# Annex G

# Report of the Sub-committee on In-Depth Assessment (IA)

Members: Ainley, An, Baba, Bannister, Borodin, Bøthun, Branch, Brandao, Bravington, Bravington, Brownell, Burt, Butterworth, Cañadas, Childerhouse, Chilvers, Cooke, Donovan, Ensor, Fujise, Gales, Gallego, Galletti, Gedamke, Goodman, Goto, Gunnlaugsson, Hakamada, Hammond, Hatanaka, Hayashi, Hedley, Hester, Holloway, Hughes, Hyugaji, Ilyashenko, Ipatova, Jackson, Kasuya, Kato, Kell, Kitakado, Kock, Leaper, Lens, Lima, Lockyer, Lorenzoni, Lovell, Lyrholm, Macrander, Magloire, Marcondes, Miller., C., Miyashita, Morishita, Murase, Nakamura, Newell, Nishiwaki, Ohsumi, Øien, Okada, Okamura, Palka, Park, Park, Pastene, Perrin, Polacheck, Ponce, Punnett, Punt, Rambally, Rea, Rebecca, Rosenbaum, Shimada, Skaug, Straley, Strbenac, Tamura, Tichotsky, Van Waerebeek, Wade, Walløe, Williams, Yamakage, Yasokawa, Yoshida, Young, Zelensky, Zerbini.

## 1. ELECTION OF CHAIR

Palka welcomed the participants and was elected Chair.

## 2. APPOINTMENT OF RAPPORTEURS

Branch, Burt, Hedley, Punt and Zeh were appointed as rapporteurs.

## 3. ADOPTION OF AGENDA

The adopted Agenda is given in Appendix 1.

## 4. DOCUMENTS AVAILABLE

The following documents were relevant to the work of the sub-committee: SC/59/IA1-25, SC/59/O8, SC/59/Rep5, Ainley *et al.* (2007), Karnovsky *et al.* (2007) and Smith *et al.* (2007).

## 5. SOWER CRUISES

### 5.1 Report from the intersessional Workshop on the 2006/07 cruise

Initial planning of the 2006/07 cruise was undertaken at the 2006 Annual Scientific Committee meeting where it was agreed that high priority projects for the cruise should include BT mode experiments, school size estimation, fin whale abundance estimation, biopsy sampling/photo id, and reducing errors in angle/distance estimation by using direct data entry and satellite-tagging. The planning meeting, which took place in Tokyo (SC/59/Rep5) during September 2006 considered each item. Participants agreed that all projects should be accorded high priority for the cruise except for satellite tagging as no suitable system for long-term-tag deployment was available for the 2006/07 cruise. Detailed plans for the cruise were finalised.

### 5.2 2006/07 cruise report

SC/59/IA1 presented the report of the 2006/07 SOWER cruise. This was the 29th cruise in the series and had four main research components: to conduct experiments designed to interpret minke whale abundance estimates from previous cruises and to improve design for future cruises; to undertake fin whale research in latitudes north of 60°S and to continue both blue whale and humpback whale research. The research area used for the cruise was the western part of Area III (000°-020°E longitude). The Japanese Research Vessel *Shonan Maru No.2* departed from Cape Town for the research area on 21 December 2006 and returned on 23 February 2007.

The fin whale research area was located between latitudes 55°S and 61°S, and longitudes 000° and 005°E and much of this area was within the Norwegian EEZ surrounding Bouvet Island. From 27 December to 2 January a survey for fin whales was conducted in closing mode and a total of 100 n.miles of trackline were covered on primary search effort. The cruise track in the fin whale research area was provisionally planned as a single transect across the area, however, based on the observed distribution of fin whales during the first two days of research, the track was substantially modified to increase survey coverage in the northern part of the area. Sixteen groups of fin whales (comprising 43 animals) were detected. The most frequently sighted species was humpback whales, consisting of 53 groups (102 animals). Biopsy sampling and photo-id studies of fin and humpback whales were undertaken.

After completion of the fin whale research the ship moved south for the minke and blue whale research which was carried out for the remainder of the research period (4 January to 13 February). This research was conducted in the vicinity of the ice edge between 000°-020°E. As the aim of this cruise was not to obtain an abundance estimate but to conduct experiments, the cruise track design was completely flexible and some parts of the region were surveyed more than once. The experiments included a continuation of big eye BT mode trials that were started on the 2005/06 cruise using big eye 25x binoculars mounted on the Upper Bridge to investigate *g*(0). Another version of BT mode was also evaluated as a potential future survey method. School size estimation experiments were conducted in order to investigate the relationship between Passing mode school size estimates and confirmed school sizes derived from closing mode. The data collection system that had been used on SCANS II was used to evaluate observer estimates of sighting angles and radial distances. Additional trials of the minke whale visual dive time experiment were also planned.

During the minke whale research, a total of 187 hours of searching was conducted and 2258 n.miles were covered. Minke whales were the most frequently sighted species in this part of the research area, and sightings totalled 651 groups (2,174 animals). Due to good weather (only 28.4% of time was lost to poor weather) and a high sighting rate for minke whales, the suggested target minimum sample sizes for the BT mode and school size estimation experiments were all achieved.

During big eye BT mode, the survey covered 1,207 n.miles during 107 hours. A total of 82 sightings (all species) were first detected by the big eyes. Sightings by the big eyes included 64 groups of minke whales and 2 groups were classified as 'like minke'. During the same period, 172 groups of minke whales and 31 'like minke' groups were detected by the Top Barrel. Of the 64 groups of minke whales initially sighted by the big eyes (called the tracker platform in BT mode, see Item 5.1.1 for terminology), 34 groups were subsequently detected by the Top Barrel (primary platform).

Trials of a different configuration of BT mode - Option 2 - were also conducted. In this configuration, the Top Barrel was the tracker platform searching with 7x50 binoculars and the Independent Observer Platform was the primary platform with observers searching with the naked eye. Option 2 was carried out for a total of 24 hours and 276 n.miles were covered. Sightings included 116 groups of minke whales and 30 'like minke' groups. Of these, a total of 89 groups (79 minke whale and 10 'like minke' groups) were detected by the tracker platform. The primary platform subsequently detected 25 of these groups.

During the school size estimation experiment conducted in IO mode (called SS-III), a total of 393 n.miles were covered during 35 hours. Sightings included 178 minke whale and 10 'like minke' groups. Ninety-nine abeam closures were attempted and 96 closures were successful, including to groups classified as 'like minke'.

Although not included in the cruise plans, additional school size estimation data were obtained using a similar protocol to SS-III but conducted during normal passing mode (SS-II) instead of IO mode. SS-II trials were conducted when, due to logistic reasons, SS-III trials or the other experimental modes were not feasible. During the SS-II trials, 241 n.miles were covered during 9 hours. Sightings included 48 minke whale groups and 7 'like minke' groups. Abeam closures were attempted on 32 groups and closure was successfully completed for 30 groups.

The SCANS-II data collection system was operated for 16 days with the video camera mounted on top of the big eyes. Video recordings were made of 54 whale sightings of 6 species, including 45 minke whale detections and 2 'like minke' detections. For a further 5 days, the video system was mounted on the 7x50 binoculars in the Top Barrel during the school size estimation experiment and 24 minke whale sightings were recorded.

The minke whale visual dive time experiment was planned for 2 days, with the emphasis on trials conducted on a range of group sizes in poorer weather conditions as well as trials on solitary animals in the full range of survey conditions. However, only one trial (on a group of three whales which lasted 1 hour) was attempted. Opportunities for trials in poorer weather during this cruise were restricted because mainly good weather was experienced. Opportunities for trials on solitary individuals in good weather conditions were limited because in order to complete the main experiments (BT mode and school size trials), attempts were made to stay in areas of higher sighting rate and few solitary individuals were encountered in these areas.

There were 55 sightings of blue whales (121 animals) during the cruise. The blue whales were almost all sighted during the minke whale research component near the pack ice. Fifty-one groups (117 animals) were identified as true blue whales; 47 groups of blue whales (119 animals) were approached for biopsy and photo-identification, which was conducted for a total of 80 hours. A total of 121 biopsy samples were collected from 72 true blue whales. Photographs were obtained of 114 individual blue whales including all but 3 of the biopsied whales. Video was recorded of 49 sightings (116 animals) and video images of 96 animals were obtained. Acoustic recording using sonobuoys was conducted by the ship's Chief Radio Operator at 55 stations, mainly in the vicinity of the blue whale sightings. Sounds attributed to blue whales were recorded at 40 of 45 stations and results included very high quality recordings of 28Hz sounds and social sounds.

During the cruise, biopsy samples were collected from 15 fin whales. Fourteen of the biopsied fin whales were photographed for identification studies. Biopsy samples were also collected from 72 humpback whales and photo-ID images were obtained from 160 humpback whales including all but 3 of the biopsied whales. A biopsy sample was collected from one individual killer whale and the six killer whale groups were photographed.

Other species observed during the cruise were sei, sperm and southern bottlenose whales and hourglass dolphins. A group of Layard's beaked whales (6 animals including one calf) was also detected. Although not part of the cruise plans, minke whales were photographed opportunistically and the resulting images were assessed for their utility in photo-id studies. During the cruise the Estimated Angle and Distance Training Exercise, and Experiment, were completed as in previous years.

Ensor (Cruise Leader on the *Shonan Maru No. 2*) expressed his thanks to the Captain and crew for their hard work and fellow researchers for their substantial contribution and to the many people and organisations who had provided equipment and help for this cruise. The sub-committee expressed its gratitude to the Government of Japan for providing the vessel and thanked the officers and crew, the Cruise Leader and the researchers for all their work to ensure a successful cruise.

It was agreed that any studies undertaken for the purposes of research, such as the feasibility of photo-id for minke whales, would be discussed at the planning meeting.

One aspect of the experimental use of the SCANS II data collection system on the cruise was the use of video cameras to measure distances to sightings. SC/59/IA25 presented the analysis of 21 video sequences of minke whale sightings taken from the Top Barrel. Of these, distances to 7 sightings could be measured with certainty. The main reason for the remaining sightings not being detectable on video appeared to be related to image quality and the characteristics of minke whale blows. Although the small sample size precluded detailed analysis, the mean distance error of approximately 30% was similar to that observed on the SCANS-II survey and is large enough to have a potentially substantial effect on estimates even if there was no overall bias. Improvements in video quality using high definition cameras would increase the proportion of body cues that could be detected. However, it seems likely that detection of more distant blow cues will remain problematic. The sub-committee expressed its thanks to the Sea Mammal Research Unit for the loan of the equipment and to Russell Leaper for his help and advice on the installation and use of the equipment.

During the blue whale research component of the cruise, 15,572 photographs of blue whales were collected during 47 sightings. Over half of these photographs have been examined and SC/59/IA9 presented provisional results from this work. Thirty-eight whales have been uniquely identified and two of these were resighted during the cruise. None of the 38 whales matched the whales identified from the 2005/06 cruise which covered the same survey area.

## 5.3 Review of experiments

The sub-committee reviewed the following specific experiments conducted on the 2006/07 survey: SS-III; SS-II; BT mode ('Big Eye' and 'Option 2'); SCANS-II; and visual dive time. Discussion focussed on two main aspects (i) their usefulness in providing extra data or information for assisting in analyses or interpretation of results from CPII and CPIII data and (ii) their practicability of implementation on future SOWER surveys.

SS-III EXPERIMENT: SURVEY IN IO MODE WITH CLOSING WHEN ABEAM

Since data from this experiment are directly useful for some methods of analysis of CPII and CPIII data, and they are also an important diagnostic for all methods, the sub-committee **recommended** that these data be encoded and validated as **high** priority. It noted that this task should be completed well before the proposed Methods Development and Abundance Estimates Workshop, by which time the analyses of these data would be completed. There were no practical problems in implementing this experiment on the vessel. The sub-committee **recommended** that in principle the protocols of the experiment can be adapted as a new survey mode to replace Closing mode. However, logistical issues, together with the results of analyses specified above, need to be considered at the Tokyo planning meeting.

SS-II EXPERIMENT: SURVEY IN PASSING MODE WITH CLOSING WHEN ABEAM

This experiment was first conducted on the 1984/85 survey. The sub-committee suggested that a comparison of the new data and those from that experiment be conducted. In particular, the data from the 1984/85 experiment may be less reliable than the new data because the topmen may have adjusted their initial school size estimates during the course of the experiment. It was considered likely that this change in recording behaviour no longer occurs. It was also noted that if the analyses of the SS experiment data yielded similar results for SS-II and SS-III, then future surveys could operate in IO mode and SS-II mode (with SS-II mode replacing Closing mode). This would allow for the normal scheduled rest periods for the crew, which would not be an option if alternating IO and SS-III modes were used.

BIG-EYE BT MODE: BIG EYES ON UPPER BRIDGE AND 7X50 BINOCULARS IN THE BARREL

The sub-committee noted two changes from last year's Big-Eye BT mode experiment: (i) the binoculars and mounting were of higher quality, leading to a higher proportion of Big-eye sightings and more duplicates; and (ii) the initial Big-Eye sightings were closed upon when abeam to confirm school size. Potentially, these data could be used to estimate *g*(0) for 7x50 topmen sightings, therefore providing a comparison with *g*(0) estimates from the analyses of the CPII and CPIII data. With the addition of confirmed school size data and the mis-underestimation of school sizes being appropriately incorporated, an analysis of these data should provide more insight than the analysis of the Big-Eye BT data from the 2005/06 survey (presented in SC/59/IA5) and as such, the sub-committee **recommended** that these data are validated and analysed as **high** priority. Noting the improvement in quality of the Big-Eyes on this year's survey, the sub-committee **agreed** that there remained some practical issues in operating in this mode (their narrow field of view makes it difficult to detect and track minke whale cues). Moreover, it is only possible to mount the Big-Eyes on the Upper Bridge so there remains quite considerable overlap is search areas between that of the Big-Eye observer and of the topmen in the barrel, searching with 7x50 binoculars. As this negates the intended utility of BT mode, it was **agreed** that further Big-Eye BT mode experiments were only potentially useful in the context of analysing and interpreting existing data; Big-Eye BT mode was not suitable for general use in future SOWER surveys.

BT OPTION 2: 7X50 BINOCULARS IN THE BARREL; NAKED EYE SEARCHING FROM THE IO PLATFORM

This BT mode option was included as an experiment to test its potential utility in future SOWER surveys. In terms of practicability, it was easily implemented, although refinements in the data recording systems would enhance the data quality, so further 'experimental' uses of the mode should still be considered in this regard. The data have not yet been analysed. The main purpose of any analysis would not be to obtain a *g*(0) estimate (this would not be useful for interpreting existing CPII and CPIII data as it would apply to naked eye Primary observers), rather it would be to assess search area separation and measurement error issues. The sub-committee considered these to be of **medium** priority, depending on the future of the SOWER programme.

SCANS II : SIGHTING TIMES, RANGE AND BEARING DATA RECORDING SYSTEM

Because the SCANS II system had been developed for surveying small cetaceans at lower latitudes than the SOWER survey, there were a number of practical problems associated with climatic conditions in the Southern Ocean that prevented its full implementation. Furthermore, the platform configuration on the *Shonan Maru No. 2* precluded the use of the direct data acquisition component of the system. The sub-committee noted that these types of difficulties could be overcome, but with the medium- to long-term future of the SOWER programme currently uncertain, further consideration of this was deferred. In the short-term and recognizing the need to evaluate the extent and effect of measurement errors, it was recommended that the experiment be continued in a reduced form, perhaps just the video component of the system (which would yield accurate ranges for a proportion of the sightings). In addition, given the high proportion of blow cues seen on the SOWER surveys, the sub-committee **agreed** that enhancements to the system (improved resolution and/or use of infrared) to increase the range at which these cues could be detected would be extremely valuable. The sub-committee also noted that the still camera had been used extremely successfully on the SCANS II survey for bearing measurements. Unfortunately, it had not been possible to evaluate its use on SOWER because of loss of data due to hard drive failure. Data could be recovered from this drive (which also included video tracks of Big-Eye sightings). The sub-committee **recommended** attempting to recover these data so the data could be analyzed.

VISUAL DIVE TIME EXPERIMENT

The sub-committee considered that this experiment had been very useful for identifying realistic scenarios for incorporation into the simulated data set, and (potentially at least) for designing suitable estimators of abundance. The sub-committee **agreed** that the results from analyses of data from this experiment (e.g. SC/58/IA21) should be used to condition the diving behaviour of whales in the simulated data, if this had not already been done. In terms of practicability, the experiment is generally straightforward to conduct. Some improvements in video/audio recording would, however, still be useful. Only one trial was conducted during the most recent cruise, but this demonstrated that it was possible to do so in poor weather. It is more difficult to conduct the experiment on whales encountered as single individuals.

