Annex E

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

Members: Donovan (Convenor), Allison, Andersen, Breiwick, Butterworth, Cooke, DeMaster, George, Givens, Gunnlaugsson, Holloway, Kingsley, Lovell, Mae, O'Hara, Palsbøll, Pamplin, Postma, Punt, Punnet, Rambally, Suydam, Tanaka, Walløe, Waples, Witting, Yoshida, Zeh.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks

Donovan welcomed the participants to the meeting. He outlined his plans for the two 'pre-meeting' days. These would be dedicated to reviewing the results of the Greenlandic Research Programme, specifically the results of the analyses of 2002 and 2004 aerial digital photo-based strip-width survey for marine mammals off West Greenland.

1.2 Election of Chair

Donovan was elected Chair.

1.3 Appointment of rapporteurs

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

1.4 Adoption of Agenda

The adopted agenda is given as Appendix 1.

1.5 Documents available

The documents available to the SWG were SC/57/AWMP1-7 and SC/57/AWMP9-11.

2. GREENLANDIC FISHERIES AND THE GREENLANDIC RESEARCH PROGRAMME

The primary reasons for the SWG's inability to develop a *Strike Limit Algorithm* (*SLA*) for the Greenlandic fisheries that will satisfy all of the Commission's objectives are the lack of recent abundance estimates and the poor knowledge of stock structure. This caused the Committee to agree to develop a Greenlandic research programme in 1998.

2.1 Review of results from programme

2.1.1 Stock structure, range, movement

2.1.1.1 GENETICS INCLUDING SIMULATION STUDIES

Last year, the SWG **agreed** to a two-step process related to the possible initiation of a large-scale study on migration rates based on assigning individuals to areas. The first of these steps was to conduct simulation studies to determine whether a satisfactory percentage of correctly assigned individuals to the different areas can be obtained for realistic numbers of loci and samples. The Commission funded Palsbøll to conduct these simulation studies and the resultant report is given in SC/57/AWMP11.

Palsbøll summarised the findings from these simulations. The population genetic parameters necessary for the simulations (local levels of genetic diversity and directional rates of gene flow) were estimated from the available genetic data from West Greenland, East Greenland/Iceland, the Barents Sea and the North Sea. Genotypes were simulated from four areas by varying sample sizes, the number of genetic markers, migration rate and population size. These genotypes were then employed to estimate the mean number of immigrants (with a 95% confidence interval) among 500 samples. Given the observed migration rates (and two overlapping generations) and applying a 0.99 assignment criterion, 75 genetic microsatellite-like markers would be required to detect at least 2.4 (95% CI; 0-6; if abundance was 16,000) to 32 (95% CI 22-43; abundance of 2,400) immigrants. The proportion of individuals that could be assigned successfully from the simulations based on 16 simulated genetic markers yielded a lower proportion of correctly assigned individuals (15% with a 0.95 criterion) than estimated from the observed data (40%), suggesting that the realised rate of gene flow may be smaller than that estimated from the genetic data. Simulations revealed that a rate of gene flow at 25% of the estimated population size yielded the observed proportion of correct assignments (40%). Although the statistical power to assign individuals increases with lower rates of gene flow, fewer migrants are expected among a random sample of 500 individuals. Only with the lowest levels of abundance (2,400) and a high proportion of successful assignments (75%-100%) is it expected that there will be successful detection of migrants among a sample of 500. Palsbøll mentioned that the analytical approach which was employed to estimate the rates of gene flow was unable to finalise the estimation and thus the estimates may be biased to an unknown extent. Palsbøll also pointed out that the low degree of genetic divergence observed among populations could also be due to recent population divergence (e.g. after the last glacial maximum) and little or zero current gene flow.

The SWG welcomed this report and discussed its implications in the overall context of the value of various genetic approaches in addressing issues related to providing management advice and an *SLA* for common minke whales (*Balaenoptera acutorostrata*) off West Greenland, particularly in light of the preliminary (and subsequently not accepted) estimate of abundance derived from the photographic survey (see Item 2.1.2.2). The SWG **agreed** that the currently available data had low power to reject any West Greenland samples as belonging to the putative West Greenland population (Appendix 2). Furthermore, the interpretation of any estimates of the number of migrants in the West Greenland population depends on whether such migrants become 'part' of this population or whether they return to their population of birth.

The SWG noted that the total geographical area occupied by common minke whales harvested off West Greenland during summer is largely unknown and that surveys consequently cover an unknown fraction of the range of the stock. Given this, and the likely low power to estimate the number of migrants, the SWG **agreed** that the most valuable contribution of genetic methods would be if they could provide a lower bound for the size of the West Greenland population (or rather the population or populations potentially available to be hunted in West Greenland), which could then be compared with estimates from sightings surveys and lower bounds from population models where total abundance may be estimated from the sex ratio of the hunt (see Item 3.1). Such genetic estimates would provide valuable independent estimates of abundance (which would be valuable even if only a lower bound can be estimated).

The SWG therefore **recommended** that an assessment of the statistical power of various genetic approaches to estimate abundance be conducted intersessionally and presented to the 2006 meeting of the Scientific Committee. This assessment should be based on a range of population abundances. Palsbøll, Skaug and Waples agreed to carry out an assessment of the statistical power of four different approaches (Table 1) that use genetic data to infer abundance (either census population size or effective population size) given a realistic range of sample sizes and genetic markers (Appendix 3). Witting and Punt agreed to provide the range of abundances needed for this calculation.

Table 1

Estimators to be examined.

Reference	Basis
Estimator of census population size	
Skaug (2001)	Based on the fraction of close relatives (1st and 2nd order relatives) in a random population sample.
Pearse *et al.* (2001)	Based on 'gametic' mark-capture-recaptures of males.
Estimator of effective population size	
Waples (1991)	Based on the degree of linkage disequilibrium.
Waples (1989)	Based on the temporal shift in allele frequencies.

For these analyses, in addition to the genetic information, the following data are required for each sample: sex; location and date of capture; an indication of age (e.g. length).

The SWG noted that these estimators provide estimates of current and effective population size. An estimate of the effective population size in a baleen whale, which could be compared to an estimate of the census population size, would also be of considerable value given recent controversial (see IWC, 2005, pp.32-4) genetic estimates of the historic abundances of common minke, fin (*B. physalus*) and humpback whales (*Megaptera novaeangliae*) by Roman and Palumbi (2003) in which this (unknown) parameter was used.

Genetic analyses of West Greenland fin whales have been undertaken by Danielsdóttir and colleagues using both allozymes and microsatellite loci (e.g. SC/57/PFI4). These studies revealed some degree of genetic heterogeneity between West Greenland and Canada as well as Iceland. Another study by Bérubé *et al.* (1998) used microsatellites as well as mitochondrial control region sequences and failed to detect any significant heterogeneity between samples from West Greenland and those collected from adjacent areas. The difference in results between the two sets of studies is surprising given that the study by Bérubé *et al.* (1998) is based on substantially larger sample sizes for the western North Atlantic than those of Danielsdóttir and the number of loci is similar (7 versus 9). Palsbøll noted that comparison of the actual F_{st} values (i.e. the degree of precision) may reveal that they are not statistically different. The present genetic information available is insufficient to determine whether the animals found off West Greenland comprised the total population or are part of a larger population.

2.1.1.2 CATCH DISTRIBUTIONS

SC/57/AWMP10 reported analyses of the distribution of takes of fin and common minke whales in the West Greenland fishery from hunter reports received from 1990 to 2004. Takes of both species were strongly clumped, apparently in the neighbourhood of larger communities. Fin whales were clumped into three groups: north, near Aasiaat and Kangaatsiaq, central, between Nuuk and Maniitsoq, and south, near Qaqortoq. Common minke whale catches were also aggregated near communities, but into more groups and with less clear boundaries. There was evidence of seasonality in the distribution of catches. For fin whales, there appeared to be more catches early in the year in the northernmost group; for common minke whales, the catch season was shorter further north. The sex ratio of common minke whale catches for each reporting community varied from year to year. Overall there was some indication that the sex ratio of caught common minke whales changed slightly with latitude, with a higher proportion of males further north. Overall, the sex ratio for the catch in West Greenland was constant over the period from 1990-2004 at about 76% female[1]. Both the fin whale and common minke whale fisheries were near to the shore, or inside the fjords, although fin whales in the central group, between Nuuk and Maniitsoq, had a somewhat more offshore distribution on the eastern (inshore) edge of the Sukkertoppen Deep.

The results in SC/57/AWMP10 do not suggest marked differences in the sex ratio of the catch along the west coast of Greenland. However, there is some evidence that the sex ratio of the catch differs somewhat among communities. The SWG noted that conclusions regarding any spatial aspect to the sex ratio of the catches depended critically on whether hunters are able to correctly sex caught animals. Witting noted that there may be some errors when assigning sex to the catch, but that estimates of sex ratio by hunters and biologists are similar when comparisons have been made. The SWG **recommended** that if sex ratio data are to be used as the basis of assessments/management advice or for a future *SLA*, genetic methods should be used to determine sex (see Item 3).

[1] Sex data first became available in 1955, although in many years there were relatively high proportions of animals of unknown sex recorded. Over the period 1955-2004, the percentage of females in the catch (excluding animals of unknown sex) has almost always been over 60% with an overall (simple) average of about 72% (from data in Appendix 7).

2.1.2 Abundance and trends

A summary of information on recent abundance estimates is given in Appendix 7.

2.1.2.1 METHODS

SC/57/AWMP1 used sequences of images of surfacing common minke whales taken during an aerial survey in Faxaflói, Iceland in 2003 to estimate the average time period during which a surfacing common minke whale can be identified on an image. The author estimated this to be 7.2sec (SE=0.07), for the type of digital images that were taken during the West Greenland surveys in 2002 and 2004. When the estimated time period is multiplied by an independent estimate of surfacing frequency, common minke whales are estimated to be available approximately 11% of the time for identification on aerial images.

For the reasons given below, the SWG revised these estimates.

There was some discussion as to how these data might best be analysed in the longer term, such as developing parametric models of the sequence of events during surfacing, with estimation taking into account the left- and right-censored nature of the data. However, the SWG agreed to focus primarily on whether modifications could be made to the approach in SC/57/AWMP1 that might allow the immediate provision of an improved estimate with a more appropriate standard error.

To this end, the SWG appointed a Working Group to recompute surfacing time for common minke whales (and its associated standard error) in terms of the revised methodology suggested. The Working Group's report, which includes details of this methodology, is given as Appendix 4. The SWG **agreed** to the estimated average surfacing time, as measured from 'emerging' to 'vanishing', of 6.90sec (CV=0.052) presented in the Appendix. It noted that this estimate is probably negatively biased because the measurement is taken from some time during the process of the whale appearing to some instant during the process of its vanishing, instead of from the respective exact start and finish times. A positively biased estimate is provided by measuring from the 'not appeared' to the 'gone' states, and yields 9.24sec. However, the SWG considered that the true value would be much closer to 6.90 rather than 9.24sec, as the processes of appearing and vanishing would both be of rather short duration.

