Annex F
Report of the Standing Working Group (SWG) on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP)

Members: Donovan (Chair), Albert, Allison, Born, Borodin, Breiwick, Buckland, Butterworth, Cooke, DeMaster, George, Givens, Goto, Hakamada, Hester, Innes, Magnússon, Melnikov, Moronuki, Okamoto, Okamura, Ohsumi, Poole, Punt, Raftery, Rooney, Schweder, Senn, Skaug, Slooten, Tanaka, E., Tanaka, S., Wade, Walløe, Witting, Zeh, Zhu.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks
Bannister welcomed the participants.

1.2 Election of Chair
Donovan was elected Chair. He recalled that at last year's meeting he had expressed some concern at the limited membership of the SWG. The SWG had agreed that a number of factors were important for it to be efficient and effective. These included: (a) some continuity of membership; (b) several 'groups' of developers; (c) experts in the management procedures field who are not developers; and (d) broad areas of expertise.

He was pleased to note the progress in this. In particular the composition of the present group was broader, including additional experts who, at present, were not developers. He especially welcomed Magnússon who had been specifically invited to attend this sub-committee and reiterated that the contribution of invited participants would be greatly enhanced if they can be invited on a longer-term basis

The short intersessional period had meant that it had been difficult for developers to produce many results for the SWG to examine at this meeting. He therefore believed that considerable attention should be devoted to developing a timetable for ensuring that as rapid progress as possible is made towards producing an AWMP that satisfactorily meets the Commission's objectives.

1.3 Appointment of rapporteurs
Punt acted as rapporteur, with assistance from the Chair.

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

1.5 Review of documents
The documents available to the SWG were SC/50/AWMP1-7 and relevant extracts from the Chairman's Report of the 49th meeting of the Commission. Punt and Givens agreed to revise the glossary of terminology (Appendix 2) and full details of the latest trial scenarios, statistics and assumptions (Appendix 3) as necessary. The SWG had agreed last year that these would be living documents whose contents may change to reflect the AWMP development process.

For ease of reading, unless another reference is given, 'Last year' refers to IWC (1998, annex I), the report of this SWG from 1997.

1.6 Commission comments from the Monaco meeting
Last year, the Committee had agreed that it was appropriate for the Chair of the Standing SWG to present its work to the Commission. At last year's Commission meeting he presented the relevant sections of the Scientific Committee's report to the Aboriginal Subsistence Whaling Committee. In addition, he presented a less technical working paper to that Committee highlighting the questions to the Commission raised by the SWG during its 1997 meeting and had informal discussions with some Commissioners. The SWG appreciated the Commission's efforts to answer its questions (IWC, 1998), noting that some of these questions were complex (e.g. the issue of multi-species fisheries) and would be considered further by the Commission.

1.7 Report of the e-mail correspondence group
An e-mail correspondence group (awmp-grp) chaired by DeMaster operated intersessionally. Although the number of messages sent via the group was relatively low (20–25), the SWG agreed that it had been useful and had facilitated technical discussions and distribution of software. The SWG also thanked Givens for setting up the AWMP web page[1] which contains information about the AWMP development process, an archive of awmp-grp e-mail messages, and copies of software used to evaluate candidate *SLAs* and to plot the results of the simulations. Givens recalled that some issues surrounding the distribution of some of the software raised last year remained to be addressed. It was **agreed** that Allison needs to discuss this further with the Secretariat and provide advice to Givens.

2. INITIAL EXPLORATION TRIALS – GENERAL ISSUES

2.1 Common Control Program
The Common Control Program is the computer code used by developers to run the *Initial Exploration Trials* for scenarios that involve a single[2] stock (IWC, 1998). This program also calculates the performance statistics and the information

[1] http://www.stat.colostate.edu/~geof/iwcawmp.html
[2] This remains the case until the Secretariat validates the multi-stock code presented by Punt and used in SC/50/AWMP3

needed to compare the performance of candidate *SLA*s using the graphical format developed by Zeh (see Item 2.2.2). The only portion of code which an AWMP developer needs to supply is that implementing their candidate *SLA*. Allison reported that she had completed the changes to the Common Control Program specified at last year's meeting, but due to the short intersessional period, it had not been possible to complete it in time for the developers to use in papers for this year's meeting. The SWG thanked Allison for completing this task. Punt noted that the specifications agreed last year had been changed slightly to reflect the fact that the gestation time for baleen whales is considered to be one year, rather than the two years that had been inherent in last year's specification (Section A, Appendix 3). The SWG **approved** this change.

2.2 Statistics and performance plots

2.2.1 Statistics

SC/50/AWMP6 reported two problematic features of need statistic N1, Total Need Satisfaction. The first arises because N1 (which defines need satisfaction as the ratio of the total catch over the management period to the total need over this period) is not a monotonically increasing function of need satisfaction, so that an increase in N1 does not necessarily imply an increase in the satisfaction of need. The author proposed a variant of the N1 statistic, that defines need satisfaction as the average of the ratio of the catch to the level of need (constrained to be less than 1). The SWG **agreed** that this variant (henceforth referred to as the N9 statistic – the average need satisfaction) contained useful information not summarised by the N1 statistic; it avoids giving greater weight to satisfying need when need is large. It **recommends** that N9 should become one of the mandatory statistics and that the current N1 statistic should become optional. It further **agreed** that for future *Initial Exploration Trials*, the catch would be constrained to be no larger than the level of need.

The second problem identified in SC/50/AWMP6 arises because there is a trade-off between the satisfaction of current and future need. The author suggested that hunters would be more interested in current rather than long-term need satisfaction. This view was echoed by several members of the SWG. Neither N1 nor N9 differentiate between the two need components. Instead, they measure need satisfaction for the entire simulation period. As this period is usually 100 years, current need satisfaction is represented only marginally in N1 and N9. Hence, *SLA* optimisation with respect to N1 and N9 does not guarantee the satisfaction of current need. However, it was also noted that the values for the performance statistics are calculated for 20, 50 and 100 year management periods. Use of statistics based on a 20-year management period should allow an evaluation of how well need is satisfied in the short term.

During last year's meeting, the SWG refined the set of statistics used to summarise the performance of candidate *SLA*s and divided them into those that are 'mandatory' and those that are 'optional'. It was noted that despite this, there are still a large number of mandatory statistics. In fact, none of the papers presented to this meeting had reported all of the mandatory statistics but that this had not prevented a useful discussion of the results (see Item 5). The SWG agreed that it was not necessary to report all the 'mandatory' statistics when presenting papers. Instead it agreed that developers must at least include the 5% and median values for the D1 (final depletion - both mature and 1+ component of the population) and the N9 (average need satisfaction) statistics. However, developers must bring encoded versions of all of the statistics to meetings so that these can be discussed if the SWG so wishes.

The SWG noted that the present performance statistics to compare candidate *SLA*s do not include any that directly assess performance in terms of the variation over time in strike limits. It was agreed that such statistics could be developed after consideration of Commission comments this year (see Item 7).

Table 1 summarises the SWG's consideration of performance statistics thus far in the development process.

2.2.2 Performance plots

Last year, the SWG had agreed that the task of summarising and interpreting the vast array of results from different developers would be greatly facilitated if the format used for presentation of statistics was standardised. Zeh reported that the *S-Plus* software that she had developed last year for this purpose is available through the web site. She intends to make some changes to this software (including addition of the new N9 statistic) and provide a revised version to Givens for inclusion on the web site (the e-mail group will be notified when the revised software is available). Zeh and Allison agreed to discuss this further to ensure that the statistical output from the Common Control Program can easily be integrated with plotting software.

2.3 Review of simulation framework

During the development of the current set of *Initial Exploration Trials* (IWC, 1996; 1997), a number of modelling issues were identified that would require investigation in the future. The SWG agreed to review the issues considered at last year's meeting to determine whether progress had been made on any of these (and whether any new issues had been identified).

2.3.1 Density dependent survival rate

At present the Common Control Program assumes that density dependence acts on fecundity and the calf survival rate. In principle, this can lead to oscillatory population trajectories although the results examined to date do not indicate that this is a severe problem. Such problems would be avoided by allowing density dependence to act on the non-calf survival rate. Punt indicated that intersessionally, he would attempt to incorporate density dependence on the survival rate for juveniles into the Common Control Program and present the resultant population trajectories for consideration at the 1999 meeting.

2.3.2 Component to which MSYL applies

The SWG considered this issue in considerable detail at its 1997 meeting (IWC, 1998). The Committee had agreed that to progress its work in the short term, developers should carry out the *Initial Exploration Trials* using only the 1+ component (the component which, on balance, appeared scientifically preferable to the SWG). Trials using the mature component would be postponed until further in the development process when candidate *SLA*s were more fully specified and comparison with the RMP more appropriate and rewarding. This has the advantage of not increasing the number of trials, but provides no early information on the consequence of this choice (IWC, 1998). Givens noted that SC/50/AWMP1 showed that if density dependence acted on the mature component of the population (assuming that $MSYL = 0.6$ applied to the mature component), this implied a peculiarly high value for $MSYL_{1+}$ (greater than K in some instances).

Table 1

Performance statistics for use in the *Initial Exploration Trials.*

ID	Mandatory	Optional	Can be shown using Zeh graph program	Used to explain performance to layperson	Used to evaluate performance for Scientific Committee	Name	Comment
D1	1+, mature		Yes	Yes	Yes	Final Depletion	1996
D2	1+, mature		Yes	Yes	Yes	Lowest Depletion	1996
~~D3~~						~~Lowest Stock Level under Exploitation~~	DELETE: misleading (1997)
~~D4~~						~~Lowest Depletion under Exploitation~~	DELETE: misleading (1997)
~~D5~~						~~Relative Survival Probability~~	DELETE: not useful (1997)
D6	1+	Mature	Yes	Yes	No	Trajectories 1 and 2	1996
D7	1+	Mature	Yes	Yes	No	Pointwise Quantile Trajectories	1996
N1		Yes	Yes	Yes	Yes	Total Need Satisfaction	1996
N2	Yes		Yes	Yes, after conversion	Yes	Longest Shortfall	Rescale to 0-1; must convert to years for interpretation by Commission - 1996
N3		Yes	No	Yes	No	Severe Shortfall Frequency	Demote to optional (1997)
N4		Yes	No	Yes	Yes	Shortfall Frequency	1996
N5	Yes		Yes	Yes	Yes	Block Need Satisfaction	1996
~~N6~~						~~Adapted Utility~~	DELETE: undesirable properties (1997)
N7		Yes	Yes	No	Yes	Percent Need Satisfaction Pointwise Quantile Trajectory Plot	1996
N8		Yes	Yes	No	Yes	Percent Need Satisfaction Trajectory Plot	1996
N9	Yes		Will be	Yes	Yes	Average need satisfaction	See Item 2.2.1
R1	1+, mature		Yes	Yes	Yes	Relative Recovery	To be redefined
R2		1+, mature	No	No	Yes	Relative Probability of Recovery	1996
R3		1+, mature	No	Yes	Yes	Time Frequency in Recovered State after Recovery	1996
R4		1+, mature	No	Yes	Yes	Relative Time to Recovery	1996

2.3.3 Density dependence on the mature rather than 1+ component

Last year, the SWG agreed that density dependence would act on the mature female rather than the 1+ component. This year, Punt reported that this choice had some undesirable features. These include negative values for the resilience parameter (and hence f_{max}) and reducing the recovery times for populations currently at very low levels. The SWG **encouraged** Punt to present additional information on this at next year's meeting.

2.3.4 Protocol for generating other sources of data

No proposals for new simulated data were presented. It was recognised that should any such proposals be made in the future, the inevitable uncertainty that use of such data would entail should be fully represented.

2.3.5 Time trends in MSYR and K

These issues had been considered during the development of the RMP (e.g. IWC, 1992). *Inter alia*, these can be used to model the effects of changing environment (e.g. habitat degradation). It was **agreed** that these trials are too complex to be considered at this stage of the development process.

2.3.6 Age- and length-structured population dynamics model

It was **agreed** that this did not require attention at present.

2.3.7 Block quotas and carryover

Last year, the Commission had been asked to indicate how much emphasis it should place on developing an AWMP that incorporates block quotas and a mechanism for carryovers. At the Commission, Denmark, Norway and the USA all stated that they believed that such provisions were extremely important and should be incorporated as design features (IWC, 1998). It was noted that some previous papers (Butterworth and Punt, 1994; Givens and Thomas, 1997) had considered the issue of block quotas/carryover in simulation trials. The SWG **acknowledged** the importance of incorporating this feature into the final *SLA*s. In terms of the present development process, however, it was **agreed** that considering strike limits on an annual basis will provide sufficient information.