## 5.4 Recommendations for the 2007/08 cruise

SC/59/IA2 presented plans for an aerial survey by Australia in December 2007-January 2008 for minke whales off Eastern Antarctica, where Casey Station (66º 17S, 110º 32E) would be the operational base. The survey would be conducted by two fixed-wing CASA-212 aircraft, primarily to investigate the feasibility of using aerial surveys for minke whales in the pack ice, but also to attempt to estimate their relative or absolute abundance. The paper described the intended approach for collecting the data, which in addition to visual double-platform observers, would include infrared and high-resolution video footage from cameras mounted beneath the aircraft. Digital still photographs would also be used to record the ice conditions at the time of the survey, primarily to facilitate ground-truthing of remotely-sensed data and thus permitting extrapolation from the surveyed strips to the survey region. Other uses of the photographs in the analysis included the development of an appropriate covariate to model how 'ice complexity' affects cue detectability, and to examine the perpendicular distance distribution of open water areas (and thus of cue availability) within the surveyed strips. Noting that the objective of obtaining abundance estimates from this survey was an ambitious one given that it was effectively a pilot project, the authors of SC/59/IA2 considered that the utility of the aerial survey data would be greatly enhanced if it were possible to integrate the proposed survey with the 2007/08 IWC-SOWER survey; such a collaboration would provide directly comparable estimates of minke whale densities within the pack ice and in open water and allow a check on whether the distribution of whales in open water was comparable to most SOWER surveys. It was noted that the aerial survey proposed in SC/59/IA2 was dependent upon the successful implementation of an airlink between Hobart and Casey which would be attempted for the first time during the 2007/08 austral summer. Final availability of this airlink and some other logistics could not be confirmed until closer to the proposed survey dates.

The sub-committee welcomed this proposal and agreed that concurrent surveying of the open water by the SOWER vessel would provide valuable information. A subgroup under Bannister was asked to plan for a joint exercise in 2007/8 between the SOWER Cruise and the minke whale aerial survey detailed in SC/59/IA2. The subgroup's report is attached as Appendix 2. The aircraft are expected to be available for the first two weeks of January, 2008, although the precise logistics have yet to be finalised. They will operate from the Australian Antarctic Station Casey, at ca 110°E. The Government of Japan has offered the research vessel *Shonan Maru No 2*. On the understanding that the aircraft will be available for the first two weeks in January, the vessel will be required to span that period. To coincide with the aerial survey, the vessel's research area will be concentrated on ca 110°E. Given a cruise duration of 60 days, 40 days will be available for research, to allow for transit to and from the home port in Australia (Fremantle). The target species and order of priority will be as in previous years (see Appendix 2, Item 5.5), as will the priority items for research. A systematic sighting survey will be undertaken, using standard protocols. Detailed recommendations are given in Appendix 2 Item 5.6.

Four researchers, including the Cruise Leader, will be required. A Planning Meeting will be held in Tokyo at the end of September. Kato informed the sub-committee that the venue had been booked for the period 29 September-2 October 2007.

Details of the collaborative research with the aircraft are given in Appendix 2, Item 6.1. In essence, the joint exercise will provide for comparison of minke whale density in the ice with density close to the ice in the southern stratum, and further north.

Further details, including the budget and an outline contingency plan should the aircraft not in the event be available, are given in Appendix 2. In sub-committee discussion, it was recommended that final plans, including a contingency plan in the event that the aerial survey does not go ahead, should be formulated at the Planning Meeting. Members are encouraged to submit proposals for research by the vessel in such a contingency to the Convenor, Kato, by 21 September, for consideration by the SOWER Steering Group (Kato, Bannister, Best, Bravington, Brownell, Clark, Donovan, Ensor, Gales, Hedley and Palka).

### 5.5 Recommendations for the long term

SC/59/IA3 introduced new methodology to examine the precision that might be obtained from line transect surveys when covariate-based spatial models are used to analyse the data. Using data from the CPII and CPIII IDCR/SOWER surveys, it focussed on what level of precision might reasonably be obtained from future SOWER surveys with only one survey vessel, given surveys designed with spatial analyses were used. It was expected that such designs would be rather different from the designs in CPII and CPIII, for which there were two vessels and designs were based on obtaining estimates from design-based estimators. The approach described assumed that in the future, encounter rate should only be estimated from IO mode effort, whilst both IO and Closing mode data should be used in estimating mean school size (taking into account measurement error in recording of school sizes). Negligible uncertainty in effective strip half-width (*ESW*) and *g*(0) was assumed since these could be estimated quite precisely from the existing CPII and CPIII data, and so SC/59/IA3 described approaches for estimating the likely precision of encounter rate and mean school size estimates. Preliminary results presented in the paper suggested that an optimal survey design would continue to allocate more effort to the southernmost region of the survey area, and that a reduction in the proportion of Closing mode effort would improve precision in the abundance estimate. Tentatively, the authors considered that with an appropriate survey design and a spatial analysis, reasonably precise estimates of minke whale abundance could be achieved from SOWER surveys using only one vessel.

These results were encouraging, especially that it is probably possible to obtain reasonably precise abundance estimates of minke whales using only one vessel. The sub-committee recommended this investigation should continue, specifically, a spatial component for variance in mean school size could be incorporated to facilitate the use of the methods in SC/59/IA3 in planning future SOWER abundance surveys.

## 6. SOUTHERN HEMISPHERE MINKE WHALES

### 6.1 Abundance and trends using IDCR/SOWER data

#### *6.1.1 Analyses of previous IDCR/SOWER cruises*

An objective of the 2004/05 cruise was to investigate the relationship between minke whale and sea ice and SC/59/IA16 presented estimates of the sightings survey from the Japanese ice breaker (*Shirase*) which was conducted simultaneously with the SOWER cruise. The collaborative research between the ice breaker and the SOWER vessels was conducted inside and outside the pack ice zone in the sector off western Enderby Land (40°E-50°E) in mid February. *Shirase* also conducted research in Prydz Bay (70°E-82°E) in early March. The numbers of the primary sightings of minke whales, including 'like minke', within the two ice fields were 6 groups (7 animals) and 16 groups (22 animals), respectively. The abundance of minke whales in the pack ice was estimated using the sighting data from *Shirase*. Ice concentration was used as a covariate in the models to estimate both *ESW* and encounter rate but the models without ice concentration were selected based on a minimum AIC. However, the estimated abundances from the models both with and without ice concentration were not significantly different. The density and abundance of the minke whales within the ice field off western Enderby Land were estimated to be 0.04 animals per n.miles$^2$ and 522 animals (CV=39.4%; C.I. 214 – 1,272). There was no significant difference between these results and the results obtained from SOWER vessels in the open water (an area extending from the ice edge up to 60 n.miles north). In Prydz Bay, the abundance of the minke whales was estimated to be 2,464 animals (CV=62.22%; C.I. 621 – 9,775). Again, there were no significant differences between this estimate and the two abundance estimates obtained from previous IDCR/SOWER cruises in this sector. Although Prydz Bay was closed by pack ice in 2004/05 and so the SOWER vessels could not survey there, many minke whales were distributed both in the open waters and within the pack ice. These results showed that the number of minke whales distributed within the ice field cannot be ignored when the total population of this species is discussed.

The sub-committee thanked the authors for this work and **agreed** that this analysis had confirmed that there were substantial numbers of minke whales within the ice and had demonstrated the need to take these into account when estimating the absolute abundance of minke whales. However, there was concern over the application of standard line transect methodology to this data since some of the assumptions on which line transect methods are based would be violated. It was suggested that analyses of the measurements to the sightings within and outside the ice would reveal this and that other methods, such as modelling the availability of animals within the ice and then modelling detectability, would be more appropriate. It was confirmed that no calves were seen within the ice and it was not possible to tell if there were differences in the lengths of animals inside and outside the ice. Only minke whales had been seen within dense pack ice but killer whales and Arnoux's beaked whales had been seen in loose pack ice.

One of the objectives for the 2005/06 IDCR/SOWER cruise was to conduct experiments to help in interpreting minke whale abundance estimates from the second and third circumpolar series (CPII and CPIII). Trials of BT survey mode (which requires one 'Primary' platform to search close to the vessel and a second 'Tracking' platform to search sufficiently far ahead of the vessel that animals are unlikely to have reacted to the vessel's presence before being detected and to track whales sighted) were conducted for this purpose. On the 2005/06 cruise, the Tracking platform searched using both high-powered binoculars ('big eyes') and 7x50 binoculars on the Upper Bridge and the Primary observers searched using 7x50 binoculars. The aim was to provide an independent estimate of *g*(0) that could be compared with those that resulted from the new methods under development. SC/59/IA5 presented the results of an analysis of the 2005/06 BT mode data. Examination of the sighting angles and radial distances suggested that there had not been a sufficient separation of search areas between the Tracking platform and the Primary observers, even for big eye sightings. The Primary platform was considerably higher than the Tracking platform and good weather was experienced during the survey which may have accounted for the large sighting distances recorded by the Primary observers. Examination of all duplicate sightings did not suggest that there was evidence of responsive movement overall, but for duplicates that were seen initially with Trackers using 7x50 binoculars, animals tended to be moving away from the vessel when they were seen by the Primary observer. Possible interpretations were a) responsive movement towards the vessel for both 7x50 and BE duplicates with the movement occurring before detection by the 7x50 trackers and b) unmodelled heterogeneity. Both responsive movement and unmodelled heterogeneity can be alleviated by detecting animals before they have responded and separating the search regions between the Tracker and Primary observers. Thus, it was concluded that the platform configuration and implementation should be reconsidered for future cruises.

Since 1987/88 over 21,000 identification photographs of blue whales have been collected on IDCR/SOWER cruises. SC/59/IA10 outlined the ongoing work to archive and analyse these photographs. Photographic film from the 1987/88 – 2002/03 is being digitized and in combination with the digital images collected from the 2003/04 – 2006/07 cruises will create a photo-id catalogue of blue whales. Photographs from all six Management Areas have been obtained and work is currently underway to match photographs between all years and Management Areas. During the cruises, sightings of an estimated 309 whales were made. Analysis of the sightings has resulted in a photographic catalogue of 142 uniquely identified blue whales, and this catalogue is expected to increase when all of the photographs have been examined. A discussion of this paper is in Annex H item 7.6.

#### *6.1.2 CP series*

This year, the sub-committee continued its focus on obtaining estimates of minke whale abundance from the IDCR/SOWER surveys. Standard datasets (extracted from DESS) had been made available. In addition to the estimates from the 'standard' method presented last year (Branch, 2006), the only new estimates available to the sub-committee were from the hazard probability method of Okamura and Kitakado (SC/59/IA14). The other two new methods that have been presented to the sub-committee – Cooke's integrated approach and Bravington's spatial model – still require some development before they can be reliably applied to the IDCR/SOWER data, but the sub-committee was informed that estimates should be available by SC60.

SC/59/IA14 presented minke whale abundance estimates for the IDCR/SOWER circumpolar surveys, using a hazard probability model similar to previous models presented to the Scientific Committee (e.g. Okamura *et al*., 2005). Specifically, the current model treated school size distribution, errors in recorded time, and the structure of the detection pattern differently than in the most recently presented model (i.e. in SC/58/IA9). The basic structure of the current model corresponded to the model for the simulation tests described in SC/59/IA15, with detection function covariates of weather, observed and confirmed school sizes, and platform. The authors noted that this form of the model performed well in the simulation tests, with small bias in density (typically less than 10%). Diagnostic plots indicated the model performed very well when applied to the IDCR/SOWER data. The estimated g(0)s by Area and year, integrated over school size heterogeneity, were generally between 0.4 and 0.6. The abundance estimates, therefore, were larger than those of Branch (2006). The difference in the total abundance in each Area between CPII and CPIII was generally reduced in comparison with the results from the standard methods, although the g(0) values for CPII were unexpectedly smaller than those for the CPIII survey. The authors considered that that was probably due to a trade-off between g(0) and mean school size. For example, in the survey of Area III in 1987/88, Branch (2006) estimated mean school sizes to be 3.29-4.77, and *ESW*s to be 0.51-0.57. In the same Area and year, the results of SC/54/IA14 were 1.66-1.78 for mean school size and about 0.24-0.31 for *ESW*s.

In comparing estimates between CPII and CPIII surveys, the authors excluded estimates from Areas II and V (as these were considered to be influenced by sea ice on a large scale because of the complex coastlines). The ratio of CPIII to CPII was thus 0.77 for abundance and 0.63 for density using their model. However, they cautioned that comparisons in total abundance should only be made after taking proper account of the uncertainty, including estimation of the additional variance.

In discussion, the authors confirmed that no model selection had been undertaken on the real data at this stage. Rather, the model used in the data analysis had been selected according to performance in the simulation tests. Unlike the model presented in Okamura *et al*. (2005), this model conditioned on confirmation status in both Passing and Closing modes for estimating mean school size (since the model that included confirmation status performed no better in the simulation tests than the present model). As in previous analyses of IDCR/SOWER data (e.g. Branch and Butterworth, 2001), the analyses in SC/59/IA14 had assumed that by using only confirmed school sizes in Closing mode, then an unbiased estimate of mean school size could be obtained. The procedure associated with 'confirmation' is quite different for IO mode compared to closing mode. There is a possibility that estimates of school size based only on confirmed sightings could be biased, and indeed that the likely direction of bias might be different in the two modes. The reasons are complex, and it is not easy to check using only IDCR/SOWER data where the true school size is unavailable (though SS III data from the 2007 SOWER school size experiment might be useful).

The sub-committee agreed to add 'confirmation' (dependent on school size and/or survey mode) to the list of factors possibly to be tested in the simulation trials (see item 6.1.7) and to discuss intersessionally further ways of checking bias. It was noted that it would not be necessary to 'cross' this with other factors, at least in the first instance.

As it was expected that estimates from all three new methods would be produced intersessionally, further consideration was given to identifying suitable diagnostics to facilitate a comparison of estimates and to evaluate goodness-of-fit. Such diagnostics had proven to be extremely valuable in assessing methods to analyse North Atlantic minke whale data. An initial list of diagnostics was compiled at SC58 (Appendix 3 of Annex G; IWC 2006); further suggestions were made in the sub-committee which were an extremely useful start in deciding exactly what diagnostics would be most useful to examine the three new methods. Noting that further elaboration of the suggestions may still be required, the sub-committee recommended that they be applied to the relevant aspects of the three new methods; details were referred to those involved with the proposed workshop (see item 6.1.7). As previously recommended, it was also agreed that diagnostics appropriate for assessing spatial model fits be used, where appropriate. Diagnostics which would help assess how well the model had distinguished between local clustering and large-scale trend in distribution (and associated issues such as variance estimation) would be particularly useful.

*6.1.3 Simulated data*

In order to test the robustness of the three new methods under development, a simulated data set has been produced which incorporates bias due to heterogeneity in factors related to the distribution, density and behaviour of minke whales, and to the manner in which the surveys were conducted (including measurement errors in recording of data).

SC/59/IA15 presented some results from applying the hazard probability model of SC/59/IA14 to the simulated data. Of the 38 different scenarios generated, true density was known to the authors for 32; the model was applied 'blindly' to the remaining 6 scenarios. For most of the scenarios 1-32, the bias was small and seemed acceptable. Four scenarios were identified which had higher bias than the other cases; these scenarios had a density gradient and the highest density regions were surveyed only in Closing mode, therefore such bias is expected with this model. Excluding these 4 problematic scenarios, the mean bias in density was -2.1%. SC/59/IA15 also presented results from the authors' own simulated data set produced to evaluate the robustness of their model for various heterogeneities that might have not been taken up in the existing simulated data produced by IWC. For this simulation, the authors focused on problems related to measurement errors in sighting distances and sighting times. The results from this additional simulation testing, indicated that errors in recorded sighting times (including rounding errors) could have relatively big impacts on abundance estimates, whilst random whale movement and measurement error in sighting distances had a relatively small impact. The model proposed in SC/59/IA15 was thus able to produce less biased abundance estimates for simulated data with errors in sighting distances and sighting times, and with random whale movement.