SC/57/AWMP2 analysed several aspects of aerial digital photo based strip-transect surveys for common minke whales and found that nearly all the common minke whales that were surfacing within the photo-frame were photographed when pictures were taken every 2.6 sec. This percentage dropped linearly from 85% to 21% when pictures were taken every 5.2sec to every 13sec. SC/57/AWMP2 also found that the proportion of common minke whales that were identified during a single reading of non-overlapping images was 0.85 and that the distributions of perpendicular distances to whales identified on the images did not differ significantly from uniform. The author believed that this confirmed that strip-transect analysis can be applied to aerial photo surveys for common minke whales, and that the distribution of perpendicular distances for surfacing whales identified during the reading process did not differ significantly from the perpendicular distances for the true distribution of surfacing common minke whales, indicating that the image reading process does not induced a bias to the distribution of perpendicular distances.

In the discussion that followed, Witting clarified that most of the factors examined had been with a view towards no more than qualitative confirmation that the method was viable. The only result from the experiment off Iceland intended for use in estimating abundances from the surveys off West Greenland was for the proportion of whales on the photographic images that were missed by readers. The Working Group stressed the need to reconsider the method used to estimate the variance of this proportion. Some concerns were also expressed about the reliability of using estimates obtained for one area and set of conditions for a different area and conditions. Aspects of this analysis and conclusions are considered further in Appendix 5 (and see Item 2.1.2.2).

2.1.2.2 2004 PHOTOGRAPHIC SURVEY

SC/57/AWMP3 described the results from an aerial digital photo-based strip-transect survey for marine mammals off West Greenland that was carried out over a total of 4.5 months in the late summer and autumn of 2002 and 2004. The total block area of the survey was 290,000km^2, with 3.7% of the area covered by images taken at sea state three or less. Sightings included two common minke whales, three humpback whales, seven fin whales, and 1,366 harp seals. Uncorrected estimates of animals at the surface were found to be 46 (CV=0.74) common minke whales, 100 (CV=0.64) humpback whales, 250 (CV=0.48) fin whales, and 33,000 (CV=0.22) harp seals. Correcting the common minke whale estimate for whales missed by observers and for animals not at the surface gives an estimate of 510 (CV=0.75) whales, which is significantly smaller than the revised estimate of 6,390 (CV=0.41) whales in 1993 (Hedley *et al.*, 1997). Correcting the fin whale estimate for animals not at the surface gives an estimate of 980 (CV=0.48) whales, which is similar to an estimate of 1,100 (95% CI=520-2,100) whales in 1987-88 (IWC, 1992). A rough correction of the humpback estimate for animals not at the surface suggests an abundance of approximately 400 whales, which is similar to a mark-recapture estimate of 359 (CV=0.08) animals for 1988-1993 (Larsen and Hammond, 2004).

For the reasons given below the SWG did not accept these estimates.

There was considerable discussion of the methods used to obtain these abundance estimates, and in particular the protocols that had been followed to examine the photographs and develop correction factors. Of particular concern were: (1) clarification of the procedures used to exclude portions of the photographic images on which it would not be possible to identify a whale, even if present, from the estimated overall area covered by the photographs; and (2) the possibility of whales, especially common minke whales being overlooked (only one common minke whale was seen in 2002 and one in 2004 in around 67hr of effort; during those seasons 139 and 172 whales were taken by hunters).

Two small Working Groups were established to review methodological considerations associated with these abundance estimates further: one examining aspects of the examination of the photographs; and the other the surfacing rate used to correct abundance estimates from both cue-counting and photographic surveys.

The first group focussed on developing recommendations on the best protocol for examination of photographs to determine (a) the number of whales of a given species seen on the photographic images, (b) the probability of readers missing a whale on an image and (c) the area covered by the photographs after excluding those parts of photographs on which it would not be possible to identify a whale if present. The Working Group's report is provided as Appendix 5.

Discussion of the Working Group's report focused on whether following the protocol described in Appendix 5 would lead to appreciable improvements in the estimates from the 2002-04 West Greenland aerial surveys, given the very small numbers of whales currently identified on the photographs (two common minke, three humpback and seven fin whales). The SWG recognised that the method used would not require as many whale observations as distance based methods to attain the same level of precision, as it does not require estimation of an effective size (e.g. effective search half-width for line transects) from the data to obtain the area searched.

The SWG noted that following the protocol will give more confidence in the number of whales identified on the images and the estimate of the area covered by the photographs. However, unless there are appreciably more sightings, in particular of common minke whales, abundance estimates based on only a few more identified whale images on the photographs would constitute enormous extrapolations and probably be considered unacceptable. It noted that given the different sizes of common minke and fin whales, it believed that the problem of readers missing whales was greater for common minke whales.

The SWG **agreed** that the protocol developed in Appendix 5 represented the most appropriate way to thoroughly analyse the photographs and to arrive at the most reliable abundance estimate from the survey. It **recommends** that this procedure be undertaken whilst recognising that even if this is done, it might be impossible to arrive at acceptable abundance estimates. This is discussed further under Item 3.2.

The second Working Group was asked to review the surfacing rate estimate used to correct abundance estimates for West Greenland common minke whales both with respect to photographic and cue-counting surveys. SC/57/AWMP3 had used the value of 53 surfacings hour^{-1} with no associated variance used previously by the Committee and in conformity with corrections previously applied to visual aerial surveys. The report of this Working Group is provided as Appendix 6.

The SWG discussed whether estimates of surfacing rates should be based on data only for the area to which they will be applied. There was general agreement that this was the case, providing sufficient data are available. However, it was noted that when there are few data, there is great value in using comparable data for other areas.

Appendix 6 summarises information on surfacing rates for common minke whales in the Northern Hemisphere and provides an estimate of 49.2 surfacings hour^{-1} for use when estimating abundance using cue counting and aerial digital photo-based strip-transect surveys for common minke whales off West Greenland. There was considerable discussion in the Working Group as to the appropriate way to quantify uncertainty from quite different studies. The SWG did not view the estimate of 49.2 surfacings hour^{-1} as a universal estimate of the surfacing rate of North Atlantic common minke whales. It agreed that since the surfacing rate would vary among studies, the standard deviation should be used (SD=8.4) rather than the standard error. The SWG noted that the data from Stern (1992) was based on a different platform (a 5m *Boston Whaler*) and on common minke whales in a different ocean than the remaining data. The surfacing rate estimate from Stern (1992) is among the lowest of those listed in Appendix 6. However, the SWG had no strong evidence to reject this estimate.

The SWG **agreed** that the surfacing rate (and standard deviation) in Appendix 6 was sufficient for use at this meeting. However, it also **recommended** that if possible, the original data on which the estimate is based (and any other data on surfacing rates for common minke whales in the Northern Hemisphere) should be obtained and re-analysed to determine the various components of variance and hence the most appropriate measure of variance of surfacing rate to be used when estimating abundance. It was noted that information on animal behaviour during the monitoring period should also be examined to see if it might explain some of the variation in surfacing rates. The SWG had not had time to thoroughly review the basis for the estimated correction factor used in SC/57/AWMP3 for fin whales. It also **recommended** that this be reviewed, updated and re-analysed as possible. The SWG therefore established an intersessional working group under Kingsley (Skaug, Cooke, Witting, Øien, Gunnlaugsson) to obtain and examine the available data for fin and common minke whales with a view to providing the SWG with appropriate estimates (including variance) at the next annual meeting.

It was noted that one member of the small group had considered that for surveys carried out in the same area, uncertainty and variability in surfacing behaviour would constitute a fully correlated variation. There was no time to discuss this and it was referred to the intersessional e-mail group.

2.2 Preliminary consideration of management procedures

SC/57/AWMP6 outlines a multi-stock age- and sex-structured population dynamics model that allows for dispersal among putative populations. This model could form the basis of an operating model to evaluate candidate *SLA*s for common minke whales off West Greenland. It is parameterised in terms of values for biological parameters, the rate of dispersal among populations, the carrying capacity of all populations combined, and the fraction of the total that each population constituted of the total prior to the start of exploitation. The values for these parameters are estimated using the 'backwards' approach to Bayesian assessment, implemented using the SIR algorithm.

The approach of SC/57/AWMP6 was developed as a potential operating model and hence explicitly models regions other than West Greenland. This is somewhat different from SC/57/AWMP4 that has no explicit geographical structure but attempts to estimate the fraction of the West Greenland stock that is found in a larger area than just West Greenland. This is because the model in SC/57/AWMP6 attempts to mimic the actual situation in the North Atlantic. The SWG welcomed this paper that will prove valuable in its attempt to develop an *SLA* for the Greenlandic fisheries.

3. MANAGEMENT ADVICE FOR COMMON MINKE AND FIN WHALES OFF GREENLAND

3.1 Catches

SC/57/AWMP3, 4 and 10 presented information on catches and the complete catch history is given in Appendix 7. Catches of common minke whales from West Greenland in 2004 were 44 males, 129 females and 2 of unknown sex (4 additional animals were struck and lost). Catches of fin whales were 5 males and 6 females (2 additional animals were struck and lost). In 2003 the equivalent catches were 58 males, 117 females (7 additional animals struck and lost) for common minke whales and 2 males, 4 females (2 additional animals were struck and lost) for fin whales.

3.2 Assessment

SC/57/AWMP4 provided a Bayesian assessment for the common minke whale stock of the West Greenland fishery. The fraction of females in the West Greenland catch has remained around 0.72 since the beginning of the hunt in 1948. This fraction is incompatible with abundance estimates from aerial surveys if West Greenland common minke whales comprise a single stock. It was shown that there is no conflict between the historical catches and the abundance estimates if West Greenland common minke whales are a subcomponent of a larger stock and the dispersal of whales into the West Greenland area is sex-specific or the catches are sex-selective. This model was used in a Bayesian assessment to estimate the abundance and status of the overall stock that supplies the West Greenland hunt, applying a likelihood penalty that reflects a diminishing return in log-likelihood with equilibrium abundance. This penalty was used as a tuning parameter to set upper limits on the equilibrium abundance, and it was illustrated that a 30% return tuning is likely to result in a somewhat conservative assessment. This tuning estimates an equilibrium abundance of 17,500 (95% CI=13,700-21,800) individuals, a current depletion of 0.92 (95% CI=0.79-0.96), and a maximum sustainable yield rate of 0.09 (95% CI=0.04-0.10). While there was no evidence that a West Greenland harvest at current levels poses a threat to the overall stock for tuning levels between 10% and 50% return, the proposed assessment will not necessarily identify local depletion in West Greenland.

