ANNEX 6

REPORT OF THE WORKING GROUP ON ECOSYSTEM MONITORING AND MANAGEMENT

(Cape Town, South Africa, 26 July to 3 August 2010)

CONTENTS

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INTRODUCTION

Opening of the meeting

1.1 The 2010 meeting of WG-EMM was held at the National Research Aquarium, Cape Town, South Africa, from 26 July to 3 August 2010. The meeting was convened by Dr G. Watters (USA) and local arrangements were coordinated by Mr J. Khanyile, Department of Environmental Affairs (DEA), South Africa.

1.2 Dr Watters opened the meeting and welcomed the participants (Appendix A). He thanked Dr M. Mayekiso, Deputy-Director General, DEA, for hosting the meeting, and welcomed Mr A. Wright, CCAMLR Executive Secretary, to the meeting.

Adoption of the agenda and organisation of the meeting

1.3 The provisional agenda was adopted without change (Appendix B).

1.4 The Working Group formed a krill subgroup (coordinator: Dr Watters) and a VME subgroup (coordinator: Dr S. Parker, New Zealand) which considered matters under Agenda Items 2 and 3.1 concurrently.

1.5 The Working Group considered discussions from two meetings held during the 2009/10 intersessional period:

- WG-SAM (Annex 4)
- SG-ASAM (Annex 5).

1.6 Documents submitted to the meeting are listed in Appendix C. While the report has few references to the contributions of individuals and co-authors, the Working Group thanked all the authors of papers for their valuable contributions to the work presented to the meeting.

1.7 In this report, paragraphs that provide advice to the Scientific Committee and its working groups have been highlighted. A list of these paragraphs is provided in Item 4.

1.8 The report was prepared by Drs C. Jones (USA), S. Kasatkina (Russia), S. Kawaguchi (Australia), B. Krafft (Norway), P. Penhale (USA), D. Ramm (Data Manager), K. Reid (Science Officer), C. Reiss (USA), B. Sharp (New Zealand), P. Trathan (UK), J. Watkins (UK) and Watters.

Feedback from previous meetings of the Commission, the Scientific Committee and the working groups

1.9 Dr Watters outlined the feedback from previous meetings of the Commission, Scientific Committee and other working groups which had been used to structure WG-EMM's agenda, and highlighted key requirements for advice on:

- scientific observation of the krill fishery (SC-CAMLR-XXVIII, paragraph 6.28);
- krill escape mortality (SC-CAMLR-XXVIII, paragraphs 4.13 to 4.15);
- krill B_0 and precautionary yield estimates (SC-CAMLR-XXVIII, paragraphs 3.3 to 3.7);
- VMEs (e.g. SC-CAMLR-XXVIII, paragraphs 4.247 to 4.252);
- MPAs (e.g. SC-CAMLR-XXVIII, paragraphs 3.28 to 3.33);
- a three-year work plan for the Working Group (SC-CAMLR-XXVIII, paragraph 14.2).

KRILL

Krill biology and ecology

2.1 WG-EMM-10/P8 described a plausible model of krill population dynamics at South Georgia and indicated that the timing and magnitude of recruitment has been a primary driver of inter- and intra-annual variability of krill biomass in the region. Results from the model also indicate that competition between the fishery that operates during winter and krill predators that forage during summer may occur despite the temporal separation of these activities.

2.2 WG-EMM-10/P9 and 10/P10 provide models that describe the spatial distribution of krill swarm types based on environmental factors. The Working Group agreed that while the krill fishery currently focuses its operations on shelf regions due to the relatively high predictability of locating fishable krill swarms compared to offshore areas, additional information on the predictability of fishable krill swarms offshore would facilitate the development of management measures to distribute fishing effort in space.

2.3 In considering these papers, the Working Group recalled the importance of understanding krill population dynamics and the overall population structure of krill for an integrated assessment, and noted the increasing amount of information, both from observations and models, that could assist in the development of an integrated assessment of krill.

New monitoring efforts

2.4 WG-EMM-10/9 outlined a proposal to conduct research surveys in Subarea 48.2 for the next five years using the Norwegian krill fishing vessel *Saga Sea*. WG-EMM-10/20 outlined plans by Argentina to study the ecology and monitor the abundance of euphausiid larvae in the Weddell Sea–Scotia Sea Confluence (parts of Subareas 48.1 and 48.2).

2.5 The Working Group welcomed Norway's proposal for a krill fishing vessel to commit five days each year for the next five years to conduct a research survey. In considering the proposal, WG-EMM suggested that the research be conducted using similar standards (e.g. a set of parallel acoustic transects that are run every year) to annual scientific surveys undertaken by the US AMLR Program and the British Antarctic Survey in Subareas 48.1 and 48.3 respectively.

2.6 The Working Group agreed that a regular survey in Subarea 48.2 would complement the annual surveys conducted by the US AMLR Program and the British Antarctic Survey. Together these three surveys could form an integrated monitoring effort extending across the Scotia Sea and linking three areas containing major concentrations of krill that are the focus of the present commercial fishery. Such an integrated effort could also make an important contribution to the Southern Ocean Observing System (SOOS) and provide valuable information for use within analyses of the international ICED Program (Integrating Climate and Ecosystem Dynamics – www.iced.ac.uk).

2.7 The Working Group advised that:

(i) the timing of the Norwegian survey should be before the start of the fishery, preferably in mid-January, to align the survey timing to the other survey efforts in Area 48. Conducting the survey before the start of fishing operations will ensure that conduct of the research effort is less likely to be impeded by ice;

(ii) a set of transects similar to those run by the US AMLR Program in 2008 (Figure 1) would be appropriate to conduct a krill survey within the proposed time frame of five days. In order to avoid confounding of the results due to advection of krill, the survey effort would best start from the east and work towards more western transects. If time permits, it would be preferable to have transects extended northwards beyond 60°S, and to add an extra transect to the west of the transects illustrated in Figure 1 if possible;

(iii) acoustic data collection should, if possible, be done using a calibrated scientific echosounder using 38 and 120 kHz. Acoustic data collection is encouraged 24 hours per day, however, only data collected during the daytime should be used for subsequent estimation of krill biomass;

(iv) net sampling should be conducted at standard stations located every 20 n miles along transects. Following protocols from the CCAMLR-2000 Survey, each net haul should be an oblique tow sampling from the surface down to 200 m (or within 20 m of the bottom if the water is shallower than 200 m). The use of a Norwegian macroplankton trawl net (38 m^2 mouth area, 3 mm mesh size) was considered appropriate to provide length-frequency data on krill, although attention to ensure adequate sub-sampling of large catches will be required;

(v) hydrographic data should be collected by XBT or CTD. As a minimum, collection of temperature profile data is recommended to estimate sound velocity profiles, which are essential for processing acoustic data. Such profiles could be collected using XBTs, although the use of a CTD would provide additional information to characterise water masses in the area, which may assist in the interpretation of variability in krill biomass;

(vi) nutrient measurements were deemed not practical.

2.8 The Working Group thanked Argentina for its proposal in WG-EMM-10/20 and noted that the Weddell Sea–Scotia Sea Confluence is historically known as an area with high densities of larval krill that are variable in time and space. Monitoring in this area has the potential to provide useful data on krill recruitment processes that are indicative of spawning biomass.

2.9 In order for WG-EMM to provide detailed advice on the development of the program, and how best the information developed from a monitoring effort could be utilised, further details on how other zooplankton within the same size range as larval krill (e.g. copepods, amphipods and other euphausiids such as *Thysanoessa macrura*) can be separated from krill larvae when using acoustic methods would be required. The Working Group also suggested that consideration be given to using a CPR in the monitoring effort.