Preliminary results from applying four analytical methods were also presented this year. In addition to the hazard probability method described above, the simulated data were also analysed using Cooke's integrated method, the IWC 'standard' line transect method and the direct duplicate method (Palka, 1995). The integrated method had the smallest biases, whilst the standard and direct duplicate analysis methods had the largest biases. The results from the integrated model tended to be positively biased, while the other three models tended to be negatively biased. The integrated model method had the least variability. Overall, these preliminary results indicated that the largest bias in density was from those scenarios for which (i) whale density was correlated with weather conditions, and (ii) IO and Closing modes did not have even coverage over areas with a whale density gradient. Given these results, the sub-committee considered whether any such biases might affect our ability to look at trend (e.g. whether the bias might be expected to be constant over the period of the CP surveys). It concluded that since whale density might have changed, say between CPII and CPIII, then the extent of the bias from each model would be expected to differ between circumpolar surveys which would have implications for trend estimation.

The sub-committee recognized the value of these simulated data sets for evaluating the different analysis methods. It agreed that there were other factors that might require simulation tests in order to fully evaluate the reliability of new abundance estimates that the Committee expects next year. A list of potential factors to test is given in Appendix 3. Precisely which factors require simulation tests, and exactly how to do so, will be agreed by an intersessional email group (convened by Palka) in time for the intersessional workshop proposed in Appendix 3.

*6.1.4 Additional variance*

The abundance estimates presented in SC/59/IA14 are those for the surveyed areas in the CP surveys. For estimates of additional variance, estimates first need to be calculated by 'comparable area'. These calculations will be completed intersessionally, and the additional variance estimated using methodology such as that previously presented to the Scientific Committee (Kitakado and Okamura, 2005; Skaug *et al.,* 2004).

*6.1.5 Extrapolation to unsurveyed areas*

It was agreed that extrapolating to unsurveyed areas, especially when there are variations in density within the survey region, as is likely to be the case for IDCR/SOWER data, raises difficulties. It can likely best be addressed using a spatial model, but even then, the question of how to quantify uncertainty in the unsurveyed regions arises. The sub-committee recommended that this issue is discussed further intersessionally

*6.1.6 Conclusions*

One of the three new methods under development reached the stage where preliminary estimates of abundance for the CPII and CPIII surveys were presented. The key new feature of this method is estimation of detection probability along the trackline, *g*(0), which resulted in estimates of this quantity which were substantially less than one. This represents an important advance over the past 'standard' method for which the assumption and expectation were that *g*(0) was essentially one. This results in increases in the abundance estimates for both the CPII and CPIII surveys. In relative terms, the extent of the decrease in estimated abundance from CPII to CPIII is reduced, but some differences still remain (see also below).

*6.1.7 Work plan*

Whilst the new estimates presented this year are only preliminary, they did reveal that the appreciable decline in minke whale abundance estimates made using the standard method from CPII to CPIII cannot be explained by differences in *g*(0) alone. This year, the sub-committee briefly considered other reasons for the difference in estimates, including effects that might pertain only to specific Areas. For example, in the Weddell Sea in Area II, the Ross Sea in Area V (both large embayments) and in Area VI, large and complex differences in sea ice extent occurred. The question of what to do about unsurveyed areas (there was a large unsurveyed polynya south of the ice edge in Area II in CP III) was also considered. For further discussion of these points, see section 3.5. The sub-committee **agreed** that it would therefore be appropriate to develop at least the first two, and perhaps the following three, sets of abundance estimates for next year's Scientific Committee meeting:

(1) Estimates by Area from the surveyed regions.

(2) Estimates by Area from comparable surveyed areas in CPII and CPIII, where appropriate. (These are considered to be the best available way to estimate CPII:CPIII ratios.)

(3) Estimates obtained using the most appropriate method for extrapolating northwards to 60°S. (The uncertainty in these extrapolated estimates would be less accurately quantified, but this may not matter for some applications.)

In addition the sub-committee recognised that a number of detailed issues with respect to the new methods and the abundance estimates remain. These include: the analysis of recent data from SOWER experiments; appropriate simulation tests; diagnostic checks including some of those used in evaluating abundance estimates of North Atlantic minke whales; and space/time extrapolation/interpolation. These issues must be resolved before the Committee can agree on a set of abundance estimates with reasonable confidence. Experience from Committee discussion in recent years – both in IA and in other sub-committees such as AWMP, RMP and BRG – has shown that it is impossible to resolve such matters satisfactorily during the main Committee meeting or in intersessional email groups. The in-depth assessment of Southern Hemisphere minke whales has already taken much longer than anticipated, and if the Committee is going to finish this soon, then an intersessional workshop will be necessary. After such a workshop (and some associated intersessional email correspondence), the IA sub-committee in 2008 should be able to quickly come to an agreement on best available estimates, leaving enough time during the 2008 meeting for discussion of interpretation. Therefore, the sub-committee **strongly recommended** that such an intersessional workshop takes place.

### 6.2 Abundance and trends using JARPA data

SC/59/IA11 presented analyses of JARPA minke whale data to address several recommendations offered during the JARPA Review Meeting. The Advisory Group decided on the priority of each recommendation, in particular paying more attention to addressing possible bias rather than variance issues. High priority was assigned to the following items. a) re-estimation of detection function by pooling sighting data; b) investigation of the 'shoulder' of detection function; c) extrapolation of density to unsurveyed areas, and d) abundance estimates accounting for the order that the strata were surveyed. After pooling sighting data (i.e., increasing simple size) the shape of detection functions, including the 'shoulder', was improved in most of the cases, but the shape of some of the detection functions still need further investigation. Extrapolating density into un-surveyed area did not change the abundance estimates substantially except in one instance, and it is further suggested that a different method of extrapolation would not significantly affect the abundance estimates in Areas IV and V. Further analysis of extrapolation should therefore have a lower priority. A linear model was used to show that the date that the strata were surveyed did not affect the estimates in Areas IV and V because the JARPA sighting data were collected over a short time period in January to February. Over this period of peak migration, the abundance is quite stable. The estimated rate of increase did not change substantially after examination of the detection function or extrapolation to Prydz Bay was taken into account. Other recommendations offered by the JARPA review meeting will be considered in the near future.

Questions were raised about the effective strip width, which varied by a factor of two between years; however the reason for this was the change in weather conditions between the southern and northern strata. It was accepted that the modifications to the detection function estimation method, and accounting for the extrapolation, made very little difference to abundance estimates.

SC/59/IA19 examined some of the issues with the JARPA survey design, stating that the JARPA surveys took place over three to four months and thus considerable changes can occur in the location of the ice edge during the survey. The IDCR/SOWER surveys minimized these logistical difficulties by using two ships simultaneously surveying the north and south strata while the ice edge was in approximately the same location, but during the JARPA surveys the south and north strata were surveyed sequentially. To investigate the implications, the following were reviewed: the adequacy of coverage of strata, the sequence that strata were surveyed, the extent of sea ice during the survey and other related information. In Area IV there were trends in the timing of the survey of the ice edge strata, in the extent of sea ice at the time of the survey of the ice edge strata, and in whether a gap occurred between the northern and southern strata. In particular, the last three surveys (from 1999/00 to 2004/05) were different from the previous five surveys in all these categories. In Area V there was also a trend in the timing of the survey of the strata, with a different sequence occurring during the last three surveys. The ice edge stratum (SW) was surveyed later (March) during the last three surveys than it was during the first five surveys (December-February); furthermore, coverage was particularly low during the last two surveys, whereas it had been medium or high during earlier surveys. The Ross Sea was surveyed later during the first five surveys, and there were gaps in coverage between the southern and northern strata in the east in the first two surveys. The Ross Sea was surveyed earlier in the year during later surveys, and the extent of ice was high or medium during three of the last four surveys, whereas it was low in all of the first four surveys. The fact that the timing of the surveys changed directionally over the time period confounds interpretation of trends in abundance of whale species as their density is related to distance from the ice edge. Given that minke whale density is relatively high in the ice edge strata, these changes may be particularly important to interpretation of trends in minke whale abundance.

In response, it was pointed out that the survey gaps between the northern and southern strata in the Ross Sea in 1990/91 and 1992/93 were not due to changes in the survey design but because of poor weather. As far as survey design, JARPA was planned to be conducted mainly in January and February to cover the feeding migration peak of the minke whales, and most strata in Area IV and V were surveyed in these months.

The sub-committee noted that there was some search effort conducted in March, especially in the Ross Sea, and that it was clear that the order in which the strata were surveyed had changed over time, and this could cause a trend in the estimates because of different ice extent later in the season. However, the analysis in SC/59/IA11 had examined a GLM of estimates of abundance by stratum including covariates of year, survey mode, and a quadratic dependence on the time at which the survey took place (indicated by the middle day of the period of the survey) to allow for the possibility of indications of a migration peak in the data. No significant temporal dependency was detected unless Area V was considered in isolation. Analyses of the IDCR/SOWER data had, also, failed to detect such trends over the January-February period (Brandão *et al*. 2002). In further discussion it was suggested that an interaction between north/south strata and the temporal dependence be considered, as the impact of migration patterns might differ by latitude, although this effect would probably be small compared to the extent of additional variance. There was no agreement whether the analyses in SC/59/IA11 had a satisfactory basis for a correction for this issue because the sub-committee did not have time to complete its discussion on both SC/59/IA11 and SC/59/IA19.

The sub-committee recognized that during the last several years the process of reviewing the JARPA abundance estimates has been drawn out and there has not always been clarity about the complex analyses suggested and results reported. Comments on these issues made by Wade and Childerhouse are in Appendix 4A. After a brief discussion it was evident there would other views, but due to a lack of time, the issues could not be fully discussed. These views are reported in Appendices 4B – 4D and were not discussed further. As a way to expedite progress, the sub-committee recommended that the Advisory Group on abundance estimates (already appointed during the JARPA review meeting) be reconstituted intersessionally with some additional members.

### 6.3 Abundance and trends using other datasets

SC/59/IA20 reported on a helicopter survey from the German research vessel 'Polarstern' in the central and eastern Weddell Sea from 28 November 2006 to 26 January 2007. A total of 8619 km were covered. Environmental information was collected continuously during the survey and included percentage ice coverage. A total of 71 sightings of 155 minke whales were recorded. Mean group size was 2.18 with a maximum group size of 7. Sighting rates were lowest in the pack ice with a mean of 0.0021 sightings per km. Sighting rates were 0.0034 for the Larsen A and 0.0060 for the Larsen B area. The highest sighting rates were found east of James Ross Island (0.074 sightings per km). The behaviour of minke whales was different in the dense pack ice compared to the loose pack ice; whales were much more elusive in loose pack ice where killer whales occurred.

The sub-committee welcomed this presentation, noting that it provided valuable information on whale presence within the pack ice, even in early December. The preliminary findings supported previous work presented, suggesting that there may be a non-negligible proportion of minke whales south of the (IWC-defined) ice edge and in polynyas, in some areas. Further development of suitable analysis methods for obtaining density and abundance estimates from aerial surveys over the pack ice was encouraged. In this regard, the observed difference in whale behaviour in dense pack ice relates to different availability of cues, and its effect could be important in developing suitable such methods.

SC/59/IA21 described a helicopter-based cetacean survey from the German research vessel 'Polarstern' in the Elephant Island – South Shetland Islands – Bransfield Strait region from 19 December 2006 to 6 January 2007. A total of 2570 nm were covered on survey effort. 39 sightings comprising 91 whales were obtained. The sightings included 4 species of baleen whales (humpback whale, fin whale, sei whale and minke whale) and three species of beaked whales (southern bottlenose whale, Gray's beaked whale and strap-toothed whale). The species showed a clear spatial segregation in the study area: humpback whales occurred at a mean water depth of 254m while fin whales and minke whales were found on the outer shelf and the slope at a mean depth of 1106m. Beaked whales were only sighted in oceanic waters over a mean water depth of 3198 m.

The sub-committee appreciated receiving this information, which had been compiled in only a short time after the survey was completed, and looked forward to receiving some further results from the survey in the future.

### 6.4 Catch-at-age analyses

#### *6.4.1 Report from intersessional working group*

The report of the intersessional working group on VPA analyses related to Antarctic minke whales is attached as Appendix 5. Four tasks had been identified as of highest priority for work between the 2006 and 2007 SC meetings:

- Develop appropriate error models for the catch-at-age data to be used in the population modelling to take into account potential errors and biases in the ageing and length data and how these may have changed over time;
- Examine the data from the 1984 ageing workshop to provide insights for the development of error models for the catch-at-age data—particularly with respect to potential biases arising from unreadability of ear plugs being related to age;
- Develop a set of questions with respect to minke whale ageing that could be distributed to those who have had experience in this area to provide a better understanding of the problems involved and potential errors in the catch-at-age data;
- Checking the commercial catch data for possible coding errors and updating these data if necessary.

Progress on the first and second tasks was not accomplished intersessionally, but is expected to be possible shortly after SC59.

#### *6.4.2 Preliminary results*

SC/59/IA18 provided a summary of responses from experienced researchers to a questionnaire on minke whale aging and length measuring. Such a questionnaire was identified as a high priority for intersessional work at last year's IWC SC meeting, and was prepared by the e-mail intersessional group on VPA analysis related to Southern Hemisphere minke whales. Although the sample size was small, the responses confirm that there are still unresolved issues in the age reading of earplugs from Antarctic minke whales. The two most important issues based on the questionnaire are: (1) the assessment of the readability of individual earplugs, and (2) undercounting of bands in older animals as the result of tight packing of growth layers. SC/59/IA18 notated that the consequence of non-migration of whales to and/or from the Antarctic on the formation of growth layers is also a potential source of bias in age estimates. Resolution of these issues remains a high priority for the completion of the minke whale catch-at-age analyses. Their resolution will most likely require further collaborative and comparative earplug readings and analyses among readers with different assessments of the extent to which both non-readability and tight packing occur.

Additional responses were provided to some questions during the meeting. Ivashchenko and Tormosov described Soviet procedures for measuring minke whales on factory ships. Length was measured from the tip of the head to the fluke notch with a steel tape with one end attached to a metal pole held at the tip of the head. Experienced technicians on the factory ships made the measurements. There were occasional problems that could have led to some positive bias in measurements, but these were not common.

The sub-committee agreed that the presence of international inspectors on factory ships from 1972 and the absence of a minimum length regulation for minke whales helped to ensure that measurements were conducted and reported correctly. It was also noted that because the possible biases are small and measurement error can be allowed for in modelling, further investigations along these lines are probably no longer necessary.

SC/59/O8 addressed one of the tasks of the intersessional working group and a recommendation that was made during the JARPA review (SC/59/Rep1). It had been noted that whales aged 5 or younger had longer body lengths on average in the commercial catch than in the JARPA catch, and it was suspected that this might be due in part to coding errors. A cross-check with original ageing notes and biological records for 2,270 whales aged 5 or younger uncovered 45 coding errors. In addition, 474 of the age readings were categorized as “biologically unlikely” on the basis of large body size, recorded ovarian corpora counts or large testes weight. Correcting the coding errors and eliminating the biologically unlikely ages reduced the mean difference considerably. However, the authors suggested it might still be best to exclude the 5 year or younger age class from analyses such as VPA. Older ages from commercial and JARPA data sets could be treated as comparable.

The sub-committee welcomed the report that checking for coding errors and biologically unlikely ages was being extended to older age classes, as well as the plans to train young Japanese scientists to read earplugs and use multiple readers for each earplug.

SC/59/O8 also reported results of an inter-reader ageing calibration using 100 good earplug samples retained from commercial whaling. These tended to be from older whales. They had originally been read by Kato, and Zenitani then re-read them. The mean difference between the two readers was 0.01 ± 0.220 (S.E.) years.

In discussion, it was pointed out that this result indicated that the difference between commercial and JARPA ages in whales of intermediate ages (primarily 15-30 years old) were unlikely to be due to a learning effect.  This in turn counters the possibility that estimates of a historical increase in recruitment are an artefact of under-aging of these whales in earlier years as compared to more recent years. However, both readers were from the same “school”, so a bias affecting both readings was still possible. The sub-committee recommended further experiments (Appendix 6) to provide additional insight into ageing errors. It was noted that power analyses should be carried out to verify the suggested sample sizes as some of the proposed experiments would involve days or weeks of work. Some further checking could be done without additional data reconciliations or age readings. Confidence intervals on estimates of possible relative bias in commercial versus JARPA readings should be checked, and modelling should be used to determine how much relative bias would be needed to significantly change catch-at-age results.