SC/57/AWMP5 provided a Bayesian assessment for West Greenland fin whales, using the historical catches and three abundance estimates from 1988 to 2003 in an age- and sex-structured population dynamics model. The model assumes density-regulated dynamics, and a population in dynamic equilibrium in 1922. It projects the population from 1922 to 2015 under the influence of the historical catches. Over the simulated period, the yearly production reached a maximum of 64 (CI=35-126) individuals in 1931, and the production in 2005 was estimated to be 12 (CI=11-17) individuals. The equilibrium abundance was estimated at 2,250 (CI=1020-7480) individuals, with a minimum depletion of 0.75 (CI=0.33-0.95) in 1938, and a 2005-abundance that is close to equilibrium, the estimated depletion being 0.96 (CI=0.43-0.99). Given the data and the model, the probability of meeting aboriginal subsistence whaling-like management objectives over the period from 2005 to 2010 was estimated to be 0.92 for annual catches equal to the current quota (19 whales) and to be 0.97 for annual catches of ten whales, which is the average annual catch between 2000 and 2004.

In addition to these papers, Punt summarised the implications of some preliminary work he had carried out involving the application of a Schaefer production model to fin and common minke whales assuming that the common minke whales in the survey area comprise a single stock. The results for common minke whales suggest that the estimates of stock status are highly sensitive to assumptions regarding the CV for the 2003 abundance estimate. The results for fin whales suggest that the data are uninformative about key model outputs such as *Maximum Sustainable Yield Rate* (*MSYR*), current depletion and current replacement yield and that Bayesian analyses for fin whales are very sensitive to the priors selected for the parameters of the model, particularly that specified for the extent of additional variance.

In reviewing the above approaches, the SWG made the following observations.

(1) The results of the Bayesian analyses are very sensitive to choices of priors, specifically the upper bounds for the priors for *MSYR* and the extent of additional variance for the survey estimates of abundance.
(2) The high values for the extent of additional variance imply that the model assigns little weight to the estimates of abundance. The results are therefore determined primarily by the assumed prior distributions and in the case of SC/57/AWMP4, the sex ratio data.
(3) The realised priors for some model parameters in Bayesian analyses differ substantially from the specified priors owing to the impact of the constraints imposed by the model structure. A low information content of the data implies that these constraints are the key reason why the posteriors for some parameters such as *MSYR* differ from the specified priors.
(4) The approach used in SC/57/AWMP4 to make use of the data on the sex ratio of the catch has the potential to determine a lower bound for the abundance of the total stock (rather than just that component that feeds off West Greenland). However, at present, the fits to the data on sex ratio are poor.
(5) The penalty imposed on equilibrium abundance in SC/57/AWMP4 is highly influential, including on the lower bound of equilibrium abundance and *MSYR*, but the tuning levels are essentially arbitrary.
(6) The production model assessments assume that the estimates of abundance pertain to absolute population size although this assumption is likely to be invalid to some (possibly substantial) extent.
(7) In the case of the fin whale assessment, the posterior median time trajectory of 1+ abundance did not correspond well to the observed estimates of abundance.

The SWG recognised the considerable effort expended by the authors in attempting to provide assessments for common minke and fin whales off West Greenland. However, it **agreed** that in the light of the observations listed above, none of the preliminary assessments can be used as the basis for management advice.

Recognising that the consistently skewed sex ratio in the West Greenland common minke whale catches (see Item 2.1 and Appendix 7) is a conspicuous feature of the fishery, the SWG **agreed** that the sex-ratio data should be incorporated into future attempts at assessments because they can in principle provide information about the lower bound for the total abundance of the stock. However, any assessment based on these data must examine the sensitivity of the results to assumptions associated with their inclusion, including sensitivity to: (1) the assumption that the catch is taken uniformly from all age-classes greater than age one; (2) the assumption that there have been no changes in sex selectivity over time; and (3) the form of the likelihood function for the sex ratio data. The SWG **agreed** that it might be valuable to base future preliminary assessments for common minke whales off West Greenland on maximum likelihood methods because they are not affected by the choice of priors. The SWG established an intersessional Working Group comprising Witting (Chair), Punt, Cooke, Butterworth, Donovan and Givens to develop and undertake appropriate analyses related to the inclusion of sex ratio data in assessments and hence to determining a lower bound for the abundance of the stock as soon as possible. The group should also consider similar issues for fin whales.

3.3 Management advice

3.3.1 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. This is the reason the Committee first called for the Greenland Research Programme in 1998.

Despite receiving preliminary estimates of abundance from a photographic survey carried out in 2002 and 2004, the SWG **agreed** that, once again, it is in the deeply unfortunate position of being unable to provide satisfactory management advice on safe catch limits; **it views this as a matter of great concern**. The present uncertainties over the preliminary abundance estimates are such that the SWG does not consider them acceptable estimates. Although it has suggested further work with respect to the data collected on the photographic surveys, it cautions that there is no guarantee that this further work will result in significantly greater values, or, in the case of common minke whales, an agreed estimate.

3.3.2 Common minke whales

Taken at face value, the preliminary estimate of abundance for common minke whales suggests that about a 90% decline has occurred since the previous survey in 1993. However, the SWG has considerable doubts over this estimate (see Item 2.1.2.1) and there are several indications that such a decline has probably not occurred (e.g. the consistently high predominance of females in the catch suggests that the abundance estimate does not represent the total number of animals available to the fishery). Nonetheless, the SWG **urged that considerable caution be exercised in setting catch limits for this fishery** because it has no scientific basis for providing advice on safe catch limits.

Given this, the SWG **strongly recommended** that a re-examination of the existing photographs be undertaken as a matter of urgency, according to the protocols given in Appendix 5. It also **strongly recommended** that preparations be made to carry out a cue-counting survey in the summer of 2006 targeted especially at common minke whales so that if the intersessional group overseeing the re-examination of the photographs concludes that this will not result in an acceptable estimate, a survey can be carried out. The SWG recognises that the prevailing weather conditions in Greenland mean that there is no guarantee that a survey will result in sufficient coverage to allow an abundance estimate to be obtained in any one survey.

The SWG also **strongly recommends** that the sex ratio data be fully investigated *inter alia* to determine whether it can be used to obtain at least a minimum estimate for the total stock and be incorporated into an assessment model (see Item 3.2).

3.3.3 Fin whales

Last year, the Committee had expressed special concern over the absence of an abundance estimate for fin whales since 1987/88 and had advised that in the absence of an agreed abundance estimate for fin whales from the 2004 survey, it would likely recommend that the take of fin whales of West Greenland be reduced or eliminated. This year the SWG received a preliminary estimate (that was not considered acceptable, see Item 2.1.2.1 and the **recommendation** for reanalysis of the photographs given above) from the photographic surveys that was not appreciably different from the previously accepted estimate. Despite the fact that the SWG has more confidence in this preliminary estimate than it has for the common minke whale estimate (see Item 2.1.2.1), the SWG is not in a position to provide satisfactory management advice on safe catch limits. It therefore **urged that considerable caution be exercised in setting catch limits for this fishery**. As interim *ad hoc* advice, the SWG suggested that a take of 4-10 animals (approximately 1% of the lower 5th percentile and of the mean of the most recent estimates of abundance) annually was unlikely to harm the stock in the short-term, particularly since this does not take into account the possibility that the fin whale stock extends beyond West Greenland (see Item 2.1.1.1). One member noted that observations of increase rates of fin whales may be appreciably higher than 1% (Gunnlaugsson, 2004; Branch and Butterworth, 2001; Gunnlaugsson, 2003; Butterworth and Cunningham, 2000; Pike *et al.*, 2004). However, the data for West Greenland provide no information on trends in abundance in that region.

3.3.4 Other research recommendations

Last year, the Committee repeated its strong recommendation that samples for genetic analysis be collected from the catch as a matter of high priority and urged the Committee to encourage the Government of Denmark and the Greenland Home Rule authorities to assist with logistical and if necessary, financial support. The SWG **repeated** its recommendation this year and was pleased to be informed that 103 common minke whale samples, 8 fin whale samples and 4 samples of unknown species had been collected last year. The SWG strongly **recommended** that these samples be analysed in accordance with the advice of the intersessional working group on genetics established under Item 2.

The SWG reiterated its **great concern** at its continued lack of ability to provide management advice on these stocks, with serious implications for both the hunt and for the stocks involved. It **strongly urged** the relevant authorities to provide the necessary funds to allow all of the research recommendations given under Items 3.3.2, 3.3.3 and 3.3.4 to be carried out.

4. PREPARATION FOR A BOWHEAD WHALE *IMPLEMENTATION REVIEW*

The SWG discussed planning for the 2007 *Implementation Review* for the Bering-Chukchi-Beaufort Seas bowhead whales. The purpose of an *Implementation Review* is to determine whether any new information that has become available indicates that the present situation is outside the region of parameter space tested during *SLA* development. If this is the case, additional trials would be developed to test the performance of the *SLA* in this new region. If performance is found to be unacceptable under these new trials, revisions to the *SLA* will be required. In the case of the bowhead whale, a variety of new hypotheses concerning genetic population structure have been developed that have implications for management. Although there is little firm basis yet for assessing the plausibility of these hypotheses, they represent an untested region of parameter space. There is no new evidence that any other biological or demographic factors lie outside the region previously tested.

The SWG emphasised that *Implementation Reviews* are scheduled to occur every five years irrespective of whether that coincides with the year in which the Commission sets catch limits although they happen to coincide for the bowhead whale in this instance. The questions regarding stock substructure noted above have stimulated considerable relevant research (see Annex F). The resulting data collection and analyses are expected to be completed in time for formulating management advice in 2007. Therefore, the SWG **agreed** to aim to complete the *Implementation Review* at the 2007 meeting whilst recognising that this did not preclude delaying completion to 2008 or later if circumstances warranted.

To meet the goal of finishing the bowhead *Implementation Review* at the 2007 meeting, the SWG **agreed** to the approximate timeline given below.

(1) *First intersessional Workshop*. This will be held in Seattle or La Jolla in or around March 2006. Its task will be to specify the basic structure and types of simulation trials needed for the *Implementation Review*. This meeting may be held in conjunction with a planned US meeting to review progress on the ongoing US bowhead stock structure research program. This meeting will also initiate discussions on the ranges of parameter values to be tested, but not the specific choices.

(2) *2006 Annual Meeting*. This meeting will review progress on trial design and coding. It seems appropriate that the stock structure discussions should occur in joint sessions of the SWG and the BRG sub-committee with this leading to a refinement of the trial structure and parameter value ranges.

(3) *Second intersessional Workshop.* This will be held in Fort Collins, Colorado, in or around October 2006. Coding of the trials must be completed before this Workshop. The purpose of this meeting is to review the coding of trials and their behaviour within the agreed parameter ranges. The Workshop will finalise trial structure.

(4) *Data availability.* In accordance with the Committee's Data Availability Agreement (DAA), all bowhead data relevant to management advice for the 2007 meeting should normally be submitted 6 months in advance of that meeting. This deadline will thus most likely be in December 2006. However, given the collaborative nature of the analyses being undertaken, the SWG suggests that provided all collaborators agree, consideration should be given to allowing an extension to this deadline should it be required.

(5) *Third intersessional Workshop.* This will be held in or around March 2007. Given that a conference on the biology of bowhead whales is planned by the North Slope Borough, Alaska around this time, holding it immediately after in the same venue may be appropriate. The purpose of the workshop is to select specific parameter values for the designed trials, after confirming that the trial structure and coding revisions are satisfactory. After this meeting, the trials will be run by the Secretariat in advance of the 2007 SC meeting.

