Annex E

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

Members: Donovan (Chair), Allison, Andersen, Archer, Baba, Bass, Bickham, Bjørge, Borodin, Brandao, Brandon, Breiwick, Butterworth, Childerhouse, Chilvers, Cipriano, Clark, Deimer-Schuette, DeMaster, Dueck, Edwards, Ettyne, Fernholm, Fortuna, Gallego, Galletti, Gedamke, George, Givens, Goodman, Goto, Gunnlaugsson, Hakamada, Hammond, Hatanaka, Hayashi, Heide-Jørgensen, Hester, Holloway, Huebinger, Hyugaji, Ilyashenko, Iñíguez, Ipatova, Jorde, Kell, Kitakado, Knoche, Kock, Laidre, Lawrence, Litovka, Lockyer, Lovell, Lyrholm, Marcondes, Martien, Mate, Meek, Melnikov, Miasnikov, Mikhno, Miller, C., Morin, Nakamura, Newell, Okada, Okamura, Ottoy, Palka, Pastene, Ponce, Postma, Punt, Rambally, Read, Robbins, Rosa, Schweder, Scordino, Simmonds, Skaug, Strbenac, Suydam, Taylor, Tichotsky, Van Waerebeek, Víkingsson, Wade, Walløe, Waples, Weinrich, Wiese, Winship, Witting, Yamakage, Yasokawa, Yatabe, Yoshida, Young, Zeh, Zelensky.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks
Donovan welcomed the participants.

1.2 Election of Chair
Donovan was elected Chair.

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

1.4 Adoption of Agenda
The adopted Agenda is shown as Appendix 1.

1.5 Documents available
The primary documents considered by the SWG were SC/59/AWMP2-8 and SC/59/Rep3-4.

2. B-C-B BOWHEAD WHALE *IMPLEMENTATION REVIEW*

2.1 Review of intersessional Workshops
2.1.1 2nd Intersessional Workshop – Chair's summary

Donovan introduced the report of the 2nd Intersessional Workshop held in Seattle in January 2007 (SC/59/Rep3). The primary focus of this Workshop was to finalise the stock structure hypotheses for the Bering-Chukchi-Beaufort (B-C-B) Seas bowhead whales and work towards incorporating these hypotheses into a final modelling framework. The Workshop benefited tremendously from the considerable effort that had been extended in field and laboratory work, and in analyses of genetic and other data related to stock structure. After extensive review of the information available to it at that time, including the nine hypotheses considered at the 1st Intersessional Workshop, the Workshop agreed to four hypotheses that it believed captured the broad biological hypotheses that are consistent with the major sources of information, and differ in ways that might affect the implications of different levels of aboriginal subsistence need (see Fig.1 at the end of this report; further details of the hypotheses can be found in the full specifications given as Appendix 2 to the present SWG report). It considered that these hypotheses are sufficient for the purposes of evaluating whether the *Bowhead Strike Limit Algorithm* (*SLA*[1]) is robust to uncertainty regarding stock structure. It did not consider the relative plausibility of the different hypotheses.

One of the most important tasks arising out of the stock structure hypotheses was the assignment of past catches to putative stocks or sub-stocks in accord with those hypotheses. The SWG began its consideration of that topic at the 2nd intersessional Workshop and completed it at the 3rd Workshop held in Copenhagen in March 2007 (SC/59/Rep4). It was greatly facilitated in its work by the provision of detailed historic catch data by Bockstoce and Botkin.

In terms of future genetic analyses, the Workshop agreed that unless there are exceptional circumstances, the agreed stock structure hypotheses would be used in the *Implementation Review* with the focus of any further genetic analyses being to assist in assessing the plausibility of the hypotheses. The Workshop also agreed that after the Annual Meeting, it will be valuable to develop guidelines for the use of genetic data in *Implementations* and *Implementation Reviews,* based *inter alia* on the valuable experience gained during the *Bowhead Whale Implementation Review*.

The Workshop also made progress with the use of AWMP-lite, conditioning, trial structure and performance statistics.

2.1.2 3rd Intersessional Workshop – Chair's summary

Donovan introduced the report of the 3rd Intersessional Workshop held in Copenhagen in March 2007 (SC/59/Rep4). This Workshop was a primarily technical workshop to complete the necessary outstanding tasks identified in SC/59/Rep3 (hereafter called the January workshop) to ensure that AWMP-lite could be successfully used to run an agreed set of trials by the 2007 Annual Meeting. One of the most important tasks of the Workshop was to finalise the catch and relative exposure matrices for the hypotheses agreed at the January Workshop. It was

[1] The algorithm that produces limits on strikes for the B-C-B bowhead whale stock.

agreed that matrices for each of five eras: 1848-68, 1869-88, 1889-1919, 1920-89, and 1990+ were required. Catches during the first two eras were almost exclusively by commercial whalers, but the distribution of whales among areas is assumed to have changed after 1868. The catches during the third era were made by both commercial and aboriginal subsistence whalers, which affects the temporal pattern of catches by area compared to the situation in the second era. The last two eras also differ in terms of the monthly split of the catches to area and season, although only aboriginal subsistence catches occurred during these two eras. Sensitivity to the matrices is addressed via the trial structure (see Table 1, Trials BE45, BE46 and BE49).

Developing these matrices was a complex and time-consuming piece of essential work and the Chair expressed his thanks to all those involved in developing the agreed matrices (for details see SC/59/Rep4, Annex D). The other major piece of work undertaken at the Workshop was the completion of AWMP-lite (use of this had been agreed at last year's Scientific Committee meeting) subject to final checking of the code. Again this represents a tremendous amount of work (so much so that 'lite' is a misnomer) and the Chair thanked Punt for his efforts, noting that without AWMP-lite, it would not be possible to complete the *Implementation Review* on time.

The Workshop also agreed: (1) that conditioning had been satisfactorily accomplished subject to final checking of the code; (2) the final trial structure (see Appendix 2 and Table 1); and (3) the format for examining results at the 2007 Annual Meeting.

2.1.3 Discussion

In discussion, the SWG thanked Donovan and the participants for their work in what was a very busy and productive intersessional period. It noted that the work involved in documenting the catch series for the B-C-B Seas bowhead whales had been a substantial undertaking, and that the summary of catches in Annex D of SC/59/Rep4 would provide the basis for assessments and management advice in the future. The SWG **endorsed** the recommendations of the January and March intersessional Workshops, including the hypotheses for consideration in trials and the final set of trials.

Allison reported that she had validated the latest version of AWMP-lite. The major changes to AWMP-lite since the March Workshop related to finalising the catch data used in AWMP-lite, modifying how the random numbers are generated so that results can be replicated, and modifying the code for the *Bowhead SLA* so that the first year for which the *Bowhead SLA* is used to determine *Strike Limits* is 2006. The SWG thanked Allison for completing this task, which was necessary in order to complete the *Bowhead Whale Implementation Review* at this year's meeting.

2.2 Review of results of runs agreed at the 3rd Intersessional Workshop

Based on the stock structure analyses, relative exposure matrices and previous examination of the performance of the *Bowhead SLA* during its development, the March Workshop developed a final list of trials (Table 1) that it agreed adequately covered uncertainty. It anticipated no need for further trials at the Annual Meeting unless these arose under discussions of new information in the sub-committee on bowhead, right and gray whales (BRG).

The SWG noted that the trials on which the *Bowhead Whale Implementation Review* is based do not include uncertainty regarding the biological parameters of the operating model nor initial population size. As a result, the inter-simulation variability in the values for the performance statistics is due to the impact of the observation error associated with the survey estimates of abundance. AWMP-lite is based on the 'best estimates' for the values for the parameters of the operating model; uncertainty in biological parameters is ignored because AWMP-lite is based on an age-aggregated rather than an age-structured model. The SWG agreed that ignoring parameter uncertainty associated with initial population size and biological parameters did not compromise its ability to evaluate the performance of the *Bowhead SLA* because the between-trial variability is larger than the impact of uncertainty in biological parameters and initial population size. The trials do examine the major source of parameter uncertainty, i.e. that relating to the value for the intrinsic rate of growth by conducting trials for $MSYR_{1+}$=1%, 2.5% and 4%.

Table 2 (at the end of this report) lists the values for the performance statistics selected during the 3rd Intersessional Workshop for all of the trials when the catch is determined using the *Bowhead SLA* and when it is set to need. These statistics include measures related to conservation performance and need satisfaction, as well as diagnostic statistics which assess the extent to which each trial is plausible (e.g. does not lead to implausibly small population sizes in the past and is able to mimic the observed rate of increase at Barrow).

The SWG noted that for most of the trials in Table 2, performance was fine, even when catch is set equal to need. Therefore the SWG used the information in Table 2 to focus on those few trials for which the conservation performance of the *Bowhead SLA* could potentially be poorer than desirable, i.e. those in which the final depletion is below 0.6*K* (where *K* = carrying capacity) and a reduction in population size occurs (i.e. a value for the relative increase statistic below 1). These are trials 9, 12-14 and 16. These trials, all of which are based on the assumption $MSYR_{1+}$=1%, were chosen based on the results when the catch equals the need, because this scenario leads to the greatest impact on population size (catch=need always leads to lower values for the final depletion and relative increase statistics than when the strike limit is based on the *Bowhead SLA*).

Appendix 3 summarises the performance of the *Bowhead SLA* for the selected 'difficult' trials (the full set of trial results will be archived by the Secretariat) as well as for the baseline trial (trial 1); the latter because performance for this trial is more reflective of the results for most trials. It shows time trajectories of: (a) future depletion (lower 5%iles and medians) relative to both carrying capacity and the population size in 2006; (b) 1+ population size from 1848 (median trajectories after 2006); and (c) need and catch (lower 5%iles and medians). Appendix 3 superimposes the results for the single-stock hypothesis (A) on those for the two two-stock hypotheses (B and D).

The SWG also noted that trials BE43 and BE44 examine sensitivity to the assumption underlying the baseline trial for stock hypothesis D that the sizes of the W and E stocks are the same at present; assuming the two stocks to be the same size today does not mean that their initial population sizes (and hence their current status relative to carrying capacity) were the same.

The SWG noted that the Committee has already agreed that the *Bowhead SLA* performs acceptably if the B-C-B bowhead whales constitute a single stock (IWC, 2003, p.22). It therefore focused on the difference between the performance statistics for the two-stock trials and those for

Table 1

The *Implementation Review trials* for bowhead whales. The survey frequency is 10 years; all trials are based on a deterministic model; no age data are generated; differences from the base-case are shown in **bold**. Note that apart from Trial BE49, reference to hypothesis 'B' in the column 'Baseline' is applicable to hypotheses 'B' and 'C'.

Trial No.	Description	$MSYR_{1+}$	z	Final need	Historical survey bias	Future survey bias	Survey CV (true, est)	Mixing parameter, γ	Baseline
BE01	Base case	2.5%	1.04	134	1	1	0.25, 0.25	0	A, B, D
BE02	Constant need	2.5%	1.04	**67**	1	1	0.25, 0.25	0	A, B, D
BE09	$MSYR_{1+}$ = 1%	**1%**	1.04	134	**0.67 → 1**	1	0.25, 0.25	0	A, B, D
BE10	$MSYR_{1+}$ = 4%	**4%**	**11.22**	134	1	1	0.25, 0.25	0	A, B, D
BE11	Bad data	2.5%	1.04	134	1	**1→1.5 in yr 25**	**0.25, 0.10**	0	A, B, D
BE12	Difficult 1%	**1%**	1.04	134	**1 → 1.5**	**1.5**	**0.25, 0.10**	0	A, B, D
BE13	Difficult 1%; constant need	**1%**	1.04	**67**	**1 → 1.5**	**1.5**	**0.25, 0.10**	0	A, B, D
BE14	Need increases to 201	2.5%	1.04	**201**	1	1	0.25, 0.25	0	A, B, D
BE16	$MSYR_{1+}$ = 1%; 201 need	**1%**	1.04	**201**	**0.67 → 1**	1	0.25, 0.25	0	A, B, D
BE20	$MSYR_{1+}$ = 4%; 201 need	**4%**	**11.22**	**201**	1	1	0.25, 0.25	0	A, B, D
BE41	Cape Pe'ek abundance=400	2.5%	1.04	134	1	1	0.25, 0.25	0	B
BE42	Cape Pe'ek abundance=1,300	2.5%	1.04	134	1	1	0.25, 0.25	0	B
BE43	Barrow Spring W:E ratio=40:60	2.5%	1.04	134	1	1	0.25, 0.25	0	D
BE44	Barrow Spring W:E ratio=60:40	2.5%	1.04	134	1	1	0.25, 0.25	0	D
BE45	Less different mixing	2.5%	1.04	134	1	1	0.25, 0.25	-0.25	B,D
BE46	More different mixing	2.5%	1.04	134	1	1	0.25, 0.25	0.25	B,D
BE47	Stocks have different *MSYR*	**1% (W)**, 2.5%(E)	1.04	134	1	1	0.25, 0.25	0	B
BE48	Stocks have different *MSYR*	**4% (W)**, 2.5%(E)	1.04	134	1	1	0.25, 0.25	0	B
BE49	Coast hugging stock	2.5%	1.04	134	1	1	0.25, 0.25	0	**C**

the equivalent single-stock trials. The only trials for which there may be slight questions regarding performance are those for which $MSYR_{1+}$=1%. The SWG noted that $MSYR_{1+}$=1% is assigned low posterior probability in recent assessments of the B-C-B bowhead stock (Brandon and Wade, 2006). Indeed, the only way it was possible to mimic the observed increasing trend at Barrow was to incorporate a linear increase in survey bias over the period 1978-2002 into trials with $MSYR_{1+}$=1%, for which there is no evidence. The SWG also noted that the *Bowhead SLA* did not impact the smaller W stock in trials based on hypothesis B and consequently the future time-trajectory of abundance for this stock hardly differed from the time-trajectory of abundance if there were no future catches from this stock.

The SWG focused on the results for the E stock when trial BE09 is based on stock structure hypothesis B because this is the case for which the difference between the relative increase for the E stock and that for the equivalent single stock trial was greatest. Although the relative increase for the E stock was below that expected if the *Bowhead SLA* was applied to a single stock, this could be explained because the two-stock trial begins with a higher 2006 abundance for the E-stock than the single-stock trial so the difference between the trials in the value for relative increase statistic was due to starting state and not ending state after 100 years of *SLA* management. Indeed, the final depletions are similar after 100 years of *SLA* management in the one- and two-stock cases.

2.3 Additional consideration of stock structure issues and possible additional trials

The Chair briefly summarised the discussions of stock structure that took place in the BRG sub-committee, noting that most members of the SWG had also attended those sessions. No new evidence was presented that indicated that the stock structure hypotheses agreed at the January Workshop insufficiently captured the plausible range. The SWG had not formally addressed the issue of relative plausibility in its discussions at the January Workshop and no formal consideration occurred during discussions within BRG. He had not requested discussion of that issue in view of the results of the trials which had revealed no management problems associated with any of the hypotheses. If anything, the discussions within BRG suggested that the two-stock scenarios are less plausible than seemed the case when they were developed. The SWG concurred with the Chair's conclusion that there was no need to consider any major new stock hypotheses in the trials.

However, the Chair noted that there was some discussion in the BRG sub-committee that was relevant to the sensitivity trials with respect to the split (in hypothesis D) of the present current population sizes of the putative E and W stocks at Barrow. He agreed that this could be discussed under this Item in the context of whether additional trials might be required, stressing the agreed view of the SWG that new trials would only be considered in the case of exceptional new information (SC/59/Rep3) and the long-term philosophy of the SWG that in taking uncertainty explicitly into account in its work, this should remain within plausible bounds when developing management advice. A quite extensive discussion ensued and a brief summary of that is given below.

Schweder referred to his view that the uncertainties identified with the reliability of *STRUCTURE* during the discussions in the BRG sub-committee questioned the assumption underlying the trials based on stock structure hypothesis D that the split of the current sizes of the two stocks could be reasonably assumed to lie between 40:60 and 60:40 (the results of *STRUCTURE* runs had indicated a 50:50 split). He also noted that a variable fraction of E and W whales present at Barrow in the spring and autumn from year to year might explain the 'Oslo bump'. He therefore believed that there was no justification for any particular split in the current population sizes and therefore requested that additional (more extreme) trials be conducted in which one of the stocks is at 5% and 10% of the total present abundance at Barrow. Other members noted that original motivation for stock hypothesis D included the results from *STRUCTURE* runs and the 'Oslo bump'. They argued that because *STRUCTURE* is now not considered very reliable for application to the B-C-B bowhead whales and because the 'Oslo bump' is no longer evident in the data, the plausibly for stock hypothesis D is now sufficiently small that conducting additional trials in which one of the stocks is a very small fraction of the total population size was inappropriate. It seemed inconsistent to use the results from *STRUCTURE* to provide justification for a hypothesis, but to reject the inference of the same results that implied an approximately even split. They also noted that attempts to replicate an 'Oslo bump' using simulations have been unsuccessful unless the stocks differ greatly genetically, regardless of their relative sizes (SC/59/Rep3).

In conclusion, the SWG noted: (1) its philosophy for agreeing trials referred to by the Chair above; (2) the conclusion that no major new information that was not available to the January Workshop had been presented to the BRG sub-committee; (3) the general view that two-stock scenarios are less plausible than seemed the case when they were developed. It agreed that there was no evidence to suggest that a scenario based on stock hypotheses D in which one of the two stocks is very small (5% or 10% of the total) should be considered as having anything other than very low plausibility, whilst noting that it was not impossible, although Schweder expressed his view that such low values for one stock were as plausible as the values agreed at the March Workshop. While not a scientific issue and thus one he was reluctant to raise, the Chair recalled that there had been considerable discussion of possible bowhead stock structure uncertainty at the Commission meeting last time the block quotas were proposed for renewal; this led to the unfortunate situation of the Scientific Committee's agreed advice being questioned. He therefore was reluctant to follow a course that might lead to a similar situation occurring unnecessarily. He therefore proposed that whilst the additional trials proposed should be run, it should be stressed that the SWG believed they were of very low plausibility and at best might be considered robustness trials. The results would not therefore change the management advice developed under Item 2.4, i.e. that the *Bowhead SLA* is the appropriate tool for providing management advice for the bowhead whale fisheries. In fact, on inspection of the results of these robustness trials (Table 3), the SWG agreed that they were satisfactory.