It had been noted during the JARPA Review that it was not necessarily safe to assume there were no relative biases in older ages since the problem in the young whales had been recognized through inconsistencies in lengths at age, and for older whales, lengths don’t vary. The sub-committee discussed whether the sample size for the proposed experiments was sufficient and whether a sample stratified by length should be used for the experiments proposed in Annex Y to insure that old whales were adequately represented. It was noted that a random sample of 250 may not provide sufficient readings for larger animals to resolve the question of undercounting of bands in older animals as the result of tight packing of growth layers. It was further noted that it was important to ensure that the sample size for the experiment were sufficient given the expense in having a reader from another reading “school” participate in the experiment as it would be difficult to augment the sample size subsequently. Using a length-stratified sample would complicate analyses, so it was agreed that a random sample should be used initially for the left/right earplug experiment by the Japanese readers. These initial results should then be appropriated considered prior to having the plugs read by a reader from another school. If the results from the initial experiment suggested that a sample size of 250 was inadequate, the initial random sample could be supplemented with additional earplugs either from a random sample across all length classes or a stratified sample with higher proportions of larger whales.

SC/59/IA4 provides further development of statistical catch-at-age models for southern hemisphere minke whales developed by Punt and Polacheck (2005, 2006). The model is applied to catch, catch-at-length, and age-length keys as well as indices of relative and absolute abundance in order to identify a “reference case” set of specifications related to vulnerability, examine the sensitivity to using reduced portions of the commercial catch-at-age data for assessment purposes, and to examine an alternative density- dependence function. The results confirm results obtained by Punt and Polacheck (2005, 2006) that the data support a non-uniform vulnerability pattern for JARPA and dome-shaped vulnerability for the period of commercial harvest. It is proposed that these types of vulnerability curves should be used in reference case analyses so that the reference case analysis is centred well within the range of possible parameter and model options. The results again confirm the result from earlier studies that the recruitment of Antarctic minke whales in Areas III-W, IV, V and VI-W increased until about the early- to mid-1960s and declined thereafter. This result is generally robust to assumptions about the form of the vulnerability patterns for the catches by JARPA and during the period of commercial whaling, the density-dependence function, and the weight assigned to the early ageing data. However, the model had difficulty in achieving biologically reasonable estimates for stock E and had convergence problems when vulnerabilities were assumed to be age-specific – both of these issues require further analyses. As with previous analyses, the model predicts large changes in carrying capacity changes and somatic growth rates. There is no obvious known source or cause to associate with these changes particularly the large decline in estimated carrying capacity between 1960 and 1980).

SC/59/IA13 documented additional modifications to the ADAPT-VPA methodology originally developed by Butterworth *et al*. (1999) and showed results for applications to the abundance estimates and catch-at-age data for the I- and P-stocks of Antarctic minke whales. The modifications to the methodology allow for: 1) inter-annual differences in the distribution of the population between different management Areas, 2) incorporation of a stock-recruitment relationship in the estimator, 3) the effects of possible ageing-error, and 4) the effects of possible change in age-at-sexual maturity over time as indicated by analyses of readings of transition phases in ear plugs. The last was in response to a request made by the JARPA review workshop; application to the I-stock led to no qualitative changes to key results. In further response to requests by that workshop, performance of the estimator in the complete absence of commercial catch-at-age data was examined for the I-stock, and found to lead to convergence difficulties likely related to insufficient information to estimate early recruitment trends in such circumstances.

The sub-committee noted that there are few data for the P-stock (Areas V-E and IV-W) with the result that model estimates (e.g. of natural mortality) are more uncertain for the P-stock than for the I-stock. The sub-committee agreed that consideration could be given to estimating common values for some parameters of the P- and I-stocks and encouraged further work along these lines. The sub-committee agreed that consideration needs to be given to accounting for the impacts of partial (age/length dependent) presence of the total population in the area over which age samples were collected when fitting to the JARPA and IDCR-SOWER abundance estimates.

The sub-committee noted that results of the analyses in SC/59/IA4 and SC/59/IA13 remained preliminary because the Committee has yet to final decisions regarding how the data from JARPA and IDCR-SOWER programme should be used to obtained abundance estimates as well as how the catch-at-age data should be included in the analyses. The sub-committee re-established the intersessional working group on catch-at-age analysis under Polacheck, with members Butterworth, Cooke, Leaper, Mori and Punt to co-ordinate the intersessional work.

The JARPA Review (SC/59/Rep1) noted that the transition phase data suggested a decline in age-at-maturity from around 11 years in pre-1955 cohorts to 7-8 years in post-1980 cohorts, but the ADAPT-VPA analyses suggested that *per capita* recruitment (i.e. recruitment per mature female) was high in the 1950s and 1960s but low post-1980. The JARPA Review recognized that these results were in apparent contradiction to the conventional expectation that high ages at maturity and low somatic growth rates would tend to be associated with low per capita recruitment rates, while low ages at maturity and high somatic growth rates would tend to be associated with high *per capita* recruitment rates.

SC/59/IA22 provided a counter example to show that inferences incompatibility between population trends from ADAPT-VPA and independently estimated changes in the age-at-sexual-maturity of Antarctic minke whales over the late 1940s to late 1960s are not robust to plausible variants of the ADAPT-VPA assessment (specifically in this case admitting the possibility of a small negative slope in selectivity at larger ages). Final conclusions on this matter should await fuller investigations on the ability to the ADAPT-VPA estimator to reliably estimate the shape of the time-trend in carrying capacity over this period, upon which inferences of compatibility or otherwise are critically dependent.

In discussion, the sub-committee agreed that the sensitivity tests in SC/59/IA22 showed that it was possible for some configurations of the ADAPT-VPA to reflect an increase in recruitment per adult female from the late 1940s to late 1960s that the decrease in age-at-maturity suggested by transition phase analyses for this period would suggest. However, it also agreed that the low recruitment rates after 1970 remain inconsistent with the low ages-at-maturity after 1970; put another way, the subsequent lack of increase in age at maturity was much less than might have been expected from the size of these earlier trends given the large drop in recruitment per adult female suggested by the VPA for the post-1970 period.

The sub-committee noted that the sensitivity tests in SC/59/IA22 also lead to model outcomes that differed from those for the reference case considered during the JARPA Review and that it would be desirable to develop diagnostic statistics to quantify the extent to which the recruitment rates from VPA analyses are consistent with the *a priori* expectations based on trends in age-at-maturity. Such statistics should be developed intersessionally by the catch-at-age analysis working group under Polacheck.

## 6.5 Reasons for differences between minke abundance estimates from CPII and CPIII

### *6.5.1 Report from intersessional email group on abundance estimates and sea ice extent changes*

Established at SC58, the terms of reference for this group were to: (1) collaborate with sea ice experts and abundance analysts to obtain abundance estimates by 10° longitudinal slices using the newly developed abundance estimation methods; (2) provide information on sea ice extent so it could be most usefully included as a covariate in abundance estimation; and (3) examine hypotheses that could explain if, and how, a change in sea ice extent might be related to the abundance estimates. It was reported that some, though not all, of these tasks had been achieved intersessionally and that considerable progress had been made, as is reported below. In particular, it had not been possible to obtain abundance estimates using any of the new methods, but that density estimates had been calculated using the standard line transect analysis method (reported in SC/59/IA6). Relative indices comparing sea ice extent between the CPII and CPIII surveys had also been computed by 10° longitudinal slice; these were to be used to examine the relationship between the density estimates in SC/59/IA6 and sea ice extent (see section 3.5.2).

### *6.5.2 Preliminary results*

SC/59/IA7 updated the table listing possible reasons for the appreciable decrease in minke whale abundance estimates from the standard method (IWC, 2003). The literature was reviewed for hypotheses explaining the appreciable decrease in minke abundance estimates between CPII and CPIII. Most work had focused on changes in the probability of detecting a school on the trackline, g(0), or an increased proportion of minke whales present in the pack ice in CPIII. Other factors were regarded as having only a small impact on the CPIII:CPII ratio. If, however, the decrease in the estimates reflected a real decline in the abundance and not a change in survey design or availability of whales, the most likely explanations included top-down and bottom-up effects resulting in a combination of increased mortality and a lower carrying capacity. Top-down effects could include increased predation from krill-eating predators, while bottom-up effects could include climate changes resulting in a lower krill abundance.

The sub-committee did not discuss this paper in detail this year because new abundance estimates were expected to be available at next year's meeting.

#### 6.5.2.1 ANIMALS WITHIN THE SEA ICE

SC/59/IA6 presented density estimates of minke whales by 10° longitudinal slice, from the ice edge to the northern boundary of the northern strata (usually 60°S), using data from the three circumpolar sets of IDCR/SOWER surveys. In general, the estimates were calculated using the 'standard' line transect methodology (Branch and Butterworth, 2001), but with no stratification. Separate detection functions for IO and Closing modes were estimated by pooling together all data from a single survey (sample sizes were often too low to estimate detection functions reliably using data from the 10° longitudinal slices.

The resulting estimates from SC/59/IA6 were used in SC/59/IA26 to examine the relationship between minke whale abundance and pack ice extent by 10° longitudinal slice using linear regression. The results of the regression were compared with those from a previous analysis (Shimada and Murase, 2006) in which a similar analysis, but by Area, had been carried out and had appeared to demonstrate a clear negative correlation between abundance and ice extent. There was, however, no clear pattern observed in the data examined by 10° slice. This was probably because of the difference in the northern boundary between CPII and CPIII, and because in some years estimates were from multiple years of data, the abundance and density by 10° slice were not comparable between CP sets of surveys.

In discussion, the difficulties in obtaining estimates using design-based methods by 10° slices were pointed out. In particular, it was agreed that the standard method for obtaining density estimates is probably unsuitable for examining the relationship with sea ice extent because it fails to take account of the systematic variation (in density, environmental conditions, etc.) with latitude. Furthermore, it was recommended that estimation variance (at least) must be accounted for in examining the relationship between density and ice extent, so the simple regression techniques employed in SC/59/IA26 were inappropriate. Recommendations for how the analyses should proceed are presented in Appendix 7. An intersessional working group was established to investigate these issues further with Shimada and Palka as co-convenors.

A new method for estimating the proportion of whales in the sea ice was also briefly discussed. The proposed approach was to model log(abundance) using a linear normal random effects model, extended to account for the possibility that the proportion of whales in the sea ice could be nonlinear. Noting the conceptual appeal of the approach, the sub-committee encouraged its application when the revised estimates of abundance by longitudinal slice were available.

Ainley *et al*. (2007) reported on an icebreaker survey in the Amundsen and southern Bellinghausen Seas from mid-February to late-March, 1994. These areas are unusual in that the pack ice does not retreat fully to the Antarctic continent in the summer months, but there is very little information about whale distribution in this region (no surveys have been undertaken in the areas since). The paper reported over 100 minke whales sighted in the pack ice, and focussed on examining the relationship between whale sightings and several oceanographic factors. It was found that whale presence was related to the proximity of coastal polynyas in early autumn, and to distance from the marginal ice edge zone later on in the season. Whale density was higher in the lower ice concentrations.

In discussion, the sub-committee noted that these results provided further evidence of minke whale presence in the pack ice. Interpretation of the results from the IDCR/SOWER surveys clearly needs to allow for the potential of there being a proportion of minke whales present in the ice in the summer months. However, there are still practical difficulties in conducting line transect surveys in pack ice (changes in vessel speed and direction, for example) but also, at this point, there is still fairly substantial theoretical work to do to take into account differences between open-water and pack-ice surveys.

Karnovsky *et al.* (2007) and Smith *et al*. (2006) summarize existing knowledge about Ross Sea biological oceanography. This area, and that of the western Weddell Sea, has been intensively investigated over the years by the RISP, ROAVVERS, AMERIEZ and other programs, with hundreds of publications existing to describe their attributes. What is described is applicable to much discussion at this meeting about polynyas and particularly the Ross Sea polynya (in Area V), as well as the ice-free embayment during summer of the Weddell Sea (Area II). Pointed out in Karnovsky *et al.* (2007) is the fact that polynyas are not the same. Some are very productive supporting robust food webs, others are not. Most of the waters in the two ice-free areas (in Areas II and V) are largely devoid of birds, seals or whales (see also SC/59/IA12) owing to the dominance of the colonial alga, *Pheaocystis antarctica*. As indicated in these two papers (Karnovsky *et al.,* 2007 and Smith *et al*., 2006), this phytoplankter, *Phaeocystis*, is too 'gummy' for the grazing by zooplankton and thus a food web resulting in abundant krill or fish does not develop. It is only in the marginal ice zones of these open-water areas of Areas II and V that minke whales are present in any appreciable number, areas where single-celled diatoms, efficient for grazing, occur.

The sub-committee welcomed the presentation of the results from all of these studies. Together these studies confirm that some minke whales are within the sea ice and polynyas. However, they also document that it is difficult to predict the density of minke whales within the sea ice and in polynyas that have not been surveyed.

###### 6.5.2.2 OTHER

SC/59/IA12 explored a GAM-based modelling approach for estimating the abundance minke whales using data obtained by the *Kaiyo Maru*-JARPA joint survey in the Ross Sea in austral summer in 2005. The joint survey was designed as a multi-disciplinary study combing surveys on cetacean, krill and oceanography. A hierarchical structure with three strata of spatial models is considered in this study: (1) presence/absence of Antarctic and ice krill, (2) biomass density of Antarctic and ice krill and (3) school counts of Antarctic minke whales. Three abiotic factors, distance from physical boundary (combination of coast, ice edge and shelf ice lines) and integrated temperature and salinity mean from surface to 200m (ITEM-200 and ISAM-200) as well as latitude and longitude were used as covariates for models (1) and (2). Predicted surfaces of krill were also used as covariates in the model (3). The response variable was the number of minke whale schools per 5 nautical mile segment of trackline; this was related to environmental factors on the same scale. Predicted school counts of Antarctic minke whales were generally low where ice krill was distributed, while they were generally higher where Antarctic krill were distributed, indicating that the abundance of Antarctic minke whales could relate to the biomass of Antarctic krill. School counts of Antarctic whales increased as ITEM-200 increased while they increased as ISAM-200 decreased. Noting the large difference between abundance estimates in the Ross Sea between the CPII and CPIII surveys, the authors suggest that a GAM-based model such as that in SC/59/IA12 could contribute to interpreting the reasons for such difference in the context of a change in spatial distribution. They conclude that the continuation of a multi-disciplinary ecological survey such as JARPA II is critically important to relate changes in the abundance of Antarctic minke whales to their environment.

The sub-committee agreed that this type of approach for relating the spatial distributions of whales and krill to features of their environment was worth pursuing. Some technical problems with the models presented in SC/59/IA12 were pointed out, and the authors agreed that these issues warranted further investigation before the predictions from the models could be interpreted with confidence.

*6.5.3 Work plan*

Future work was identified that would help elucidate any differences in Area-specific estimates, when they are finalized next year. The following topics were considered likely to be important for interpreting these results:

(1) Further examination of the relationship between density/abundance and sea ice extent, including in regions of complex and changing ice extents (such as the Ross Sea in Area V).

(2) Further investigation, including a review of the relevant ecological literature, into the presence and likely abundance of minke whales in polynyas (such as those found in the Weddell Sea in Area II).

Furthermore, the sub-committee considered that any further insight into the relationship between features of the environment (such as proximity to the Antarctic slope front or krill density) and whale density (such as that presented in SC/59/IA12 for Area V) might be valuable, particularly if it could be extended to include other Areas.

### 6.6 Dwarf minke whale

SC/59/IA24 reported sightings of Southern Hemisphere dwarf minke whale (*Balaenoptera acutorostrata*) made during the 33rd (1997) and 43rd (2007) Chilean Scientific Expeditions to the Bransfield and Gerlache Straits in Area II. It also conducted a review of previous records of minke whale in the same region. Four whales were confirmed as dwarf minke whales in the 1997 Expedition based on observations of their external characteristics. One whale (or possibly two) was confirmed as a dwarf minke whale in the 2007 Expedition. Among the previous records in the area, a total of five animals were identified as possible dwarf minke whales. Based on geographical considerations, it is suggested that whales sighted in summer around the Bransfield and Gerlache Straits could be related to dwarf minke whales previously reported for the Patagonian channels (in the southern tip of South America) and the wintering ground off Brazil. To confirm this link, biopsy samples should be obtained from animals sighted in the Antarctic and their genetic composition should be compared with those in the Patagonian channels and Brazil. The possibility that some animals remain in the Antarctic in the austral winter can not be discarded. This work is part of the research program on marine mammals of the Marine Biology Group of the CEQUA research center based in Punta Arenas, Chile.

