Annex G

Report of the Sub-Committee on the Comprehensive Assessment of Whale-Stocks – In-Depth Assessments

Members: Palka (Chair), Baba, Baker, Bannister, Berggren, Birtles, Branch, Brandao, Bravington, Brownell, Burt, Butterworth, Childerhouse, Cipriano, Clapham, Cooke, DeMaster, Diake, Donovan, Ensor, Forde, Fujise, Funahashi, Gales, Gidding, Goodman, Goto, Groch, Gunnlaugsson, Hakamada, Hammond, Hatanaka, Haug, Hayashi, Hedley, Hester, Holloway, Hughes, Kato, Kell, Kim, Z.G., Kim, K.W., Kingsley, Kitakado, Kock, Komatsu, Leaper, Lee, Lens, Lima, Lyrholm, Matsuda, Matsuoka, Mikhalev, Miyashita, Mori, Morishita, Murase, Nagatomo, Nakatsuka, Nishiwaki, Ohsumi, Øien, Okamura, Olafsdottir, Palazzo, Park, Pastene, Perrin, Pike, Polacheck, Punt, Rademeyer, Rambally, Rennie, Ridoux, Sadler, Shimada, Simmonds, Skaug, Smith, Sohn, Tanaka, Taylor, Thiele, Tomita, Vikingsson, Walløe, Weinrich, Williams, Yamakage, Yamamura, Zeh.

1. INTRODUCTORY ITEMS

1.1 Election of chair and appointment of rapporteurs

Palka welcomed the participants and was elected Chair. Hedley acted as rapporteur.

1.2 Adoption of agenda

The adopted agenda is given as Appendix 1.

1.3 Review of documents

The following documents were relevant to the work of the sub-committee: SC/55/IA1-12; SC/55/E8; SC/55/E19.

2. MATTERS RELEVANT TO MORE THAN ONE STOCK

2.1 DESS: progress with data entry and analysis options

In addition to the inclusion of data from the 2001/2002 SOWER circumpolar survey and the 2001 NASS Icelandic aerial and shipboard surveys, two new import facilities have been written for DESS. As recommended in IWC (2003b, p.248), the import facility has been extended to allow inclusion of resightings data from IO mode on the SOWER surveys. Four years of resightings data (1998/99-2001/02) have been encoded by the Secretariat and imported into DESS; the remaining datasets from three earlier surveys will be incorporated intersessionally. DESS has also been modified to import 'DAS' data files (the output data from *WinCruz Antarctic*), and this has allowed inclusion of data from two vessels on the 2000 IWC-CCAMLR survey to be included.

Two minor changes to the analysis options have been made. The new default option for estimation of mean school size is to use a size bias regression method regardless of the significance of the regression, unless the regression indicates that estimated detection probability decreases with increasing (logarithm of) school size, or provides an estimate of mean school size less than one. In such cases, the default option is to use the mean of observed sizes within a perpendicular distance of 0.5 n.miles (IWC, 2002b, p.196). A modification of the SMALLMAN program means that DESS can now deal with the situation where all observed school sizes in a stratum are equal (and hence have zero variance).

The latest version of DESS is 3.3, and the changes noted above are documented in appendices to the DESS manual.

2.2 SOWER Circumpolar cruises

2.2.1 SOWER 2002/03

SC/55/IA1 presented the report of the 2002/03 SOWER circumpolar survey. This survey was the 25th in the series and comprised a minke whale component and a blue whale component. The planned survey area was the eastern part of Area V, between 170°E and 170°W, including the Ross Sea. During the survey, however, this area had to be modified because of abnormally high pack ice concentrations in the Ross Sea. A contingency research plan was adopted which extended the research area westward to 150°E. The revised aim was to complete coverage of the other remaining gap in coverage in the third circumpolar series (CP III).

The 2002/03 survey was the first in the series in which there was overlap of the SOWER research area with that of JARPA. Detailed planning to ensure that, as far as possible, the SOWER vessels preceded the JARPA vessels, had been undertaken at the 2002 Tokyo Planning Meeting. In practice, this required considerable coordination between the SOWER and JARPA surveys, and achieving this aim was only possible because JARPA was prepared to modify its schedule when necessary. In most parts of the SOWER survey area, the SOWER vessels preceded the JARPA vessels. However, because the SOWER vessels were unable to enter the Ross Sea, the sector between 165°E and 170°E (the first part of the modified research area) was surveyed after the JARPA research. There was a five-day period between completion of the JARPA research and the start of the SOWER survey in this sector.

Throughout the cruise, the weather was generally poor. Nevertheless, good trackline coverage was achieved in the first part of the original survey area (north of the Ross Sea between 170°E and 170°W), and in most of the northern strata of the contingency area (150°E-170°E). However, coverage was poor in the southern strata of the contingency area. As a consequence of persistent bad weather during the latter part of the survey, it was not possible to carry out the feasibility study of biopsy sampling of minke whales, although the Estimated Angle and Distance Experiment was completed.

Minke whales were the most commonly sighted species in the research area, with 309 pods comprising 651 animals. Humpback whales were seen frequently (116 pods; 223 animals), and interestingly, a large number of fin whales (52 pods; 238 animals) were also seen in the western part of the area, concentrated between 150°E and 155°E from the ice-edge to 61°S. Of 8 blue whale pods (comprising 24 animals) encountered – 7 of which were field identified as true blue whales – research was conducted on 5 pods (9 animals). Six biopsy samples were obtained from 4 blue whales, 3 individuals were videotaped, and 35mm photo-identification images were obtained from 9 individuals. Dive time data were collected for one solitary blue whale. Acoustic recordings were made at 99 stations during the cruise. Sounds attributed to blue whales were recorded from both vessels and in the vicinity of seven of the groups of blue whales. At five acoustic stations very high intensity sounds attributed to blue whales were recorded (weak sounds attributed to blue whales were also recorded at numerous stations from both vessels). Sounds attributed to fin, humpback, sperm and killer whales were also recorded.

As cruise leader, Ensor thanked the following people for their assistance during the survey: Atushi Wada (ICR) and Hiroto Murase for providing essential ice information; Shigetoshi Nishiwaki (Cruise Leader of JARPA) for his cooperation in coordinating SOWER and JARPA activities; and the captain and crew of the *Nisshin Maru* for support during a medical emergency and for hospitality on board.

The sub-committee expressed its gratitude to the Government of Japan for providing the vessels to conduct the survey. It also thanked the officers and crew of each vessel, the Cruise Leader (Paul Ensor) and the other researchers for their efforts to ensure that the cruise successfully achieved its objectives.

Some members of the sub-committee were concerned that it had not been possible for the SOWER vessels to always precede the JARPA vessels. Whilst it was recognised that this situation had been unavoidable, it was noted that this feature of the survey may require some consideration in future analyses. It was noted that there was a 2.5 week gap between surveying the eastern and western halves of the 10° sector between 160°E and 170°E, and that during this time there had been a substantial shift in the location of the ice-edge. Ensor replied that fairly dramatic changes in ice edge location are a common feature of this area of the Southern Ocean, and that (albeit limited) observations on board the vessels during the survey did not suggest significant changes in oceanographic patterns. Therefore, he did not believe the 2.5 weeks difference in coverage of the 10° sector to be of importance in this particular case.

The sub-committee noted that for the third year running, the planned minke whale biopsy feasibility study had not been completed. It was acknowledged that the cruise schedule was tight and weather conditions towards the end of the cruise were poor. The sub-committee urged that an attempt be made to complete this study on the forthcoming 2003/04 survey.

2.2.2 Plans for future SOWER CPIII cruises

The 2002/03 SOWER survey had been unable to enter the Ross Sea due to unsuitable ice conditions and SC/55/IA6 presented a revised plan to survey this area. The Government of Japan has offered to provide two vessels for this purpose. The principle strategy for the upcoming cruise is to conduct a minke whale survey covering the area 170°E to 170°W, including the Ross Sea. This area represents the only remaining gap in the third circumpolar set of surveys. As with recent cruises, a blue whale research component is to be incorporated into the 2003/2004 cruise.

The report from the *ad hoc* Working Group to plan logistic aspects of the proposed 2003/04 IDCR/SOWER survey is given as Appendix 2. It noted that contingency plans needed to be developed in case the Ross Sea was closed again. Possibilities include (but are not restricted to) the following:

(1) re-survey either Area V west between 140°-170°E to investigate inter-annual variation;
(2) allocate more days for blue whale research;
(3) biopsy other species of interest (humpback, right and killer whales);
(4) conduct the first CPIV survey in Area VI;
(5) collect dive time data on minke whales;
(6) design and conduct an experiment that would help estimate $g(0)$;
(7) design and conduct an experiment (perhaps similar to SSII) to investigate mis-estimation of school sizes in passing mode.

Gales informed the sub-committee that it would be relatively straightforward to attach a VHF radio tag on a minke whale, and that this could be expected to transmit for a few days. He is currently developing satellite tags for blue whales, and the electronic development of the project is complete. Experimentation is ongoing to ensure that the devices can be successfully attached to the animals. In this regard, some specific adaptations of the device would be required so that it is appropriate for minke whales. It was **agreed** that discussions between Gales, Kato and other members of the SOWER Steering Group would continue, and if the Tokyo Planning Meeting recommended that satellite tagging be conducted on the forthcoming cruise, Gales would work with the Group to try to facilitate it.

There was insufficient time to finalise contingency plans, but members of the sub-committee were strongly encouraged to consider these more carefully, and submit suggestions prior to the Tokyo Planning Meeting. Members of the SOWER Steering Group (Donovan, Bannister, Best, Brownell, Childerhouse, Ensor, Hedley, Kato), plus Butterworth, undertook to work on developing contingency plans for discussion at this meeting.

The sub-committee **endorsed** the proposal for the 2003/2004 cruise and expressed its thanks to the Government of Japan for the offer to make the survey vessels available; especially, as for the 2003/2003 cruise, the duration of the cruise will again be longer than the normal SOWER cruises.

The sub-committee discussed archiving, access and analysis of acoustic recordings from the recent SOWER cruises, which are detailed in Appendix 3. The sub-committee thanked Clark and Cornell University for their assistance in data archiving, and **agreed** that the protocols suggested in Appendix 3 should be adopted. Recognising the importance of collecting acoustic data for blue whale sub-species identification, the sub-committee **recommended** that the acoustic systems on the forthcoming cruise (and any future cruises) be updated and identical on each ship.

Hofmann commented that the large icebergs (C19 and B15) that calved off the Ross Shelf and prevented the SOWER vessels from entering the Ross Sea in the 2002/03 survey had grounded. As a result, the oceanographic circulation patterns in the Ross Sea had significantly altered, and this had detrimentally impacted land-based predators such as penguins. It is reasonable to assume that higher trophic levels (such as whales) would also be affected. Although very recent satellite images suggest that the more northern iceberg (C19) is now moving around Cape Adare and out of the Ross Sea, the 'before-and-after' effects of the environmental changes that have occurred in this area need to be considered in planning future surveys and assessing trends. Sighting and krill data from JARPA surveys may be useful in this regard. The sub-committee **recommends** the 'before-and-after' effects on minke whale distribution of these icebergs and the associated changed environment be investigated.

2.3 Future cruises after CPIII

The *ad hoc* Working Group to plan logistic aspects of the proposed 2003/04 IDCR/SOWER survey ran out of time to discuss plans for future cruises after completion of the third circumpolar series. The sub-committee **recommends** that a Steering Group be established to define possible objectives of any future cruises, and to formulate plans on how to address those objectives. Steering Group members were provisionally nominated to be the SOWER Steering Group members, plus Leaper and Palka.

SC/55/E8 contained the report of the *ad hoc* Working Group on Ice Data Collection in the Antarctic. The report describes the use of automated sightings survey and sea ice data collection systems used by IWC observers on SO-GLOBEC cruises in the Antarctic (for further details see Annex K, Appendix 3). The use of these or other similar systems on future IWC Antarctic cruises following completion of CPIII should be considered.

2.4 Evaluation of abundance estimators against simulated datasets

Last year it was recommended that simulated datasets be used to investigate the robustness of the new analysis methods. To create simulated data more similar to those data collected during the IDCR/SOWER surveys, the program that produced simulated data to investigate the Norwegian analysis methods was modified. SC/55/IA9 reported the changes made. These included the following: three platforms simultaneously surveying, two of which do not communicate to each other; detection functions for each platform resemble those from the actual surveys; the ship travels at 11.5 knots; groups of simulated minke whales have dive time patterns similar to that reported in the literature and group size distributions similar to that recorded in the actual surveys. Nine simulated scenarios were produced that include platform heterogeneities, platform and school size heterogeneities, platform and weather heterogeneities, and platform, school size and weather heterogeneities. These simulated data and the associated document will be submitted to the Secretariat.

The sub-committee expressed its gratitude to Okamura for trialling the methods of SC/55/IA5 (see Item 3.3.1) on these simulated datasets. Detailed examination of the results of the simulations from his and other methods will be reported at next year's meeting.