2.4 Management advice

The SWG **agreed** that the *Implementation Review* had been extremely thorough and it commended the efforts of all of the scientists involved in the process. It **strongly recommends** that the *Bowhead SLA* continues to be used to provide management advice.

3. GREENLANDIC FISHERIES AND THE GREENLAND RESEARCH PROGRAMME

3.1 Review of new information

The SWG welcomed the presentation of considerable new data and analyses this year resulting from ongoing efforts under the Greenland Research Programme. These efforts are critically important to enable progress toward development of AWMP *SLAs* and for provision of interim management advice.

3.1.1 Stock structure, range and movement

Last year, the possibility of obtaining a minimum estimate of abundance of common minke whales off West Greenland using genetic methods had been considered and an intersessional working group had been established to investigate this further. No progress was made during the intersessional period but the SWG **agreed** that the working group should continue to investigate this further. No new information on minke or fin whale stock structure was presented at this year's meeting. In 2006, samples from 133 minke whales were collected (130 from West Greenland and 3 from East Greenland). Samples from 6 West Greenland fin whales were also collected. Past examination of stock structure considerations for minke whales off West Greenland has focused on the extent to which minke whales in these areas are distinct from minke whales in other areas in the North Atlantic, whether there is evidence for sub-structuring within West Greenland, and whether animals available to hunters along the West Greenland coast constitute a small portion of a larger stock. This past work strongly supports the hypothesis that West Greenland minke whales constitute only a portion of a larger stock.

There was some discussion as to how much effort should be placed on analysing the more recently collected samples for west Greenlandic minke whales. Witting commented that there is no evidence for substock structure within the minke whales summering off West Greenland. The assessment methods based on sex ratio information have been designed to try to avoid the difficulties in determining what portion of the total population summers within the hunting grounds off West Greenland. Given this, and the expense involved in undertaking genetic analyses, he believed that it was wiser to wait until specific questions related to management were developed before analysing the new biological samples. While the SWG saw no reason to alter its view of minke stock structure and its prioritisation of the assessment efforts involving sex ratio information above stock structure investigations, some members felt that there was merit in analysing the available new genetic samples to assist in the *SLA* development process. It was noted that a decision on whether the sex ratio information is sufficient to provide management advice and to form the basis of an *SLA* should be taken next year. That would be an appropriate time to consider this issue further.

3.1.2 Catch distributions

3.1.2.1 COMMON MINKE WHALES

SC/59/AWMP3 provided an update of SC/M07/AWMP7 (Simon *et al*., 2007a), analysing the West Greenland catch data for minke whales from 1987 to 2006. The authors found a significant effect on the sex ratio of catch month and catch area. There seems to be a smaller fraction of females from December to February, a high fraction from March to May, and an intermediate female fraction from June to November. The fraction of females in the West Greenland catches also seems to be declining from the south to the north. No significant interaction between catch area and month was detected.

The SWG welcomed this paper which addressed some of the issues raised at the March Workshop. Discussion at this meeting continued to focus on those issues related to the use of the sex ratio data in assessment models and in particular on possible confounding between year and sex ratio. Available data show that the sex ratio of captures varies somewhat with latitude. If the relative hunting effort in different latitudes has varied over years, it is possible that the observed trend in the annual sex ratio time series may not accurately reflect the true sex ratio in West Greenland. SC/59/AWMP3 investigated dependencies between annual sex ratios and two variables: month and area (and their interaction). In discussion, it was **agreed** that a Generalised Linear Model (GLM) analysis should be used, treating month as a factor (rather than as a continuous predictor as had been done in the paper) and including also predictors of year and the interaction between year and area. This could permit detection of confounding of the sort that would give rise to concern. The results of this analysis are given in Appendix 4.

In summary, the analysis revealed:

(1) the proportion of females in the SW region (in the observed dataset) has declined as years progress; and
(2) sampling effort (for sexed whales in the dataset) has shifted northward as years progress.

Thus the proportion of females in the SW region has declined over time while, simultaneously, effort has shifted away from the SW. These two trends could offset each other, thereby yielding an apparently flat time series of sex ratios that does not fully reflect underlying demography. Efforts to resolve this in the context of the assessment process are thus accorded high priority.

Options for modifying the modelling and assessment approach to accommodate spatially dependent interannual trends in sex ratios were therefore discussed (see Appendix 4) and it was **agreed:**

(1) there should be stratification by area (SW and NW+CW) – NW and CW can be combined since they show no significant sex ratio differences; and
(2) there is no need to stratify by month.

In reaching these conclusions it was noted that only the most recent dataset from Greenland (1987-2006) had been examined. In this regard it was **agreed** that an intersessional group under Laidre (members: Allison, Larsen, Witting and Givens) will investigate:

(1) the Norwegian catches to determine if the data:
  (a) suggest a similar spatial division at about 63°N;
  (b) exhibit a similar Year:Region interaction; and
  (c) exhibit a lack of Year:Region and Month:Region interaction in the catch proportion data (Appendix 4, Fig. 1).

(2) the dataset from the first Greenland fishery period to determine:
  (a) if the data are of sufficient quality to investigate spatial division; and
  (b) if so, examine questions (a)-(c) above for the dataset.

It was noted that population modelling will be simpler if the same stratification is appropriate for all three periods. To the extent possible, the above work should take into account the uncertainty implicit in having animals of unknown sex. It will also be valuable to receive information on when regional quota agreements were in force and what they were.

3.1.2.2 FIN WHALES

SC/59/AWMP2 provided an update of SC/M07/AWMP3 (Simon *et al*., 2007b), presented at the Copenhagen workshop, analysing the West Greenland catch data for fin whales from 1987 to 2006. More females than males had been caught over the years, although the sex ratio was not significantly different from 1:1. However, there was a significantly higher number of years where more females than males had been caught. There were also no significant differences in the distribution of catches of males and females in relation to latitude or time of the year. The SWG **welcomed** this paper.

3.1.3 Abundance and trends

AUTHORS' SUMMARY

Results from an aerial line transect and cue counting survey of large whales in West Greenland conducted in August and September 2005 were presented (SC/59/AWMP7 and SC/59/AWMP9). Three issues were raised at the 2006 meeting that would require further analysis of the survey results: (1) cue counting estimates of fin whale abundance based on small groups only; (2) corrections for perception bias; and (3) examination of the effects of measurement errors. The authors responded to these in the following manner.

(1) Cue-counting methods were applied to estimate the abundance of solitary fin whales and to compare with line transect abundance of solitary fin whales. Using a cue rate of 50 cues per hour (Heide-Jørgensen and Simon, 2007), a cue counting abundance estimate of 8,889 (n=50, CV=0.68) solitary fin whales was achieved. This estimate is ~10 times bigger than a similar line transect calculated solely for solitary fin whales (719, CV=0.40). However, the detection function fitted to the observed radial distance distribution in the cue counting estimate showed a somewhat unrealistic rapid drop off close to the origin and cue counting estimates were not developed any further for fin whales.
(2) New estimates including corrections for perception bias were developed for fin and minke whales. Sightings from the right side of the plane (where there were two independent observers) were used to estimate perception bias ($g(0)$). Conditional detection functions for each observer (conditional on detection by the other observer) were estimated using iterative logistic regression. Models were selected using Akaike Information Criterion (AIC) and a model with radial distance and observer (and Beaufort Sea State for minke whales) as explanatory variables was found to be best on this basis.

For the fin whale, after truncating at 2.5km there remained 27 detections by the rear observer, 20 by the front observer and 6 duplicates. The probability of detecting a whale on the trackline was estimated to be 0.34 (CV=0.29) for the rear observer, 0.26 (CV=0.32) for the front observer and 0.51 (CV=0.21) for both observers combined. Total fin whale abundance was estimated to be 1,652 animals (CV=0.37) and log-based 95% confidence interval (CI) (811-3,367) and log-based 90% CI (910-3,000). Correction for perception bias resulted in an abundance estimate of 3,218 animals (CV=0.43; 95% CI=1,431-7,240; 90% CI=1,630-6,355). This point estimate of abundance is negatively biased because no correction was applied for availability bias; also, the $g(0)$ for the left side of the aircraft is likely to be lower than the combined $g(0)$ for the right side – because the left side had only one observer.

For the common minke whale the probability of detecting a cue at distance 0.2km was estimated to be 0.36 (CV=0.39) for the rear observer, 0.22 (CV=0.42) for the front observer and 0.45 (CV=0.33) for both observers combined. The sample size was 21 detections by the rear observer, 11 by the front observer, with 4 duplicates. Cue densities were converted to animal densities by dividing by an estimated cue rate of 46.3 cues per hour (CV=10.6). If detection at distance 0.2km is assumed to be certain, total minke whale abundance is estimated to be 4,856 animals (CV=0.49) and log-based 95% CI (1,910-12,348) and log-based 90% CI (2,219-10,628). If detection at distance 0.2km is estimated as above, total minke whale abundance is estimated to be 10,792 animals (CV=0.59; 95% CI=3,594-32,407; 90% CI=4,289-27,156). In obtaining this estimate it is assumed that the observer on the left side of the aircraft has the same probability of detecting a cue at 0.2km as the two observers on the right side of the plane.

(3) The sample size of four minke whale cues detected by both front and rear observers in the right side of plane is too small to estimate the distance measurement error process reliably. However, comparison of measurement of cues from both minke and fin whales suggest that the difference in measurement error between the two platforms within about 1.5km is negligible and it was not attempted to incorporate distance measurement error in the abundance estimation. The level of distance 'binning' used in analysis should make the line transect estimates of fin whale abundance insensitive to both the small errors there appear to be at distances less than 1.5km and the more substantial errors at larger distances. The apparent lack of substantial errors at smaller distances indicates that little, if anything, would be gained by incorporating a measurement error model in estimation.

DISCUSSION

The SWG welcomed this additional analysis of the results presented last year which attempted to correct for known survey biases and was produced in response to comments from the SWG. In discussion, it was noted that the survey had been designed to run from the south towards the north, but poor weather in the southern areas during the first period of the survey resulted in the northern areas being surveyed earlier than the southern areas. It was noted that this could bias abundance estimates upwards if the survey effort followed whale migration. However, the authors commented that the survey had been completed in a relatively short time and that this was not during the peak in the migration period. In their view this concern was unwarranted.

With respect to West Greenland minke whales, the SWG **agreed** that the bias-corrected cue-counting abundance estimate of 10,800 whales in 2005 (95% CI=3,600-32,400) was acceptable and could be used for assessment purposes. It was noted that the confidence intervals were very wide and that this in part was due to the fact that the estimated perception bias adjustment was based on only four duplicate observations and was thus highly uncertain, as well as the fact that the CV on the cue rates was high. The uncorrected estimate was 4,900 (95% CI=1,900-12,400). SC/59/AWMP7 documented a number of reasons why the estimate might remain negatively biased. The SWG recognised that a better perception bias adjustment should be obtained in future years as more data become available and that this should reduce the CV of the estimate.

For West Greenland fin whales, the SWG **agreed** that the bias-corrected line-transect abundance estimate of 3,200 whales in 2005 (95% CI=1,400-7,200) was acceptable and could be used for assessment purposes. The uncorrected estimate was 1,700 (95% CI=800-3,400). Similar caveats to those above also apply to this estimate. In particular, the potential negative bias in the agreed estimate was believed to be more substantial than for common minke whales because there was no adjustment for availability bias. The perception bias adjustment was based on only six duplicates and again a better perception bias adjustment should be obtained in future years as more data become available.

3.1.4 Progress with the development of management procedures

No direct progress on this issue was reported since recent efforts have focussed on obtaining satisfactory assessment methods (see Item 4.2). However, the SWG **re-emphasises** the importance it attaches to developing satisfactory *SLAs* for the Greenlandic fisheries as soon as possible, so that it can provide robust long-term management advice. The multispecies nature of the fishery will form part of any considerations of *SLAs*.

4. MANAGEMENT ADVICE FOR MINKE AND FIN WHALES OFF WEST GREENLAND

4.1 Catch data and biological sampling

SC/59/ProgRepDenmark reported the following catch information for 2006. East Greenland: 2 common minke whales (2 males; 0 females; 1 struck and lost); West Greenland: 175 common minke whales (43 males; 128 females; 4 unidentified sex; 6 struck and lost) and 9 fin whales (2 males; 6 females; 1 struck and lost; 1 unidentified sex). Information on biological sampling is considered under Item 3.1.1.

4.2 Assessment

4.2.1 Common minke whales off West Greenland

SC/59/AWMP6 used the sex ratio in the catch history of the common minke whale off West Greenland to assess the current status of the population that supplies the West Greenland hunt. The female fraction in common minke whale foetuses is around 1/2, but the fraction in the West Greenland catch has varied around 3/4 since the beginning of the hunt in 1948. This difference most likely reflects sex specific behaviour, where females tend to occur in other areas than males. Using a frequentist statistical approach, discrete and age-structured population dynamic models with density regulation were fit to the sex ratios in the historical catches under the assumption of five different patterns of age-structured migration. The authors concluded that only two migration models are plausible, i.e. a flat migration pattern where individuals in all age classes are equally likely to migrate to West Greenland, or a migration pattern where it is predominately the mature individuals that migrate to West Greenland. By including abundance estimates from aerial surveys off West Greenland in the model fitting, the precision of the estimated population status was improved. Using an $MSYR_{(1+)}$ of 0.04 for the most likely migration model, where predominately mature individuals migrate to West Greenland, the authors estimated a carrying capacity of 19,000 whales with a lower 95% confidence limit (LCL) of 13,900, a current abundance of 16,200 (LCL:9,600) and a current depletion ratio of 0.85 (LCL:0.69). The parameters of the assessment model are adult survival, juvenile survival, age of reproductive maturity, reproductive rate for mature females, $MSYR_{(1+)}$, $MSYL_{(1+)}$, the ratio of the migration rate of females to that for males for each fishery separately, age-specific migration rates, and the fraction of the West Greenland aggregation that is targeted by surveys off West Greenland.

The SWG welcomed the presentation of this paper which built upon the valuable discussions held at the March Workshop (SC/59/Rep4). There was considerable discussion of the method which is complex, with the focus of those discussions being on whether the method itself can be used to provide an acceptable assessment that is able to obtain estimates of the lower 5th percentile (5%ile) for quantities of management relevance. Issues surrounding the sex ratio data themselves and the future work required are given under Item 3.1.2.

The simulations and assessment analyses in SC/59/AWMP6 do not use a profile likelihood function for *K* (carrying capacity) maximised over the 'nuisance' parameters but rather a conditional likelihood function for *K*, given the specific values for these parameters. Some concern was expressed at conditioning on $MSYR_{(1+)}$ since assessment results (understandably) are very sensitive to the choice for this parameter. It was noted that $MSYR_{(1+)}$ could be treated as a second parameter in a profile likelihood (along with *K*) or some sort of integration with respect to $MSYR_{(1+)}$, to average over the uncertainty, could be performed.

In response to a query, the authors of SC/59/AWMP6 also noted that they had found some disconnected confidence sets for the model that applied both the sex ratio and the abundance data. Such disconnected confidence sets had been a matter of concern raised at the March Workshop (SC/59/Rep4) because they meant that the correct determination of quantiles of the likelihood function was unclear. Reliable estimation of these quantiles is essential for assessment. No estimate of the frequency of such problems in the current analyses was provided and it was **agreed** that this should be considered further at the proposed intersessional workshop (see Item 10).

SC/59/AWMP8 presented an alternative assessment of West Greenland minke whales, again based on sex ratio data. This was a development of work previously presented to the SWG (Brandao and Butterworth, 2006). The approach is to estimate a lower confidence limit on the size of the West Greenland minke whale population by taking account of the continuing sex bias in the catch data. The lower 5%ile estimated for the pre-exploitation size of the population (*K*) is in the range of 25,000–35,000 animals, depending on assumptions made about intrinsic population growth rate and the extent to which Greenland operations have remained comparable over time. However, a simulation test of the method suggests that it provides positively biased estimates of this lower 5%ile, with the true value for the specific case investigated being some 17,000 rather than 27,000.

The SWG also welcomed this paper and found it valuable to compare the methods used in SC/59/AWMP6 and SC/59/AWMP8.

Discussion focussed on four possible differences in approach:

(1) the method for determining the values for the nuisance parameters when generating simulated catch data;
(2) the method for obtaining a likelihood profile from the simulated data;
(3) distributional assumptions made in fitting the models; and
(4) the method for generating the sex distribution of the simulated catches with regard to variability due to partial sampling of sex information for many of the early catches.

With regard to (1), both papers had estimated nuisance parameters from the best fitting (high *K*) model for this purpose and it was **agreed** that this was the best approach.

With regard to (2), however, the approaches differed as follows:

(a) SC/59/AWMP8 treated the simulated data sets exactly like the original data by estimating all nuisance parameters separately for each simulated dataset, conditional on the *K* value under consideration, when calculating likelihoods; and
(b) SC/59/AWMP6 did not re-estimate all nuisance parameters from each simulated dataset.

The SWG **agreed** that the approach used in SC/59/AWMP8 was preferable.

With regard to (3), although there were differences in approach, it was agreed that these were unlikely to make much difference in the results. SC/59/AWMP8 had assumed that the observed number of females caught each year is distributed about the expected number according to a normal distribution with variance proportional to this expectation, with the intent of approximating a Poisson-like process. The authors estimated the coefficient of proportionality ('overdispersion') separately for each of the three periods/fishery types. By contrast, SC/59/AWMP6 had assumed log-normally distributed errors in the sex ratio.

With regard to (4), the differences in the approaches of the two papers could make non-negligible differences in the results.

SC/59/AWMP8 assumed that the total annual reported catches as well as the total annual catches for each of the periods/fishery types were as known in the generation process. It then proceeded as follows.

(1) If there were Norwegian catches in the period for which data were being generated, the split of the total Norwegian catch into males and females was made by using the sex selectivity parameter estimated from the original data with Poisson-like variability as estimated for that fishery added.
(2) The remainder of the total catch not attributed to the Norwegians was then split into males and females using the estimated sex selectivity parameter for the Greenlandic period in question or the first Greenlandic period if no Greenlandic catches are available for that period, again with Poisson-like variability for the fishery added.
(3) If there was an associated Greenlandic catch for the period, then the male and female catches generated were sampled without replacement (and with autocorrelation for the first Greenlandic period) to generate the sub-sample of the Greenlandic catches which were sexed.