The sub-committee welcomed this new information for this region and **encouraged** further work to investigate the migratory corridor postulated.

## 7. CONSIDERATION OF PROPOSALS FOR FURTHER IN-DEPTH ASSESSMENTS

### 7.1 North Pacific sei whales

SC/59/IA17 identified potential sources of information that would facilitate a comprehensive assessment of North Pacific sei whales. Additionally, preparatory suggestions of how to proceed with work to be undertaken prior to such an assessment were made (Appendix 8).

The sub-committee expressed its appreciation to Cooke for co-ordinating this review, and **agreed** to the suggestions made as an initial way forward. An intersessional Working Group convened by Cooke, comprising Brownell/Palka, Kato, Miyashita and Ohsumi, assisted by Allison, was established to facilitate the work outlined. With regard to the data and suggestions relating to JARPN II, Hatanaka pointed out that the first review of this programme would be at the end of 2007, and that all the data would be worked up and analyses completed prior to this review. He had hoped that the sei whale assessment would have coincided with that review. The sub-committee **agreed** that the Working Group initially concentrate on the suggestions made in SC/59/IA17 which did not relate to JARPN II data, and follow up on those that do require these data after the review.

### 7.2 Sperm whales

SC/59/IA23 is a progress report on work undertaken towards a sperm whale assessment. The report is attached as Appendix 9. There had been progress on population structure, historical catches, and survey methods; in addition substantial information is being accumulated on abundance and distribution and on the potential effects of acoustic activity.

The sub-committee noted that interest had been shown in the status of sperm whales by IUCN and the US Government, at both global and regional levels.

The Committee had agreed at its 2003 meeting to pursue the possibility of conducting a sperm whale in-depth assessment. The results of a workshop held at Woods Hole, Massachusetts in March 2005 in response to that initiative had been reported to the 2005 Scientific Committee meeting. The workshop had identified many topics requiring additional research. Foremost among those were: the development of provisional hypotheses about population structure; obtaining information on female survival rates; improving information on historical catch data, including the effects of differential exploitation by sex; improving methods to correct abundance survey data to account for bias; refining population modelling approaches.

Progress on those priority topics, and others, is detailed in Appendix 9. While there has been good progress on several fronts, work is urgently needed on population structure, catches, female survival rates, and population modelling.

The sub-committee noted that a recently published sperm whale population assessment had not incorporated the main feature of sperm whale population structure in relation to the catches. The dominant feature of sperm whale population structure is the prevalence of schools of female and juvenile animals in lower latitudes, while single males and bachelor schools occur in higher latitudes especially in summer. 19th century sperm whale catches were mainly in lower latitudes and would have to a large extent consisted of juveniles and females.  In the 20th century there were very large pelagic catches in higher latitudes, especially in the North Pacific, which consisted primarily of larger male animals. A reconstruction of the population history will need to take these features into account, at least in broad terms.

However, there are problems of interpretation of the historical catch data, which need to be addressed. Until 1972 the minimum size limit for pelagic whaling was 38ft, which, if respected, would have largely precluded the catch of females. It was an open secret that the size limit was not respected (Tønnessen and Jonsson 1982). The reported length distributions pf catches data show an implausible heaping of catches just above the size limit (Cooke *et al.* 1983). In view of the misreporting of sizes, it is to be expected that the recorded data are also inaccurate with respect to the sex and numbers caught. If undersize whales were caught but reported as being of legal size, it is likely that females would have been declared as males, because of the biological implausibility of large-size females. Further, catches of undersize whales may have been reported as a smaller number of larger whales, both to overcome the legal size limit, and, in later years when catch quotas were in effect, to conceal the total numbers caught. From 1972, the pelagic size limit was reduced to 30ft, and international observers were placed on factory ships. Sperm whale catch records from coastal whaling were also subject to some level of misreporting (Kasuya 1999).

Preliminary to conducting a population assessment disaggregated by size and sex, it would be necessary to examine the historical evidence and attempt to place approximate bounds on the size and composition of the catches (Kasuya 2003). This could be done by relating the positions of the catches (which are believed to be approximately correct) with other information on the occurrence of sperm whales by size and sex at the different latitudes. On this basis it may be possible to construct “low”, “best” and “high” catch series for female sperm whales, as has been done by the Committee in recent years in some baleen whale assessments.

Previously, the Committee had indicated that its work programme would not permit progress on a sperm whale assessment until 2008. In the light of current commitments, the sub-committee could not recommend including a sperm whale assessment in the immediate future, but agreed that it would encourage work to be undertaken in parallel along the lines indicated in Appendix 9.

### 7.3 Comprehensive assessment procedures

Recent experience in the Committee indicates that assessments by species are taking over five years to complete. In the light of this, the question of how to deal with new assessment proposals was briefly considered. The approach taken by this sub-committee this year of reviewing the available information and outlining and completing preliminary work was considered useful, but further consideration of how and when to begin new assessments before existing assessments were fully completed was still needed, especially given the current workload of the Scientific Committee.

## 8. WORKPLAN AND BUDGET REQUEST

The sub-committee agreed that obtaining Antarctic minke whale abundance estimates from the IWC/SOWER surveys and conducting the 2007/08 IWC/SOWER survey are the highest priority items for next year. High priority topics to be discussed during the next year are:

1) Produce agreed abundance estimates of Antarctic minke whales;

2) Continue development of the catch-at-age analyses of the Antarctic minke whales;

3) Develop recommendations for future SOWER cruises, both for the short- and long-term;

4) Continue to examine, and then, agree on reasons for differences between minke abundance estimates from CPII and CPIII (these may be Area specific differences).

To complete the work recommended to address these topics, there are funding implications (Table 1). The sub-committee agreed all the projects in Table 1 are important in order to complete these topics.

Table 1. Proposed projects that have funding implications needed to address priority items for next year.

| Work Plan Topic | Contact person | Project description | Agenda Item | Cost |
|---|---|---|---|---|
| 1 | IWC | SOWER 2007/08 cruise and planning meeting | 5.4 | £66,754 |
| 2 | Burt | Analysis of BT mode data from 2006/07 & import SOWER data into DESS | 5.3 | £10,000 |
| 3 | Palka (convenor) | SOWER abundance estimate workshop | 6.1 | £4,000 |
| 4 | Punt& Polacheck | Continue Antarctic minke whale catch-at-age analyses | 6.4 | £6,000 |
| 5 | Leaper | Recover data from crashed hard drive | 5.3 | £1,000 |
| | | TOTAL | | £87,754 |

## 9. ADOPTION OF REPORT

The report was adopted on 14 May 2006 at 2230 The sub-committee expressed its appreciation to Palka for chairing the meeting. The Chair expressed her thanks to participants for their cooperation and to the rapporteurs for their efforts.

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APPENDIX 1

Agenda

1. Election of chair
2. Appointment of rapporteurs
3. Adoption of agenda
4. Documents available
5. SOWER cruises
    5.1. Report from intersessional workshop on the 2006/07 cruise
    5.2. 2006/07 cruise report
    5.3. Review of experiments
    5.4. Recommendations for the 2007/08 season
    5.5. Recommendations for the long term
6. Southern Hemisphere minke whales
    6.1. Abundance and trends using IDCR/SOWER data
        6.1.1. Analyses of previous IDCR/SOWER cruises
        6.1.2. CP series
        6.1.3. Simulated data
        6.1.4. Additional variance
        6.1.5. Extrapolation to unsurveyed areas
        6.1.6. Conclusions
        6.1.7. Work plan
    6.2. Abundance and trends using JARPA data
    6.3. Abundance and trends using other datasets
    6.4. Catch-at-age analyses
        6.4.1. Report from intersessional working group
        6.4.2. Preliminary results
    6.5. Reasons for differences between minke abundance estimates from CPII and CPIII
        6.5.1. Report from intersessional email group on abundance estimates and sea ice extent changes
        6.5.2. Preliminary results
            6.5.2.1. Animals within the sea ice
            6.5.2.2. Other
        6.5.3. Work plan
    6.6. Dwarf minke whale
7. Consideration of proposals for further in-depth assessments
    7.1. North Pacific sei whales
    7.2. Sperm whales
    7.3. Comprehensive assessment procedures
8. Work plan and budget request
9. Adoption of Report

Appendix 2

REPORT OF THE SMALL GROUP FOR FUTURE SOWER PLANNING, INCLUDING THE 2007/08 CRUISE

Members: Bannister (Chairman), Baba (I), Branch, Bravington, Burt, Butterworth, Childerhouse, Chilvers, Cook, Donovan, Ensor (Rapporteur), Fujise, Gales, Gedamke, Hakamada, Hedley, Hughes, Kato, Kitakado, Leaper, Leaper, Okamura, Palka, Polacheck, Murase, Miyashita, Morishita, Nishiwaki, Ohsumi, Shimada and Yamakage (I). (I – interpreter)

1. Bannister welcomed the participants. Ensor acted as rapporteur.

2. Terms of Reference

The following term of reference had been agreed by the Sub-committee:

- to plan for a joint exercise in 2007-2008 between the SOWER Cruise and the 'within ice' minke whale aerial survey detailed in SC/59/IA2

3. ADOPTION OF AGENDA

The adopted agenda is shown below.

4. Aerial Survey

*4.1 Timing*
The timing of the aerial survey will be restricted by a combination of factors including the availability of the aircraft and transport of observers and equipment from Australia to the research base in Antarctica. Currently it is anticipated the aircraft will be available for two weeks from 1 January, 2008, but the precise logistics have yet to be finalized.

*4.2 Area*
The operational base for the aerial survey will be Casey Station (Australian Antarctic Station, longitude 110ºE). During the development phase of this programme by the Australian Antarctic Division, various other locations further west (including Bunger Hills and Davis Station) had been evaluated. They offer more options for aerial survey; they are geographically closer to more extensive areas of sea ice as well as to potentially higher densities of minke whales in the marginal ice zone (as determined from previous shipboard surveys). But there is no option to change the area of main operation from Casey Station as the decision has already been made for logistical reasons by the Australian Antarctic Division. While the aircraft have considerable endurance (8 hours) their activities are to be concentrated on the Casey Station area. Nevertheless, given the possibility of only limited sea ice in the vicinity of Casey Station, some flexibility in the aerial survey plans will be required.

5. SOWER CRUISE

*5.1 Availability of vessel.*
Kato announced that the Government of Japan will be able to offer the research vessel *Shonan Maru No.2*.

*5.2 Timing*
On the understanding that that the aircraft will be available during the first two weeks of January 2008, the SOWER vessel survey will be required to span that period.

*5.3 Area*
To coincide with the aerial survey the SOWER vessel research area will be centred on approximately the same longitude (110ºE).

*5.4 Length of cruise*
A cruise duration of 60 days (southern home port to southern home port) was indicated. With a 10 day each way transit from the closest country (Australia) this would give approximately 40 days available in the research area.

*5.5 Target species*
Target species and general order of priority would be as in previous cruises, i.e.

1. Antarctic minke and blue whales
2. fin whales
3. humpback whales
4. sei and right whales
5. sperm whales

5.5 Priority items for research, including biopsy, photo-id, telemetry, acoustics, special experiments
In addition to collaboration with the aircraft (see Item 6 below), it was recommended that biopsy sampling, photo-id and acoustics studies on the target species should be undertaken by the SOWER vessel as on recent cruises.

Telemetric methods to investigate the use of the pack ice habitat by minke whales were discussed as they would be particular relevant this year considering the collaborative research with the aerial survey. However, the group concluded that currently there were no reliable systems available for long-term attachment of transmitters to minke whales from the type of vessel used.

*5.6 Methodology*
A systematic sighting survey by the SOWER vessel was proposed using established standard protocols. Survey mode should include IO mode, however as an alternative to standard Closing mode it may be informative instead to conduct abeam closure procedures such as SS-III (or SS-II) as during SOWER 2006-2007. A final decision on survey design and research modes was deferred to the Planning meeting.

It was also noted that it could be desirable to undertake additional trials of the potential new survey method, BT-Option 2, as evaluated on the 2006-2007 cruise to increase the sample size Furthermore it was recommended that the 2006-2007 BT-Option 2 data be analyzed prior to the Tokyo Planning meeting prior to making a decision on this matter.

With respect to the continuing concerns related to SOWER distance and angle estimates, it was recommended that more data related to distance and angle measurements should be obtained on the forthcoming cruise using at least some components of the SCANS recording system. It was agreed that additional distance measurements using the video system attached to the 7x50 binoculars in the Top platform were required, as well as bearing measurements. It was noted that modification of the equipment would facilitate SCANS data recording on the SOWER vessel. This would have a financial implication, but as various options for modification were identified the funds required would depend on the upgrade option selected.

It was recommended that acoustic studies should also be undertaken. A supply of sonobuoys will be required.

*5.7 Participants, including Cruise Leader*
Four researchers will be required for the cruise including Cruise Leader.

*5.8 Planning meeting*
It was agreed that logistic details of the cruise would be decided at a Planning Meeting in Tokyo during four days in the last week of September 2007. Kato agreed to act as convenor and indicated that a venue at Tokyo University of Marine Sciences and Technology will be available.

Participants at the Planning Meeting should also include representatives from the aerial survey component.

*5.9 Home port and responsible persons*
Fremantle, Western Australia was selected as the home port and Bannister kindly offered to act as home port organiser.

## 6. Collaboration with the aircraft

*6.1 Collaborative research*
Collaborative research between the SOWER vessel and the aerial survey will be the priority research item for the cruise.

The overall strategy is as follows:

1. the aircraft will survey inside the ice to obtain a density estimate of minke whales there.
2. the aircraft will also survey outside the ice to obtain a density estimate of minke whales there.
3. The results of 1 and 2 will then be compared to provide information on the relative proportions of animals inside and outside the ice.
4. The SOWER vessel will obtain an abundance estimate of minke whales in an area outside the ice, i.e. within the southern stratum, to include the area surveyed by the aircraft.
5. Comparison of the results of 2 and 4 will permit 'calibration' of the aircraft operation against the vessel operation.
6. The vessel will also survey an area further north, i.e. in the northern stratum, possibly as far north as 60°S. Comparison between the results of that operation with the results of 4, combined with the calibration results of 5, will allow comparison between minke whale densities in the more extensive area, i.e. in the southern and northern strata combined, with those in the ice.

*6.2 Coordination with the aerial survey*
It was noted that several avenues of communication would be available for the ship and aircraft and the operational base for the aircraft (including email and telephone via satellite); coordination of the two components of the research program was not anticipated to be a problem. It was agreed that consideration should be given to the inclusion of a Japanese observer in the aerial survey team.

## 7. Relevant recommendations from the 2006-2007 cruise
The Group considered the recommendations from the 2006-2007 cruise particularly those with financial implication and/or those with a temporal element that required attention prior to the time of the Planning meeting. These included: purchase of a computer and software for acoustics; modification of acoustics receivers; re-supply of sonobuoys and re-supply of biopsy darts and ammunition.

## 8. Budget
A preliminary budget is presented below.

## 9. Contingency plans should the aerial survey not take place
In the case that the aerial survey does not take place, it was agreed in principle for the shipboard research to be conducted within the same region of the Antarctic (Area IV). In that event a systematic sighting survey for abundance estimation would be undertaken. Detailed plans would be developed during the Planning Meeting.

## 10. Other business

Attention was drawn to the fact that JARPA was also scheduled to operate in Area IV during the 2007-2008 season and there would be an overlap of the research areas. It was **agreed** that detailed coordination of the two programmes would be deferred to the Planning Meeting.

The group welcomed the information that it is the view of the Australian Government that the research be regarded as a collaborative survey effort between the Australian Government and the IWC. The resulting data would be available for incorporation into DESS and the normal data access conditions will apply.