(6) *2007 Annual Meeting.* The primary task at this meeting is to assess the relative plausibility of the trials chosen, examine the trial results, and evaluate continued management under the *Bowhead SLA*. If the SWG determines that the completed review indicates unsatisfactory performance of the *Bowhead SLA*, it will develop a workplan for its revision.

This timeline cannot be met without the imposition of certain deadlines. The SWG **agreed** that the trial structure and parameter ranges will be based only on evidence available at or before the 2006 Annual Meeting. Furthermore, the SWG **agreed** that choices for parameter values and trial plausibility judgments shall be based upon only the data available in advance of the 2007 Annual Meeting pursuant to the DAA. Decisions by the SWG will be based on evidence that meets these deadlines. If new evidence becomes available subsequent to the applicable deadline, it shall not be used for the present *Implementation Review* unless completion of the *Implementation Review* is postponed to 2008 or later.

The cost of the first intersessional meeting that falls in the coming financial period is estimated to be £7,500 (5 Invited Participants). Furthermore, the SWG **strongly recommends** continuation of the AWMP Developers' Fund, which will be required to support coding work and other efforts in the next two years.

5. SCIENTIFIC ASPECTS OF AN ABORIGINAL SUBSISTENCE WHALING SCHEME

In 2002, the SWG developed scientific aspects of an aboriginal whaling management scheme (AWS) intended for use in conjunction with the *Bowhead SLA* (IWC, 2003b, pp.154-9). These proposals were agreed by the Scientific Committee (IWC, 2003a, pp.27-8) and reported to the Aboriginal Whaling Subcommittee of the Commission. At the 2003 and 2004 meetings, the Chair of the SWG discussed such matters with interested commissioners and representatives of the hunters. The Commission has not yet adopted the AWS and in particular the USA has expressed some concerns (IWC, 2005, p.13).

At this year's SWG meeting, Suydam conveyed continuing concerns by the hunters over the concept of the 'grace period' (before reducing or eliminating quotas in the absence of periodic surveys) and hunters' interest in maintaining a high degree of flexibility in the management scheme (for example having block quotas over the longest possible time period). Suydam noted that despite their concerns, hunters recognise the importance of scientific data and expect to continue supporting research on bowhead whales.

The SWG thanked Suydam for his comments. It reaffirmed its desire to accommodate hunters' concerns as much as possible. In particular it noted that in developing the AWS it had recognised the difficulties in obtaining abundance estimates under adverse environmental conditions and had taken that into account when developing the grace period approach. However, it also reiterated its view that it would not be appropriate for it to recommend that catching continues in the absence of an abundance estimate over a 15 year period. The question of the lengths of blocks in block quotas is the responsibility of the Commission.

The SWG therefore again **recommended** the aforementioned scientific components of an aboriginal whaling management scheme to the Commission, noting that it forms an integral part of the long-term use of the *SLA*.

6. CONSIDERATION OF FISHERY TYPE 3

The SWG had received no new information on this item at this meeting, but agreed that it should remain in its agenda for next year.

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

In recent years, the SWG has examined the stock structure of humpback whales in the North Atlantic in the context of the fishery of St. Vincent and the Grenadines. It has stated that the most plausible hypothesis is that the whales from St. Vincent and the Grenadines are part of the West Indies breeding population, numbering around 10,750 animals in 1992, but has encouraged the collection of additional data. This year, two papers were received providing more consideration of stock structure in this area.

SC/57/AWMP9 provided an update on a new assessment of North Atlantic humpback whales. A total of 3,615 biopsy samples were collected. The sample processing and data analysis should be completed in time for high-precision estimates of abundance to be available by 2007. The paper also hypothesised that the demographic population structure of this stock is likely complex, with whales from more than one feeding ground perhaps sharing the same winter breeding ground, or separate but uncertain breeding grounds.

The SWG was pleased to receive this report and expresses its continuing support for this programme.

SC/57/AWMP7 reported that one humpback whale landed at St. Vincent and the Grenadines in 1999 was matched to a specific catalogued individual photographed in the Gulf of Maine. This is the first stock assignment from this fishery, and the most southeasterly sighting of a Gulf of Maine humpback whale. Based on its length, the authors believed that the second animal landed at the same time was likely a calf and if so, a member of the same population. The SWG welcomed this paper, noting that this now confirms that the animals found off St. Vincent and The Grenadines are part of the West Indies population.

The SWG also welcomed the updated report on catches submitted to the Secretariat. In 2004, there were no whales taken. In February, 2005, there was a single male humpback whale taken measuring 35ft in length.

The Commission has adopted a total block catch limit of 20 for the period 2003-07. The SWG **agreed** that given the new information presented this year in SC/57/AWMP7 this catch limit will not harm the stock. The SWG also repeats its recommendations of previous years that wherever possible photographs and genetic material are collected from the catch. It was pleased to hear that two photographs (one from the 2003 catch and one from the 2005 catch) have been obtained and arrangements will be made to send the photographs to the North Atlantic catalogue.

8. WORK PLAN AND BUDGET REQUEST

The SWG **agreed** that the items below should be given priority during the intersessional period.

8.1 Greenland

(1) The photographs from the 2002 and 2004 surveys should be re-examined (Item 2.1.2.2) and advice be provided throughout the process on: (a) whether a survey should be undertaken in summer 2006 (see below); and (b) an agreed method to obtain acceptable abundance estimates from the data, if possible. An intersessional e-mail group to provide such advice was established comprising Butterworth, Donovan, George, Givens, Hammond, Kingsley, Punt, Witting (Convenor) and Zeh.

(2) The data on which the estimate of surfacing rate in Appendix 4 is based (and any other data on surfacing rates for fin and common minke whales in the Northern Hemisphere) should be obtained and re-analysed to determine the various components of variance and hence the most appropriate measures of variance of surfacing rate when estimating abundance (Item 2.1.2.2). An intersessional group to co-ordinate this was established comprising: Gunnlaugsson; Hammond; Kingsley (Convenor); Witting; Øien and Cooke.

(3) Preparations should be made to carry out a cue-counting survey in summer 2006 (see Item 3.3). A final decision on whether to conduct the survey will be taken by the intersessional group established under (1) above.

(4) The sex ratio data for common minke whales should be fully investigated *inter alia* to determine whether it can be used to obtain at least a minimum estimate for the total stock and be incorporated into an assessment model (Item 3.2). An intersessional group to forward this work was established comprising: Witting (chair), Punt, Cooke, Butterworth, Donovan and Givens. This information should be provided to the intersessional group established under (1).

(5) An assessment of the statistical power of various genetic approaches to estimate abundance (Item 2.1.1.1 and Appendix 3) should be completed. This will be carried out by Palsbøll, Skaug and Waples and the cost will be £3,500.

8.2 Bowhead whales

To meet the goal of finishing the bowhead *Implementation Review* at the 2007 Annual Meeting, an intersessional Workshop will be required (see Item 4). The USA has offered to host the Workshop in either Seattle or La Jolla in or around March 2006. The Workshop will specify the basic structure and types of simulation trials needed for the *Implementation Review*. The cost for Invited Participants is estimated at around £7,500.

There is also a considerable amount of Secretariat time involved (Allison primarily). Given the unknown nature of the final stock structure hypotheses, it is difficult to estimate accurately the amount of Secretariat time required for the *Implementation Review*. This could be up to 15 months for the entire process (i.e. to the end of the 2007 review); it may be up to 8 months between the first and second intersessional Workshops.

8.3 Priority topics for the 2006 meeting

(1) Review progress on the Greenlandic research programme (especially with respect to abundance, stock structure and the use of sex data in assessments) and attempt to provide management advice.

(2) Review progress on and refine design of trial specifications and coding for bowhead whales.

(3) Review information on the St. Vincent and the Grenadines fishery and provide management advice.

The SWG drew attention to the fact that this is a particularly heavy workload for the 2006 Annual Meeting. It noted that unless it has a pre-meeting, it will require considerably more sessions than normally allocated at an annual meeting.

9. OTHER BUSINESS

There was no other business.

10. ADOPTION OF REPORT

The Chair of the SWG thanked the participants for their co-operation during a difficult meeting and especially his rapporteurs. The SWG thanked the Chair for not sneaking in references to Ireland and Manchester City playing football. The report was adopted at 21:37 on 6 June.

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Appendix 1
AGENDA

1. Introductory items
   - 1.1 Convenor's opening remarks
   - 1.2 Election of Chair
   - 1.3 Appointment of rapporteurs
   - 1.4 Adoption of Agenda
   - 1.5 Documents available
2. Greenlandic fisheries and the Greenlandic Research Programme
   - 2.1 Review of results from programme
     - 2.1.1 Stock structure, range, movement,
       - 2.1.1.1 Genetics including simulation studies
       - 2.1.1.2 Catch distributions
     - 2.1.2 Abundance and trends
       - 2.1.2.1 Methods
       - 2.1.2.2 2004 photographic survey
   - 2.2 Preliminary consideration of management procedures
3. Management advice for common minke and fin whales off Greenland
   - 3.1 Catches
   - 3.2 Assessment
   - 3.3 Management advice
     - 3.3.1 Introduction
     - 3.3.2 Common minke whales
     - 3.3.3 Fin whales
4. Preparation for a bowhead whale *Implementation Review*
5. Scientific aspects of an Aboriginal Subsistence Whaling Scheme
6. Consideration of Fishery Type 3
7. Management advice for humpback whales off St. Vincent and the Grenadines
8. Work plan and budget request
   - 8.1 Greenland
   - 8.2 Bowhead whales
   - 8.3 Priority topics for the 2006 meeting
9. Other business
10. Adoption of report

Appendix 2

INFORMAL ANALYSIS OF AVAILABLE GENETIC DATA

L.W. Andersen

Methods

Population assignment was conducted using the assignment tests implemented in GeneClass2 (Piry *et al.*, 2004) which use the individual's multilocus genotype likelihoods to identify population origin (Paetkau *et al.*, 1995b). The method used to calculate the individual likelihoods of belonging to a certain population is the frequency-based method (Paetkau *et al.*, 1995a) that calculates the allele frequencies for each allele and estimates the likelihood of a diploid genotype occurring in the population according to Hardy-Weinberg proportions (allele frequencies of homozygotes are squared, of heterozygotes twice the product of the allele frequencies). The method assumes loci to be at Hardy-Weinberg equilibrium and linkage equilibrium and that the observed allele frequencies are close to the exact frequencies in the population. To detect migrants in the four common minke whale populations a likelihood computation L=L_home/L_max_not_home was used, describing the likelihood calculated from the home population (L_home) of the individual compared to the highest likelihood value (L_max) among the populations sampled, where the home population of the individual was not included (Piry *et al.*, 2004; Paetkau *et al.*, 1995b).

The exclusion probability (at the 1% level) of a population as origin and the probability of an individual to be a migrant are calculated based on the resampling algorithm by Paetkau *et al.* (1995b).

