	γ_9	0	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	γ_9	0	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	γ_9	0	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	γ_9	0	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	γ_9	0	0	γ_7	0
Age 10 Female												
Apr.	0	2	0	0	0	0	4	γ_9	0	0	$2\gamma_7$	$2\gamma_6$
May	0	1	0	0	0	0	2	γ_9	0	0	$2\gamma_7$	$3\gamma_6$
Jun.	0	0	0	0	0	0	1	γ_9	0	0	$2\gamma_7$	$3\gamma_6$
Jul.	0	0	0	0	0	0	1	γ_9	0	0	$2\gamma_7$	$3\gamma_6$
Aug.	0	0	0	0	0	0	1	γ_9	0	0	γ_7	$2\gamma_6$
Sep.	0	0	0	0	0	0	1	γ_9	0	0	γ_7	γ_6
Age 10 - Male												
Apr.	0	2	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6
May	0	1	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6

Month/ Age-class	Sub-Area 1	2	3	4	5	6	7	8	9	10	11	12
W Stock (Option K) for trials with O and W stocks												
Age 4												
Apr.	0	0	1	1	0	0	0	0	0	0	0	0
May	0	0	1	1	0	0	0	0	0	0	0	0
Jun.	0	0	1	1	0	0	0	0	0	0	0	0
Jul.	0	0	1	1	0	0	0	0	0	0	0	0
Aug.	0	0	1	1	0	0	0	0	0	0	0	0
Sep.	0	0	1	1	0	0	0	0	0	0	0	0
Age 10 - Female												
Apr.	0	0	2	2	0	0	0	1	2	0	0	γ_{10}
May	0	0	1	1	0	0	0	1	1	0	0	$2\gamma_{10}$
Jun.	0	0	0	0	0	0	0	1	1	0	0	$2\gamma_{10}$
Jul.	0	0	0	0	0	0	0	1	1	0	0	$3\gamma_{10}$
Aug.	0	0	0	0	0	0	0	1	1	0	0	$3\gamma_{10}$
Sep.	0	0	0	0	0	0	0	1	1	0	0	$2\gamma_{10}$
Age 10 - Male												
Apr.	0	0	2	2	0	0	0	1	2	0	0	γ_{10}
May	0	0	1	1	0	0	0	1	3	0	0	γ_{10}
Jun.	0	0	0	0	0	0	0	2	4	0	0	$2\gamma_{10}$
Jul.	0	0	0	0	0	0	0	2	4	0	0	$2\gamma_{10}$
Aug.	0	0	0	0	0	0	0	2	4	0	0	γ_{10}
Sep.	0	0	0	0	0	0	0	2	3	0	0	γ_{10}
W Stock (Option M) for trials with O and W stocks (some W stock animals in the Japanese coastal waters)												
Age 4												
Apr.	0	0	**1**	**1**	0	0	**0**	0	0	0	**0**	0
May	0	0	**1**	**1**	0	0	**0**	0	0	0	**0**	0
Jun.	0	0	**0**	**0**	0	0	**1**	0	0	0	**0**	0
Jul.	0	0	**0**	**0**	0	0	**1**	0	0	0	**1**	0
Aug.	0	0	**0**	**0**	0	0	**1**	0	0	0	**1**	0
Sep.	0	0	**0**	**0**	0	0	**1**	0	0	0	**0**	0
Age 10 - Female												
Apr.	0	0	2	2	0	0	0	1	2	0	0	γ_{10}
May	0	0	1	1	0	0	0	1	1	0	0	$2\gamma_{10}$
Jun.	0	0	0	0	0	0	0	1	1	0	0	$2\gamma_{10}$
Jul.	0	0	0	0	0	0	0	1	1	0	0	$3\gamma_{10}$
Aug.	0	0	0	0	0	0	0	1	1	0	0	$3\gamma_{10}$
Sep.	0	0	0	0	0	0	0	1	1	0	0	$2\gamma_{10}$
Age 10 - Male												
Apr.	0	0	2	2	0	0	0	1	2	0	0	γ_{10}
May	0	0	1	1	0	0	0	1	3	0	0	γ_{10}
Jun.	0	0	0	0	0	0	0	2	4	0	0	$2\gamma_{10}$
Jul.	0	0	0	0	0	0	0	2	4	0	0	$2\gamma_{10}$
Aug.	0	0	0	0	0	0	0	2	4	0	0	γ_{10}
Sep.	0	0	0	0	0	0	0	2	3	0	0	γ_{10}

[1] $X = (\gamma_2 + \gamma_{11})/2$.

converted to the percentages of each age-class in each sub-area. The values for the parameters γ_1 - γ_{11} will be determined to mimic available data (see Section F). In many trials, the catch mixing matrix for each of the 100 simulations and for each of the years of the associated pre-management and 100 year management periods is selected at random from two possibilities (e.g. matrices A and B for the J stock). In this case, a random number is generated for each year from U[0,1]; if this number is larger than 0.5, then the catch mixing matrix used for stock J is matrix A, otherwise it is matrix B.

Catch mixing matrices are specified for ages 4 and 10 (these being three years below and above the assumed age-50%-maturity). Few animals of age 4 are mature while most of age 10 are. The catch mixing matrices for ages 0-3 are assumed to be the same as that for age 4 and those for ages 11+ the same as that for age 10. The catch mixing matrices for ages 5-9 are calculated by interpolating linearly between those for ages 4 and 10.

The model considers a future six-month whaling season (April-September). In order to account for historical catches outside these months, all catches in January-March are added to those in April and the catches after September are assumed to have been taken in September. The historic commercial and scientific catches by sex, sub-area, month and year are given in Table 3.

Table 3

Commercial and scientific catches by sub-Area and sex for each season and year. The sub-Areas are shown in Fig.1.

Area	Yr	Males						Females					
		J-A	M	J	J	A	S-D	J-A	M	J	J	A	S-D
1	1951	0	0	0	1	0	0	0	0	0	0	0	0
1	1957	17	0	0	0	0	0	11	0	0	0	0	0
2	1948	0	0	2	0	0	1	0	0	0	0	0	0
2	1950	0	0	1	2	0	0	0	0	0	1	0	1
2	1951	0	1	0	0	0	0	0	0	0	0	0	0
2	1952	1	0	0	0	0	0	1	0	0	0	0	0
2	1954	1	0	0	0	0	0	1	0	0	0	0	0
2	1957	1	0	0	0	0	0	1	0	0	0	0	0
2	1965	1	0	0	0	0	0	1	0	0	0	0	0
2	1966	2	0	0	0	0	0	1	0	0	0	0	0
2	1981	0	1	0	0	0	0	0	0	0	0	0	0
2	1985	1	0	0	0	0	0	0	0	0	0	0	0
5	1940	13	4	4	3	2	3	11	4	3	3	2	1
5	1941	25	8	7	6	4	4	22	7	6	6	3	4
5	1942	32	10	9	8	5	7	30	10	8	8	4	4
5	1943	25	8	7	6	4	4	22	7	6	6	3	4
5	1944	24	7	6	6	3	4	20	7	6	5	3	3
5	1945	2	1	1	1	1	0	0	0	0	0	0	0
5	1955	0	1	1	0	0	0	3	3	2	0	0	0
5	1956	0	1	1	0	0	0	3	3	2	0	0	0
5	1957	34	11	11	7	4	6	36	14	12	7	4	6
5	1958	46	11	13	6	3	4	55	22	21	7	3	3
5	1959	53	13	13	8	5	6	67	28	25	9	5	4
5	1960	36	18	13	11	5	5	57	38	31	12	4	9
5	1961	22	14	10	4	1	2	50	33	21	5	1	2
5	1962	7	21	16	10	1	1	35	39	27	12	0	0
5	1963	79	14	16	12	12	6	108	25	17	14	12	3
5	1964	83	18	14	18	8	21	98	25	14	18	8	20
5	1965	22	11	12	12	9	5	28	14	14	13	8	4
5	1966	19	22	10	20	19	17	46	41	22	21	19	15
5	1967	74	25	16	9	9	0	102	43	27	11	9	0
5	1968	54	17	16	22	7	7	83	35	28	23	6	6
5	1969	54	20	25	17	17	4	83	39	37	19	16	3
5	1970	88	41	52	35	2	4	116	60	63	37	1	3
5	1971	98	42	55	20	14	0	125	61	66	21	14	0
5	1972	108	41	52	36	11	37	134	59	63	38	10	36
5	1973	110	44	60	34	14	15	136	63	72	36	14	13
5	1974	80	40	18	9	5	7	108	58	30	11	4	6
5	1975	4	61	40	18	5	12	33	80	51	20	5	9
5	1976	143	23	19	5	0	5	170	41	30	6	0	2
5	1977	169	53	15	9	1	78	197	72	27	10	0	77
5	1978	83	44	32	8	0	38	97	49	34	7	0	35
5	1979	115	44	5	2	0	0	144	62	17	4	0	0
5	1980	101	67	60	63	41	12	100	67	59	62	41	12
5	1981	149	4	4	25	21	17	147	4	3	24	20	16
5	1982	113	2	15	29	17	8	89	5	18	44	21	30
5	1983	50	11	0	23	13	6	48	15	1	20	14	5
5	1984	21	43	14	10	0	1	18	36	11	15	0	3
5	1985	14	3	1	4	5	1	15	2	1	3	5	0
5	1986	0	0	0	0	0	0	0	0	0	0	0	0
6	1940	0	7	6	2	1	8	0	6	5	1	0	6
6	1941	1	12	11	3	1	14	0	12	11	2	1	12
6	1942	1	16	15	3	2	18	0	16	14	3	1	16
6	1943	1	13	11	3	1	13	0	12	11	2	1	12
6	1944	1	11	10	2	1	14	0	11	10	2	1	11
6	1945	0	1	1	0	0	2	0	0	0	0	0	0
6	1948	43	13	0	0	0	0	32	6	0	0	0	0
6	1949	15	5	0	0	0	0	17	12	0	0	0	0
6	1950	0	11	3	0	0	1	0	7	2	0	0	0
6	1951	34	25	2	1	0	0	28	9	1	1	0	0
6	1952	110	31	1	0	0	0	27	13	3	0	0	0
6	1953	76	11	3	0	0	0	42	4	2	0	0	0
6	1954	26	6	1	0	0	0	20	7	0	0	0	0
6	1955	13	7	0	0	0	0	9	6	0	0	0	0
6	1956	13	2	1	0	0	0	18	5	0	0	0	0
6	1957	3	16	18	3	2	17	0	16	17	3	1	16
6	1958	1	16	23	2	1	10	0	15	22	2	1	9
6	1959	1	19	23	3	2	11	0	18	23	2	1	9
6	1960	1	14	18	3	2	9	0	14	18	3	1	8
6	1961	1	10	8	1	1	4	0	9	8	0	0	3
6	1962	0	20	19	3	0	3	0	20	18	3	0	2

Area	Yr	Males						Females					
		J-A	M	J	J	A	S-D	J-A	M	J	J	A	S-D
6	1963	1	7	11	4	4	8	0	6	11	4	4	7
6	1964	3	22	16	7	3	12	2	22	15	7	2	11
6	1965	6	19	18	5	3	23	5	17	17	5	3	21
6	1966	0	23	9	7	7	15	2	23	9	7	7	19
6	1967	4	28	18	3	3	3	8	27	18	3	3	2
6	1968	10	14	20	8	3	12	3	14	19	8	2	10
6	1969	11	20	35	7	6	9	10	19	35	6	6	8
6	1970	7	55	82	14	1	6	3	54	81	14	0	3
6	1971	5	57	86	8	5	1	3	56	86	7	5	0
6	1972	2	36	41	6	3	35	1	35	41	5	3	34
6	1973	1	35	42	10	8	86	3	35	42	9	7	83
6	1974	7	32	45	13	5	47	6	32	44	12	5	44
6	1975	13	87	60	7	2	8	3	87	60	6	2	4
6	1976	3	24	24	1	0	25	1	23	24	1	0	24
6	1977	4	74	18	3	0	117	2	74	17	2	0	114
6	1978	1	57	41	2	0	234	1	56	40	2	0	232
6	1979	5	82	108	37	13	64	23	82	108	36	12	63
6	1980	0	33	9	2	3	75	0	32	9	2	2	73
6	1981	1	69	31	11	6	47	0	68	30	11	6	46
6	1982	8	32	25	8	7	95	1	39	28	14	3	90
6	1983	0	30	37	4	2	65	0	31	37	3	1	60
6	1984	6	60	11	6	5	21	4	69	13	5	5	16
6	1985	0	8	7	2	2	18	0	5	8	1	1	16
6	1986	8	9	4	31	0	0	4	8	1	4	0	0
7	1930	1	3	2	1	0	0	1	2	1	0	0	0
7	1931	1	3	2	1	0	0	1	2	1	0	0	0
7	1932	1	3	2	1	0	0	1	2	1	0	0	0
7	1933	1	3	2	1	0	0	1	2	1	0	0	0
7	1934	3	5	3	1	1	1	2	4	2	0	0	0
7	1935	3	5	3	1	1	1	2	4	2	0	0	0
7	1936	3	5	3	1	1	1	2	4	2	0	0	0
7	1937	7	14	7	2	1	1	7	9	5	1	1	0
7	1938	8	16	8	2	2	2	8	11	6	1	1	1
7	1939	8	16	8	2	2	2	8	11	6	1	1	1
7	1940	10	19	10	2	2	2	9	12	7	1	1	2
7	1941	7	14	7	2	1	1	7	9	5	1	1	0
7	1942	8	16	8	2	2	2	8	11	6	1	1	1
7	1943	12	25	12	3	2	3	12	16	9	2	1	2
7	1944	10	19	10	2	2	2	9	12	7	1	1	2
7	1945	8	16	8	2	2	2	8	11	6	1	1	1
7	1946	8	15	7	2	1	1	8	9	5	1	1	0
7	1947	9	17	9	2	2	2	9	11	6	1	1	2
7	1948	15	26	13	1	0	0	11	16	9	0	0	0
7	1949	13	34	15	1	0	0	10	18	4	0	0	0
7	1950	0	45	16	2	19	22	0	19	5	1	7	12
7	1951	23	38	24	14	0	0	17	16	10	2	0	0
7	1952	31	39	22	1	0	0	35	32	11	2	0	0
7	1953	30	16	29	1	0	0	33	8	15	2	0	0
7	1954	10	10	8	22	1	0	7	15	6	9	0	1
7	1955	32	53	23	1	6	4	25	31	24	0	4	2
7	1956	15	92	33	1	8	18	12	64	39	7	3	5
7	1957	46	48	21	5	4	6	50	39	20	4	3	6
7	1958	32	49	24	6	11	9	43	57	23	4	5	2
7	1959	18	27	13	3	6	5	23	31	13	2	3	1
7	1960	17	26	13	3	6	4	23	30	12	2	3	1
7	1961	22	33	16	4	8	5	30	39	16	3	3	1
7	1962	13	20	10	2	5	3	17	23	9	2	2	1
7	1963	13	21	10	3	5	3	17	24	10	2	2	1
7	1964	22	33	16	4	8	6	30	40	16	3	3	1
7	1965	15	22	19	4	0	0	21	35	36	0	0	0
7	1966	22	34	16	4	8	6	34	46	18	3	4	2
7	1967	14	21	10	3	5	3	23	31	12	2	3	1
7	1968	14	20	12	1	2	4	24	39	13	2	2	1
7	1969	4	12	7	1	3	1	8	17	6	1	2	0
7	1970	19	64	10	7	4	2	27	54	6	5	0	0
7	1971	23	20	34	7	3	0	23	19	22	4	1	0
7	1972	15	13	5	0	1	12	35	38	2	0	0	4
7	1973	32	42	11	1	14	18	34	36	25	2	4	5
7	1974	15	27	7	5	24	13	34	34	1	3	12	5
7	1975	11	27	2	16	38	10	13	33	0	6	13	7
7	1976	32	17	2	6	7	10	51	19	1	5	9	9

cont...