2.3.8 Allowing for temporal auto-correlation among survey estimates

Initial Exploration Trials condition on past survey data and temporal auto-correlation can, if desired, be readily taken into account for such data. However, there are several sources of potential correlation between future surveys, and the SWG reiterated that this issue merits eventual consideration.

2.3.9 Multi-species issues

When Greenland presented its need request to the Commission, it expressed this as a number of tons of whale meat, with need not assigned to species. At present, Greenlanders take minke and fin whales; humpback whales were taken up to 1985. At last year's meeting, the SWG requested that the Commission provide it with an estimate of the maximum proportion of total need that minke whales might be expected to supply for the harvest off West Greenland. This clarification should lead to a better balance between need satisfaction, risk and recovery being achieved. At that Commission meeting, Denmark was strongly of the view that a multi-species model should be considered and developed as a priority; it could not agree to the initial development of a single species model without simultaneous multi-species consideration (IWC, 1998). The SWG reiterated that it **recognised** the importance of this issue. It is discussed further under Item 4.3.

2.3.10 Confounding of bias factor and K
At last year's meeting, the SWG agreed to continue to use the current protocol to allow for bias in the *Initial Exploration Trials* and encouraged development of alternatives. No papers dealing with this issue were presented during the meeting and the SWG **agreed** to retain this item on its agenda.

2.3.11 100 year time horizon
At last year's meeting, the SWG agreed that, although need may be difficult to specify over time horizons exceeding 20 years, preliminary trial results indicated that a full 100 years was necessary for the stock to recover in some cases, even with zero catch. It had agreed, therefore, to retain the 100-year management period as mandatory.

2.3.12 Survey frequency
The SWG agreed that the frequency of future surveys required or used by an AWMP was an important issue, both for AWMP development and testing, and also as part of a broader aboriginal subsistence management scheme which would include certain data requirements. For the present, it **agreed** to consider survey frequency on a stock-specific basis. Details of present assumptions used in the trials are given in Appendix 3.

2.4 Facilitating AWMP comparison and tuning
Each candidate *SLA* is likely to achieve a different balance among the objectives specified by the Commission for an AWMP. This makes it difficult to compare candidate *SLA*s. Tuning, or rather more specifically *equivalence tuning*, is a way to provide *SLA* developers with the opportunity to adjust their *SLA*s to strive towards a pre-specified balance of risk, catch and recovery.

SC/49/AS10 had suggested a new approach to tuning candidate *SLAs* that would consider need and recovery as well as final depletion. This approach, denoted *H-tuning*, involved selecting the values for the parameters of the *SLA*s to match as adequately as possible the strike limits set by a pre-specified *SLA* which is based on perfect information about stock dynamics and operating model parameter values. The target *SLA* is not intended to represent ideal *SLA* performance, rather it is meant to illustrate a particular balance between need satisfaction, population depletion and recovery to which candidate *SLAs* may all be tuned. The SWG had agreed that this was a promising approach.

SC/50/AWMP4 described methods for *equivalence tuning* AWMP *SLAs*. It compared the relative merits of *depletion tuning*, as was used for RMP *CLA* candidates, and *H-tuning*. *Depletion tuning* aims to achieve a pre-specified median final depletion on a trial, whereas *H-tuning* aims to match a pre-specified set of strike limit trajectories for a collection of trials. *Depletion tuning* is familiar (it was used during the RMP development process) and conceptually simpler. However, it focuses on stock depletion only and places the management simulation within an optimisation loop, which can be computationally very slow. Examples presented in SC/50/AWMP4 show that care should be taken when choosing a target depletion for *depletion tuning*. *H-tuning* considers need satisfaction and stock recovery objectives more explicitly, and is computationally much faster because it places simulation outside the optimisation loop. However, it was agreed that the speed of *H-tuning* is achieved at the expense of some accuracy and, unlike *depletion tuning*, *H-tuning* does not yield an exact equivalence. During the development of the RMP, tuning had been used to ensure that the range of variants for each candidate *CLA* spanned a range so that is was possible to compare them to assess the trade-offs among the management objectives that they achieve. SC/50/AWMP4 also suggested ways for evaluating and comparing the degree to which *SLA*s are equivalenced if *H-tuning* is used.

Theoretically, the selection of the best *SLA* among several candidates can depend on how the candidates are equivalence tuned; requiring an exact *depletion tuning* target could result in an inferior candidate being selected. However, if *SLA* strike limits are likely to change smoothly with tuning parameter values, and if *MSYR* is not high, then the two tuning methods should provide similar results.

SC/50/AWMP4 also identified several problems with the specifications of *H-tuning* drafted last year (IWC, 1998, annex I). In particular it suggested that they should include a clear specification of how the catch limits to be compared to those corresponding to *H* are calculated.

The SWG reiterated that it found *H-tuning* a promising idea. It **agreed** with the authors of SC/50/AWMP4 that their recommended method for implementing *H-tuning* was appropriate. Revised specifications are included in Appendix 3. The SWG further considered the relative merits of *H-tuning* and *depletion-tuning*. A question was raised as to whether the performance of an *H-tuned SLA* might be inferior in terms of actual performance (as measured by the values for performance statistics). However, it was noted that *H-tuning* is merely a method for equivalencing and that eventual comparisons would be based on the full set of performance statistics. A potential advantage of *H-tuning* is that it is possible, although not mandatory, for more than one trial to be used. However, it was noted that it would be difficult to select weights if more than one trial was used as part of the tuning.

The SWG **agreed** that at present, results should be presented for both *depletion tuning* and *H-tuning*. It was noted that current implementation of *H-tuning* gives additional weight to trials in which the catches under *H* are high. It was requested to select an objective function that did not have this property. The SWG **agreed** that the approach presented in Appendix 3 should be adopted. A small group chaired by Magnússon was established to specify the technical details of how this can be achieved.

3. DESCRIPTION OF FISHERY TYPE 3

During last year's meeting, the SWG agreed that it would be valuable to begin consideration of an additional type of fishery in the development of an AWMP. This arose out of its discussions of multi-species fisheries. It was further agreed that this new type of fishery would refer to populations to be harvested that were small, although the question of how small was left to be discussed. DeMaster and Breiwick undertook to examine this matter intersessionally. DeMaster reported that in an effort to develop objective criteria for determining a minimum population size to be used in the *Initial Exploration Trials* for type 3 fisheries, he had carried out exploratory simulations to determine the minimum population size that could sustain an annual take of one or more animals while not increasing the 95%-ile time to recovery by more than 10%. The population model used was similar to that described by Wade (1998) with the additional feature that the underlying maximum rate of growth of the population was also allowed to vary annually. Using CVs between 0.2-0.3 for the maximum rate of growth, estimates of abundance and the number of animals harvested annually, and assuming an initial population status of 0.1 relative to carrying capacity, DeMaster reported that a minimum population of 1,000 animals was required to meet the objective of not increasing the 95%-ile time to recovery by more than 10%. However, he noted that the 95%-ile of the time to recovery was only increased by 7% for a population of 500 animals, where an average of one animal was removed every four years. Finally, he noted that the results of such simulations used to estimate the distribution of recovery times were quite sensitive to assumptions regarding the initial status of the population. The SWG thanked DeMaster for conducting this work. It noted that the analysis had been conducted in a scale-invariant manner, and that alternative models of variability needed consideration to fully reflect the implications of small population size.

The SWG **agreed** that, for exploratory purposes, it will initially examine fishery type 3 as a case in which the current population size is small (~ 300) and where demographic and environmental variability may have an impact on recovery times. Although the number 300 was largely arbitrary and intended to allow an exploratory investigation of the problem, it was loosely based on considerations of the size of the West Greenland humpback whale feeding aggregation, the lower confidence interval of the abundance estimate for fin whales in the West Greenland area and possible sizes of some Canadian stocks of bowhead whales. Initial trials for fishery type 3 would need to consider cases in which the population is depleted to a small fraction of its pre-exploitation size and ones where it is close to this size. The SWG's initial attempts to address this problem are detailed in Appendix 3.

4. DESCRIPTION OF POTENTIAL PROCEDURES

4.1 Fishery type 1

No new approaches were presented.

4.2 Fishery type 2

SC/50/AWMP5 introduced a new *SLA* for fishery type 2 based on likelihood methods. This approach was an improvement on an *SLA* introduced in Givens (1997a), in that the new variant used the entire historical catch record, 1848-present, and required fewer parameters for model fitting.

4.3 Other

SC/50/AWMP6 compared the management procedures of commercial and subsistence whaling by assuming that subsistence catches are more fundamental than commercial catches. This leads to a unified whaling procedure that primarily allocates catches into the satisfaction of need, but also allows for commercial catches when need is smaller than the catch limit set under the RMP.

Past work on AWMPs have focussed mainly on single species systems, but SC/50/AWMP7 considered the multi-species situation where need is given in tons of whale meat, not assigned to specific species. The paper develops multi-species *SLA*s that satisfy need by converting the total need into catch limits of the different species considered. The multi-species *SLA*s are simple algorithms that are superimposed on top of the upper catch limits of the underlying single species *SLAs*. The multi-species *SLA*s can fulfil larger needs than single species *SLA*s, and they can optimise the recovery rates of the multiple species when need is satisfied. Four different algorithms were proposed based on principles of respectively species ranking, even catch, even exploitation and even recovery. The multi-species algorithms require no estimates beyond those of the underlying single species AWMPs and, thus, they can be applied to any combination of species given that each species has a single species AWMP.

The SWG appreciated this contribution to the consideration of the multi-species issue. Additional suggestions for allocation schemes suggested include relative productivity of the populations and an 'even risk of extinction' approach. This is discussed briefly under Item 7.1.

5. INITIAL EXPLORATION TRIALS

In discussing this Item, it was agreed that a small working group, convened by Magnússon, should develop revised trial specifications based on the general discussion in the full SWG. It was **agreed** that the principles of the revisions should be agreed by the SWG but that the details of the trials could be completed by the small group after the closure of the sub-committee. These are included in Appendix 3.

5.1 Fishery type 1

At its 1996 meeting, the Committee defined fishery type 1 as a case where there is relatively little available information and stock identity problems (e.g. West Greenland minke whales) and where the Committee has had considerable problems in providing advice under Para.13(a) of the Schedule.

5.1.1 Review progress with existing trial structure

Punt reported that he had developed a control program to implement the multi-stock trials for fishery type 1 that had been specified at last year's meeting. SC/50/AWMP3 presented results for the application of a Small Areas variant of the *SLA* developed by Punt and Butterworth (1997). Performance for these trials was relatively poor and depended primarily on the value for the *MSY* rate.

5.1.2 Modifications to trials

The SWG **agreed** to combine the single stock and multi-stock trials for fishery type 1 to be able to distinguish the impact of *MSYR* from that of stock identity uncertainty. A unified set of trials for this type of fishery was agreed upon (Table 2). In addition to the eight trials agreed last year (IWC, 1998, annex I, table 7) a further four were specified such that a 1% and a 7% MSYR trial was carried out for all combinations. These trials are to be carried out with and

Table 2

The set of trials agreed for fishery type 1.

Trial	$MSYR_{1+}$	Initial population	Catch in Area 1	Need	Survey interval	Stock structure
MM1	0.01	High	0	Const.	10yrs	Boundary between middle and 2
MM1a	0.07	High	0	Const.	10yrs	Boundary between middle and 2
MM2	0.01	High	0	Const.	10yrs	Boundary between 1 and middle
MM2a	0.07	High	0	Const.	10yrs	Boundary between 1 and middle
MM3	0.07	High	0	Const.	10yrs	Mixing in middle cell
MM4	0.07	High	Yes[1]	Const.	10yrs	Mixing in middle cell
MM5	0.01	Low	0	Const.	10yrs	Boundary between middle and 2
MM5a	0.07	Low	0	Const.	10yrs	Boundary between middle and 2
MM6	0.01	Low	0	Const.	10yrs	Boundary between 1 and middle
MM6a	0.07	Low	0	Const.	10yrs	Boundary between 1 and middle
MM7	0.01	Low	0	Const.	10yrs	Mixing in middle cell
MM8	0.01	Low	Yes[1]	Const.	10yrs	Mixing in middle cell
MM9	0.01	High	0	Inc.	10yrs	Boundary between middle and 2
MM10	0.07	High	0	Inc.	10yrs	Mixing in middle cell
MM11	0.01	Low	0	Inc.	10yrs	Mixing in middle cell
MM12	0.01	High	0	Const.	2-10yrs[2]	Boundary between middle and 2
MM13	0.07	High	0	Const.	2-10yrs[2]	Boundary between 1 and middle

[1] Catches set using RMP. [2] Surveys every 2 years until year 10, and every 10 years thereafter.

without information about stock identity. Need is taken to be constant in all these cases and a further three trials consider increasing need (Appendix 3).