2.10 The Working Group encouraged Argentina to report on survey efforts conducted during the forthcoming intersessional period to WG-EMM and to provide further details on intentions to conduct repeat surveys in following years, including additional information on how vessels of opportunity may be used so that the implications of such a sampling design might be considered.

The krill fishery and scientific observation of the fishery

Fishing activity

2008/09 season

2.11 Five Members fished for krill in Area 48 during the 2008/09 fishing season and reported a total catch of 125 826 tonnes; two vessels used the continuous fishing system. The largest catch of krill was taken from the South Orkney West (SOW) SSMU in Subarea 48.2 (89 184 tonnes), and the remainder of the catch was taken predominantly in Subarea 48.1, notably 19 691 tonnes from Antarctic Peninsula Bransfield Strait East (APBSE) SSMU and 2 745 tonnes from the Antarctic Peninsula East (APE) SSMU. The Working Group noted that this is only the second time that fishing has been reported from SSMU APE; previously, 25 tonnes of krill were taken in 1995/96 (WG-EMM-10/5).

2009/10 season

2.12 As of the start of the WG-EMM meeting, 10 of the 11 krill fishing vessels licensed by Members (People's Republic of China, Japan, Republic of Korea, Norway, Poland and Russia) have fished in Area 48 during the 2009/10 fishing season. The total catch reported to May 2010 was 108 550 tonnes, most of which has been taken from Subareas 48.1 and 48.2 between February and May. Approximately 40% of the catch has been taken by two vessels using the continuous fishing system. Based on the current cumulative catch trajectory as at the end of May (Figure 2 and paragraph 2.15), the forecast of the total catch of krill for the current season is 150 000–180 000 tonnes (WG-EMM-10/5), and data available at the time of the meeting indicated that, by the end of June 2010, the total catch had reached ≈140 000 tonnes. The final catch will be higher than forecast if current catch rates continue beyond July.

2.13 The Working Group noted that the Secretariat provides forecast closure dates once the catches in a fishery (or area) exceed 50% of the respective catch limits. This season, for the first time ever, the catch of krill in Subarea 48.1 has exceeded 50% of the apportioned trigger level (155 000 tonnes), and the Secretariat has begun providing a forecast closure date for the fishery in this subarea. Currently, the closure date is estimated to occur after the end of the fishing season.

2.14 The Working Group also noted the current requirement for vessels to begin reporting catches at 10-day intervals once the catch reaches 80% of the trigger level (CM 23-06). The Working Group advised the Scientific Committee that the reporting requirements in CM 23-06 are not consistent with the spatial allocation of the trigger level among subareas and should be revised accordingly.

Trends in the krill fishery

2.15 The Working Group noted that approximately 80% of the krill catch was taken between April and July (Figure 2), and this temporal distribution of catches had typified the fishery over the last two decades. Information from the fishery suggested that this preference for fishing during the winter may be related to increased spatio–temporal stability of krill concentrations on the fishing grounds, as well as the desire to minimise catches of 'green krill' feeding on phytoplankton.

2.16 The Working Group noted a marked increase in the daily catch-rate capacity in recent years by vessels using the continuous fishing system (up to 800 tonnes per day per vessel), as well as vessels using conventional trawls (including vessels that use pumps to clear the codend) (up to 400 tonnes per day per vessel) (Figure 3).

2.17 Voluntary reporting of transhipments in the krill fishery (motivated by the introduction of CM 10-09 in 2008) was reported in WG-EMM-10/5. The Working Group noted that further reporting of information on transhipments would help increase understanding about the operation of the fishery.

Notifications for 2010/11

2.18 Seven Members submitted notifications for a total of 15 vessels intending to participate in krill fisheries in Subareas 48.1, 48.2, 48.3 and 48.4, and Divisions 58.4.1 and 58.4.2, during the 2010/11 fishing season. No notifications were submitted for participation in exploratory krill fisheries during 2010/11. The total notified level of catch of krill in 2010/11 is 410 000 tonnes.

2.19 This is the third year in which the Working Group has reviewed details from krill fishery notifications. The Working Group thanked the Secretariat for translating notifications submitted in languages other than English; these translations enabled the Working Group to fully evaluate every notification.

2.20 The Working Group noted that all the notifications had sufficient information and advised the Scientific Committee that these notifications meet the requirements in CM 21-03.

2.21 The Working Group also noted the range of methods notified for determining the estimate of green weight of krill caught, and advised the Scientific Committee that standardisation of methods is required to achieve better estimates of catch. Further, the Working Group reiterated that the conversion factor required in the notifications is the factor that converts catch in volume to mass (SC-CAMLR-XXVIII, Annex 4, paragraphs 3.45 and 3.49). The Working Group also noted that a range of conversion factors (7.6 to 10.0) related to meal production were reported in the notifications, and further information from Members would be required to clarify the basis for these values.

Data reporting

Fine-scale catch and effort (C1) data

2.22 The Working Group noted the delays in the submission of C1 data from the Polish-flagged vessel that fished during 2008/09 and 2009/10 (WG-EMM-10/5). The Secretariat advised that the data from March to May 2010 had been submitted immediately prior to the meeting of WG-EMM, and that Poland is currently working to submit the data from 2008/09.

Analysis of data from the krill fishery

Maxim Starostin, Subarea 48.2

2.23 WG-EMM-10/8 reported on fishing activity by the Russian trawler *Maxim Starostin* during 2009 near the South Orkney Islands (Subarea 48.2), and WG-EMM-10/16 further presented spatial distributions and size/age compositions of Antarctic krill (*Euphausia superba*) from catches made during January–March in both the 2008/09 and 2009/10 seasons.

2.24 In considering WG-EMM-10/8, the Working Group noted that inferences based on the catches (or lack thereof) of age 1+ krill need to consider the size selectivity of commercial nets.

2.25 Conventional trawls may be more size selective than continuously pumped trawls because the higher volumes of krill in the codend might force smaller individuals out of the net. Differences between vessels among suction effects of pumps in the codends may also affect size selectivity. The Working Group reiterated the importance of acquiring more detailed information on the operation of all fishing methods.

2.26 The Working Group was informed that, in the future, the *Maxim Starostin* may switch fishing gear according to swarm types. The vessel may use the continuous fishing system when fishing large swarms and switch to conventional trawling when fishing smaller swarms.

Historical data

2.27 The Working Group noted the value of fishery-dependent data and reiterated advice from WG-SAM that data from the fishery will be useful for estimating size-specific fishing mortality rates (Annex 4, paragraph 2.7). The Working Group further noted that fishery-dependent data need to be standardised, quality controlled and organised so that they are available for further systematic analysis.

2.28 The Working Group recalled that last year Ukraine had processed and submitted haul-by-haul catch and effort data from 57 krill fishing trips conducted by vessels from the former Soviet Union. Further processing and validation of these data has been delayed due to the Secretariat's limited data management resources and high workload. The Working Group was informed that this task is currently scheduled for completion in early 2011, and looked forward to reviewing the data in the future.

Escape mortality

2.29 The Working Group recalled that the Scientific Committee recommended that there should be a concerted effort to estimate escape mortality in the krill fishery through evaluation of existing information and the continued development of existing models (SC-CAMLR-XXVIII, Annex 4, paragraphs 3.5 and 3.6). Three papers were presented to address this problem.

2.30 WG-EMM-10/10 described a field study of krill escape mortality using fine-meshed chafers that would collect data necessary to estimate by-catch and escape mortality of krill, larval and juvenile fish, and other species of euphausiids. At least five experiments (preferably three per month) to estimate escape mortality of each commercial trawl per fishing season were proposed.