Table 3 continued.

Area	Yr	Males J-A	Males M	Males J	Males J	Males A	Males S-D	Females J-A	Females M	Females J	Females J	Females A	Females S-D
7	1977	11	21	2	20	24	29	16	28	0	7	1	5
7	1978	37	46	9	32	51	53	47	46	1	12	4	6
7	1979	34	53	9	31	55	64	26	21	3	10	9	8
7	1980	33	22	25	37	9	35	40	40	7	9	1	5
7	1981	30	38	55	38	25	3	32	29	11	9	3	2
7	1982	37	34	46	25	13	7	38	24	14	12	6	1
7	1983	24	34	24	32	10	10	42	27	18	13	6	4
7	1984	37	22	18	16	17	42	29	7	19	13	10	16
7	1985	30	7	37	35	12	43	17	16	18	10	4	7
7	1986	44	13	20	28	20	33	26	9	12	17	5	15
7	1987	32	46	15	13	10	50	25	17	11	6	2	12
7	1996	0	0	0	0	15	13	0	0	0	1	0	2
7	1997	0	0	2	0	0	0	0	0	0	0	0	0
8	1949	0	0	0	0	0	0	0	0	1	0	0	0
8	1952	0	0	0	0	0	0	0	0	0	0	1	0
8	1953	0	0	0	0	0	0	0	0	0	0	0	1
8	1954	0	0	0	0	0	1	0	0	0	0	0	0
8	1955	0	0	0	0	0	0	0	0	0	1	0	0
8	1956	0	0	0	0	0	0	0	0	0	1	0	0
8	1957	0	0	0	0	0	1	0	1	0	1	0	0
8	1959	0	0	0	0	0	0	0	0	0	0	1	0
8	1960	0	0	0	0	1	0	0	0	0	0	0	0
8	1973	0	0	0	0	0	14	0	0	0	0	0	7
8	1996	0	0	0	11	5	0	0	0	0	0	0	0
8	1997	0	0	0	30	0	0	0	0	0	1	0	0
9	1949	0	0	0	0	1	1	0	0	0	1	0	0
9	1950	0	0	0	1	1	0	0	0	0	0	0	0
9	1951	0	0	0	0	0	0	0	0	2	1	0	0
9	1952	0	0	0	1	0	0	0	0	1	0	0	0
9	1953	0	0	0	0	3	0	0	0	0	1	1	0
9	1954	0	0	0	0	0	0	0	0	0	0	1	0
9	1955	0	0	0	0	0	1	0	0	0	0	0	0
9	1956	0	0	1	0	1	0	0	0	0	1	1	0
9	1957	0	0	0	1	0	0	0	0	0	0	0	0
9	1958	0	0	0	1	0	0	0	0	1	0	1	0
9	1960	0	0	0	1	0	0	0	0	0	0	0	0
9	1969	0	0	0	0	3	0	0	0	0	0	8	0
9	1970	0	0	1	1	4	0	0	0	0	0	0	0
9	1994	0	0	0	6	8	4	0	0	0	2	1	0
9	1995	0	0	14	56	21	0	0	0	0	5	4	0
9	1997	0	20	35	0	0	0	0	7	5	0	0	0
10	1949	0	0	0	1	4	0	1	1	0	0	3	0
10	1950	0	3	2	1	2	5	0	0	0	0	0	0
10	1951	0	2	3	0	0	0	0	1	0	1	0	0
10	1952	0	0	5	4	0	0	0	0	0	0	0	0
10	1953	12	13	11	2	0	0	0	3	1	0	0	0
10	1954	9	4	15	4	0	0	0	4	0	0	0	0
10	1955	2	1	6	11	0	0	0	5	0	2	0	0
10	1956	3	10	17	17	0	0	0	2	5	6	0	0
10	1957	1	5	8	16	1	0	1	2	6	4	0	0
10	1964	0	0	4	1	0	0	0	1	3	0	0	0
10	1967	0	0	2	0	0	0	0	1	2	0	0	0
10	1968	0	0	2	0	0	0	0	0	12	0	0	0
10	1969	0	0	5	2	0	0	0	1	4	0	0	0
10	1970	0	1	6	1	0	0	0	2	2	0	0	0
10	1971	0	0	5	2	1	0	0	2	5	2	0	0
10	1972	0	0	2	0	0	0	0	0	1	1	0	0
10	1973	0	1	12	0	2	0	0	1	4	0	1	0
10	1974	0	0	5	1	0	0	0	0	0	0	0	0
10	1975	0	7	11	0	0	2	0	1	5	0	0	0
10	1976	0	0	6	1	0	3	0	0	2	3	0	6
10	1977	0	0	0	0	0	0	0	0	2	0	0	0
10	1979	0	0	8	0	0	0	0	0	7	0	0	0
10	1980	0	0	0	5	5	0	0	0	5	0	0	0
10	1981	0	0	0	7	6	0	0	0	0	2	0	0
10	1982	0	0	4	5	0	0	0	0	6	0	0	0
10	1983	0	0	1	2	3	0	0	0	0	1	4	0
10	1985	0	0	0	0	2	0	0	0	3	0	1	1
11	1930	0	0	0	0	0	0	0	1	1	0	0	0
11	1931	0	0	0	0	0	0	0	1	1	0	0	0
11	1932	0	0	0	0	0	0	0	1	1	0	0	0
11	1933	0	0	0	0	0	0	1	1	1	0	0	0
11	1934	0	0	0	0	0	0	0	1	1	0	0	0
11	1935	0	0	0	0	0	0	0	1	1	0	0	0
11	1936	0	0	0	0	0	0	0	1	1	0	0	0
11	1937	0	0	0	0	0	0	0	1	1	0	0	0
11	1938	0	0	0	0	0	0	0	1	1	0	0	0
11	1939	0	0	0	0	0	0	0	1	1	0	0	0
11	1940	0	0	0	0	0	0	0	1	1	0	0	0
11	1941	0	0	0	0	0	0	0	1	1	0	0	0
11	1942	0	0	0	0	0	0	0	1	1	0	0	0
11	1943	0	0	0	0	0	0	0	1	1	0	0	0
11	1944	0	0	0	0	0	0	0	1	1	0	0	0
11	1945	0	0	0	0	0	0	0	1	1	0	0	0
11	1946	1	1	3	4	1	2	5	8	7	4	1	1
11	1947	1	1	3	5	1	2	6	9	9	5	1	1
11	1948	0	1	2	13	7	3	19	10	9	12	1	0
11	1949	0	0	4	1	1	0	6	8	6	3	4	0
11	1950	0	5	5	3	0	5	0	12	16	3	0	1
11	1951	1	3	3	7	0	0	27	17	20	6	0	0
11	1952	1	7	3	9	0	0	30	37	20	9	0	0
11	1953	2	3	12	18	1	0	12	17	19	9	0	0
11	1954	10	9	21	18	0	0	15	30	53	21	1	1
11	1955	0	1	17	16	4	5	15	33	37	26	5	3
11	1956	2	4	9	25	13	15	9	22	11	22	11	8
11	1957	2	1	7	6	2	12	10	31	14	3	1	10
11	1958	1	9	32	32	14	5	9	25	50	40	22	8
11	1959	1	5	17	18	8	2	5	14	27	22	12	4
11	1960	1	4	14	15	6	2	4	11	23	18	10	4
11	1961	1	5	19	20	9	3	5	15	31	25	14	5
11	1962	1	4	17	17	8	2	5	13	27	21	12	4
11	1963	1	4	14	14	6	2	4	11	22	18	10	3
11	1964	0	4	14	14	6	2	4	11	22	17	10	3
11	1965	1	5	16	31	13	1	9	21	22	22	18	1
11	1966	1	7	24	25	11	3	5	15	30	24	13	5
11	1967	1	5	19	19	9	2	5	14	28	23	12	5
11	1968	0	2	11	5	5	1	1	12	25	8	6	4
11	1969	1	3	15	18	5	1	2	24	38	17	11	5
11	1970	1	2	27	6	1	1	6	11	30	12	2	4
11	1971	2	4	11	21	10	6	6	6	10	13	9	8
11	1972	1	1	22	40	17	1	4	5	37	56	21	7
11	1973	1	17	47	18	13	5	3	2	36	26	22	4
11	1974	0	6	12	25	10	7	2	11	21	19	9	3
11	1975	0	4	20	17	12	5	0	8	28	11	5	2
11	1976	6	10	15	27	17	2	5	15	19	27	19	9
11	1977	1	16	17	5	3	12	4	10	9	2	3	0
11	1978	2	8	3	3	1	0	8	24	7	0	0	0
11	1979	0	2	10	3	0	1	10	22	16	4	0	1
11	1980	1	4	9	7	7	11	3	23	31	1	2	2
11	1981	0	2	6	4	1	14	10	11	14	12	0	9
11	1982	0	2	1	1	0	1	15	15	6	10	0	1
11	1983	1	2	1	0	0	0	13	3	10	2	2	1
11	1984	1	22	16	1	4	2	14	34	27	0	0	0
11	1985	0	17	5	0	1	5	16	20	8	0	2	9
11	1986	1	7	6	1	2	2	13	25	7	1	4	0
11	1987	0	3	3	5	3	2	15	18	10	1	2	3
11	1996	0	0	0	0	19	0	0	0	0	0	11	0
12	1949	0	0	0	2	0	0	0	0	1	0	0	0
12	1950	0	0	1	0	0	0	0	0	0	1	0	0
12	1951	0	0	0	0	0	0	0	1	0	0	1	0
12	1952	0	0	0	0	0	0	0	1	0	0	0	0
12	1953	0	0	0	0	0	0	0	0	0	0	1	0
12	1954	0	0	0	0	0	1	0	0	0	0	0	2
12	1955	0	0	0	2	1	0	0	0	0	2	0	0
12	1956	0	0	0	0	0	1	0	0	1	1	0	0
12	1957	0	0	0	0	0	0	0	0	1	1	0	0
12	1958	0	0	0	0	0	0	0	0	0	0	0	1
12	1960	0	0	0	0	0	0	0	1	0	0	1	0
12	1961	0	0	0	0	0	0	0	0	1	0	0	0
12	1962	0	0	0	0	0	0	0	0	1	0	0	0
12	1973	0	0	0	11	9	10	0	0	4	14	14	6
12	1974	0	0	1	22	3	0	0	0	1	18	16	0
12	1975	0	0	0	8	4	0	0	0	0	11	7	5

Table 4

Q matrix: the fraction of the catch in sub-Area k which is taken by sex and month. Dashes indicate sub-Areas/months for which catch limits are defined to be zero. The remaining entries reflect the historic commercial catches from 1978-87 (or if there was none, then the entire historic commercial and scientific catch).

	Males							Females						
Area	Jan.-Apr.	May	Jun.	Jul.	Aug.	Sep.-Dec.	*n*	Jan.-Apr.	May	Jun.	Jul.	Aug.	Sep.-Dec.	*n*
Option A1														
1-6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	0.127	0.118	0.097	0.108	0.083	0.127	1,760	0.121	0.088	0.043	0.042	0.019	0.028	909
8	0.0	0.0	0.0	0.229	0.125	0.333	33	0.0	0.021	0.021	0.063	0.042	0.167	15
9	0.0	0.042	0.096	0.410	0.253	0.036	139	0.0	0.006	0.042	0.036	0.078	0.0	27
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	0.113	0.098	0.041	0.031	0.062	211	-	0.319	0.223	0.051	0.020	0.043	400
12	-	0.0	0.010	0.236	0.089	0.063	76	-	0.016	0.052	0.251	0.209	0.073	115
Option A2														
1-6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	0.127	0.118	0.097	0.108	0.083	0.127	1,760	0.121	0.088	0.043	0.042	0.019	0.028	909
8	0.0	0.0	0.0	0.229	0.125	0.333	33	0.0	0.021	0.021	0.063	0.042	0.167	15
9-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	0.113	0.098	0.041	0.031	0.062	211	-	0.319	0.223	0.051	0.020	0.043	400
12	-	0.0	0.010	0.236	0.089	0.063	76	-	0.016	0.052	0.251	0.209	0.073	115

The trials will be conducted using two options related to the sub-areas for which future catch limits might be set:

(a) sub-areas 7,8,9 (April), 7,8,9,11,12 (May - September)[1] - factor A1;

(b) sub-areas 7,8 (April), 7,8,11,12 (May - September)[1] - factor A2.

The future ($t \geq 1998$) commercial catches by sex, sub-area, month and year are calculated using the equation:

$$C_t^{m/f,k,q} = C_t^k \, Q^{m/f,k,q} \qquad (6)$$

$Q^{m/f,k,q}$ is the fraction of the commercial catch in sub-area k which is taken during month q and are males/females, the values of which are given in Table 4, and

C_t^k is the commercial catch limit for sub-area k and year t ($t \geq 1998$). Note that C_t^k is equal to the catch limit set by the RMP less any pre-specified incidental catch.

Some of the entries in the Q matrix are determined by the options related to the sub-areas for which catch limits might be set (i.e. Q is zero for both the April and May-September periods for sub-area 9 for factor A2). The non-zero entries in the Q matrix (see Table 4) reflect the historical breakdown of catches over the last 10 years of commercial whaling (1978-87) within each sub-area. In sub-areas for which there was no catch between 1978-87 (8, 9, and 12), the entries in the Q matrix are set using the entire historic commercial and scientific catch in these sub-areas. Sensitivity to these assumptions may be investigated in future trials. For the trials based on *Small Areas* which are combinations of sub-area 11 and other sub-areas, the entire catch is assumed to be taken from sub-area 11 as this should reflect the highest risk. For trials based on *Small Areas* which are combinations of sub-areas including sub-area 7 but not sub-area 11, the entire catch is assumed to be taken from sub-area 7.

Incidental catches of minke whales are known to occur off South Korea and Japan but the level of such catches is uncertain. Therefore two options are considered both for the incidental catch off Korea and for that off Japan. The incidental catches will be apportioned to stock and age class in the same way as for the commercial catches (i.e. using Equation 5).

[1] Note: the Q matrix is zero for sub-areas 8 and 9 in April so no catches will be allocated. The matrix elements for these sub-areas are based on a very small number of catches. In practice the split by month will be dictated by operational factors as well as by the numbers of whales available (which the historic catches are intended to represent).

Incidental catch off Korea

Option K(i) The incidental catch by Korea in sub-area 6 is assumed to be zero until 1988 after which it increases linearly to 78 in 1995. It is 129 in 1996 and 78 in 1997. The catch in each year is apportioned to month according to the average of the proportions of the annual incidental catch by month taken in 1996 and 1997 (Table 5(a). The catch is apportioned by sex according to the average monthly historic ratio of commercial catches off Korea within this sub-area from 1982-86 (the only years for which data by month and sex are available). These values are also given in Table 5a. In future years the incidental catch is set at $78\, P_t / P_{1997}$ where P_t is the 1+ population size in year t averaged over all months and apportioned by month according to the mean of the 1996-97 values and to sex using the 1982-86 ratio above.

The rationale for these levels of catch is: (a) comments by Kim that minke whales returned to inshore areas only gradually after the end of commercial whaling in 1986 - hence the linear increase; (b) indications by Kim that 1996 was environmentally abnormal, so that the incidental catch that year was atypically high; and (c) suggestions, in part in the light of (a), that such catches should therefore be expected to increase in future should the population size increase. More details are given in Appendix 7.