Present *SLA*s do not perform well in cases of low stock size combined with high MSYR. It is possible that the poor performance is due to the rather long interval between surveys. In order to investigate whether this performance could be improved by more frequent surveys, it was **agreed** that two trials should be carried out when surveys were carried out every second year for the first ten years (six surveys in all) followed by surveys every ten years thereafter.

These two trials consist of the combinations low stock size/low MSYR and high stock size/high MSYR. These trials represent the first step at addressing this issue and further robustness trials will be considered in the future.

The issue of data availability and the ability to develop a successful *SLA* for fishery type 1 is discussed in further under Item 10.

5.2 Fishery type 2

At its 1996 meeting, the Committee defined fishery type 2 as a case where there is a relatively large amount of information and Para. 13(a) of the schedule has largely been met (e.g. Bering-Chukchi-Beaufort Seas stock of bowhead whales).

5.2.1 Review progress with existing trial structure

SC/50/AWMP2 contrasted two methods for conditioning the *Initial Exploration Trials* for fishery type 2. The difference between the two methods lies in that one conditions on pre-specified choices for *MSYL*, *MSYR* and P_0 whereas the other does not. The distributions for four biological parameters (age-at-maturity, the survival rate for juveniles, the greatest age at which natural mortality for juveniles applies and the survival rate for adults) were found to be sensitive to the method chosen. Not conditioning on the pre-specified values for *MSYR*, *MSYL* and P_0 leads to values for the maximum pregnancy rate which have previously been considered to be unrealistic by the Scientific Committee and notably broader distributions for the number of mature females. It was shown that even if the suggested method for conditioning the trials was adopted, an inconsistency would remain between the population trajectories underlying the trials and the actual data for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Suggestions were made for re-designing the trials for fishery type 2 to avoid this lack of consistency.

Givens introduced Appendix 4 which agreed that the solution proposed in SC/50/AWMP2 solved the conditioning problem, but noted that it also reduced considerably the amount of variation in future population trajectories in any trial, while simultaneously making the extreme trials (B3 and B7) even more extreme. This was considered further by the trials group and an agreed revised method for conditioning the trials is given in Appendix 3.

The SWG considered the question of introducing stochasticity into fishery type 2 trials as noted in Appendix 4. It **agreed** that a move to a stochastic model was desirable but was unsure whether the parameter choices in Appendix 3 would introduce sufficient additional variation in population trajectories. It **agreed** that the operating model for the fishery type 2 trials should be made stochastic. The specifications for the stochastic model are given in Appendix 3.

Cooke noted that a low level of variation in the biological parameters within each trial was only a concern if this meant that it was possible for an *SLA* to 'identify' the trial and hence perform unrealistically well. Givens considered that *SLA* performance could be examined on a broad spectrum of trials and it would not be unreasonable for an *SLA* to select among a small number of stock status scenarios and set the strike limit accordingly. He noted that the 'tri-level reluctant shift' *SLA* of SC/49/AS10 had adopted such a strategy.

Further discussion in the SWG related to whether uncertainty should be expressed using a large number of trials with little within-trial variation or a small number of trials with greater within-trial variation. Some members preferred the latter, more integrative, approach (except with respect to *MSYR*) because a small number of trials would simplify *SLA* comparison and would discourage 'worst-case' reasoning when examining *SLA* performance. Other members agreed with the merits of using a small number of trials with greater within-trial variation, but also saw merit to spanning the range of uncertainty with separate specific trials to isolate problematic scenarios. The SWG **agreed** that this matter required further consideration.

5.2.2 Modifications to trials

The SWG noted that the introduction of stochasticity will require some exploratory work. It was **agreed** that the assumptions in the trials agreed last year should remain unchanged (except that as a result of the new conditioning approach, the initial population ($= P_{1993}$) is no longer fixed). The **agreed** trials are summarised in Table 3.

Table 3

Initial Exploration Trials for fishery type 2.

			Need		Data Quality				
Trial no.	$MSYR_{1+}$	Initial population P_0	Initial level	Final level	CV_{est}	$\gamma_{12.9}$	$\lambda_{12.9}$	Bias B_A	Comments
B1	0.025	8,200	68	68	0.25	0	1	1	1996
B2	0.025	8,200	68	68	0.125	4	2	1.5	Replace (7a)
B3	0.04	9,400	100	200	0.25	0	1	1	Deleted 1997
B4	0.04	9,400	68	68	0.25	0	1	1	Deleted 1997
B5	0.01	9,400	100	200	0.25	0	1	1	1996
B6	0.01	9,400	68	68	0.25	0	1	1	1996
B7	0.01	7,200	100	200	0.25	0	1	1	1996
B8	0.01	7,200	68	68	0.25	0	1	1	Deleted 1997
B9	0.04	7,200	100	200	0.25	0	1	1	Deleted 1997
B10	0.04	7,200	68	68	0.25	0	1	1	1996

5.2.3 Fishery type 3

The SWG agreed that the trials for fishery type 3 (limited information, small stock size of 300) should be based on stochastic population dynamics models that allow for variation in the birth-death process and possibly depensation. It was agreed to focus on stochastic population dynamics and to consider three kinds of models (see Appendix 3):

(i) simple demographic stochasticity (on survival and birth rate);
(ii) demographic stochasticity plus environmental stochasticity without auto-correlation;
(iii) same as (ii) but with auto-correlation.

Some initial simulations and explorations are needed are needed to determine feasible and reasonable combinations and ranges of parameter values but the focus is on low population size (~300 whales) and a K value either close to the population size or much higher. MSYR values of 1%, 4% and 7% will be considered for each of the three types of stock model. The SWG's initial attempts to address this problem are detailed in Appendix 3.

6. PLANNING FOR FUTURE SELECTION OF *SLAS*

6.1 Clarification of management and performance objectives

The SWG recalled the (summarised) objectives given by the Commission:

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

Highest priority shall be accorded to the objective of ensuring that the risks of extinction to individual stocks are not seriously increased by subsistence whaling.

6.2 Specification of performance measures

The SWG **agreed** that the performance measures, as amended in this report (see Item 2.2.1), were satisfactory for the purposes of *SLA* evaluation at this time.

6.3 Statistical design of performance evaluation trials

At last year's meeting, the SWG agreed to a staged process of *SLA* evaluation and selection. No work on the optimal experimental design of simulation trials was carried out during the intersessional period.

6.4 Quantitative strategies for ranking, optimising and merging *SLAs*.

No methods for ranking *SLAs* were considered at this time.

At last year's meeting, the SWG encouraged further work on methods for optimising *SLAs*, noting that the ideas in Givens (1997b) appeared highly promising. Givens presented SC/50/AWMP5 wherein several potential AWMP *SLAs* were reviewed and enhanced, including the likelihood approach referred to under Item 4.2 and the Punt and Butterworth (1997) *SLA*. The focus was on an optimisation method for improving the performance of existing *SLAs* and for creating enhanced, merged *SLAs* from existing candidates. This approach has several appealing statistical optimality properties. Optimisation of existing *SLAs* was very effective. For example, by applying this approach to the Punt and Butterworth (1997) *SLA*, a new variant was created which was superior on the B3 *Initial Exploration Trial* and which provided 50% more need satisfaction on the B7 *Initial Exploration Trial* while reducing the final stock size by only 0.01K below that achieved by the original *SLA*, based on 5th percentile performance. Results for merging two *SLAs* were dependent on the quality and correlation of the candidates to be merged, as well as the fitting model and loss function. A key feature of the optimisation method is that it isolates *Initial Exploration Trial* simulation outside the optimisation loop to enable fast computation. In the SC/50/AWMP5 examples, the method used an objective function that was within 4% of the one used in a standard approach, but to obtain the exact answer the standard approach would have required up to 600,000% more computing time. The optimisation method in SC/50/AWMP5 therefore allows preliminary research effort to be concentrated on a wide-ranging and intensive search for optimal *SLA* performance.

The approach in SC/50/AWMP5 does not explicitly consider variation over time in strike limits. This could be dealt with by including an extra term in the function minimised, and some members considered that this would, in due course, be an essential refinement. However, while agreeing that this could theoretically be a concern, Givens argued that any such problem would be identified during the *SLA* evaluation phase – his method was intended for creating, not evaluating, candidate *SLA*s. Using a different loss function would also be an alternative for *SLA* developers. The SWG **agreed** that strike limit trajectories are usually smooth functions of time, and therefore the application of the approach in SC/50/AWMP5 (which is a function of existing *SLA*s) would not be likely to cause excessive catch limit variation.

It was noted that one *SLA* examined at this meeting had been tuned so that the strike limit was a polynomial function of its nominal strike limit and the calendar year. Concerns were raised as to whether this constituted an inappropriate management strategy since: (1) aboriginal need is a linear function of time in most *Initial Exploration Trials*; (2) whale stocks exist independent of the human calendar; and (3) some such strategies can lead to dangerous time extrapolation if continued indefinitely. However, given that the primary objective is good simulation performance, regardless of the intricacies of the *SLA*, and more importantly that several RMP candidates had successfully used the time variable with various degrees of explicitness, it was **agreed** that no restriction regarding the use of the time variable should be adopted at this stage.

7. DIALOGUE WITH COMMISSION AND HUNTERS

The SWG reiterated the importance it attached to continuing dialogue with the Commission and hunters throughout the development process (IWC, 1998, annex I). It agreed that the procedure adopted last year, i.e (1) a presentation by the Chairman of the SWG of its report and a less technical Chairman's discussion paper, and (2) informal discussions with interested Commissioners, had proved successful. It **recommends** that this procedure be repeated this year.

7.1 Approach for Oman

The SWG noted the questions posed to the Commission during last year's meeting (IWC, 1988, annex I) and discussed which were the questions which most urgently required further comment from the Commission.

7.1.1 Multi-species considerations

The SWG noted the importance which some delegations placed on developing a multi-species operating model. It reiterated that it recognised this and is starting to develop a multi-species operating model. As a first step in this process, trials are being constructed for fishery type 3. In addition, it is examining options involving multi-species *SLA*s superimposed on top of the upper catch limits of underlying single species *SLAs*. The multi species *SLA*s can fulfil larger needs than single species *SLA*s, and they can optimise the recovery rates of the multiple species when need is satisfied. A number of features of this approach will require input from the Commission and hunters, as can be seen in the discussion under Item 4.3.

7.1.2 Need satisfaction

At present, need satisfaction is considered over 20, 50 and 100 year periods. The SWG requests the Committee to ask the Commission to comment on whether greater emphasis should be placed on satisfying current rather than projected future need.

7.1.3 Catch variability considerations

At last year's meeting, the SWG requested that the Committee ask the Commission to provide it with a general indication of the importance of variability in catches. For example, would it prefer an AWMP that achieves a slightly higher level of total need satisfaction averaged over a longer time period at the expense of greater variability in strike limits or would it prefer to sacrifice some satisfaction of total need to ensure less variability in catches? The Commission had agreed to give consideration to this during the year. The SWG agreed that resolution of this issue was important for its work. The SWG agreed that the Chairman should request information on catch variability by presenting the Commission with a series of time trajectories of strike limits which reflect the trade-off between need satisfaction and variation in strike limits and ask the Commission to select among the alternatives.

8. WORKPLAN (INCLUDING COMPUTING NEEDS AND FINANCIAL IMPLICATIONS)

As noted under Item 1, the Chair indicated that he believed that it was important that the SWG began to consider how best to ensure that it could progress as efficiently as possible to being able to present the Commission with an AWMP that satisfied the Commission's objectives. In this context he wished to thank Givens for producing an extremely useful discussion paper on this subject.

In order to enable progress to be made he believed that it was important to have a general discussion on the likely form the SWG believed the AWMP might take, before considering more detailed aspects of the workplan.

At its 1996 meeting, the SWG had agreed that the *Initial Exploration Trials* should be case-specific rather than generic because there are a limited number of cases for which aboriginal subsistence harvesting is likely (IWC, 1997). However, it did not reach consensus on whether the AWMP should include a generic *SLA* or case-specific *SLA*s.

At this meeting, the SWG agreed that there were three alternatives:

(1) an *SLA* which is completely generic;
(2) a generic core *SLA* with case-specific modifications; and
(3) completely case-specific *SLA*s.

The SWG **agreed** that it in principle it would be preferable to have a single generic *SLA*. However, the primary task of the AWMP is to satisfy the management objectives established by the Commission to the greatest extent possible for the fisheries of concern.