The sub-committee discussed additional features that need to be incorporated into simulated datasets for testing abundance estimators. The most challenging and realistic cases will occur when there are (positively or negatively) correlated spatial patterns in school density, school size distribution and weather conditions. Some detailed proposals were considered for how to represent spatial structure of these three quantities, based on linear gradients between 'high' and 'low' corners of one or more rectangular survey regions with zigzag tracks. Different combinations can be tested (higher school density associated with higher school sizes and better weather; higher school density associated with lower school size and better weather; etc.). For methods that directly estimate $g(0)$, it is also important to include some measure of realism concerning the sighting process and animal behaviour. These issues can be included in the simulated data by, for example, varying the synchronicity of the surfacing patterns by randomising the proportion of individuals surfacing each time the school surfaces. It was **agreed** that the proposals in Appendix 4 were important and represented a useful way to proceed.

An e-mail correspondence group on Abundance Estimation was established to discuss matters related to the simulated datasets and further analytical issues (see Item 3.3.1). Palka offered to coordinate this.

3. ANTARCTIC MINKE WHALES

3.1 Review of new data from SOWER cruise

The 2001/02 IWC-SOWER Circumpolar cruise covered the western part of Area V, from 130-150°E (with additional limited coverage from 150-155°E). SC/55/IA2 presented estimates of minke whale abundance from this survey, obtained using standard IWC methods (Branch and Butterworth, 2001b). Small sample sizes in the northern strata precluded fully stratified estimation, so Akaike's Information Criterion (AIC) was used to select the most appropriate options for pooling components of the estimation across strata. Effective strip half-width was estimated by pooling over all strata. Mean school size was estimated as 1.92 (CV = 12.6) using a size bias regression method. Since larger school sizes are encountered in the southern strata than the northern strata, the effect of pooling across strata for estimating mean school size was also investigated. For the southern strata, mean school size was estimated as 2.2 (CV = 14.5%) but in the northern strata, all confirmed schools were of size one (with zero variance). Using the pooled estimate of mean school size, the abundance of minke whales was estimated to be 9,484 (CV = 34.3%) from closing mode, and 8,620 (CV = 33.9%) from IO mode. The combined estimate having corrected for closing mode bias was 9,593 whales (CV = 24.7%) with a 95% confidence interval (5,950-15,460). Although the inclusion of sightings classified as 'like minke' had only a small effect on the closing mode estimate (an increase of about 5%), the IO mode estimate was increased by some 30% to 11,234 (CV = 28.0%).

Area V was also surveyed in 1980/81, 1985/86 and 1991/92. These surveys covered the entire longitudinal range (130°E-170°W) but not the full latitudinal range (ice-edge to 60°S). The 2001/2002 survey achieved substantially less longitudinal coverage than planned due to bad weather. There was only partial overlap in coverage between years, so comparisons with previous surveys in Area V remain limited.

In discussion, Matsuoka commended the authors of SC/55/IA2 for using separate estimates of mean school size by northern and southern strata. He also expressed the view that the unusually wide latitudinal width of WS stratum may have negatively biased the abundance estimate there. It was also queried that the estimate of R (the factor used to convert Closing mode estimates to pseudo-passing mode) was an updated estimate of 0.826, not the previous estimate of

0.751. Burt confirmed that this was the case, and that the use of the new estimate facilitated comparisons with estimates presented in Branch and Butterworth (2001b), which had also used R = 0.826. This procedure was recommended by the sub-committee last year.

It was noted that this Area, along with other Areas, have been surveyed at least partially multiple times. Appendix 5 presents two ways to combine the data collected in CPIII to obtain data for a complete circumpolar abundance estimate. The final decision on the best way can be made after it is known what areas are covered in the upcoming SOWER 2003/2004 survey.

3.2 Updated estimates by Area

No new updated estimates were produced this year because Area V had already been surveyed in 1991/92 as part of CPIII, and the latest results from Area V (2001/02 survey) covered a smaller longitudinal range than had been the case in the 1991/92 survey.

3.3 Abundance estimation methodological issues

3.3.1 Analytical methods

Last year, three papers (Birney *et al.*, 1975; Bravington, 2002; Okamura *et al.*, 2002) were presented which proposed new methodological approaches that could be used to analyse IDCR/SOWER data (see IWC, 2003a, pp.34-35). This year, two papers (SC/55/IA5 and SC/55/IA10) were introduced which both dealt with mis-estimation of school sizes, a prevalent feature of the IO (or passing) mode data collected on IDCR/SOWER surveys.

SC/55/IA5 extended the hazard probability model of Cooke (2002) to address bias induced by unconfirmed school sizes. The method requires data from closing mode (for which most sightings are of confirmed size) and passing mode (for which most sightings are unconfirmed, and recorded school sizes generally underestimate true school sizes). Assuming some probability distribution for true school sizes, the distribution of unconfirmed school sizes is estimated conditional on the distribution of true size. A likelihood function is formulated, combining the components due to the hazard probability of detection, the probability that a school is of a certain size given its status (confirmed or unconfirmed) and its recorded size. Maximisation of the likelihood yields parameter estimates that are used to estimate density using the Horvitz-Thompson estimator. The authors note that the bias correction factor for incorrectly recorded school size is treated as a nuisance parameter and therefore not used directly in the estimation of density. The method was applied to data from the 1989/90 and 1993/94 IDCR surveys in Area I, and initial results appear promising.

In discussion, it was suggested that estimation of the surfacing rate parameter could be pooled across CPII and CPIII, since this variable would not be expected to change significantly. Alternatively, setting a prior penalty on this parameter would help restrict its estimation to realistic values. It was also suggested that future developments of the method may attempt to incorporate platform-specific detection functions, as well as a more flexible parameterisation for correcting the bias due to underestimation of unconfirmed school sizes (this bias is assumed constant in the current method).

Bravington (2002) had introduced a way of dealing with $g(0)$ being less than 1 using only single-platform data, and allowing a consistent approach to school size effects: the Big Beautiful Model (BBM). SC/55/IA10 presented an extension of the BBM to allow for school size sometimes being underestimated (e.g. in IO mode), provided that data exists from a subset of the survey where estimation error is not a serious issue (e.g. in Closing mode). The extended method estimated an empirical 'mis-measurement' transition matrix for school size, as a function of sighting conditions. No use was made of perpendicular distance data from IO mode, where the uncertainty about true size would greatly complicate analysis; Bravington considered that this sacrifice of data was unlikely to cause much inefficiency. Butterworth noted, though, that not all school sizes are confirmed even in Closing mode, and so this makes it difficult to ground-truth school size distributions. He proposed testing the sensitivity of abundance estimates to different assumptions about the true size of those unconfirmed Closing mode schools.

Ensor noted that most unconfirmed sightings in Closing mode were considered to be solitary animals. However, occasionally large groups cannot be confirmed due to their behaviour of splitting when approached by a vessel.

It was suggested that data from the SSII experiment from the 1985/86 IDCR survey could be used to test the assumptions used in estimation of the transition matrix empirically. This experiment operated in 'simulated passing mode' survey – a combination of the current passing and closing modes – whereby closure was only attempted once the sighted school was estimated to be abeam of the vessel. Observers were required to provide their best estimates of school size before closure on the school. He cautioned that during the course of the experiment, observers began to change their behaviour (deliberately over-estimating school size). Because of this self-correcting effect, data from the early part of the survey are more reliable. Mori has encoded the data, and agreed to give these to Bravington.

The sub-committee welcomed these papers, which attempt to address an important problem in the estimation of minke whale abundance from IDCR/SOWER data. The two methods treat confirmed or unconfirmed status differently. In SC/55/IA5, the likelihood is formulated conditional on status, whereas SC/55/IA10 proposed modelling confirmation itself as a random variable. Okamura and Bravington had a short discussion on these two approaches. Okamura stated that the probability of confirmation had no effect on the ESW and the abundance estimates. It was agreed to continue discussions on this and other technical issues by e-mail.

An e-mail correspondence group on Abundance Estimation was established to discuss further analytical issues and matters related to the simulated datasets (see Item 2.4). Palka offered to coordinate this.

3.3.2 Spatial patterns

SC/55/IA3 presented estimates of minke whale abundance for Area IV using JARPA survey data from 1989/1990 to 1999/2000. Only data from time periods comparable to those from the IDCR/SOWER surveys were used in the analyses. Whale density was modelled using generalised additive models (GAMs) with spatially referenced covariates (latitude, longitude and distance from the ice-edge) using the 'count model' of Hedley *et al.* (1999). This type of model had previously been investigated by simulation (Clarke *et al.*, 2000) to examine whether it could correct for the inherent bias in closing mode and particularly SSV (Sighting and Sampling Vessel) mode where survey effort is reduced in areas of clustered minke whales. Estimates of individual abundance were obtained by multiplying the predicted school density surfaces by stratum-specific estimates of the expected school size, obtained using the Horvitz-Thompson estimator. Somewhat surprisingly, the resulting estimates of abundance were in general comparable to those obtained using a design-based approach (Hakamada *et al.*, 2001). This does not suggest that design-based estimates are unbiased for SSV data, but it is contrary to the simulation results of Clarke *et al.* (2000). The authors suggest that the GAMs have (at least in part) corrected for the SSV bias, but have also modelled the densities in the southern strata more reliably. In the southern strata the trackline design can sometimes lead to over-surveying in high-density areas along the ice-edge. A relatively low estimate was obtained for 1997/1998, which the authors suggested may be attributed to the extensive ice coverage observed in that year. Conversely an outlying high estimate obtained for 1999/2000 seemed to be a result of higher estimates of expected school size obtained for the southern strata in that year, and/or the greater survey effort allocated to the area between the continental slope and continental shelf, where higher minke whale densities have been reported (Murase *et al.*, 2002a). Estimates of the abundance of schools of size 1, and of schools of size 2 or more, were also reported.

In discussion, it was suggested that the authors may wish to investigate models which use data from all years combined in order to facilitate interpretation of trends in density. Concern was expressed about the use of the covariate 'distance from the ice-edge' in the model, since the ice-edge location varied substantially during the course of the survey. The authors agreed, but the implications for deciding what the survey area should be (since the ice-edge also represents the southern boundary of this area) and how the estimates are linked with minke whale migration are unclear.

It was questioned whether the higher proportion of SV sightings closer to the trackline than SSV sightings in 1999/2000 indicated a behavioural interaction with the vessel, and perhaps a positive bias in abundance due to animal attraction. Hedley disagreed that animal attraction was a likely cause for this difference (detection functions were not noticeably spiked at zero distance), but commented that a difference in the detection function between SV and SSV modes could have been expected *a priori* due to their different design.

The sub-committee was informed that in April 2003, Bravington, Hedley and Simon Wood (University of Glasgow, UK) participated in a short workshop sponsored by CSIRO Australia, to consider spatial smooths of line transect data for abundance estimation. Bravington and Hedley summarised progress on a new modelling framework designed to systematically address some of the difficulties that can arise in practical applications (IWC, 2003b, p.255). The new framework encapsulates spatial structuring as the composite of a smooth density surface (large-scale variation) and a spatial random field (small-scale variation, or 'clustering'), and uses an approximate likelihood for inference. Parameter estimation and smoothing parameter selection are handled simultaneously using an extension of the *mgcv* software (Wood, 2001; 2003), provisionally named MAGIC (Multiple Approximate Generalised Information Criterion). The framework makes use of spatially-varying strip-widths estimated *a priori* (e.g. using the BBM approach in Bravington (2002) and SC/55/IA10), and includes uncertainty in their estimation.

Cooke commented that separation of the likelihood into a 'strip width' component and a 'density' component was pragmatically attractive, but in his experience, this approach only worked well if the estimation was restricted to good detectability conditions. Otherwise, identifiability problems arise because the data do not provide information to distinguish between a strip width of zero (in poor conditions) and zero density.

3.3.3 Additional variance

The total variance of abundance estimates derives from two sources: sampling variance (the variance associated with each individual abundance estimate) and additional variance (or 'process error'). Additional variance is the extent to which the variability of combined surveys exceeds the contribution from sampling variability that is estimated from each survey separately. This can occur, for example, when parts of a population move between strata. In the case of the North Atlantic minke surveys, the survey strata are well defined and do not change between surveys. SC/55/NAM1 estimated additional variance for these surveys, assuming a closed total population and incorporating population dynamics. However, the situation for IDCR/SOWER surveys is more complicated. The survey strata and ice-edge position differ between surveys (even when the same Area is being surveyed), and so much of the variation between surveys could be attributed to changes in the environment. Interpretation of the variation also requires assumptions about the degree to which whales move longitudinally between Areas, north of 60°S and into the pack ice.