Option K(ii) An incidental catch of 150 whales per annum in sub-area 6 since 1988 is assumed; the sex and timing within the year of these catches is selected as for option K(i). The future catches in the sub-area will also be assumed to be 150 whales per annum. This option for trials is included following information from Anon. (1997) and Mills *et al.* (1997) which indicated

Table 5

(a) Incidental catches by Korea by month (the catches for Jan.-Apr. and Sep.-Dec. will be combined for input to the trials).

Month	Monthly catch in 1996	Monthly catch in 1997	Historic sex ratio M:F (commercial catch 1982-86)
Jan.	7	18	0 : 0
Feb.	2	5	0 : 0
Mar.	2	1	1 : 1
Apr.	8	11	19 : 8
May	11	11	125 : 139
Jun.	7	7	73 : 78
Jul.	8	3	47 : 25
Aug	6	3	12 : 8
Sep.	7	6	97 : 95
Oct.	26	6	76 : 66
Nov.	11	4	0 : 0
Dec.	34	3	0 : 0
Total	129	78	450 : 420

(b) Incidental catches by Japan, Option (Ji).

Year/sub-Area	1	2	6	7	10	11	Total
1955-1978[1]	0	0.1	2.2	1.1	0.2	0.2	3.8
1979	0	0	0	0	0	0	0
1980	0	0	1	2	0	0	3
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983[2]	0	0	5	1.7	0.7	0.7	8
1984	0	0	0	2	1	1	4
1985	0	0	2	0	0	0	2
1986	0	1	9	3	0	0	13
1987	0	0	3	1	0	0	4
1988[3]	0	1.6	4.8	1.6	0	0	8
1989[4]	0	2.7	4	1.3	0	0	8
1990	0	1	4	15	0	0	20
1991	0	2	2	1	0	0	5
1992	0	1	7	0	0	0	8
1993	0	4	9	1	0	0	14
1994	0	9	6	1	0	0	16
1995	0	8	12	0	0	0	20
1996[2]	1	11	13	1.3	0.3	0.3	27
1997	0	18	8	1	0	0	27
Total (1979-1997)	1	59.3	89.8	32.9	2	2	187

[1] Catches are assumed to begin in 1955 when fishery nets were substantially improved. Catches are taken to equal the mean values from 1979-1987 (years of commercial whaling). [2] Catches off Hokkaido are allocated evenly to sub-Areas 7, 10 and 11. [3] Catches in 1988 are allocated to sub-Areas using information from 1987 and 1989. [4] Two individuals in 1989, whose catch position is unknown, were allocated in proportion to the composition of the six of known position.

that incidental catches up to a level of 128 whales per year had been taken incidentally in Korean fisheries. In addition further catches may have occurred in China-Taiwan and North Korea. When this option is used, the RMP will not be given the true incidental catches but rather will be given the smaller incidental catches listed for Option K(i).

Option K(i) will be used as part of the specifications for the base-case trials while sensitivity trials will be carried out to investigate the effect of option K(ii) (trials NPM45-48).

Incidental catch off Japan

Option J(i) The catches between 1979-1997 are taken to be the reported catches as listed in Japanese progress reports - see Table 5b. Future catches are taken to be the mean values over the years 1996 and 1997. The sex and timing within the year of these catches will be selected according to the historic ratio of catches off Japan within the relevant sub-area since 1979, or if there was none then the entire historic catch.

Option J(ii) An incidental catch of 93 animals is assumed to have been taken in each year from 1900 to the present, and is assumed to continue indefinitely. This estimate of the level of incidental catch was reported by Tobayama *et al.* (1992). Catches are allocated among sub-areas in the same ratio as the 1979-97 catches listed in Table 5b, and the sex and timing within years as for option Ji. When this option is used, the RMP will not be given the true incidental catches but rather will be given the smaller Japanese incidental catches listed for Option J(i).

Some of the incidental catch by Japan is taken from sub-areas in which a catch limit will be set. For all trials the total catch (commercial + incidental) from the sub-areas will be taken as equal to the catch limit set by the *RMP* if the *RMP* catch limit exceeds the incidental catch. Note: the original trial specifications included sensitivity tests to examine the case when the catch from the sub-area is equal to the limit set by the *RMP* plus the incidental catch, but following advice from the Commission (IWC Resolution 1998-2) these sensitivity tests have been deleted.

E. Generation of data

The estimates of absolute abundance (and their associated *CVs*) for the years prior to 1998 provided to the *CLA* are identical to the actual estimates and *CVs* for North Pacific minke whales from surveys conducted in August/September (see Table 6(a)). The sightings mixing matrix for a year in which a survey takes place is the average of the catch mixing matrices for August and September for that year. The values for the parameters of the various distributions have been selected to achieve *CVs* for *Small Areas* comparable to those for the surveys in Table 6(a). The estimates of abundance for a *Small Area* (say *Small Area E*) are generated using the formula:

$$\hat{P} = PYw/\mathrm{m} = P^* \, b^2 \, Yw \qquad (7)$$

Y is a lognormal random variable $Y = e^{e}$ where $e \sim N[0,s^2]$ and $s^2 = \mathrm{Ln}(a^2 + 1)$,

w is Poisson random variable with $E(w) = \mathrm{var}(w) = \mathrm{m} = (P/P^*)/b^2$, Y and w are independent,

P is the average current total (1+) population size in the *Small Area* (*E*) over August-September:

$$P = P_t^E = \frac{1}{2}\sum_{k \in F}\sum_{q \in Aug/Sept}\sum_{s}\sum_{a=1}^{x}\left(V_{t,a}^{m,s,k,q}(R_{t,a}^{m,s} + U_{t,a}^{m,s}) + V_{t,a}^{f,s,k,q}(R_{t,a}^{f,s} + U_{t,a}^{f,s}\right) \qquad (8)$$

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

F is the set of sub-areas making up *Small Area E*.

Note that under the approximation

$CV^2(ab) = CV^2(a)\, CV^2(b)$: $E(\hat{P}) = P$

and $CV^2(\hat{P}) = a^2 + b^2P^*/P$.

For consistency with the first stage screening trials for a single stock, the ratio $\alpha^2 : \beta^2 = 0.12 : 0.025$, so that:

$$CV(\hat{P}) = \mathrm{t}(0.12 + 0.025P^*/P)^{1/2} \qquad (9)$$

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

$$\sqrt{(\alpha^2 + \beta^2)} = 0.38\tau \qquad (10)$$

Table 6

Data used to condition the trials.

(a) The abundance data used to condition the trials.

Sub-Area	Timing	Estimate	CV	Estimate also used by *CLA*	Source
6	Aug.-Sep. 1992	893[1]	0.67	No	Miyashita and Shimada (1994)
7	Aug.-Sep. 1990	1,741[1]	0.655	No	Buckland *et al.* (1992); *Rep. int. Whal. Commn* 47: 211
7	Aug.-Sep. 1991	2,202	0.383	Yes	*Rep. int. Whal. Commn* 47: 211
8	Aug.-Sep. 1990	1,057	0.706	Yes	Buckland *et al.* (1992); *Rep. int. Whal. Commn* 47: 211
9	Aug.-Sep. 1990	8,264	0.396	Yes	Buckland *et al.* (1992); *Rep. int. Whal. Commn* 47: 211
9	Jun.-Jul. 1994	4,673	0.441	No	*Rep. int. Whal. Commn* 47: 211
9	Jun.-Jul. 1995	2,145[2]	0.315	No	*Rep. int. Whal. Commn* 47: 211
10	Aug.-Sep. 1992	707[1]	0.57	No	Miyashita and Shimada (1994)
11	Aug.-Sep. 1990	2,120	0.449	Yes	Buckland *et al.* (1992); *Rep. int. Whal. Commn* 47: 211
12	Aug.-Sep. 1990	15,641	0.363	Yes	?
12	Aug.-Sep. 1992	11,948	0.46	Yes	Miyashita and Shimada (1994); *Rep. int. Whal. Commn* 47: 211

[1] Minimum estimate. [2] Estimate based on some extrapolation to unsurveyed areas.

(b) Estimates of the proportion of 'J' whales used to condition the trials

Sub-Area	Month	Sex	Years	Estimate	SE	Data used	Source
7	Aug.-Sep.		1980-87	0.018	0.023	Isozyme	*Rep. int. Whal. Commn* 47:214
11	Apr.		1980-87	0.512	0.045	Isozyme/mtDNA	*Rep. int. Whal. Commn* 47:214-5
11	May		1980-87	0.049	0.023	Isozyme	*Rep. int. Whal. Commn* 47:214
11	Jun.-Jul.		1980-87	0.076	0.016	Isozyme	*Rep. int. Whal. Commn* 47:214
11	Aug.	M	1980-87	0.315	0.116	Isozyme	Pastene *et al.* (1998)
11	Aug.	F	1980-87	0.044	0.069	Isozyme	Pastene *et al.* (1998)
12	Jun.		1973-75	0.089	0.051	Conception/flipper colour	*Rep. int. Whal. Commn* 47:215
12	Jul.		1973-75	0.013[1]	0.008	Conception/flipper colour	*Rep. int. Whal. Commn* 47:215
12	Aug.		1973-75	0.015[1]	0.009	Conception/flipper colour	*Rep. int. Whal. Commn* 47:215

[1] Based on the centre of the confidence interval.

The value of t is calculated from the equation defining the true value of the *CV* by substituting the value of the *CV* for each abundance estimate and the depletion to which it corresponds (Equation 9), and solving for t. If more than one abundance estimate exists for a particular sub-area, the value assumed for t is calculated taking the true CV to be the root mean square of the values obtained from the abundance estimates for that sub-area, and the depletion to be the mean value over the corresponding years. The values of t applicable to each sub-area will be calculated separately for each replicate once the conditioning has been accomplished.

An estimate of the *CV*, X_i is also generated for each sightings estimate, $\hat{P}_i$:

$$X_i = \sqrt{(\sigma^2 \text{CHISQ}} \qquad (11)$$

where $s^2 = Ln(1 + a^2 + b^2\, P^*/\hat{P})$, and CHISQ is a random number from a Chi-square distribution with 10 degrees of freedom. The value 10 is chosen to roughly indicate the number of trackline segments in a sightings survey in a *Small Area*.

Table 1 lists the pattern for future surveys. The trials will 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 1999 would first be used for setting the catch limit in 2001.

Four trials consider the case where $g(0) = 0.5$. To implement this, the observed P is taken to be half of its actual value (Equation 8).

In trials in which *Small Areas* which are comprised of sub-areas which are surveyed in different years, the abundance estimate is taken to be a combination of the estimates of abundance in the sub-areas over 3 years and taken to refer to the mean year (IWC, 1998).

F. Parameter values

Following the decision by the sub-committee on North Pacific minke whales (IWC, 1992, p.160), the values of the biological and technological parameters have been taken to be equal to those for the North Atlantic minke *Implementation Simulation Trials* (IWC, 1991, pp.108-112c), i.e.:

$r_{50} = 4$; $s_r = 1.2$; where r is recruitment

$m_{50} = 7$; $s_m = 1.2$; where m is maturity

$MSYL = 0.6$

The maturity ogive is modified so that the first age at which a female can be mature is three, i.e. $b_0 = b_1 = b_2 = 0$.

Natural mortality is age-dependent, and identical to that for the North Atlantic minke trials:

$$M_a = \begin{cases} 0.085 & \text{if } a \le 4 \\ 0.0775 + 0.001875a & \text{if } 4 < a < 20 \\ 0.115 & \text{if } a \ge 20 \end{cases}$$

The MSYR scenarios considered are specified in Section G. The *MSYR* used does not apply to the recruited populations defined for this model, but rather applies to the rates which would apply if the age at recruitment were equal to the age at maturity.

The process used to select the initial (pre-exploitation) sizes of each of the stocks and the values for the parameters γ_1 - γ_{11} used to define the catch mixing matrices is known as the conditioning process. The process involves first generating the target data, as detailed in steps (a) to (h) below, that will be 'fitted' to the above model. Values for the initial population sizes and the ts are then selected by minimising the negative of the log-likelihood which contains terms related to the target data generated in steps (a)-(h). The number of animals in sub-area k at the start of year t is calculated starting with guessed values of the initial population size and projecting the operating model forward to 1998 in order to obtain values of abundance etc. for comparison with the generated data. (When performing the projections, mixing is stochastic, and the catches from each sub-area are set to their historic values - Tables 3 and 5.) A different set of data is generated (and hence a different set of parameters selected) for each of the 100 replicates within a trial. (Note that not all of the ts are estimated in all trials - for example, t_9 is used only in mixing matrix J and hence is estimated only for trials NPM33-NPM38.) The results showing the fits to the conditioning data will be forwarded to the Steering Group. If the fits are not sufficiently good, extra free parameters should be added to the mixing matrices to improve them, and to ensure that the initial conditions modelled are such that all of the historic catches can be taken.

The information used in the conditioning is as follows.

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

$$P_t^k = O_t^k \exp[\mu_t^k - (\sigma_t^k)^2/2] \qquad \mu_t^k \sim N[0;(\sigma_t^k)^2] \qquad (12)$$

P_t^k is the abundance for sub-area k in year t,
O_t^k is the actual survey estimate for sub-area k in year t (see Table 6(a)), and
σ_t^k is the CV of O_t^k.

The values of abundance generated for sub-areas 6 and 10, and one of those for sub-area 7, are assumed to be minima – in the conditioning process the terms for those sub-areas/years are not added to the log-likelihood but the 'true' abundance in those sub-areas must exceed the generated values.

(b) Estimates of the proportion of J whales in sub-areas 7, 11 and 12 are generated from the appropriately truncated normal distributions which correspond to the observed data (see Table 6(b)) which are based on isozyme, mtDNA, conception date and flipper colour information. Although data do exist for sub-areas other than those listed in Table 6(b), the sample sizes are so low that their information content is effectively nil.

(c) The ratio of the size of the exploitable population in sub-areas 5, 6 and 10 combined averaged over April-September 1987 to that in 1973 is 0.18. This specification is based on a GLM analysis of CPUE data for the South Korean fishery. Sensitivity tests (NPM25 - NPM28) consider assuming that this ratio is 0.43.

(d) The fraction of the O stock in sub-area 12 is fixed by specifying the percentage which the O stock comprises of the combined O-W abundance in that sub-area in August-September 1995. The base-case choice for this percentage is 30%. Some sensitivity tests (NPM9 - NPM12) consider alternative choices of 10% and 100%. The model parameter values are selected to satisfy this requirement exactly. The base-case choice is derived from the estimates of abundance from sub-areas 7, 8, 9 and 11 in August to September on the assumption that the ratio of O to W animals in sub-area 12 in August-September is roughly the same as the ratio of the abundance in sub-areas 7 and 11 to that in sub-areas 8 and 9. The rationale for using these data is that at the time of the surveys the bulk of the animals in these sub-areas are males, whilst females predominate in catches in sub-area 12. The base-case choice should be reasonably conservative in terms of possibly overestimating the fraction of O animals because at least some of the animals in sub-area 9 should migrate to the north of this sub-area (which has never been surveyed) instead of to sub-area 12.

(e) For trials NPM29 - NPM32, the mean proportion of the O stock (1+ animals) in sub-area 10 from May-July is assumed to be 0.05 in the pristine situation i.e. the proportion will be 0.1 in years in which the parameter $\gamma_8 > 0$.

(f) For trials NPM17 - NPM20, the point estimates of the fraction of the J stock animals in sub-area 12 in June to August are doubled (Table 6(b)).