The SWG **agreed** that given the results so far, and the well-documented differences between the fisheries in terms of data availability, stock identity complexity and the nature of the fisheries themselves (e.g. the multi-species nature of the Greenlandic case), it was extremely unlikely that a single *suitable* generic *SLA* could be developed. It is therefore clear that either of the alternatives (2) or (3) are most likely to enable us to satisfy the Commission's objectives. It **draws this to the attention** of the Committee and the Commission. The SWG **agreed** that to the extent possible it would be preferable to follow option (2).

Thus, a likely potential scenario is that the Commission might establish an Aboriginal Whaling Scheme that comprises the scientific and logistical (e.g. inspection/observation,) aspects of the management of all aboriginal fisheries. Within this, the scientific component might comprise some general aspects common to all fisheries (e.g. guidelines and requirements for surveys and for data c.f. the RMP) and an overall AWMP (within which there will be common components and case-specific components).

An important implication of this is that given the different degrees of difficulty, it will be possible to develop *SLAs* for some stocks before others. The SWG **agreed** that it could best fulfil its role of providing the Commission with advice on stocks subject to aboriginal whaling if it presented available components of the AWMP to the Commission as and when they were ready. It **draws this to the attention** of the Committee and the Commission. This is considered further under Item 8.2.

The SWG reaffirmed that its aim was to produce an AWMP that satisfactorily meets the Commission's objectives as quickly as possible. The SWG noted that improvements beyond this point would not be justified in terms of time and cost.

8.1 Short-term (1 year)

The SWG identified a number of tasks that required work during the coming year, including computing tasks for the Secretariat. These are given in Table 4. The SWG **recommends** that the highest priority be accorded to the computing tasks by the Committee. It stressed that the pace of the development process was critically dependent on the appropriate software being available as soon as possible.

The SWG recalled that, last year, it had noted that it would probably require an intersessional meeting between the 1998 and 1999 meetings. In order to give developers as much time as possible and to ensure that adequate time is available for the SWG to consider the results of their work, the SWG **recommends** that its work commences three days immediately prior to the next Scientific Committee meeting. It also **draws the Committee's attention** to its request that invited participants be invited on more than a one off basis.

The SWG noted the importance of continuity to its work. It therefore **recommends** that Donovan act as co-ordinator of its intersessional activities during the coming year.

8.2 Medium-term funding

Last year the SWG had recognised that during the development of the *RMP*, the Committee and the Commission had established a fund to help support the work of some developers and had requested that the Committee and the Commission should consider establishing a similar scheme for AWMP development. This year it **recommends** that such a fund be established. It agreed that the fund should initially be established at a level of £5,000 with a maximum of £1,500 available annually to each developer. It is envisaged that the fund should carry-over from year to year, such that each year it begins with £5,000. Developers wishing to draw on the fund should apply to the Secretariat. The decision to approve the application should be taken by the Chairman of the Standing SWG and the Chairman of the Committee.

8.3 Long-term

The SWG noted the steps it had previously identified in the development of the AWMP (IWC, 1998, annex I):

(1) summarise existing data for stocks harvested by aboriginal whalers (completed);
(2) clarify management and performance objectives of the *AWMP* (may require additional input from the Commission and hunters as work proceeds);
(3) specify performance measures (on-going);
(4) specify simulation trials (on-going);
(5) specify candidate *SLAs* (on-going);
(6) subject candidate *SLAs* to stock-specific simulations trials and compute performance measures under a range of scenarios;
(7) if required, modify candidate *SLAs* in light of simulation results and repeat simulation trials;
(8) recommend *SLAs* to the Commission.

In the light of its discussions above, it reiterates that it believes that it is most appropriate to provide the Commission with recommended *SLAs* for different fisheries at different times.

The SWG **agreed** that it was not in a position to develop a precise timetable for its work. However, it believed it would be in a stronger position to do so at its next meeting. It therefore confined itself to:

(1) an elaboration of the process above by which it would arrive at recommended *SLAs*;
(2) general comments on a timetable on a fishery by fishery basis.

Table 4

Work to be carried out by in the coming year.

Task	Estimated time/to be done by
Secretariat computing	
(1) Revise the program to implement the multi-stock trials for fishery type 1 as detailed in Appendix 3.	1 month
(2) Implement the stochastic dynamics model (including the 3 methods given in Appendix 3) and apply the stochastic backwards method to obtain input parameters for fishery type 2. This may require iteration through the AWMP correspondence group. As a first step, modify the control program to input rather than pre-specify P_0 and apply the deterministic backwards method to obtain input parameters for fishery type 2 that can be used until the task is completed.	2 months
(3) Modify the common control program to implement and run trials to investigate the effects of 3 different methods of incorporating stochasticity into fishery type 3 trials.	
(4) Finalise the plotting program (in collaboration with Zeh).	
Other	
(1) Software distribution questions (Item 1.7).	Secretariat
(2) Incorporate density dependence on the survival rate for juveniles into the common control program and present trajectories (Item 2.3.1).	Punt
(3) Additional information on density dependence on the mature rather than 1+ component (2.3.3).	Punt
(4) Begin work on the gray whales (Item 8.3).	DeMaster

With respect to (1), it identified the following types of trials necessary.

Evaluation Trials. Such trials would be used for formal comparison of candidate *SLA*s. Their number would be limited, compared to the number of *Robustness Trials*. Development of *Evaluation Trials* would commence prior to that of *Robustness Trials*. More than one round of such trials is likely before a favoured *SLA* is identified. Developers would be able to adapt their efforts accordingly.

Robustness Trials. Trials to examine *SLA* performance for a full range of plausible scenarios. These would be applied to the restricted set of *SLA*s found to perform well in *Evaluation Trials*. The number of such trials would be potentially large. Results will be used to fine tune *SLA*(s) for acceptable performance. Again, more than one round may be necessary.

With respect to (2) the following comments were made.

Greenland fisheries
The Chairman of the SWG referred to discussions in the sub-committee on Aboriginal Subsistence Whaling (Annex I). That sub-committee had noted with great concern that it has never been able to provide satisfactory scientific advice on either fin or minke whales off West Greenland. The reason that satisfactory advice cannot be given is the lack of requisite data, particularly on stock structure and abundance. That sub-committee had recognised that the logistical difficulties of obtaining the necessary information are enormous, both in terms of the physical environment (including weather conditions) and the level of resources required.

The Chairman had indicated to that sub-committee that even at this stage in the development process, it was clear that developing an *Strike Limit Algorithm* for the Greenland Fisheries that would fulfil all the Commission's objectives will be an extremely difficult, if not impossible task, given the available data.

The sub-committee on aboriginal subsistence whaling had therefore **recommended** that the Committee establishes a SWG, in collaboration with Greenlandic scientists, to determine a costed research programme that will enable the Committee to provide satisfactory advice to the Commission as soon as possible. At a minimum this programme will address questions of stock identity and abundance. The programme will take into account the work of this SWG, where the important relationship between data requirements and management procedures has already been stressed.

The SWG **agreed** that providing advice on the Greenlandic fisheries was a matter of the highest priority. It concurred that, given our present state of knowledge, developing an *Strike Limit Algorithm* for the Greenland Fisheries that would fulfil all the Commission's objectives will be an extremely difficult, if not impossible task.

It therefore **strongly recommends** that the above SWG be established and that representatives of the AWMP Group should be included. Noting that the Greenlandic scientists are currently designing a research programme it **further recommends** that an Intersessional Correspondence Group be established to assist in this process. Noting the SWG's full workload, and the fact that the sub-committee on Aboriginal Subsistence Whaling does not need to carry out a major reassessment next year, it suggests that the Committee considers giving the Greenlandic research programme high priority status in the work of that sub-committee next year.

In view of the above, the SWG **agreed** that it would be in a stronger position to provide advice on a timetable, for providing the Commission with a recommended *SLA* for this multi-species fishery, when the results of the research programme begin to become available.

Bering-Chukchi-Beaufort Seas stock of bowhead whales
The SWG noted that last year the Commission had established catch limits for this stock until the year 2002. It therefore **agreed** that it would be highly desirable if it could be in a position to recommend an *SLA* for this fishery to the Commission by that year. It hoped to be able to give the Commission more advice on whether this was achievable after its next meeting.

Eastern stock of gray whales
Although the fishery type 2 *Initial Exploration Trials* have been based on the bowhead whale situation, the SWG **agreed** that the eastern stock of gray whales was essentially a fishery type 2 stock. It believed that it was likely that a single *SLA* (or minor variants) would be applicable to both stocks. The SWG **agreed** that consideration of this fishery should begin in the near future. DeMaster indicated that such work may be undertaken within the USA. The SWG noted that last year the Commission had also established catch limits for this stock until the year 2002. It therefore **agreed** that it would be highly desirable if it could also be in a position to provide a recommendation to the Commission for this fishery by that year. It hoped to be able to give the Commission more advice on whether this was achievable after its next meeting.

St. Vincent and The Grenadines humpback whales
The SWG has not yet considered this fishery in any detail. It noted that the Committee was intending a major review of North Atlantic humpback whales at the year 2000 meeting.

9. ANY OTHER BUSINESS

The SWG noted that the Committee has in the past expressed concern over the status of the Baffin Bay-Davis Strait and Hudson Bay-Foxe Basin stocks and that this was re-iterated in Annex G this year. It also noted the kill of one whale in 1996 from the Hudson Bay-Foxe Basin stock and that Canada, a non-member nation, had authorised up to two strikes in 1998 from the Baffin Bay-Davis Strait stock.

DeMaster indicated that he was planning to begin exploratory work on developing a management procedure for these stocks. The SWG **agreed** that, provided that this did not interfere with its priority work to develop *SLA*s for those stocks that the Commission was managing directly, it would be prepared to review and comment on work on other stocks

10. ADOPTION OF REPORT

The report was adopted at 17:00 on 6th May 1998.

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Punt, A.E. and Butterworth, D.S. 1997. Preliminary evaluation of a (generic) strike limit algorithm for aboriginal subsistence whaling with comments on performance statistics and simulation trials. Paper SC/49/AS7 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished) 22pp.

Appendix 1

AGENDA

1. Introductory items
    - 1.1 Convenor's opening remarks
    - 1.2 Election of Chair
    - 1.3 Appointment of rapporteurs
    - 1.4 Adoption of agenda
    - 1.5 Review of documents
        - 1.5.1 Update of glossary
        - 1.5.2 Update of 'trials' appendix
    - 1.6 Commission comments from the Monaco meeting
    - 1.7 Report of the e-mail correspondence group
2. *Initial Exploration Trials* - general issues
    - 2.1 Common Control Program
    - 2.2 Statistics and performance plots
    - 2.3 Review of simulation framework
    - 2.3 Facilitating AWMP comparison and tuning
3. Description of fishery type 3
4. Description of potential procedures
    - 4.1 Fishery type 1
    - 4.2 Fishery type 2
    - 4.3 Other
5. *Initial Exploration Trials* - specific
    - 5.1 Fishery type 1
        - 5.1.1 Review progress with existing trial structure esp. multi-stock trials
        - 5.1.2 Modifications to trials
    - 5.2 Fishery type 2
        - 5.2.1 Review progress with existing trial structure incl. conditioning
        - 5.2.2 Modifications to trials
    - 5.3 Fishery type 3
6. Planning for future selection of *SLA*s
    - 6.1 Clarification of management and performance objectives
    - 6.2 Specification of performance measures
    - 6.3 Statistical design of performance evaluation trials
    - 6.4 Quantitative strategies for ranking, optimising and merging *SLA*s
7. Dialogue with Commission and hunters
    - 7.1 Approach for Oman
    - 7.2 Future
8. Workplan (including computing needs and financial implications)
    - 8.1 Short-term (1 year)
    - 8.2 Long-term
9. Any other business
10. Adoption of report

Appendix 2

TERMINOLOGY

Table 1 contains working definitions agreed in order to ensure consistency in the terminology used during the development of the AWMP. No attempt was made to change the definitions of terms currently used by the Committee, but rather it was considered important to be consistent in the use of terminology in describing the process by which the AWMS will be developed. This Table is viewed as a living document whose contents may change to reflect AWMP development progress.

REFERENCE

International Whaling Commission. 1994. Report of the Scientific Committee, Annex H. The Revised Management Procedure (RMP) for Baleen Whales. *Rep. int. Whal. Commn* 44:145-52.