The sub-committee discussed modelling choices for estimation of additional variance. It was **agreed** that due to the constantly varying nature of the IDCR/SOWER survey strata, additional variance should be calculated based on the estimates of abundance from the surveys, rather than estimated density, and that (as in the case of North Atlantic minke whales) population dynamics should be incorporated into the estimation (Appendix 6). Parts of the surveyed areas that are common across surveys ('sub-strata') were defined (Appendix 7); those which have survey coverage in more than one year contribute to the estimation of additional variance. An exponential growth model was suggested for modelling the change in abundance over time, with a single common parameter (α) for growth rate. It was noted that models more flexible than the exponential could be used for this component of the estimation, and also that α could be allowed to vary across Areas and/or years, provided that there was sufficient support from the data. Additional variance would then be estimated using an extension of the approach of Punt *et al.* (1997) to allow for the covariance structure (as there would be some correlation between parameter estimates from different sub-strata).

The procedural mechanism for estimating additional variance from the 'standard methodology' (Branch and Butterworth, 2001b) and from the new methods (e.g. Cooke, 2002; SC/55/IA5, SC/55/IA10) was also discussed. It was **agreed** that for comparability purposes, the methods should all use the same approach for estimating additional variance, likely that outlined above (or a variant thereof). All methods should provide abundance estimates and associated covariance matrices for the sub-strata in Appendix 7. Cooke informed the sub-committee that he had the code (in C++) used by Punt *et al.* (1997) for approximate estimation of additional variance, including correlation between parameter estimates pooled across sub-strata.

3.3.4 Producing DESS datasets

The sub-committee **recommends** that a standardised DESS dataset for use by all methods under consideration be created. The extraction options for this dataset are tabulated in Appendix 8. In addition, it was agreed that data from the Estimated Distance and Angle Experiments should be included, together with a pdf version of the DESS manual. It was also requested that brief documentation describing the data fields be included. Further details of the surveys and analysis options used by the standard method can be found in Branch and Butterworth (2001b); Branch (2001); Matsuoka *et al.* (2003); and the survey manual Information for Researchers (available from the Secretariat). Preliminary versions of the standardised DESS dataset and associated documentation would be circulated to the method developers when they are available. Then when these are finalised (after the CPIII series is complete), they will be lodged with the Secretariat.

3.3.5 Other

SC/55/IA12 presented analyses to help quantify the effect of $g(0)$ being less than 1 on estimates of minke whale abundance. A number of papers presented last year had suggested that $g(0)$ was less than 1 for minke whales on IDCR/SOWER surveys. In particular, Murase *et al.* (2002b) showed that mean minke whale school size from CPII to CPIII dropped from about 2.5 to 1.5 roughly independently of latitude, suggesting an increased proportion of smaller schools. If $g(0)$ is less than 1 and increases with school size, this could lead to an increase in the CPIII/CPII abundance ratio when abundance estimates are corrected to account for schools being missed on the trackline. A simple Kelker strip approach was applied to assess the likely size of such an effect. For a strip half-width of 0.2 n.miles and assuming $g(0) = 0.3$ for schools of size 1, the CPIII/CPII abundance ratio for closing mode increased by 15% from 0.63 to 0.72. Generalised linear models were used to investigate the effect of timing of the surveys on the abundance ratio. Despite an estimated 20% migration-related drop in minke whale density after 11 February, this was shown to have only a relatively small (about 2-3%) impact on the abundance ratio.

This paper provided useful information on where to focus methodological developments. It is clear that any method adopted for analysing IDCR/SOWER data will need to take account of $g(0)$ varying by school size. The reasons for the apparent change in true school size distribution between CPII and CPIII are not well understood, but this is evidently an important biological issue and may have further implications for interpreting trends.

3.4 Inter-year comparisons and trends

3.4.1 Extrapolation to unsurveyed regions

3.4.1.1 NORTH TO 60°S

No new methods were presented suggesting ways to extrapolate density to 60°S, for those surveys that did not survey that far north. Methods which are able to model the density gradient (such as Stahl and Borchers, 2001) are likely to be most appropriate for this type extrapolation.

SC/55/IA11 carried out sensitivity tests to assess the impacts of assumptions made for extrapolation and interpolation. Tests were based on ‘comparable area’ estimates of abundance of minke and killer whales for the three circumpolar sets of IDCR-SOWER surveys, CPI-CPIII (Branch and Butterworth, 2001a; b). Although minke whale sighting rate dropped by 50% or more from latitudes 63-64°S to 60-62°S, coarse adjustments of the extrapolation assumptions to the unsurveyed northern areas to allow for this decrease made virtually no difference to the estimated drop in minke whale abundance from CPII to CPIII. This was because of the large contribution to the CPIII estimates from an extrapolation for the unsurveyed area on the 1991/92 cruise in Area V. However, this region may not reflect typical density decrease rates with lowering latitudes because of the much greater distance from the ice-edge in the Ross Sea compared to other Management Areas. Comparisons excluding Area V indicated an increase in the CPIII to CPII abundance ratio from 53% to 59% for closing mode, and from 41% to 45% for IO mode, when extrapolations are adjusted similarly. The authors note that such an appreciable contribution to the difference (about a 10% effect) warrants careful consideration of the methods used to extrapolate northwards.

3.4.1.2 INTO THE PACK-ICE

Minke whales are known to occur within the pack ice during the time period that the IDCR/SOWER surveys are conducted (Naito, 1982; Ensor, 1989; Thiele and Gill, 1999). The IDCR/SOWER survey vessels cannot survey within pack ice of low ice concentration at normal survey speed, and do not survey in pack ice of more than about 30% ice concentration. Last year, the Committee recommended (IWC, 2003b, p.261) that efforts be made to identify possible other data sources that could be used to estimate whale density in the pack ice region, specifically:

> The Secretariat should make an official request to the APIS co-ordinators inquiring about availability and access to any cetacean data that their member countries may have collected within and outside the pack ice.

Ian Boyd from the Sea Mammal Research Unit, University of St Andrews, UK was contacted in this regard. Although a data holder, he did not think his data would contain anything of interest to the IWC. He suggested contacting Marthan Bester and John Bengston – both of whom are involved in APIS data coordination. Bester responded that he did not think the data were readily available, and offered to put out a request for incidental cetacean sightings data to seal researchers via the Antarctic Seal Researcher Distribution List. This list is maintained by the SCAR Seal Expert Group within the new Life Sciences Standing Scientific Committee.

It was reported that David Borchers had inquired about the use of US APIS data in this regard. Whilst these data could be made available, they were not believed to be useful because the effort spent searching for whales could not be quantified and whale sightings were only incidentally recorded.

Members of the Scientific Committee were unable to source new data within the pack ice. The analysis of data from cetacean sightings surveys within the pack ice is, however, important to the work of the sub-committee. Last year the sub-committee discussed data from a systematic cetacean sightings survey (part of the Australian APIS project) that was conducted in the pack ice region (Thiele *et al.*, 2002). Gales and Thiele undertook to investigate whether any further analyses could help elucidate approaches for estimating minke whale density in the pack ice.

It had also been recommended that national programmes with vessels operating in the pack ice should be requested to conduct dedicated cetacean observations from their vessels. Whilst no progress was reported on this recommendation, the sub-committee welcomed the news that the National Research Institute of Far Seas Fisheries (Japan) and the Institute of Cetacean Research (Japan), in collaboration with the Japanese National Institute of Polar Research, plan to study the distribution pattern of marine mammals and sea birds in relation to sea ice condition. The collaboration will begin in the 2003/2004 season, and a sighting survey within the pack ice will be conducted from an ice breaker, during transit between homeports and the Antarctic base. It is hoped that in the near future, aerial sighting surveys may be possible using helicopters.

The sub-committee **agreed** that in the long-term future, it will be important to be able to estimate minke whale density in the ice, and develop appropriate practical and analytical methods for doing so. For the period of the IDCR/SOWER surveys however, density in the ice cannot be retrospectively estimated, and so analyses which describe the likely effect on the IDCR/SOWER abundance estimates are of value. In this regard, SC/55/IA7 presented a qualitative analysis on the relationship between the distribution of minke whales and Antarctic sea ice coverage in the austral summer using meteorological satellite data for the 1988/89 (CPII) and 1998/99 (CPIII) IDCR/SOWER circumpolar surveys in the waters between 80°E and 130°E in Area IV. The following factors were compared between 1988/89 and 1998/99: monthly sea surface temperature; total area of sea ice; area of sea ice of less than 40% ice concentration; sea ice condition in the Ross Sea and Prydz Bay in January; ice-edge location; and area of continental slope covered by sea ice. The comparison indicated that the 1998/99 season was colder than 1988/89 season in this Area. The estimated abundance of Antarctic minke whales in 1998/99 was very much lower than that in 1988/89 (Branch and Butterworth, 2001b; Burt and Stahl, 2001). In January 1998/99, both the Ross Sea and Prydz Bay were covered by sea ice, though they are well known to be relatively high density areas of minke whales. There was no evidence for unusually high abundance in the northern stratum that year, therefore the author concluded that the relatively low abundance estimate was due to a correspondingly high number of minke whales in the pack ice region that year.

The sub-committee noted that these qualitative analyses are useful to understand the effects of oceanographic processes, sea ice condition and dynamics on minke whale density. However, it may be difficult to extrapolate findings from small-scale studies to the entire circumpolar region.

SC/55/E19 noted that the definition of the ‘ice-edge’ in IDCR/SOWER surveys (as the southern boundary of the research area, beyond which the survey vessels cannot safely access to survey) is a term peculiar to the IWC. It provided definitions of ‘ice-edge’ as used by other marine science disciplines in the Antarctic, and it was suggested that such a physically-based definition should be used in modelling the IDCR/SOWER data. The sub-committee **agreed** that is was important to state clearly what definition of ‘ice-edge’ was being used in analyses, and that a climatological definition may be more appropriate for some models. An intersessional group (under Palka) was established to investigate this, and to try to source other explanatory variables (e.g. shelf break, coastlines, southern boundary, the ACC) that are likely to influence whale distribution.

The sub-committee **recommends** analyses be conducted to, if possible, estimate the order of magnitude of the numbers of minke whales in the ice using any data available (including past data), such as that collected in the IDCR/SOWER, SO-GLOBEC or APIS surveys.

3.4.2 Trends in abundance

The sub-committee suggests three methods to estimate trends in abundance. One method is a simple comparison of the abundance estimates from the three series of CP surveys. Another method focuses on the growth rate parameter value(s) that come out of the additional variance analysis (see Item 3.3.3). The third method involves catch-at-age population dynamic models, for example but not limited to, the ADAPT VPA methods used in Butterworth *et al.* (2002). This method is discussed more fully next.

3.4.2.1 POPULATION DYNAMIC MODELS

No papers were submitted for consideration under this agenda item. The sub-committee noted that the types of population dynamic models useful for examining trends were not limited to traditional Virtual Population Analyses (VPA) and noted that a variety of general catch-at-age methods could be used. Polacheck reported on progress made by the intersessional Working Group on VPA Analysis related to Southern Hemisphere minke whales, established at last year’s meeting[1]. The intersessional Working Group undertook extensive efforts to fulfil its first term of reference to request the required summary data following the established data policies. However, it was unable to succeed in producing a proposal that would provide it access to JARPA data. Members of the group were unable to make any progress on the other terms of reference or to carry out any initial analyses because the data needed for catch-at-age analyses could not be made available in time. Based on its terms of reference and the IA sub-committee report from last year, the sub-committee clarified the following specific issues for further investigation.

(1) Examine the sensitivity to the assumptions of fixing certain parameters to allow others to be estimated.
(2) Examine the implications of uncertainties in stock structure on the results of catch-at-age analyses and their conclusions.
(3) Investigate the levels of uncertainty in the catch-at-age data and their effect on results of a catch-at-age analysis.
(4) Examine selectivity constraints and possible lack of fit to the age distribution in the plus group.
(5) Explore possible links between environmental (e.g. climate) changes and estimated trends in minke whale abundance from a catch-at-age analysis.
(6) Check the consistency between the catch-at-age results and data on blubber thickness, pregnancy rates, length and age at first ovulation.
(7) Explore the possible effect of the geographical and ecological segregation of the mature and immature components of the stock which may be exploiting different resources and thus interact differently with prey species and competitors.

Items (1), (3) and to a partial extent (4), have already been examined by Butterworth *et al.* (1999) within the context of their VPA analysis, therefore Butterworth sought advice from the sub-committee as to what further sensitivity tests should be conducted. Since it is difficult to know in advance what combinations of factors may lead to the same or different results, no specific suggestions were received; nevertheless members of the sub-committee considered that further exploration of these issues could be considered, particularly in the context of the other issues listed above that the sub-committee identified as needing to be addressed. It was noted that the first part of item (5) would be facilitated through assistance from the Standing Working Group on

[1] Report available from the Secretariat.

Environmental Concerns, since *a priori* hypotheses relating recruitment to environmental variables over given time frames are required.

The sub-committee **agreed** that investigation of all seven items were of high priority for its work in order to complete the Southern Hemisphere minke whale review. It was **recommended** that the previous intersessional Working Group (comprising Polacheck (Chair), Butterworth, Cooke, Smith, Leaper and Punt) attempt to ensure that sufficient analyses are developed to address the above issues in order that the sub-committee can complete the Southern Hemisphere minke whale review. The Working Group welcomes other interested members of the Scientific Committee to join. It was noted that work undertaken under the auspices of this group does not preclude other analyses being submitted. It is important that this group determine data requirements and likely analytical techniques before the end of the plenary sessions[2]. These can then be adopted by the Committee as a whole, which can submit a formal request for data under any new data availability procedures, should these be adopted.