By contrast, for data based trajectories SC/59/AWMP6 used the catch sex ratio of the three fisheries and the total catch (tables 1 and 2 of SC/59/AWMP6). For generated data sets, the sex ratio of the total catch from 1948 to 1954, where there was no reporting of sex, was again given by table 2 of the paper. The generated sex ratios of the three fisheries for the periods 1955-78 (Greenland), 1985-2006 (Greenland), and 1968-85 (Norway) were calculated using the expectation of the trial (equation 14 in SC/59/AWMP6 given sex biased migration estimated from the original data) with Monte Carlo simulated variation on the log of the sex ratio (variation determined separately for each fishery from the original data of that fishery assuming an infinite abundance), with the reported sex ratio of a fishery being identical to the sex ratio of that fishery.

In the time available, the SWG was not able to determine which, if either, approach was preferable and it refers this issue to the proposed intersessional workshop (see Item 10).

In conclusion, the SWG **welcomed** the considerable progress on assessment methods made at the March Workshop and at the present meeting. However, the SWG was not yet in a position to accept an agreed assessment for this stock at this meeting, although it recognised that substantial progress had been made in agreeing the statistical basis for using sex ratio data in assessments. This conclusion was based on the complexities of the assessment methods proposed and the questions remaining about aspects of the modelling approaches presented as well as the data themselves. The SWG therefore **strongly recommends** that an intersessional workshop be held to make progress on West Greenland minke assessment with the goal of being in a position to accept a final assessment at the 2008 annual meeting. It notes that to obtain comparable results from the two approaches, fixed values of $MSYR_{(1+)}$ (1%, 2.5% and 4%) should be considered, notwithstanding efforts to handle $MSYR_{(1+)}$ in a more integrated manner.

4.2.2 Fin whales off West Greenland

SC/59/AWMP4 updated the SC/M07/AWMP4 (Witting, 2007a) assessment paper for fin whales off West Greenland using discrete population dynamics models with exponential, density regulated, and inertia dynamics. Models were fit to different combinations of the 1988 estimate, the perception bias corrected estimate for 2005, and the uncorrected estimate for 2005. The abundance data were generally unable to reveal the underlying dynamics, with the most reasonable and somewhat conservative models being those that were fitted to the 1988 and the uncorrected 2005 estimate, with the perception bias of the 2005 survey being incorporated as a prior in the assessment model. For this case with an informative log normal prior on $MSYR_{(1+)}$, the density regulated model suggested that fin whales off West Greenland have recovered to a current depletion of 90% (90% CI=75%-97%), with the Q_1 estimate (see Wade and Givens, 1997) for sustainable harvest being 26 whales per year (95% CI=14-55). The exponential model suggested an intrinsic annual growth rate of 2% (95% CI=-2%-7%).

The SWG welcomed this paper which had benefited from discussions at the March Workshop. In discussion, the choice of harmonic mean estimator for the Bayes Factor used for model comparison was questioned. A more reliable (arithmetic mean) estimator based directly on the Monte Carlo results was suggested for future use. It was also agreed that it was not appropriate to compare models fit to different data using the Bayes Factor. However, the SWG **agreed** that effective model selection could be done informally at the present meeting, and thus Bayes Factor considerations would not prevent the use of the method at this meeting. The SWG was pleased to conclude that the analyses presented in SC/59/AWMP4 were acceptable for formulating interim management advice. It noted that this is the first time that an acceptable assessment method has been developed for this stock.

It was **agreed** that the 'D' model of SC/59/AWMP4 was the most appropriate upon which to base such advice. This model uses the 1988 abundance estimate of 1,100 (CV=0.35), the uncorrected recalculated abundance estimate of 1,652 (CV=0.37) for 2005, and a beta distributed abundance bias with mean=0.51 and CV=0.21 as given by the detection probabilities of the 2005 aerial survey. It uses the standard density dependent population model for consistency with previous practice in the Scientific Committee. The population productivity value underlying the Q_1 estimate is not based on data for the population itself but is primarily informed by either the pre-specified value for $MSYR_{(1+)}$ or the prior distribution for $MSYR_{(1+)}$.

Table 4 presents the posterior median and 90% intervals for *d*, the current depletion (population size relative to the pre-exploitation level) and Q_1 (as defined by Wade and Givens, 1997). Since the 1+ abundance is estimated to be above *MSYL* (the lower 5%-iles for population exceed *MSYL*), Q_1 represents 90% of the estimated MSY. Results are presented for two assumptions for $MSYR_{(1+)}$: a lognormal prior from the East Greenland-Iceland (EGI) fin whale stock from Branch and Butterworth (2006) which reflects a median estimate of about 1.5%; and 1% which is the lower bound of the plausible range used for recent AWMP trials.

In presenting these results, the SWG noted that given that the abundance data available for the population are limited, a number of different models would be consistent with these data. Nevertheless, the degree of safety associated with the Q_1 values can be judged by the fact that 1% of the lower 5%ile of the best estimate of abundance of 3,200 (1,600-6,400) for 2005 is 16.

Table 4

Q_1 (see text) and depletion median estimates with 90% credibility intervals in parentheses for two assumptions about productivity.

MSYR values	Q_1	Depletion
Lognormal prior	26 [14; 55]	0.90 [0.75; 0.97]
1%	19 [13; 30]	0.85 [0.71; 0.93]

4.3 Management advice

4.3.1 Introduction

As it has stated on many occasions, the Committee has never been able to provide satisfactory management advice for either the fin or common minke whales off West Greenland. This reflects the lack of information on stock structure and abundance, and the absence of appropriate assessments. It has viewed this matter with great concern and was the primary reason the Committee first called for the Greenland Research Programme in 1998.

The present catch limits set by the Commission are up to 175 common minke whales struck in each year for the period 2003-07 with a provision that up to 15 strikes may be carried over from one year to the next and a catch of up to 19 fin whales each year. New catch and strike limits are due this year.

4.3.2 Common minke whales off West Greenland

The SWG stresses that it is in a **considerably stronger position** than it has been in recent years in terms of being able to provide management advice for this stock. In particular, it has accepted a new abundance estimate from the 2005 aerial survey. That estimate is 10,800 with 95% CI=3,600-32,400 (see Item 3.1.3). In addition, considerable progress was made at the March Workshop (SC/59/Rep4) and at the present meeting on developing an assessment method incorporating the available sex ratio data. The SWG plans to hold an intersessional Workshop so that at the 2008 Annual Meeting it will be possible to make a final recommendation on whether this method can be used to give management advice in the short (5-year) term and if so, to provide that advice. Should this work prove successful, it would open the door to beginning development of a full *SLA* approach for providing long-term advice.

The new abundance estimate is not significantly different to the 1993 estimate accepted by the Committee, although the power to detect differences is low. Questions about stock structure remain. Although the survey estimate does not apply to the whole population available (*inter alia* given the consistent strong female bias in the catches), it is not presently possible to determine by how much. This issue will be addressed should the proposed assessment method prove to be applicable next year. However, despite the great improvement in the situation compared to previous years, the Committee remains **concerned** that it is not in a position to give authoritative advice on safe catch limits this year. Given that, it **agreed** that it was not possible for it to give more than interim *ad hoc* advice for the forthcoming season, noting that it believed that there was a reasonable chance that it would be in a position to provide advice at the 5-year block timescale next year. Therefore, the SWG **recommended** that any quota established by the Commission on the basis of the interim *ad hoc* advice below be limited to one year only.

While the SWG does not feel in a position to recommend a single number, it offers the following advice to the Commission: under the assumption that (a) $MSYR_{mat}$ is 3%[2]; (b) that the true population has a sex ratio of 1:1; and (c) that the population is underestimated by factors between 2 and 2.7[3], the estimated annual replacement yield ranges from about 170 to 230 whales if the lower 5% bound of the revised 2005 aerial survey estimate is used.

The SWG agreed that **the Commission should exercise caution** when setting catch limits for this stock. It emphasised its **strong recommendation** that safe management of aboriginal whaling is best accomplished under an agreed AWMP *SLA*. It therefore **agreed** that development of an *SLA* for this fishery begin as soon as practical.

Finally, the SWG noted that new aerial and shipboard surveys will be undertaken in summer and autumn 2008 as part of the extensive T-NASS survey endorsed by the Committee last year and it expects new abundance estimates to be provided at that time.

4.3.3 Fin whales off West Greenland

The SWG welcomed the new agreed abundance estimate for this stock and the new agreed assessment method. The assessment results suggest that this fin whale stock is above its *MSYL* - perhaps considerably above it. The SWG therefore believed that it was able to provide interim management advice for this stock for the 5-year block period.

While the SWG did not feel in a position to recommend a single strike limit, it offered the following advice to the Commission: depending on assumptions about productivity, the estimated posterior median for Q_1 varies between 19 and 26 while the lower 5% credibility values are 13 and 14.

The SWG also noted that given that the abundance data available for the population are limited, a number of different models would be consistent with these data. Nevertheless, the degree of safety associated with the Q_1 values can be judged by the fact that 1% of the lower 5%ile of the best estimate of abundance of 3,220 (1,630-6,355) for 2005 is 16.

Although the SWG was pleased to be in a position to provide this interim advice, it **emphasised** that safe long-term management of aboriginal whaling is best accomplished under an agreed AWMP *SLA*. It therefore **agreed** that development of an *SLA* for this fishery should begin immediately.

[2] The Committee has elsewhere suggested that the likely value for common minke whales lies towards the upper end of the range 1-4% (IWC, 2004, p.10).

[3] Although not accepted as appropriate to use to provide management advice at this meeting, the value of 2.7 is broadly compatible with the results of the methods that attempted to use sex ratio information to obtain a lower bound for the total population abundance.

5. REQUEST FOR MANAGEMENT ADVICE FOR OTHER LARGE WHALES OFF WEST GREENLAND

The Chair reminded the SWG that this had been included on the Agenda in response to a request made at the last Commission meeting by Denmark. The Danish Commissioner had stated that:

> 'Bearing in mind that the absence of scientific knowledge on minke and fin whale stocks could lead to a reduction in quota of large whales, Denmark indicated that on behalf of Greenland, it would like to request the Scientific Committee to evaluate the situation regarding other large whales off West Greenland. In particular, it was seeking advice on the viability of obtaining the missing 220 tons of meat from catches of other species of large whale such as bowheads and humpbacks. It was noted that these two species have been caught by Greenland in the past and that there are signs that the West Greenland stocks are increasing and that they could sustain a small and well-regulated catch.' (IWC, 2007, p.20).

5.1 Humpback whales

5.1.1 Review of available information

5.1.1.1 STOCK STRUCTURE, FEEDING, AGGREGATIONS AND MOVEMENTS

On the basis of past evidence considered by the Committee over many years, and in particular the in-depth assessment completed in IWC (2002, pp.39-44; 2003, pp.44-46), the SWG **agreed** that the humpback whales found off West Greenland belong to a separate feeding aggregation whose members mix on the breeding grounds in the West Indies with individuals from other similar feeding aggregations.

The SWG further **agreed** that this West Greenland feeding aggregation was the appropriate management unit to consider when formulating management advice.

5.1.1.2 ABUNDANCE AND TRENDS

SC/59/AWMP7 presented the results of an aerial survey of large whales off West Greenland conducted in August and September 2005. Information on fin and common minke whales was considered under Item 3. The survey covered the area between Cape Farewell and Disko Island on the West Greenland coast out to the 200m depth contour and there were 21 sightings of humpback whales. The mean group size of humpback whales was 3.30 but groups as large as 95 animals were seen. Humpback whales were found both in offshore and coastal areas of West Greenland with the exception of Store Hellefiske Bank and the Cape Farewell offshore area. The line transect abundance estimate of humpback whales is 1,218 (CV=0.56; 95%CI=423-3,508), uncorrected for availability and perception bias.

In discussion, there were a number of comments about the estimate presented. Some members questioned whether the standard line transect analysis presented here was the most appropriate method for animals exhibiting such a high degree of spatial clustering and with several incidences of very large (e.g. in one case, 95) estimated school sizes. A number of clarifications were made with respect to how group size was estimated, the experience of the observers concerned and whether additional data on 'sub-groups' and the area covered by large schools were collected. The details are not included here. The SWG agreed that there was merit in examining whether methods could be developed to better estimate abundance from such surveys of highly clustered animals that may occur in very large aggregations, although it was recognised that the method used in SC/59/AWMP7 was generally accepted.

Several members commented that they were surprised at the resulting abundance estimate because the point estimate of abundance was considerably larger than what they expected in comparison with past estimates such as those obtained from mark-recapture estimates in the early 1990s (e.g. Larsen and Hammond, 2004). However, the SWG noted that the estimates were not significantly different at the 5% level and **agreed** that the difference in estimates did not imply infeasible increase rates when confidence intervals were taken into account. Laidre commented that tracking data showing that 1 of 5 tagged animals crossed Baffin Bay (Dietz *et al*., 2002) suggested that some variation in abundance may be attributable to movement of individuals and that the results showed that humpback whales covered a wider area than simply the areas previously surveyed.

In conclusion, the SWG **agreed** that the estimate in SC/59/AWMP7 is an underestimate in so far as it does not correct for perception or availability bias. It was unclear whether investigations to develop methods better suited to highly clumped, large school size animals might result in positive or negative bias. Whilst welcoming this estimate, some of the concerns expressed about the analysis methods prevented the SWG from endorsing this estimate for use in assessment or management at this meeting. Noting the substantial negative biases in the estimate, however, the SWG **agreed** that the new data suggested that West Greenland humpback whale abundance was probably higher than previously believed. The SWG also noted that there would be shipboard and aerial surveys off West Greenland this summer and looked forward to receiving abundance estimates for humpback whales next year. Some members suggested that there was value in considering further photo-identification work with a view to updating the existing mark-recapture estimates.

The SWG briefly reviewed past abundance estimates for West Greenland humpback whales, particularly in the context of the assessment of SC/59/AWMP5 (see Item 5.1.1.3), which used several of these estimates and omitted several others. Some past estimates had been agreed by the Scientific Committee, while others had not. The SWG **agreed** to establish an intersessional correspondence group consisting of Hammond (Convenor), Heide-Jørgensen, Witting and Larsen, to determine the best collection of abundance estimates to use for future assessments. This group should report to the planned intersessional workshop on Greenlandic assessments.

5.1.1.3 ASSESSMENT METHODS

SC/59/AWMP5 updated the SC/M07/AWMP5 (Witting, 2007b) assessment paper for humpback whales off West Greenland using discrete population dynamics models with exponential, density regulated, and inertia dynamics. To account for uncertainty in the catch history, separate trajectories were made with 0, 5 and 10% of the West Indies catches allocated to the West Greenland summer aggregation. Using the abundance estimates agreed at an earlier IWC assessment of North Atlantic humpback whales, the best estimate for the abundance in 2005, and 5% of the West Indies catches allocated to West Greenland, the density regulated model suggested that humpback whales off West Greenland have recovered to 37% (95% CI=25%-65%) of the carrying capacity, with the Q_1-estimate for sustainable harvest being eight whales per year (95% CI=5-15). The exponential model suggested an annual growth rate of 4% (95% CI=0%-10%).

In discussion, the SWG noted its earlier agreement that the best collection of abundance estimates to use for assessment purposes would be a question addressed by the intersessional correspondence group and the proposed intersessional workshop. It was noted that the model used in SC/59/AWMP5 was essentially the same as that used for fin whales discussed earlier.

One issue that resulted in considerable discussion was how best to account for the fact that the humpback whales off West Greenland have been caught and surveyed in the West Indies. Some members believed that the approach used in SC/59/AWMP5 was satisfactory, referring to the case of Eastern North Pacific Gray whales which – although not entirely analogous – represented another instance where potential disagreement between historical whaling data on breeding grounds and current abundance/trend data on feeding grounds has been addressed through simplified models and adjustments rather than via complex spatio-temporal modelling of breeding and feeding aggregations. In the West Greenland humpback whale case, the exponential growth model in SC/59/AWMP5 was somewhat akin to the approach favoured for the gray whale. These members also noted that the lower fifth percentile of the Q_1 was quite insensitive to choices of 5%, 7% and 10% as the fraction of West Indies historical harvest allocated to the West Greenland feeding aggregation.

Other members believed that an isolated analysis of the West Greenland feeding aggregation was too simplistic. They believed that the dynamics of the various feeding aggregations needed to be modelled along with the historic harvest for the West Indies breeding population which was shown to be difficult to do during the in-depth assessment. This source of model uncertainty is ignored in the approach of SC/59/AWMP5. They also noted that the application of an exponential model to the humpback whale data led to extremely uncertain results (e.g. RY ranging from 1.3 to 170 for model E_A).

After discussion, the SWG **concluded** that it was not in a position to agree upon an assessment at this meeting. The assessment of these whales is complex and merits more careful consideration than could be given in the time available at this meeting. Furthermore, despite the similarities of the proposed assessment method to the method agreed for West Greenland fin whales, the situation is rather different because current depletion is sensitive to assumptions regarding historical catches in the West Indies (posterior median 29-97%) for a range from 0-10% catch allocation (table 4 of SC/59/AWMP5). Therefore, greater confidence in the assessment is required before using it to formulate management advice. The SWG referred West Greenland humpback assessment methodological development to the proposed intersessional workshop. Two specific questions addressed by this Workshop should be the selection of abundance estimates to use in assessment and the appropriateness or otherwise of conducting an assessment on the West Greenland feeding aggregation on its own.

5.1.2 Management advice

The SWG agreed that it was unable to respond to the request for management advice at this time. The large abundance estimate discussed – but not fully endorsed – in Item 5.1.1.2 was a source of both encouragement and concern. Concern over the consistency of this estimate with previous ones is one reason for the SWG to proceed cautiously. On the other hand, the lower confidence bound for abundance would be one which, if endorsed after future study, might permit formulation of *ad hoc* interim management advice.

The SWG notes that it may receive new abundance estimates at the next Annual Meeting. It also notes that there will be time for a more detailed examination of assessment methods at the proposed intersessional workshop. It therefore **agreed** that it should be in a better position to provide such advice at the next Annual Meeting.

The SWG also referred to the general difficulty surrounding the provision of *ad hoc* interim advice on catch limits. It draws the Commission's attention to its view that it is inappropriate to provide such advice for long time periods. The appropriate way to provide such advice is through the development of *SLAs* that have been thoroughly tested for robustness to uncertainty and have been agreed can meet the Commission's stated long-term management objectives.