(g) Trials will be run to test the effect of potentially different proportions of J whales in the total (scientific, commercial and incidental) catch taken by Japan. The mean proportion of J whales in the total Japanese catch from 1993-98 is taken to be 39.2% in these trials, the parameter values being selected to satisfy this requirement exactly. (The figure of 39.2% is derived from: (a) the observed proportion of 32.5% of RFLP haplotypes 2/5 in North Pacific minke whale products purchased in Japan from 1993-98, which are assumed to be randomly selected from catches during this period; and (b) the different proportions of 2/5 types occurring in the two stocks: 2/5 types occur in 76.7% of J stock samples and about 4% of O (or O/W) stock samples.) The mean proportion of J whales in the catch over these years will be output in trials when this proportion is not included in the conditioning (see section G).

(h) For trials NPM41-44 (cases for which g(0) = 0.5) the values of the actual abundances are halved for comparison with the conditioning targets.

The abundance in sub-area 13 is taken to be 0 for all of the trials because abundance estimates are unavailable for this sub-area, and because allowing for animals in sub-area 13 may lead to over-optimistic results if catches are taken from sub-areas 8 and 9 as well as from coastal Japanese waters and the Okhotsk Sea.

G. Trials

Trials NPM1 - 4 are the base case trials (Table 7a).

Trials NPM1 - 4 will be used to test the effects of the two options for the level of Japanese incidental catch (Ji and Jii) and the effects of setting the fraction of J animals in the total catch by Japan when conditioning (i.e. including or not including condition (g) above). All combinations of these options will be tested (16 trials in all). The results of these 16 trials will be considered by the Steering Group and used to select the base case options to use with the remaining sensitivity trials which are listed in Table 7b.

H. Management options

Two issues relate to specifying the management options: (a) the designation of *Areas* (*Small*, *Medium* and *Large*); and (b) the management procedure variants to consider. The selections listed below may be reconsidered once the results of the trials specified in this Appendix have been carried out.

Designation of areas

SMALL AND RESIDUAL AREAS

Sub-areas 1, 2, 3, 4, 5, 6, 10 and 13 are *Residual Areas*. There are three alternative *Small Area* definitions.

(a) Sub-areas 7, 8, 9, 11 and 12 (i.e. *Small Areas* = sub-areas).
(b) Sub-areas 7+8, 9, 11 and 12.
(c) Sub-areas 7+11+12, 8 and 9.
(d) Sub-areas 7+8+9+11+12.

Table 7

Trials.

(a) The base-case trial NPM1-4.

Trial No.	Number of stocks	MSYR (mixing matrix) Stock J	Stock O	Stock W	O Stock % sub-Area 12	Comments
NPM1	3	1 (A/B)	1 (F)	1 (K)	30	Base-case trial 1
NPM2	3	4 (A/B)	1 (F)	4 (K)	30	Base-case trial 2
NPM3	2	1 (A/B)	1 (G)	-	-	Base-case trial 3
NPM4	2	4 (A/B)	1 (G)	-	-	Base-case trial 4

(b) Remaining sensitivity trials.

Trial No.	Number of stocks	MSYR (mixing matrix) Stock J	Stock O	Stock W	O Stock % sub-Area 12	Comments
NPM5	3	4 (A/B)	4 (F)	4 (K)	30	NPM1 + MSYR=4%
NPM6	3	1 (A/B)	4 (F)	1 (K)	30	NPM1 with $MSYR_O$=4%
NPM7	2	4 (A/B)	4 (G)	-	-	NPM3 + MSYR=4%
NPM8	2	1 (A/B)	4 (G)	-	-	NPM4 with MSYR=4%
NPM9	3	1 (A/B)	1 (F)	1 (K)	10	NPM1 + 10% O stock in sub-Area 12
NPM10	3	4 (A/B)	1 (F)	4 (K)	10	NPM2 + 10% O stock in sub-Area 12
NPM11	3	1 (A/B)	1 (F)	1 (K)	100	NPM1 + no W stock in sub-Area 12
NPM12	3	4 (A/B)	1 (F)	4 (K)	100	NPM2 + no W stock in sub-Area 12
NPM13	3	1 (C/D)	1 (F)	1 (K)	30	NPM1 + ignore sub-Area 5 catches
NPM14	3	4 (C/D)	1 (F)	4 (K)	30	NPM2 + ignore sub-Area 5 catches
NPM15	2	1 (C/D)	1 (G)	-	-	NPM3 + ignore sub-Area 5 catches
NPM16	2	4 (C/D)	1 (G)	-	-	NPM4 + ignore sub-Area 5 catches
NPM17	3	1 (A/B)	1 (F)	1 (K)	30	NPM1 + greater fraction J stock in sub-Area 12
NPM18	3	4 (A/B)	1 (F)	4 (K)	30	NPM2 + greater fraction J stock in sub-Area 12
NPM19	2	1 (A/B)	1 (G)	-	-	NPM3 + greater fraction J stock in sub-Area 12
NPM20	2	4 (A/B)	1 (G)	-	-	NPM4 + greater fraction J stock in sub-Area 12
NPM21	3	1 (A/E)	1 (F)	1 (K)	30	NPM1 + no J stock in sub-Area 7
NPM22	3	4 (A/E)	1 (F)	4 (K)	30	NPM2 + no J stock in sub-Area 7
NPM23	2	1 (A/E)	1 (G)	-	-	NPM3 + no J stock in sub-Area 7
NPM24	2	4 (A/E)	1 (G)	-	-	NPM4 + no J stock in sub-Area 7
NPM25	3	1 (A/E)	1 (F)	1 (K)	30	NPM1 + depletion of J stock = 0.43
NPM26	3	4 (A/E)	1 (F)	4 (K)	30	NPM2 + depletion of J stock = 0.43
NPM27	2	1 (A/E)	1 (G)	-	-	NPM3 + depletion of J stock = 0.43
NPM28	2	4 (A/E)	1 (G)	-	-	NPM4 + depletion of J stock = 0.43
NPM29	3	1 (A/B)	1 (F/H)	1 (K)	30	NPM1 + O stock in sub-Area 10
NPM30	3	4 (A/B)	1 (F/H)	4 (K)	30	NPM2 + O stock in sub-Area 10
NPM31	2	1 (A/B)	1 (G/I)	-	-	NPM3 + O stock in sub-Area 10
NPM32	2	4 (A/B)	1 (G/I)	-	-	NPM4 + O stock in sub-Area 10
NPM33	3	1 (A/B)	1 (J)	1 (K)	30	NPM1 + O-W mixing in sub-Area 8
NPM34	3	4 (A/B)	1 (J)	4 (K)	30	NPM2 + O-W mixing in sub-Area 8
NPM35	3	1 (A/B)	1 (J)	1 (L)	30	NPM1 + no W stock in sub-Area 8
NPM36	3	4 (A/B)	1 (J)	4 (L)	30	NPM2 + no W stock in sub-Area 8
NPM37	3	1 (A/B)	1 (J)	1 (L)	100	NPM1 + no W stock in sub-Area 8
NPM38	3	4 (A/B)	1 (J)	4 (L)	100	NPM2 + no W stock in sub-Area 8
NPM39	3	1 (A/B)	1 (F)	1 (M)	30	NPM1 + O-W mixing in sub-Areas 7+11
NPM40	3	4 (A/B)	1 (F)	4 (M)	30	NPM2 + O-W mixing in sub-Areas 7+11
NPM41	3	1 (A/B)	1 (F/H)	1 (K)	30	NPM1 + g(0) = 0.5
NPM42	3	4 (A/B)	1 (F/H)	4 (K)	30	NPM2 + g(0) = 0.5
NPM43	2	1 (A/B)	1 (G/I)	-	-	NPM3 + g(0) = 0.5
NPM44	2	4 (A/B)	1 (G/I)	-	-	NPM4 + g(0) = 0.5
NPM45	3	1 (A/B)	1 (F)	1 (K)	30	NPM1 + 150 incidental Korean catch/year (option Kii)
NPM46	3	4 (A/B)	1 (F)	4 (K)	30	NPM2 + 150 incidental Korean catch/year
NPM47	2	1 (A/B)	1 (G)	-	-	NPM3 + 150 incidental Korean catch/year
NPM48	2	4 (A/B)	1 (G)	-	-	NPM4 + 150 incidental Korean catch/year

Given the fact of migration, *Small Areas* may need to be developed somewhat differently from earlier approaches.

MEDIUM AREAS

Medium Areas are supposed to represent the known or suspected range of distinct biological stocks. Only one *Medium Area* (sub-areas 2, 3, 4, 7, 8, 9, 10, 11 and 12) is defined in the North Pacific because future surveys will not cover most of the sub-areas.

LARGE AREA

There is no *Large Area.*

COMBINATION AREAS

The *Combination area* comprises all sub-areas 7, 8, 9, 11, 12 (i.e. a 'West Pacific - East of Japan' combination area).

Management procedure variants

The following three management variants will be considered for each of the trials listed in Section G for each of the *Small Area* definitions, following selection of conditioning choices and the Japanese incidental catch option as detailed in section G.

(a) Catch limit calculations by *Small Area*, no *capping*, no *cascading*.
(b) Catch limit calculations by *Small Area* with *Medium Area capping*, no *cascading* (initially base-case trials only because results with *capping* are unlikely to differ much from those with no *capping* and no *cascading*)
(c) *Cascading* over the *Combination Area*.

If 4 out of the 16 base-case options outlined above are retained this gives 48 trials × 4 *Small Area* options × 2 procedure variants ((a) and (c)) × 2 options related to sub-areas with catches + 4 base-case trials × 4 *Small Area* options × 1 procedure variant (b) × 2 options related to sub-areas = 800 trials in all. The number of options and procedures must be restricted for many of the trials. An initial suggestion is:

(i) 4 base-case trials × 4 *Small Area* options × 2 variants × 2 sub-area options = 64 trials;
(ii) other trials × 2 *Small Area* options ((a) and (c)) × 1 variant (a) × 1 sub-area option (a) = 88 trials.

Trial NPM1 will be conducted first to reduce the number of *Small Area* options, procedure variants, and options related to sub-areas with catches. The remainder of the trials under (i) will then be conducted for those options which were not deleted based on the results of trial NPM1.

I. Output statistics

Population-size and continuing catch statistics are produced for each stock, and catch-related statistics for each sub-area. Catch related statistics will be produced both for the total catches (commercial and incidental) and for the commercial catches alone.

(1) Total catch (TC) distribution: (a) median; (b) 5th value; (c) 95th value.
(2) Initial mature female population size (P_{1998}) distribution: (a) median; (b) 5th value; (c) 95th value.
(3) Final mature female population size (P_f) distribution: (a) median; (b) 5th value; (c) 95th value.
(4) Lowest mature female population over 100 years (P_{low}) distribution: (a) median; (b) 5th value; (c) 95th value.
(5) Average catch over the last 10 years of the 100 year management period: (a) median; (b) 5th value; (c) 95th value.
(6) Continuing catch (C_c): (a) median; (b) 5th value; (c) 95th value.

The continuing catch statistic is defined as follows.

First, the 'sustainable yield' function of population size is defined as:

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

Next the average catch over the final ten years of the simulation, $\overline{C}$, and the average 'sustainable yield' over this period, $\overline{SY}$, are calculated. The continuing catch statistic is then defined as the minimum of $\overline{C}$ and $\overline{SY}$.

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Appendix 7

BYCATCHES OF MINKE WHALES IN KOREAN WATERS

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Baleen whales were abundant in the waters of the Korean peninsular until the early 19th century when foreign whaling fleets began large-scale whaling. It was not until after World War II that Korean fishermen began taking minke whales. The total catch of minke whales from 1962 to the ban on commercial whaling in 1986 was 13,734 animals. The taking of all cetaceans in Korean waters has been banned by the Ministry of Marine Affairs and Fisheries (MOMAF, Notice No. 85-17) since 1 January 1986.

In recent years, an increase in the population of minke whales in Korean waters is suggested by the increased bycatch and more frequent sightings in coastal waters.

Bycatches have been controlled since 1996 under the MOMAF guidelines on the prohibition of whale catching in Korean waters. These guidelines were revised in December 1997 in order to facilitate biological sampling from the bycatch, including the DNA sampling of market whale meat. Biological sampling was carried out under the revised guidelines by the fisheries extension service of MOMAF located in fisheries ports, in collaboration with the National Fisheries Research and Development Institute (NFRDI). The tracing of whale meat distribution was the responsibility of the fisheries authorities of regional governments.

Table 1

Bycatch of minke whales by region and fishing gear during 1996 and 1997. KN: Kyeong-Nam province (southeastern part of South Korea); PS: Pusan City (southeastern extremity of South Korea); KB: Kyeong-Buk province (central part of the east coast of South Korea); KW: Kang-Won province (northern part of the east coast of South Korea).

					Total	
Fishing gear	KN	PS	KB	KW	*n*	%
1996						
Set-net	1		16	14	32	24.8
Coastal trap	2		44		45	34.9
Offshore trap			5		5	3.9
Coastal drift gillnet			33	2	35	27.1
Offshore drift gillnet			5		5	3.9
Coastal gillnet			3	2	5	3.9
Others			1	1	2	1.6
Total	3		107	19	129	100.0
%	2.3		82.9	14.7		
1997						
Set-net	1		16	19	36	46.2
Coastal trap	2		16		18	23.1
Offshore trap			6		6	7.7
Coastal drift gillnet			7	3	10	12.8
Offshore drift gillnet			1		1	1.3
Coastal gillnet				3	3	3.8
Others		1	3		4	5.1
Total	3	1	49	25	78	100.0
%	3.8	1.2	62.8	32.1		

Table 2

Bycatch of minke whales by month and region in Korean waters in 1996 and 1997. For abbreviations see Table 1.

Month	KN	PS	KB	KW	Total
1996					
Jan.			4	3	7
Feb.			2		2
Mar.			2		2
Apr.			7	1	8
May	1		6	4	11
Jun.	1		5	1	7
Jul.	1		6	1	8
Aug.			6		6
Sep.			7		7
Oct.			25	1	26
Nov.			11		11
Dec.			26	8	34
Total	3		107	19	129
1997					
Jan.			16	2	18
Feb.			2	3	5
Mar.			1		1
Apr.			7	4	11
May			6	5	11
Jun.	1	1	4	2	8
Jul.	2				2
Aug.			2	1	3
Sep.			5	1	6
Oct.			4	2	6
Nov.			1	3	4
Dec.	3	1	1	2	3
Total			49	25	78

Table 3

Reported strandings of minke whales in Korean waters in 1997.

Area	No.	Remarks
Offshore of Kang-won province	2	Decayed and drifting in the sea
Kyeong-Buk province	1	Decayed on the beach

Table 4

Number of minke whales reported by the Mun-Whoi Broadcasting Company (MBC) in its sea survey on cetaceans in the coastal waters of the East Sea from 19-31 May 1997.

Date	No.	Area
19 May 1997	1	Kyeong-Nam (14km from Tae-Bun port)
22 May 1997	5	Kyeong-Buk (15km from Kang-Gu port)
31 May 1997	1	Kang-Won (2km from Samchuk port)

Table 5

Number of minke whales reported by the Education Broadcasting Company (EBS) in its sea survey on cetaceans in the coastal waters of the East Sea from April-November 1997.