3.4.2.2 POWER OF DETECTING A TREND

No papers were submitted for consideration under this agenda item. But in brief discussion, it was noted that once trends and its confidence have been estimated from the additive variance models (see Item 3.3.3), power to detect the trend would then be estimated using standard methods.

Power to detect and interpret a trend is implicitly tied to factors influencing additional variance. Longitudinal movement of whales is one such factor. Using estimates of minke whale abundance by 30° longitudinal sector and year, Punt *et al.* (1997) had estimated the additional variance to be substantial, suggesting longitudinal movement of this degree is quite plausible. However, additional variance is known to decrease with longitudinal width, so that at the 60° sector level it is not significantly different from zero (Butterworth *et al.*, 1999). The implications for trend estimation from IDCR/SOWER data when considering environmental and biological effects are less clear. There is evidence from some populations (e.g. right whales) that changes in biological parameters such as reproductive rate are not necessarily dependent on density of the population so environmental changes do not only impact on carrying capacity.

In conclusion, the sub-committee **agreed** that any trend estimation method should not extrapolate between Areas, since any changes in biological parameters could be Area-specific. Most information on these parameters exists in Areas III, IV and V whereas most environmental information is in Area II. Mori and Palka undertook to discuss these matters further with Reilly, in the hope that Eugene Murphy from the British Antarctic Survey, UK could provide insights into environmental changes in other Areas, and how these changes influence the power to detect trends in minke whale abundance.

3.4.2.3 OTHER POSSIBLE REASONS FOR TRENDS

SC/55/IA4 presented analyses on the likely effect of killer whale predation on minke whales in the Antarctic. The author reported that given estimated consumption rates of killer whales and their estimated abundance, it was not possible for killer whales to have killed enough minke whales to explain a possible decline of the magnitude estimated in Branch and Butterworth (2001b). Discussion of this paper can be found in Annex K, item 6. The sub-committee briefly discussed whether or not multi-species interactions should be considered when interpreting possible trends in minke whale abundance. It was **agreed** that whilst multi-species analyses may provide consistency checks for examination of trends, they should not be viewed as the primary tool for trend estimation.

The sub-committee noted that it had made progress in addressing the hypotheses listed in the response to Resolution 2001-7 (IWC, 2002a), which requested the Scientific Committee to provide a list of plausible hypotheses that may explain the apparent population decline. However, the sub-committee **agreed** that, as stated last year, the most appropriate time to fully address this Resolution would be after completing its work on reviewing the IDCR/SOWER abundance estimates and trends.

3.5 Stock structure

SC/55/IA8 presented the results of a restriction fragment length polymorphism (RFLP) analysis of mitochondrial DNA (mtDNA) in Antarctic minke whales from Areas IIIE, IV, V and VIW sampled during 1987/88-2001/02 JARPA surveys. Samples were stratified under the same geographical and temporal criteria used in previous analyses. A total of 4,982 samples was examined in this study. Quantification of the mtDNA differentiation among strata was carried out using Analysis of Molecular Variance (AMOVA) and both haplotype (Fst) and sequence (PHIst) statistics were used. No significant geographical or temporal mtDNA heterogeneity was found in Areas V and VIW and thus whales in these Areas were assumed to belong to a single stock (core), which was compared to different longitudinal/temporal strata in Areas IIIE and IV. The pattern of longitudinal and temporal mtDNA heterogeneity is consistent with the hypotheses of a core stock in Areas VIW, V and IVE. Heterogeneity found in Area IVW can be interpreted as an ‘intrusion’ of a different stock in some years or the overlap of two stocks with a temporal component. It is recommended that grouping of samples be made considering alternative longitudinal and temporal definitions and that other factors, such as the distance from the ice-edge, are incorporated into the analyses. Microsatellite data have been obtained for minke whales sampled in six JARPA surveys. Analysis of these data is underway and results from this marker will assist in the interpretation of the results of the mtDNA analysis. Pastene reported that no significant difference between sexes have been found in the longitudinal/temporal/year strata. The analysis presented in SC/55/IA8 pooled male and female samples. He suggested that an alternative approach would be to repeat the analysis presented in SC/55/IA8 on females only and compare the results.

The analyses presented in SC/55/IA8 have a number of implications for trend estimation from the catch-at-age analyses discussed in Item 3.4.2.1. At this stage, only preliminary conclusions about stock structure can be drawn, but more concrete conclusions will be able to be made following the completion of the microsatellite analyses. Since the results of catch-at-age (CAA) analyses will need to be robust to assumptions about stock structure, there was some discussion about where to draw the stock boundary line in Area VI, the eastern part of which has little or no genetic or catch data on which to base hypotheses. It was suggested that the intersessional Working Group on CAA examine the reasons for the current Area boundaries in this regard. The sub-committee **recommended** that alternative analyses from those carried out in SC/55/IA8 be conducted to check for

[2] This was done and the version adopted by the Plenary has been appended to this report (Appendix 10).

consistency. Pastene agreed, and commented that he planned to investigate the Bayesian analyses discussed in the Working Group on Stock Definition (Annex J).

4. WORK PLAN AND BUDGET REQUEST

Appendix 9 details the tasks identified by the sub-committee to further the review of Antarctic minke whale abundance estimates, together with an indication of priorities for next year. Noting the need to explain why the estimates of abundance using the standard methods for the third circumpolar set of surveys are appreciably lower than estimates for the second CP (Resolution 2001-7, IWC, 2002a), the sub-committee **strongly recommends** that substantial progress be made on all tasks given high priority.

To successfully complete its review of the IDCR/SOWER abundance estimates and trends and to address Resolution 2001-7, resources are required. The sub-committee **agreed** that the highest priority request in this regard is to complete the last year of the IDCR/SOWER survey, and high priority is given to requests to maintain and utilise the DESS database, and to develop and test new analytical methods that result in less biased abundance estimates and trends. Financial details of the IDCR/SOWER cruise have been discussed in Appendix 2.

5. ADOPTION OF REPORT

The report was adopted at 14:30 on 3 June 2003.

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Appendix 1

AGENDA

1. Introductory items
   - 1.1 Election of chair and appointment of rapporteurs
   - 1.2 Adoption of agenda
   - 1.3 Review of documents
2. Matters relevant to more than one stock
   - 2.1 DESS: progress with data entry and analysis options
   - 2.2 SOWER Circumpolar cruises
     - 2.2.1 SOWER 2002/03
     - 2.2.2 Plans for future SOWER CPIII cruises
   - 2.3 Future cruises after CPIII
   - 2.4 Evaluation of abundance estimators against simulated datasets
3. Antarctic minke whales
   - 3.1 Review of new data from SOWER cruise
   - 3.2 Updated estimates by Area
   - 3.3 Abundance estimation methodological issues
     - 3.3.1 Analytical methods
     - 3.3.2 Spatial patterns
     - 3.3.3 Additional variance
     - 3.3.4 Producing DESS datasets
     - 3.3.5 Other
   - 3.4 Inter-year comparisons and trends
     - 3.4.1 Extrapolation to unsurveyed regions
       - 3.4.1.1 North of 60°S
       - 3.4.1.2 Into the pack-ice
     - 3.4.2 Trends in abundance
       - 3.4.2.1 Population dynamic models
       - 3.4.2.2 Power of detecting a trend
       - 3.4.2.3 Other possible reasons for trends
   - 3.5 Stock structure
4. Work plan and budget request
5. Adoption of report

Appendix 2

REPORT OF THE *AD-HOC* WORKING GROUP TO PLAN LOGISTIC ASPECTS OF THE PROPOSED 2003/2004 IWC-SOWER CIRCUMPOLAR CRUISE

Members: Kato (Convenor), Bannister, Bravington, Brownell, Childerhouse, Clark, Donovan, Ensor, Hedley, Hughes, Matsuoka, Miyashita, Murase, Nakatsuka, Nishiwaki, Pastene, Shimada, Sohn, Yamakage (I).

1. BACKGROUND AND TERMS OF REFERENCE

Kato introduced the meeting's terms of reference. The main task of the group was to discuss the logistic aspects of planning for the cruise. As this cruise is intended to complete coverage of the third circumpolar series, the sub-committee had made a specific request for initial ideas to be put forward in relation to any subsequent cruises.

2. ELECTION OF CHAIR AND APPOINTMENT OF RAPPORTEURS

Kato was elected Chair. Ensor and Murase acted as rapporteurs.

3. ADOPTION OF AGENDA

The agenda was adopted.

4. RELEVANT DOCUMENTS

Documents SC/55/IA1 and SC/55/IA6 were considered. The meeting also referred to Annex H, Appendix 8 (the Report of the IWC-SOWER blue whale acoustics Working Group meeting) and last year's *Ad-Hoc* Working Group Report (IWC, 2003).

5. PLANNING FOR THE 2003/2004 CRUISE

5.1 Principle strategy for the 2003/2004 cruise
The principle strategy for the cruise will be to conduct a minke whale survey covering the area 170°E to 170°W, including the Ross Sea. This area represents the only remaining gap in the third circumpolar set of surveys (Fig. 1). The 2002/2003 cruise had been planned to cover this area, however on that cruise unusual ice conditions in the Ross Sea prevented completion of coverage of the area and led to adoption of a contingency plan which extended the research area westward to 150°E. As with recent cruises, a blue whale research component will be incorporated into the 2003/2004 cruise. A contingency plan for the 2003/2004 cruise is required in case ice again prevents access to the Ross Sea. It was recognised that by the time the planning meeting occurs (September 2003), models of the predicted ice conditions in the Ross Sea for the forthcoming season should be available from USA sea ice modellers; it was therefore decided that contingency options should be evaluated at the planning meeting in the light of information available at that time.

5.2 Number and identity of vessels offered
Nakatsuka reported that the Government of Japan will again offer the two research vessels *Shonan Maru* and *Shonan Maru No.2*, provided that this year's plan is comparable to the previous ones. The group expressed its gratitude for this generous offer from the Japanese Government.

5.3 Length of the cruise
The total cruise (southern home port to southern home port) will be 80 days, with 67 days in the research area. As last year, refuelling at sea is required since the cruise will exceed the vessels' normal 60-day endurance. Refuelling (from a

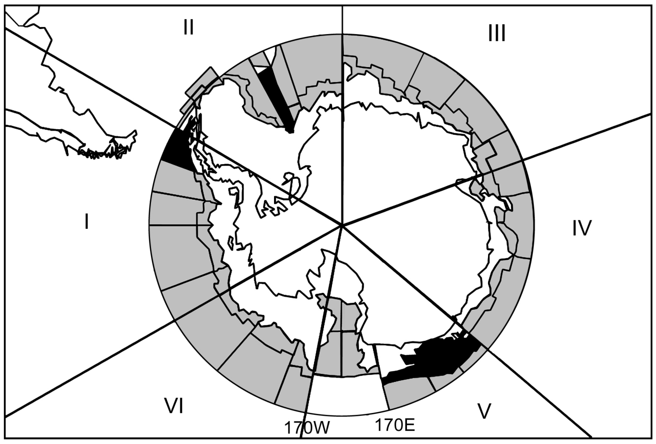

Fig. 1. Map of the area covered during CPIII. The shaded areas have been covered once during CPIII. Black areas represent overlap of coverage (double coverage). For clarity, coverage of the Northern Stratum 170°E to 170°W achieved during the 2002/2003 SOWER cruise is not shown.

visiting tanker) will take place in early January and it is anticipated that the research vessels will not be required to transit to the refuelling vessel.

5.4 Research area

SC/55/IA6 proposed that the survey be conducted in the area 165°E to 170°W. However, it was agreed that for the 2003/04 cruise, priority should be given to covering the area 170°E to 170°W (including the Ross Sea) as last year's cruise had completed coverage west of 170°E. As last year, the research area will be divided into three latitudinal strata, with two strata in the Ross Sea.

5.5 Survey timing and itinerary

The itinerary proposed in SC/55/IA6 was amended to provide seven additional days in the research area (a total of 67 days will be available south of 60°S). Recognising that the itinerary will be finalised at the planning meeting, a provisional indication of timing is shown in Table 1.

Table 1

Provisional timing of itinerary.

Date	Event
Thurs. 27 November 2003	Leave Setoda (Japan)
Tues. 16 December 2003	Arrive Hobart (Australia)
Fri. 19 December 2003	Leave Hobart
Fri. 26 December 2003	Start survey (67ºS, 170ºE)
Mon. 1 March 2004	End the survey (67ºS, 170ºE)
Mon. 8 March 2004	Arrive Hobart
Thurs. 11 March 2004	Leave Hobart
Tues. 30 March 2004	Arrive Shiogama (Japan)

5.6 Survey methodology

5.6.1 Minke whale component

The group recommended that the same survey methods and experiments used in previous years be adopted for the 2003/2004 cruise, to ensure comparability with estimates made in CPII surveys.