5.2 Bowhead whales off West Greenland

5.2.1 Review of available information

5.2.1.1 STOCK STRUCTURE AND MOVEMENTS

The SWG noted the discussions in the BRG sub-committee regarding stock structure of bowhead whales off West Greenland. In particular, that sub-committee had concluded that a single shared Canada-Greenland stock in the eastern Arctic should be recognised as the working hypothesis. It had further recommended that a thorough discussion of stock structure, including comprehensive analyses of genetic data, should occur at the next Annual Meeting. The SWG concurred with this.

5.2.1.2 ABUNDANCE AND TRENDS

The SWG noted the discussions in the BRG sub-committee regarding the results of a 2006 dedicated sighting survey for bowhead whales off west Greenland. That sub-committee had concluded that this survey was properly conducted and it had accepted the abundance estimate of 1,230 bowhead whales (95% CI=500-2,940; 90% CI=570-2,550) in the survey area. The SWG noted that this estimate does not reflect the total population size of the Canada-Greenland stock, but only the animals present in West Greenland in the winter.

5.2.1.3 CATCHES

The SWG noted that there have been a very small number of takes by Canadian hunters from this putative Canada-Greenland stock of bowhead whales.

5.2.1.4 ASSESSMENT METHODS

No assessment or proposed method of assessment of these whales was presented.

5.2.2 Management advice

The SWG **emphasised** that no assessment of this putative stock has been undertaken. The new abundance estimate of whales wintering off West Greenland could form the basis of *ad hoc* interim advice as the Committee has in the past provided advice based on 1% of the lower confidence interval of the abundance estimate. For the present estimate that would be five whales. However, the SWG **again referred** to the general difficulty surrounding the provision of *ad hoc* interim advice on catch limits. It draws the Commission's attention to its view that it is inappropriate to provide such advice for long time periods (see Item 8). The appropriate way to provide such advice is through the development of *SLAs* that have been thoroughly tested for robustness to uncertainty and have been agreed can meet the Commission's stated long-term management objectives.

6. MANAGEMENT ADVICE FOR COMMON MINKE WHALES OFF EAST GREENLAND

6.1 Review of available information

In recent years, a catch of 12 minke whales off East Greenland has been allowed. No new information on stock structure, abundance or trends was available this year. However, the SWG noted that catches off East Greenland are believed to come from the much larger (see Table 2) Central stock of minke whales.

6.2 Assessment methods

No assessment information was presented this year.

6.3 Management advice

The present catch limit represents a very small proportion of the Central stock (see Table 5 for the estimates agreed at the most recent RMP *Implementation Review*). The SWG **agreed** that the present catch limit poses no threat to the stock.

Table 5

Estimates of abundance of North Atlantic common minke whales.

Areas (see Fig.2)	Year	Estimate	Approx. 95% confidence intervals	
Central stock				
CM	1997	26,700	20,300	35,100
CIC	2001	43,600	30,100	63,100
CG, CIP	2001	23,600	14,300	39,000

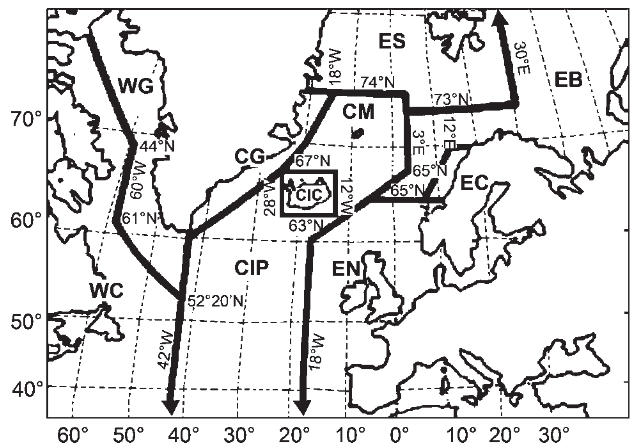

Fig. 2. Map showing North Atlantic common minke whale.

7. MANAGEMENT ADVICE FOR HUMPBACK WHALES OFF ST. VINCENT AND THE GRENADINES

7.1 Review of new information

The catch in 2007 was reported to be one female; it was not accompanied by a calf and was not lactating.

The SWG was informed that genetic samples for the whales caught in 2005-07 have been collected and plans for analysis are in place. The fluke photographs for the 2000, 2003, 2005 and 2006 catches had been submitted for comparison to the North Atlantic Humpback catalogue and no matches were identified.

The SWG welcomed this information and particularly commended the collection of genetic samples and fluke photos. It **strongly encouraged** the continued collection of such data from future catches.

7.2 Management advice

In recent years, the Committee has agreed that the animals found off St. Vincent and The Grenadines are part of the large West Indies breeding population. The Commission adopted a total block catch limit of 20 for the period 2003-07. The Committee **agreed** that renewal of this catch limit for another 5-year block will not harm the stock.

8. SCIENTIFIC ASPECTS OF AN ABORIGINAL SUBSISTENCE WHALING SCHEME

In 2002, the Scientific Committee **strongly recommended** that the Commission adopt the Aboriginal Subsistence Whaling Scheme (AWS) (IWC, 2003, pp.22-23). This covers a number of practical issues such as survey intervals, carryover, and guidelines for surveys. The Committee has stated the AWS provisions constitute an important and necessary component of safe management under AWMP *SLAs* and the SWG concurs with this view. It **reiterates its recommendation** of recent years and will keep this item on its Agenda.

During discussions of *ad hoc* interim advice for several whale stocks this year, the SWG expressed concern, noting the undesirability that such interim advice would replace or slow down the development of AWMP *SLAs*. The SWG was particularly concerned that interim advice should not be renewed or regenerated over long time periods. The important question of appropriate time spans for interim advice will be considered further at next year's Annual Meeting.

8.1 General issues arising out of the B-C-B bowhead *Implementation Review*

The undertaking of the extensive *Implementation Review* for B-C-B bowhead whales gave rise to a number of general issues that require further deliberation and consideration by the Committee. These include:

(1) clarification of how to handle Data Availability Agreement (DAA) deadlines when a multi-year, multi-workshop process occurs;
(2) clarification of how to apply the DAA to data from either non-member countries or non-governmental sources;
(3) clarification of the DAA with respect to the provision of interim advice rather than advice within the *SLA* framework;
(4) balancing the need to meet DAA deadlines with the provision of the best scientific advice, including direct requests from workshops for data/analyses that could be provided in time to provide advice but strictly fall outside the DAA deadlines;
(5) consideration of corrections to datasets against the deadlines;
(6) streamlining and improving communications regarding DAA issues; and
(7) protocol for genetic data submission and error reporting.

There was insufficient time to discuss these issues in detail. The Chair will draw the attention of the Data Availability Group (DAG) to these issues and will work with Givens and Martien in the intersessional period to develop a suggested approach to these that is best suited to the needs of the SWG. In particular, they would consider whether it was appropriate and if so how consideration of such issues might be incorporated into the AWS.

The SWG noted misunderstandings arising out of some of the above issues had led to delays in transmitting some relevant data and papers to the IWC Secretariat.

The SWG **recommended** that the most recent revised catch data for Greenland operations be submitted to the Secretariat, along with any other available data relevant for management considerations. The SWG also **recalled** the fact that computer programs related to approved abundance estimation and stock assessment analyses must be submitted to the Secretariat for validation.

Finally, the SWG **agreed** that Allison should amend the code for the *Bowhead SLA* to allow it to be used as a standalone program.

9. PREPARATION FOR AN *IMPLEMENTATION REVIEW* OF EASTERN GRAY WHALES

The *Implementation Review* for eastern Pacific gray whales is scheduled for 2009. The SWG encourages scientists to submit relevant research and data (in accordance with the DAA) in the coming year so that consideration of this issue can begin at the next Annual Meeting with the intent that work be completed in 2009.

10. WORK PLAN

The SWG agreed that the following priority work was required during the intersessional period and at the next Annual Meeting.

(1) Furthering work on developing appropriate long-term management advice for the Greenlandic fisheries.
    (a) Hold an intersessional workshop with the primary focus of:
        (i) working towards completing work on a sex-ratio based assessment of common minke whales off West Greenland;
        (ii) further consideration of the assessment of humpback whales off West Greenland;
        (iii) beginning work on developing *SLAs* for Greenlandic fisheries with an initial focus on fin whales and noting the multispecies nature of Greenlandic fisheries.
(2) Further consideration of issues arising out of the *Implementation Review* with special reference to the DAA and the AWS.
(3) Further consideration of issues related to the provision of ad hoc interim advice, particularly with respect to timeframes.
(4) Validation and amendment of computer programs associated with *Implementations* and assessments.

11. ADOPTION OF REPORT

The SWG thanked Donovan for his hard work and expert guidance during a long and difficult bowhead *Implementation Review* and progress on other matters. The Chair expressed his thanks to the rapporteurs and to the participants themselves. It was particularly pleasing to have completed the long and complex *Implementation Review* for B-C-B bowhead whales. This will also allow more time to address the important issue of moving from interim management advice to more thorough *SLA*-based advice for the other aboriginal subsistence fisheries.

The report was adopted at 21:32 on 15 May 2007.

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a

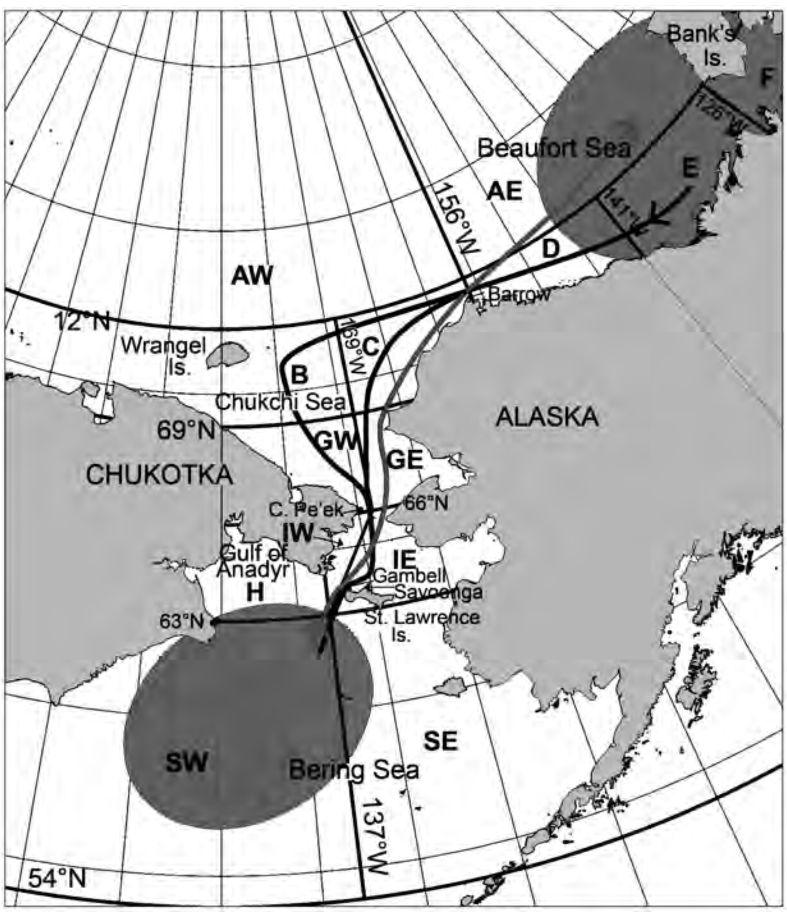
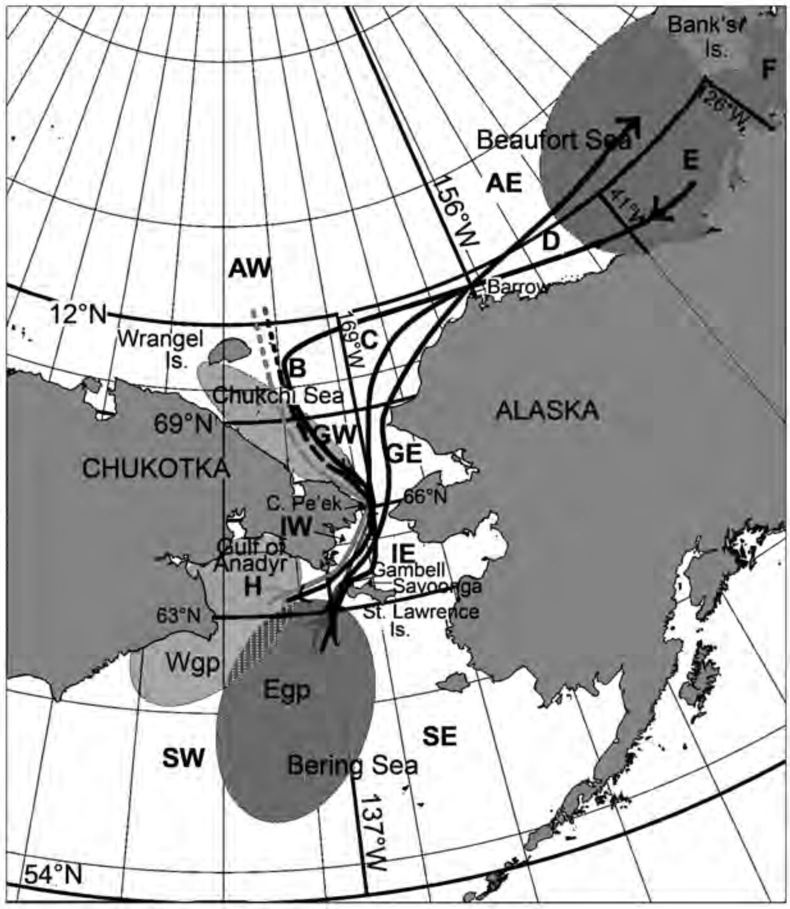


Fig. 1. The stock structure hypothesis. a. Hypothesis A.

Table 3
Performance statistics for the additional trials specified during Item 2.3 and 2.4.

		Slope	Minimum Size		Bayes Factor		D1 (Final Depletion)				D10 (Relative increase)				R1 (Relative Recovery)				N9 (Average Need Satisfaction)	
		Barrow	W Stock	E Stock	SingleStk	BE01	W Stock		E Stock		W Stock		E Stock		W Stock		E Stock			
Hypoth.	Type				(Hypoth A)		Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median
D	GUP	1.229	49	1,319	13.85	10.20	0.781	0.788	0.782	0.790	2.648	2.672	0.968	0.978	0.896	0.896	1.000	1.000	0.885	0.984
D	Need	1.229	49	1,319	13.85	10.20	0.781	0.781	0.782	0.782	2.648	2.648	0.968	0.968	0.896	0.896	1.000	1.000	1.000	1.000
D	GUP	1.352	67	1,237	7.47	5.50	0.788	0.793	0.783	0.789	2.210	2.225	0.979	0.987	0.923	0.923	1.000	1.000	0.896	0.988
D	Need	1.352	67	1,237	7.47	5.50	0.788	0.788	0.783	0.783	2.210	2.210	0.979	0.979	0.923	0.923	1.000	1.000	1.000	1.000

b



c

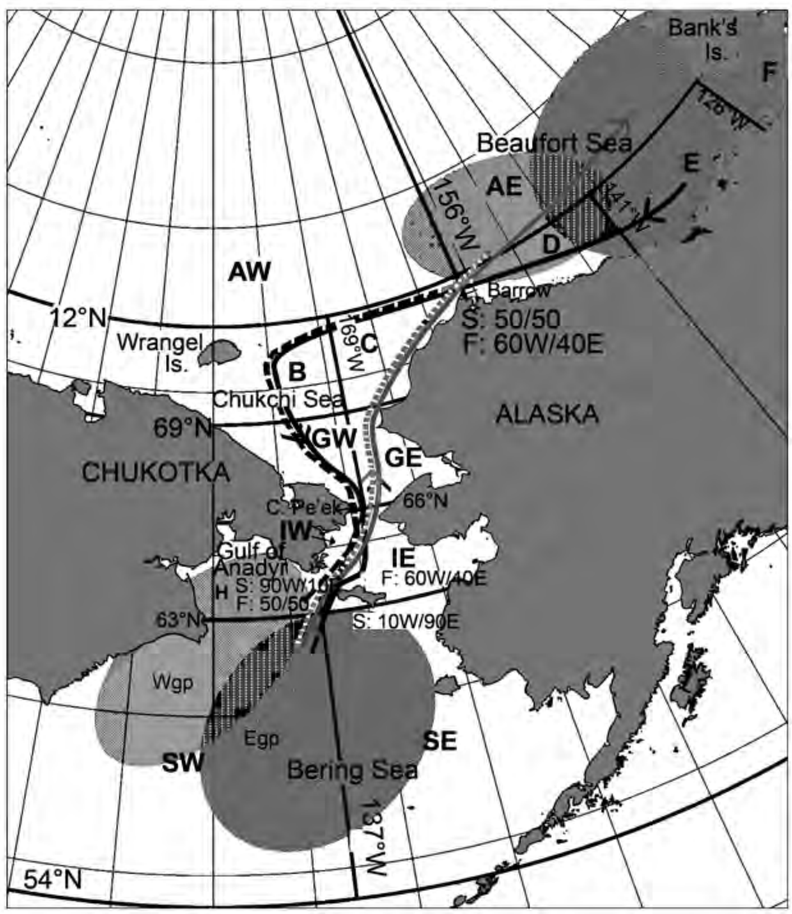


Fig. 1. (continued) The stock structure hypothesis.
b. Hypotheses B and C.
c. Hypothesis D.

Table 2

Performance statistics for *Implementation Review trials* for bowhead whales.