Results of assignment tests

In the West Greenland sample four of the 166 individuals sampled were excluded from all the four sampled populations at the 1% level. The remaining 162 individuals could either belong to the West Greenland population or be immigrants, but the data do not contain sufficient information to discriminate between these two hypotheses.

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Appendix 3

STATISTICAL POWER AND EXPERIMENTAL DESIGN OF GENETIC ESTIMATES OF CENSUS AND EFFECTIVE POPULATION SIZE OF THE WEST GREENLAND COMMON MINKE WHALE STOCK

P. Palsbøll, H. Skaug and R. Waples

Objectives

(1) To conduct an assessment of the statistical power of genetic estimates of minimum census and effective population size as a function of sample sizes and number of genetic markers.

(2) Providing the outcome of (1) suggests this approach is feasible, to propose an experimental design and associated costs.

Background

Recent sighting surveys off West Greenland for common minke whales have yielded a range of abundance estimates from 500 to 16,000 common minke whales. This proposal is aimed at exploring if it is practically feasible to obtain a meaningful estimate of the minimum abundance from genetic analysis and if so what would be the level of the required cost and effort. Such a genetic estimate would contribute another estimate that is independent of those obtained from sighting surveys. Such genetic estimates of abundance refer to the entire putative West Greenland stock and not simply those in the survey area, as they are in effect mark-recapture estimates, or based upon the population allele frequencies (i.e. which represent the entire population).

Genetic methods may be used to estimate either census or effective population size, the ratio of which is of considerable interest and importance. The methods for estimating census population size from genetic data are relatively recent, some of which may be ruled out (mark-recapture based upon genetic tagging) if all samples are to come from the current catch, as opposed to skin biopsy sampling.

One approach by which to estimate census population size is to compare the number of close relatives in a random sample, which is negatively correlated with abundance (Skaug, 2001). How many such pairs that are expected depend upon the demographic model and the time of sampling. If mother-offspring pairs are available (e.g. as females with foetuses) then the foetus constitutes an indirect sampling of a male (i.e. the father) which may have been sampled at a later occasion (Pearse *et al.*, 2001). With samples collected from a catch this method may have limited power.

Effective population size of a finite population may be estimated from the degree of linkage disequilibrium, or the change in allele frequencies over time (see Waples, 1991).

Materials and Methods

We will estimate the degree of precision (especially the lower bound) of genetic estimates of census and effective population size given a restricted range of abundances (provided by the AWMP). The methods to be investigated are:

(1) census population size;
  (a) from the fraction of close relatives (1st and 2nd order relatives) in a random population sample (Skaug, 2001);
  (b) from 'gametic' mark-capture-recaptures of males (Pearse *et al.*, 2001);

(2) effective population size;
  (a) from the degree of linkage disequilibrium (Waples, 1991);
  (b) from the temporal shift in allele frequencies (Waples, 1989).

To investigate the degree of precision for different sample sizes and number of genetic markers we will employ simulated data generated by population genetic (Laval and Excoffier, 2004) and demographic simulations (Anderson and Dunham, 2005). The parameter values employed in the simulations will be estimated from the collected data when possible.

We will need to have access to the previously collected genetic data from West Greenland common minke whales (Andersen *et al.*, 2003). In addition we will need data on the location, sex and date as well as some indication of age (e.g. overall length).

In the event that the above assessment demonstrates it will be feasible to obtain a reasonably precise estimate of the lower bound of abundance with a feasible number of samples and loci we will provide an estimate of the cost and effort required for the associated genetic analysis.

Time line and deliverables

1 September 2005: Project start.

1 February 2006: Final report submitted to IWC Secretariat of the assessment of genetic estimation of census and effective population size.

1 March 2006: Cost estimates and time line for genetic analyses submitted to the IWC Secretariat.

Note that the timeline here is deliberately conservative. It is hoped that the final report can be submitted considerably earlier than this.

Estimated costs

Personnel time and computing resources: £3,500.

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Appendix 4

ESTIMATING THE UNCERTAINTY ASSOCIATED WITH THE SURFACING TIME OF COMMON MINKE WHALES

A.E. Punt, G.H. Givens and L. Witting

Table 1 lists the sea state and estimated time in seconds for the surfacing/diving state intervals for 20 dive sequences. For the purposes of this Appendix, the surfacing time is defined to be the time either: (a) between the 'em' and 'va' states; or (b) between the 'no' and 'go' states (see SC/57/AWMP1). The point estimates of the surfacing time (6.90sec/9.24sec) are calculated as the sum over the six/eight central columns of Table 1 of the expected time for each state interval. The expected time for state interval *i* is determined as the average value of the times for state interval *i* across dive sequences.

The uncertainty of the estimate of surfacing time is determined using bootstrapping. Each bootstrap replicate is generated by selecting 25 rows from Table 1 at random (and with replacement), finding the average time for each of the eight states, and hence values for the two surfacing times. The standard deviations for the surfacing times are then the standard deviations of 10,000 bootstrap replicates.

The left panel of Fig. 1 shows the histogram of the 10,000 bootstrap replicate surfacing times based on the 'em' to 'va' states. Table 2 lists the mean, median and coefficient of variation for the surfacing times.

The data on which the above analyses are based includes data not included when estimating surfacing time in SC/57/AWMP1. Therefore, the sensitivity of the results to excluding the data ignored in SC/57/AWMP1 is examined. This sensitivity test involves only using interval times for the range of states 'em-su' to 'he-ba' if there are data for at least two of 'em-su', 'su-he' and 'he-ba', and using data for the range of states 'ba-ju' to 'di-va' if there are data for at least two of 'ba-ju', 'ju-di' and 'di-va'. The data excluded for the purposes of this sensitivity test are shaded in Table 1. The right panel of Fig. 1 shows the histogram of the 10,000 bootstrap replicate surfacing times based on the 'em' to 'va' states for this sensitivity test. Table 2 lists the mean, median and coefficient of variation for the surfacing times for this sensitivity test.

Table 1

Sea state and estimated time in seconds for the surfacing/diving state intervals for 20 dive sequences. The shaded values are excluded from the sensitivity test.

Sea	No-em	Em-su	Su-he	He-ba	Ba-ju	Ju-di	Di-va	Va-go
0					2.62	2.66	1.32	1.32
1						1.03	1.03	1.03
1						2.84	1.43	1.43
1	1.35	1.35	1.36	1.36				
2					2.53	1.26	1.26	2.54
2					2.63	0.9	0.9	0.9
2				0.5	0.5	0.5	0.5	0.5
2				0.52	0.52	0.52	0.52	0.52
2			1.31	1.31	2.69			
2		0.89	0.89	0.89	1.34	1.34		
2		1.27				2.52	1.27	
2		1.28	1.29	1.29		2.53	1.28	
2	0.71	0.71	0.71	0.71	0.94	0.94	0.94	2.82
2	0.93	0.93	0.93	1.4	1.4	0.94	0.94	0.94
2	1.27	1.27	1.26	1.26	2.53			
2	1.36	1.36						
3					0.94	0.94	0.94	
3					2.47	1.24	1.24	
3			2.55	2.55				
3		1.5	1.5	0.76	0.76	0.76	0.76	
3	0.58	0.58	0.58	0.58	0.78	0.78	0.78	
3	0.69	0.69	0.69	0.69				
3	0.69	0.69	0.69	0.69	0.68	0.68	0.68	0.68
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
3	2.85	0.95	0.95	0.95				
Average	1.118	1.016	1.104	1.013	1.505	1.285	0.973	1.221

Table 2

The mean, median, and standard deviation of the bootstrap distributions for the surfacing time.

	Surfacing time	
	'Em-su' to 'di-va'	'No-em' to 'va-go'
Baseline analysis		
Mean	6.90	9.24
Median	6.90	9.23
Coefficient of variation	0.052	0.052
Sensitivity test		
Mean	6.76	9.07
Median	6.76	9.07
Coefficient of variation	0.053	0.053

Key: No = not clearly visible; Em = emerging; Su = surfacing; He = head breaking surface; Ba = back breaking surface; Ju = just dived; Di = diving; Va = vanishing; Go = gone.

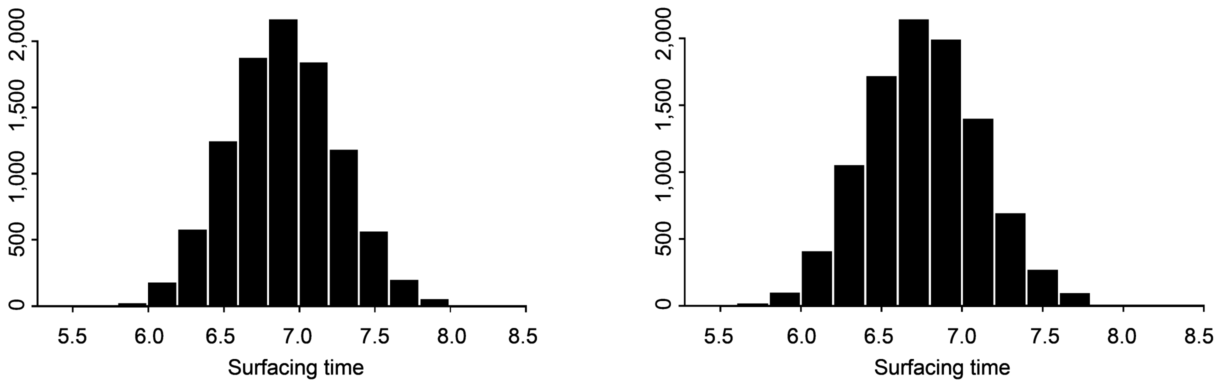

Fig. 1. Surfacing time distributions based on the entire data set (left panel) and the data used in SC/57/AWMP1 (right panel).

Appendix 5

REPORT OF THE AWMP 'SMALL GROUP' TO CONSIDER PROTOCOLS FOR EXAMINING AND ANALYSING PHOTOGRAPHS

Members: Butterworth, Donovan, Givens, Hammond, Kingsley, Punt, Witting and Zeh.

Discussion

The group first considered the components of the process relating the numbers of whales actually present to those identified on a photograph, and specified five as follows.

(1) If a whale is within the strip being surveyed, will it be seen? This relates to the fraction of time a whale spends on the surface.

(2) If a whale is available to be photographed, will it be in the photograph frame? Estimation of the proportion of the overall area covered by the photographs will account for this aspect.

(3) If a whale is on the surface in the photograph frame, will it be on the image? Yes – by design.

(4) If the whale is on the image, is it possible to see it? This will depend on the quality of the image and the environment in which the whale has surfaced (sea state, glare, etc.). These must also be taken into account in

estimation of the proportion of the overall area covered by the photographs.

(5) If it is possible in principle for the whale to be seen on the image, does the reader see it? This needs to be estimated from data to be able to make allowance for this effect in estimating abundance from the survey.

In discussion of these in relation to the analyses presented in SC/57/AWMP3, the group stressed the need for clarification of the protocol adopted under (2)–(4) to exclude photographs or portions of photographs from calculation of the area effectively covered. Upon receiving clarification from Witting, the group agreed that the single reading approach adopted was not sufficient to provide confidence that all whales on the photographs had been identified or that the appropriate area coverage had been determined; this has subsequent implications for the acceptability of the estimates with respect to both numbers of sightings and correction factors.