PRELIMINARY CRUISE BUDGET (values in pounds sterling).

| Item | Grant | Travel | Insurance | Shipboard | Shore | Bank charge | Total |
|---|---|---|---|---|---|---|---|
| **Cruise** | | | | | | | |
| Cruise leader | 10310 | 1700 | 100 | 831 | 550 | 30 | 13521 |
| Scientist 1 | 6200 | 1700 | 100 | 831 | 550 | 30 | 9411 |
| Scientist 2 | 6200 | 1700 | 100 | 831 | 550 | 30 | 9411 |
| Japan | 6200 | 1700 | 100 | 831 | 550 | 30 | 9411 |
| Sub-total | | | | | | | 41754 |
| **EQUIPMENT/COMMUNICATIONS** | | | | | | | |
| Computer for acoustics | | | | | | | 1000 |
| Freight and DiFAR modifications to acoustics receivers | | | | | | | 1000 |
| SCANS equipment upgrade: GBP1750 to GBP5000 depending on degree of upgrade | | | | | | | 5000 |
| External hard drive (2) | | | | | | | 300 |
| Camera batteries (3), card reader (1) and storage cards (2x2GB) | | | | | | | 300 |
| Repairs/maintenance IWC camera | | | | | | | 200 |
| Repairs/maintenance Larsen guns | | | | | | | 200 |
| Sonobuoys (3 pallets=144) | Based on freight only | | | | | | 2000 |
| Biopsy<br>darts x50 @ 31 each<br>plugs x1000 @ 1.4 each<br>ammunition x 500 | | | | | | | 3000 |
| Communications | Inmarsat time for reception of ice edge data and communication with steering group | | | | | | 500 |
| **Planning Meeting**<br>Travel and subsistence 6 participants | 6x1500 | | | | | | 9000 |
| **Annual Meeting** | | | | | | | |
| Cruise leader<br>Travel and subsistence | | | | | | | 2500 |
| **Total** | | | | | | | **66754** |

## Agenda

1. Chairman's opening remarks; appointment of Rapporteur
2. Terms of Reference
3. ADOPTION OF AGENDA
4. AERIAL SURVEY
    *4.1 Timing*
    *4.2 Area*
5. SOWER CRUISE
    *5.1 Availability of vessel*
    *5.2 Timing*
    *5.3 Area*
    *5.4 Length of cruise*
    *5.5 Target species*
    *5.6 Priority items for research, including biopsy, photo-id, telemetry, acoustics, special experiments*
    *5.7 Methodology*
    *5.8 Coordination with aerial survey*
    *5.9 Participants, including Cruise Leader*
    *5.10 Planning meeting*
    *5.11 Home port and responsible persons*
6. Relevant recommendations from 2006-2007 cruise
7. Budget
8. Contingency plans if aerial survey does not take place
9. Other business

Appendix 3

# PROPOSAL FOR INTERSESSIONAL WORKSHOP ON SOWER ABUNDANCE ESTIMATES

## Proposal for intersessional workshop on SOWER abundance estimates

In the last couple of years, the Scientific Committee has been developing and testing new methods to estimate minke whale abundance in the Antarctic from SOWER/IDCR cruises. The new methods are needed because the assumptions of basic line transect methods are violated in the Antarctic minke whale data, and these violations lead to bias in absolute abundance and in trends. Although good progress has been made with the new methods, to the point where preliminary abundance estimates from one method were discussed by the Committee this year, there are still a number of important details (in particular concerning analysis of recent data from SOWER experiments, appropriate simulation tests, diagnostic checks including some of those used in evaluating abundance estimates of North Atlantic minke whales, and space/time extrapolation/interpolation) that need to be resolved before the Committee can agree on a set of abundance estimates with reasonable scientific confidence. Experience from Committee discussion in recent years– both in IA and in other subcommittees such as AWMP, RMP and BRG– has shown that it is impossible to sort such things out satisfactorily during the main Committee meeting or in intersessional email groups. The IA of Antarctic minke whales has already taken a lot longer than anticipated, and if the Committee is going to finish its IA of Antarctic minke whales soon, then an intersessional workshop will be necessary. After such a workshop (and some associated intersessional email), the IA subcommittee in 2008 should be able to quickly come to an agreement on best available estimates, leaving enough time during the 2008 meeting for discussion of interpretation.

## Terms of reference and draft agenda

TOR are required for the workshop, and for the intersessional email group which will precede and follow the workshop. These TOR, and the draft agenda for the workshop itself, would follow the list of tasks below in the obvious way.

Tasks before the workshop:

- Validation and analysis of recent SOWER experimental data [Hughes, Bravington]
- Select and implement further simulations (e.g. incorporating some or all of: bigger measurement errors, duplicate ID, unmodelled heterogeneity via measurement error in covariates, multi-year surveys, model selection, confirmation status) [Palka]
- Further discussion and specification of diagnostics [Skaug, Cooke, all]
- Discuss additional variance and interpolation/extrapolation techniques [Skaug, Kitakado]
- Prepare preliminary estimates for different methods so that diagnostics can be considered [Okamura, Cooke, Bravington]
- Circulate clear descriptions of the methods 2 weeks before the workshop [OCB]

## Tasks during the workshop

- Examine additional SOWER analyses
- Examine diagnostics of estimates
- Identify any final extra simulations
- Refine methods and clearly identify differences
- Prepare summary paper for IWC that compares and contrasts the methods

## Tasks after the workshop and before IWC 60

- Developers have the opportunity to refine final estimates
- Ensure final abundance estimates & diagnostics are circulated among workshop members in good time before IWC
- Subgroup could meet during first 2 days of IWC 60 to finally discuss numbers (not interpretation)

## Participants

Likely participants would be Kitakado, Okamura, Skaug, Cooke, Palka, Bravington, Polacheck. Pre-workshop email correspondence group would contain the former, plus Hughes, Hedley, Schweder. Steering committee would be Palka, Cooke, Okamura, Bravington. Palka would act as Chair.

## Timing/location

Probably Dec 2007, perhaps Jan 2008. Venue TBA, if possible aligned with other IWC meetings.

## Budget

Travel and subsistence for 3 invited participants, expected to amount to about GBP 4K.

## Appendix 4

### STATEMENTS REGARDING THE JARPA ESTIMATES OF ANTARCTIC MINKE WHALES ABUNDANCE AND TRENDS AND THE PROCESS USED TO REVIEW THESE ESTIMATES

Wade and Childerhouse presented Appendix 4A. to the sub-committee After a brief discussion it was evident there would other views, but due to a lack of time, the issues could not be fully discussed. These other views are documented in Appendices 4B-4D and were not discussed further.

## Appendix 4A

Wade and Childerhouse

Wade and Childerhouse described the discussion about JARPA abundance estimates as a philosophical debate about whether problems in experimental design and data collection can necessarily always be fixed by complex analysis. In their view, the change in design for the last three JARPA surveys, described in SC/59/IA19, and other issues, confounds interpretation of trends in abundance of any whale species from JARPA data. Further analyses of JARPA data can attempt to account for these temporal and spatial differences, but it was unclear whether complex analysis methods and modelling can satisfactorily correct for fundamental changes in the sampling design through time, and they would potentially increase the uncertainty of the estimates to levels at which they would be uninformative. They believe that priority should be given to addressing the considerable issues remaining regarding abundance estimation from IDCR/SOWER surveys rather than on incremental improvements to JARPA abundance estimates when fundamental issues exist about the changes in JARPA survey design. For example, data on trends in abundance in Area IV presented to the sub-committee appeared entirely driven by the last three surveys, which is particularly worrisome given the changes described in SC/59/IA19. One way forward would be to divide the JARPA abundance estimates into two separate indices of relative abundance – one using the first five surveys and another using the last three surveys, as this would solve the issue of the change in survey design between those two periods.

## Appendix 4B

Hatanaka and Hakamada

Hatanaka and Hakamada recalled that at the JARPA review meeting, it was recognized that considerable progress has been made in addressing the issues related to abundance and trends and that provided the recommendations made are followed, the Committee should soon be able to agree estimates (SC/59/Rep1). They noted that JARPA sighting surveys in Area IV/V were conducted mainly in January and February to cover the peak migration period of the minke whales and that survey efforts in March were a small portion of the total efforts. Because sighting data were collected mainly during January and February to estimate abundance in Area IV/V, the effect of movement of ice edge on abundance could be smaller than described in SC/59/IA19. Figures 1 and 2 shown below are plots of mid-days of the survey period and log of abundance for the southern strata as estimated using SSV. These figures suggest no substantial change in abundance by month. Therefore, they do not agree with the view that the last three JARPA surveys confound interpretation of trends in abundance of whale species from JARPA data. Accordingly, they do not support the idea of dividing the JARPA abundance estimates into two separate indices. They noted that modelling work to account for changes in JARPA survey design was underway and judgment of whether or not these can improve estimates of abundance and should await results.

Regarding a philosophical debate about whether problems in experimental design and data collection can necessarily be fixed by further complex analysis, Hatanaka and Hakamada expressed the view that it was precisely for this reason that abundance estimates between CP II and CP III should not be compared given not only the changes in experimental design but also the changes in physical conditions. Abundance estimation and trend studies based on JARPA data would rather help in understanding the results from CP II/CP III studies by providing an independent perspective to the issue.

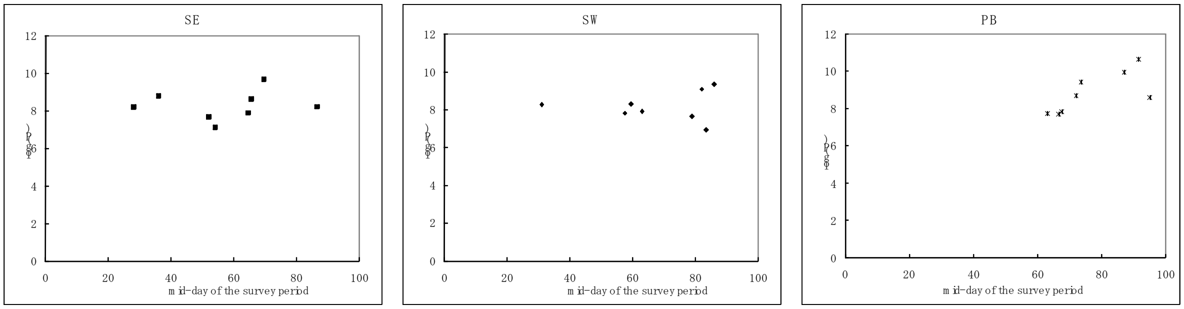


Fig. 1. Plot of mid-day of the survey period and log of abundance estimate for SE, SW and PB in Area IV.

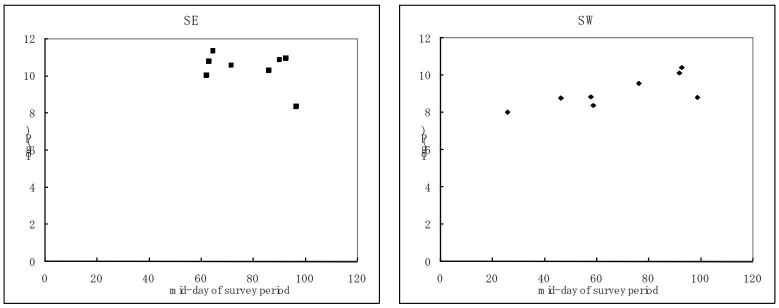


Fig. 2. Plot of mid-day of the survey period and log of abundance estimate for SE and SW stratum in Area V.

## Appendix 4C

### Butterworth

In response to Appendix 4A, Butterworth commented that **all** abundance surveys (not only those of JARPA) considered by the Scientific Committee failed to meet ideal design criteria, so that further analyses/assumptions were always needed to arrive at abundance estimates. The Committee had in the past accepted estimates requiring additional (and often simple) assumptions or analyses. An example of such an assumption is the proposal at the JARPA review workshop for extrapolation procedures for portions of JARPA survey strata with zero coverage, which had been recommended for implementation by the workshop (SC/59/REP1, pg 9). Many of the issues raised in SC/59/IA19 apply to the IDCR/SOWER surveys as well as to the JARPA surveys, and differences are more of degree and judgment (which inevitably varies between individuals) than of principle or philosophy. While abundance estimation from the IDCR/SOWER surveys should receive higher priority for further consideration, this was no reason to exclude further consideration of the JARPA surveys; indeed when viewed in broad terms over the last 20 years, the time spent in the Committee in considering JARPA surveys is a very small fraction of that expended on IDCR/SOWER surveys. The “design” issue singled out for reservation concerning potential acceptance of JARPA survey estimates is one that has been well known for many years, so that it seems strange that only now is it argued as categorically precluding their acceptance as comparable over time, seemingly under any circumstances. If this is the case, why was a change in design to avoid this not advocated on one of the numerous earlier opportunities provided by presentation of JARPA results to the Committee? Furthermore why is this particular “problem” insurmountable when analyses presented addressing it, as are detailed above, point to an absence of any detectable effect for Area IV? The sub-committee should perhaps consider recommending alternation of the order of strata coverage in future years of these surveys, which would provide a further basis to check whether the design feature in question does actually lead to differences of import.

## Appendix 4D

### Polacheck and Bravington

Polacheck and Bravington stated that, in their opinion, there are serious issues of comparability between JARPA surveys in different years, which currently confound attempts to interpret the abundance data. If a reliable time series of relative abundance could be obtained from the JARPA data, it would be of great value to the Committee. However, it is not clear whether the comparability issues can be resolved by data analysis. The appropriate priority to give to this difficult and perhaps impossible task is a matter for the Scientific Committee, but not (in P and B’s opinion) for IPs.

IA Appendix from Bravington: to be corroborated by Polacheck after the meeting.

## Appendix 5

### REPORT OF THE INTERSESSIONAL WORKING GROUP ON VPA ANALYSIS RELATED TO SOUTHERN HEMISPHERE MINKE WHALES - 2007

Members: Polacheck (Chair), Butterworth, Cooke, Leaper, Mori and Punt

The 2002 IWC Scientific Committee Meeting established an intersessional working group to address concerns about the catch at age analyses for Southern Hemisphere minke whales in Areas IV and V presented at that meeting. Subsequent meetings of the Committee have maintained this intersessional working group. During the first two years, the primary focus of the working group was on obtaining access to the data required for the catch-at-age analyses. The working group obtained access to most of the data shortly before the 2004 SC Meeting. Since 2004 substantial progress has been made in the catch at age analyses. In particular, an integrated statistical catch-at-age model was developed following on from conclusion at the 2002 meeting that this was the most appropriate modelling framework for addressing these issues. Funding has been provided by the IWC to Punt and Polacheck for this work. In addition, Mori and Butterworth have continued to make substantial progress in the application of the ADAPT-VPA methodology to the analyses of the minke whale data. This work was also assisted with funds provided by the IWC. The SC has concluded that having results from both modelling approach is valuable for providing comparisons of the sensitivity of the results to differences in methodology.

Comparisons of length-at-age data in the commercial and JARPA Antarctic minke whale catches presented at the 2005 and 2006 Scientific Committee Meeting suggested apparent inconsistency in these data (Punt and Polacheck 2005, Polacheck and Punt 2006). Aging and/or length measurement errors were considered as one possible hypotheses contributing to this apparent inconsistency and there are questions with respect to the age and length that need to be resolved. The 2006 IWC Scientific Committee meeting noted that the catch-at-age data are the fundamental input into the population modelling of southern hemisphere minke whale, and the Working Group on Population Modelling (IWC 2007) identified the following tasks as being of highest priority for work during the intersessional period between the 2006 and 2007 meetings:

(1) Develop appropriate error models for the catch-at-age data to be used in the population modelling to take into account potential errors and biases in the aging and length data and how these may have been changed overtime;
(2) Examine the data from the 1984 ageing workshop to provide insights for the development of error models for the catch-at-age data - particularly with respect to potential biases arising from unreadability of ear plugs being related to age;
(3) Develop a set of questions with respect to minke whale aging that could be distributed to those who have had experience in this area to provide a better understanding of the problems involved and potential errors in the catch-at-age data.
(4) Checking the commercial catch data for possible coding errors and updating these data if necessary if necessary.

The Intersessional Working Group developed and circulated a questionnaire relative to Task 3. The results from this exercised are summarized in Polacheck (2007) and the responses confirmed that there are still outstanding questions concerning the age reading of earplugs from Southern Hemisphere minke whales. The Working Group was unable to make any progress with respect to Task 2 because of mis-understandings and communication problems prevented access to the data from the 1984 workshop. These problems have been resolved and it is anticipated that the data will be made available shortly after SC59. Given the lack of access to these data and the recommendations from the JARPA review that repeat ageing of a subset of the data throughout the period of commercial and JARPA data to check for possible learning trends, it was considered that it would not be productive to attempt developing error models for the catch-at-age data until the data from the 1984 workshop could be examined and until results from the comparative reading work were available. As such no progress was made with respect to Task 1. Progress with respect to task 4 is reported in SC/59/O8,

In addition the highest priority task listed above, last years Scientific Committee considered that it was a high priority to ensure further work was undertaken on the population modelling and identified a number of high priority areas for further work. To help achieve this, the need for access to updated JARPA data had been identified at last year's meeting. However, because of mis-understandings and communication problems updated data were not received, but this is not anticipated o be a problem in the future.