			Slope	Minimum Size		Bayes Factor		D1 (Final Depletion)				D10 (Relative increase)				R1 (Relative Recovery)				N9 (Average Need Satisfaction)	
			Barrow	W Stock	E Stock	SingleStk	BE01	W Stock		E Stock		W Stock		E Stock		W Stock		E Stock			
Hypoth.	Trial	Type				(Hypoth A)		Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median
A	1	GUP	1.826	1,039		1.00	0.74	0.785	0.790			1.135	1.142			1.000	1.000			0.917	0.993
A	1	Need	1.826	1,039		1.00	0.74	0.785	0.785			1.135	1.135			1.000	1.000			1.000	1.000
B	1	GUP	0.592	22	1,760	716.4	527.5	0.981	0.982	0.790	0.826	3.705	3.707	0.938	0.981	0.998	0.998	1.000	1.000	0.703	0.781
B	1	Need	0.592	22	1,760	716.4	527.5	0.980	0.980	0.670	0.670	3.700	3.700	0.795	0.795	0.998	0.998	1.000	1.000	1.000	1.000
D	1	GUP	1.860	435	578	0.88	0.65	0.800	0.804	0.775	0.779	1.181	1.187	1.115	1.122	1.000	1.000	1.000	1.000	0.929	0.994
D	1	Need	1.860	435	578	0.88	0.65	0.800	0.800	0.775	0.775	1.181	1.181	1.115	1.115	1.000	1.000	1.000	1.000	1.000	1.000
A	2	GUP	1.826	1,039		1.00	0.74	0.887	0.887			1.283	1.283			1.000	1.000			1.000	1.000
A	2	Need	1.826	1,039		1.00	0.74	0.887	0.887			1.283	1.283			1.000	1.000			1.000	1.000
B	2	GUP	0.592	22	1,760	716.4	527.5	0.982	0.982	0.836	0.844	3.708	3.708	0.993	1.003	0.998	0.998	1.000	1.000	0.905	0.979
B	2	Need	0.592	22	1,760	716.4	527.5	0.982	0.982	0.836	0.836	3.708	3.708	0.993	0.993	0.998	0.998	1.000	1.000	1.000	1.000
D	2	GUP	1.860	435	578	0.88	0.65	0.895	0.895	0.882	0.882	1.321	1.321	1.269	1.269	1.000	1.000	1.000	1.000	1.000	1.000
D	2	Need	1.860	435	578	0.88	0.65	0.895	0.895	0.882	0.882	1.321	1.321	1.269	1.269	1.000	1.000	1.000	1.000	1.000	1.000
A	9	GUP	0.700	4,480		1.00	0.12	0.496	0.507			0.968	0.990			0.985	1.000			0.873	0.983
A	9	Need	0.700	4,480		1.00	0.12	0.496	0.496			0.968	0.968			0.985	0.985			1.000	1.000
B	9	GUP	0.473	219	5,206	1.87	0.22	0.691	0.691	0.484	0.533	2.928	2.932	0.786	0.865	0.994	0.994	0.960	1.000	0.810	0.911
B	9	Need	0.473	219	5,206	1.87	0.22	0.690	0.690	0.465	0.465	2.927	2.927	0.756	0.756	0.994	0.994	0.924	0.924	1.000	1.000
D	9	GUP	0.702	2,033	2,410	1.00	0.12	0.509	0.519	0.482	0.494	1.040	1.062	0.906	0.927	0.981	0.981	0.957	0.980	0.873	0.983
D	9	Need	0.702	2,033	2,410	1.00	0.12	0.509	0.509	0.482	0.482	1.040	1.040	0.906	0.906	0.981	0.981	0.957	0.957	1.000	1.000
A	10	GUP	3.676	881		1.00	0.04	0.972	0.974			0.987	0.989			1.000	1.000			0.938	0.993
A	10	Need	3.676	881		1.00	0.04	0.972	0.972			0.987	0.987			1.000	1.000			1.000	1.000
B	10	GUP	-0.025	25	5,134	729,543	28,730	1.000	1.000	0.976	0.982	3.338	3.338	0.991	0.998	0.997	0.997	1.000	1.000	0.694	0.781
B	10	Need	-0.025	25	5,134	729,543	28,730	1.000	1.000	0.957	0.957	3.338	3.338	0.971	0.971	0.997	0.997	1.000	1.000	1.000	1.000
D	10	GUP	3.160	364	502	1.17	0.05	0.974	0.976	0.969	0.971	1.059	1.061	0.981	0.983	1.000	1.000	1.000	1.000	0.939	0.993
D	10	Need	3.160	364	502	1.17	0.05	0.974	0.974	0.969	0.969	1.059	1.059	0.981	0.981	1.000	1.000	1.000	1.000	1.000	1.000
A	11	GUP	1.826	1,039		1.00	0.74	0.785	0.789			1.135	1.140			1.000	1.000			0.985	0.996
A	11	Need	1.826	1,039		1.00	0.74	0.785	0.785			1.135	1.135			1.000	1.000			1.000	1.000
B	11	GUP	0.592	22	1,760	716	528	0.980	0.980	0.670	0.695	3.700	3.701	0.795	0.825	0.998	0.998	1.000	1.000	0.855	0.974
B	11	Need	0.592	22	1,760	716	528	0.980	0.980	0.670	0.670	3.700	3.700	0.795	0.795	0.998	0.998	1.000	1.000	1.000	1.000
D	11	GUP	1.860	435	578	0.88	0.65	0.800	0.805	0.775	0.779	1.181	1.187	1.115	1.122	1.000	1.000	1.000	1.000	0.985	0.994
D	11	Need	1.860	435	578	0.88	0.65	0.800	0.800	0.775	0.775	1.181	1.181	1.115	1.115	1.000	1.000	1.000	1.000	1.000	1.000
A	12	GUP	0.790	3,047		1.00	0.09	0.281	0.323			0.776	0.892			0.742	0.742			0.823	0.936
A	12	Need	0.790	3,047		1.00	0.09	0.275	0.275			0.759	0.759			0.742	0.742			1.000	1.000
B	12	GUP	0.583	225	3,389	1.68	0.16	0.668	0.670	0.299	0.382	3.042	3.049	0.645	0.823	0.990	0.991	0.921	0.921	0.735	0.829
B	12	Need	0.583	225	3,389	1.68	0.16	0.666	0.666	0.217	0.217	3.033	3.033	0.468	0.468	0.990	0.990	0.921	0.921	1.000	1.000
D	12	GUP	0.791	1,411	1,616	1.00	0.09	0.296	0.334	0.264	0.303	0.859	0.968	0.703	0.807	0.734	0.734	0.759	0.759	0.826	0.940
D	12	Need	0.791	1,411	1,616	1.00	0.09	0.290	0.290	0.257	0.257	0.840	0.840	0.685	0.685	0.734	0.734	0.759	0.759	1.000	1.000
A	13	GUP	0.790	3,047		1.00	0.09	0.485	0.485			1.340	1.340			0.775	0.775			0.986	1.000
A	13	Need	0.790	3,047		1.00	0.09	0.485	0.485			1.340	1.340			0.775	0.775			1.000	1.000
B	13	GUP	0.583	225	3,389	1.68	0.16	0.671	0.671	0.487	0.487	3.057	3.057	1.050	1.050	0.993	0.993	0.924	0.924	0.923	1.000
B	13	Need	0.583	225	3,389	1.68	0.16	0.671	0.671	0.487	0.487	3.057	3.057	1.050	1.050	0.993	0.993	0.924	0.924	1.000	1.000
D	13	GUP	0.791	1,411	1,616	1.00	0.09	0.492	0.492	0.475	0.475	1.427	1.427	1.262	1.262	0.771	0.771	0.786	0.786	0.985	1.000
D	13	Need	0.791	1,411	1,616	1.00	0.09	0.492	0.492	0.475	0.475	1.427	1.427	1.262	1.262	0.771	0.771	0.786	0.786	1.000	1.000

Cont.

			Slope	Minimum Size		Bayes Factor		D1 (Final Depletion)				D10 (Relative increase)				R1 (Relative Recovery)				N9 (Average Need Satisfaction)	
			Barrow	W Stock	E Stock	SingleStk	BE01	W Stock		E Stock		W Stock		E Stock		W Stock		E Stock			
Hypoth.	Trial	Type				(Hypoth A)		Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median
A	14	GUP	1.826	1,039		1.00	0.74	0.729	0.755			1.054	1.092			1.000	1.000			0.776	0.895
A	14	Need	1.826	1,039		1.00	0.74	0.663	0.663			0.959	0.959			1.000	1.000			1.000	1.000
B	14	GUP	0.592	22	1,760	716	528	0.981	0.982	0.790	0.825	3.705	3.707	0.938	0.979	0.998	0.998	1.000	1.000	0.593	0.659
B	14	Need	0.592	22	1,760	716	528	0.977	0.977	0.446	0.446	3.688	3.688	0.529	0.529	0.998	0.998	0.884	0.884	1.000	1.000
D	14	GUP	1.860	435	578	0.88	0.65	0.747	0.768	0.714	0.738	1.102	1.133	1.028	1.063	1.000	1.000	1.000	1.000	0.798	0.901
D	14	Need	1.860	435	578	0.88	0.65	0.687	0.687	0.649	0.649	1.014	1.014	0.934	0.934	1.000	1.000	1.000	1.000	1.000	1.000
A	16	GUP	0.700	4,480		1.00	0.12	0.397	0.444			0.774	0.867			0.787	0.882			0.735	0.866
A	16	Need	0.700	4,480		1.00	0.12	0.318	0.318			0.621	0.621			0.632	0.632			1.000	1.000
B	16	GUP	0.473	219	5,206	1.87	0.22	0.690	0.691	0.429	0.510	2.924	2.930	0.697	0.827	0.992	0.992	0.852	1.000	0.681	0.769
B	16	Need	0.473	219	5,206	1.87	0.22	0.685	0.685	0.245	0.245	2.907	2.907	0.398	0.398	0.992	0.992	0.486	0.486	1.000	1.000
D	16	GUP	0.702	2,033	2,410	1.00	0.12	0.413	0.458	0.379	0.426	0.845	0.936	0.712	0.801	0.981	0.981	0.752	0.846	0.736	0.868
D	16	Need	0.702	2,033	2,410	1.00	0.12	0.337	0.337	0.299	0.299	0.688	0.688	0.562	0.562	0.981	0.981	0.593	0.593	1.000	1.000
A	20	GUP	3.676	881		1.00	0.04	0.967	0.969			0.982	0.984			1.000	1.000			0.835	0.919
A	20	Need	3.676	881		1.00	0.04	0.953	0.953			0.968	0.968			1.000	1.000			1.000	1.000
B	20	GUP	-0.025	25	5,134	729,543	28,730	1.000	1.000	0.976	0.982	3.338	3.339	0.991	0.998	0.997	0.997	1.000	1.000	0.589	0.663
B	20	Need	-0.025	25	5,134	729,543	28,730	0.999	0.999	0.922	0.922	3.337	3.337	0.936	0.936	0.997	0.997	1.000	1.000	1.000	1.000
D	20	GUP	3.160	364	502	1.17	0.05	0.969	0.972	0.963	0.966	1.054	1.057	0.975	0.978	1.000	1.000	1.000	1.000	0.841	0.919
D	20	Need	3.160	364	502	1.17	0.05	0.957	0.957	0.948	0.948	1.041	1.041	0.960	0.960	1.000	1.000	1.000	1.000	1.000	1.000
B	41	GUP	0.590	10	1,768	692.9	510.2	0.954	0.954	0.790	0.826	7.838	7.842	0.937	0.980	0.996	0.996	1.000	1.000	0.704	0.782
B	41	Need	0.590	10	1,768	692.9	510.2	0.952	0.952	0.670	0.670	7.825	7.825	0.796	0.796	0.996	0.996	1.000	1.000	1.000	1.000
B	42	GUP	0.578	34	1,783	741.4	546.0	0.988	0.988	0.790	0.826	2.650	2.651	0.936	0.979	0.999	0.999	1.000	1.000	0.703	0.780
B	42	Need	0.578	34	1,783	741.4	546.0	0.986	0.986	0.670	0.670	2.646	2.646	0.794	0.794	0.999	0.999	1.000	1.000	1.000	1.000
D	43	GUP	1.821	300	754	1.01	0.74	0.800	0.804	0.778	0.782	1.280	1.286	1.065	1.071	1.000	1.000	1.000	1.000	0.930	0.995
D	43	Need	1.821	300	754	1.01	0.74	0.800	0.800	0.778	0.778	1.280	1.280	1.065	1.065	1.000	1.000	1.000	1.000	1.000	1.000
D	44	GUP	1.839	591	412	0.96	0.71	0.800	0.804	0.770	0.774	1.112	1.118	1.199	1.206	1.000	1.000	1.000	1.000	0.927	0.994
D	44	Need	1.839	591	412	0.96	0.71	0.800	0.800	0.770	0.770	1.112	1.112	1.199	1.199	1.000	1.000	1.000	1.000	1.000	1.000
B	45	GUP	1.544	55	1,105	3.35	2.46	0.962	0.966	0.769	0.791	1.228	1.233	1.047	1.078	1.000	1.000	1.000	1.000	0.848	0.959
B	45	Need	1.544	55	1,105	3.35	2.46	0.961	0.961	0.765	0.765	1.228	1.228	1.042	1.042	1.000	1.000	1.000	1.000	1.000	1.000
D	45	GUP	1.843	498	525	0.94	0.69	0.796	0.801	0.777	0.781	1.128	1.134	1.157	1.164	1.000	1.000	1.000	1.000	0.924	0.994
D	45	Need	1.843	498	525	0.94	0.69	0.796	0.796	0.777	0.777	1.128	1.128	1.157	1.157	1.000	1.000	1.000	1.000	1.000	1.000
B	46	GUP	0.352	23	2,264	3,374.1	2,484.7	0.978	0.979	0.795	0.834	4.303	4.304	0.919	0.964	0.998	0.998	1.000	1.000	0.677	0.756
B	46	Need	0.352	23	2,264	3,374.1	2,484.7	0.977	0.977	0.647	0.647	4.297	4.297	0.748	0.748	0.998	0.998	1.000	1.000	1.000	1.000
D	46	GUP	1.829	339	711	0.97	0.71	0.804	0.807	0.774	0.777	1.269	1.274	1.057	1.062	1.000	1.000	1.000	1.000	0.931	0.996
D	46	Need	1.829	339	711	0.97	0.71	0.804	0.804	0.774	0.774	1.269	1.269	1.057	1.057	1.000	1.000	1.000	1.000	1.000	1.000
B	47	GUP	0.381	223	2,169	15.54	2,052.9	0.616	0.617	0.796	0.832	3.390	3.393	0.922	0.965	0.991	0.992	1.000	1.000	0.678	0.758
B	47	Need	0.381	223	2,169	15.54	2,052.9	0.614	0.614	0.650	0.650	3.377	3.377	0.753	0.753	0.990	0.990	1.000	1.000	1.000	1.000
B	48	GUP	0.708	3	1,617	1,341.3	244.8	0.998	0.998	0.788	0.823	2.862	2.862	0.948	0.990	0.999	0.999	1.000	1.000	0.717	0.797
B	48	Need	0.708	3	1,617	1,341.3	244.8	0.997	0.997	0.681	0.681	2.859	2.859	0.820	0.820	0.999	0.999	1.000	1.000	1.000	1.000
B2	49	GUP	1.227	26	1,235	16.40	12.08	0.989	0.989	0.764	0.812	2.239	2.241	0.988	1.051	0.999	0.999	1.000	1.000	0.801	0.870
B2	49	Need	1.227	26	1,235	16.40	12.08	0.988	0.988	0.731	0.731	2.238	2.238	0.946	0.946	0.999	0.999	1.000	1.000	1.000	1.000

Appendix 1

AGENDA

1. Introductory items
   - 1.1 Convenor's opening remarks
   - 1.2 Election of Chair
   - 1.3 Appointment of rapporteurs
   - 1.4 Adoption of Agenda
   - 1.5 Documents available

2. Bowhead whale *Implementation Review*
   - 2.1 Review of intersessional Workshops
     - 2.1.1 2nd Intersessional Workshop – Chair's Summary
     - 2.1.2 3rd Intersessional Workshop – Chair's Summary
     - 2.1.3 Discussion
   - 2.2 Review of results of runs agreed in Copenhagen
   - 2.3 Additional consideration of stock structure issues and possible additional trials
   - 2.4 Management advice

3. Greenlandic fisheries and the Greenlandic research programme
   - 3.1 Review of new information
     - 3.1.1 Stock structure, range and movement
     - 3.1.2 Catch distributions
       - 3.1.2.1 Common minke whales
       - 3.1.2.2 Fin whales
     - 3.1.3 Abundance and trends
     - 3.1.4 Progress with the development of management procedures

4. Management advice for minke and fin whales off West Greenland
   - 4.1 Catch data and biological sampling
   - 4.2 Assessment
     - 4.2.1 Common minke whales off West Greenland
     - 4.2.2 Fin whales off West Greenland
   - 4.3 Management advice
     - 4.3.1 Introduction
     - 4.3.2 Common minke whales off West Greenland
     - 4.3.3 Fin whales off West Greenland

5. Request for management advice for other large whales off West Greenland
   - 5.1 Humpback whales
     - 5.1.1 Review of available information
       - 5.1.1.1 Stock structure, feeding aggregation and movements
       - 5.1.1.2 Abundance and trends
       - 5.1.1.3 Assessment methods
   - 5.2 Bowhead whales
     - 5.2.1 Review of available information
       - 5.2.1.1 Stock structure movements
       - 5.2.1.2 Abundance and trends
       - 5.2.1.3 Catches
       - 5.2.1.4 Assessment methods

6. Management advice for common minke whales off East Greenland
   - 6.1 Review of available information
   - 6.2 Assessment methods
   - 6.3 Management advice

7. Management advice for humpback whales off St. Vincent and The Grenadines
   - 7.1 Review of new information
   - 7.2 Management advice

8. Scientific aspects of an Aboriginal Subsistence Whaling Scheme
   - 8.1 General issues arising out of the B-C-B bowhead *Implementation Review*

9. Preparation for an *Implementation Review* of eastern gray whales

10. Work plan

11. Adoption of report

Appendix 2

IMPLEMENTATION REVIEW FOR BOWHEAD WHALES

This Appendix specifies the model used to model the four population hypotheses; a full rationale is given in SC/59/Rep3.

Hypothesis A. Single stock – no feeding ground site fidelity. There is one breeding area in the western and central northern Bering Sea, one primary summer feeding area in the Canadian and eastern Alaskan Beaufort Sea, and one primary spring migration route northeast along the Alaskan coast from April to early June and east across the Beaufort Sea. The western autumn migration in September through November bifurcates after passing Barrow, with some whales moving southwest and others west towards the Chukotka coast. The migration is completed when bowheads move south along the Chukotka coast through the Bering Strait and into the northern Bering Sea. A single population might deviate from the expectations under panmixia, for instance due to social or demographic structure assortative mating, or the effects of a recent bottleneck in a long-lived species.

Hypothesis B. Single stock with feeding ground site fidelity. There is one breeding stock but two summer feeding areas (the eastern Beaufort Sea and the western Russian Chukchi Sea), and fidelity to feeding areas and migratory routes. Most whales migrate as for hypothesis A.