5.6.2 Blue whale component

The group recommended that the same protocol as in recent cruises be used (acoustics, dive times, photography for morphology, biopsy and photo-identification).

5.7 Time allocation of the two components

The group recognised that potentially 60 days are necessary to provide coverage (comparable with recent SOWER cruises) of the survey area for the minke whale component. Six days will be allocated to the blue whale research component (increased from two days allocated on the 2002/2003 cruise). An extension of the daily research time if blue whales are encountered near the end of the research day will facilitate the blue whale research. It was agreed that the question of flexibility in end of daily research time would be discussed with senior ship personnel prior to the planning meeting.

5.8 Priority of research items

The research priorities are the same as last year. However, it was noted that minke whale biopsy feasibility trials have been a priority item for the last three years but have not been completed due to logistic constraints; therefore, a resolute effort should be made to complete the trials on the 2003/04 cruise. Details will be finalised at the planning meeting, however the plan for previous years was adopted: each vessel to attempt biopsy sampling on 10 groups of minke whales in the Northern Stratum, with no more than 30 minutes normally spent on each group (maximum of five hours per vessel).

5.9 Participants

A total of four researchers can be accommodated on each vessel. Kato announced that Japan would allocate one Japanese researcher to each vessel and it was indicated that the Government of Japan would cover the costs of participation of both Japanese researchers. Ensor agreed to act as cruise leader. The group nominated Matsuoka as senior scientist. It was recommended that the request for applications by other researchers be advertised as usual with the formal choice of participants made at the planning meeting. However, an earlier appointment of acoustics researchers is desirable (see Item 5.12). It was noted that the selection process for the other Japanese researcher should follow similar principles as for the international researchers (but advertisement is not required).

5.10 Planning meeting

It was agreed that the planning meeting should take place in Tokyo, for four days, in September. Provisional timing for the meeting is 24-27 September. Besides the cruise leader, captains and relevant crewmembers, the group recommended that the meeting also include Steering Group members Bannister, Brownell, Childerhouse, Clark, Donovan, Hedley and Kato. Kato was requested to convene the meeting.

5.11 Home port and responsible persons

The home port for the start and end of the cruise will be Hobart; Bravington agreed responsibility for home port arrangements. He indicated that although for recent cruises, his Institute (CSIRO) had willingly assisted with press liaisons, there had been some inherent difficulties and he proposed the planning meeting consider providing more detailed material for the press. Suggestions included additional information possibly on the IWC website. Also, it was important to provide access to archive video and possibly selected acoustic recordings. These comments were noted and the issue was referred to the planning meeting.

5.12 Review of recommendations

The following recommendations had arisen following last years cruise (SC/55/IA1):

(1) The sonobuoy reception on the *Shonan Maru* (currently 2 n.miles or less, compared to 4.5 n.miles two years ago) appears to be significantly less than the *Shonan Maru No.2* (up to 8 n.miles this year). The receivers vary by ship and year, and all are the same model (ICOM). This discrepancy suggests that there may be a problem with the antenna, preamp, or voltage supply for the *Shonan Maru*. It is requested that this equipment be examined and replaced, if necessary, before the next field season. Additionally, it is suggested that the acoustics researchers test the reception on both ships simultaneously prior to departure from the homeport, allowing time to consult a marine technician. Cost of such test to be financed by IWC. It is essential that if acoustic equipment is replaced, the acoustic data collection systems are the same on both ships.

(2) In addition to the recommendations in Annex H, Appendix 8, it is essential that the equipment provided by the IWC include sufficient DAT tapes to provide for a minimum of 150 hours recording at full bandwidth (100 90 min. tapes) for each vessel.

(3) The printer aboard *Shonan Maru No.2* (Canon BJ200) malfunctioned and must now be repaired or replaced. On the *Shonan Maru* only one of the IWC computers had the necessary printer driver (Compaq IJ700) and this computer was dedicated to acoustics monitoring for much of the cruise, during which time the printer could not be used. A copy of the printer driver software for installation on the backup computer is needed.

(4) If the research area for the 2003/04 cruise includes the Ross Sea, the research period for this area should be from the middle of January to late February. Specifically, the research period for south of 69°S should be set from February in order to allow maximum time for the ice to clear.

(5) Last year, the Scientific Committee had felt that installation of time recording devices to record sighting times from the IOP and Top platform in IO mode would help facilitate the application of a new method of estimating $g(0)$ as proposed by Cooke at the 2001 meeting. This method requires a distinction between simultaneously detected duplicates and delayed duplicates. There was insufficient time after the 2002/03 cruise Planning Meeting to install such devices although the ship personnel agreed to undertake installation for future cruises. Specifications for the entire system should be finalised and made available with enough advance time for implementation prior to the 2003/04 cruise.

5.12.1 Substantial items

Some discussion of recommendation (5) had already occurred in the sub-committee where it was suggested that should the design of such a system be technically difficult, or expensive, it was possibly not worth pursuing since this cruise was expected to be the final cruise in the third circumpolar set, and as plans for future cruises had not been finalised the value of data from only one cruise would be marginal. The *ad-hoc* group agreed that, although a final decision had yet to be made on the design of a system, technical installation of the equipment prior to this cruise was feasible. Miyashita indicated that his Institute operated a system which may meet the requirements, and he agreed to take responsibility for organising any equipment if required. However, further advice from the sub-committee on the likely value of resulting data would be sought (considering also that there may be a financial cost).

5.12.2 Technical items

Recommendations (1)-(4) were referred to the Planning Meeting. However, recommendation (1) had been noted in the sub-committee; Shimada mentioned that diagnostic tests had been conducted in Japan on return of the vessels from the last cruise. With regard to recommendation (4), it was noted that the proposed itinerary for the cruise (Item 5.5) had effectively addressed this recommendation.

Recommendations from Annex H, Appendix 8 were also considered. With respect to the potential cost savings of arranging early shipment of sonobuoys, Ljungblad would be asked to order 150 sonobuoys for the forthcoming cruise. Donovan agreed to assist Ljungblad with the freight arrangements so that the sonobuoys could be shipped as early as possible.

Following consideration of Annex H, Appendix 8 it was recommended that identical acoustics monitoring and recording systems and software be used on both ships. Further, it is imperative that both systems have the capability to use direction-finding software (DIFAR). It was recognised that this may have a financial implication since new equipment will be required.

It was agreed that the two acoustics researchers should be selected as soon as possible by the Steering Group, via e-mail and in collaboration with Clark. Prior to the cruise the acoustics researchers would be required to meet and test all aspects of the acoustics equipment to ensure standardisation of monitoring and recording methods on both ships as well as operation of the direction finding software.

5.13 Budget

Based on an inventory of IWC-owned acoustic, biopsy and computer equipment remaining after the 2002/2003 cruise, Ensor noted that with the exception of the replacement printer detailed in Item 5.12.3, minor costs would be associated with maintenance of the IWC-owned equipment.

New computers are required so acoustic recording can be conducted in an identical manner on each ship. Additional funds were necessary to update and maintain the acoustics archive currently maintained by Clark.

The preliminary budget is given in Table 2.

6. INITIAL DISCUSSION ON FUTURE PLANNING AFTER CPIII

Lack of time precluded an initial discussion of future cruises, thus the group forwarded this issue to the full sub-committee.

Also in this context, advice would be sought on the research priorities if, after survey of the northern stratum, the Ross Sea is inaccessible due to ice. Suggestions for such research included: re-survey of areas already covered during the third circumpolar set of cruises and/or experiments designed to improve the results of previous abundance estimates.

Table 2
Preliminary budget, 2003/2004 cruise (values in pounds sterling).

Researchers	Grant	Travel	Ship	Other	Acoustics archive	Acoustics, freight, etc	Computers	SC/56	Ice data	Bank charges	Planning meeting	Total
C/leader	12,240	400	1,120	300				1,100		55	1,300	16,515
S/Sci												0
Japan 1												
Other	7,360	2,700	1,120	300						55		11,535
Other	7,360	2,700	1,120	300						55		11,535
Other	7,360	2,700	1,120	300						55		11,535
Other	7,360	2,700	1,120	300						55		11,535
Other	7,360	2,700	1,120	300						55		11,535
Japan 2												0
Bannister											1,600	1,600
Brownell											800	800
Childerhouse											1,300	1,300
Donovan											1,800	1,800
Hedley											1,700	1,700
Clark											1,700	1,700
									500			500
Total	**49,040**	**13,900**	**6,720**	**1,800**	**2,000**	**3,450**	**3,100**	**1,100**	**500**	**330**	**10,200**	**92,140**
Air freight sonobouys*						3,450						
Printer							100					
Acoustics computers (two)							3,000					

*A substantial saving could be made if these were sent by surface rather than air freight, although this would require prompt despatch to Hobart.

Survey of the northern stratum is expected to take approximately 20 days. If the Ross Sea is not accessible at the time of completion of the northern stratum, about 47 days would be available for such a contingency research plan.

7. OTHER MATTERS

The meeting noted that a summary of a subset of the results from blue whale acoustics recordings from the two most recent SOWER cruises had been presented this year with sole authorship by the researcher who collected these data (SC/55/SH5). The Scientific Committee had expressed its gratitude for this contribution and recognised the aim was to provide a brief summary of the key points of the results for consideration of this important topic with potential to assist with blue whale sub-species identification. The work had been completed in a very short time frame between the end of the cruise and the following Scientific Committee meeting and there was no deliberate intention to disregard the usual spirit of cooperation between acoustics researchers in presenting acoustics results in a collaborative manner.

To facilitate the copying of acoustics recordings to accommodate several requests for access to the acoustic data, it was recommended that an item should be included in the budget to assist Clark in maintaining and updating the acoustics archive.

REFERENCE

International Whaling Commission. 2003. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on the comprehensive assessment of whale stocks — in-depth assessments. Appendix 2. Report of the *ad-hoc* working group to plan logistic aspects of the proposed 2002/2003 IWC/SOWER circumpolar cruise. *J. Cetacean Res. Manage. (Suppl.)* 5:269-71.

Appendix 3

IDEAS RELATED TO PROTOCOLS FOR IWC-SOWER ACOUSTIC DATA ACCESS, ANALYSIS AND COLLABORATION

C.W. Clark

Acoustic recordings have been collected since the beginning of the SOWER and IWC-SOWER cruises. Several participating researchers (e.g. Doherty, Findlay, Ljungblad, Rankin and Shimada) have been responsible for collecting these acoustic data during the cruises and some have interests in analysing and publishing peer reviewed scientific papers with these data. The data will also be available to other scientists who have not participated in IWC-SOWER activities.

It would be helpful to have the SOWER Steering Group agree on and clarify the following matters that pertain to these acoustic data: (1) archive; (2) access; (3) analysis and interpretation; and (4) publication of results.

In particular it would be valuable to have an agreed protocol on these topics. Here I propose some protocols with the hope of simplifying data availability and clarifying the situation as I now know and understand it. I welcome and encourage discussion and resolution on this matter.

(1) Archive

The Bioacoustics Research Program at Cornell (Cornell), with the recommendation of the sub-committee, is presently responsible for archiving all acoustic recordings into a standard format. To date, all recordings sent to Cornell have been on digital audio tapes (DATs) using various commercial DAT recorders sampling at one of the three standard sampling rates (e.g. 32kHz, 44.1kHz or 48kHz). In the field a form is filled out for each DAT. At the end of the season the forms are sent to the IWC Secretariat, and DATs are given to the Senior Scientist who sends them to Cornell.

At Cornell, all DAT recordings are converted into digital data files (not audio files) in the AIF format. By this procedure, the acoustic recording from a single DAT is converted into a series of AIF files (named by the year, month, day, hour, minute and second) in a folder (named by the year, month, day and tape number) so that each file and each folder has a unique, unambiguous name. All these data are NOT burned onto data CDs as originally proposed four years ago. Instead, the data are archived on 120GB hard disk drives. There are two copies of every drive, one is stored in the Bioacoustics Research Program lab and one is stored off site. I made the decision not to use CDs since the CD cost ($/GB) was significantly higher than a hard drive and access is significantly faster and easier via a hard drive.

At Cornell a technician screens each AIF file, scores for presence/absence of blue, fin, humpback, minke and ‘other’ species, counts the number of sounds for blue and fin whales, and enters any comments (e.g. sound quality, sound variants).

Thus, a person requesting acoustic data would receive for every DAT the acoustic data files as well as an EXCEL spreadsheet associated with the DAT. My intention is to provide large samples of such data (e.g. all the IWC-SOWER data from a season’s cruise) on a single hard drive. Copies of the original tape logs would need to be acquired from the IWC as we have not transferred these notes into an electronic format. For some cruises, the task of transferring notes into electronic files was completed by each acoustic technician before the end of the cruise. It would be good if this could be a standard procedure delegated by the senior scientist.