Nevertheless, substantial work was competed in the intersessional period in relationship to some of the high priority modelling tasks identified at last year's meeting (Some of this work was undertaken independently of the intersessional working group). Results of this work are presented in Mori *et al.* (2007), Butterworth and Mori (2007) and Punt and Polacheck (2007)[1]. Modelling work undertaken in these papers addresses the following high priority areas for work identified at last year's meeting:

1) Investigate sensitivity to the use of reduced portions or alternate versions of the commercial catch-at-length/age data.
2) Determine a revised "reference case" analysis reflecting what has been learned with respect to the most likely assumptions about selectivity, etc.
3) Examine the sensitivity to alternative specification for the vulnerability/selectivity functions both in length and age based context (the former only relevant to the statistical catch-at-age approach).
4) Develop methods to appropriately quantify the statistical uncertainty in the trend and other estimates derived from the population models.
5) Examine potential model simplification (e.g. reduced parameterization);
6) Consider alternative density dependent relationships and ensure that the implicit or explicit estimated reproductive outputs from the models are plausible;
7) Examine the sensitivity to time changes in maturity at age and data for supporting such changes;
8) For the ADAPT VPA approach develop sex-specific model structure;
9) For the ADAPT VPA approach, include the estimation of the stock recruitment relationship within the model.

The Working Group helped to facilitate this work through e-mail discussion. The extent to which additional work with respect to these is required will need to be evaluated by the Scientific Committee.

---

[1] The analyses in Mori *et al* (2007) are based on updated JARPA data available to Mori as a member of the Institute of Cetacean Research in Japan.

In addition a set of minimum common output statistics to be used when reporting results from catch at age models for Southern Hemisphere minke whales was developed by Butterworth, Mori, Punt and Polacheck and then reviewed by the Intersessional Working Group on VPA Analysis (Table 1).

Of the high priority task for model work identified at last year meeting, no progress was made on the following:

1) Implement the error models to be developed for the catch-at-age data within the population models and assess their impact on the estimates derived from these model;

The lack of progress on the first of this stems from the lack of any progress on the development of error model for the catch at age data (see above).

### References

Butterworth, D.S. and M. Mori. 2007. On the compatibility of results from ADAPT VPA and transition-phase-based trends in age-at-maturity for the I stock of Antarctic minke whales. Document SC/59/IA22 presented to the IWC Scientific Committee, June 2007. (unpublished).

IWC. 2007. Report of the Working Group on Population Modelling. Appendix 4 to the Report of the Sub-committee on In-depth Assessment (IA). *J. Cetacean. Res. Manage.* 9(Suppl.): 00–00.

Mori, M., D.S. Butterworth and T. Kitakado. 2007. Further Progress on the application of ADAPT-VPA to Antarctic minke whales. Document SC/59/IA3 presented to the IWC Scientific Committee, June 2007. (unpublished).

Polacheck, T. and A.E. Punt. 2006. Minke whale growth models for use in statistical catch-at-age models. Document SC/58/IA3 presented to the IWC Scientific Committee, June 2006. (unpublished). 36pp.

Polacheck, T. 2007. Summary of responses to a length-measurement and age-reading questionnaire on southern hemisphere minke whales. Document SC/59/IA18 presented to the IWC Scientific Committee, June 2007. (unpublished). 8pp

Punt, A.E. and T. Polacheck. 2005. Application of statistical catch-at-age analysis for Southern Hemisphere minke whales in Antarctic Areas IV and V. Document SC/57/IA9 presented to the IWC Scientific Committee, June 2005. (unpublished). 71pp.

Punt, A.E. and T. Polacheck. 2007. Further Development of Statistical Catch-at-age Models for Southern Hemisphere Minke Whales. Document SC/59/IA4 presented to the IWC Scientific Committee, June 2007. (unpublished). 32pp.

Table 1: Suggested set of minimum common output statistics to be used when reporting results from catch at age models for Southern Hemisphere minke whales

(a) Statistics

| |
|---|
| $b_{rec,1945\text{-}68}$ - slope of the linear regression of the estimates of the logarithms of the numbers of recruits (age 1 animals) on time (1945-68). |
| $b_{rec,1968\text{-}88}$ - slope of the linear regression of the estimates of the logarithms of the numbers of recruits on time (1968-88). |
| $b_{rec,1988\text{-}End}$ - slope of the linear regression of the estimates of the logarithms of the numbers of recruits on time (1988-last year). |
| $N_{tot,1945\text{-}68}$ - slope of the linear regression of the estimates of the logarithms of the numbers of 1+ animals on time (1945-68). |
| $N_{tot,1968\text{-}88}$ - slope of the linear regression of the estimates of the logarithms of the numbers of 1+ animals on time (1968-88). |
| $N_{tot,1988\text{-}Endr}$ - slope of the linear regression of the estimates of the logarithms of the numbers of 1+ animals on time (1988-last year). |
| $N_{End\text{-}5,1}/N_{1968,1}$ – Ratio of the number of recruits in 1999 to that in 1968. |
| $K_{1930}$ – Carrying capacity in 1930. |
| $K_{2000}/K_{1960}$ – ratio of $K$ in 2000 to that in 1960. |
| $K_{1960}/K_{1930}$ – ratio of $K$ in 1960 to that in 1930. |
| Natural mortality (ages 0-3, 10-30, 35+) |
| Average proportions in each management area |
| Survey $q$ for JARPA. |
| MSYR (1+) |

(b) Plots

| |
|---|
| Total (1+) population size versus year (by stock and by area) |
| Age 1 animals (recruits) versus time |
| Carrying capacity versus year (*) |
| Natural mortality versus age (*) |
| Number of females beyond the age-at-first parturition (*) |
| Number of calves as a fraction of the number of females beyond the age-at-first parturition (*) |
| Selectivity-at-age (*) |
| Selectivity-at-length (*) |
| Brody growth coefficient versus year (*) |

* Final reference runs only

## Appendix 6

## SUGGESTIONS FOR A WAY FORWARD TO FURTHER EVALUATE AGEING ERROR FOR SOUTHERN HEMISPHERE MINKE WHALES

DONOVAN, BUTTERWORTH, PASTENE, PUNT AND MORISHITA

Paper SC/59/O8 provides a very helpful perspective and suggestions to help clarify the use of Antarctic minke whale age data in the commercial and research permit periods. On the basis of the paper, some areas for further work suggest themselves and these are outlined below. We recognise that these involve, in some cases, quite substantial additional work but believe that this will assist considerably in addressing the issues raised *inter alia* at the JARPA review meeting as well as past IA sub-committee meetings and allow the valuable analyses involving both commercial and scientific permit data to be undertaken.

The second experiment is designed to confirm the proposal in SC/59/O8 to limit analyses to using only data for animals aged 6 and over.

### EXPERIMENT 1. QUANTIFYING AGE READING ERROR

#### (a) Left/right earplugs (same animals) two Japanese readers.

*Experimental procedure.*
Randomly select 250 animals from the total JARPA catch (not pre-screened for readability) for which both the left and right earplugs have been collected. Each earplug needs to be read by readers 1 and 2 in random order and without reference to biological information. After all of the earplugs have been read, this should be repeated twice. The three readings are recorded as well as what would be recorded as the best reading following the present reading protocol. All information normally recorded about the earplug (e.g. broken, irregular layers, neonatal core missing etc) should be recorded for each blind reading.

*Data analysis*
The aim is to estimate the distribution of estimated age (mean and variance) as a function of true age, reader and examine other possible covariates (e.g. length of animal, sex etc). Software already exists that has been used to analyse similar data for fish otoliths. Kitakado is familiar with such analyses and would be an excellent person to do the work.

#### (b) Left earplug, readers from two schools (Japan, plus we propose Christina Lockyer or Peter Best)

*Experimental procedure (essentially as above)*
The same animals as in the above experiment are used and the readings from the above experiment for the Japanese readers can be used. Thus the only new reading that needs to be done is by Lockyer or Best. She should read the left plugs in random order and without reference to biological information. After all of the earplugs have been read once, this should be repeated twice. Note: if she deems the left earplug is unreadable for any animal, she should read the right earplug following the usual protocol. All readings or attempted readings will be recorded. The three readings are recorded as well as what would be recorded as the best reading following the present reading protocol. All information normally recorded about the earplug (e.g. broken, irregular layers, neonatal core missing etc) should be recorded for each blind reading.

*Data analysis*
The aim is to estimate the distribution of estimated age (mean and variance) as a function of true age, reading school and examine other possible covariates (e.g. length of animal, sex etc). As above, software already exists that has been used to analyse similar data for fish otoliths and Kitakado is familiar with such analyses and would be an excellent person to do the work. The results of this experiment can be integrated with a similar analysis of the readings from the 1983 ageing workshop.

### EXPERIMENT 2. CONFIRMING THE PROPOSAL TO EXCLUDE ANIMALS 5 AND YOUNGER FROM VPA ANALYSES

*Experimental procedure*
This requires no new age readings. For all animals if the comments are already coded electronically (or a suitable subset[2] if the information is only recorded on paper) construct an Excel spreadsheet of the comments recorded when the plug was read (e.g. broken, irregular layers, neonatal core missing etc) e.g.

| Identifier | Date | Age | Sex | Length | Reader | Testes weight | Comments on state of earplug |
|---|---|---|---|---|---|---|---|

*Data analysis*
The objective is to determine if there is anything inherent in the state of the earplug that allows one to predict whether a particular age estimate is biologically unreasonable using for example a GLM. The results of the GLM could also be used to predict/identify animals for which the age estimate is in error but would not be evident from the length of the animal.

[2] including those for which the age-estimates are ‘acceptable’ and ‘biologically unlike’, but with a focus on the latter

Appendix 7

WORK PLAN FOR THE SEA ICE INTERSESSIONAL WORKING GROUP

Members: Shimada (convenor), Branch, Bravington, Burt, Hedley, Kitakado, Murase, Nishiwaki, Okamura, Palka

The small group discussed future abundance estimates which could be compared with changes in sea ice extent. The small group agreed that it was a lower priority to produce further refinements of estimates using the standard method, since this method had been shown to be negatively biased by the simulations. Instead, highest priority would be accorded to developing abundance estimates using the newer methods (by Okamura & Kitakado, by Bravington and by Cooke) by 10° longitudinal slice, or by 30° if the 10°-slice estimates would be computationally difficult to obtain.
The small group agreed that using the actual survey northern boundaries in CPII and in CPIII for abundance estimates was inappropriate since most CPII surveys left an unsurveyed region between 60°S and the northern boundary. Instead, two alternative methods were advanced (Figs 1-2):

1. The Common Northern Boundary method. In this method, the northernmost boundary of the CPII surveys would also be used for the CPIII surveys. Any sightings or effort recorded in CPIII north of this Common Northern Boundary would be excluded from the analyses.

2. The Fixed Distance from the Ice Edge method. A fixed distance (or set of distances) would be chosen from the ice edge (suggestions included 60 n.miles and 120 n.miles), and the analysis would be based only on the sightings and effort recorded within this distance of the southern ice survey boundary. This would be relatively easy to do since the standard dataset developed for analysis included the distance from the ice edge to each sighting, to the start of each survey leg, and to the end of each survey leg.

The small group also suggested that results should be presented as ratios of CPIII:CPII abundance estimates (or as densities) since the purpose was to compare these particular estimates with the changes in the ice extent, not to produce new abundance estimates. All analysts were encouraged to present results in this manner at the next SC meeting.

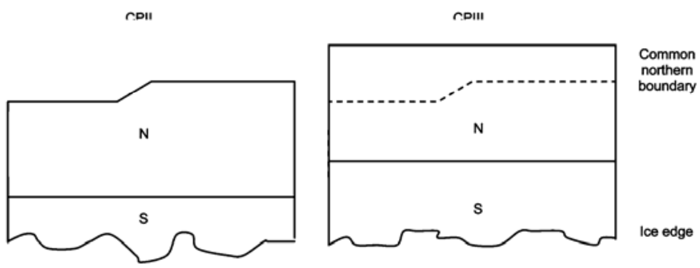


**Figure 1**. Example of the Common Northern Boundary method, showing sample north (N) and south (S) strata in CPII and CPIII. Sightings and effort in CPIII between the dashed line and 60°S would be excluded from the analyses.

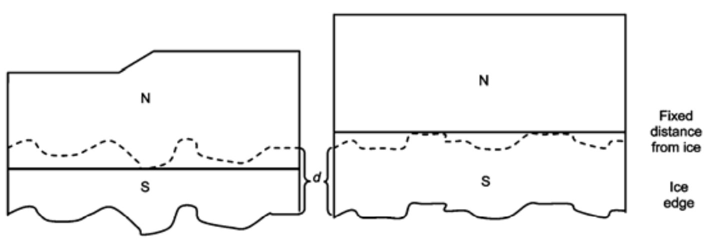


**Figure 2**. Example of the Fixed Distance from the Ice Edge method. Sightings and search effort in both CPII and CPIII that were further than a distance *d* from the respective ice edges would be omitted from the analyses.

Appendix 8

## PREPARATION FOR A COMPREHENSIVE ASSESSMENT OF NORTH PACIFIC SEI WHALES

Cooke, Baker, Butterworth, Kato, Pastene, Walløe and Brownell

### Previous assessment

The last assessment of North Pacific sei whales was performed by Tillman (1977), and seems to have been accepted by the Scientific Committee in 1974 (Gambell 1977). The exploitable stock (≥40 ft) is estimated to have declined from 42,000 in 1963 to 8,600 in 1974, during a period of intensive pelagic whaling.

The assessment was based on a combination of the following data:

- JSV sightings 1965-73 (Wada 1975)
- Japanese pelagic catch and tonnage-corrected effort in Zone N 1965-74, from catch and effort data on NP1 and NP2 forms (now held by IWC)
- Length data on NP3 forms (now held by IWC), converted to age distributions using age-length keys constructed from unpublished age-length data supplied by Dr H. Omura and Dr S. Ohsumi.

### Stock structure

Masaki (1977) hypothesised three sei whale stocks in the North Pacific with boundaries at 155°W and 175°W, although the evidence was relatively weak by modern standards. Kanda *et al.* (2006) found no evidence of spatial heterogeneity in nucleotypes of sei whales taken under JARPN II in 2002 and 2003, but all the whales were taken between 145°-170°E, which is well within the boundaries of Masaki's proposed western stock.

SWFSC, La Jolla, holds samples from 20 North Pacific sei whales: 8 from Hawaii, 1 each from Oregon and Washington, and 10 from elsewhere in the North Pacific, in addition to some samples from the Southern Hemisphere. mtDNA sequences from the Hawaiian samples were used in a phylogenetic analysis by Baker *et al.* (2004), together with sequences from 32 market samples representing at least 20 individuals.

Old tissue samples from Canadian, US, Japanese and Russian commercial whaling exist, and DNA may be extractable from some of them, depending how they have been preserved.

*Recommendation*:

Inventories should be compiled of:

(i) mtDNA sequences that have been obtained from NP sei whales to date

(ii) both recent and old potentially useable tissue samples from all parts of the North Pacific

At this stage, it is not known whether there is any population structure among North Pacific sei whales, and there is insufficient information to formulate stock structure hypotheses, apart from the null hypothesis of panmixis.

Inclusion of sequences from Southern Hemisphere sei whales in phylogenetic analyses may also contribute to an understanding North Pacific stock structure, especially if it emerges that North Pacific sei whales do not group into a single clade.

### Catch history

The IWC catch data base contains sei whale catches in the North Pacific during 1904-75, but some of these were Bryde's whales. A division of historical sei catches in the North Pacific into sei and Bryde's whales has been conducted by the Scientific Committee in the context of the Bryde's whale RMP Implementation (IWC, 2007).

USSR catch data for sei whales has been falsified, especially in the period 1966-71 (Doroshenko, 2000). The sei whale catch in these years was exaggerated, to hide the catch of protected species.

From 1970 onwards, sei whale catches in the North Pacific were limited by a combined sei/Bryde's catch limit, which was reduced progressively from 4,924 in 1970 to 2,000 in 1975. From 1976, sei whales were protected, and there was a specific Bryde's whale limit. There may have provided some incentive to underreport, but international observers were present on factory ships from 1972 onwards, at least during the official whaling season.