(Table 1 on next page)

Table 1

Procedures (schemes, procedures and algorithms)	
AWMP	Aboriginal Subsistence Whaling Management Procedure.
AWS	Aboriginal Subsistence Whaling Scheme.
SLA	*Strike Limit Algorithm*: an algorithm that produces limits on strikes for a management stock (note: for some hunts all strikes may not result in a mortality).
Objectives	
Biological stock	Biological population.
Block limit	Limit on strikes, where applicable with a time period >1yr.
Management stock	Management unit for which a limit on strikes is set and where the area must be specified on a case by case basis.
Minimum stock level	(See Para. 13(a) of the Schedule - note: acceptable risk level not defined).
Need	Specified by the Commission.
Development (trials, evaluations and tuning)	
Additional variance	The extent by which variability of successive abundance estimates exceeds the estimated variability of the estimates. This is implemented as the difference between the CV provided to the *SLA* (CV_{est}) and the true CV used when generating the abundance estimate (CV_{true}).
Carryover strikes	Unused strikes that can be added to the strike limit for the subsequent year or group of years.
Case-specific trial	A trial in which the population size and other input parameters are customised to represent a specific application.
Common control program	The computer code which is used by developers to conduct *Initial Exploration Trials* and calculate performance statistics.
Conditioning	The process of selecting specifications/parameter values for case-specific trials to ensure that they are not inconsistent with already existing data.
Design criterion	A way to evaluate an *SLA*, expressed in terms of what an *SLA* should look like, conceptually or structurally; any criterion that is not a performance criterion.
Demographic stochasticity	Taking account of random variability in the number of births and deaths each year.
Equivalence tuning	A way to provide *SLA* developers with the opportunity to adjust their *SLA*s to strive towards a pre-specified balance of risk, satisfaction of need and recovery.
Evaluation Trials	Trials used for formal comparisons of candidate *SLA*s. Their number would be limited, compared to the number of Robustness Trials. Evaluation Trials would be initiated prior to Robustness Trials.
Generic trial	A trial in which the population size or the other input parameters are not customised to represent a specific application.
H	An *SLA*, which represents a particular balance among risk, need satisfaction and recovery and which operates in the idealised case when the parameters of the common control programme are known exactly.
H-optimisation	A method for improving performance of *SLA*s, singly or merged, by minimising the Bayes risk (i.e. weighted expected loss) of its strike limits relative to those of an idealised *SLA, H*.
Initial Exploration Trials	Case-specific simulation trials for assessing the merits of performance statistics and to provide a framework for developers in the AWMP.
Merging of *SLA*s	Any method for combining *SLA*s that produces a new *SLA* that provides strike limits depending on the limits given by the component *SLA*s.
Need Envelope	Sets bounds on the situations that an AWMP will have to be able to cope with, at least with respect to the objective to fulfil 'need' requirements - used for the purposes of simulations only.
Performance criterion	A way to evaluate an *SLA*, expressed in terms of a performance statistic.
Performance statistic	A statistic used to evaluate how well a specific *SLA* achieves some or all of the objectives for the AWMP.
Performance tuning	A way to change the behaviour of an *SLA* to reflect management objectives.
Retrofitting	*Post hoc* adjustment of the output of an *SLA* to optimally resemble a different *SLA* or set of management objectives.
Robustness Trials	Trials to examine *SLA* performance for a full range of plausible scenarios. These would be applied to a restricted set of *SLA*s found to perform well in Evaluation Trials. The number of these trials would be potentially large.
Fishery type 1	A case where there is relatively little available information and stock identity problems and where the Committee has had considerable problems providing advice under Para. 13(a).
Fishery type 2	A case where there is relatively large amount of information and Para. 13(a) has largely been met (e.g. Bering-Chukchi-Beaufort bowhead whales).
Fishery type 3	A case where there is relatively little available information, small population size and stock identity problems (e.g. West Greenland fin whales) and where the Committee has had or would have considerable problems providing advice under Para. 13(a).
Revised Management Procedure (RMP) the RMP is described in detail in IWC (1994, pp.145-52).	
CLA	*Catch Limit Algorithm*, the process described in IWC (1994, pp.147-8) that is used in the RMP to calculate a catch limit for a Management Area.
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

Appendix 3

THE INITIAL EXPLORATION TRIALS

This Appendix provides the specifications for the *Initial Exploration Trials*. The trials are based upon the age- and sex-structured population dynamics model used for the evaluation of *Catch Limit Algorithms* for the RMP. The trials model three types of fishery:

(1) a case where there is relatively little available information and stock identity problems (e.g. West Greenland minke whales) and where the Committee has had considerable problems in providing advice under Para. 13(a) of the Schedule. The trials consider both the case when the stock identity is uncertain and the case when the boundaries of the stock being managed are known (which is equivalent to the single stock case);
(2) a case where there is a relatively large amount of information and Para. 13(a) of the Schedule has largely been met and in which it is known that the region managed contains only a single stock (e.g. Bering-Chukchi-Beaufort bowhead whales);
(3) a case where the current population size is small (~300) and where demographic and environmental variability may have an impact on recovery times (e.g. West Greenland humpback feeding aggregation, fin whales off West Greenland which are at population levels near the lower confidence limit and some Canadian stocks of bowhead whales).

In order to begin exploration of stock structure a simple 2 stock model has been developed and is specified in section G. This models the problem of setting strike limits based on surveys of an area which include either more than just the stock from which the removals are taken, or only a part of that stock.

A. The population dynamics model

A.1 Basic dynamics

The underlying dynamic model is age- and sex structured and is governed by the equations:

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

$R^{m/f}_{t,a}$ is the number of recruited males/females of age a at the start of year t;
$U^{m/f}_{t,a}$ is the number of unrecruited males/females of age a at the start of year t;
δ_a is the fraction of unrecruited animals of age a-1 which recruit at age a (assumed to be independent of sex);
S_a is the annual 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 sex and whether or not an animal is recruited);
$C^{m/f}_{t,a}$ is the catch of males/females of age a during year t (whaling is assumed to take place in a pulse at the start of each year); 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).

A.2 Births

Density dependence is assumed to act on the female component of the mature population and affects fecundity and infant survival. 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.

$$\begin{aligned} U^{m/f}_{t+1,0} &= 0.5(1-\alpha_0) B_{\text{init}} N^f_{t+1}\{1 + A(1-(D_{t+1}/D_{\text{init}})^z)\} \\ R^{m/f}_{t+1,0} &= 0.5\alpha_0 B_{\text{init}} N^f_{t+1}\{1 + A(1-(D_{t+1}/D_{\text{init}})^z)\} \end{aligned} \quad (2)$$

B_{init} is the average number of live births per year per mature female in the pristine (pre-exploitation) population;
A is the resilience parameter;
z is the degree of compensation;
N^f_t is the number of mature females at the start of year t:

$$N^f_t = \sum_{a=1}^{x} \beta_a (R^f_{t,a} + U^f_{t,a}) \quad (3)$$

D_t is the size of the component of the population in year t upon which the density dependence is assumed to act;
D_{init} is the pristine size of the component of the population in year t upon which the density dependence is assumed to act;
α_0 is the proportion of animals of age 0 which are recruited; and
β_a is the proportion of females of age a that are mature (assumed to be independent of year and whether or not an animal is recruited).

In these trials $D_t = N^f_t$ and $D_{\text{init}} = N^f_{\text{init}}$. The common control program maintains the option to use $D_t = N^{1+}_t$ and $D_{\text{init}} = K^{1+}$ as were specified in a previous definition of these trials, where

N^{1+}_t is the 1+ population size at the start of year t:

$$N^{1+}_t = \sum_{a=1}^{x} (R^f_{t,a} + U^f_{t,a} + R^m_{t,a} + U^m_{t,a}) \quad (4)$$

K^{1+} is the pristine total (1+) population size:

$$K^{1+} = \sum_{a=1}^{x} (R^f_{\text{init},a} + U^f_{\text{init},a} + R^m_{\text{init},a} + U^m_{\text{init},a}) \quad (5)$$

A.3 Catches

The historical ($t<0$) catches are taken to be equal to the reported catches by sex and year. For fishery type 1 these are taken to be the catches from 1930 to 1992 from *Small Areas*

WG, CG, CIP, CIC and CM for North Atlantic minke whales (IWC, 1993, p.194), and those for fishery type 2 are taken to be the catches from 1848-1993 for the Bering-Chukchi-Beaufort bowhead whales (IWC, 1995, p144), apportioned equally between males and females.

Catches are taken uniformly from the recruited component of the population:

$$C_{t,a}^{m/f} = C_t^{m/f} R_{t,a}^{m/f} / \sum_{a'} R_{t,a'}^{m/f} \qquad (6)$$

where $C_t^{m/f}$ is the catch of males/females in year t. The total catch in a given year is taken to be the strike limit for that year, $C_t = C_t^m + C_t^f$. Future catches are assumed to be split 50:50 male:female in fishery type 2. Two different options will be considered for fishery type 1: (i) a sex ratio of 35:65 males:females, based loosely on the sex ratio of historical catches off West Greenland and (ii) 65:35 males:females to examine the implications of the reverse sex ratio. The current set of trials considers only option (i).

A.4 Recruitment

The proportion of animals of age a that would be recruited if the population was pristine is either a knife edged function of age or is given by:

$$\alpha_a = \begin{cases} 0 & \text{if } a < a_{r,\min} \\ [1+\exp[-(a-r_{50})/\sigma_r]^{-1} & \text{if } a_{r,\min} \le a < x-1 \\ 1 & \text{if } a \ge x-1 \end{cases} \qquad (7)$$

r_{50} is the age-at-50%-recruitment;
σ_r is a parameter which determines the width of the recruitment ogive; and
$a_{r,\min}$ is the first age at which an animal can be recruited (taken to be age 2 for fishery type 1).

The number of unrecruited animals of age a that survive to age a+1 is $U_{t,a}^{m/f} S_a$. The fraction of these which then recruit is:

$$\delta_{a+1} = \begin{cases} [\alpha_{a+1} - \alpha_a]/[1-\alpha_a] & \text{if } \alpha_a < 1 \\ 1 & \text{otherwise} \end{cases} \qquad (8)$$

The current set of trials are based on the knife edge function only, although both options are available in the common control program.

A.5 Maturity

The proportion mature (actually that past the age of first parturition) at each age is either a knife edged function of age or is given by:

$$\beta_a = \begin{cases} 0 & \text{if } a < a_{m,\min} \\ [1+\exp\{-(a-m_{50})/\sigma_m\}]^{-1} & \text{if } a_{m,\min} \le a < x-1 \\ 1 & \text{if } a \ge x-1 \end{cases} \qquad (9)$$

m_{50} is the age-at-50%-maturity;
σ_m is a parameter which determines the width of the maturation ogive; and
$a_{m,\min}$ is the first age at which an animal can be mature (taken to be age 2 for fishery type 1).

A.6 Initialising the population vector

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

$$R_{\text{init},a}^{m/f} = 0.5 N_{\text{init},0}\, \alpha_a \exp[-\sum_{a'=0}^{a-1} M_{a'}] \qquad \text{if } a < x$$

$$U_{\text{init},a}^{m/f} = 0.5 N_{\text{init},0} (1-\alpha_a) \exp[-\sum_{a'=0}^{a-1} M_{a'}] \qquad \text{if } a < x \qquad (10)$$

$$R_{\text{init},x}^{m/f} = 0.5 N_{\text{init},0} \exp[-\sum_{a'=0}^{x-1} M_{a'}] / (1-\exp[-M_x]) \qquad \text{otherwise i.e. when } a = x$$

$R_{\text{init},a}^{m/f}$ is the number of animals of age a that would be recruited in the pristine population;
$U_{\text{init},a}^{m/f}$ is the number of animals of age a which would be unrecruited in the pristine population; and
$N_{\text{init},0}$ is the total number of animals of age 0 in the pristine population.

The value of $N_{\text{init},0}$ is selected so that the 1+ population size in the first year in which the *SLA* is applied (t = 0) is equal to a pre-specified value.

A.7 Estimation of A and z

The values of A and z depend on the values specified for *MSYR*, *MSYL* and the parameters which determine the maturity and recruitment ogives. The detailed algorithm for calculating A and z from *MSYR* and *MSYL* is given by Punt (1999). For these trials both *MSYR* and *MSYL* are defined in terms of uniform selectivity harvesting on the 1+ population. For all of the trials *MSYL* = 0.6. In the future it is anticipated that trials for some fishery types may be conducted in which *MSYL* is defined in terms of uniform selectivity harvesting on the mature population.

A.8 Stochastic Dynamics Model

A preliminary stochastic version of the above dynamics model was developed for fishery type 2. This model, detailed in Adjunct 1, allows for stochastic births/calf survival and deaths; additional simple autocorrelative environmental stochasticity can be added to the birth/calf survival process. The appropriate use of such a model in the Initial Exploration Trials will be examined in the future.