The other group of whales migrates north through the Bering Strait in late May-June and summers along the Chukotka coast and further north, with at least a few whales remaining in the northern Gulf of Anadyr throughout the summer. The whales from this group return to the Gulf of Anadyr in the fall and mix with the first group during the breeding season. Whales from both groups are available to the hunters at St. Lawrence Island in autumn while only whales from the first group are available to these hunters in spring. Whales from both groups are available to hunters at Chukotka in the fall.

Hypothesis C. Two stocks – spatial segregation-St Lawrence mixed. Identical to hypothesis B, except that each group constitutes a separate breeding stock.

Hypothesis D. Two stocks – mixed migration. There are two breeding areas: one in the western (the W stock) and the other in the central northern Bering Sea (the E stock). In spring, before moving through the Bering Strait, the W whales migrate closer to Gambell (indeed some whales may winter in the vicinity of St. Lawrence Island and the south part of Chukotka) whereas the E whale movements see them preferentially available to harvests from SW Cape by hunters from Savoonga (see Fig. 1 pp. 133-134 of this volume). Once through the Bering Strait, it is primarily W whales that may be found in the vicinity of Chukotka. All the E and most of the W whales then move northeast along the Alaskan coast from April to early June and into feeding areas in the Canadian and eastern Alaskan Beaufort Sea, with the E whales moving further to the east. Both W and E whales are equally susceptible to harvest from Barrow and other coastal locations during this period, consistent with the even abundance for a two population hypothesis suggested by the *STRUCTURE* analyses, the absence of an 'Oslo bump', and *STRUCTURE* results showing spring Barrow mixing for whales taken in spring (Falush *et al*., 2003; Pritchard *et al*., 2000).

The temporal distributions of the western autumn migration in September through November differ somewhat for W and E whales, leading to the 'pulsing' behaviour evident in the genetics data, and for W whales to be more exposed to hunting at Barrow in the fall than E whales due to their slightly longer availability in the harvesting area during the hunting period. Although equal harvest susceptibility for the two stocks in the fall Barrow hunt should perhaps be considered the more biologically plausible, it was assumed that W whales are more susceptible than E whales to explore a more extreme case, particularly since the case of equal susceptibility might produce aggregate results similar to those for a single-stock scenario.

All whales move to Chukotka and follow the canonical southward migration after passing Barrow. The migration is completed when whales move back through the Bering Strait and into the northern Bering Sea, with W and E whales being equally susceptible to harvest from Gambell, but with a slightly greater propensity for W whales to be harvested at Savoonga because the harvest from Savoonga during fall is from the village and not the SW Cape (Fig. 2). Inferences about equal or differential susceptibility of W and E whales to harvests from Gambell and Savoonga at different times are informed by the results from some of the *STRUCTURE* analyses as well as by traditional knowledge of the areas in the Bering Sea from which whales come or to which they are headed and the possibility that W stock animals may include summer residents near Barrow and winter residents near Chukotka/St. Lawrence Island.

A. BASIC POPULATION DYNAMICS

The population dynamics model is based on the assumption that there are two 'stocks' (referred to as Stock W and Stock E respectively)[1] whose dynamics are governed by the Pella-Tomlinson model i.e.:

$$\begin{aligned} N_{t+1}^W &= N_t^W + \tfrac{r^W}{z} N_t^W (1-(N_t^W / K^W)^z) - C_t^W \\ N_{t+1}^E &= N_t^E + \tfrac{r^E}{z} N_t^E (1-(N_t^E / K^E)^z) - C_t^E \end{aligned} \qquad (A.1)$$

where

N_t^i is the number of stock i (i= 'W'/'E') animals at the start of year t;

K^i is the carrying capacity of stock i ($N_{184}^i = K^i$);

r^i determines the intrinsic rate of growth for stock i;

z is the degree of compensation (the Pella-Tomlinson shape parameter); and

C_t^i is the catch during year t from stock i.

For this model, therefore, *MSYL* is the solution of the equation $1=(z+1)MSYL^Z$ and *MSYR* is $r/(1+z)$. The catch by stock is determined by apportioning the catches by year, season and area to stock, taking account of mixing matrices (i.e. the combined effect of the distribution of stocks at the time of harvesting as well as the relative extent to which different stocks are exposed to harvesting owing to the time of the harvest), according to:

$$C_t^i = \sum_s \sum_A C_t^{A,s} \frac{Z_t^{A,s,i} N_t^i}{Z_t^{A,s,E} N_t^E + Z_t^{A,s,W} N_t^W} \qquad (A.2)$$

where

$C_t^{A,s}$ is the catch in area A during season s of year t:

$$C_t^{A,s} = C_t \theta_e^{A,s} \qquad (A.3)$$

C_t is the total catch during year t (where year t is in era e; Table 1);

$\theta_e^{A,s}$ is the proportion of the catch during era e that was taken in area A during season s; the catch mixing matrix; Table 2);

$Z_t^{A,s,i}$ is a measure of the proportion of stock i animals that are exposed to the harvest in area A during season s of year t ($t \in e$) (the relative exposure matrices)

$$Z_t^{A,s,i} = \sum_{m \in s} V_e^{A,m,i} \bar{C}_e^{A,m} / \sum_{m \in s} \bar{C}_e^{A,m} \qquad (A.4)$$

$V_e^{A,m,i}$ is the proportion of stock i animals in area A during month m for a year in era e ($t \in e$) (the distribution matrix; see Annex D of SC/59/Rep4); and

$\bar{C}_e^{A,m}$ is the average annual catch in area A during month m over the years defined by era e (see Table 3).

Note that Eqn. A.2 implies that the harvest during the year is sufficiently small that there is no need to remove catches in Spring-Summer (March-August) before determining the split among stocks of the catch during Fall-Winter (September-February). The distribution matrices, V, differ between 1848-68 and 1869+, as discussed in Annex D of SC/59/Rep4.

B. CONDITIONING

The values for the parameters of the population dynamics model are: (a) the intrinsic rate of growth for each stock; (b) the stock-specific carrying capacities; and (c) the values for

[1] The model is modified straightforwardly for the case in which there is only one stock.

the mixing and catch allocation matrices. The first and third of these quantities are pre-specified as the part of the specifications for each trial and the values for the stock-specific carrying capacities are estimated by minimising an objective function. The components of the objective function are:

(a) the abundance estimates at Barrow:

$$L_1 = 0.5(\ell n\mathbf{N}^{obs} - \ell n(\hat{\mathbf{N}}))^T \boldsymbol{\Sigma}^{-1}(\ell n\mathbf{N}^{obs} - \ell n(\hat{\mathbf{N}})) \quad \text{(B.1)}$$

Where

$\mathbf{N}^{obs}$ is the vector (over year index t) of observed abundance estimates;

$\hat{\mathbf{N}}$ is the vector of model-predicted abundance estimates corresponding to $\mathbf{N}^{obs}$ (the total population size for stock hypotheses[2] A and D, and the abundance of stock E for stock hypotheses B and C); and

Σ is the variance-covariance matrix for the observed log-abundances, as given by Zeh and Punt (2005) and replicated here as Table 4.

(b) the abundance estimate at Cape Pe'ek (assumed to pertain to the size of Stock W; trials based on stock hypotheses B and C only):

$$L_2 = \Omega^1(\chi N^W_{2001} - U)^2 \quad \text{(B.2)}$$

where

U is the target abundance at Cape Pe'ek (base-case value 900 see below);

χ is the fraction of Stock W that is north of 63°N (the southern extent of area IW) in June; and

Ω^1 is the weight such that the abundance of Stock W mimics U closely (set to a very large value during the conditioning).

(c) the ratio of the abundance of Stock W to the total abundance in 2001 (trials based on stock hypothesis D only). This constraint reflects the observation from the *STRUCTURE* runs of no 'pulses', but the potential presence of two stocks of roughly equal size, during the spring migration (Givens *et al*., 2007).

$$L_3 = \Omega^2(N^W_{2001} / (N^W_{2001} + N^E_{2001}) - \delta)^2 \quad \text{(B.3)}$$

where

δ is the target ratio of the abundance of Stock W to the total population abundance (base-case value 0.5); and

Ω^2 is the weight so that $N^W_{2001} / (N^W_{2001} + N^E_{2001})$ mimics δ closely (set to a very large value during the conditioning).

C. DATA GENERATION

The historic (t<2006) abundance estimates (and their *CV*s) are provided to the *SLA* and are taken to be those in Table 4. An estimate of absolute abundance together with an estimate of its *CV* is generated, and is provided to the *SLA*, for the year t=2006 and then once every F years during the management period (where F=10). The *CV* of the abundance estimate (CV_{true}) may be different from the expected value of the *CV* provided to the *SLA*.

[2] The stock hypotheses are described in Annex D.

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

$$\hat{S}_t = B_A P^* \beta^2 Y_t w_t \quad \text{(C.1)}$$

where

B_A is the bias;

P^* is the reference population level (the pristine 1+ population size of the component of the population surveyed at Barrow);

β^2 is a constant (see Equation C.6)

Y_t is a lognormal random variable:

$$Y_t = e^{\phi_t} \quad \phi_t \sim N[0; \ell\text{n}(1+\alpha^2)] \quad \text{(C.2)}$$

w_t is a Poisson random variable, independent of Y_t, with $E(w_t) = P_t / (P^* \beta^2)$ where

P_t is the current 1+ population size of the component of the population surveyed at Barrow.

The *SLA* is provided with an estimate of *CV* for each sightings estimate, $CV_{est,t}$. The value for the estimate of $CV_{est,t}$ is given by:

$$\hat{C}V_{est,t} = \sigma_t \sqrt{(\chi^2_n / n)} \quad \sigma^2_t = \ell\text{n}(1 + E(CV^2_{est,t})) \quad \text{(C.3)}$$

where

$E(CV^2_{est,t})$ is the actual *CV* for the abundance estimate for year t:

$$E(CV^2_{est,t}) = \theta^2(a^2 + b^2 / (w_t \beta^2)) \quad \text{(C.4)}$$

θ is the parameter that determines the relationship between the parameters a and b and the expected value of the observed *CV*:

$$\theta = CV_{est} / \sqrt{a + b / 0.6} \quad \text{(C.5)}$$

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

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

α^2, β^2 are constants given by:

$$\alpha^2 = \theta^2 a + \eta 0.1; \; \beta^2 = \theta^2 b + \eta 0.013 \quad \text{(C.6)}$$

η determines the relationship between the observed and actual *CV*s:

$$\eta = [(CV^{true})^2 - (CV^{est})^2]0.6 / 0.73 \quad \text{(C.7)}$$

D. TRIALS

Trials are only conducted for stock hypotheses A, C and D because stock hypothesis B is implemented by assuming that each group is a single stock, which will lead to the highest risk. The trials for each stock structure hypothesis (Table 5) are based on the *Evaluation Trials* developed for the *Bowhead Implementation* (IWC, 2003). The trials focus on the impacts of three factors: (1) *MSYR*; (2) final need; and (3) data quality (survey bias and the difference between the true and estimated *CV*s). For the trials in which in there is a historical survey bias, the bias mimics the assumption on which the *Bowhead Evaluation Trials* are based, i.e. the bias starts in 1978 and ends in 2002.

D.1 Sensitivity to catch allocation between stocks

In addition to the factors considered during the *Bowhead Implementation*, the trials in Table 5 also explore the sensitivity of the results to the elements of the distribution matrices by considering distribution matrices in which the two stocks are more and less separate (trials BE45 and BE46, see Table 5) as well as trials in which the movement patterns in the spatial separation hypothesis are changed (trial BE49; see Section C of Annex D of SC/59/Rep4 for the rationale for this trial). Trials BE45 and BE46 involve modifying the elements of the distribution matrices using the formula:

$$V_e^{A,m,W/E} = \tilde{V}_e^{A,m,W/E} / \sum_{A'} \tilde{V}_e^{A',m,W/E} \qquad \text{(D.1)}$$

where

$\tilde{V}_e^{A,m,W/E} = \max(V_e^{A,m,W/E} + \gamma[V_e^{A,m,W/E} - \bar{V}_e^{A,m}],0)$,

$\bar{V}_e^{A,m} = \frac{1}{2}\left(V_e^{A,m,W} + V_e^{A,m,E}\right)$, and γ is set to −0.25 for trial BE45 and 0.25 for trial BE46.

D.2 Sensitivity to abundance estimate assumptions

The trials in Table 5 explore the sensitivity to the size of the population at Cape Pe'ek (trials BE41 and BE42) as well as to the split of the total population size at Barrow between the Stocks W and E (trials BE43 and BE44). The only available abundance estimates for Stock W under stock hypotheses B and C are based on counts conducted from Cape Pe'ek on the Chukotka Peninsula in 2000 and 2001. Data for estimating detection probability were not collected. Low and high estimates to the nearest 100 whales are based on analyses of the Cape Pe'ek counts by Melnikov and Zeh (2007). If all passing bowheads are assumed to have been detected, an estimate of 470 with 95% confidence interval 332 to 665 is obtained. Thus, 400, which lies between 332 and 470, is used for the low estimate. If detection probabilities similar to those estimated from the Point Barrow bowhead counts are used, an estimate of around 900 (the base-case value) with upper confidence limit 1,300 is obtained.

The data on absolute abundance at Barrow only pertain to Stock E for stock hypotheses B and C. For these hypotheses therefore, there is no direct information on the productivity of Stock W. The baseline trials assume that the productivity of Stock W is the same as that of Stock E; trials BE47 and BE48 explore the implications of the productivity of Stock W differing from that of Stock E.

Each trial consists of 100 simulations of a 100-year projection period. Trials are run for catch=0, catch=need and catch given by the *Bowhead SLA*.

E. PERFORMANCE STATISTICS

The performance statistics are listed below (N_t^i is number of stock i animals at the start of year t, K^i is the carrying capacity of stock i, $\tilde{N}_t^i$ is number of stock i animals at the start of year t in the absence of exploitation after 2005 and Q_t is subsistence need in year t). The statistic identification numbers are set to those used in developing and evaluating the *Bowhead SLA* (IWC, 2003). Values for the risk and recovery statistics are provided for each stock in multi-stock trials while the catch statistics are based on the total catch from all stocks. Bold numbers indicate those statistics that will primarily be used to evaluate results, although all statistics will be calculated and archived.

E.1 Risk

D1. Final depletion: N_T^i / K^i.

D2. Lowest depletion: $\min(N_t^i / K^i):\ t = 0,1,...,T$.

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

D7. Plots of $\{N_{t[x]}^i$: t = 0,1,..,$T\}$ where $N_{t[x]}^i$ is the x^{th} percentile of the distribution of N_t^i. Results are presented for x = 5 and × = 50.

D8. Rescaled final population: $N_T^i / \tilde{N}_T^i$.

D9. Minimum population level: $\min(N_t^i):\ t = 0,1,...,T$.

D10. Relative increase N_T^i / N_0^i.

E.2 Need

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

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

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

N5. Proportion of block need satisfaction: Γ/(T – h + 1) where Γ is the number of blocks of h years in which the total catch equals 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 x^{th} 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: $\frac{1}{T}\sum_{t=0}^{T-1} \frac{C_t}{Q_t}$

N10. AAV (Average Annual Variation):

$$\sum_{t=-1}^{T-2} \left| C_{t+1} - C_t \right| \ / \ \sum_{t=-1}^{T-2} C_t$$

N11. Anti-curvature: $\frac{1}{T-1} \sum_{t=0}^{T-2} \left| \frac{C_t - M_t}{\max(10, M_t)} \right|$ where

$M_t = (C_{t+1} + C_{t-1}) \ / \ 2$

N12. Mean downstep (or modified AAV):

$$\sum_{t=-1}^{T-2} \left| \min(C_{t+1} - C_t, 0) \right| \ / \ \sum_{t=-1}^{T-2} C_t$$

E.3 Recovery

R1. Relative recovery: $N_{\tilde{t}_r^i}^i / \tilde{N}_{\tilde{t}_r^i}^i$ where $\tilde{t}_r^i$ is the first year in which $\tilde{N}_t^i$ passes through *MSYL*. If $\tilde{N}_t^i$ never reaches MSYL, the statistic is $N_T^i / \tilde{N}_T^i$. If $N_o^i > MSYL$ the statistic is min (1, N_T^i / *MSYL*).

R3. Time frequency in recovered state = (the number of years for which $N_t^i > 0.9\,MSYL$, given that $t \geq t_r^i$)/ $(T - t_r^i + 1)$ where t_r^i is the first year in which the stock i reaches *MSYL* (or T otherwise).

R4. Relative time to recovery:

$$RTR^i = \begin{cases} 1 & \text{if } N_0^i \geq MSYL \\ (T - t_r^i)/T & \text{if } N_0^i < MSYL \text{ and } N_T^i \geq MSYL \\ \min_t (t \mid \tilde{N}_t^i \geq N_T^i)/T & \text{if } N_0^i < MSYL \text{ and } N_T^i < MSYL \end{cases}$$

In addition to the risk, need and recovery statistics, the following four statistics are reported to assist with the interpretation of the plausibility of the trials:

– Minimum population size (by stock) over the pre-management period (1848-2005).
– Slope of a log-regression of the population size at Barrow (see Section B) on year (1978-2001).
– The Bayes Factor comparing the model scenario being investigated with the base-case single stock model (BE01) (with reference to a discrete uniform prior over these two scenarios), i.e.

$$BF_1 = \frac{\exp(-0.5(\ell n\mathbf{N}^{obs} - \ell n(\hat{\mathbf{N}}_M))^T \boldsymbol{\Sigma}^{-1}(\ell n\mathbf{N}^{obs} - \ell n(\hat{\mathbf{N}}_M)))}{\exp(-0.5(\ell n\mathbf{N}^{obs} - \ell n(\hat{\mathbf{N}}_{\mathrm{BE01}}))^T \boldsymbol{\Sigma}^{-1}(\ell n\mathbf{N}^{obs} - \ell n(\hat{\mathbf{N}}_{\mathrm{BE01}})))} \quad \text{(E.1)}$$

where

$\hat{\mathbf{N}}_{\mathrm{M}}$ is the vector of model-predicted abundance estimates corresponding to $\mathbf{N}^{obs}$ for the model scenario being investigated; and

$\hat{\mathbf{N}}_{\mathrm{BE01}}$ is the vector of model-predicted abundance estimates corresponding to $\mathbf{N}^{obs}$ from the single-stock BE01 trial based on the age-structured control program.