2.31 WG-EMM-10/18 recommended field studies on krill escape mortality, including data collection and processing using the complex application of fine-meshed chafers and acoustic methods to estimate the total amount of krill passing through the trawl. Details of the chafer design and how chafers might be mounted to the trawl were provided. The paper also raised the need for an operating manual to achieve appropriate levels of accuracy and precision for krill escape mortality estimates.

2.32 The Working Group considered the proposed work and noted that data collection on escape mortality should be supported by the development of the operating manual. The Working Group endorsed the experimental work on krill escape mortality to be undertaken on board the Russian vessel *Maxim Starostin* as an important contribution to this issue. It looked forward to receiving a report at a future WG-EMM meeting and encouraged other Members to participate in such work.

2.33 WG-EMM-10/19 reported on an analysis, based on field and modelling data, of trawl catchability and escape mortality in relation to the krill fishery. The Working Group discussed the modelling results presented and noted that it would be important to compare the field and modelling data.

2.34 To define krill escape mortality, estimates of both the total amount of krill passing through the meshes and the proportion of these krill that become moribund through the escape process are required. The Working Group recognised that there are practical difficulties in separating krill killed during escapement from those that escaped from the trawl without fatal injuries, but then subsequently died in the chafer. However, the Working Group noted that krill passing through small meshes are likely to be damaged even when they appear visually viable. Therefore the Working Group agreed that, without evidence to the contrary, it would be appropriate to assume that all krill escaping through the small mesh would not survive the process.

2.35 The Working Group noted that estimates of escape mortality in the krill fishery require a quantitative understanding of the process of krill passage from the trawl mouth to the codend. This process will be influenced by many factors, including:

- fishing gear construction
- vessel speed and hauling/veering rates of the trawl
- towing duration
- quantity of krill in the codend
- krill density and distribution in the trawl swept volume.

2.36 The Working Group noted that elaborating a standard approach to collecting and processing data on escape mortality would be necessary to achieve an appropriate level of accuracy and precision.

2.37 The Working Group agreed that the documents on krill escape mortality would be useful guidance for developing an operating manual to detail the required standard approaches to investigating the escape mortality of krill (Annex 4, paragraphs 2.20 to 2.23), and that this could also contain measurements that could be used by scientific observers.

2.38 The Working Group asked Russia and Ukraine to submit documents to ad hoc TASO outlining field study approaches to investigate the krill escape mortality and its implication for the workload of scientific observers. The Working Group requested that TASO review this manual (once developed) to determine the practicality of its implementation.

2.39 The Working Group was informed that the Institute of Marine Research in Norway has applied for funding to support a pilot study to develop a mathematical model, based on demographic data on *E. superba*, to quantify size selection through different trawl nets. This pilot study is intended to provide baseline data for a larger study involving comparative *in situ* trawling experiments, including testing existing and newly developed trawl gear (from the pilot project), with acoustic measurements and video monitoring in a flume tank. The larger study will also evaluate performance of the same fishing gear on the krill fishing grounds in the Southern Ocean and include sampling krill within and outside the nets.

CPUE

2.40 The Working Group welcomed WG-EMM-10/17 that included an analysis of the temporal dynamics of standardised CPUE based on CCAMLR fishery data from Subareas 48.1 to 48.3, including 15 SSMUs. The Working Group noted that various factors (e.g. vessel, product, season, swarm types, krill condition, by-catch) were likely to influence CPUE and suggested that examining different measures of CPUE, that included different ancillary data, might provide a means of interpreting indices of CPUE. The Working Group encouraged further analysis of CPUE, including the development of summary indices of CPUE, from the krill fishery, noting that these analyses could be very useful in understanding the relative importance of areas to the historical krill fishery.

Scientific observation

2.41 WG-EMM-10/4 presented a summary of observations on board krill trawlers operating in the Convention Area. The Working Group considered the format of the summary so that it could be effectively utilised in deliberations and analyses regarding observer deployment in the krill fishery, and requested that statistics on the level of observer coverage be included.

2.42 The Working Group agreed that turning the information contained in Table 1 of WG-EMM-10/4 into a map, or possibly an animation, would help to visualise observer coverage in time and space.

Observer deployment

2008/09 season and prior seasons

2.43 Eight scientific observer logbooks from five out of six vessels that operated during the 2008/09 fishing season were submitted to CCAMLR. At present, the CCAMLR database holds scientific observer data from 57 logbooks summarising observations made between 1999/2000 and 2008/09 in Subareas 48.1, 48.2, 48.3 and 48.4.

Current season

2.44 The Secretariat has received 10 notifications of the placement of CCAMLR scientific observers appointed in accordance with CM 51-06 on krill fishing vessels in Area 48 during 2009/10 (WG-EMM-10/4). It was clarified that each of the Chinese vessels that operated in the current season carried three observers.

Observer coverage in the krill fishery

2.45 WG-SAM recommended that WG-EMM develop a table indicating time–area strata where variability in the size structure of the krill population is highest (Annex 4, paragraph 2.11) and, thus, where higher levels of observer coverage would be required. Such a table would provide useful guidance on how a systematic program of observer coverage could be optimised to yield data that would be most useful in an integrated assessment for krill (Annex 4, paragraph 2.11).

2.46 Observers are required to provide a variety of important data (e.g. data on the by-catches of larval fishes, seabirds and marine mammals, as well as the size composition of the catch in different locations and time), and the requirements for optimising sampling coverage and intensity may vary depending on the questions that are to be addressed with the data that are collected.

2.47 The Working Group recalled that the current instructions for observers on krill fishing vessels (SC-CAMLR-XXVII, Annex 4, paragraph 4.48) provide a mechanism for the spatial distribution of sampling to occur at spatial scales that are smaller than the subarea scale (hereafter referred to as strata).

2.48 As has been advised in previous years, data collected during an initial period of systematic observer coverage are needed to characterise underlying variability and assist with the design of an observer program in the long term (SC-CAMLR-XXVI, Annex 4, paragraphs 4.44 to 4.47). A two-year program with sampling effort distributed across potential time–area strata would be a useful start to establishing baseline data on the variability of krill size structure and other biological parameters.

2.49 WG-EMM suggested, for the 2010/11 and 2011/12 fishing seasons, the following three options to distribute observers among 50% of all time–area strata in a manner consistent with the requirements of CM 51-06 (Table 1).

(i) **Option 1**: divide all notified vessels into two approximately equal-sized groups; divide the fishing season into two six-month periods, and require observer coverage according to Table 1.

(ii) **Option 2**: divide the fishing season into four quarters and divide periods in which all vessels would be required to carry observers according to Table 1.

(iii) **Option 3**: require 50% coverage of vessels, and at least 20% coverage of hauls, for each time–area stratum fished throughout the two fishing seasons.

2.50 Recalling that the advice from the Working Group and the Scientific Committee remains that 100% observer coverage across all vessels is the best way to achieve systematic observer coverage, WG-EMM noted the following consequences of adopting each of the three options listed in paragraph 2.49 (all of which would provide less than 100% coverage).

Option 1 allows cross-vessel comparisons within each group of vessels but may not allow cross-group comparisons. Between-year comparisons in any subarea or spatial stratum may also be made.

Option 2 allows cross-vessel comparisons and an assessment of interannual variation for the time–area strata in which observations are collected. Increased coverage will also occur in areas where there is substantial variation in the size structure of krill and where there have been the fewest previous observations from historically important fishing grounds (Subareas 48.1 and 48.2). However, data might not be collected from about half of the time–area strata. Furthermore, if there are large shifts in the spatial distribution of the fishery between years and between areas where all vessels are required to carry observers, less than 50% coverage may be achieved over all time–area strata.

Option 3 allows consideration of interannual variation for all the time–area strata in which fishing occurs, however, it may not allow cross-vessel comparisons.