(2) Access

My working assumption is that Cornell will provide acoustic data and any associated data files to anyone who asks for it, although there might be rare exceptions that need to be considered. One protocol could be that anyone who has been directly involved in the cruises would make their request directly to Cornell with a copied message to IWC, while anyone who has not been directly involved in the cruises would make this request directly to the IWC who would then forward the request to Cornell. There needs to be some stipulation on data distribution and use for publication. I propose that only the IWC Secretariat can authorise distribution. For use in publication, considering that this is a regular issue with the Cornell Macaulay Library of Natural Sounds, I propose to confer with its director, Professor Jack Bradbury, for guidance on a limited number of solutions. [For example, cruise participants should be given first chance on publication of results, but what are the conditions under which others can publish on these data?]

(3) Analysis and interpretation

As mentioned above, Cornell technicians screen the acoustic data files. This has been completed up until the 2000-2001 season, but not for the 2001-2002 or 2002-2003 seasons. This screening process should be considered preliminary analysis. It was and will be done in order to provide users with a standardised guide through the data and a mechanism for quickly finding out where sounds of certain species are located in the data series.

(4) Publication of results

Collaboration within the collecting group to publish on the results should be strongly encouraged. Additionally, the group should be encouraged to seek collaborations with other scientists outside of the group. Thus, for example, given the successful efforts of the passive acoustics component of the GLOBEC project, it would be valuable to share, compare and collaborate with the GLOBEC team.

Additional items of concern include the following.

(a) Funds to support the continued growth and maintenance of the acoustic data collection

The amount of data collected varies considerably between vessels and between years. This makes it difficult to predict the budget for the costs of archiving and screening data prior to the season. For the existing two-years’ of data that have not been screened I predict, given what data are already in hand, that it will require approximately 1.5 months of time for an experienced person to screen the data and enter the results into a database. The cost for this is approximately $3,600 (USD). This assumes a Cornell cost-sharing in that Cornell will provide all the infrastructure and support, and make and maintain copies of all data.

(b) Upgrading field equipment for collecting acoustic data and analysing it in real-time, and confirming/ standardising mechanisms for documenting acoustic data collection effort in the field

In the future, I strongly recommend upgrading all data collection mechanisms and making them identical on the two ships. This would include:

(i) Use of computer systems for acquisition, processing, display and storage of all acoustic data

It would still be advisable to have DAT recorders and DATs available. This scenario would require having backup systems on each boat. This would eliminate discrete signal conditioning hardware units (e.g. filters, amplifiers) and associated cables, and take advantage of newer, faster and more flexible software solutions. This would thereby merge the collection and display under one program, and allow for the use of the DIFAR software in realtime.

(ii) Data storage direct to hard disk

This will require a daily backup protocol, a relatively simple and painless procedure, while allowing rapid access into the data without the pain of labelling, changing, and rewinding tapes. Storage on hard disk is also less expensive than DAT. This procedure also means that it is very easy for the acoustician to make backups throughout the cruise and have copies available before the end of the cruise, thereby eliminating the hassle of sending single, original tapes to Cornell or worrying about original tapes getting lost in shipment.

This would also allow the acoustician to conduct data analysis, such as automatic detection and measurement, during the cruise. This could lead to more expedient integration of acoustic results into the ongoing scientific activities and the cruise report.

Appendix 4

SPECIFICATIONS OF NEW SIMULATED DATASETS

D. Palka

To more accurately simulate the sighting procedure used in the IDCR/SOWER surveys and the characteristics of the minke whale population, the existing program used to create simulated data sets (SC/55/IA9; Polacheck *et al.*, 2000) could be modified to include the following. Items labelled [New] are features that will hopefully be added to the simulations before next year's meeting.

(1) Underlying density of animals
- (a) Clustered groups of whales, modelled by a Neyman-Scott process that includes gradients in density, conditioned on SH minke data. [New]
- (b) A skewed distribution of group sizes like that from SH minkes (e.g. group sizes ranging from 1-300, where most are less than 5). [Already included]
- (c) A density gradient such that there is a gradient in density, group size and weather, also include where the density of groups is correlated with group size. [New]

(2) Whale movement
- (a) Assume there is no responsive movement. [Consider later]
- (b) Assume whales are stationary for most datasets; add random movement at speeds much less than the ship's speed for one scenario. [New]

(3) Whale surfacing patterns
- (a) All whales in a group surface together at the same time. [Already included]
- (b) Assign a surfacing pattern to each whale group. For each surfacing of a whale group when in IO mode, the group is assigned a size that can vary around the true size (including above true size). For each surfacing when in Closing mode, the group is assigned the true group size. For each platform, the group size assigned to the surfacing that was first detected by that team will be recorded in the output dataset. Detection probability for a surfacing is dependent on assigned size. Consider recording the largest group size of all the surfacings that were detected by a team. [New]

(4) Platforms
- (a) Three platforms. [Already included]
- (b) Separate detection functions for each platform. [Already included]
- (c) Partial independence between platforms (i.e. the bridge team stops searching after a group is detected). [Already included]

(5) Closing/IO mode
- (a) Survey mode will alternate from Closing to IO mode every 5 hours (about 60 n.miles). [New]
- (b) Effect of Closing mode will be incorporated as sections of the trackline that are not surveyed after a group of whales is detected by the Top platform and that group is within 3 n.miles perpendicular distance from the trackline. [New]

(6) Detection function
- (a) Accounts for observers using binoculars (can detect out to 9,000m = 4.9 n.miles). [Already included]
- (b) Determine if can add in effects for differential detectability for body and blow sighting cues. [New]
- (c) *g*(0)ranges from 0.3-1, depending on conditions and group size. [Already included]
- (d) Detection function could be dependent on group size, weather and interaction between group size and weather. [Already included]
- (e) Detection function could be dependent on sighting cue, dive time. [Consider later]
- (f) Include heterogeneity between platforms. [Already included]
- (g) Include heterogeneity within a platform. [Code already included; Consider later]

(7) Covariates
- (a) Weather (e.g. Beaufort). [Already have 3 levels. Consider using 4-5 levels]
- (b) Group size. [Already included]
- (c) Sighting cue (could interact with weather or interact with distance from ice-edge). [Consider later]
- (d) Hidden variables (i.e. not available to analyser)… could be aspect (direction of body). [Consider later]

(8) Measurement error
- (a) Errors exist in the angle, radial distance, time. [Code already exists; Consider how to parameterise the error models]
- (b) Errors exist in some recorded school sizes. [At least partially addressed in 3b]
- (c) Errors due to variable sightability conditions. [Consider later]

(9) Output
- (a) Effort dataset: date, time, platform, watch code, weather code, IO/Closing mode. [Already included]
- (b) Sightings dataset: date, time, platform, whale id, distance ahead along the trackline, perpendicular distance from the trackline to the whale, radial distance between ship and group, angle between line of sight to whale and trackline, swim direction, group size, watch code, weather code. [Already included]

The timetable for this work plan is:

Time	Event
June/July 2003	Provide standard IDCR/SOWER dataset, documentation, distance experiment data and resighting data.
June to Sept. 2003	Communicate via e-mail to finalise parameterisation of the simulation models and define scenarios.
October 2003	Send first set of simulated data to analysers, even if all new aspects not yet included. This will be used to determine if datasets appear correct.
Nov. 2003 to June 2004	Iterate production of simulated datasets and getting results from analysers.
June 2004	Present results to IWC SC meeting.

REFERENCE

Polacheck, T., Palka, D., Borchers, D., Cooke, J.G., Skaug, H.J. and Dixon, C. 2000. Simulation comparison of different methods for estimating whale density from double-team line transect data. Paper SC/52/RMP18 presented to the IWC Scientific Committee, June 2000, Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].

Appendix 5

COMBINING ESTIMATES FROM THE THIRD CIRCUMPOLAR SET OF SURVEYS

Trevor A. Branch and Paul Ensor

Some longitudinal regions in the third circumpolar sets of surveys (CPIII) in the IDCR/SOWER programmes have been covered by more than one survey. This overlap in their longitudinal coverage is shown in Figs 1a-b, and detailed in Table 1. The complete set of surveys in CPIII are described and two ways of obtaining a complete circumpolar abundance estimate are suggested: a 'survey-once' method and a 'combined-survey' method. It is worth considering these issues now in order to standardise the approach used by analysts to obtain circumpolar estimates for minke whales.

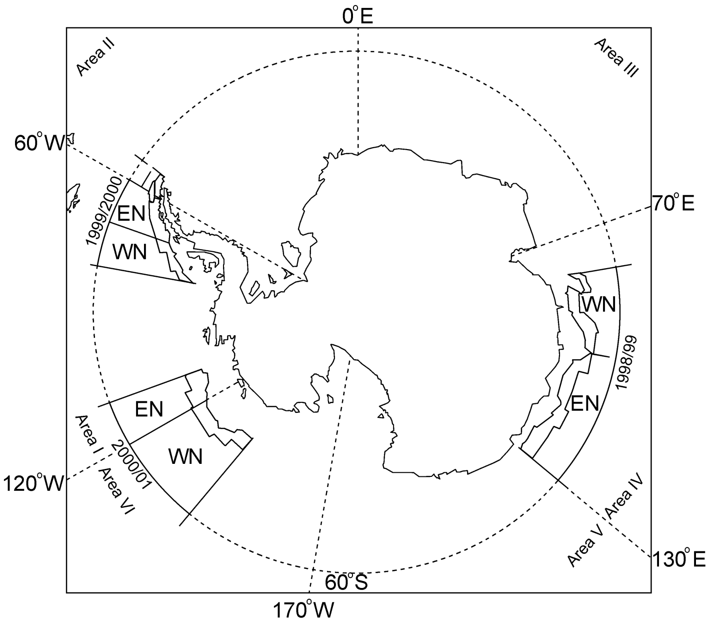

Fig 1a. Strata covered by SOWER circumpolar surveys in 1998/99 to 2000/01 (from Branch, 2003).

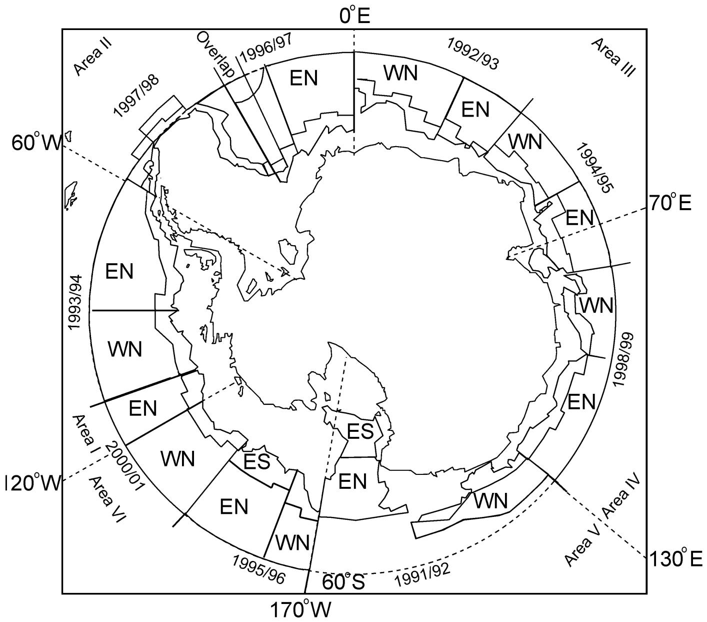

Fig. 1b. Strata covered by SOWER circumpolar surveys in 1991/92 to 2000/01, excluding the 1999/2000 survey (from Branch, 2003).

Table 1

Description of areas surveyed each year during CPIII. All surveys were from the ice edge northwards to 60ºS, except for the 1991/92 survey which covered the Ross Sea but not the area north of the Ross Sea to 60ºS, and a small northern circular bite in 1996/97 which fell within the EEZ of the South Sandwich Islands. In addition, the 1997/98 survey extended northwards beyond 60ºS, this area is typically included in circumpolar abundance estimates.

Survey	Areas	Longitude	Longitude	Comments
1991/92	V	130ºE	170ºW	Northern regions unsurveyed
1992/93	III	0ºE	40ºE	
1993/94	I	110ºW	60ºW	70ºW-60ºW poorly surveyed
1994/95	III+IV	40ºE	80ºE	
1995/96	VI	170ºW	140ºW	
1996/97	II	30ºW	0ºE	30ºW-25ºW poorly surveyed 30ºW-20ºW northern 'bite' missing
1997/98	II	60ºW	25ºW	30ºW-25ºW overlap 1996/97 (including area north of 60ºS)
1998/99	IV	80ºE	130ºE	
1999/00	I+II	80ºW	55ºW	80ºW-60ºW overlap 1993/94 60ºW-55ºW overlap 1997/98 60ºW-55ºW poorly surveyed
2000/01	I+VI	140ºW	110ºW	
2001/02	V	130ºE	155ºE	130ºE-155ºE overlap 1991/92 150ºE-155ºE hardly surveyed
2002/03	V	150ºE	170ºW	150ºE-170ºW overlap 1991/92 150ºE-155ºE overlap 2001/02 Ross Sea inaccessible
2003/04[1]	V	165ºE	170ºW	165ºE-170ºW overlap 1991/92 165ºE-170ºW overlap 2002/03 Ross Sea and North of Ross Sea

[1]Proposed survey for 2003/04, there is still some discussion whether the eastern boundary should be at 165ºE or at 170ºE.