– The Bayes Factor comparing the model scenario being investigated with the equivalent single stock model (with reference to a discrete uniform prior over these two scenarios).

$$BF_2 = \frac{\exp(-0.5(\ell n\mathbf{N}^{obs} - \ell n(\hat{\mathbf{N}}_M))^T \boldsymbol{\Sigma}^{-1}(\ell n\mathbf{N}^{obs} - \ell n(\hat{\mathbf{N}}_M)))}{\exp(-0.5(\ell n\mathbf{N}^{obs} - \ell n(\hat{\mathbf{N}}_{\mathrm{SS}}))^T \boldsymbol{\Sigma}^{-1}(\ell n\mathbf{N}^{obs} - \ell n(\hat{\mathbf{N}}_{\mathrm{SS}})))} \quad \text{(E.2)}$$

where

$\hat{\mathbf{N}}_{\mathrm{SS}}$ is the vector of model-predicted abundance estimates corresponding to $\mathbf{N}^{obs}$ for a model that is identical to that underlying the current trial, except that it is based on stock hypothesis A (single stock).

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Table 1

The catch series used when conditioning the operating model.

Year	Catch	Year	Catch	Year	Catch	Year	Catch
1848	18	1888	160	1928	30	1968	27
1849	573	1889	127	1929	30	1969	32
1850	2,067	1890	136	1930	17	1970	48
1851	898	1891	284	1931	32	1971	25
1852	2,709	1892	346	1932	27	1972	44
1853	807	1893	180	1933	21	1973	51
1854	166	1894	234	1934	21	1974	42
1855	2	1895	117	1935	15	1975	32
1856	0	1896	118	1936	24	1976	74
1857	78	1897	130	1937	53	1977	72
1858	461	1898	309	1938	36	1978	15
1859	372	1899	234	1939	18	1979	20
1860	221	1900	148	1940	20	1980	32
1861	306	1901	55	1941	38	1981	26
1862	157	1902	162	1942	26	1982	14
1863	303	1903	116	1943	14	1983	16
1864	434	1904	86	1944	8	1984	16
1865	590	1905	105	1945	23	1985	14
1866	554	1906	69	1946	20	1986	22
1867	599	1907	96	1947	21	1987	29
1868	516	1908	123	1948	8	1988	28
1869	382	1909	61	1949	11	1989	25
1870	637	1910	37	1950	23	1990	41
1871	138	1911	48	1951	23	1991	47
1872	200	1912	39	1952	11	1992	46
1873	147	1913	23	1953	41	1993	51
1874	95	1914	61	1954	9	1994	38
1875	200	1915	23	1955	36	1995	57
1876	76	1916	23	1956	11	1996	44
1877	270	1917	35	1957	5	1997	62
1878	80	1918	27	1958	5	1998	50
1879	266	1919	33	1959	2	1999	48
1880	480	1920	33	1960	33	2000	43
1881	435	1921	9	1961	17	2001	66
1882	242	1922	39	1962	20	2002	45
1883	42	1923	12	1963	15	2003	40
1884	160	1924	41	1964	24	2004	45
1885	377	1925	53	1965	14	2005	66
1886	168	1926	35	1966	24		
1887	240	1927	14	1967	12		

[*Tables on following pages*]

Table 2

The catch mixing matrices.

	Area													
Era Season	SW	SE	H	IW	IE	GW	GE	B	C	D	EF	AW	AE	Total
1848-1868														
Sp-Su	2,000	22	1,698	926	478	2,556	368	688	1,057	12	0	8	0	9,813
Fa-Wi	6	10	10	35	0	496	87	770	600	0	0	4	0	2,018
1869-1888														
Sp-Su	293	0	199	119	112	176	146	147	854	73	0	26	0	2,145
Fa-Wi	0	0	0	40	0	43	19	890	1,363	138	2	155	0	2,650
1889-1919														
Sp-Su	49	10	37	24	244	22	311	0	552	62	999	6	0	2,316
Fa-Wi	0	0	0	37	0	11	0	415	219	22	414	151	0	1,269
1920-1989														
Sp-Su	0	0	0	0	165	0	430	0	932	0	0	0	0	1,527
Fa-Wi	0	0	0	64	0	20	0	0	106	60	1	0	0	251
1990-2005														
Sp-Su	0	0	0	0	78	0	87	0	299	2	0	0	0	466
Fa-Wi	0	0	0	9	21	3	0	0	193	95	2	0	0	323
Total	**2,348**	**42**	**1,944**	**1,254**	**1,098**	**3,327**	**1,448**	**2,910**	**6,175**	**464**	**1,418**	**350**	**0**	**22,778**

Table 3

The breakdown of the catches by month.

	Area													
	SW	SE	H	IW	IE	GW	GE	B	C	D	EF	AW	AE	Total
Era 1 (1848-1868)														
March	0	0	0	0	0	0	0	0	0	0	0	0	0	0
April	18	0	8	0	1	0	0	0	6	0	0	0	0	33
May	593	0	166	16	1	0	0	0	62	0	0	0	0	838
June	1,099	4	854	188	71	337	36	8	3	0	0	0	0	2,600
July	237	12	640	451	184	505	101	134	110	0	0	0	0	2,374
August	53	6	30	271	221	1,714	231	546	876	12	0	8	0	3,968
September	6	6	10	18	0	470	79	661	594	0	0	4	0	1,848
October	0	4	0	8	0	26	8	109	6	0	0	0	0	161
November	0	0	0	9	0	0	0	0	0	0	0	0	0	9
Era 2 (1869-1888)														
March	0	0	0	0	0	0	0	0	0	0	0	0	0	0
April	40	0	13	0	13	0	22	0	13	0	0	0	0	101
May	214	0	76	40	86	26	43	0	131	0	0	0	0	616
June	39	0	110	79	13	97	41	0	6	0	0	0	0	385
July	0	0	0	0	0	53	40	66	112	0	0	0	0	271
August	0	0	0	0	0	0	0	81	592	73	0	26	0	772
September	0	0	0	6	0	6	0	605	1,179	138	2	150	0	2,086
October	0	0	0	5	0	37	19	285	184	0	0	5	0	535
November	0	0	0	29	0	0	0	0	0	0	0	0	0	29
Era 3 (1889-1919)														
March	0	0	0	0	4	0	0	0	0	0	0	0	0	4
April	10	4	6	0	106	0	104	0	45	0	0	0	0	275
May	39	6	31	12	114	4	201	0	458	0	0	0	0	865
June	0	0	0	12	20	18	6	0	25	0	4	0	0	85
July	0	0	0	0	0	0	0	0	4	0	165	0	0	169
August	0	0	0	0	0	0	0	0	20	62	830	6	0	918
September	0	0	0	5	0	6	0	248	134	22	414	110	0	939
October	0	0	0	5	0	5	0	167	85	0	0	41	0	303
November	0	0	0	27	0	0	0	0	0	0	0	0	0	27
Era 4 (1920-1989)														
March	0	0	0	0	4	0	0	0	0	0	0	0	0	4
April	0	0	0	0	109	0	143	0	81	0	0	0	0	333
May	0	0	0	0	52	0	279	0	797	0	0	0	0	1,128
June	0	0	0	0	0	0	8	0	34	0	0	0	0	42
July	0	0	0	0	0	0	0	0	7	0	0	0	0	7
August	0	0	0	0	0	0	0	0	13	0	0	0	0	13
September	0	0	0	9	0	11	0	0	47	45	1	0	0	113
October	0	0	0	9	0	9	0	0	59	15	0	0	0	92
November	0	0	0	46	0	0	0	0	0	0	0	0	0	46
Era 5 (1990-2005)														
March	0	0	0	0	0	0	0	0	0	0	0	0	0	0
April	0	0	0	0	67	0	46	0	49	0	0	0	0	162
May	0	0	0	0	11	0	34	0	239	0	0	0	0	284
June	0	0	0	0	0	0	7	0	10	0	0	0	0	17
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	1	2	0	0	0	3
September	0	0	0	1	0	1	0	0	91	91	2	0	0	186
October	0	0	0	1	0	2	0	0	102	4	0	0	0	109
November	0	0	0	7	21	0	0	0	0	0	0	0	0	28

Table 4

Estimates, CVs (actually the standard errors of the log abundance estimates) and the correlation matrix for the indices of abundance for the B-C-B stock of bowhead whales. Source: Zeh and Punt (2005).

Year	Estimate	CV	Correlation										
1978	4,765	0.305	1.000										
1980	3,885	0.343	0.118	1.000									
1981	4,467	0.273	0.056	0.050	1.000								
1982	7,395	0.281	0.094	0.084	0.035	1.000							
1983	6,573	0.345	0.117	0.104	0.049	0.084	1.000						
1985	5,762	0.253	0.070	0.062	0.020	0.078	0.062	1.000					
1986	8,917	0.215	0.072	0.064	0.017	0.092	0.064	0.113	1.000				
1987	5,298	0.327	0.124	0.110	0.052	0.088	0.110	0.065	0.067	1.000			
1988	6,928	0.12	0.028	0.025	0.013	0.017	0.024	0.009	0.007	0.026	1.000		
1993	8,167	0.071	0.001	0.001	0.001	0.000	0.001	-0.001	-0.002	0.001	0.000	1.000	
2001	10,545	0.128	0.008	0.007	0.005	0.001	0.007	-0.004	-0.008	0.008	0.003	0.000	1.000

Table 5

The *Implementation Review trials* for bowhead whales. The survey frequency is 10 years; all trials are based on a deterministic model; no age data are generated; differences from the base-case are shown in bold. Note that apart from Trial BE49, reference to hypothesis 'B' in the column 'Baseline' is applicable to hypotheses 'B' and 'C' (see Annex D of SC/59/Rep4).

Trial No.	Description	$MSYR_{1+}$	z	Final need	Historical survey bias	Future survey bias	Survey CV (true, est)	Mixing parameter, γ	Baseline
BE01	Base case	2.5%	1.04	134	1	1	0.25, 0.25	0	A, B, D
BE02	Constant need	2.5%	1.04	**67**	1	1	0.25, 0.25	0	A, B, D
BE09	$MSYR_{1+}$ = 1%	**1%**	1.04	134	**0.67 → 1**	1	0.25, 0.25	0	A, B, D
BE10	$MSYR_{1+}$ = 4%	**4%**	**11.22**	134	1	1	0.25, 0.25	0	A, B, D
BE11	Bad data	2.5%	1.04	134	1	**1→1.5 in yr 25**	**0.25, 0.10**	0	A, B, D
BE12	Difficult 1%	**1%**	1.04	134	**1 → 1.5**	**1.5**	**0.25, 0.10**	0	A, B, D
BE13	Difficult 1%; constant need	**1%**	1.04	**67**	**1 → 1.5**	**1.5**	**0.25, 0.10**	0	A, B, D
BE14	Need increases to 201	2.5%	1.04	**201**	1	1	0.25, 0.25	0	A, B, D
BE16	$MSYR_{1+}$ = 1%; 201 need	**1%**	1.04	**201**	**0.67 → 1**	1	0.25, 0.25	0	A, B, D
BE20	$MSYR_{1+}$ = 4%; 201 need	**4%**	**11.22**	**201**	1	1	0.25, 0.25	0	A, B, D
BE41	Cape Pe'ek abundance=400	2.5%	1.04	134	1	1	0.25, 0.25	0	B
BE42	Cape Pe'ek abundance=1,300	2.5%	1.04	134	1	1	0.25, 0.25	0	B
BE43	Barrow Spring W:E ratio=40:60	2.5%	1.04	134	1	1	0.25, 0.25	0	D
BE44	Barrow Spring W:E ratio=60:40	2.5%	1.04	134	1	1	0.25, 0.25	0	D
BE45	Less different mixing	2.5%	1.04	134	1	1	0.25, 0.25	-0.25	B,D
BE46	More different mixing	2.5%	1.04	134	1	1	0.25, 0.25	0.25	B,D
BE47	Stocks have different *MSYR*	**1%(W)**, 2.5%(E)	1.04	134	1	1	0.25, 0.25	0	B
BE48	Stocks have different *MSYR*	**4%(W)**, 2.5%(E)	1.04	134	1	1	0.25, 0.25	0	B
BE49	Coast hugging stock	2.5%	1.04	134	1	1	0.25, 0.25	0	**C**

Appendix 3

TRAJECTORIES PLOTS FOR SELECTED CASES

Graphs are shown for trials BE01 (the base case or reference trial) and trials BE09, 12, 13, 14 and 16, these last 5 trials being selected as those trials showing a final depletion < 0.6 when Catch=Need.

The top 6 plots on each page show results for the trial based on stock structure hypothesis B and also show the A hypothesis results (the single stock model) for comparison.

The 1st graph shows:

Solid black lines: 5% and 50%iles of the distribution of depletion (N_t/K) for the W stock (B hypothesis)

Dotted lines: the depletion trajectories when Catch = 0 and Catch=Need for the W stock (B hypothesis)

Dash-dot lines: 5% and 50%iles of the distribution of depletion (N_t/K) for the A (single) stock hypothesis.

In several instances the lines are on top of each other and so it is not possible to distinguish all the lines on the graph.

The 2nd graph has the same format as the 1st except the solid lines are grey and show the depletion of the E stock.

The 3rd graph shows the population trajectories from 1848 to 2106. The median trajectories are shown from 2006-2106.

Solid black line: W stock (B hypothesis)
Solid grey line: E stock (B hypothesis)
Dash-dot lines: A (single) stock hypothesis.

The 4th and 5th graphs are the same as the 1st and 2nd except the stock sizes are scaled by the population sizes in 2006, instead of by K.

The 6th graph shows:

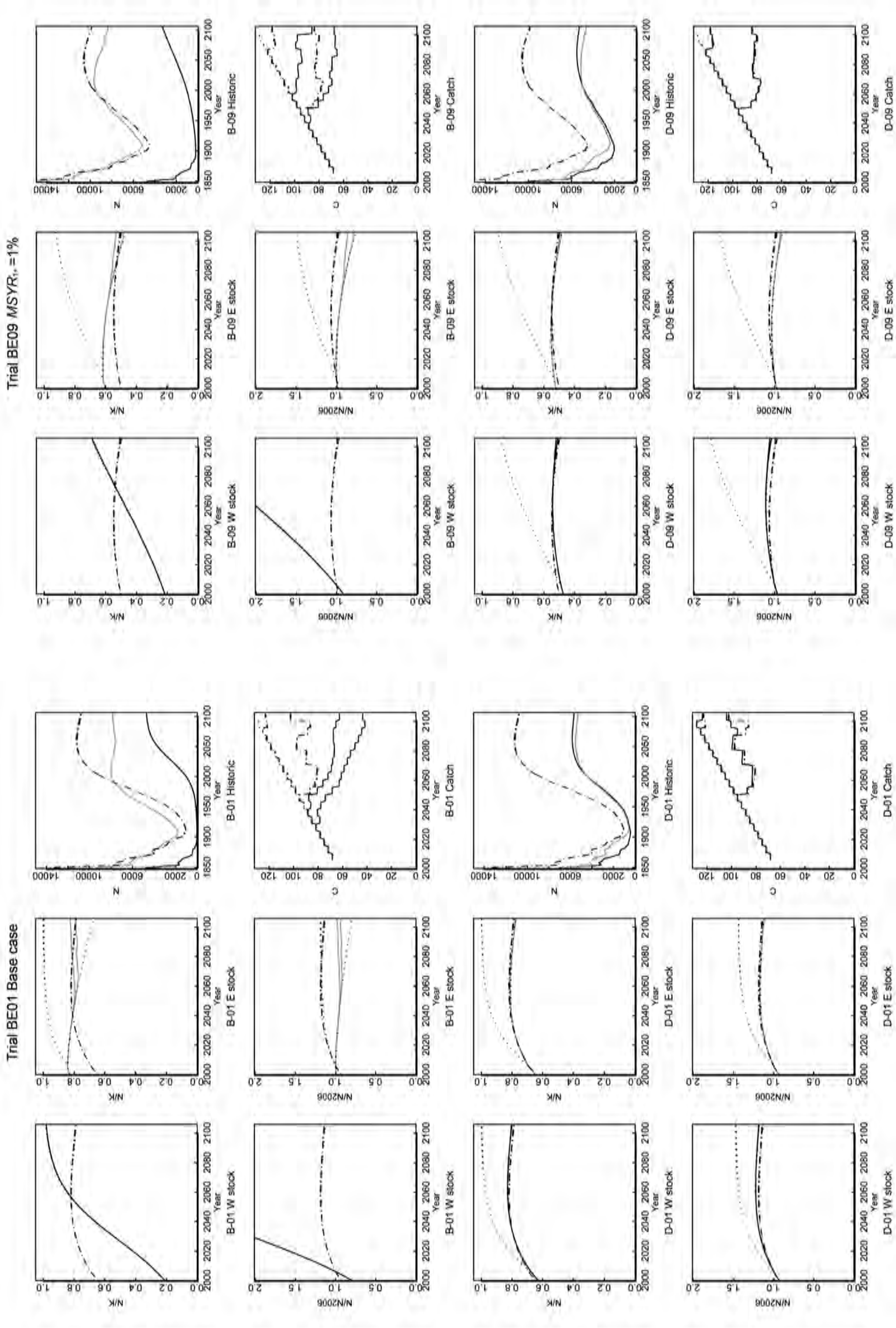
Solid black lines: 5% and 50%iles of the total catch trajectory (B hypothesis)