2.51 The Working Group noted that the Commission had agreed to review CM 51-06 in 2010 based on the advice from WG-EMM and WG-SAM. In considering its recommendations above, the Working Group noted that the options outlined in paragraph 2.49 and illustrated in Table 1 could be modified to accommodate changes in levels of observer coverage.

2.52 The Working Group requested that ad hoc TASO consider the time budget for observers in the krill fishery and advise whether 20% haul coverage could be achieved by increasing the number of hauls observed per five-day period.

Estimates of B_0 and precautionary yield for krill

Estimation of B_0

2.53 Dr Watkins, Convener of the fifth meeting of SG-ASAM, provided a summary and review of the results from that meeting. The Subgroup focused on the estimation of krill biomass (B_0) from a reanalysis of the acoustic data from the CCAMLR-2000 Survey.

2.54 Through a combination of pre-meeting correspondence and meeting discussions, the Subgroup assessed and revised the protocol that had been provided by SG-ASAM-09 (SC-CAMLR-XXVIII, Annex 8, Appendix E). A number of issues relating to the protocol were identified by SG-ASAM-10 (Annex 5, Table 1) and corrections/modifications were made to the protocol or the associated computer code. Solutions to the major issues are summarised below:

(i) Computer code was modified to account for a series of errors relating to the parameterisation of krill shape within the SDWBA model (Annex 5, paragraphs 2.13 to 2.19).

(ii) Inspection and validation of code used to undertake the SDWBA inversion to estimate the orientation distribution of krill from the acoustic data was carried out (Annex 5, paragraphs 2.21 to 2.26).

(iii) A method for correcting the sample-averaging effect on orientation variance was implemented (Annex 5, paragraphs 2.27 to 2.29).

(iv) It was recognised that changing SDWBA code and revising orientation distribution required recalculation of target identification windows (Annex 5, paragraphs 2.30 to 2.35).

2.55 A revised estimate of krill biomass (B_0) from the CCAMLR-2000 Survey of 60.3 million tonnes with a sampling CV of 12.8% was generated using the full SDWBA model (Annex 5, Table 4). The Subgroup advised that the output from the full SDWBA was preferred on a scientific basis because fitting the simplified model to the results from the full model introduced additional errors and uncertainty into estimates of TS that could propagate through to errors in target identification (Annex 5, paragraph 2.41).

2.56 Noting SG-ASAM's justification for the use of the full SDWBA model, rather than the simplified model, the Working Group recommended that, in the future, estimates of B_0 should use the full SDWBA model in preference to the simplified model.

2.57 The Working Group recognised the significant amount of work conducted by SG-ASAM both during pre-meeting correspondence and during the meeting to ensure that a fully validated estimate of biomass was formulated.

2.58 The Working Group discussion of the recalculation of B_0 focused on two main areas: the technique used to generate the krill orientation distribution and the lack of an estimate of total uncertainty in the estimation of B_0.

2.59 As described by SG-ASAM-10 (Annex 5, paragraphs 2.25 to 2.28), the parameters of the krill orientation distribution are estimated by a least-squares 'inversion' (or fit) of the full SDWBA model. This includes comparison of the distribution of dB differences (the difference between acoustic backscatter at 120 and 38 kHz, $S_{v120kHz-38kHz}$) for the CCAMLR-2000 acoustic data with model-derived dB difference distributions (one for each orientation angle and standard deviation) generated using the probability density function of krill length sampled during the survey. Figure 4 shows the curve generated from the field data and the model-derived curve using the best fitting orientation parameters.

2.60 The Working Group noted that Figure 4 did not provide any goodness-of-fit statistic and sought further clarification from members of SG-ASAM present about the appropriateness of both the model and the fitting procedure. Discussions of these issues had also taken place at SG-ASAM and the Subgroup had concluded that:

(i) the new inversion code would provide results comparable to those illustrated in Conti and Demer (2006) (Annex 5, paragraph 2.21);

(ii) a statistical indication of goodness-of-fit was an important next step (Annex 5, paragraph 4.1(i)).

2.61 The CV provided with the recalculation of B_0 represents the sampling error. It includes no estimate of the uncertainty associated with the model (methodological errors including uncertainty in TS and target identification). While SG-ASAM had intended to explore aspects of model uncertainty, the processes to produce a single B_0 estimate were manually and computationally intensive and precluded any investigation in a reasonable time frame (Annex 5, paragraph 2.43). In addition, the Subgroup recognised that complex interactions within the model meant that a full evaluation of uncertainty in B_0 would require a probability density function of B_0 (Annex 5, paragraph 2.44) and that this would only be achieved once streamlined efficient code that could be implemented in Monte-Carlo simulation was available (Annex 5, paragraph 4.1(viii)).

2.62 Having considered the issues discussed above, the Working Group agreed that the recalculated B_0 estimate of 60.3 million tonnes with a sampling CV of 12.8%, derived using the full SDWBA, now represented the best estimate of krill biomass (B_0) during the CCAMLR-2000 Survey.

2.63 The Working Group further agreed that the presently calculated uncertainty in the B_0 estimates (CV = 12.8%) would be at best the lower limit. Given that an estimate of total uncertainty was not available at this meeting, the Working Group considered how best to proceed.

2.64 The Working Group concluded that a sensitivity analysis using the GYM to investigate the effect of differing levels of total uncertainty on the precautionary catch limit would be appropriate. The GYM was run with three levels of the CV in B_0 to simulate the inclusion of both sampling error and increasing levels of methodological error (Table 2).

2.65 The Working Group agreed that the relatively small effect on the harvest rate of increasing total CV indicated that while there is a need to investigate methodological uncertainty in the acoustic method, the estimates of γ were relatively insensitive to differences in total uncertainty, therefore the present results, and particularly the present CV, could be used to provide a robust estimate of the precautionary catch limit.

2.66 The Working Group noted that similar conclusions had been reached when uncertainty in the variance of B_0 had been discussed in 1995 and a sensitivity analysis conducted with the KYM (SC-CAMLR-XIV, Annex 4, paragraphs 4.53 to 4.56).

2.67 However, the Working Group also noted that as CV increases there is a switch in the γ that is used to calculate the precautionary catch limit.

Estimation of precautionary catch limits for krill

2.68 The Working Group agreed with the conclusion of SG-ASAM-10 'that the intersessional work and model exploration conducted at this meeting had shown that the value for B_0 provided at the 2007 meeting of WG-EMM was incorrect and that the difference in that value and the value of B_0 from the full SDWBA provided during this meeting arose simply as a result of the correction of errors that were included in the calculation in 2007' (Annex 5, paragraph 2.42).

2.69 Based on the advice from SG-ASAM of the revised B_0 estimate for Subareas 48.1 to 48.4 (60.3 million tonnes with a survey CV of 12.8%; paragraph 2.55) and γ (0.093; Table 2), the Working Group generated a new precautionary catch limit of 5.61 million tonnes for Subareas 48.1, 48.2, 48.3 and 48.4 and agreed that this would be appropriate for a revision of CM 51-01.

2.70 The Working Group noted that the current trigger level (620 000 tonnes) is not linked to the assessment of B_0.

2.71 The Working Group considered the status of biomass estimates for Divisions 58.4.1 and 58.4.2 and noted the recommendation of SG-ASAM (Annex 5, paragraph 5.2) that with appropriate parameterisation the revised protocol could be applied to these areas to generate new estimates of B_0 and, hence, precautionary catch limits. However, the Working Group noted that such recalculations were not possible at this meeting and that given the present or likely notified catch for these regions, the present B_0 values and catch limits should remain until the appropriate reanalysis can be carried out.