*Recommendations:*

(i) the same division into sei/Bryde's that has been used to construct North Pacific Bryde's whale catch series be used to construct sei whale catch series

(ii) the corrected USSR data be entered unto the IWC catch database, if this has not already been done.

### Data on abundance and trends

| | |
|---|---|
| 1965-75 | commercial Japanese Scouting Vessel (JSV) attached to pelagic whaling fleets, daily counts and effort only (Wada 1975-77) |
| 1976-82 | chartered JSV, collecting standard line-transect data (Wada 1978-81; Ohsumi and Yamamura 1982; Prog. Rep. Japan 1982-84). |
| 1983-present | dedicated sightings surveys (summer) (Prog. Rep. Japan 1985-present) |
| 1994-1999 | JARPN surveys (Fujise *et al.* 1995-97; Zenitani *et al.* 1999). |
| 2000-present | JARPN II surveys (Fujise *et al.* 2001-03; Tamura *et al.* 2004-06). |

Preliminary analyses of Japanese sighting data with respect to sei whales have been reported by Miyashita *et al.* (2002) and Hakamada *et al.* (2004).

Recent sightings surveys suggest that sei whales are scarce in the waters of the US west coast (excluding Alaska) and Hawaii in summer (Barlow, 2003a,b).

Some of the dedicated sightings surveys and some of the JARPN surveys encountered few or no sei whales, because the survey effort was too far south. This is relevant negative information, which is useful for bounding the summer range of sei whales. Likewise, the absence of sei whale sightings in the Okhotsk Sea and the Sea of Japan represents relevant negative information.

Most winter surveys in the North Pacific to date have found few or no sei whales. The winter distribution of sei whales is poorly known, but is perhaps not a high priority for a first assessment.

A tendency for inter-annual, and possibly also long-term, shifts in sei whale distribution pose an especial challenge for the analysis of data collected over many years, with limited coverage in individual years.

*Recommendations:*
(i) The available sightings data be plotted and inspected visually to enable selection of:

(a) a span of summer months for sightings data to be used for an assessment

(b) the geographical range over which sei whale density is non-negligible in these months (i.e. areas outside the main summer distribution could be excluded, e.g. waters south of 35°N, Okhotsk Sea, etc.).

(ii) Consideration be given to conducting a spatio-temporal modelling analysis of the full set of sei whale sightings data. This may require identification of the respective data holders and preparation of a proposal for submission to the Data Availability Group.

### Biological parameters
Age and reproductive data from Japanese commercial whaling have been analysed by Doi and Ohsumi (1970) and Masaki (1976). Age at sexual maturity was estimated at 9-10, and mortality rates at 0.06-0.08 for males and 0.10-0.12 for females. From commercial whaling samples from the eastern North Pacific (California), Rice (1977) estimated a mean age at maturity of 10 years for both sexes.

Modern age and reproductive samples (from ~400 sei whales) have been collected under JARPN II during 2002-06, and are awaiting analysis with respect to biological parameters.

*Recommendation:*
Historical age and reproductive data from commercial whaling in the eastern and western North Pacific should be recompiled and presented, so that comparisons with results from modern catches can be made when the latter are available.

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Appendix 9

# PROGRESS TOWARD AN IN-DEPTH ASSESSMENT OF SPERM WHALES

Tim D Smith


## ABSTRACT

Progress toward developing information essential for the conduct of an In-Depth Assessment of sperm whales is reviewed. Progress has been made on population structure, historical catches, and survey methods. In addition, substantial information is being developed on abundance and distribution in several studies and on the potential effects of anthropogenic noise on sperm whales. Progress has been slower than was hoped, and the timing of such an assessment requires further discussion.


## INTRODUCTION

There is a need to better understand the status of sperm whale populations both world-wide and regionally. The IUCN is interested in completing an assessment of status on a worldwide basis (B. Taylor personal communication) and the US has revised a draft recovery plan for sperm whales (originally drafted by R. Reeves) and will be circulating it soon for public comment (J. Barlow, personal communication). Although the IUCN classification as vulnerable and the US classification as endangered were based on global considerations, the need for considering the status on regional levels consistent with population structure has been discussed (B. Taylor and R. Reeves, personal communication).

The Scientific Committee agreed in 2003 (IWC 2003, p49, IWC 2004, section 10.6.1) to pursue the possibility of conducting an In-Depth Assessment of sperm whales. In support of this interest, a workshop to review assessment-related research on sperm whales was held in Woods Hole, Massachusetts, USA, 1-3 March 2005. The results of that workshop were reviewed in 2005 (IWC 2006), based on a summary of the report of the workshop (SC/57/IA8). The report of the workshop was finalized as Smith *et al.* (2005). Workshop participants identified many topics where additional research is needed (Table 1), with the following five having highest priority (SC/57/IA8):

- Developing provisional hypotheses about population structure;
- Obtaining information on female survival rates;
- Improving historical catch data in several ways, including spatial resolution to match hypothesized population structure; further exploring the effects of differential exploitation by sex;
- Improving methods to correct abundance survey data to account for bias;
- Refining population modelling approaches.

Subsequent to that workshop there has been progress on developing needed information. That progress is described below, first relative to these five priority topics and second relative to other topics.

## PROGRESS

### Developing provisional hypotheses about population structure

Mesnick, Taylor and Morin have continued the analysis of tissue samples to determine population structure in the North Pacific (S. Mesnick, personal communication). Morin *et al.* (2006) report on a new method of sex determination using genetic markers and Morin *et al.* (2007) report on the characterization of 18 new single nucleotide polymorphism (SNP) markers for sperm whales; these provide a necessary addition to the genetic tools employed for understanding population structure on a global scale. Rendell *et al.* (in preparation) will provide a direct comparison of genetic and acoustic markers for determining stock structure in the Pacific.

A global compilation of all known mitochondrial DNA haplotypes (n=28) has been posted on GenBank (S. Mesnick, personal communication).

Plans have been developed for a study of population genetics using old tooth samples, as recommended by the workshop (Smith *et al*, 2005), and funding continues to be sought.

### Obtaining information on female survival rates

No progress. It should be noted, however, that Marcoux *et al.* (2006) identified a distinctive vocalization (coda) that was produced only by females in breeding areas.

### Improving historical catch data

No progress has been made on resolving uncertainties about 20th century sperm whale catch data in the North Pacific. No additional data are known for the Soviet pelagic fishery, so no further advance is expected (R. Brownell, personal communication).

Aguilar and Borrell (2007) reported on a study of logbooks of 19$^{th}$ century whaling voyages on the Straits of Gibraltar Ground, including observations on the effects of the prevailing winds on the seasonal distribution of whaling effort in this area. They estimated minimum removals from 1862-1889 at 237.

Using 19$^{th}$ and 20$^{th}$ century estimates of removals and encounter rates, Smith *et al.* (in review) identified several possible causes of the apparent inconsistency between catch data and the encounter rate data that has been noted in previous assessments. They were able to determine that the inconsistency was restricted primarily to the North Pacific, to rule out some explanations and to shed some light on others. They suggest that further resolution may be possible based on additional logbook studies and also suggest that the inconsistency may be due to one or more breeding populations primarily distributed north of 40º N having been subject to whaling primarily in the 20th century.

Bannister *et al.* (in review) produced a critical evaluation and synthesis of information on 19th century whaling grounds for sperm whales.

### Improving methods to correct abundance survey data to account for bias

J. Barlow (personal communication) reported further progress in estimating g(0) for sperm whales; results will be forthcoming. Because of sexual segregation by latitude and differences in schooling and diving behaviour by sex, there is a need for regional estimates of this parameter (B. Taylor, personal communication, T. Kasuya, personal communication).

### Refining population modelling approaches

No progress.

### Abundance and Distribution

Several new estimates of regional abundance and density have appeared (Barlow 2006, Gero *et al.* 2006, Lewis *et al.* 2007). The areas include the eastern Caribbean, the Ionian Sea and Straits of Sicily, and the Hawaiian Island region. Barlow (2006) estimated the density of sperm whales in a large area around the Hawaiian Islands at roughly 3 times that of estimates for the eastern tropical Pacific and California offshore regions made with comparable methods.

Additional field studies related to abundance and distribution are planned or continuing in 2007, including the eastern Mediterranean (IFAW, personal communication), the Norway and Barents Seas (N. Øien, personal communication), the North Atlantic (D. Pike, personal communication), the Sargasso Sea (H. Whitehead, personal communication), the western North Pacific (JARPN and JARPN II) and the Antarctic Areas III-VI (IDCR and SOWER).

The 2007 Trans North Atlantic Sightings Survey (TNASS), coordinated by the Scientific Committee of NAMMCO, will cover the shelf waters of Eastern Canada, Davis Strait, West Greenland and inshore and offshore waters off Iceland and the Faroe Islands. Both visual and acoustic methods will be used. Together with the bordering CODA and Norwegian surveys, a large portion of the North Atlantic will be surveyed systematically in 2007 (D. Pike, personal communication).

Plans are being developed for a proposal for a follow–up survey on the former whaling grounds off Albany, Western Australia (J. Bannister, personal communication).

Preliminary analyses of Japanese sightings data based on Japan Progress Reports has provided some insight into rates of increase, which may provide insight into movement or immigration (T. Kasuya, personal communication).

Photo-identification studies are continuing in connection with whale watching operations from Andenes, North Norway, to the Bleik Canyon area (N. Øien, personal communication). Studies are continuing (for four years thus far) in the western Mediterranean around the Balearic Islands. Studies include habitat use and vocal dialects, as well as developing a photo-identification catalogue. There are 47 known individuals but too few resightings to allow calculating confidence limits for population size estimates (L. Rendell, personal communication).

The Pelagos Cetacean Research Institute continued its long-term (10 years thus far) research program on sperm whales in the Hellenic Trench, Eastern Mediterranean. To date, 150 sperm whales have been photo-identified, consisting of mature males and individuals belonging to stable, apparently resident social units. Mark-recapture analysis suggests a total abundance of around 200 animals in that region. Photo-identification studies are planned in parallel with the 2007 acoustic survey by IFAW, with a goal of producing a mark-recapture estimate of abundance for the entire Eastern Mediterranean.

Kaschner *et al.* (2006) developed a method of determining habitat suitability for marine mammals that may prove useful in extrapolating information on distribution and abundance, along the lines used by Whitehead (2002).

### Life History

Watwood *et al.* (2006) reported on foraging behaviour from acoustic studies in the Gulf of Mexico, off the northeast USA, and in the Ligurian Sea. They found differences in average depth of dive, but more similarities than differences in foraging among the three regions. MacLeod *et al.* (2006) compared prey selection and specialization among toothed whales more generally. P. Madsen (personal communication) is preparing information on male sperm whale foraging off northern Norway.

Mendes *et al.* (2007) used stable isotope ratios from sperm whale teeth to describe ontogenetic movements and trophic ecology. From the prey side, Ruiz-Cooley *et al.* (2006) used stable isotopes to estimate the trophic position of jumbo squid, a known prey of sperm whales.

JARPN II will continue to collect and analyze stomach contents of sperm whales from the western North Pacific, with the goal to elucidate the role of the sperm whale in the marine ecosystem and construct an ecosystem model (S. Ohsumi, personal communication).

### Human Interactions

The US Minerals Management Service's Sperm Whale Seismic Study (SWSS) in the Gulf of Mexico completed its final field season in the summer of 2005. A final report is expected this year. Results from this study and other related studies were reviewed by the Scientific Committee in a previous discussion on the potential effects of acoustic activity on sperm whales (IWC 2007, section 12.1). Recently published papers related to this issue include DeRuiter *et al.* (2006), Laplanche *et al.* (2006), Madsen *et al.* (2006), Nosal and Frazer (2006), Thode *et al.* (2006), and Tiemann *et al.* (2006a, 2006b). New acoustic methods have been developed that may have implications for other field research, especially related to foraging and abundance surveys.

J. Straley (personal communication) continued collection of distribution and abundance data off Sitka, Alaska, in collaboration with A. Thode. They have determined that sperm whales in that area are using fishing vessel engine cycling as a cue in their predation on fish caught on longline gear. Mesnick and Warner have continued compilation of accounts of depredation globally and have found that sperm whale depredation of demersal longlines has been recorded in waters of the North Pacific, North Atlantic and Southern Oceans, and that reduction of catch varies widely but includes losses of catches for entire deployments of gear (S. Mesnick, personal communication). A symposium hosted by the Vancouver Aquarium, "Fisheries Depredation by Killer and Sperm Whales: Behavioural Insights, Behavioural Solutions" was held Oct. 2-5, 2006, in British Columbia, Canada (*http://www.killerwhale.org/depredation/index.htm).*

## DISCUSSION

While substantial progress has been made towards filling the many gaps in information identified by the 2005 workshop (Table 1), progress on certain high priority issues has not been as rapid as was hoped. Further work is urgently needed on population structure, female survival rates, and population modelling approaches.

The workshop recommended organizing an email consultation group to keep people abreast of developments, and that group provided input for this report. It also recommended organizing a follow-up workshop. The timing, scope and participants for such a workshop need to be discussed further.

The previous discussion within the Scientific Committee indicated that because of its schedule, an assessment could not in any event be undertaken prior to 2008. Because the process of scheduling an assessment can stimulate research, it may be useful for the Scientific Committee to discuss how an assessment may fit into its ongoing schedule.

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Table 1. Description of research tasks by general category recommended to be addressed in preparation for in-depth assessment of sperm whale populations, with an indication of recent progress towards each task (“?” indicates progress not known). Modified from Table 2 in Smith *et al.* (2005).

| Category | Prog | Description |
|---|---|---|
| Pop. Structure | Yes | Provisionally identify units to test for discreteness. |
| Pop. Structure | Yes | Continue and expand genetic analyses, integrated with data on vocal clans as possible. |
| Pop. Structure | No | Conduct comprehensive analysis and synthesis of Discovery mark program, including USSR data. |
| Pop. Structure | Yes | Conduct global inventory of photo-identification data, linking catalos to the maximal extent possible. (Also applies to Abundance) |
| Pop. Structure | ? | Conduct global inventory of tissue collections. |
| Pop. Structure | Yes | Conduct global inventory of coda repertoires. |
| Pop. Structure | No | Establish unified, comprehensive database on sperm whale morphometrics. |
| Pop. Structure | No | Refine provisional population units. |
| Abundance | No | Conduct global inventory of dive profiles. |
| Abundance | Yes | Refine estimates of g(0). |
| Abundance | No | Improve automation of photograph matching; evaluate use of dorsal fins and other features besides the flukes in photo-identification of individuals. |
| Abundance | No | Improve methods for estimating group size acoustically, especially for large groups (up to 30 individuals). |
| Abundance | No | Develop consensus on relative merits of acoustic and visual surveys. |
| Abundance | Yes | Evaluate methods of extrapolating densities to unsurveyed areas. |
| Abundance | Yes | Conduct additional surveys in selected areas. |
| Human Interactions | Yes | Improve estimates of whaling removals in 18th and 19th centuries, by region and sex, including estimates of statistical precision. |
| Human Interactions | Yes | Resolve problems surrounding misreported and under-reported catches in North Pacific during 20th century: USSR, Japan. |
| Human Interactions | ? | Improve reporting and estimation of incidental mortality of sperm whales in fisheries, especially drift gillnets. |
| Human Interactions | ? | Obtain additional measures of chemical contaminants in sperm whale tissues and improve understanding of effects, including dose-response relationships whenever possible. |
| Human Interactions | Yes | Get more and better data (both qualitative and quantitative) on sperm whale interactions with longline fisheries. |
| Human Interactions | Yes | Determine effects of human-induced noise on behaviour and ecology of sperm whales, especially in relation to oil and gas industry. |
| Life History | No | Compare observed calf proportions in different study areas and refine understanding of calving rate and maximal potential rate of increase. |
| Life History | Yes | Determine function of codas. |
| Life History | No | Determine population effects of differential depletion by sex. |
| Life History | No | Obtain more precise estimates of adult female survival. |
| Modelling | No | Establish population modelling working group to ensure interaction among researchers. |
| Modelling | No | Refine modelling approaches – e.g., alternative values of $r_{max}$, sensitivity to input parameters. |
| Coordination | Yes | Organize e-mail consultation. |
| Coordination | No | Conduct follow-up workshop in two years to review progress. |
| Coordination | No | Determine when sufficient information is available to allow in-depth assessment of sperm whales. |