Date	No.	Area
Apr.-Nov.	27	Near Kuryong-Po waters, Kyeong-Buk province

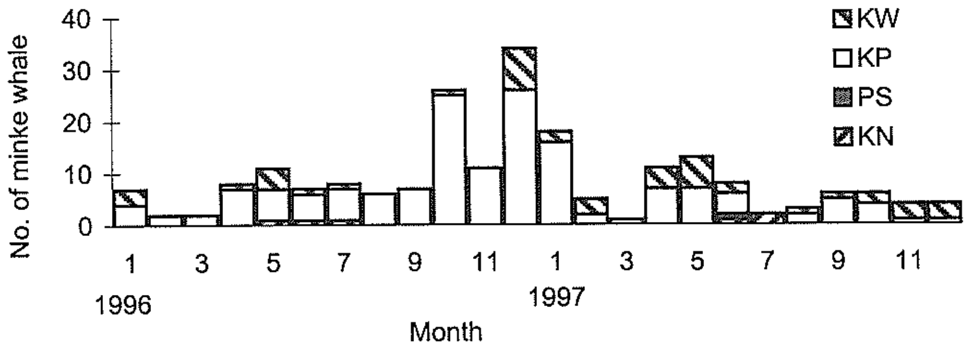

Fig. 1. Minke whale bycatch by month and region from coastal fishing in Korean waters, 1996 and 1997. KN: Kyeong-Nam province; PS: Pusan city; KB: Kyeong-Buk province; KW: Kang-Won province.

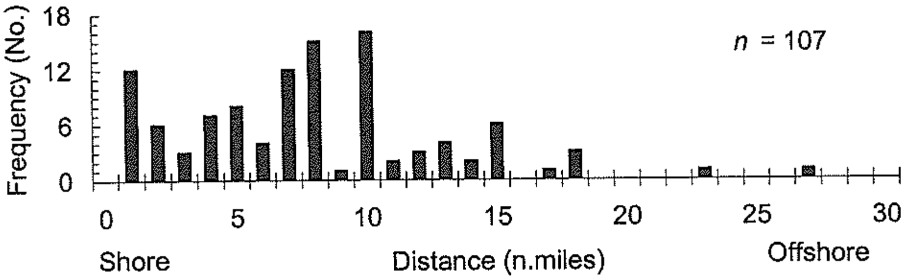

Fig. 2. Location of minke whale bycatch, Kyeong-Buk province, 1996. Distance from shore corresponds to fishing gear location.

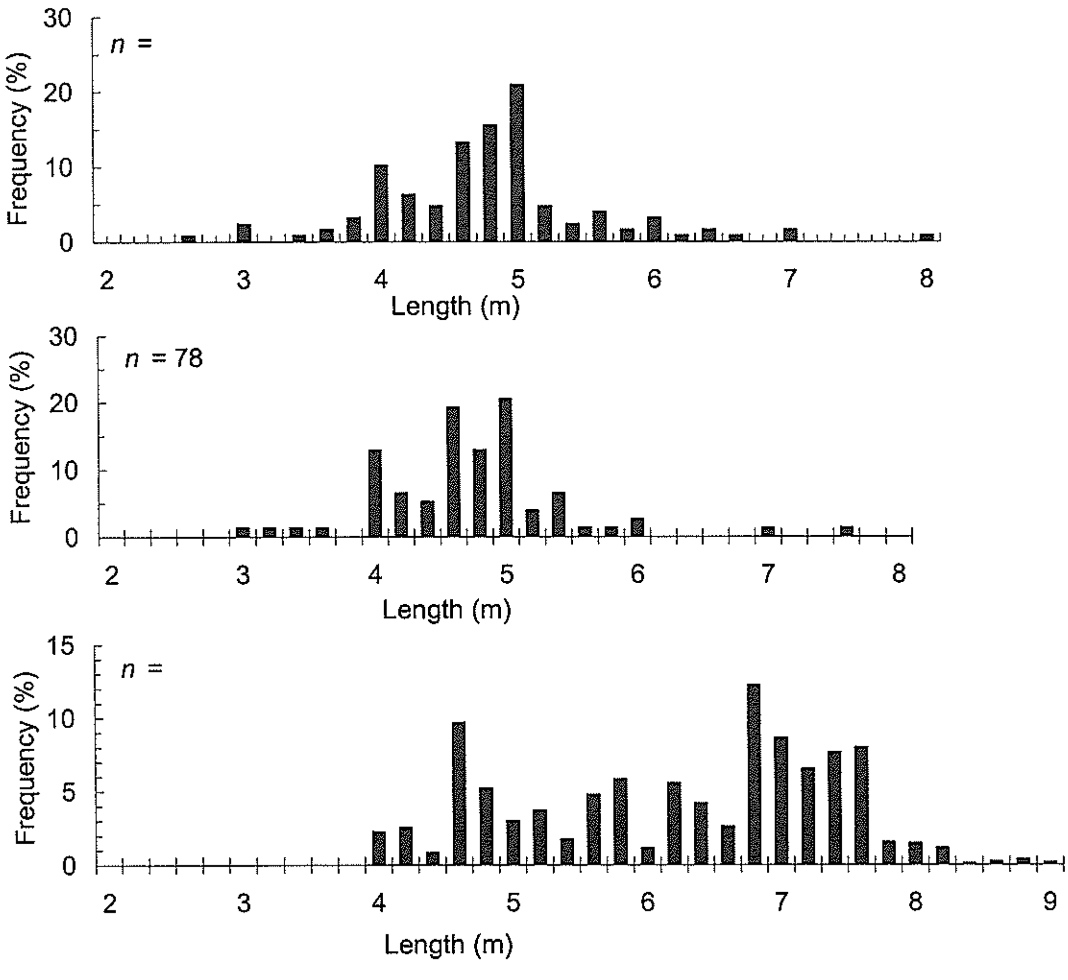

Fig. 3. Body length distribution of minke whale bycatch: 1996 (top); 1997 (middle); commercial take (bottom).

Bycatch data for minke whales were collected by MOMAF from January 1996 to December 1997, according to MOMAF guidelines (Notice No. 85-17). If a fisherman finds dead cetaceans entangled in his fishing gear, he is obliged to report his bycatch to the local marine police agent. The agent then reports the information to the police inspection division and the fisheries authority of the regional government. The species is identified by examining the inspection report and the photographs submitted by the police. Body length data are also submitted by the police, measured from the tip of mouth to the corner of fluke.

Bycatch data for minke whales from the coastal fisheries are presented in Table 1, by region and fishing gear. There were 129 animals in 1996 and 78 in 1997; Kyeong-Buk province took 82.9% and Kang-Won 14.7% in 1996, with 62.8% and 32.1%, respectively, in 1997. This shows that most entanglement occurred in the East Sea of Korea. The types of fishing gear that caused most entanglement were trap nets, gillnets and setnets (38.8%, 34.9% and 24.8%, respectively, in 1996, and 30.8%, 22.9% and 46.2%, in 1997).

Bycatches by month and region are presented in Table 2 and Fig. 1. Greatest numbers were from October 1996-January 1997, followed by the months between April-June.

Bycatch positions in Kyeong-Buk province in 1996 are presented in Fig. 2. Most bycatches occurred within 20 n.miles of the shore, corresponding to the location of coastal fishing gear.

Fig. 3 plots body lengths of minke whales from recent bycatches and from the commercial take between 1982 and 1986. Lengths ranged from 2.5-8.0m with a mode of 4-5m in 1996 and 3.0-7.6m with a mode of 4-5m in 1997. The commercial catch range was 4-9m with two peaks between 4-5m and 6-8m during the combined 1982 to 1986 period. Thus bycaught animals were generally smaller than those commercially taken and included length classes of 2.5-4m which did not appear in the commercial take.

In 1997, two minke whales in Kang-Won province and one in Kyeong-Buk province were reported, with photographs by marine police, as stranded but decayed (Table 3).

From 19-31 May 1997, Mun-Whoi Broadcasting Company (MBC) conducted a non line-transect survey for cetaceans in Korean waters following random tracks set in the coastal waters of the East Sea, using a chartered squid angling vessel *Dong Bang Ho* (60 G/T). It recorded on video tape seven minke whales encountered within a distance of 14km from the coast (Table 4). The Education Broadcasting Company (EBS) carried out four surveys in different months (between March and November 1997) along a random line set in the South and East Sea. The aim was to investigate whale species in Korean Waters for a documentary programme. It reported (video tape and photographs) to the NFRDI that a total of 27 minke whales were encountered during the surveys (Table 5).

Appendix 8

REPORT OF THE INTERSESSIONAL CORRESPONDENCE GROUP ON NORTH PACIFIC SIGHTINGS SURVEY STEERING GROUP (NPSSSG)

Members: Smith (Chair), Borchers, Butterworth, Hatanaka, Kato, Miyashita, Øien, Polacheck, Palka, Skaug.

This Correspondence Group was established during the 1997 meeting of the Scientific Committee to provide oversight for planned sightings surveys of the North Pacific minke and Bryde's whales (see IWC, 1998, item 7.1.2). Oversight for the minke whale survey was thought useful because Japan anticipated adopting a new sightings survey methodology. Oversight for the Bryde's whale survey was thought useful because the Committee has not previously evaluated the conduct and results of the several surveys that have been conducted, and because a systematic survey over four years was anticipated.

General responsibilities for both surveys included making arrangements for participation in the surveys by Committee representatives and analysis of earlier survey data to assist in planning. Based on the discussion when the Committee reviewed draft survey plans in 1997, specific tasks were identified as needing to be addressed in preparing survey plans. These are listed below, with a brief summary of progress under each.

Minke whale survey

1. Arrange for Scientific Committee participation in the survey

Japan will cover travel, salary and on board costs for participants. Applications were planned to be solicited through the Secretariat. Qualifications for and candidates for participation have not been discussed within the group.

2. Identify how to adapt Norwegian sightings survey methods to the North Pacific for use on Japanese survey vessels

Comments were made in reviewing the January draft proposal that addressed this issue. Particularly important was the use of binoculars and its effect on sightings distances. It is unclear how this might affect the applicability of the Norwegian survey methodology.

3. Select the analysis method to be used

No discussion.

4. Review draft survey plan to be circulated by Japanese scientists

A revised draft survey plan was circulated and comments received. Comments are reproduced here because there was relatively little discussion of them. Comments relative to both survey plans are in Adjunct 1, and those relative to the minke whale survey are in Adjunct 2.

5. Submit minke whale survey plan for Scientific Committee review in Oman

A plan was submitted (SC/50/RMP4).

Bryde's whale survey

1. Arrange for Scientific Committee participation in the survey

Japan will cover travel, salary and on board costs for participants. Applications were planned to be solicited through the Secretariat. Qualifications for and candidates for participation have not been discussed within the group.

2. Submit previous data to IWC Secretariat
Data were submitted in mid-December.

3. Make data and more detailed data summaries available to Steering Group members
Shimada and Miyashita are planning to prepare a paper for the annual meeting. Shimada provided revisions of those data in Shimada and Miyashita (1997) to the Correspondence Group on Specification of Implementation Simulation Trials for the Western North Pacific Bryde's Whale.

4. Evaluate effects of platform and observer heterogeneity
Okamura, Miyashita and Shimada are planning to prepare a paper for the annual meeting.

5. Evaluate spatial and temporal pattern of previous survey
Shimada and Miyashita are planning to prepare a paper for the annual meeting using a GLM approach.

6. Develop method of estimating abundance from previously collected data, accounting for platform, observer, spatial and temporal heterogeneity
Not discussed.

7. Develop method of estimating variance of abundance estimates, accounting for co-variances across areas and surveys
Not discussed.

8. Review draft survey plan to be circulated by Japanese scientists
A revised draft survey plan was circulated and comments received. Comments are reproduced here because there was relatively little discussion of them. Comments relative to both survey plans are in Adjunct 1, and those relative to the Bryde's whale survey are in Adjunct 3.

9. Submit North Pacific Bryde's whale survey plan for Scientific Committee review in Oman
A plan was submitted (SC/50/RMP5).

Summary
Several of the specific tasks identified were completed by the group. Draft survey plans were reviewed, but there was little discussion of the reviews in the group. Thus, how the various comments have been accommodated will require further discussion. Little progress was made for either survey on selecting analysis methods and for the Bryde's whale survey on examining previously collected data. Thus, further discussion of analysis methods and results of analyses of previous data will be required. Finally, qualifications and selection of individuals to represent the Committee will need to be discussed.

Adjunct 1. General Comments on Survey Protocols for Japanese Sightings Surveys

Distance and angle estimation/testing

There is a need to estimate radial sightings distances more precisely by using reticle binoculars. This is especially true with the Bryde's whale proposal which will use 7x binoculars as the primary search method. The same method can also be used with many minke whale sightings (although, perhaps not all can be relocated using binoculars after being sighted by eye). Linking groups seen by independent teams will be aided by more accurate distances. Also, potential bias can be eliminated. Are radial distances, distances from the bow of the ship to the animal, or from the platform to the animal group?

It would be better if more precise estimates of radial distance were obtained. However it was indicated that reticle binoculars were not easy to use aboard the *Shonans* - the ones available had to be held at an angle and were very uncomfortable. Perhaps there are better reticle binoculars on the market than those currently used by SOWER/IDCR.

One way to avoid having to record the port/starboard variable is to make the sighting angles range from 0-360°. So sightings seen on the starboard side are 0-90 degrees and those on the port side are 270-360°. If the angle board is labelled like this then there will not be any confusion as to whether the sighting is on the starboard or port side. The same angle board and labelling convention would also be helpful when reporting the swim direction variable.

If the surveys are to be run using the same observers as those used during IDCR/SOWER cruises, then it does not make sense to change the method of recording sighting angles. Many of the observers have up to 20 years experience of the present recording methods either during IDCR or JARPA and it would inevitably lead to confusion if a different set of angles are used. Besides, during closing mode the Captain requires the information in terms of Port or Starboard to move the ship towards the sighting.

The distance and angle estimation experiments should focus on the range of distances that will be encountered in the survey. For example, with minke whales, if the search area is 1,500m, then training and testing should focus on that range. For the minke whale experiment, if the ship is going to be travelling at 10kts from some distanct point heading towards the buoy at the same time the observers are recording distances, then the ship will cover the 1,500m in about 5 mins. Will this be enough time to do what you want? If there are several buoys out then will the team leader indicate which buoy to look at? The problem with looking at one buoy and travelling towards it is the distance guesses are correlated, because it is obvious that the next distance has to be less than the last distance; using several buoys might remove some of this auto-correlation. Also, remember to take into account the difference between where the observers are standing and where the radar is located.

The auto-correlation problem is unlikely to be a problem if the same method is used as during IDCR/SOWER cruises. Observers are located in the mess during the trials and only move to the observation platforms for one attempt (measurement). They then return to the mess until their number is called again (each observer has a unique number).

In situations like NILS it is obviously important to train observers to record distances and angles because the observers have little experience. However, the Japanese observers have many years experience - and probably each have their own 'error' for distance and angle. Thus it may not be a good idea to conduct extensive training as one would have to conduct extensive testing as well, and this is extremely time consuming.

Analysis methods

In choosing the method used to estimate $g(0)$, an *a-priori* power analysis should be done to see if anticipated sample sizes (based on previous surveys) will be adequate. This is especially a concern with the SCANS-type method because only duplicate sightings are used for abundance estimation. For Bryde's whales, $g(0)$ is probably quite high and most of the tracker's sightings will be seen by the primary team. This may not be true for minke whales. The IDCR approach is probably not the most appropriate method. If the secondary observer position has a variable number of observers; this will introduce a high level of heterogeneity.

Weather codes for rain, fog, fog patches, etc. do not specify the distance and angles within which these codes apply. Fog located 3 n.miles behind the vessel does not affect sightings as much as rain on the trackline 0.5 n.miles from the vessel. Some attempt should be made to standardise these measures. Also, swell height should be recorded (in addition to Beaufort Sea state).

Adjunct 2. Comments on Survey Protocols for Minke Whale Sightings Surveys

General

Is the only purpose to obtain minke whale abundance estimates? Are there any other important species that need to be considered during the planning of the protocols?

A formal classroom training session before anyone gets on the ship is helpful. This way everyone can become familiar with procedures.