Reviewing parameters used in the GYM

2.72 The Working Group agreed that it was timely to consider a review of the parameters used in the GYM because, although the parameters had been reviewed in 2007, the only changes to those used to set the precautionary catch limit since 1995 had been the survey CV (SC-CAMLR-XXVI, Annex 4). However, the Working Group agreed that a full review of these parameters would not be possible during the present meeting.

2.73 The Working Group recalled the discussions on recruitment variability that had taken place at previous meetings (see for example SC-CAMLR-XIV, Annex 4, paragraphs 4.42 to 4.45; SC-CAMLR-XV, Annex 4, paragraphs 3.51, 3.52, 6.20 to 6.24 and 7.6 to 7.15; SC-CAMLR-XXVI, Annex 4, paragraph 2.33) and noted that there had been no changes to the recruitment parameter since 1995 and so the GYM presently was based on recruitment data collected prior to 1994.

2.74 The Working Group considered whether the degree of recruitment variability presently used in the model was an underestimate, and whether recruitment variability was likely to have been changing over time as a result of the ongoing environmental changes in the Southern Ocean.

2.75 The Working Group agreed that a full review of recruitment variability and its implementation within the GYM was desirable but would not be possible during the meeting. The Working Group, however, agreed that a sensitivity analysis, similar to that conducted for uncertainty in B_0 estimation, would be undertaken during the meeting.

2.76 The sensitivity of harvest rate to increased levels of recruitment variability (using CV values of 1.5 (19.8%) and 2 (25.2%) times the present CV of 12.6%) was investigated using 10 001 iterations of the GYM (Table 3). These results indicate that the γ_2 (escapement gamma) was relatively insensitive to increasing levels of recruitment variability but γ_1 (stable recruitment gamma) showed a marked decrease as recruitment CV increased. However, the Working Group also noticed that with further increase in recruitment CV the GYM terminated prematurely. This error occurred at different recruitment CV levels with varying numbers of iterations.

2.77 The Working Group noted there was insufficient time to fully explore why the parameter bounds for recruitment variability in the sensitivity trials caused the GYM to cease running. The Working Group requested that the Secretariat, with the help of members familiar with the assessment, document this for the next meeting. The Working Group agreed that the inclusion of a time series of year-class strengths in the GYM assessment would be useful to explore.

2.78 The Working Group considered the application of the current three-stage decision rule currently used by CCAMLR to determine the precautionary catch limit for krill and noted that for stocks such as krill that experience high interannual variability in abundance, the probability with which the biomass may fall below 20% of the initial biomass may be greater than 0.1 even in the absence of fishing. This would result in a γ_1 being equal to 0 and hence a modification of this part of the decision rule may be required provided that the objectives in Article II can still be met. Given also the potential impact of climate change on recruitment variability, the Working Group agreed that both the recruitment variability and the specification of the current decision rule relating to the maintenance of stable recruitment should be investigated.

SPATIAL MANAGEMENT TO FACILITATE THE CONSERVATION OF MARINE BIODIVERSITY

Vulnerable marine ecosystems

3.1 The Working Group agreed that, in the future, advice on bottom fisheries and strategies to avoid significant adverse impacts on VMEs should be organised within the structure of the 'Report on Bottom Fisheries and Vulnerable Marine Ecosystems' endorsed by the Scientific Committee in 2009. WG-EMM-10/15 provided a draft template and work plan for that report, noting that, unlike Fishery Reports as produced by WG-FSA, the Bottom Fishery Report will need to be assembled from the outputs of WG-SAM, WG-EMM and WG-FSA. The template includes types and locations of existing bottom fisheries, details of registered VMEs and Risk Areas, assessments of impacts to VMEs, strategies to avoid significant adverse impacts on VMEs, as well as strategies to provide management advice that is robust to uncertainty.

Management framework

3.2 WG-EMM-10/29 presented a proposed set of definitions for terms specifically relevant to the management of VMEs in the CAMLR Convention Area using an exposure-effects risk assessment framework. The Working Group agreed that these definitions enhance a common understanding of terminology related to VMEs. The Working Group recommended the adoption of definitions of fragility, vulnerability, threat, footprint, impact and ecological consequence. Some members felt that the flow diagram in Figure 1 of WG-EMM-10/29 was useful for illustrating the relationships among the terms, although some terms require further consideration. The Working Group agreed to refer the paper to WG-FSA for further discussion.

3.3 The agreed definitions are as follows:

Fragility – The susceptibility of an organism (or habitat) to impact (physical damage or mortality) arising from a particular interaction with a particular type of threat (e.g. bottom trawls or longlines). Fragility refers to an intrinsic physical property of the organism and the nature of the threat, without reference to the actual presence or intensity of the threat.

Example: Tall, brittle organisms would be more fragile as a result of shearing forces exerted by lateral longline movement than low profile or flexible organisms.

Vulnerability – The susceptibility of species (or habitat) to impact by a particular type of threat over time, without reference to the actual presence or intensity of the threat. Vulnerability incorporates fragility but also includes other spatio-temporal and ecological factors affecting the resistance or resilience of the species (or habitat) to impact and/or the potential for recovery from impact over time (e.g. longevity, productivity/growth rate, dispersal and colonisation, rarity, community/habitat patch size, succession and spatial configuration).

Example: A species with high fragility but, as a population, also has high productivity (i.e. rapid growth, reliable and abundant recruitment) would have lower vulnerability than species with comparable fragility and slower growth, or with comparable fragility and infrequent, or lags, in recruitment.

Threat – An anthropogenic perturbation (e.g. bottom fishing) that can be expected to exert an impact on vulnerable organisms or habitats. The level of threat reflects factors extrinsic to the organism or habitat (e.g. intensity of fishing effort).

Impact – Change in status to a particular population, habitat or other identifiable component of an ecosystem, arising from mortality or damage associated with a threat over time. Conceptually, impact is the product of vulnerability and threat.

Example: A highly vulnerable organism in an area with no fishing experiences no impact. An organism with low vulnerability in an area of moderate fishing intensity experiences relatively low to moderate impact.

Fishing footprint – The area of the seafloor within which fishing gear interacts with benthic organisms. Fishing footprint may be expressed per unit of fishing effort for a particular gear configuration (e.g. for longlines, km^2 seabed contacted per km of longline deployed), or as a cumulative footprint when calculated and summed for all fishing gear deployments in a defined period and area. This areal measure does not incorporate the level of impact within the footprint.

Ecological consequence – The magnitude of ecological effects likely to arise from a particular level of impact. For example, impacts to VMEs may affect benthic-pelagic coupling, the availability of three-dimensional structural habitat for associated species, reproductive output of benthic organisms, succession in the benthic assemblage or the viability of the affected population. Ecological consequence is a function of the level of impact.

3.4 The Working Group noted that estimates of fragility might encompass examination of how different forces exerted by the fishing gear (e.g. from hooks, anchors, snoods and mainline) might affect different types of organisms in different locations. The Working Group further noted that estimating fragility is conceptually straightforward, but that vulnerability incorporates spatio–temporal patterns and dynamic processes that may not be measurable in the field and is likely to be best assessed using a simulation modelling approach.

3.5 The Working Group discussed the concept of 'risk', noting that it may be a different concept from considering solely the likelihood of ecological consequences of an impact. It will need to incorporate consideration of both current impacts and the potential for impacts in the future given a proposed management strategy. It also noted that in defining risk, consideration will need to be given to conceptual issues concerning the relationships between impact, ecological consequence and significant adverse impacts, especially in relation to integrating potential impacts in time and space, and uncertainty. The Working Group recommended that WG-FSA further consider the definition of risk.

3.6 With respect to bottom fishing effects on VMEs, the Working Group agreed that there are currently data available to inform estimates of impact, but that the functional form of the relationship between impact and ecological consequence is currently unknown, and that various hypothetical forms of the relationship between impact and ecological consequence may be plausible (see Figure 5), including linear, non-linear, stepwise or a variety of other forms; any of which may be taxon or assemblage specific.