B. Data generation

B.1 Absolute abundance estimates

An estimate of absolute abundance together with an estimate of CV is provided to the *SLA* once every F years during the management period (beginning in year (-1+F)). The CV of the abundance estimate (CV_{true}) is generally different from the CV provided to the *SLA*.

For fishery type 1, an estimate of abundance will also be generated for the whole stock in 1992, the year prior to the first year in which the AWMP is applied. The pre-management abundance estimates for fishery type 2 are taken to be the N_4/P_4 values in Zeh *et al.* (1995).

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

$$\hat{S} = B_A P\, Y w \;/\; \mu = B_A P^* \beta^2 Y w \qquad (11)$$

B_A is the bias;
P is the current 1+ population size ($= N_t^{1+}$);

Y is a lognormal random variable: $Y = e^{\varepsilon}$ where $\varepsilon \sim N[0;\sigma_\varepsilon^2]$ and $\sigma_\varepsilon^2 = \ell n(1+\alpha^2)$;
w is a Poisson random variable, independent of Y, with $E(w) = \mathrm{var}(w) = \mu = (P/P^*)/\beta^2$;
P^* is the reference population level (the pristine 1+ population, $= K^{1+}$).

Note that under the approximation $CV^2(ab) = CV^2(a) + CV^2(b)$

$$E(\hat{S}) = B_A P_t \text{ and } CV^2_{true}(\hat{S}) = \alpha^2 + \beta^2 P^* / P.$$

The ratio of $\alpha^2 : \beta^2$ is 0.12 : 0.025.

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

$$X = \sigma\sqrt{(CHISQ / n)} \quad (12)$$

where

$$\sigma^2 = \ell n(1 + CV^2_{est})$$

CHISQ is a random number from a Chi-square distribution with n degrees of freedom where $n = 19$ (the value assumed for the single stock trials); and

$CV^2_{est} = \theta^2(a^2 + b^2 / w\beta^2)$ where a^2 and b^2 are constants and equal to 0.02 and 0.012 respectively.

Note that under the approximation $E(1 / w) \approx 1 / E(w) = 1 / [(P / P^*) / \beta^2] = \beta^2 P^* / P$, this gives:

$$E(CV^2_{est}) = \theta^2(a^2 + b^2 P^* / P) \quad (13)$$

The relationship between CV_{est} and CV_{true} is given by $\eta = [E(CV^2_{true}) - E(cv^2_{est})] / (0.1 + 0.013P^* / P)$ where η is a constant known as the additional variance factor.

The value of θ is set so that required CV_{est} is obtained when $P = 0.6K$, i.e. $\theta^2 = E(CV^2_{est}) / 0.04$.

The values of α and β are computed from a, b, CV_{est} and CV_{true} as:

$$\alpha^2 = \theta^2 a^2 + \eta 0.1 \qquad \beta^2 = \theta^2 b^2 + \eta 0.013. \quad (14)$$

B.2 Age-class data

The information available to an *SLA* is estimates of the proportion of calves, n_c/n, and mature animals, n_m/n from a sample of n animals. n equals 250 for fishery type 2 and 0 for fishery type 1. The information is available in every year for which an abundance estimate is available. n_c and n_m are generated from n independent Bernoulli (p_c) or Bernoulli (p_m) trials in which p_c and p_m are generated from Beta (x,y) to account for overdispersion. The values for x and y are calculated separately for calves and mature animals:

$$x / (x + y) = \begin{cases} p(L) & \text{for mature animals (15a)} \\ 1 - p(L) & \text{for calves (15b)} \end{cases}$$

$$xy(n^{-1} + (x + y)^{-1}) / ((x + y + 1)(x + y)) = c \quad (15c)$$

[Equations 15a and 15b set the mean Bernoulli parameters, and 15c establishes the marginal variance of the Bernoulli observations.]

L is the length defining calves or mature animals;
c is 0.035^2 for the calves, and 0.07^2 for mature animals;

$p(L)$ is the proportion of whales larger than length L:

$$p(L) = \sum_{a=0}^{x} p_a(L)(R_a^f + R_a^m + U_a^f + U_a^m) \Big/ \sum_{a'=0}^{x}(R_{a'}^f + R_{a'}^m + U_{a'}^f + U_{a'}^m) \quad (16)$$

$p_a(L)$ is the proportion of whales of age a that are assigned as being larger than length L:

$$p_a(L) = \begin{cases} 0 & \text{if } a \le {}_{\min}(L) \\ (1 + \exp[-(a - a_{50}(L) + \gamma_L) / (\lambda_L \sigma_L)])^{-1} & \text{if } a_{\min}(L) < a < a_{\max}(L) \\ 1 & \text{if } a \ge {}_{\min}(L) \end{cases} \quad (17)$$

$a_{\min}(L)$ is the last age at which no whales may exceed length L;
$a_{\max}(L)$ is age at which all whales exceed length L;
$a_{50}(L)$ is the age at which the length of 50% of whales of that age exceed length L;
σ_L is the dispersion parameter;
γ_L is a bias term to account for error in $a_{50}(L)$; and
λL is a term to account for error in σ_L.

This approach takes account of three sources of error: Bernoulli sampling error, overdispersion through the Beta distribution of the Bernoulli parameter, and error in the assumed relationship between age and length through the values of γ_L and λ_L. If $\gamma_L = 0$ and $\lambda_L = 1$, $p_a(L)$ is not subject to error, otherwise, $p_a(L)$ allows for some error in the assignment of age classes.

The values for some of the parameters are taken to be fixed for these trials (see Table 1).

Table 1

Age-class parameter values.

	Juveniles/adults (L=6)	Mature animals (L=12.9)
$a_{\min}(L)$	0	10
$a_{\max}(L)$	1	30
$a_{50}(L)$	1	20
σ_L	0	1.91

The value 0 for σ_6 reflects the assumption that calves can be indentified without error. The value 1.91 for $\sigma_{12.9}$ was chosen so that animals aged 13 or younger have at most a 2.5% chance of exceeding 12.9m and animals aged 27 or older have at least a 97.5 chance of having reached 12.9m.

The pre-management values of n_c/n, and n_m/n are taken to be the values given in Angliss *et al.* (1995).

C. Need

The level of need in each year, Q_t, will be supplied to the *SLA*. The need is given by:

$Q_t = Q_0 + t(Q_{100} - Q_0) / 100$ where Q_0 is the need at the start of the first year in which an AWMP is applied and Q_{100} is the value 100 years later.

The current need for the fishery type 1 trials is computed by assuming the total identified need for edible products from whales (670 tons; Denmark, 1988) is obtained from minke whales (2 tons per minke whale). Trials are performed with $Q_{100} = Q_0$ (i.e. constant need) and with $Q_{100} = 3Q_0$.

D. Trials

The factors considered in trials are chosen from those given in Table 2.

The single stock and stock identity trials for fishery type 1 have been integrated into a common specification, which is detailed in Section D(i). The single stock trials are a special case of this model, in which the SLA is provided with exact information about the stock boundary.

The set of trials for fishery type 2 is given in Section D(i).

Di. Fishery Type 1

Basic concepts and stock structure

The objective of the trials is to begin to address the problems of stock identity for fishery type 1. The trials are an extension of the Type 1 trials that assumed a single stock hypothesis (IWC, 1998). For these trials the area is divided into three cells as shown in Fig. 1, which are labelled 1, Middle and 2. There are two biological stocks and an aboriginal catch will be taken from Cell 2 (i.e. the strike limits will be removed from the population in Cell 2). Three alternative stock structure hypotheses are considered:

(a) Stock 1 feeds in Cells 1 and middle, and Stock 2 feeds in Cell 2 (see Fig. 1a.). There is no mixing between stocks.
(b) Stock 1 feeds in Cell 1, and Stock 2 feeds in Cells middle and 2 (see Fig. 1b.). There is no mixing between stocks.
(c) Stock 1 feeds in Cells 1 and middle, and Stock 2 feeds in Cells middle and 2 (see Fig. 1c). The stocks mix in the middle cell (but do not move permanently from one stock to the other i.e. there is no 'leakage'). The catch mixing matrix (IWC, 1993, p.190) is given in Table 3.

Stock structure hypotheses (a) and (b) are considered to capture: (a) the possibility that the strike limit is based on

Table 2

Factors considered in the trials.

Quantity	Fishery type 1	Fishery type 2	Fishery type 3
$MSYR_{1+}$	0.01; 0.04; 0.07	0.01; 0.025; 0.04	0.01; 0.04; 0.07
$MSYL_{1+}$	0.6	0.6	0.6
[1,2] P_0	25,000; 40,000	See [4] below	~300
[3] CV_{true}	0.3	0.25	
CV_{est}	0.3	0.25; 0.125	
[2] Bias B_A	1; 1.5	1; 1.5	
Inter-survey period F	10 years, 2-10years[6]	5 years	
Age class data: calves	N/A	$\gamma_6=0$ $\lambda_6=1$	N/A
Age class data: mature	N/A	$\gamma_{12.9}=0; 4$ $\lambda_{12.9}=1; 2$	N/A
Selectivity	Knife-edged - age 1	Knife-edged - age 1	See [7] below
Maturity	$m_{50}=7$; $\sigma_m=1.2$, $a_{m,min}=2$	Knife-edged - age a_m.[4]	See [7] below
Natural mortality	$M_a=0.05yr^{-1}$	M_J and M_m[4,5]	See [7] below

[1] P_0 is the 1+ population size in year 0, where 0 is the year for which strike limits are first set by the *SLA* (i.e. $t=0$). Year 0 is 1993 for fishery type 1 and 1994 for fishery type 2.
[2] For the trials in which $B_A \neq 1$, the value of P_0 is taken to be the specified value divided by B_A.
[3] This CV is assumed to apply to a stock which is depleted to 60% of its 1+ pre-exploitation size.
[4] Priors are specified for a_m, a_T, and M_m - see details in Section F.
[5] Natural mortality is M_J from ages 0 to a_T and M_m thereafter.
[6] Surveys every 2 years up to year 10 and every 10 years thereafter.
[7] Parameters typical of those of West Greenland fin and humpback populations will be used.

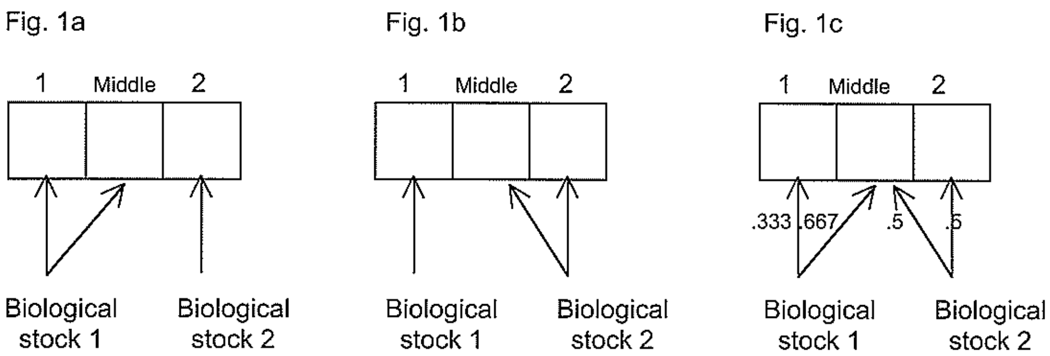

Fig. 1.

Table 3

The catch mixing matrix.

	Cell 1	Middle	Cell 2
Stock 1	0.333	0.667	0.0
Stock 2	0.0	0.5	0.5

surveys that cover more that just the stock being managed; and (b) the opposite case in which the stock being managed is found in an area in which harvesting does not occur.

Initial population sizes

Two sets of initial population sizes are considered and are given in Table 4. (Initial refers to the year for which strike limits are first set by the *SLA* i.e. $t=0$).

Table 4

Initial population sizes.

	Cell 1	Middle	Cell 2
High	10,000	30,000	10,000
Low	5,000	15,000	5,000

The abundances in Cells middle and 2 combined approximately match the values used for the previous fishery type 1 trials.

Future catches in other areas

No catch will be taken in the middle cell. Two options are considered for the level of catch taken in Cell 1. For most trials no catch will be taken from this cell, as this should be the more difficult case. Two sensitivity trials consider the case in which a commercial catch limit will be set in Cell 1 using the RMP. These sensitivity tests are conducted because catches in Cell 1 will affect the trends in 1+ abundance in the middle cell. These may, in turn, affect the overall performance of the SLA used to manage harvesting in Cell 2.