After a few days of data collection, team/cruise leaders should review the data and inform the observers how they can improve, i.e. rounding angles or distances, not tracking animals, not concentrating in the 45° sectors, etc.

An expert familiar with the Norwegian survey protocol should accompany the first minke whale cruise. Modifications to field protocols are inevitable on the first of this type of survey.

Distance and angle experiments

Seen in light of the need for dive time observations, it would be best to spend time there than doing several sets of experiments. Perhaps one mid-way experiment is sufficient, and instead use all opportunities to do distance/angle training underway. Use of recorders with accurate timing for the dive time experiments is suggested.

Allocation of survey effort

All available time is put into one transect for each of the blocks. Looking into the figure, this might seem reasonable, but there is also an option for running two transects, at least in OSW and PA. This would perhaps increase the chances of having one basic coverage within a smaller time frame. It is not clear how the expected migration directions of minke whales within the blocks are; is this taken care of, and is there any strategy for the sequence of covering blocks?

Timing

It is of major importance for the duplicate identification that the observers activate the tape recorder immediately after a whale has been detected. Measuring of distance and angle should be done after activating the tape.

Listening to tapes

It is an advantage if team leaders listen to the tapes at the end of the day. In this way observers that do not follow the protocol can be corrected.

Searching and tracking

Use of binoculars or naked eyes: the procedures referred to here are based on 'Norwegian' conditions. In Japanese waters blows are seldom seen from minkes, and the naked eye is preferred by whalers (which we primarily use as observers). The important thing here is to be consistent and go for one of them. If observers are used to binoculars, it would be best to go for them. That implies, however, that search angles and ahead-sector has to be reconsidered from what was used in NILS-95. Relevant earlier data must be studied to decide on these matters. This seems to be a point for consideration as the Bryde's surveys use other directives (for binocular search). Acceptable weather conditions for primary search must be adjusted to expected cues (see above).

Naked eye versus binoculars

A question: will an observer using binoculars automatically search further out (at longer distance) than an observer using the naked eye? If, at the extreme, only the horizon is searched, it will cause problems in the analysis if hazard probability models are to be used. This especially applies to Schweder's method, but also to the Skaug method which the protocol mentions. Thus the protocol should ensure that all distances are searched, also with binoculars.

Table 1 shows cues of minke whales which led to the first sightings recorded during the last Japanese sighting cruises in the North Pacific in August and September of 1983-1996. During these cruises, binoculars were used for searching. A blow can be sometimes be seen in the northern-most area of the Okhotsk Sea where the air temperature is cold. In the other area, a blow cannot be seen.

Table 1

Cues of minke whales in the North Pacific in August and September 1983-1996.

Cue	Number	%
Body	275	65.9
Blow	66	15.8
Body and blow	10	2.4
Body under water	4	1.0
Jump or splash	49	11.8
Ring	11	2.6
Other	2	0.5
	417	100.0

Search protocol

To ensure the trackline is covered, it might be a good idea to have each observer survey 5-10° to the other side of their main viewing area. Thus, the port observer surveys from 45° port to 10° starboard. If observers are not supposed to search on the opposite side, there may be an increased tendency to round to zero degrees. Also, there is no reason to confine search between 45° left and right. Despite instructions to confine search to 45° right to 45° left, the Norwegian found an almost uniform distribution of sighting angles to 90°.

Is 1,500m ahead a sufficient distance for the maximum distance? What has previous data indicated in the North Pacific? Is there an obvious blow?

There are three people per observation team and at any time two are on watch. So do the observers rotate positions, two on watch and one off watch, where each position is for one hour?

Basing the efficiency parameter on each topman involves too many combinations and there may not be enough data to produce precise estimates. To avoid this problem, it would much easier to simply assign an observer to one team and the team to one platform. This will limit the variability and allow reduction in bias by including team within platform as a covariate, if needed.

Are there any obstacles in front of either of the platforms?

Search by naked eyes only may result in bias if minke whales are avoiding the vessel at close range. It might be better to detect whales further from the ship, before they have a chance to react.

Acceptable sightings conditions for minke whale surveys should probably be limited to Beaufort 0-3 (if practical). Beaufort 4 it is almost impossible to see minke whales (they are more difficult to see in the North Pacific than in the Antarctic).

Data recording

Obviously, the swim direction and appearance category are redundant and given the swim direction is recorded correctly then the appearance category does not have to be recorded.

How often does the computer record position: once a minute, once an hour?

Any weather factors that might be used in the analysis as covariates should be recorded as frequently as possible, more frequently than the once an hour that has been suggested. This will improve the analysis.

How is the start and end of a transect recorded on the sightings survey activity and weather form?

Will the recorded speed reflect the speed through the water or over ground? If possible, it would be nice to record both, since both speeds can be useful.

Does each observer carry around their own tape recorder, and stay on the same platform? Should the observer state these facts onto the tape recorder to make transcribing less confusing?

Is pod size the best guess for the entire pod or the pod size that came up at that surfacing?

Both cue and tracking mode (whether observer is tracking or not) are variables to be recorded on the survey sightings form, so they should also be discussed under the section Protocol of Observers/Reporting/2. Particulars.

Analysis method

The analysis method assumes that minke whales are usually solitary. Is that true for this area?

How will data collected from platforms other than the primary and secondary platforms be used?

Before using Skaug's new models it would seem wise to test out the model on both the Norwegian minke whales and the simulated datasets that are already available. If the method results in biased or imprecise estimates, then it would not be good to use it on this new data.

Transect layout

Do the minke whales migrate through this area or is there some general movement patterns that the animals follow? If so, then the tracklines should not follow this movement pattern.

Dive times

Following minke whales at 500m is likely to affect their behavior and 1km would be better if sightings conditions allow. It is important to record every surfacing, not just time at first surfacing and time at diving. Acceptable sightings conditions for dive-time studies should be defined *a priori* to be Beaufort 0-2 and swell heights of less than 1.5m. Missed surfacings are inevitable with whitecaps. Recording the relative distance and bearing for each surfacing and dive does not seem practical.

A tape recorder or computer should be used to record the data. A computer could be used by pressing a key to indicate when the animal surfaced and pressing another key when the animal goes down. The computer could automatically log the times to 100th of a second. This would accurately record short dives. Attaching a time-depth recorder (possibly with suction-cup mounted tag with a flotation device) would produce more accurate information of a typical dive pattern when the ship is not present. The ship could circle the tagged animal to see how the dive patterns change in the presence of a survey ship, not a ship chasing the animal.

Adjunct 3. Comments on Survey Protocols for Bryde's Whale Sightings Surveys

General

If the estimation of $g(0)$ is necessary for this species and there is only one ship that has an IO platform then is it worth the other two ships going out this year? How will it be determined when to do 'other experiments and observations'? What type of sample sizes will be needed?

Search protocol

Consideration should be given to getting an outside expert experienced with 25x binoculars if they are going to be used in a tracking experiment. Why will the ship be running at 11.5 knots for this survey and 10 knots for the minke whale survey?

Data recording

The reticles in the 7×50 binoculars can be used to accurately estimate the radial distance. Will they be used? Will the binoculars be mounted on a stable tripod or monopod or will the observer be holding the binoculars maybe with a handheld stand?

Will high and low pod sizes for the Bryde's whales be recorded?

Why do the observers call the sightings down to researchers who record the data for this survey and the observers record their own sightings on tape recorders for the minke whales? It seems awkward to have someone else who is not on the sighting platform record the data when the observer himself or herself could just as easily record the data with less chance of a miscommunication mistake?

How is the time of the initial sighting recorded? Are the times approximate or nearly exact? Timing will be important for matching between platforms.

Analysis methods

How will the data collected from the Captain and helmsman be used in that abundance estimate? Will they be recording when they are dedicated to looking for animals or when they are running the ship and doing their other jobs?

Transect layout

The idea of spreading out the actual survey effort over the entire study area would be a good way to get coverage.

Dive times

Dive times should also be recorded for Bryde's whales on an opportunistic basis.

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Appendix 9

MINKE WHALE ABUNDANCE IN THE CM MANAGEMENT AREA FROM NASS95 - ICELANDIC DATA: REQUIREMENTS UNDER THE RMS

N. Øien

The guidelines and requirements referred to here are given in IWC (1997, pp.227-28). Sections of paragraph 2 on requirements are summarised below with comments in italics.

2.1 Oversight by the Scientific Committee: Design, conduct, verification and analysis of data shall be under oversight by the Scientific Committee. *Iceland is not a member of the IWC and the survey was therefore planned under another body.*

2.2 Notification and planning: This includes review of plans for survey design, data collection, verification and analysis **in advance** of the survey. *A planning meeting for the survey (NASS95) was held in Tromsø in December 1994 and there were members of the IWC Scientific Committee present.*

Notification of the Secretariat at least 4 months prior to their start.??

When 'standard methodology' (defined by DESS and standard line transect analysis) is used, as it was in the Icelandic survey, oversight is not required beyond that sufficient to ensure that the 'standard methodology' is followed. This may involve participation in cruise planning meetings, the survey itself and post-cruise meetings, but necessary involvement is to be decided by the Scientific Committee itself. However, the non-member status of Iceland may make this a bit different?

2.3 Survey conduct: Eventual Scientific Committee representatives should submit independent reports to be considered at a post-cruise meeting, etc. *No IWC Scientific Committee participation, neither is it strictly required for 'standard' surveys.*

2.4 Survey documentation and data provision and verification: Documentation to be provided to the Secretariat no later than six months prior to the meeting of the Scientific Committee in which data from the survey are to be used as input to the CLA:

1. Cruise planning report. *Not available.*
2. Field instructions and example data sheets. *Not available for NASS95, but similar to NASS87 and NASS89 (for which extensive planning meetings were held).*
3. Cruise summary report. *Exists as a NAMMCO document, but not submitted to IWC.*
4. Documentation of any experiments conducted, e.g. g(0) experiments. *None conducted.*
5. Documentation of methods used to estimate distances and angles to sighted groups. *Distance experiments were conducted, but no documentation published.*
6. Specification of data verification procedure. *Verification conducted, but no published document.*
7. Documentation of observations excluded for any reason. *Not applicable.*
8. Description of analysis methodology planned to be used, including factors or covariates to be used. *Standard line transect with g(0) = 1.*
9. Documentation of additional information related to the conduct of the survey necessary for interpretation of the data. *Notes given in information file for the data.*
10. Data provided to Secretariat. *Not within the required time frame.*

2.5 Data analysis: These analyses fall into the category 'standard', and the following rules are to be followed:

(a) circulate analyses to the Scientific Committee 3 months prior to the meeting they are to be used; *not done*

(b) any alternative analyses to be circulated 2 months prior to the meeting. *Not done.*

REFERENCE

International Whaling Commission. 1997. Report of the Scientific Committee, Annex K. Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme. *Rep. int. Whal. Commn* 47:227-35.

Appendix 10

REPORT OF THE INTERSESSIONAL CORRESPONDENCE GROUP ON THE SPECIFICATION OF *IMPLEMENTATION SIMULATION TRIALS* FOR THE WESTERN NORTH PACIFIC BRYDE'S WHALES

Members: Allison, Butterworth, Goto, Hammond, Hatanaka, Kato, Miyashita, Oshumi, Palka, Pastene, Perrin, Punt, Smith, Yagi.

This Correspondence Group was established during the 1997 meeting of the Scientific Committee to advance progress on the seven tasks identified by the *Ad hoc* Working Group on the Specification of *Implementation Simulation Trials* for the western North Pacific Bryde's Whales (IWC, 1998). Completion of these tasks 'would assist in, and simplify, the development of plausible stock structure hypotheses and hence the construction of trials' (IWC, 1998).

Extraction of the historical catch and abundance data for the western North Pacific (tasks 1 and 2)

Shimada (SC/50/RMP16) presents estimates of abundance by 5° × 5° square based on data collected from 1988–1996. The estimates exclude the area around Kochi. Estimates of abundance are also provided by 5° latitude band (10°N–45°N).

Summary of the mark-recapture information for North Pacific Bryde's whales as it relates to movement between areas (task 3)

Kishiro (1996) examined movements of Bryde's whales in the western North Pacific using marks recovered by Japanese and Soviet whaling vessels. Kishiro (SC/50/RMP18) provides plots of the mark-recapture data by month of release and month of recapture.

Provision of information on the likely areas and timing of future harvesting (task 4)

Adjunct 1 lists the information on the likely areas and timing of future harvests provided by Hatanaka in consultation with other Japanese scientists.

Joint analysis of the samples from SC/49/NP5 and SC/49/NP6 (task 5)

The main purpose of this task is to extend the geographical coverage of the mtDNA sequencing analysis presented in SC/49/NP5 by incorporating data used in Yoshida *et al.* (1997). SC/50/RMP9 examined Bryde's whale samples from two longitudinal sectors in the western North Pacific: Gr-1 ($n=79$) and Gr-2 ($n=71$). The Gr-1 involved samples obtained during past whaling operations in Taiji, Ogasawara and biopsy samples collected in that sector. The Gr-2 involved samples taken during past whaling operations in the central western North Pacific and biopsy samples collected in that sector. For comparison, Bryde's whale samples from three outgroups were used: south Javan ($n=23$), south Fijian ($n=24$) and Peru ($n=24$). The outgroups samples were obtained during past scientific or commercial whaling operations. As in Pastene *et al.* (1997), the statistical analysis in SC/50/RMP9 was based on both haplotype and sequencing statistics.

Summary of the information (particularly as regards distribution and abundance) about Bryde's whales in other areas, including local forms (tasks 6 and 7)

SC/50/CAWS6 summarises information about Bryde's whales in the eastern South Pacific. This information is based on data derived from historical whaling operations off Chile and Peru and from the literature. Bryde's whales are rarely seen around Hawaii, although those waters are certainly within their range (Minasian *et al.*, 1987). Minasian *et al.* (1987) note that it is most likely that the Bryde's whales around Hawaii are a part of the population of the offshore form. These comments and the fact that Bryde's whales are not a target for whale watching off Hawaii could be argued to imply that the local form is not found around the Hawaiian Islands. However, it was noted that there has never been a systematic survey of whales in the western Leeward Hawaiian Islands and there is no whale watching in these islands. Furthermore, it was noted that the shallow water area around the Caroline Islands and northern Kiribati is nearly as large as that around the Solomon Islands where the local form is found.

Other issues

It was noted that if trials are constructed which consider only that area in which only a single (western North Pacific) stock is found, hypotheses regarding the relationship between the proportion of the stock in the area being surveyed and the size of the whole population may have to be developed. SC/50/RMP11 (Hatanaka) contrasted a range of alternative stock-structure hypotheses for the western North Pacific Bryde's whales.

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Adjunct 1. Information on the Areas and Timing of Future Harvesting

Compiled by Hiroshi Hatanaka of Seikai National Fisheries Research Institute, Japan.

Area of non-harvesting

200 n.mile zones of countries other than Japan (actually no permission to enter and, at the same time, to avoid local resident form) (Wada, 1997).

20 n.mile zone off southern Japan (west of 36°E including the Kochi area and Ryukyu Islands, to avoid local resident form) (Yoshida *et al.*, 1997).

Area south of 10°N (operationally difficult because of the many islands in the area).

Timing of the harvest

May–September (i.e. excluding the breeding and parturition seasons, and including past fishery season).

Basic information:

Breeding season (December to April) (Ohsumi, 1995)
Parturition season (October to March) (Ohsumi, 1995)
Past fishing season (April to September) (Kishiro, 1996)
Season in which abundance data were obtained (July to September) (Shimada and Miyashita, 1997).