3.7 WG-EMM-10/7 provided an up-to-date summary of VME notifications made under CMs 22-06 and 22-07. The Working Group welcomed the report and thought the content was extremely useful. The Working Group recommended that summary statistics be developed by the Secretariat to aid in assessing the reporting of VME units by vessels or VME taxa by observers.

3.8 The Working Group agreed that additional information, such as summary maps of actual VME units reported, would be useful in identifying VME clusters and providing additional information that could be useful in understanding the spatial extent of VMEs or VME indicators. The Working Group noted that reporting of VME indicator units varied among vessels and recommended the Secretariat develop data summaries to inform comparisons of VME by-catch among vessels or fleets fishing in the same region, as well as by SSRU.

3.9 The Working Group noted that VME Risk Area data are rapidly accumulating, and that the availability of these data is restricted to Members. The Working Group noted that the rules for the release of VME data in the public domain requires further consideration by the Scientific Committee and Commission.

Impact assessments

3.10 WG-SAM-10/20 described a revision of the impact assessment framework from Sharp et al. (2009) that estimates the cumulative footprint and impact on VME taxa associated with New Zealand's bottom longline fishery in the Ross Sea. WG-EMM noted that WG-SAM had requested that WG-EMM consider the nature of the distributions used to represent input assumptions of the impact assessment framework regarding footprint and fragility (Annex 4, paragraphs 4.12 to 4.19).

3.11 The Working Group welcomed the developments set out in WG-SAM-10/20 and agreed that it was important to develop a test statistic that could be used to confirm the extent to which spatial distributions of fishing effort within a pixel become random with different pixel sizes. The Working Group further recommended that summaries of effort concentration as depicted in WG-SAM-10/20, Figure 6, should be expressed as estimated impact rather than effort density on the x-axis, and that the variation in the estimated impact levels associated with each pixel should be incorporated in some way.

3.12 The Working Group noted that the R code that can be used to generate and plot probability density functions, similar to those illustrated in WG-SAM-10/20, is available from the Secretariat as the R-library 'IApdf'.

3.13 WG-EMM-10/33 presented the UK's preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on VMEs in the Ross Sea. A 'Benthic Impacts Camera System' (BICS) unit from the Australian Antarctic Division (AAD) (see WG-EMM-10/24 and paragraphs 3.25 and 3.26 below) was deployed on six sets of a longline vessel operating in Subarea 48.3. Data from these video deployments were analysed for longitudinal and latitudinal movement of the fishing line in order to estimate the fishing footprint. Information from BICS was also used to inform preliminary estimates of fragility within the standard footprint for two VME indicator taxa – gorgonians and stylasterids. Gorgonians in this study had an estimated standard-footprint fragility of 22% and were observed to rebound after being bent over by the line, due to their flexible body form. In contrast, standard-footprint fragility was estimated at 78% for stylasterids, which tended to be smaller, more brittle and easily dislodged from the rocks.

3.14 The Working Group noted that the UK reported that the identity and approximate abundance of VME taxa viewed by the camera were consistent with the types of VME by-catch retrieved from the lines at the surface, but that these observations did not enable quantitative estimates of the relationship between seafloor densities of VME taxa and the quantities observed on board.

3.15 The Working Group welcomed these field observations and encouraged continued research by Members to inform estimates of fragility and gear performance used to inform impact assessments. The Working Group recommended that future research of this kind should systematically vary the position of the camera on the line, and that researchers consider recording all relevant site-specific or deployment-specific variables that may influence the extent and nature of interactions between fishing gear and benthic organisms and their observation at the surface, e.g. depth, slope, substrate, weather, ice conditions, current speed and current direction relative to observed line movement, along with the quantities of by-catch landed in the segments related to the location of the camera unit.

3.16 WG-EMM-10/23 provided an update of efforts to quantify the dynamics and extent of interactions between fishing gears and marine benthos in Division 58.5.2 as well as several areas in Division 58.4.1. The key components required for such assessment include a seascape (i.e. application of 'landscape ecology' to the sea, relating to ecology of spatial units and the relationships between such units), vulnerability and impact assessment, as well as evaluation of potential management strategies. Details of each of these steps are summarised, and a summary of progress to date and a schedule of completion of tasks are provided.

3.17 The Working Group welcomed this paper and agreed that the large-scale effort of this research plan will be valuable in assessing the extent to which bottom fishing may exert significant adverse impacts on VMEs. The Working Group noted that the research is currently in the data collection and analysis phase, and that the final report should be available in 2011. It also noted that this work is part of an ongoing program of work by AAD, designed to explore key spatial management issues specific to the ecology of benthic organisms in the Southern Ocean.

3.18 Following the request of WG-SAM to consider the probability density functions for fragility (Annex 4, paragraphs 4.12 and 4.13), the Working Group noted that there is insufficient information to prescribe the actual form of the function for fragility in the impact assessments, and that the function may need to incorporate other variables.

3.19 The Working Group considered that a useful approach to estimating input functions for footprint and fragility could include using a hierarchy of information sources. For example, expert knowledge and the application of ecological first principles, such as those set out by WS-VME-09 (SC-CAMLR-XXVIII, Annex 10, Table 1), may be useful for characterising some aspects of these parameters, or for extending empirical observations of particular taxa to inform estimates for other taxa expected to have similar physical properties. More empirically derived data (e.g. laboratory experiments or other physical measurements) could provide a more precise description of gear performance and the nature of resistance to, and resilience from, disturbance for particular taxa. Finally, experimental observations in the field, such as those described in WG-EMM-10/23, 10/24 and 10/33, provide field-based empirical observations to estimate the nature and extent of contact between bottom fishing gear and benthic organisms, and associated fragility of VME taxa.

3.20 The Working Group noted the advice of WG-SAM (Annex 4, paragraphs 4.12 to 4.19) that combined cumulative impact assessments, following the sequential framework described in WG-SAM-10/20, be completed by WG-FSA. Following this advice, the Working Group recommended that the impact assessment method presented in WG-SAM-10/20 could be used by WG-FSA, taking account of advice in paragraph 3.11, to generate an overall impact for a fishery, including a cumulative assessment across all gear types.

3.21 The Working Group also recommended that Members undertake their preliminary assessments using this method and using standard metrics and units adopted by WG-SAM (Annex 4, paragraph 4.19). The Working Group noted that justification should also be given for the input functions used in their assessments.

3.22 The Working Group recommended that, in the absence of information that can be used to provide the shape of the probability density function for fragility, the functions utilised in WG-SAM-10/20, as well as information derived from the research trials described in WG-EMM-10/33 (mean fragility of 22% for gorgonians and 78% for stylasterids), could be used by WG-FSA to conduct an overall impact assessment for an area. The Working Group further noted that impact assessments could be summarised for various strata or locations as desired, such as vulnerable habitats identified using available data, e.g. contiguous habitats (paragraphs 3.30 to 3.34).

Identification of vulnerable habitats

3.23 WG-EMM-10/25 described a sampling program to quantitatively characterise the distribution, abundance and species composition of macrobenthic invertebrate fauna from 11 geographic areas of the HIMI region. The area was characterised from either beam trawl or benthic sled collections undertaken from 2003 to 2008. Preliminary analyses suggest that biological contrast is evident among areas; many taxa and assemblages exist in more than one area but significant heterogeneity also exists within areas. Analyses also suggest the presence of spatially restricted and/or endemic vulnerable taxa. The Working Group noted that Australia is currently using this information in evaluating the marine reserve and conservation zone established in Division 58.5.2 in 2003.