MSY rates

MSY rates (in terms of the 1+ component of the population) of 1% and 7% will be used.

Abundance estimates

Estimates of abundance for each of the three cells will be made available to the *SLA*. They will be calculated using the method described in section B.1.

Other parameters

The historic catches will be taken to be the catches from *Small Areas* CIC for North Atlantic minke whales (Cell 1), CG+CIP+CM (middle cell) and WG (Cell 2).

Trials

The set of trials is given in Table 5. The trials are run with two options: (i) the *SLA* is provided with information about where the stock boundary lies e.g. for trial MM1 it is provided with the fact that the stock being managed is found in Cell 2 only; and (ii) it has no information about the stock boundary.

The following parameters are used in all trials: future catch ratio of 35:65 male:female; bias in absolute abundance estimates = 1.

For comparison Table 6 lists the previous fishery type 1 single stock trials together with the number of the new equivalent (if there is one).

Model details

The equations for the basic dynamics and births are the same as those for single stock trials. This section describes how catches are allocated to biological stocks, and how the expected value of a survey in an area is calculated.

The pristine sizes of the biological stocks are chosen so that if these are projected forwards from unexploited equilibrium to year $t=0$, the population size in each area at the start of year 0 is equal to the initial population sizes for the trial.

Table 5

The set of trials for fishery type 1.

Trial	$MSYR_{1+}$	Initial population	Catch in Area 1	Need	Survey interval	Stock structure
MM1	0.01	High	0	Constant	10yrs	Boundary between middle and 2
MM1a	0.07	High	0	Constant	10yrs	Boundary between middle and 2
MM2	0.01	High	0	Constant	10yrs	Boundary between 1 and middle
MM2a	0.07	High	0	Constant	10yrs	Boundary between 1 and middle
MM3	0.07	High	0	Constant	10yrs	Mixing in middle Cell
MM4	0.07	High	Yes[1]	Constant	10yrs	Mixing in middle Cell
MM5	0.01	Low	0	Constant	10yrs	Boundary between middle and 2
MM5a	0.07	Low	0	Constant	10yrs	Boundary between middle and 2
MM6	0.01	Low	0	Constant	10yrs	Boundary between 1 and middle
MM6a	0.07	Low	0	Constant	10yrs	Boundary between 1 and middle
MM7	0.01	Low	0	Constant	10yrs	Mixing in middle Cell
MM8	0.01	Low	Yes[1]	Constant	10yrs	Mixing in middle Cell
MM9	0.01	High	0	Increasing	10yrs	Boundary between middle and 2
MM10	0.07	High	0	Increasing	10yrs	Mixing in middle Cell
MM11	0.01	Low	0	Increasing	10yrs	Mixing in middle Cell
MM12	0.01	High	0	Constant	2-10yrs[2]	Boundary between middle and 2
MM13	0.07	High	0	Constant	2-10yrs[2]	Boundary between 1 and middle

[1] Catches set using the RMP.

[2] Surveys every 2 years until year 10, and every 10 years thereafter.

Table 6

The previous set of trials for fishery type 1 (for comparison).

Trial	$MSYR_{1+}$	$MSYL$	Initial population P_0	Need: Initial level	Need: Final level	Data quality bias B_A	Future catch ratio M:F	New equivalent trial
M1	0.04	$MSYL_{1+}$=0.6	40,000	335	335	1	35:65	
M1a	0.04	$MSYL_{1+}$=0.6	40,000	335	335	1	65:35	
M2	0.04	$MSYL_{1+}$=0.6	40,000	335	1,005	1.5	35:65	
M3	0.04	$MSYL_{1+}$=0.6	25,000	335	335	1.5	35:65	
M6	0.07	$MSYL_{1+}$=0.6	40,000	335	1,005	1.5	35:65	
M8	0.07	$MSYL_{1+}$=0.6	25,000	335	1,005	1	35:65	
M9	0.01	$MSYL_{1+}$=0.6	40,000	335	335	1	35:65	MM1
M10	0.01	$MSYL_{1+}$=0.6	40,000	335	1,005	1.5	35:65	MM9
M11	0.01	$MSYL_{1+}$=0.6	25,000	335	335	1.5	35:65	

Catches

Catches from an area are taken uniformly from the recruited population in that area:

$$C_t^s = \sum_k \tilde{C}_t^k \left\{ V^{s,k} R_t^s \Big/ \sum_{s'} (V^{s',k} R_t^{s'}) \right\} \quad (20)$$

where C_t^s is the catch (both sexes combined) during year t from biological stock s;

$\tilde{C}_t^k$ is the catch from area k (Cell 1, Cell 2 or middle) during year t;

R_t^s is the total number of exploitable animals in biological stock s at the start of year t:

$$R_t^s = \sum_{a=0}^{x} (R_{t,a}^{s,m} + R_{t,a}^{s,f}) \quad (21)$$

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

$V^{s,k}$ is the fraction of whales from biological stock s which feed (and hence may be caught) in area k (the catch mixing matrix).

The catch from a biological stock is allocated to sexes and ages according to Equation (6).

Sightings

The expected value of a survey conducted in area k at the start of year t (P - see Equation 11) is given by:

$$P_t^k = \sum_s V^{s,k} \sum_{a=1}^{x} (R_{t,a}^{s,f} + U_{t,a}^{s,f} + R_{t,a}^{s,m} + U_{t,a}^{s,m}) \quad (22)$$

The reference population level for area k is given by:

$$P^* = \sum_s V^{s,k} \sum_{a=1}^{x} (R_{\text{init},a}^{s,f} + U_{\text{init},a}^{s,f} + R_{\text{init},a}^{s,m} + U_{\text{init},a}^{s,m}) \quad (23)$$

Future trials

Future trials should include an option in which the catch mixing matrix is density dependent. Further robustness trials will also be needed for the case in which there is a positive survey bias and the survey bias increases with time.

Suggestion

It is suggested that developers consider adding a condition such that the initial annual catch is at least 150 whales; this condition is loosely based on the current aboriginal catch quota in West Greenland.

Dii. Fishery Type 2

The new method for conditioning the trials (i.e. selecting the values for the parameters for a_m, M_J, a_T M_m and P_0 for fishery type 2). This new scheme reduces or eliminates the possibility of trials using unrealistic combinations of MSYR and the biological parameters. Further trials need to be added to examine sensitivity to a wider range of uncertainties e.g. changing the likelihood for P_0 and the proportions of calves and mature animals. The trials will be conditioned using the following scheme.

(1) The priors specified during the 1994 meeting of the Scientific Committee (IWC, 1995) for a_m, M_J, a_T *and* M_m and that specified during the 1998 meeting (IWC, 1998) for $P_0 = P_{1993}$ are used together with the (fixed) values for $MSYR_{1+}$ and $MSYL_{1+}$

(2) A 'backwards' Bayesian analysis is conducted to provide a set of 100 combinations for a_m, M_J, a_T, M_m and P_0 that are conditioned on the pre-specified values for $MSYR_{1+}$ and $MSYL_{1+}$ (and the data used for the B-C-B assessment). This involves generating N sets of parameters and the associated likelihoods from the priors for a_m, M_J, a_T, M_m and P_0, calculating the values for K which deterministically 'hit' the generated values for P_0, projecting the populations from K to year 0 using the model and calculating the likelihood. The 100 sets of parameters for use in the trials are those with the 100 highest likelihoods.

The initial set of calculations will be based on the deterministic model; an attempt will be made to extend this approach to the stochastic model described in Adjunct 1.

The set of trials for fishery type 2 is given in Table 7. Note that for reasons of consistency the trial numbers have not been altered. Hence there are gaps in the numbers where earlier trials have been deleted.

Diii. Fishery Type 3

Fishery type 3 considers the case where the population to be harvested is small. Trials will be conducted to investigate how small small should be. The trials will consider uncertainty in the trajectory due to individual variability in survival and reproduction (demographic uncertainty) and environmental uncertainty. Three kinds of models are considered:

Table 7

The set of trials for fishery type 2.

			Need		Data Quality			
Trial	$MSYR_{1+}$	MSYL	Initial level	Final level	CV_{est}	$\gamma_{12.9}$	$\lambda_{12.9}$	B_A
B1	0.025	$MSYL_{1+}$=0.6	68	68	0.25	0	1	1
B3	0.04	$MSYL_{1+}$=0.6	68	204	0.25	0	1	1
B6	0.01	$MSYL_{1+}$=0.6	68	68	0.25	0	1	1
B7	0.01	$MSYL_{1+}$=0.6	68	204	0.25	0	1	1
B7a	0.01	$MSYL_{1+}$=0.6	68	204	0.125	4	2	1.5
B10	0.04	$MSYL_{1+}$=0.6	68	68	0.25	0	1	1

(i) simple demographic stochasticity (on survival and birth rate) only;
(ii) demographic stochasticity plus environmental variability without auto-correlation;
(iii) same as (ii) but with auto-correlation.

The models are the same as those described in Adjunct 1.

Some initial simulations and explorations are needed to determine feasible and reasonable combinations and ranges of parameters but the focus is on low population size (~300 animals) and either a K value close to the current population size or much higher. *MSYR* values of 1%, 4% and 7% will be considered for each of the three types of model. The trajectories will be investigated for a range of different initial population sizes and the effects over a 1,000 year time span will be examined. Nine graphs will be produced showing the change in extinction probability with K for all of the different models with the different MSY rates.

The parameters used will be those typical of the West Greenland fin and humpback populations. No catch will be taken.

E. Tuning

Results should be presented for both *H-tuning* and *depletion tuning*.

E.1 Equivalence Tuning

H is defined as the set of strike limits computed using a target *SLA* (detailed below) which has been given perfect and complete knowledge about the stock dynamics and the operating model parameter values.

H is used for comparison with candidate *SLA*s so that their parameter values may be selected to match H as adequately as possible. The target *SLA* is not intended to represent ideal *SLA* performance but rather it is meant to illustrate a particular balance between need satisfaction, risk and recovery to which candidate *SLA*s may all be tuned. This process is known as *equivalence tuning*.

For a given trial i and replicate j, $H_t^{i,j}$ is defined as:

$$H_t^{i,j} = \min\left(Q_t, \begin{cases} 0 & \text{if } N_t^{1+} < 2000 \\ 0.8RY_t & \text{if } 2000 \le N_t^{1+} < MSYL^{1+} \\ 0.9MSY & \text{if } N_t^{1+} > MSYL^{1+} \end{cases} \right) \quad (18)$$

where RY_t is the replacement yield for year t; and
MSY is defined in terms of uniform selectivity harvesting on the 1+ component of the population.

The statistic by which tuning success is to be evaluated for trial i is:

$$Z_i = \frac{\sum_{j=1}^{100} \sum_{t=0}^{99} \left\{ H_t^{i,j}(H) - C_t^{i,j}(C) \right\}^2}{\sum_{j=1}^{100} \sum_{t=0}^{99} \left\{ H_t^{i,j}(H) \right\}^2} \quad (19)$$

where $H_t^{i,j}(H)$ is the strike limit for replicate j of trial i in year t for a trial in which a catch equal to $H_t^{i,j}$ is removed each year; and $C_t^{i,j}(C)$ is the strike limit for replicate j of trial i in year t provided by the candidate *SLA*, for a trial in which removals up to year t-1 have been determined by the same candidate *SLA*.

This approach is to be used for *equivalence tuning* on two trials for each fishery type, one that should allow need to be satisfied, and another in which need cannot be satisfied without severe depletion of the stock. The selected trials (i = 1, 2 for each fishery) are MM1 and MM9 for fishery type 1 and B3 and B7 for fishery type 2. Z is the quantity minimised where $z = z_1 + z_2$.

The Secretariat will modify the Common Control Program to output the values of Z_i (Equation 19).

E.2 Depletion Tuning

The trials for *depletion tuning* are MM1 and B7 for fishery types 1 and 2 respectively. Tuning should be achieved to match the median final depletion achieved by H for these trials to within 0.02. It is recommended that developers also consider tuning to the lower 5%ile of the final depletion for these trials.

Developers should also provide results for all trials for a range of tunings of their candidate SLAs. This range of tunings should be chosen so that the median final depletions for trials MM1 and B7 include the values used for depletion tuning as specified above.

F. Statistics

The risk- and recovery-related performance statistics are computed for the mature female and for the total (1+) population sizes (i.e. P_t is either the size of mature female component of population, N_t^f, or the size of the total (1+) population, N_t^{1+}). P_t^* is the population size in year t under a scenario of zero strikes over the years t≥ 0.