In this regard, the possibility of using multiple independent readers to apply capture-recapture analysis techniques to estimate probabilities associated with (5) was raised. Stress was laid on the desirability of incorporating covariates into the estimation of these probabilities.

The group decided to focus on defining the best protocol to use in the evaluation of the results from such a survey, ignoring considerations of cost for the moment. Such an approach, if applied to the existing survey and associated experiment data, would improve the likelihood of providing results acceptable to the Scientific Committee.

Suggested protocol

For both experimental data (in this case from off Iceland) and survey data (in this case from off West Greenland), a common two-step approach should be applied, involving two independent teams. Each team should consist of two people: a screener with experience of identifying objects on aerial photographs, and a scientist with experience in identifying whales and their species from such photographs.

A screener would be responsible for examining every photograph and recording the following:

(1) whether it shows an object meriting further examination;
(2) what area of the photograph is to be excluded for the purposes of estimating area covered, and why; six categories were identified for such reasons: glare, cloud, land, dark image, camera failure and other;
(3) a categorisation under a 3-level scheme of the likelihood of being able to see a whale in the area not excluded from the photograph;
(4) sea state.

To avoid drift in an exercise which would take considerable time (since typically some tens of thousands of photographs require examination), experiment and survey data should be interspersed (e.g. each week spend one day examining experiment and four days on survey data). Furthermore the data from each source should be ‘shuffled’ in a systematic way, without compromising the greater speed possible from consideration of photographs sequentially because of auto-correlation in covariate values. For example, photographs could be split into four sets, consisting in turn of:

Set A: photographs 1, 5, 9, 13, ….
Set B: photographs 2, 6, 10, 14, ….
Set C: photographs 3, 7, 11, 15, ….
Set D: photographs 4, 8, 12, 16, ….

The screener from the one team would examine these sets in order A, B, C then D, whereas the screener for the other would conduct examination for some permutation of this order.

The full set of photographs identified by either screener as containing an object meriting further examination would be examined independently by both scientists, without being informed of which screener(s) identified which photographs. Note that the number of such photographs will typically be considerably fewer than that originally examined by the screeners. Primary analysis will consider results from each screener/scientist team independently; the reason for extending to scientists examining photographs identified by the other team’s screener as well is that this likely small extra number will not add greatly to the length of this exercise. The responsibility of the scientist is then to determine whether the object identified is a whale (or more than one whale, and in that case how many) and the species.

The end result of this process for each team will thus be an estimate of (non-excluded) area covered, together with a set of whale sightings and associated covariate values (such as for sea-state). The group considered it premature to be prescriptive about the manner in which this analysis would best be conducted, given a number of alternative approaches suggested including capture-recapture methodology for the pair of teams, but emphasised the importance of reaching a consensus result and recommended that a process towards this end be defined for the specific case under review.

Conclusion

The group recognised that whilst the above protocols represented the best approach to analysing the data for such surveys, there was no guarantee that following these would result in finding appreciably more animals or an agreement that the estimates were acceptable. They also recognised that following the protocols will be expensive (see below) and that the SWG may wish to consider whether carrying out a further cue-counting survey should be given higher priority if a choice has to be made on budgetary grounds.

If the photographs are re-examined and the data reanalysed, the group **agreed** that this could best be achieved by an intersessional group being established to provide advice at all stages of the process leading to a revised estimate.

Budget

Witting informed the group of the costs to have the protocols followed using the same company that had originally read the photographs:

	Once	Twice
Reading of the survey photographs alone	£36,300	£54,400
Reading of the survey and experiment photographs	£41,700	£65,200

The group suggested that it may also be possible to find other screeners at a lower price.

Appendix 6

REPORT OF THE AWMP 'SMALL GROUP' TO CONSIDER COMMON MINKE WHALE SURFACING RATES

Members: Gunnlaugsson, Hammond, Kingsley (Convenor), Witting, Øien.

Background

The presented estimate for West Greenland common minke whales has corrected the surface-visible count using a surfacing rate of 53 surfacings hour^{-1}, taken from the literature, in conformity with corrections previously applied to visual aerial surveys. This external value was applied with no associated uncertainty.

Terms of reference

The primary objective was to review documented information on the surfacing rates of common minke whales and determine a value that could be used to correct aerial surveys in cases for which there is no contemporaneous local estimate. It was agreed that the possible conclusions included: (1) that the information available was too conflicting to furnish any usable single value or spectrum of values; (2) propose a central value and an appropriate associated measure of its uncertainty; or (3) propose only a credible band of uncertainty.

Information available

Seven documents containing relevant information were identified.

(1) Gunnlaugsson (1989). Report on Icelandic Common minke whale surfacing rate experiments in 1987. *Rep. int. Whal. Commn* 39: 435–6.

Data collected in connection with NASS-87, in July, from 3 survey vessels, and in August from 3 whaling vessels, all in Icelandic waters. Visual observation within a few hundred metres. 16 experiments in total, totalling 501 surfacings. Most from 40–350 m-deep water, but one experiment in 1800 m water. 'Most of the observations were made in the sheltered fjords.' Most of the experiments in shallow water on apparently feeding animals. Overall average dive-time interval of 68.3 s., reported CV 0.056 [corresponds to 52.7 s/hr[1]].

(2) Joyce *et al*. (1989). Surfacing rates of Common minke whales in Norwegian waters. *Rep. int. Whal. Commn* 39: 431–4.

Observations in July from 2 ships in the Norwegian Sea and 'on the banks' ca. 50 n.mi. from Svalbard. 13 trials of which 8 successful ones totalled 250 min. and 182 surfacings. Pooled observations from all successful trials gave 44.0 s/hr (s.e. 14.9). If 4 trials in which whales were apparently responding to the presence of the ship were omitted, mean rate was 52.4 s/hr (s.e. 9.4).

Refers to variability and to Antarctic rates from Joyce (1982); Hiby and Ward (1986); Ward and Hiby (1987) as ranging from 14.4 to 88.1 s/hr and to a mean rate of 33–37 s/hr from the Southern Hemisphere (Hiby and Hammond, 1989).

(3) Joyce *et al*. (1990). Radio tracking a Common minke whale in Icelandic waters for the examination of dive-time patterns. *Rep. int. Whal. Commn* 40: 357–361.

One successful experiment with a VHF radio-tag deployed by crossbow in July close inshore in Faxafloi. 670 surfacings in 10 hrs of recording gave an overall simple mean 65.9 s/hr; mean for 5-min periods 66.59 (c.v. 0.41); night-time rate 74.44 (c.v. 74.44), day-time 60.35 (c.v. 0.43). Refers to Ward (1988) as reviewing surfacing-rate information from the Antarctic, correcting for pod size, and obtaining a final value of 48 s/hr.

[1] Surfacings hour^{-1}.

(4) Øien *et al*. (1990). Dive time experiments on Common minke whales in Norwegian waters during the 1988 season. *Rep. int. Whal. Commn* 40:337–341.

Visual data from three sighting-survey vessels in July (8 experiments totalling 285 min. and 198 surfacings; 3 of which totalling 95 min. were excluded) and from 2 whaling vessels in August (respectively 15 experiments totalling 630 min and 396 surfacings and 13 experiments totalling 480 min and 257 surfacings). Observations on banks near Jan Mayen, in deep water in the Norwegian Sea, and on or near the slopes west of the Malangsgrunnen Bank, on the shelf off Vesterålen.

Sighting-survey-vessel results from retained experiments averaged 43.2 s/hr (c.v. 0.176); the two whaling vessels had overall averages 39.8 and 32.4 s/hr. We combined these three results before listing a time-weighted average of 37.6 s/hr in the final summary table.

(5) Stern (1992). Surfacing rates and surfacing patterns of Common minke whales (*Balaenoptera acutorostrata*) off central California, and the probability of a whale surfacing within visual range. *Rep. int. Whal. Commn* 42: 379–385.

Visual observation from a 5-m *Boston Whaler* at ranges about 100 m, apparently close inshore off Monterey Bay. Twenty 30-min sequences of 11 different whales, of which one was 'significantly different' from the others. Overall mean was 38.6 s/hr (s.d. 9.47) with minor differences between morning and afternoon.

Also presented results on the ventilation sequence (number and rate of ventilations) and durations of long dives.

(6) Folkow and Blix (1993). Daily changes in surfacing rates of Common minke whales (*Balaenoptera acutorostrata*) in Norwegian waters. *Rep. int. Whal. Commn* 43: 311–314.

4 experiments with VHF tags deployed by crossbow off the coast of northern Norway in 1991 which stayed in place variously for 2 h 40 min to 23 hrs 40 min, 0.3 to 1 km from ship. Also data from 2 tags deployed off northern Norway in 1990. Period results (from 30 min to 2 hr) ranged from 31.86 to 60.5, experiment averages between 0400 and 2200 ranged from 43.06 s/hr to 52.97 s/hr.

(7) Øien *et al*. (2003). Update on available data on surfacing rates of northeastern Atlantic Common minke whales. SC/55/NAM7 presented to IWC Scientific Committee, Berlin.

VHF results for 3 whales tagged in 2002, in the N.E. North Sea, in the Norwegian Sea and off Lofoten. Also summaries for 2 whales tagged in 2001 and 8 other results, which appear to include those from Folkow and Blix (loc. cit.). Averages by whale (including the additional results mentioned, and in some cases restricted to sea state = 4) range from 33.49 to 65.86 s/hr, simple mean 48.1 (SD 9.5). Refers to Stockin *et al.* (2001) with an overall average 54.5 s/hr with the comment that Stockin's study area was shallow.

Summary, discussion and review

Problems associated with comparing and combining data from VHF radio tags with data obtained from visual-survey experiments were discussed. Two aspects were of particular concern. The first was the possibility that VHF tracking can detect near approaches to the surface, or discreet surfacings, that would escape the notice of observers. While this might affect detection on shipboard surveys, it was agreed that it should not influence detection on aerial surveys, and would not be a problem for aerial photographic surveys. Furthermore, Øien had compared visual and VHF data and had not found consistent differences. It was therefore agreed to use VHF and visual data without differentiation.

The second aspect of this comparison was that visual experiments on surfacing behaviour are short (typically 20-50min), but that many such are conducted on any given cruise, while VHF cruises may perform only 2 or 4 experiments, but each may last for days. This made it difficult to know how to weight the different results in making any kind of average. In particular, the results of SG7 included experiments on only two whales, which added up to 100 hours of data – almost as much as all the other sources combined.