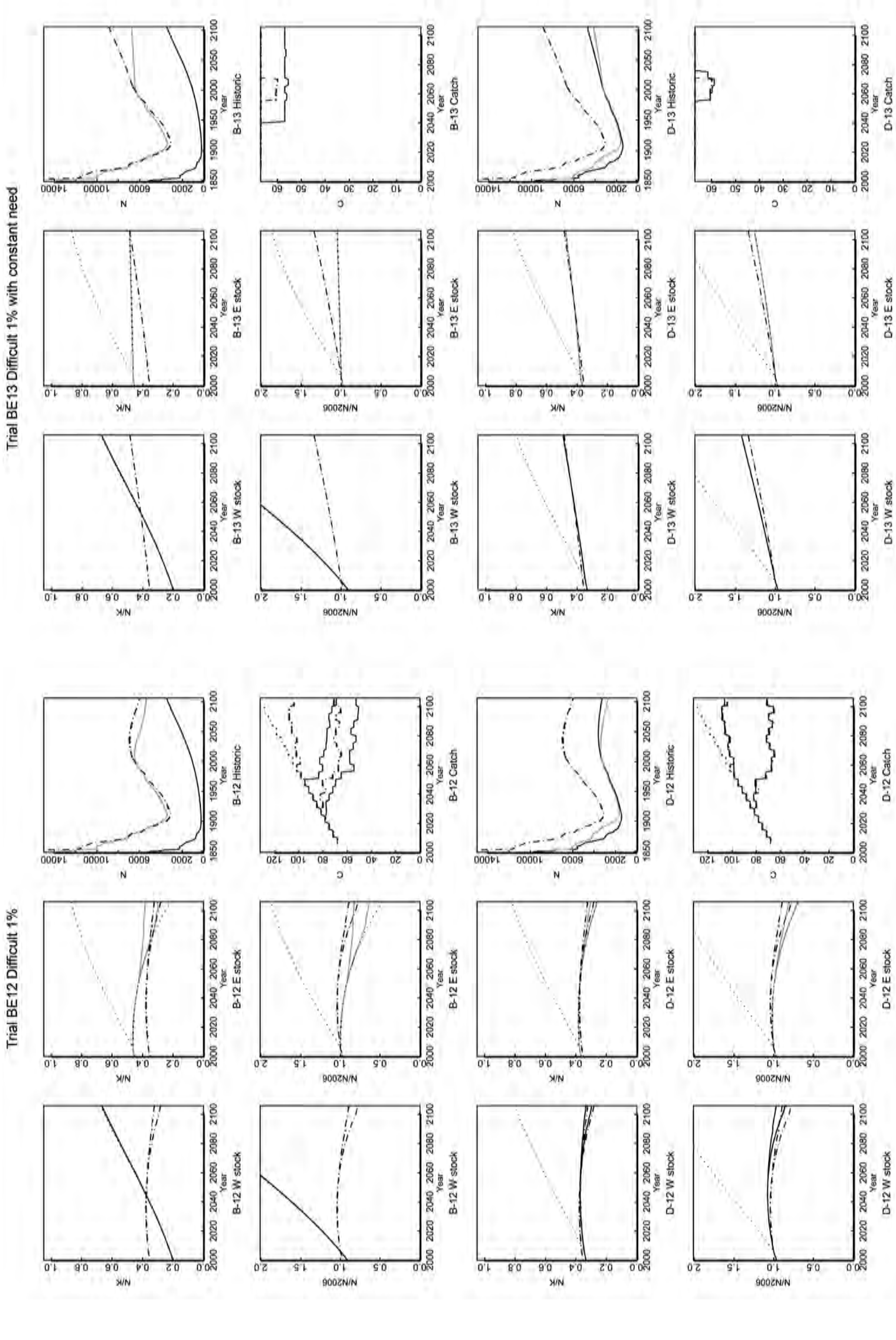
Dotted lines: the Need trajectory

Dash-dot lines: 5% and 50%iles of the total catch trajectory under the A (single) stock hypothesis.

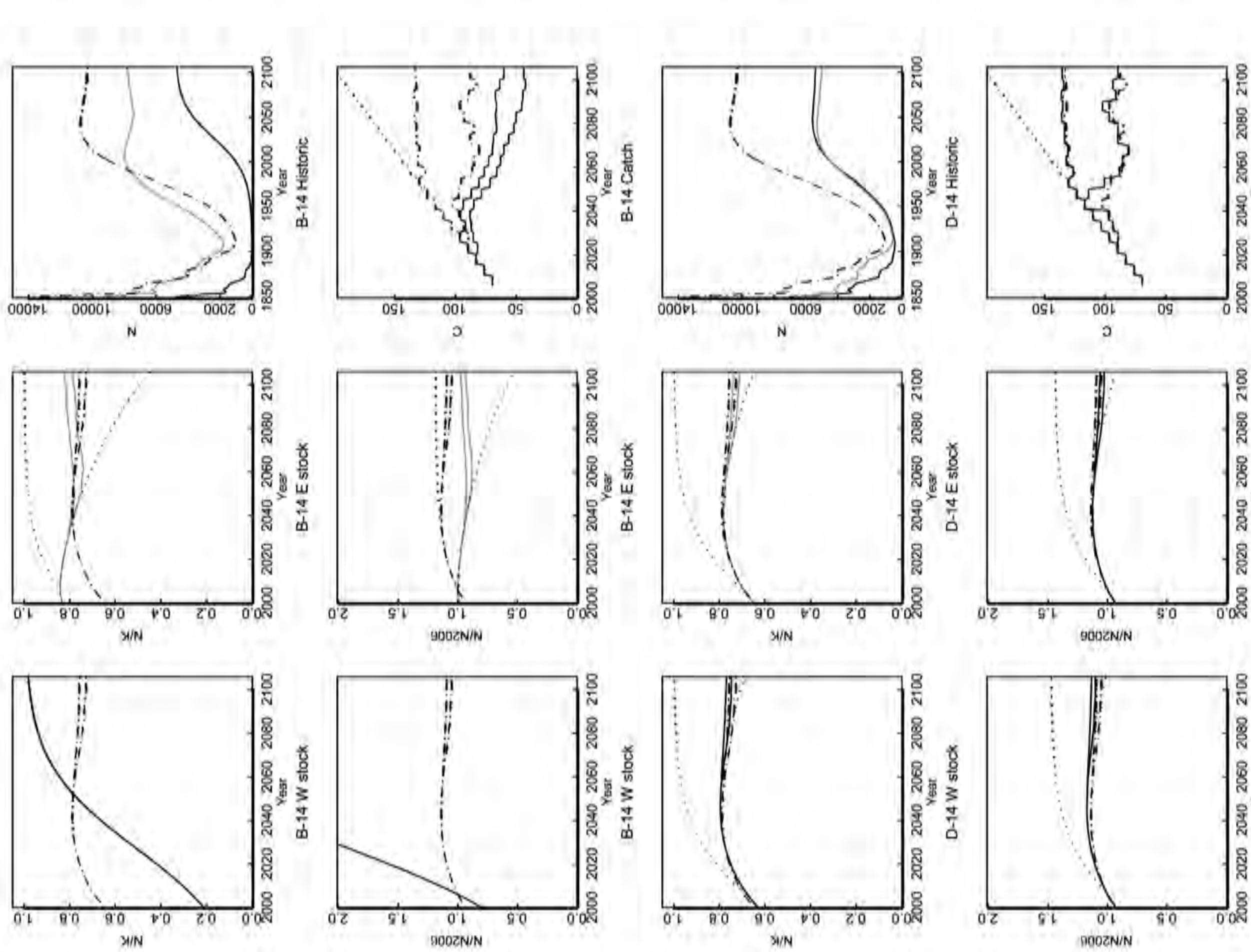
The lower 6 graphs on the page show the same information for stock structure hypothesis D.

Trial No.	Description	$MSYR_{1+}$	z	Final need	Historical survey bias	Future survey bias	Survey CV (true, est)	Baseline
BE01	Base case	2.5%	1.04	134	1	1	0.25, 0.25	A, B, D
BE09	$MSYR_{1+}$ = 1%	**1%**	1.04	134	**0.67 → 1**	1	0.25, 0.25	A, B, D
BE12	Difficult 1%	**1%**	1.04	134	**1 → 1.5**	**1.5**	**0.25, 0.10**	A, B, D
BE13	Difficult 1%; constant need	**1%**	1.04	**67**	**1 → 1.5**	**1.5**	**0.25, 0.10**	A, B, D
BE14	Need increases to 201	2.5%	1.04	**201**	1	1	0.25, 0.25	A, B, D
BE16	$MSYR_{1+}$ = 1%; 201 need	**1%**	1.04	**201**	**0.67 → 1**	1	0.25, 0.25	A, B, D

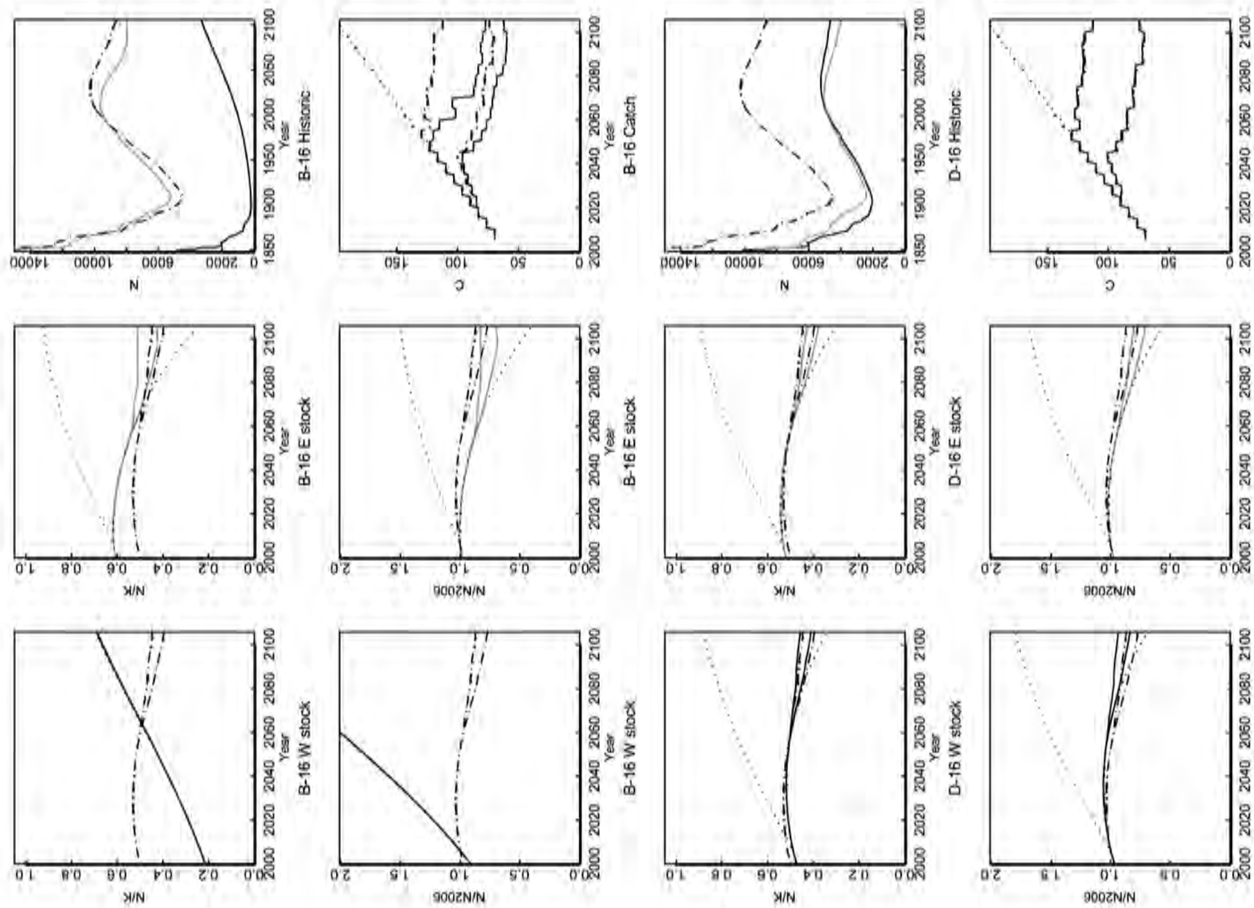

Trial BE01 Base case
Trial BE09 MSYR1+=1%
B-01 W stock
B-01 E stock
B-01 Historic
B-01 Catch
D-01 W stock
D-01 E stock
D-01 Historic
D-01 Catch
B-09 W stock
B-09 E stock
B-09 Historic
B-09 Catch
D-09 W stock
D-09 E stock
D-09 Historic
D-09 Catch
Year
N/K
N/N2006
N
C


Trial BE13 Difficult 1% with constant need
B-13 Historic
B-13 Catch
D-13 Historic
D-13 Catch
B-13 E stock
D-13 E stock
B-13 W stock
D-13 W stock
Trial BE12 Difficult 1%
B-12 Historic
B-12 Catch
D-12 Historic
D-12 Catch
B-12 E stock
D-12 E stock
B-12 W stock
D-12 W stock
N/K
N/N2006
N
C
Year

Trial BE14 Need increases to 201



Trial BE16 $MSYR_{1+}$=1% Need inc to 201



Appendix 4

INVESTIGATION AND IMPLICATIONS OF SPATIAL AND TEMPORAL PATTERNS IN SEX RATIO DATA FROM WEST GREENLAND MINKE WHALE CATCHES

Geof H. Givens, Kristin Laidre, Lars Witting, Doug Butterworth, and Mads-Peter Heide-Jørgensen

The sub-group based its deliberations on the computations set out below, which were carried out by Givens following input from sub-group members.

Data were available on 614 M and 1891 F minke whales caught between 1987 and 2006. The response variable was 1 if the whale was F and 0 if it was M. Predictor variables were Year (treated as a continuous variable and expressed as years since 1986), Month (treated as a factor variable with sum contrasts with April as the reference group), and Region (three regions northwest (NW), central west (CW) and southwest (SW) treated as a factor with CW as the reference group). Observations from January, February, and March (*n*=27) were deleted from the dataset.

We fit a standard logistic regression using the glm() function in R. Month and Year were allowed to interact with Region. Model comparisons were made using the likelihood ratio test. For simplicity, we did not fit an overdispersion parameter, but this should probably be investigated later. There was no significant Region:Month interaction however Region:Year interaction was statistically significant, as summarised below:

Model 1: Sex ~ Region + Year + Month
Model 2: Sex ~ Region + Year + Month + Region:Year

	Resid. Df	Resid. Dev	Df	Deviance	P(>|Chi|)
1	2,466	2,726.69			
2	2,464	2,717.38	2	9.30	0.01

The best model has main effects for Year, Month, and Region, and a Region:Year interaction. Here are the estimated model coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	1.052229	0.389733	2.700	0.00694	**
RegionNW	-0.082884	0.306125	-0.271	0.78658	
RegionSW	1.022538	0.321533	3.180	0.00147	**
Year	0.007525	0.014989	0.502	0.61563	
Month5	0.813130	0.407717	1.994	0.04611	
Month6	0.034720	0.360550	0.096	0.92329	
Month7	-0.137181	0.344401	-0.398	0.69040	
Month8	-0.233195	0.343092	-0.680	0.49670	
Month9	-0.262841	0.344426	-0.763	0.44539	
Month10	-0.023286	0.354193	-0.066	0.94758	
Month11	0.107542	0.420588	0.256	0.79819	
Month12	-0.598873	0.463619	-1.292	0.19645	
RegionNW:Year	0.005175	0.023299	0.222	0.82423	
RegionSW:Year	-0.061949	0.023333	-2.655	0.00793	**

Signif. codes: 0'***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
(Dispersion parameter for binomial family taken to be 1)
Null deviance: 2763.6 on 2477 degrees of freedom
Residual deviance: 2717.4 on 2464 degrees of freedom

These results show that the proportion of females in the SW region (in the observed dataset) has declined as years progress.

We also need to know whether the proportion of sampled animals (in the dataset) has shifted between regions over time. To address this question, we fit another logistic regression. In this model, the response variable was 1 if the animal is from SW and 0 otherwise. The predictor is Year. The results are:

Model 1: SW ~ 1
Model 2: SW ~ Year

	Resid. Df	Resid. Dev	Df	Deviance	P(>|Chi|)
1	2,477	3169.6			
2	2,476	3161.7	1	7.9	0.004924

with coefficients

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-0.379654	0.112044	-3.388	0.000703	***
Year	-0.023976	0.008531	-2.811	0.004945	**

This second analysis shows that sampling effort (for sexed whales in the dataset) has shifted northward as years progress. The analysis results presented above demonstrate that the female ratio in the SW region has declined over time while – simultaneously – sampling has shifted away from SW. These two trends could offset each other, thereby yielding an apparently flat time series of sex ratios that does not fully reflect underlying demography.

Given these results, a small working group considered the options for modifying the modelling and assessment approach to accommodate spatially dependent interannual trends in sex ratios. First, stratification by area was recommended, except that the NW and CW areas should be combined since they show no significant sex ratio differences. Second, the proportion of the catch in each of the three regions was examined with respect to month and year (see Fig. 1). This analysis showed that the monthly distribution of in the two strata (CW+NW and SW) did not vary substantially between the first and second decades represented in this dataset. This supports a decision not to stratify assessment modelling/analyses by month.

However, the analyses conducted here used only the most recent dataset from Greenland (1987-2006). Therefore, the working group made two suggestions about the remaining catch data. First, Cherry Allison should investigate the Norwegian catches to determine if the data suggest a similar spatial division i.e., one area north of, and one other area south of, 63.0 degrees north; if they exhibit a similar Year:Region interaction; and if they exhibit a lack of Month:Region interaction in the catch proportion data (as seen in Fig. 1). Second, the Greenlandic scientists should examine the dataset from the first Greenland fishery period to: (a) determine if the data are of sufficient quality to investigate spatial division, and (b) if they are, examine the same questions recommended for investigation with the Norwegian data. It was noted that population modelling would be simplified if the same spatial division for the later Greenland period could be used for the two earlier periods as well

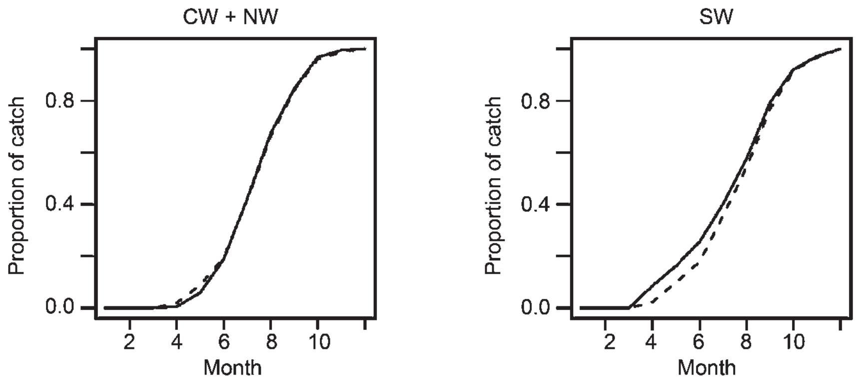


Fig. 1. Proportion of catch by month in NW and CW regions (pooled) and SW separately. Solid lines are catches in 1987-96 and dotted lines are 1997-2006.