3.24 The Working Group noted that a variety of methods could be used to examine the potential spatial extent of particular taxa, but that conclusions on whether taxa are spatially restricted or endemic are highly dependent on both sampling intensity and taxonomic resolution. The Working Group agreed that such conclusions should take account of the associated sampling intensity and taxonomic aggregation, as well as the potential for Type 1 and Type 2 errors.

3.25 WG-EMM-10/24 described BICS, a compact, autonomous underwater video camera system designed for deployment on fishing gear to observe interactions of the gear with benthos and benthic habitats, but also able to be deployed as an independent drop camera.

3.26 The Working Group noted that the camera system allows rapid, efficient and inexpensive collection of quantitative and qualitative data about benthic habitats and associated communities, and has also provided direct observations of other biological phenomena, including krill mating behaviour. The Working Group welcomed the development of the camera system, noting that it has now been successfully deployed by scientific observers, and encouraged its further use (e.g. see paragraphs 3.13 to 3.15). The Working Group further requested that ad hoc TASO comment on how well the cameras might be deployed during commercial fishing operations.

3.27 WG-EMM-10/27 described the analysis of VME taxa by-catch data by New Zealand longline vessels fishing in the Ross Sea on a segment basis relative to catch rates of Antarctic toothfish (*Dissostichus mawsoni*). The analysis detected no functional correlation between the presence of six individual VME taxa and the catch of *D. mawsoni* at the scale of an individual line segment (c. 1.2 km). These results are consistent with the results of WS-VME-09/7, which found no functional correlation between total VME units and the catch of *D. mawsoni* at the scale of entire longline sets (c. 7 km). The Working Group noted that within the spatial and environmental envelope of the fishery, the results of WG-EMM-10/27 suggested that if a relationship exists between the occurrence of the six analysed VME taxa and *D. mawsoni*, then the relationship is unlikely to be strong.

3.28 The Working Group noted that it is unlikely that adult toothfish in the fishing grounds would be strongly associated with particular benthic invertebrate taxa, and that a relationship with benthic taxa may be more likely for other demersal fish species or perhaps juvenile *D. mawsoni*, which have been shown to be negatively buoyant and more likely to exploit benthic habitats (Near et al., 2003).

3.29 The Working Group considered the extent to which fishery data are reliable for exploring these kinds of environmental relationships and noted that environmental correlations of this kind are scale dependent, such that a relationship is guaranteed at the largest scales but virtually impossible at the smallest scales, as described in WG-SAM-10/20. Also, such analyses are dependent on the degree to which commercial operations can sample benthic taxa. WG-EMM-10/28 showed that sponges and gorgonians are regularly sampled but that the detectabilities of other taxa by commercial longline gear are unknown. The Working Group agreed that it is highly unlikely that the extent to which benthic taxa may share a similar environmental envelope with the fishery (e.g. similar depth preference) can be addressed using fishery-dependent data.

3.30 WG-EMM-10/28 characterised the spatial scale of benthic invertebrate habitats in fished areas of the Ross Sea region, and assessed the utility of sponge and gorgonian by-catch data on longlines as a means of monitoring encounters with those communities. This analysis revealed contrasting areas of habitat conditions, e.g. (i) large areas of dense fishery effort where by-catch was consistently zero, (ii) areas in which by-catch of sponges and gorgonians was dispersed, and (iii) areas where by-catch observations of sponge and/or gorgonians were clustered. The Working Group agreed that, for areas with high densities of effort, consistent zero by-catch observed indicates sponge or gorgonian habitats are at densities lower than for areas where the by-catch of those taxa was observed. The Working Group noted that conclusions on the spatial distribution of by-catch may change as more data are analysed; only two years of data from a subset of vessels are available at present.

3.31 WG-EMM-10/28 included spatial proximity analyses and analysis of underwater video transects to characterise: (i) the reliability of longlines as a sampling tool for sponges and gorgonians; (ii) the average spatial scale of observed habitat patches; and (iii) the average detectability of habitat patches.

3.32 The Working Group noted that the probability of catching a particular taxon with a longline hook may be very low, but the chance of capture with a line segment containing 1 000 hooks can be much higher, although this probability may be affected by the likelihood of the line segment intersecting a habitat patch either through line orientation or patch shape and sizes.

3.33 The Working Group agreed that the analysis described in WG-EMM-10/28 was useful for quantitatively describing spatial habitat distributions with fishery by-catch data. The Working Group noted that the paper provided some of the first available analysis to describe the spatial mosaic of habitat patches in the fished area, i.e. the detectability of habitat patches and size estimates of some sponge and gorgonian habitats. These estimates can be helpful in informing spatially explicit simulation modelling.

3.34 The Working Group noted that further application of the method described in WG-EMM-10/28 could be used to inform a number of tasks that rely on assumptions about the spatial mosaic within which VME taxa habitats occur, e.g. SC-CAMLR-XXVIII, paragraphs 4.252(ii), (v) and (vi). Furthermore, in areas where effort density is sufficiently high to enable clear delineation of habitat patches, the results of the method could be used to spatially constrain the application of the bottom fishery impact assessments to particular areas of interest. The Working Group recommended that the method be applied to other VME taxa where sufficient samples are available, to assess if longlines constitute a reliable sampling tool for those taxa.

3.35 The Working Group noted that several existing Risk Areas appear in close spatial association, indicating the potential existence of a larger habitat patch. Similar analyses could be used to justify aggregating Risk Areas to encompass the actual patch size.

3.36 The Working Group noted the advice of SC-CAMLR-XXVIII, paragraph 4.251(vi), seeking advice on alternative trigger levels for a range of VME taxa, including distinction between 'heavy' and 'light' taxa because of the low likelihood of triggering a Risk Area based on 'light' taxa. The Working Group agreed that trigger levels may be too high for some communities composed primarily of 'light' VME taxa, but that information necessary to determine appropriate trigger levels is currently lacking.

3.37 The Working Group noted that setting appropriate trigger levels relies on estimating the relationship between VME by-catch observed on board the vessel and the abundance of actual VME taxa density on the seafloor.

3.38 The Working Group noted that investigation of alternate trigger levels for different taxa could consider ecological characteristics (e.g. vulnerability, abundance, diversity, contribution to ecosystem function, rarity) important in determining the need to avoid impacting the area. The Working Group concluded that developing taxon-specific trigger levels appropriate to the goal of identifying vulnerable habitats will require the consideration of factors affecting observed levels of VME taxa and their vulnerability.

3.39 In the absence of the information necessary to inform alternate trigger levels, the Working Group agreed that management strategy evaluation approaches, such as those described in WG-SAM-10/9 and 10/19, may be useful to devise strategies that are robust despite uncertainties about the abundance and catchability of different VME taxa.

3.40 The Working Group noted the advice of SC-CAMLR-XXVIII, paragraph 4.251(ii), regarding development of a process by which Risk Areas should be reviewed. The Working Group agreed that such a review process should include reference to all available information indicative of the nature, abundance and ecological importance of the area, including:

(i) ecological characteristics of the VME taxa encountered at the Risk Area, along with the likely characteristics of the benthic community, including consideration of the organisms present and their life histories, rarity and ecological structure and function, and how the Risk Area relates to the distributions of those taxa in the wider area;

(ii) benthos by-catch data in the vicinity of the Risk Area;

(iii) the reliability of longline by-catch for the taxa in question as indicators of a VME;

(iv) the environmental, bathymetric or topographic context of the Risk Area location (e.g. submarine canyon, seamount etc.) with reference to known habitat associations;

(v) diversity and abundance of taxa in the local area, to incorporate the potential ecological importance of multi-species assemblages;

(vi) the actual and/or likely level of threat to the habitat or location, and associated footprint and impact estimates;

(vii) the overall management framework in place to avoid significant adverse impact on VMEs.