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Appendix 11

CONSIDERATION OF THE FORM OF BRYDE'S WHALES AROUND OCEANIC/ISOLATED ISLANDS, ESPECIALLY IN THE LEEWARD HAWAIIAN ISLANDS AREA

H. Hatanaka, S. Ohsumi, H. Kato and T. Miyashita

The possibility and plausibility of an hypothesis that a coastal/resident form (or small/dwarf type) of Bryde's whale is found in waters around oceanic/isolated islands is discussed here, in particular the Leeward Hawaiian Islands area, in order to contribute towards the specification of *Implementation Simulation Trials* for western North Pacific Bryde's whales.

Given the differences described below, the Leeward Hawaiian area (Hawaiian Ridge) can be divided into two sub-areas: the Hawaiian Islands group (in the southern part) and the Midway Islands group (in the northern part).

1. Hawaiian Islands

There is a substantial human population in this area and whale watching is popular. Despite high effort however, Bryde's whales are seldom seen around Hawaii, and are most likely to be the offshore form (Minasian *et al.*, 1987). No coastal/resident group has been found. This information suggests that the animals around Hawaii should be treated as the offshore form in trial specifications.

2. Midway Islands

The human population is small and there has been no whale watching around these islands. However, the following information is available.

(1) Differing characteristics of the island groups: oceanic/isolated islands, e.g. Ogasawara and Hawaii, suggest the offshore form; large/close-to-continent islands, e.g. Kochi and the Philippines suggest the coastal/resident form. This indicates that the Midway Islands can be expected to be of the oceanic/isolated and the offshore form.

(2) The Midway Islands stretch like a chain from the Hawaiian Islands. Oceanographic conditions are the same for both island groups. It is reasonable to deduce that if a coastal/resident form does not exist off Hawaii, it will not exist off Midway.

(3) It is biologically doubtful that a small population is independently sustainable around small, isolated islands. Although considering fish, an expert group emphasised the importance of maintaining breeding populations with an effective size of at least 50 for short-term fitness and of at least 500 for long-term survival; this will also avoid 'genetic bottlenecks' created by the reduction of breeding populations to small sizes for one or more generations (FAO Fish.Tech.Paper, No.217). If a coastal/resident stock of several hundred/thousand exists around Midway it would have been observed by whalers, as this area was once part of a Japanese pelagic whaling ground.

(4) A total of 240 Bryde's whales were taken around Midway by Japanese pelagic whaling, between 1971 and 1979, from five blocks. All animals were measured and checked by inspectors (including scientists) on the factory ship but no dwarf/small type or anomalous animals were observed.

(5) A total of seven animals used for mark-recapture and genetic analyses were taken near Midway (see fig. 7 of SC/50/RMP11), and these data indicate that the animals were all of the offshore form. The mark-recapture data show that all of the 15 whales marked or captured within island blocks moved to, or came from, offshore blocks, i.e. no whales were recaptured in the same island block in which they were marked (SC/50/RMP18). This indicates strongly that animals around oceanic islands are not resident but migrant. In the case of Midway Islands blocks, three tagged animals were caught after being marked at low latitudes.

(6) Wada (1997) found that a coastal/resident form has only been recorded on the Asian side of the North Pacific, and was not found around the Ogasawara Islands. This pattern of distribution suggests that this form does not reach the Midway Islands region.

In conclusion, the above information suggests that the Bryde's whales found around the Midway Islands should be treated as the offshore form.

3. Other Oceanic/isolated Islands

The available information for the other three main island groups is summarised below.

(a) Kiribati Island Group
This area is further from the Solomon Islands than the distance between Kochi and Ogasawara Islands. Items (1) and (3) in the previous section are applicable.

(b) Micronesia (Caroline Island) Group
The distance between this area and the Solomon Islands group is similar to that between Kochi and Ogasawara. Items (1), (3) and (5) above are applicable. The number of specimens is three.

(c) Northern Mariana Island Group
This island group is on the Marianas Ridge which is connected to the Honshu Ridge from the Japanese mainland through the Izu and Ogasawara Islands. The situation seems to be similar to the Ogasawara Islands group in which case items (1), (3) and (7) are applicable.

In conclusion, the available information suggests that a hypothesis that a coastal/resident form is found around any of the island groups is difficult to support. Low plausibility should be given to this scenario.

4. Solomon Islands

It is known that a dwarf form of Bryde's whale is found around the Solomon Islands. The Solomon Islands are close to the islands of New Guinea, which in turn are connected through the chain of Indonesian Islands to the Asian continent. Six specimens of the dwarf form were all caught within one day on the west side of the Solomon Islands – an area surrounded by islands both of the Solomon and New Guinea groups. The available information suggests that the behaviour and ecology of this form differs from that of the offshore form. We believe that is unlikely that its habitat will include distant isolated/oceanic islands.

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Wada, S. 1997. A review of Bryde's whale taxonomy for the Indian Ocean and Solomon Sea. Paper SC/49/NP7 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 27pp.

Appendix 12

COMMENTS ON SC/50/RMP11

W. Perrin, S. Baker, Per Berggren, P. Best, R. Brownell, T. Kasuya, E. Slooten and D. Thiele

(1) It is assumed in SC/50/RMP11 that the Kochi and Solomons Islands small forms are conspecific and therefore that their ecologies must be the same, leading to the use of 20 n.miles offshore (which works for Kochi) for an offshore limit for the small forms everywhere. However,
  (a) the most recent genetic results (for cytochrome *b*, which is more appropriate for species-level analyses; A. Dizon, pers. comm.) are not consistent with the hypothesis of a single small-form species (the Kochi whales are a sister taxon to the large-form Bryde's whale clade, while the Philippine 'Bryde's whales' lie outside the sei-Bryde's whale clade; i.e., ((fin)((Phil)((sei)((largetype)(Kochi))))); and
  (b) seven Solomons small-form whales were caught far offshore in the Solomons Sea, over 60 n.miles from the nearest land, in depths of ~1-5km (from Ohsumi, 1978 and hydrographic chart).

(2) The assertion that 'it is quite doubtful biologically that a small population exists in such an isolated small area, in viewpoint of permanency and sustainability of population' has no basis in what is known about these whales and their known and likely habitats.
  (a) In point of fact, the various island groups in the West Pacific have very large shallow-water areas and inter-island depths (and distances) comparable to those in which the Solomon Islands whales (and the three Javan small-type whales) were taken.
  (b) The range of the South African inshore form (SC/50/CAWS13) is comparable in area to that of several of the major island groups in the West Pacific and Central North Pacific.
  (c) Local populations of animals do not necessarily remain stable or permanent. They may fluctuate in size, or they may become extinct and re-established through colonization from a different population of the same species (in a period short in geological time but long in terms of human perceptions and needs).

(3) The results of mark/recapture and genetic analyses (SC/50/RMP9) do not 'negate indirectly' the island-group stock hypothesis. The presence of large-form whales in some of the 5° blocks, which include some very deep water far from islands, does not negate the possibility of the presence of small-form whales in some of those same blocks. Negative evidence from small sample sizes is not conclusive, especially considering in this case that some island-group areas have not been surveyed or sampled. In addition, the cited absence of reports of small-type whales by whale watchers in the Bonins and main Hawaiian Islands cannot be considered definitive, as such lay information is not reliable. In any case, it should be kept in mind that the purpose of the 5° block scheme is not to identify all areas in which large-form whales are known to occur, but rather to identify areas in which small-form whales may occur, as a precautionary approach.

(4) Absence of small-type whales in the Bonin Islands whaling statistics cannot be used as a reliable indication of absence of small-type whales in the region. Body length could have been falsified by the whaling companies, as was done for sperm whales. Small-type whales could have been depleted there, or they could have remained undiscovered. Note that the Kochi population of small-type whales was discovered only very recently, after the end of commercial whaling.

(5) In view of the above points, the plausibility of 'Hypothesis 2' (small-form whales resident in island-group areas) cannot be considered to be 'extremely low'.

(6) The hypothesis that a pelagic stock or stocks of large-type Bryde's whales could straddle the Equator seasonally (Hatanaka's 'Hypothesis 3') was based on an analysis of catch positions for 'sei' whales taken by the MV *Sierra* in the southeast Atlantic in the 1970s (Best, 1996). This analysis indicated that the distribution of offshore animals ranged across the Equator and as far as 3°N in the (southern) winter. Conversely, during the (southern) summer, catches of Bryde's whales were made in equatorial regions as far south as 1°S, and of 'sei' whales as far south as 8°S, at the same time that the bulk of the offshore population was south of 15°S; these equatorial catches are presumed to represent Bryde's whales from the northeast Atlantic on their (northern) wintering ground. Hence the region 5-8° either side of the Equator could be inhabited by a northern stock of Bryde's whales at one time of year and by a southern stock at another time of year. This point is actually tacitly accepted in SC/50/RMP11, by denoting the southern boundary of the offshore stock in the western Pacific as 5°S (SC/50/RMP11, figs 8 and 9).

However, the point is more than just drawing boundaries on a map. If the likely seasonal changes in the distribution of the offshore stock are not correctly recognised, there is the possibility that sighting survey estimates made in tropical regions in the northern summer could be allocated to the wrong stock, thus inflating estimates of abundance. Similarly, Bryde's whales marked in tropical regions in the northern summer may not all belong to the western North Pacific population, and the failure to obtain any recoveries of these marks in the whaling operations farther north in the western North Pacific would tend to inflate mark-recapture estimates of population size.

To avoid these pitfalls, it is necessary to stratify sighting and marking data appropriately, perhaps by excluding sightings made and marks placed south of 10°S in the northern summer, when estimating population size.

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Best, P.B. 1996. Evidence of migration by Bryde's whales from the offshore population in the southeast Atlantic. *Rep. int. Whal. Commn* 46:315-31.

Ohsumi, S. 1978. Provisional report on the Bryde's whale caught under special permit in the Southern Hemisphere. *Rep. int. Whal. Commn* 28:281-7.

Appendix 13

SIGHTINGS AND ABUNDANCE ESTIMATES FOR WESTERN NORTH PACIFIC BRYDE'S WHALES

Hroyuki Shimada and Tomio Miyashita

This corresponds to task 5 for the Bryde's whale sightings survey of the NPSSSG.

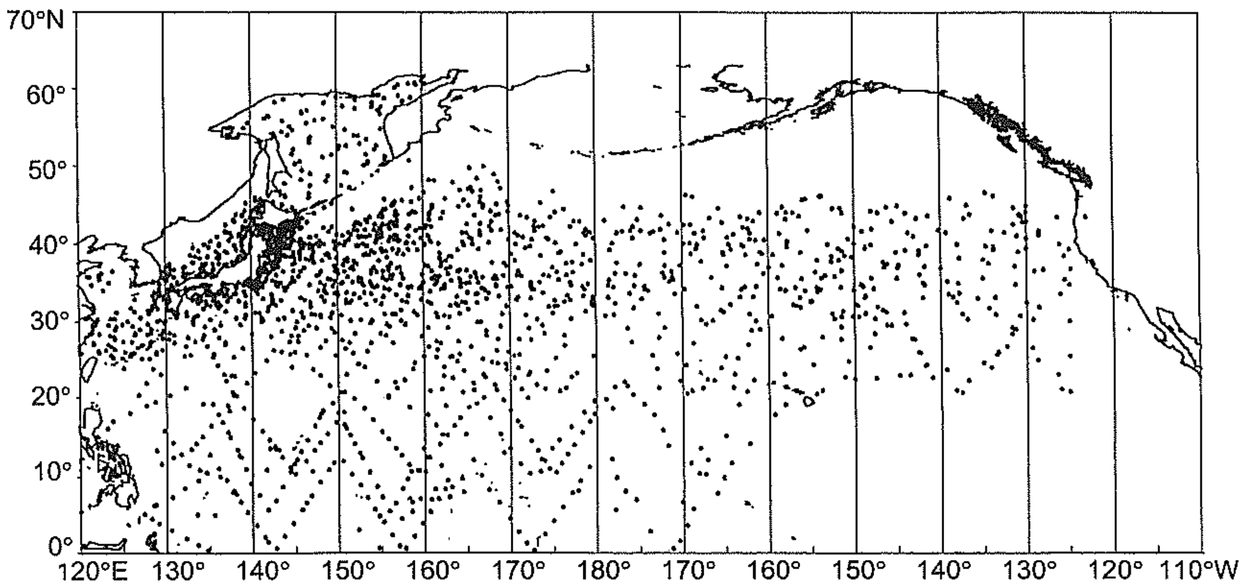


Fig. 1. Noon positions with sighting effort in August and September 1988-1996.

Table 1

Summary of effort data of sightings cruises used for the western North Pacific Bryde's whale abundance estimate by vessel, date and location (5° square). S: squid jigger (with top barrel); C: catcher boat (with top barrel); Tu: tuna long liner (without top barrel); Tr: trawler (without top barrel unless until 1995).

RV	Type	Year	Month	Lat.(N)	130E	135E	140E	145E	150E	155E	160E	165E	170E	175E	180	175W	170W	165W	160W	Total
KS2	S	1995	Aug.	10									228	145						372
				15								60	277	256						593
				20								68		132						200
			Sep.	10								210	298							508
				15							78	42	163	63						346
				20							71			47						118
		1996	Aug.	0	289															289
				5	223															223
				10	279	137														416
				15		275														275
			Sep.	20	100															100
KY1	C	1990	Sep.	35	103	66														170
				40		111														111
		1991	Aug.	35			269	102	11											382
				40			340	120												459
			Sep.	25		80														80
				30		178	341													519
		1992	Sep.	40			46	20												66
		1993	Aug.	30					184		11									195
				35				45	76	110	205									436
				40				163		186	38									387
			Sep.	20					124	201										325
				25			6	119	172	35	203									534
				30				210			144									353
		1994	Sep.	35	141	730	23													894
				40		484														484
SM2	C	1988	Aug.	35												49	116	113	108	386
				40			71	56	15				11	11	109	90				363
			Sep.	30			59	34	101	101	95	106	36				78	109	106	825
				35												54				54
		1989	Aug.	30		13				66	246	57		37	174	131			310	1,034
				35			88	101	126	89	110	288	350	292	246	389	69	306	386	2,840
				40													358	157		515
			Sep.	25													119	144	346	609
				30		106	47					110	59	115	113	86	245	144		1,025
				35				125	139	141	100					16				521
		1990	Aug.	30		13	22													35
				35			82	117	101	55									130	484
				40						25	64	75	64	109	81	11	80	114	8	632
			Sep.	30		137	124	12										112	115	501
				35				29	71	83	111	103	24	24	27	79	121			670
		1992	Aug.	25			281	523	324											1,128
				30				26												26
				35						363	402									765
				40						89	65									155
			Sep.	25	551	579	348													1,478
				30	51	20	4													76
		1993	Aug.	10						384	387	256	692	84						1,803
				15					256	69	290	777		385						1,777
			Sep.	10			284	144												428
				15		133	189	80	220											621
				20		129			1											131
		1994	Aug.	0		5	533	51		520	39									1,148
				5		104		285	307		486									1,182
				10				165	193											359
			Sep.	0						65										65
				5		229				198	387									814
				10	55	151				45	333									583
		1995	Aug.	0								39	416	54						509
				5								148		364						512
				10								101		290						391
			Sep.	0								37	298							336
				5								154								154
				10								129								129
		1996	Aug.	45						122	100	214								436
				50								31								31
			Sep.	40							138	77								215
				45							6	234								240

cont...

Table 1 continued.