In respect of visual experiments, the question as to whether observations made from whaling vessels could be considered on the same footing as those made from sighting-survey vessels, but it was agreed there was no reason for treating them differently. Stockin's mean value was included, although the original manuscript was not reviewed. The summary value of 48s hr^{-1} (Ward, 1988), was excluded as it referred to Antarctic minke whales in the Antarctic and differences with common minke whales in the North Atlantic were considered too great. The following were thus considered useful:

SG1: 16 experiments, 52.7 s hr^{-1}
SG2: (8 experiments 44.0 s/hr or) 4 experiments 52.4 s hr^{-1}
SG3: 1 long VHF experiment day-time rate 60.35 s hr^{-1}
SG4: 3 vessels, 33 visual experiments, 37.6 s hr^{-1}
SG5: 11 (short) experiments 38.6 s hr^{-1}
SG6: 4 experiments, which are included in results of SG7
SG7: 13 VHF experiments, 48.1 s hr^{-1}
Stockin (2001): 54.5 s hr^{-1}

Given that these studies were attempting to measure a parameter of the behaviour of a free-ranging wild animal under uncontrolled and varying conditions, the range of estimates obtained was not large. Values clustered between the low 40s and the mid-50s, with a few results down to the middle 30s and up to the very low 60s. There was not enough conflict in the available information to prevent us from being able to provide a value.

Problems associated with weighting the different results, in ascribing causes to the variations observed both within and between the different sets of experiments, and of knowing how those causes might apply in West Greenland and affect surfacing rates of common minke whales there, made it difficult to arrive at an incontrovertible central value and to provide a measure of the uncertainty associated with applying such a single value to the entire West Greenland aerial survey.

The studies provided central tendency values for surfacings per hour, but did not analyse variance into components. So it was not possible to determine whether one should weight their results by the number of whales watched, the number of different sets of study conditions such as site or water depth, the total observation time, or some combination of these. As noted above, VHF experiments were longer – some very much longer – than visual experiments, but there were few of them. It was agreed to use an unweighted arithmetic mean of the 7 values in the summary table, which was 49.2s hr^{-1}.

The question of deciding upon an associated measure of uncertainty was problematic. It was agreed that the conventional standard error of the unweighted mean would not be appropriate for the following reasons. Assuming that this mean represents an estimate of a global mean for the surfacing rate of common minke whales, its standard error can be reduced to small values by accumulating large amounts of data. However, this does not reduce the margin of uncertainty in applying this central rate to any particular survey, for which the appropriate rate would be that for the particular whales in the particular survey area, engaged in certain behaviours at the particular time the survey was flown etc[2,3]. Each of the results listed in the summary represents an averaging over a number of whales, a set of study areas, a range of water depths, and several different kinds of behaviour. Yet these results differ appreciably from one another. It was therefore agreed that the standard deviation of these seven results would be an appropriate measure of the uncertainty associated with using their mean to correct any given survey of a scale similar to the coverage of the studies they represent. This standard deviation is 8.40s hr^{-1}.

One member of the group agreed with use of the SD to estimate the uncertainty of a survey estimate of numbers, but considered that when comparing surveys in the same area, surfacing rates should be used without any associated uncertainty, implying that as between surveys in the same area, uncertainty and variability in surfacing behaviour would constitute a fully correlated variation. There was not time to discuss this further. Another thought that the between-study SD would probably overestimate the uncertainty incurred by applying the mean rate to a medium-scale aerial survey.

It is therefore **recommended** that a value of 49.2s hr^{-1} is used instead of the presently used value of 53, and that the SD of 8.40 is used as an associated measure of uncertainty in applying this value to the results of medium-scale surveys.

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Joyce, G.G., Sigurjónsson, J. and Víkingsson, G. 1990. Radio tracking a minke whale *Balaenoptera acutorostrata* in Icelandic waters for examination of dive-time patterns. *Rep. int. Whal. Commn* 40:357-61.

Øien, N., Folkow, L. and Lydersen, C. 1990. Dive time experiments on minke whales in Norwegian waters during the 1988 season. *Rep. int. Whal. Commn* 40:337-41.

[2] In the case of the 2002–2004 survey in West Greenland, 2 whales were seen on the survey. If whales are visible for about 7 seconds in 49, i.e. about one seventh of the time, this implies that the relevant surfacing-rate parameter would be an average over about 14 whales in different places doing different things. This is several times fewer than the number of whales observed in most of the sources we looked at.

[3] This is a 'tolerance interval' problem, i.e. estimation or prediction of an attribute of a sub-group of a population having uncertainly known parameters. Two components of uncertainty are compounded in such problems. The first is uncertainty of knowledge of the population parameter, and is estimated from the properties of the available estimate. The second is uncertainty of prediction (of the difference between the population parameter and the corresponding parameter of the sub-group) and is estimated from available knowledge of the variability within the population. In successive predictions for the same population, the uncertainty of knowledge may be regarded as fully correlated, the uncertainty of prediction as fully uncorrelated. In the present case, the 'population' is a population of averages of surfacing behaviour.

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Ward, A.J. and Hiby, A.R. 1987. Analysis of cue-counting and blow rate estimation experiments carried out during the 1985/86 IWC/IDCR minke whale assessment cruise. *Rep. int. Whal. Commn* 37:259-62.

Appendix 7

BACKGROUND INFORMATION ON MANAGEMENT ADVICE FOR COMMON MINKE AND FIN WHALES OFF WEST GREENLAND

Greg Donovan

1. Sightings surveys

Abundance estimates (all cue-counting estimates have been standardised to cue-rate agreed at 1991 meeting).

Table 1

Fin whales.

Period to which applies	*n*	Effort	Point estimate (approx 95% CI)	Coverage	Comments	Reference
1987 (28 Jul.-12 Aug.)	34 (53)	About 44hrs	1,370 (580-3,233)	Good - all blocks covered to some extent.	Some sightings in all blocks, most offshore.	Larsen *et al.*(1989); Hiby and Lovell (1989); corrected as in IWC (1992).
1988 (28 Jul.-18 Aug.)	24 (34)	About 28hrs	663 (286-1,538)	Not high coverage but OK apart from southern.	Sightings in all blocks except most northerly, about equal in/off.	Larsen and Nielsen (1989); corrected as in IWC (1992).
Combined estimate for 1987 and 1988	58 (87)	About 72hrs	1,096 (520-2,100)	See above.	**Accepted by the Scientific Committee.** See above.	Hiby and Lovell (1989); IWC (1992).
1993 (24 Jul.-20 Aug.)	8 (15)	38hr 0min	178 (26-382)	No coverage in offshore northern blocks, poor coverage in offshore mid-blocks, excludes previous good areas.	**Not accepted by the Scientific Committee.** Partial estimate only. Southerly, most offshore.	Larsen (1995).
2002 (14 Jul.- 4 Aug., 9 Sep.-4 Oct.)	2 (2)	33hr 19min	Not given	Good coverage down to around 62N. No coverage in south.	One inshore near Disko, other in mid-block (in/off?).	SC/57/AWMP3.
2004 (8 Aug.-22 Oct.)	4 (5)	33hr 50min	Not given	Good coverage up to about 67N. Very little coverage north.	Three in most southerly block other in mid-block (in/off?).	SC/57/AWMP3.
2002/2004	6 (7)	67hr 09min	980 (401-2,392)	See above.	**Not accepted by the Scientific Committee at this meeting. See Item 2.1.2.2.**	SC/57/AWMP3.

Notes: The estimates are similar apart from the 1993 estimate. Larsen (1995) pointed out that this should not be considered an estimate of the number of animals in the total West Greenland area as several blocks that were expected to contain fin whales (based on previous surveys) were not covered. Note the cue-counting estimates have high variance even though they assume no variance for the blow rates. The photographic survey took place over a much wider timescale than the cue-counting surveys. The SWG has developed a protocol to improve confidence in the process in which the abundance estimates were developed from the photographic surveys. However, it believed that the more serious problem was for the more difficult to see common minke whales rather than the fin whales.

Table 2

Common minke whales.

Period to which applies	*n*	Effort	Point estimate (approx 95% CI)	Coverage	Comments	Reference
1987 (28 Jul.-12 Aug.)	38(38)	About 44hrs	1,930 (846-4,402)	Good - all blocks covered to some extent.	Sightings in all blocks but more coastal and mid-south. None in far north.	Larsen *et al.* (1989); Hiby and Lovell (1989); IWC (1990): 43
1988 (28 Jul.-18 Aug.)	30(33)	About 28hrs	4,602 (2,163-9,792)	Not high coverage but OK apart from southern.	Similar to above plus few along outer slope.	Larsen and Nielsen (1989).
Combined estimate for 1987 and 1988	68(71)	About 72hrs	3,266 (1,702-5,718)	See above.	**Accepted by the Scientific Committee.** See above.	Hiby and Lovell (1990).
1993 (24 Jul.-20 Aug.)	56(66)	38hr 0min	8,731 (2,414-16,929)	No coverage in offshore Northern blocks, poor coverage in offshore mid-blocks.	Most inshore up to around 67N.	Larsen (1995).
Reanalysis of 1993	56(66)	38hr 0 min	6,390 (2,951-13,837)	See above.	**Accepted by the Scientific Committee.** See above.	Hedley *et al.* (1997).
2002 (14 Jul.- 4 Aug., 9 Sep.- 4 Oct.)	1(1)	33hr 19min	Not given	Good coverage down to around 62N. No coverage in south.	One north of 67N (in/off?).	SC/57/AWMP3.
2004 (8 Aug.-22 Oct.)	1(1)	33hr 50min	Not given	Good coverage up to about 67N. Very little coverage north.	One in mid-block (in/off).	SC/57/AWMP3.
2002/2004	2(2)	67hr 09min	510 (138-1,889)	Good coverage over both years.	**Not accepted by the Scientific Committee at this meeting. See Item 2.1.2.2.**	SC/57/AWMP3.

Notes: the cue-counting estimates have high variance even though they assume no variance for the blow rates. The photographic survey took place over a much wider timescale than the cue-counting surveys. The number of sightings is very low for the photographic survey and its validity (and CV) have been questioned for several reasons (see Item 2.1.2.2). The SWG has developed a protocol to improve confidence in the process in which the abundance estimates were developed from the photographic surveys, but given the very low number of sightings of common minke whales, it cannot be sure that the re-examination of the data will provide an acceptable abundance estimate.

2. Fin whale catch data

Table 3

Fin whale catches and quotas off West Greenland.