The *Initial Exploration Trials* are based on a 100-year time horizon, but a final decision regarding the time horizon for simulation trials will depend *inter alia* on interactions between the Committee and the Commission regarding need envelopes and on the period over which recovery might occur. To allow for this, results are calculated for T = 20, 50 and 100.

Statistics marked in bold face are considered the more important. All developers must report at least the 5% and median values for the D1 and N9 statistics. In addition they should bring a machine readable copy of all the statistics to meetings so that these can be discussed if the SWG wishes.

Note that for reasons of consistency the statistic identification numbers have not been altered. Hence there are gaps in the numbers where former statistics have been deleted.

F.1 Risk

D1. Final depletion: P_T/K.

D2. Lowest depletion: $\min(P_t / K){:}t = 0.1,...,T$.

D6. Plots for simulations 1 and 2 of $\{P_t : t = 0,1,..,T\}$ and $\{P_t^* : t = 0,1,..,T\}$.

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

F.2 Need

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

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

N3. Fraction of years in which $C_t \geq 0.5Q_t$.

N4. Fraction of years in which $C_t \geq Q_t$.

N5. Proportion of block need satisfaction: $\Gamma / (T - h + 1)$ where Γ is the number of blocks of h years in which the total catch equals or exceeds the total need; h is 5 for these trials.

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

N8. Plots of V_t for simulations 1 and 2.

N9. Average need satisfaction: $\frac{1}{T}\sum_{t=0}^{T-1} f_t$ where $f_t = C_t / Q_t$ if $C_t < Q_t$ and 1 otherwise.

F.3 Recovery

R1. Relative recovery: $P_{t_r^*} / P_{t_r^*}^*$ where t_r^* is the first year in which P_t^* passes through $MSYL$. If P_t^* never reaches $MSYL$, the statistic is P_T / P_T^*. If $P_0 > MSYL$ the statistic is min (1, $P_T / MSYL$).

R2. Final recovery: prob($P_T \geq MSYL$ / prob($P_T^* \geq MSYL$); 0/0 is defined as 1.

R3. Time frequency in recovered state = (The number of years for which $P_t > 0.9\ MSYL$, given that $t \geq t_r$) / $(T\text{-}t_r\text{+}1)$ where t_r is the first year in which the population reaches $MSYL$ (or T otherwise).

R4. Relative time to recovery:

$$RTR = \begin{cases} 1 & \text{if } P_0 \geq MSYL \\ (T - t_r)/T & \text{if } P_0 < MSYL \text{ and } P_T \geq MSYL \\ \min_t(t \mid P_t^* \geq P_T)/T & \text{if } P_0 < MSYL \text{ and } P_T < MSYL \end{cases}$$

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Adjunct 1. Model for Stochastic Trials

Compiled by G. Givens, A. Raftery and L. Witting.

Except as detailed below, the stochastic dynamics model will rely on the same assumptions as the model given in Appendix 3.

Mortality

Define $M_{t,a}^{R/U,m/f}$ as the number of recruited/unrecruited whales of age a and sex m/f in year t which are eligible to survive and be counted in $R_{t+1,a+1}^{m/f}$ or $U_{t+1,a+1}^{m/f}$.

Replace equations (1) of Appendix 3 with:

$$R_{t+1,a+1}^{m/f} \sim \text{Binomial}^*\left(M_{t,a}^{R,m/f}, S_a\right) \qquad 0 \leq a \leq x\text{-}2$$

where $M_{t,a}^{R,m/f} = R_{t,a}^{m/f} - C_{t,a}^{m/f} + U_{t,a}^{m/f}\delta_{a+1}$ and

Binomial*(n,p) is defined by $\frac{n}{\lceil n \rceil}$ Binomial $(\lceil n \rceil, p)$ where $\lceil n \rceil$ is the smallest integer $\geq$n

$$R_{t+1,x}^{m/f} \sim \text{Binomial}^*\left(M_{t,x}^{R,m/f}, S_x\right) + \text{Binomial}^*\left(M_{t,x-1}^{R,m/f}, S_{x-1}\right)$$

where $M_{t,x}^{R,m/f} = R_{t,x}^{m/f} - C_{t,x}^{m/f}$

$$U_{t+1,a+1}^{m/f} \sim \text{Binomial}^*\left(M_{t,a}^{U,m/f}, S_a\right) \qquad 0 \leq a \leq x\text{-}2$$

where $M_{t,a}^{U,m/f} = U_{t,a}^{m/f}\left(1 - \delta_{a+1}\right)$

Births

Define $B_{t+1,0}^{m/f}$ as the number of m/f births occurring at the start of year t+1.

Replace equations (2) of Appendix 3 with:

$$B^{m/f}_{t+1,0}\Big|N^f_{t+1} \sim \text{Binomial}^*\left(N^f_{t+1}, b_{t+1,0}\right)$$

where $b_{t+1,0} = 0.5B_{init}\{1+A(1-(D_{t+1} / D_{init})^z)\}$ is the birthing/calf survival probability; if $b^{m/f}_{t+1,0} \notin [0,1]$ insert the appropriate bound (0 or 1).

Next, let

$$U^{m/f}_{t+1,0} = (1-\alpha_0)B^{m/f}_{t+1,0}$$

$$R^{m/f}_{t+1,0} = \alpha_0 \; B^{m/f}_{t+1,0}$$

The number of births in successive years are stochastic and independent. The total number of births is correct on average. Note that this method does not place any constraints on the calving for individuals. Explicit constraints to limit the calving rates of individual whales may be added in the future.

Environmental Stochasticity with no Autocorrelation

To introduce simple environmental stochasticity into the birthing/calf survival process, let the expected birthing/calf survival probability in year t+1 be given by $b_{t+1,0}$ as above. The realised number of births in year t+1 is then a random variable, $B^{m/f}_{t+1,0}$, which has a binomial distribution with parameters N^f_{t+1} and p_{t+1} where p_{t+1} is itself a random number given by:

$$p_{t+1} = \frac{e^{q_{t+1}}}{1+e^{q_{t+1}}}$$

and where q_{t+1} is a Normal random variable distributed. $N(\mu_{t+1},\sigma^2_q)$. Then $U^{m/f}_{t+1,0}$ and $R^{m/f}_{t+1,0}$ are computed from $B^{m/f}_{t+1,0}$ as above. Choose μ_{t+1} (by integration) so that $E(p_{t+1}) = b_{t+1,0}$ and let σ^2 be a constant. The value of $\sigma^2_q = 0.31$ yields a value of approximately 0.41 for the CV of p_{t+1} when $E(p_t+1) = 0.25$, (and $\mu_{t+1} = -1.17$) which equates roughly to the analysis by Givens *et al.* (1995) of bowhead calf data (Angliss *et al.*, 1995). Hence the value of $\sigma^2_q = 0.31$ is selected for the initial set of trials incorporating simple environmental stochasticity.

Environmental Stochasticity with Autocorrelation

This case is modelled as above, but treating $p_{t+1} = \dfrac{e^{q_{t+1}}}{1+e^{q_{t+1}}}$ as random, where q_{t+1} is generated from the model

$$q_{t+1} - \mu_{t+1} = \rho(q_t - \mu_t) + \varepsilon_{t+1} \quad \text{where } \varepsilon_{t+1} \sim N(0,\sigma^2_\varepsilon)$$
$$\text{and } |\rho| < 1$$

Choose ρ such that $\text{cor}\left(\dfrac{e^{q_{t+1}}}{1+e^{q_{t+1}}}, \dfrac{e^{q_t}}{1+e^{q_t}}\right) = 0.75$ for the case when var $q_{t+1} = \sigma^2_q = 0.31$ and $\mu_{t+1} = -1.17$, so that $E(p_{t+1}) = 0.25$.

Choose σ^2_ε to solve $\sigma^2_q = \dfrac{\sigma^2_\varepsilon}{1-\rho}$

Preliminary calculations indicate this yields $\rho = 0.67$ and $\sigma^2_\varepsilon = 0.076$; hence these values are selected for the initial set of trials incorporating environmental stochasticity with autocorrelation.

Appendix 4

CONSIDERATION OF CONDITIONING AND STOCHASTICITY FOR FISHERY TYPE 2 TRIALS

Geof Givens

Initial Exploration Trials are intended to provide a *Strike Limit Algorithm* development framework which roughly reflects the operating conditions (productivity, abundance, life history, environment, aboriginal need) that an implemented *Strike Limit Algorithm* would face. Since these conditions are unknown, trials are chosen to span the range of uncertainty. The Committee and the AWMP SWG have recognised the value of limiting the number of trials, where possible, to simplify the initial evaluation of candidate *Strike Limit Algorithms*. One way the SWG has limited the current number of type 2 (bowhead-like) trials is by constructing each trial to include 100 variations which span a range of uncertainty represented by probability distributions for certain biological parameters.

Each type 2 *Initial Exploration Trial* assumes a specific fixed value of MSYR. In SC/50/AWMP2, Punt notes that each trial currently uses a distribution of biological life history parameters which is not specific to the value of MSYR being assumed. He suggests that, for a fixed value of MSYR, the biological parameters should be sampled from their conditional distribution (given MSYR) rather than their marginal distribution.

This proposal is mathematically correct and addresses the goal that trial scenarios use jointly realistic parameter sets. However, it is also important that trials reflect realistic uncertainty about future stock status. The suggested revision has several consequences:

(1) It nearly eliminates the possibility of trials using any highly unrealistic combinations of MSYR and biological parameters whose values are separately reasonable. This beneficial effect can be seen in table 1 of SC/50/AWMP2.

(2) It makes the most extreme trials (B3 and B7) more extreme. SC/50/AWMP2, fig.1a, shows that the 90% pointwise trajectory limits for the proposed revised trials are nearly non-overlapping with those from the current trials. In each case, the degree of optimism or pessimism about the stock recovery rate is exaggerated by the switch to the proposed trials.

(3) It severely reduces the uncertainty inherent in each trial scenario. This occurs because few trajectories are compatible with a fixed value of MSYR, a 150-year history of heavy catches, and a precisely known current abundance. SC/50/AWMP2, fig.1a, shows that the pointwise 90% trajectory limits are much narrower for the proposed trials than for the current ones. SC/50/AWMP2, table 1 shows that the effect of the proposed conditioning can be to make very strong assumptions about biological parameters and stock

status. For example, the proposed B3 conditioning leads to a 95% interval for age-at-sexual-maturity of (14,15) compared to the marginal interval of (15,24), and the proposed B9 conditioning amounts to assuming that current mature female depletion is between 0.391 and 0.409. Although this reduced conditional uncertainty is proper given the model, we should recognise that the model is an imperfect tool. Given doubt about model validity, such a substantial reliance upon the model to reduce uncertainty is unwarranted.

It is difficult for the Committee, including myself, to resist focussing on boundary cases like the B3 and B7 trials when comparing alternatives. The combined effect of (2) and (3) would be to make such trials less plausible and more precisely posed. These are the sorts of trials which can lead to the selection of a poor management algorithm.

SC/50/AWMP2 clearly shows that something must be fixed to improve the realism of the trials, and I agree with the motivation for Punt's proposal. The current method for relating the biological parameters and MSYR was an approximation intended to retain healthy within-trial uncertainty. If the approximation is to be replaced with Punt's exact conditional method, other steps should be taken simultaneously to address the corresponding reduction in uncertainty, otherwise the cure may be worse than the disease.

Several techniques which might be used instead or in addition to Punt's approach including the following.

(a) Switch to trials that are less extreme with respect to MSYR. For example, the proposed revised B1 trial in SC/50/AWMP2 is less problematic.
(b) Adopt Punt's proposal, but simultaneously adopt wider ranges for the biological parameter distributions. This option is not likely to fix the problem by itself.
(c) Simulate the management stock beginning in a more recent year to eliminate the strong model parameter dependencies introduced by the historical catch data. This option ignores an important and reliable data source, and is not guaranteed to fix the problem.
(d) Switch from fixed values to narrow distributions for MSYR. Or, adopt a wholly integrative approach for MSYR, as is done for the biological parameters. The fully integrative approach would reduce all type 2 *Initial Exploration Trials* to a single trial. This option would reverse a decision made two years ago by the SWG, but that should not prevent us from choosing this option if it is preferred.
(e) Introduce simple stochasticity to the production model. In recent years the Aboriginal Subsistence sub-committee has considered the merits of such an approach for bowhead assessment. Perhaps the SWG should lead the way by agreeing preliminary specifications at this meeting. Such a revision to the current model would require modest coding time and Secretariat support. I do not see why the alteration need be too complex.

The intentions of the AWMP trial structure are not best met by extreme, over-precise scenarios. We should aim instead for plausible scenarios with an appropriate expression of uncertainty.