RV	Type	Year	Month	Lat.(N)	130E	135E	140E	145E	150E	155E	160E	165E	170E	175E	180	175W	170W	165W	160W	Total
T11	C	1996	Aug.	5		88	491		147	429										1,154
				10		177	76		152	171	31									606
				15							199									199
			Sep.	10			21	173	26											219
				15				365	187											552
T15	C	1988	Sep.	35			149													149
				40			1,029	447												1,476
T18	C	1991	Aug.	20							109									109
				25							143									143
				35									81	2						83
				40								52	21		52					125
			Sep.	20							61	184								246
				25								100	243							343
				30									163							163
		1992	Sep.	30	90															90
				35	1,004	371														1,376
		1993	Aug.	10	358															358
				15	81	162														243
				20		374	160													534
				25			149													149
			Sep.	20		104														104
				25	391	98														489
				30	150															150
T25	C	1988	Aug.	30			287	297	146											729
				35			69	246	122	315										752
				40			36		303	185										523
			Sep.	30	69	74				89	348	81								662
				35			6	100	57	144	308	21								636
				40			84	22	79	271	8	76								540
		1989	Aug.	20				218	231											449
				25			161	138	189											488
				30			305	239	208											751
				35				268	309											576
				40			32	83												115
			Sep.	20							35									35
				25			7	121	173	94	434									830
				30	33	105	76			326	136									675
				35					110		255									365
				40				26	71	191	128									416
		1990	Aug.	35			35	155	84											274
				40			337	88	198	275	162	301	43							1,404
				45						74	204	305	14							597
				50							40	11								51
			Sep.	20					126	110	339		236	273						1,085
				25			129	121			71	450	81	219						1,072
				30	88	110					149	216	109							672
				35				90	28	109	89									316
				40				47												47
		1991	Aug.	30						103										103
				35			847	144		24										1,015
				40			3													3
			Sep.	25			63	14	92											169
				30				75	19	5										99
		1992	Aug.	30				758	437	474	542									2,211
				35				3	10	2										15
			Sep.	30	482	362	293	131												1,268
		1993	Aug.	30								192		173						365
				35								148	2	248						398
				40									258	68						327
			Sep.	20								87	330	2						419
				25								206		139						345
				30							28	102								130
H12	Tu	1988	Aug.	30										128	125	198	422	145	192	1,208
				35				129	140	114	139	133	136					202	194	1,185
				40															249	249
			Sep.	35									57	97		14	353			519
				40				102	144	75	78	50	42		207	282	36	352	118	1,484
KSY	Tu	1989	Aug.	20															77	77
(H12)			Sep.	35			119	53	31	147		101		42						492
				40					2			70	40	106	155	78	89	135	208	882
		1990	Aug.	35			44	125	117	67					3			271		626
				40				226	150	147	84	96	150	181	29			3	197	1,262

cont...

Table 1 continued.

RV	Type	Year	Month	Lat.(N)	130E	135E	140E	145E	150E	155E	160E	165E	170E	175E	180	175W	170W	165W	160W	Total
			Sep.	30								36	68							104
				35			120	61	30	114	111	81	51	72				120	120	879
				40												69	205	31	12	317
HS1	Tu	1988	Aug.	30										157	196	37				390
				35			51	131						163	193	395				934
				40				27	83	18		149	314	9	330	316				1,246
			Sep.	30									188	235						424
				35			171	96	182	106		226	138							917
		1989	Aug.	20							136	445	48							629
				25						77	92		415							585
				30						100			86	212	188					585
				35			37	92						16	278					423
				40									49	429						478
			Sep.	30					109	25		327								461
				35			157	93	68		198	114	203							832
				40									193							193
		1990	Aug.	20												373	379			752
				25											280	55	35	284		653
				30								111	232	228	121			54	83	829
				35			48			4	84	18	139	143						437
				40			79	138	93	49										358
			Sep.	15															1	1
				20														77	188	265
				25												93	145	79		316
				30									110	104	108					405
				35			53	140	99	91	56	92							94	625
		1991	Aug.	20													114			114
				30															210	210
				35													159	174		333
				40												41	162	22	100	324
			Sep.	20												88	98			185
				25												238				238
				30										53	171	5				228
				35										12	64					76
		1992	Aug.	30			194													194
				35			432	841	744	48										2,065
				40			46	179	526											751
			Sep.	30	84	1,030	27													1,141
				35		23														23
		1994	Aug.	25	111															111
				35	232															232
			Sep.	35	834	434														1,267
		1995	Aug.	40				7	511	619										1,136
			Sep.	35			10													10
				40			100		155	398										652
SHU	Tr	1991	Aug.	30		28	76													103
				35		16	781													797
				40			244													244
			Sep.	40			657	21												678
		1992	Aug.	30		39	203													242
				35		28	1,268	13												1,309
				40			571	8												579
			Sep.	40			581	214												794
		1993	Aug.	25	266															266
				30	468	341														809
		1995	Aug.	30		55	64													118
				35		5	740													745
				40			76													76
		1996	Aug.	30		53	127													180
				35		17	266													283

Table 2 continued.

RV	Type	Year	Month	Lat.(N)	130E	135E	140E	145E	150E	155E	160E	165E	170E	175E	180	175W	170W	165W	160W	Total
			Sep.	30								0	0							0
				35			0	0	0	0	0	0	0	0				0	0	0
				40												0	0	0	0	0
HS1	Tu	1988	Aug.	30										0	3	1				4
				35			0	0						0	1	7				8
				40				0	0	0		0	1	0	1	0				2
			Sep.	30									0	0						0
				35			0	0	1	0		1	2							4
		1989	Aug.	20							0	3	0							3
				25						0	0		0							0
				30						0			0	0	1					1
				35			0	0						0	0					0
				40									0	0						0
			Sep.	30					0	0		3								3
				35			1	0	0		0	0	0							1
				40									0							0
		1990	Aug.	20												1	0			1
				25											0	0	0	0		0
				30								1	0	2	0			0	0	3
				35			0			0	3	0	0	2						5
				40			0	0	0	0										0
			Sep.	15															0	0
				20														0	0	0
				25												1	0	0		1
				30									3	0	0				1	4
				35			0	0	0	0	0	1							0	1
		1991	Aug.	20													0			0
				30															0	0
				35													2	0		2
				40												0	0	0	0	0
			Sep.	20												0	0			0
				25												6				6
				30										0	0	0				0
				35										0	0					0
		1992	Aug.	30			0													0
				35			0	2	7	0										9
				40			0	0	0											0
			Sep.	30	0	0	0													0
				35		0														0
		1994	Aug.	25	0															0
				35	0															0
			Sep.	35	0	0														0
		1995	Aug.	40				0	0	0										0
			Sep.	35			0													0
				40			0		0	0										0
SHU	Tr	1991	Aug.	30		0	0													0
				35		0	0													0
				40			0													0
			Sep.	40			0	0												0
		1992	Aug.	30		0	0													0
				35		0	0	0												0
				40			0	0												0
			Sep.	40			0	0												0
		1993	Aug.	25	0															0
				30	0	0														0
		1995	Aug.	30		0	0													0
				35		0	0													0
				40			0													0
		1996	Aug.	30		0	0													0
				35		0	0													0

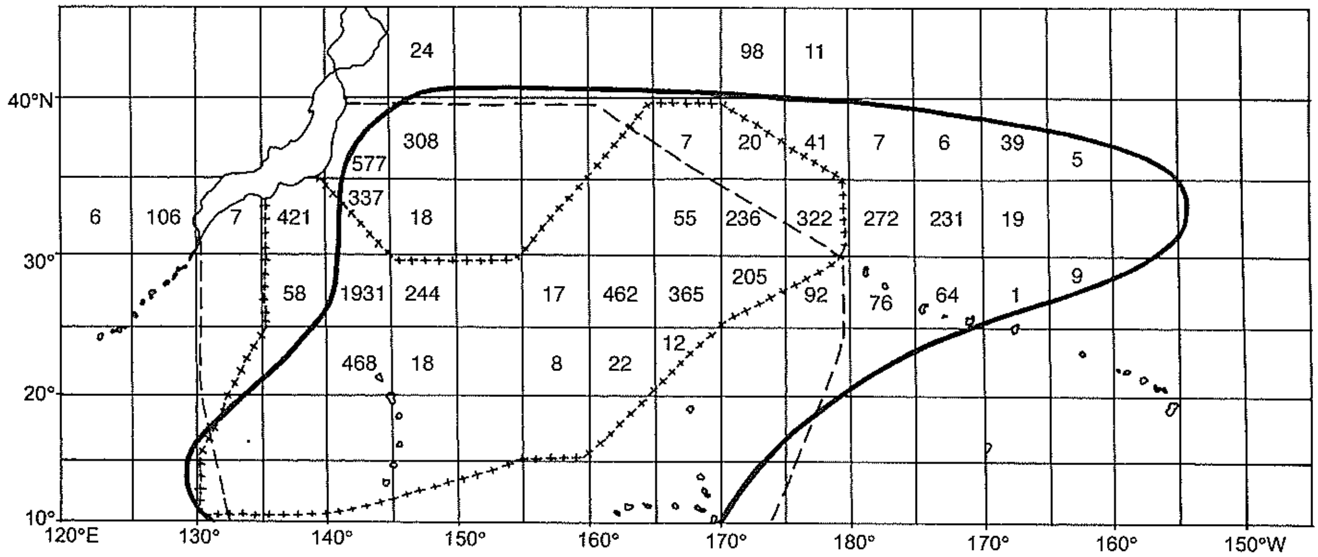
Table 3

Revised abundance estimate of Bryde's whales in the North Pacific by 5° squares excluding off Kochi in August and September 1988-1996.

5° square	Area (n.miles^2)	Effort (n.miles)	No. of sightings	No. of animals	Population	CV	95% CI	Islands
0-5°N, 170-175°E	89,600	714	1	1	56	0.882	11, 296	Yes
5-10°N, 150-155°E	88,937	453	1	2	175	0.789	38, 808	Yes
5-10°N, 155-160°E	88,937	627	4	4	252	0.603	77, 827	Yes
5-10°N, 160-165°E	88,937	873	2	2	91	1.166	13, 653	Yes
10-15°N, 130-135°E	87,611	693	10	19	1,045	0.509	376, 2,906	No
10-15°N, 135-140°E	87,611	464	7	10	841	0.489	307, 2,306	Yes
10-15°N, 140-145°E	87,611	381	1	1	102	0.767	19, 541	Yes
10-15°N, 145-150°E	87,611	483	9	10	808	0.491	302, 2,164	Yes
10-15°N, 150-155°E	87,611	371	6	7	736	0.604	208, 2,601	No
10-15°N, 155-160°E	87,611	600	8	10	650	0.576	200, 2,110	No
10-15°N, 170-175°E	87,611	1,218	3	3	96	0.696	26, 360	No
15-20°N, 135-140°E	85,635	570	3	3	201	0.740	48, 836	No
15-20°N, 140-145°E	85,635	188	2	2	405	0.993	11, 14,296	Yes
15-20°N, 145-150°E	85,635	446	2	2	171	0.686	43, 681	Yes
15-20°N, 150-155°E	85,635	663	6	9	518	0.924	95, 2,823	No
15-20°N, 155-160°E	85,635	69	2	2	1,103	0.709	316, 3,854	No
15-20°N, 160-165°E	85,635	566	3	4	269	0.863	54, 1,335	No
20-25°N, 135-140°E	83,013	608	1	1	61	0.675	15, 244	No
20-25°N, 145-150°E	83,013	218	1	1	170	0.914	25, 1,143	No
20-25°N, 150-155°E	83,013	483	5	5	383	0.531	126, 1,162	No
20-25°N, 155-160°E	83,013	311	9	13	1,545	0.513	533, 4,477	No
20-25°N, 160-165°E	83,013	751	2	3	148	0.719	36, 602	No
20-25°N, 165-170°E	83,013	784	4	5	236	0.516	86, 647	No
20-25°N, 170-175°E	83,013	615	10	12	721	0.542	250, 2,080	No
20-25°N, 175°E-180°	83,013	454	3	3	244	0.730	58, 1,029	No
20-25°N, 175-170°W	83,013	461	1	2	160	0.772	34, 753	Yes
25-30°N, 145-150°E	79,775	1,037	1	1	34	0.850	7, 162	No
25-30°N, 150-155°E	79,775	950	3	4	149	0.599	47, 478	No
20-30°N, 155-160°E	79,775	207	3	3	514	0.741	107, 2,458	No
25-30°N, 160-165°E	79,775	943	1	1	38	1.181	5, 268	No
25-30°N, 170-175°E	79,775	739	3	4	192	0.597	59, 628	No
25-30°N, 175°E-180°	79,775	358	7	18	1,784	1.889	104, 30,611	Yes
25-30°N, 175-170°W	79,775	385	7	9	822	0.674	217, 3,120	Yes
30-35°N, 145-150°E	75,934	1,783	1	1	19	1.122	3, 123	No
30-35°N, 150-155°E	75,934	1,202	4	4	112	0.634	33, 381	No
30-35°N, 155-160°E	75,934	1,356	8	11	274	0.409	122, 616	No
30-35°N, 160-165°E	75,934	1,946	14	21	365	0.448	151, 879	No
30-35°N, 165-170°E	75,934	1,504	20	38	831	0.458	377, 2,051	No
30-35°N, 170-175°E	75,934	1,108	18	37	1,128	0.315	603, 2,110	No
30-35°N, 175°E-180°	75,934	1,594	13	23	488	0.559	166, 1,435	No
30-35°N, 180°-175°W	75,934	1,482	5	7	160	0.590	52, 491	No
30-35°N, 175-170°W	75,934	672	4	6	302	0.847	62, 1,478	No
30-35°N, 170-165°W	75,934	989	4	5	171	1.036	28, 1,054	No
30-35°N, 160-155°W	75,934	1,409	1	1	24	1.119	4, 160	No
35-40°N, 140-145°E	54,344	5,951	1	1	4	0.880	1, 20	No
35-40°N, 145-150°E	71,505	3,524	5	7	63	0.524	23, 173	No
35-40°N, 150-155°E	71,505	2,919	29	44	480	0.323	253, 911	No
35-40°N, 155-160°E	71,505	2,354	36	42	498	0.298	274, 907	No
35-40°N, 160-165°E	71,505	2,378	14	16	214	0.287	120, 381	No
35-40°N, 165-170°E	71,505	1,612	10	18	342	0.431	144, 811	No
35-40°N, 170-175°E	71,505	1,530	9	15	312	0.442	129, 755	No
35-40°N, 175°E-180°	71,505	1,403	28	46	887	0.319	466, 1,687	No
35-40°N, 180°-175°W	71,505	1,056	1	1	30	0.642	8, 107	No
35-40°N, 175-170°W	71,505	1,402	9	15	341	0.376	160, 727	No
35-40°N, 170-165°W	71,505	887	2	2	72	0.802	16, 325	No
35-40°N, 165-160°W	71,505	1,491	1	1	21	0.632	6, 72	No
35-40°N, 160-155°W	71,505	1,417	2	3	67	1.298	8, 539	No
40-45°N, 160-165°E	66,525	766	1	1	39	0.691	10, 145	No
40-45°N, 165-170°E	66,525	945	1	1	31	1.026	5, 185	No
40-45°N, 170-175°E	66,525	1,185	1	2	50	0.745	12, 200	No
40-45°N, 180-175°W	66,525	963	1	3	92	0.601	28, 299	No
Total	4,802,818	65,506	374	548	22,136	0.186	15,017, 32,629	

Appendix 14

SUMMARY OF INFORMATION FOR DETERMINING STOCK BOUNDARIES FOR *IMPLEMENTATION SIMULATION TRIALS* FOR WESTERN NORTH PACIFIC BRYDE'S WHALES AND AGREED BOUNDARIES FOR THE WESTERN STOCK AND TWO SUB-AREAS



Approximate limit to sightings distribution

Approximate limit to marking data

Approximate limit to genetic data

308 Numbers are catches by Japan