Due to the overlaps among surveys in Areas I, II and V, it is necessary to decide how to combine these areas. The 'survey-once' method chooses the single survey, or part of a survey, which best covered the longitudinal area in question (Table 2). The 'best' survey was that which covered the area most recently, and with greatest search effort. Thus the regions noted in Table 1 as being 'poorly surveyed' or 'hardly surveyed' are omitted in favour of surveys with

Table 2

Proposed sections of surveys for a 'survey-once' circumpolar estimate from CPIII. The abundance for each longitudinal range is obtained from the survey which best (or most recently) surveyed that region.

Longitudinal range	Area	Survey	Comments
	V	1991/92	Omit, covered in 2001/02-2003/04
0ºE-40ºE	III	1992/93	Whole survey
40ºE-80ºE	III+IV	1994/95	Whole survey
80ºE-130ºE	IV	1998/99	Whole survey
130ºE-150ºE	V	2001/02	Exclude 150ºE-155ºE
150ºE-170ºE	V	2002/03	Exclude 170ºE-170ºW
170ºE-170ºW	V	2003/04	Whole survey
170ºW-140ºW	VI	1995/96	Whole survey
140ºW-110ºW	I+VI	2000/01	Whole survey
110ºW-80ºW	I	1993/94	Exclude 80ºW-60ºW
80ºW-60ºW	I	1999/00	Exclude 60ºW-55ºW
60ºW-25ºW	II	1997/98	Whole survey
25ºW-0ºE	II	1996/97	Exclude 30ºW-25ºW

Table 3

Proposed sections of surveys for a ‘combined-survey’ circumpolar estimate from CPIII. The abundance for each longitudinal range is obtained from the survey which best (or most recently) surveyed that region.

Longitudinal range	Area	Survey	Comments
0ºE-40ºE	III	1992/93	Whole survey
40ºE-80ºE	III+IV	1994/95	Whole survey
80ºE-130ºE	IV	1998/99	Whole survey
130ºE-150ºE	V	1991/92	Adjust for unsurveyed northern area
		2001/02	Exclude 150ºE-155ºE
150ºE-170ºE	V	1991/92	Adjust for unsurveyed northern area
		2002/03	Portion of survey
170ºE-170ºW (North)	V	2002/03	Portion of survey
		2003/04	Northern portion of survey
170ºE-170ºW (Ross Sea)	V	1991/92	Portion of survey
		2003/04	Southern portion of survey
170ºW-140ºW	VI	1995/96	Whole survey
140ºW-110ºW	I+VI	2000/01	Whole survey
110ºW-80ºW	I	1993/94	Portion of survey
80ºW-60ºW	I	1993/94	Portion of survey
		1999/00	Exclude 60ºW-55ºW

greater effort, and the 1991/92 survey in Area V is replaced by the 2001/02-2003/04 surveys. This ‘survey-once’ option requires some extraction of sightings and effort data from small areas within currently defined strata, but does not require averaging of survey estimates from different years in the same longitudinal region.

The ‘combined-survey’ method requires averaging of estimates from different surveys in the same region, whenever longitudinal regions were surveyed multiple times (Table 3). Two small longitudinal regions are omitted because they were particularly poorly surveyed: 30°W-25°W in 1996/97 and 150°E-155°E in 2001/02.

REFERENCE

Branch, T. 2003. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on the comprehensive assessment of whale stocks — in-depth assessments. Appendix 3. Updated circumpolar abundance estimates for Southern Hemisphere minke whales including results from the 1998/99 to 2000/02 IDCR-SOWER surveys. *J. Cetacean Res. Manage. (Suppl.)* 5:271-5.

Appendix 6

ESTIMATION OF ADDITIONAL VARIANCE IN IWC-IDCR SURVEYS

H.J. Skaug, A. Brandao, T. Tanaka, T. Kitakado and H. Okamura

The purpose of this Appendix is to describe how the additional variance parameter σ^2 defined below can be estimated. The method is a modification of that of Punt *et al.* (1997).

Population dynamics

The population evolves according to:

$$N_y = N_0 exp(\alpha y)$$

where

N_y = the total abundance of whales in year y;

N_0 = the abundance in year $y = 0$ (must be estimated);

α = the growth rate (may be negative). Must be estimated.

Note: it is possible to allow a more flexible growth model than the exponential model suggested above.

Random variation

It is assumed that the number of whales present in area a in year y is:

$$N_{a,y} = N_y \exp(\mu_a + \varepsilon_{a,y})$$

where

μ_a = a parameter related to the average proportion of the total population being present in area a. Must be estimated.

$\varepsilon_{a,y}$ = Gaussian random variables with $E[\varepsilon_{a,y}] = 0$ and $Var[+\varepsilon_{a,y}] = \sigma^2$.

Note: The number of whales present in an area has a constant CV under this model (regardless of the size of the area).

Statistical methods

The use of REML (Restricted Maximum Likelihood) estimates in Punt *et al*. (1997) as alternatives to maximum likelihood estimates is preferable because REML accounts for the reduction in degrees of freedom resulting from the estimation of the μ_a, and hence yields unbiased estimates of σ^2.

The vector of all log-abundance estimates is denoted by x. The covariance matrix Σ of x will be treated as ‘known’ in the present method, but must in practice be estimated from the survey data. Note that Σ is not assumed to be a diagonal matrix (as is underlying the approach of Punt *et al*., 1997). Correlation of survey estimates from different areas will cause Σ to be non-diagonal.

Likelihood function

$$\ell_{ML}(\sigma,\beta) = -0.5 \log[\det(\psi_\sigma)] - 0.5(x-X\beta)'\psi_\sigma^{-1}(x-X\beta)$$

where:

X = the model matrix of explanatory variables, and β is the parameter vector. Loosely speaking, each element of $X\beta$ is $\alpha y - \mu_a$. The exact definition of X may be found in Punt *et al*. (1997). Note that other explanatory variables, such as sea ice coverage, could easily be included in the model (by expanding X).

$\Psi_\sigma = \sigma^2 I + \Sigma$ = the total covariance matrix of x, including both survey variance and additional variance.

Restricted maximum likelihood

$$\ell_{REML}(\sigma,\beta) = \ell_{ML}(\sigma,\beta) - 0.5\log[\det(x'\psi_\sigma^{-1}x)]$$

Comments

The model for additional variance used in the Northeastern Atlantic (SC/55/NAM1) assumes that the population ‘is closed’, i.e. if whale abundance goes up in one area, it must go down in another area. The model here does not have this feature.

The present model does not ‘need extrapolation’ in the sense that if different parts of an area have been covered in a different year, the model will only use the abundance estimate for the 'common factor'. (This is not completely satisfactory; see below). Areas that have only been covered once do not contribute to the estimation of additional variance, and hence can be skipped.

This model is chosen partly because it has a nice analytical structure (on the log scale it is a linear Gaussian model). However, it has certain features that are not so desirable. For instance, consider an area *A*, which consists of two parts A_1 and A_2. Since we have a random effects model, we can talk about the variance of the number of animals present in *A*, N_A, in a given year. Consider now another model where A_1 and A_2 are treated as separate areas, and hence are given different random effects. Then it can be shown that $\text{Var}(N_A) \neq \text{Var}(N_{A1}) + \text{Var}(N_{A2})$. Thus, other models should also be investigated.

REFERENCE

Punt, A.E., Cooke, J.G., Borchers, D.L. and Strindberg, S. 1997. Estimating the extent of additional variance for Southern Hemisphere minke whales from the results of the IWC/IDCR cruises. *Rep. int. Whal. Commn* 47:431-4.

Appendix 7

REGIONS FOR ESTIMATING ADDITIONAL VARIANCE FROM IDCR/SOWER SURVEYS

T.A. Branch, K. Matsuoka, M.L. Burt and R.A. Rademeyer

Total variance of abundance estimates comes from two sources: sampling variance and additional variance. When standard line transect methods (Branch and Butterworth, 2001) are applied to the IDCR/SOWER surveys, sampling variance arises from variation in sighting rates, and in the estimation of search half-width and mean school size.

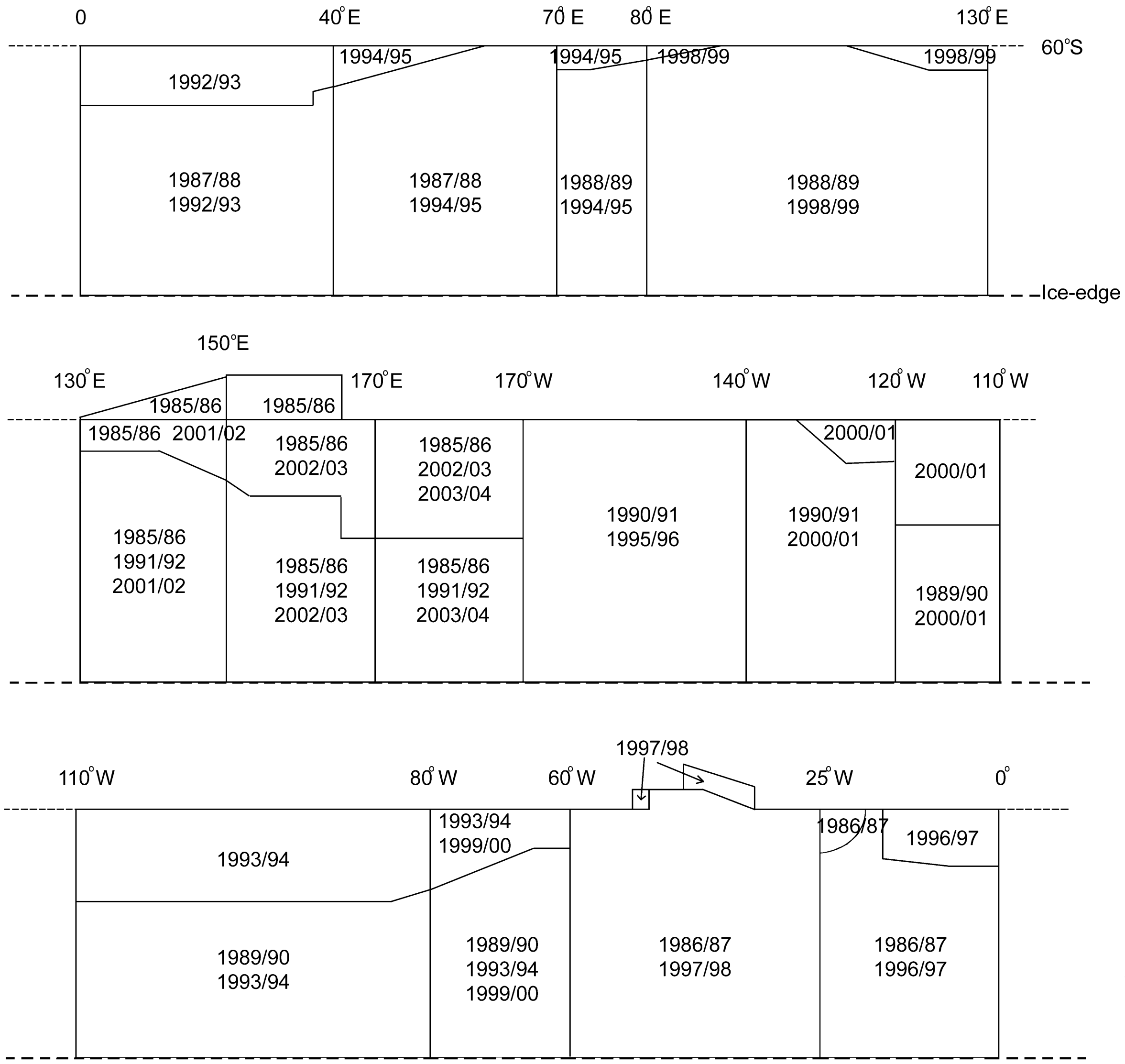

Fig. 1. Regions that have been surveyed in the second and third circumpolar sets of surveys. Those regions that have been surveyed two or three times can be used for the estimation of additional variance. Only the intersections between surveys are shown, not the individual strata within the surveys. These figures are intended to be illustrative, and are not accurately generated with GIS software.

Additional variance is the extent to which the variability of successive surveys exceeds the contribution from sampling variability that is estimated from each survey separately, e.g. inter-annual changes in observers, weather conditions, and the northern extent of the pack ice. Previous estimates of additional variance based on the first and second circumpolar sets of surveys (CPI and CPII), were 0.36 (95% CI 0.10-0.74) if no change in minke abundance is assumed, and 0.40 (95% CI 0.13-0.82) if change is estimated as a model parameter (Punt *et al*., 1997). Those estimates were based on half-Management Areas, and much of the estimated additional variance may have come from changes in the survey methodology between CPI and CPII. Later estimates of additional variance from CPI and CPII from full Management Areas, obtained a point estimate of zero (footnote 24 in Butterworth *et al.*, 1999), and were used as a justification by Branch and Butterworth (2001) to ignore the impact of additional variance on the associated CVs for their circumpolar abundance estimates.