Year	Male	Female	Unknown	Total	% Female	%Unknown	Quota	Block	%quota
1922	0	0	14	14		100.0			
1923	0	0	20	20		100.0			
1924	34	32	28	94	48.5	29.8			
1925	0	0	30	30		100.0			
1926	0	0	24	24		100.0			
1927	0	6	16	22	100.0	72.7			
1928	0	0	24	24		100.0			
1929	0	4	20	24	100.0	83.3			
1930	0	3	24	27	100.0	88.9			
1931	154	132	15	301	46.2	5.0			
1932	32	34	0	66	51.5	0.0			
1933	13	11	0	24	45.8	0.0			
1934	0	0	24	24		100.0			
1935	9	14	0	23	60.9	0.0			
1936	6	9	0	15	60.0	0.0			
1937	124	148	0	272	54.4	0.0			
1938	4	3	0	7	42.9	0.0			
1939	1	2	0	3	66.7	0.0			
1946	26	21	0	47	44.7	0.0			
1947	29	22	0	51	43.1	0.0			
1948	10	11	0	21	52.4	0.0			
1949	5	16	0	21	76.2	0.0			
1950	18	18	0	36	50.0	0.0			
1951	8	7	0	15	46.7	0.0			
1952	4	12	0	16	75.0	0.0			
1953	6	9	1	16	60.0	6.3			
1954	17	5	0	22	22.7	0.0			
1955	14	8	0	22	36.4	0.0			
1956	17	11	0	28	39.3	0.0			
1957	11	10	0	21	47.6	0.0			
1958	2	6	0	8	75.0	0.0			
1959	0	0	1	1		100.0			
1964	0	0	1	1		100.0			
1965	0	0	1	1		100.0			
1968	0	0	3	3		100.0			
1969-71	0	0	0	0					
1972	0	0	1	1		100.0			
1973	0	0	2	2		100.0			
1974	0	0	5	5		100.0			
1975	0	0	2	2		100.0			
1976	0	0	9	9		100.0			
1977	0	0	13	13		100.0			
1978	1	0	7	8	0.0	87.5	4		200.0
1979	0	0	7	7		100.0	15*		
1980	0	0	13	13		100.0	6		216.7
1981	0	0	7	7		100.0	6		116.7
1982	0	0	9	9		100.0	6		150.0
1983	0	0	8	8		100.0	6		133.3
1984	0	0	10	10		100.0	6		166.7
1985	1	2	6	9	66.7	66.7	8		112.5
1986	2	1	6	9	33.3	66.7	8	16	112.5
1987	**1**	**2**	**6**	**9**	**66.7**	**66.7**	**10**		**90.0**
1988	**2**	**3**	**4**	**9**	**60.0**	**44.4**	**10**		**90.0**
1989	3	3	8	14	50.0	57.1	23		60.9
1990	9	6	4	19	40.0	21.1	23		82.6
1991	5	6	7	18	54.5	38.9	23		78.3
1992	4	9	9	22	69.2	40.9	23	42	95.7
1993	**2**	**11**	**1**	**14**	**84.6**	**7.1**	**21**		**66.7**
1994	10	10	2	22	50.0	9.1	21		104.8
1995	9	3	0	12	25.0	0.0	19		63.2
1996	8	10	1	19	55.6	5.3	19		100.0
1997	5	5	3	13	50.0	23.1	19		68.4
1998	1	8	2	11	88.9	18.2	19		57.9
1999	3	4	2	9	57.1	22.2	19		47.4
2000	2	8	7	7	80.0	100.0	19		36.8
2001	3	4	1	8	57.1	12.5	19		42.1
2002	**5**	**8**	**0**	**13**	**61.5**	**0.0**	**19**		**68.4**
2003	3	6	0	9	66.7	0.0	19		47.4
2004	**5**	**6**	**2**	**13**	**53.8**	**0.0**	**19**		**68.4**

Bold text = survey years. *Including humpback.

2. (cont.)

Fin whale catch series

Fin whales are not the preferred species of Greenlandic hunters; humpback whales were the main 'large' whale species taken by the hunters until their allocation was removed in 1986. Most of the early catches were from commercial operations. Some of the animals in recent years considered of unknown sex are animals that were struck and lost and presumed to have died. The lack of preference for fin whales should be taken into account when considering the information on fulfilment of quotas. Given the block nature of the quotas in some years, the annual estimate of fulfilment is an approximation.

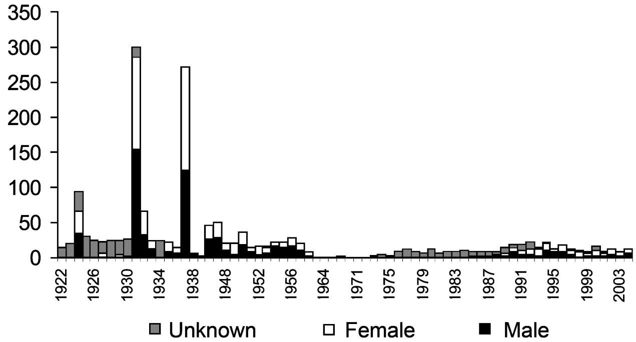

Fig. 1. Fin whale catches off West Greenland.

3. Common minke whale catch data

Common minke whale catch series

Norwegian whalers also caught whales from 1968 to 1985. The catch series held by the IWC (Total (1)) and those used in SC/57/AWMP4 (Total (2)) are slightly different; a single catch series is to be obtained during the intersessional period. The percentage of unknown sex animals in the catch varied considerably by year, only in recent years has it consistently been in the 13% or less range (and see Fig. 2). Quotas were introduced in 1976. They have been quite variable but dropped to a low of 60 in 1989 and have been climbing ever since. Block quotas have been used recently – initially expressed as a maximum catch in any one year with a total for the block not to be exceeded – followed by the present system of an annual catch of 175 with a potential to carry over up to 15 unused strikes. Years in bold are survey years. Due to carryover, what appear to be quota overruns are in fact not.

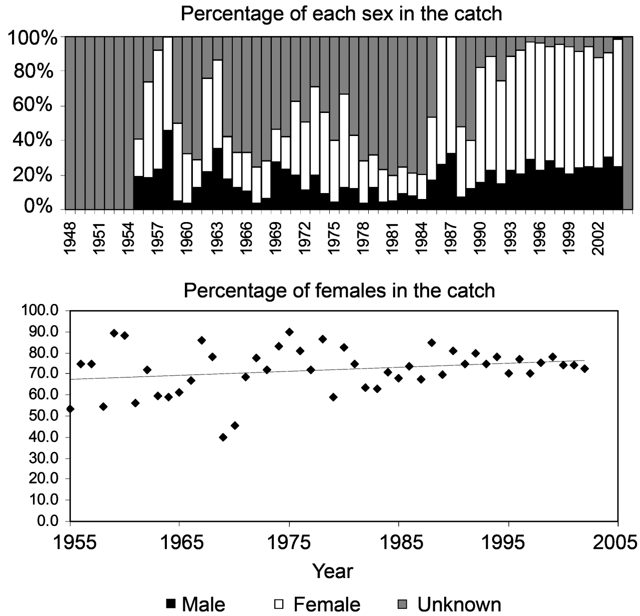

Fig. 2. Breakdown of the annual catch of West Greenland common minke whales for males, females and animals of unknown sex.

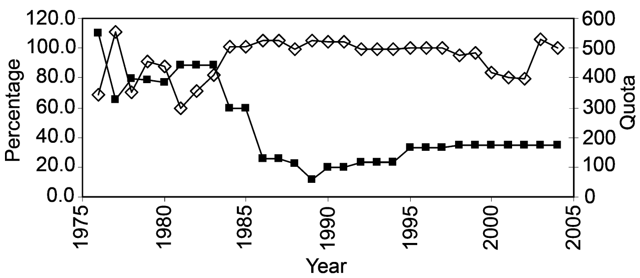

Fig. 3. Approximate percentage of the quota reached by year. Note that due to carryover, in some years it appears that the quota has been exceeded when in fact it has not (see notes above). Open diamonds=percentage reached; solid squares=actual quota (see Table).

Table 4

Minke whale catches and quotas off West Greenland.

Year	Male	Female	Unknown	Total (1)	Total (2)	Diff	% Unknown	Quota	Block	% reached[1] Annual	Block
1948	0	0	4	4	4	0	100.0				
1949	0	0	5	5	5	0	100.0				
1950	0	0	9	9	9	0	100.0				
1951	0	0	16	16	16	0	100.0				
1952	0	0	32	32	32	0	100.0				
1953	0	0	32	32	32	0	100.0				
1954	0	0	22	22	22	0	100.0				
1955	7	8	7	22	22	0	31.8				
1956	5	15	2	22	22	0	9.1				
1957	6	18	0	24	24	0	0.0				
1958	5	6	19	30	30	0	63.3				
1959	2	17	36	55	55	0	65.5				
1960	2	15	39	56	56	0	69.6				
1961	7	9	19	35	35	0	54.3				
1962	17	43	12	72	72	0	16.7				
1963	32	47	87	166	166	0	52.4				
1964	26	37	99	162	162	0	61.1				
1965	19	30	147	196	196	0	75.0				
1966	24	49	152	225	225	0	67.6				
1967	7	42	195	244	245	1	79.9				
1968	17	60	258	335	342	7	77.0				
1969	133	88	213	434	439	5	49.1				
1970	86	72	175	333	344	11	52.6				
1971	92	202	165	459	459	0	35.9				
1972	38	131	110	279	282	3	39.4				
1973	75	193	229	497	508	11	46.1				
1974	49	243	177	469	470	1	37.7				
1975	12	108	204	324	324	0	32.1				
1976	40	169	169	378	378	0	44.7	550		68.7	68.7
1977	36	93	231	360	360	0	64.2	325		110.8	110.8
1978	12	78	165	255	279	24	64.7	397		70.3	70.3
1979	31	45	249	325	359	34	76.6	394		91.1	91.1
1980	13	62	258	333	339	6	77.5	385		88.1	88.1
1981	16	47	202	265	265	0	76.2	444		59.7	59.7
1982	24	42	250	316	316	0	79.1	444		71.2	71.2
1983	25	42	269	336	364	28	80.1	444	1,778	82.0	82.0
1984	20	49	236	305	313	8	77.4	300		104.3	101.2
1985	87	187	0	274	282	8	0.0	300	588	94.0	101.2
1986	38	107	0	145	145	0	0.0	130		111.5	105.0
1987	**14**	**29**	**43**	**86**	**86**	**0**	**50.0**	**130**	**220**	**66.2**	**105.0**
1988	**6**	**34**	**69**	**109**	**109**	**0**	**63.3**	**110**		**99.1**	**99.1**
1989	14	32	17	63	63	0	27.0	60		105.0	105.0
1990	15	63	11	89	89	0	12.4	100		89.0	104.2
1991	22	66	31	109	109	0	28.4	100	190	109.0	104.2
1992	18	72	13	103	103	0	12.6	115		89.6	99.7
1993	**25**	**74**	**8**	**107**	**107**	**0**	**7.5**	**115**		**93.0**	**99.7**
1994	22	78	4	104	104	0	3.8	115	315	90.4	99.7
1995	44	103	6	153	153	0	3.9	165		92.7	100.0
1996	36	120	8	164	164	0	4.9	165		99.4	100.0
1997	42	99	7	148	148	0	4.7	165	465	89.7	100.0
1998	39	118	9	166	166	0	5.4	175		94.9	94.9
1999	34	123	13	170	157	-13	7.6	175		97.1	89.7
2000	36	102	7	145	147	2	4.8	175		84.0	84.0
2001	32	91	16	139	140	1	11.5	175		80.0	80.0
2002	**33**	**88**	**18**	**139**	**139**	**0**	**12.9**	**175**		**79.4**	**79.4**
2003	58	117	3	178	185	7	1.7	175		105.7	
2004	**44**	**129**	**2**	**175**	**175**	**0**	**1.1**	**175**		**100.0**	

Bold text = survey years. Highlight = Norway small-type whaling data included.
[1]Calculated using maximum catch in each year.

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