After the 2003/04 survey, CPIII will be completed, and additional variance can be estimated from CPII and CPIII surveys which used more consistent survey methodology than those in CPI. Here we suggest regions that could be used to estimate additional variance from CPII and CPIII (Fig. 1). Only those regions which have been surveyed two (13 regions) or three (5 regions) times can be used in the calculation of additional variance (Annex G, item 3.3.3). The southern ice-edge boundary is not considered since most of the minke whales will likely be close to the ice-edge regardless of its particular latitude in a given survey year. Note that the pictures of the proposed regions are intended to be illustrative and are not accurately drawn with GIS software.

Obtaining abundance from the proposed regions would require the sub-division of existing strata in surveys in CPII and CPIII. A test extraction from DESS 3.2 (Strindberg and Burt, 2000) confirmed that it would be possible to extract the sightings and effort from portions of the existing strata, in order to obtain appropriate abundance estimates (using whatever methods are appropriate) for the estimation of additional variance.

REFERENCES

Branch, T.A. and Butterworth, D.S. 2001. Southern Hemisphere minke whales: standardised abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys. *J. Cetacean Res. Manage.* 3(2):143-74.

Butterworth, D.S., Punt, A.E., Geromont, H.F., Kato, H. and Fujise, Y. 1999. Inferences on the dynamics of Southern Hemisphere minke whales from ADAPT analyses of catch-at-age information. *J. Cetacean Res. Manage.* 1(1):11-32.

Punt, A.E., Cooke, J.G., Borchers, D.L. and Strindberg, S. 1997. Estimating the extent of additional variance for Southern Hemisphere minke whales from the results of the IWC/IDCR cruises. *Rep. int. Whal. Commn* 47:431-4.

Strindberg, S. and Burt, M.L. 2000. *IWC Database-Estimation System Software (DESS) User Manual, May 2000*. Research Unit for Wildlife Population Assessment, Mathematical Institute, University of St Andrews, St Andrews. 300pp. [Paper available from the Office of this Journal].

[Appendix 8 overleaf]

Appendix 8

DATA SELECTION OPTIONS AND VARIABLES REQUIRED TO CREATE A 'STANDARD DATASET OF IDCR/SOWER DATA'

The different analytical methods being developed will be tested on a simulated set of data and also applied to a 'standard dataset of IDCR/SOWER data'. This appendix lists the options that will be used to select this standard dataset and also which variables will need to be included for the different methods of analysis. Table 1 contains the selection options of the data to be extracted. Table 2 lists the variables to be extracted. Documentation will also be included with the data.

Survey protocol has changed throughout the years, particularly between CPI and CPII. The data selection options shown in Table 1 reflect these changes.

Table 1

Data extraction options.

Data	Options	Values chosen
Effort	Year	1978/79 – 2001/02[1] excluding 84/85
	Vessels[2]	T16, T18, K27, T11, SM1, SM2
	Activity mode	Closing: CPI: SE CPII+III: BC, BA, BL, BR, BK[3] (in 87/88) IO mode: BO, BH, BI, BU (in 86/87), BQ (in 87/88)
Sightings	Platform	1 to 6 inclusive
	Species codes	04, 91, 92, 90, (39)
	Duplicates	Remove definite only
	Type	Primary
	School size estimate	Best
	Mixed schools	Include
	Confirmed school size	Include confirmed and unconfirmed

[1]The final set of data will contain data for surveys in 2002/03 and 2003/04. [2]Excluding V34 and V36 which were used primarily to map the ice-edge. [3]Closing with IO tracking (formerly coded BB but changed to avoid confusion with recent use of BB to define blue whale research mode).

Table 2

Variables required in the standard dataset for the different analysis methods.

Data type	Variables required	Additional variables
Survey	Year Area Vessel Strata Start/end dates Strata size	
Effort	Survey date Vessel Start/end time Start/end Latitude/Longitude Activity mode Speed of vessel Waypoints Weather variables (see below)	See Sightings for 'Distance from' variables
Sightings	Survey date Time Vessel Sighting no. Species code Sighting type Best school size estimate School size confirmed Platform/observer Duplicate information Cue Species identified Closest distance Estimated angle Radial distance Estimated angle (corrected for bias) Radial distance (corrected for bias)	Distance from: Ice-edge[1] Southern boundary of ACC[2] Continental shelf[2] Coast[2] Water depth[2]
Strata boundaries	Year Strata Latitude/longitude Ice-edge (Y/N)	
Weather (attached to effort records)	Weather code Wind direction Windspeed Surface temperature Air temperature Visibility ice cover Sightability Sea state (<= 5)Swell	Glare[3]
Resightings	Sighting No. Time Angle Distance	

[1]Ice-edge data is contained in DESS and so the distance from ice-edge to sightings and effort positions can be calculated without extra information. [2]These data or the data required to calculate these variables are not contained in DESS. [3]Recording of glare changed significantly in 2000/2001 and these data are not available in DESS at present.

Appendix 9

TASKS TO ESTIMATE ABUNDANCE FOR EACH CIRCUMPOLAR SURVEY SERIES AND DEFINE TRENDS IN THESE DATA

The list below is not exhaustive. Letters in bold indicate priority for completion by the 2004 Scientific Committee meeting: **H** for High, **M** for Medium and **L** for Low.

Abundance issues

(1) **H**: Validate the most recent year of IDCR/SOWER data (2002/03), put data into DESS and analyse using the standard method.
(2) **H**: Further develop new methods to estimate *g*(0), esw, average school size and spatial patterns.
(3) **H**: Develop simulated data that incorporate spatial patterns of density, school size and weather conditions and other features discussed in Appendix 4.
(4) **H**: Use simulated datasets (spatial and non-spatial) to evaluate the performance of the new methods, in addition to the standard method.
(5) **H**: Create a standard dataset of the IDCR/SOWER data that can be used by all the methods.
(6) **M**: Apply new methods to the standard dataset of IDCR/SOWER. It is expected this will be high priority next year.
(7) **H**: Further develop methods that estimate variance, additional variance ('process error') and trend when using the new and standard methods.
(8) **H**: Further develop methods to extrapolate to unsurveyed areas.
(9) **M**: Evaluate other datasets, then incorporate into DESS the following variables: distance to the ice-edge (as defined in DESS); to the shelf break; to land; to the nearest sea mount; and to fronts.
(10) **M**: Estimate the order of magnitude of the numbers of minke whales in the ice using any data available (including past data), such as that collected in the IDCR/SOWER, SO-GLOBEC or APIS surveys.
(11) **L**: Improve standard methods.

Trend issues

(1) **H**: Address the seven issues related to catch-at-age analyses raised last year (IWC, 2003, pp.261-263) and clarified this year (Annex G, item 3.4.2.1).
(2) **M**: Further develop the method that estimates additional variance and trends to ensure it provides an adequate measure of trend. It is expected this will be high priority next year.
(3) **M**: Develop methods, as necessary, to conduct power analyses to determine the reliability of the results from each method that estimates trend. It is expected this will be high priority next year.

Stock structure

(1) **H**: Analyse the available genetic samples using multiple techniques and analysis methods to determine the spatial and temporal patterns of the stock structure within the Areas where data are available.
(2) **H**: Conduct power analyses to assess the reliability of the results in (1) and to determine where more samples are needed to have confidence about the spatial and temporal patterns of the stock structure.

LONG-TERM TASKS TO FURTHER UNDERSTANDING OF THE ANTARCTIC MINKE WHALE (NOTE THIS LIST IS NOT EXHAUSTIVE)

Stock structure

(1) Put satellite tags on minke whales seen at the end of the summer in higher latitudes to try to find the breeding grounds.
(2) Collect samples of minke whales in the lower latitudes and analyse them to determine the relationship between animals in lower latitudes with those in higher latitudes.

REFERENCE

International Whaling Commission. 2003. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on the Comprehensive Assessment of Whale Stocks – In-Depth Assessments. *J. Cetacean Res. Manage. (Suppl.)* 5:248-92.

Appendix 10[1]

UNDER PROCEDURE 'B' OF THE DATA AVAILABILITY PROCESS

RESEARCH PROPOSAL FOR ANALYSIS OF CATCH AT AGE ANALYSES FOR SOUTHERN HEMISPHERE MINKE WHALES

Principle investigators

(1) T. Polacheck, (2) D. Butterworth, (3) J. Cooke, (4) R. Leaper, (5) A. Punt and (6) T.D. Smith.

Institution and address of principle investigators

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(2) Dept. of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa.
(3) CEMS, Mooshof, 79297 Winden, Germany.
(4) Canal House, Banavie, Fort William PH33 7LY, UK.
(5) University of Washington, Seattle, Washington, USA.
(6) Northeast Fisheries Science Center, 166 Water St, Woods Hole, Massachusetts 02543, USA.

Objective of the study

To undertake further catch-at-age analyses for Southern Hemisphere minke whales in support of the issues defined at the 2003 Scientific Committee meeting as part of the review

[1] This was agreed during Plenary discussions, see Item 10.2.3.2.

of minke whale abundance estimates and trends. In particular to ensure that the following issues can be addressed:

(1) Examine the sensitivity to the assumptions of fixing certain parameters to allow others to be estimated.
(2) Examine the implications of uncertainties in stock structure on the results of catch-at-age analyses and their conclusions.
(3) Investigate the levels of uncertainty in the catch-at-age data and their effect on results of a catch-at-age analysis.
(4) Examine selectivity constraints and possible lack of fit to the age distribution in the plus group.
(5) Explore possible links between environmental (e.g. climate) changes and estimated trends in minke whale abundance from a catch-at-age analysis.
(6) Check the consistency between the catch-at-age results and data on blubber thickness, pregnancy rates, length and age at first ovulation.
(7) Explore the possible effect of the geographical and ecological segregation of the mature and immature components of the stock which may be exploiting different resources and thus interact differently with prey species and competitors.

Data to be used

(1) Commercial catch data from 1971/72 through 1986/87 within Areas III, IV, V and VI. The commercial data will be obtained from the IWC Secretariat. The data owner is requested to authorise the Secretariat to release these data.
(2) JARPA catches from 1987/88 through 2000/01 within Areas IV and V. Specifically, a file consisting of the following information for each whale caught is needed: Serial (id) no.; Date; Position; Length; Sex; Age (where known); and Pregnancy status for females.

See explanatory note for comment on JARPA data within Areas III and VI. Next year the request for data from Areas III and VI should be reviewed in light of progress made by this Working Group and the data owners.

Methods

The primary methods of analyses will be statistical integrated catch-at-age modelling. In addition, the integrated catch at age estimates of stock-size and population parameters will be related to other available information using statistical regression and related methods. The analyses will address at least the following issues:

(1) effects of assumptions fixing certain parameters to allow others to be estimated (in particular natural mortality);
(2) initial analyses of implications of uncertainties in stock structure on the CAA results and conclusions drawn from them;
(3) initial analyses of levels of uncertainty in the catch-at-age data and their effect on the CAA results;
(4) selectivity constraints and possible lack of fit to age distribution in the plus group.

Resources needed

Data access will be arranged using the IWC Scientific Committee's data access procedures. Some of those doing analyses will require some salary support: Polacheck (£10,000) and Punt (£10,000), and one will require travel support: Butterworth (£2,000), for a total of £22,000.

Timeframe and outputs

A report on progress will be presented to the 2004 Scientific Committee meeting, but the analyses are not anticipated to be complete before the 2005 meeting. ICR scientists will have the opportunity to collaborate on or co-author any of the working papers.

Explanatory note

JARPA data within Areas III and VI, although of some use in the catch-at-age analyses, are not as high priority as JARPA data within Areas IV and V. The reason for this is the catch-at-age analyses incorporating Areas III and VI ideally require total catch, abundance estimates and catch-at-age data from each Area. However, practically such analyses would need to be accompanied by a number of additional assumptions, particularly since the JARPA programmes in these regions have taken place at different times of year so that lack of comparability of abundance estimates with the normal JARPA surveys in Areas IV and V will raise problems. Surveys in Areas III and VI take place before and after the primary survey in IV and V, consequently, the position of the ice-edge is very different and so affects the interpretation of the data. Furthermore, the samples sizes from Areas III and VI are small compared to those from IV and V and the temporal comparability question will again arise, particularly if migration patterns are age-dependent. Viewed overall, lack of an immediate request for catch-at-age and abundance estimates from the JARPA sampling in Areas III and VI will not compromise attainment of the primary objectives of this proposal.

It is also noted that JARPA data from Areas III and VI have not yet been analysed and published or presented to the IWC Scientific Committee, but will be during the JARPA review when all data will be available.