3.41 The Working Group recommended that CCAMLR encourage Members and fishers to collect new information wherever possible to inform the continued assessment of vulnerable habitats. Establishing the link between catch rates and organism density on the seafloor for each vulnerable taxon will be important to document the actual distribution and abundance of these habitats and identifying areas with no vulnerable habitats. Deployment of drop cameras as described in WG-EMM-10/24 in and near existing Risk Areas, or by systematically mapping habitats using cameras deployed from fishing vessel platforms could provide valuable data to characterise the distribution of vulnerable habitats.

Review of notifications of encounters with VMEs under CM 22-06

3.42 WG-EMM-10/14 notified the encounter of two potential VMEs from a fishery-independent research trawl survey in the South Orkney Islands, following the guidelines set out in CM 22-06, Annex 22-06/B. The notifications were justified with reference to anomalously high densities of pterobranchs and sea pens for two survey stations. The Working Group welcomed the work conducted in preparing the notification.

3.43 The Working Group noted that pterobranchs and sea pens were identified as indicator taxa by the Workshop on VMEs (SC-CAMLR-XXVIII, Annex 10). The observed densities of both taxonomic groups were considerably higher than in other locations across the survey area (i.e. more than four standard deviations greater than the mean density for all non-zero locations), and were also noted by scientists on board to be considerably higher than in other areas of the southern Scotia Arc region.

3.44 The Working Group noted that sampling benthic organisms within a survey area will yield a range of abundances and that conclusions regarding anomalously high densities should include consideration of sampling design, intensity and spatial scale of effort from which the distribution of densities is generated.

3.45 The Working Group noted that when assessing the extent to which particular observations are anomalous within a range of observations, it is important to assume appropriate density distributions, and that a lognormal distribution may be more appropriate than a normal distribution for abundance data. The Working Group further noted that, with existing data, the observed densities cannot be related to ecological importance or contribution to ecosystem function, which are other intrinsic factors that contribute to vulnerability. For some assemblages, rarity and vulnerability may be high and densities may be low. Under these circumstances, identification of VMEs may need to consider factors other than anomalously high values.

3.46 The Working Group noted that the survey design used to collect the data in WG-EMM-10/14 was described in WG-EMM-09/32, and was conducted at a sufficiently large spatial scale, was well stratified across a range of environmental variables potentially affecting VME taxa abundance, and was of sufficient sampling intensity that the Working Group could reasonably conclude the observed high densities were indicative of true anomalously high abundances of the VME taxa and not merely artefacts of sampling design.

3.47 The Working Group agreed that as a precautionary measure, designation of these two areas as registered VMEs is warranted unless additional information becomes available demonstrating that these areas do not constitute VMEs.

3.48 The Working Group agreed that a number of approaches could be used to justify the notification of a potential VME under CM 22-06, including (but not limited to): (i) anomalously high densities of VME taxa (taking account of sampling considerations as described in paragraph 3.44); (ii) observed rare or unique benthic communities; (iii) high diversity of VME taxa; (iv) benthic communities likely to be of particular importance for ecosystem function or species' life cycles; or (v) benthic communities with other characteristics likely to be vulnerable to bottom fisheries activities. Spatial scale and sampling considerations of any of these approaches should also be taken into consideration. The Working Group recommended further discussion of these types of approaches to provide guidance for future notifications.

3.49 The Working Group noted that there are a number of relevant definitions, characterisations and possible criteria that could be used to identify VMEs described in the WS-VME-09 report (SC-CAMLR-XXVIII, Annex 10) and that additional approaches could be developed in the future. The Working Group suggested that notification of encounters of VMEs through fishery-independent research activities should not be constrained by the format of CM 22-06, Annex 22-06/B, and that additional supplemental information supporting the designation of a VME could be supplied. Because notifications can be supported through a variety of approaches, the rationales used may not be transferable to other notifications, such that each case should be considered on its own merits in assisting CCAMLR to achieve its objectives of avoiding significant adverse impacts.

Evaluating management strategies

3.50 The Working Group noted that there were two papers with direct relevance to this agenda item. WG-SAM-10/9 described version 2 of Patch, a simulation model in R for evaluating spatial management strategies to inform management within CCAMLR on strategies to avoid significant adverse impacts on VMEs. WG-SAM-10/19 described a spatially explicit Schaefer production model designed to be used to simulate key processes of VME taxa population dynamics and bottom fishing effort, and to evaluate the effects of various management strategies.

3.51 The Working Group noted that it was requested by WG-SAM to evaluate simple case studies that could illustrate the operation of the models consistent with expectations under extreme scenarios to clearly illustrate the expression of particular input parameters (Annex 4, paragraph 4.7), and that WG-EMM is the appropriate body to provide guidance as to the particular spatial and ecological characteristics of VMEs (ibid., paragraph 4.9). The Working Group further noted that it was asked to consider what scenarios and performance measures provide a sound basis for evaluating management strategies to avoid significant adverse impacts on VMEs. The Working Group was unable to conduct any evaluations during the course of the meeting as the model scenarios had not yet been developed but encouraged this work to be submitted to WG-FSA.

3.52 In considering potential scenarios, the Working Group first took into account the objectives that surround evaluating spatial management strategies to avoid significant adverse impacts on VMEs. The Working Group noted the time frames set out in Article II of the CAMLR Convention and the FAO Guidelines for Deep Sea Fisheries on the High Seas, and agreed that some VME taxa and systems may have lower productivity than those for which these management objectives were initially developed. The Working Group agreed that modelling studies could be helpful in assessing benthic ecosystem dynamics and functions, and could aid in understanding the time scales necessary to reverse significant adverse impacts on VMEs. The Working Group agreed that strategies should be investigated that can meet the objectives in Article II. These strategies could include spatial management strategies, but could also consider mitigation strategies in the same way that strategies have been developed to mitigate seabird by-catch, such that the fishery can operate in areas with potentially vulnerable species, but that interactions are able to be kept to an appropriate level.

3.53 The Working Group noted that there were several factors that require consideration when performing these evaluations, including temporal scales, spatial scales and whether the framework is considering individual species or ecosystem effects. With respect to plausible operating models, the Working Group noted that plausible scenarios will need to include consideration of life-history characteristics, ecological theory, patch dynamics of sessile organisms and interaction between the fishery and habitat. The Working Group noted that currently it was likely to be easier to evaluate individual taxa in the first instance as opposed to system-based approaches.

3.54 The Working Group agreed that operating models may be used to identify and characterise the types of data that need to be collected in order to monitor and further develop options for management strategies, including mapping of habitats, to allow the development of open and closed fishing areas over particular types of VMEs, and therefore allow the measurement of the effects of bottom fisheries on VMEs.

3.55 The Working Group explored eight different factors that could be considered in developing case studies and identified the ranges of those factors that would be a priority:

Factor	Range
Succession	None, literature range (consistent with factors in patch dynamics and spatial distribution)
Productivity	Low (r = 0.01) to high (r = 0.20)
Dispersal	None, literature range
Target species and VME taxa correlation	Negative, None, Positive, Separate spatial scales (fish at larger scale than VMEs) – in all cases distinguish between causal versus incidental correlation
Gear impact (footprint*fragility)	Impact assessment range
Spatial distribution of habitats	Random, restricted (several scales)
Management action Current/new approaches	None, current, in-season versus annual step closures; representative closed areas
Fleet dynamics	Uniform random, incorporating target correlation (ideal free), historical

3.56 The Working Group recommended that these case studies, which should include extreme scenarios to clearly illustrate the expression of particular input parameters as well as values for plausible scenarios, be explored and presented along with a detailed description of the parameter values used for each scenario for consideration by WG-FSA this year.

Report of VMEs

3.57 WG-EMM-10/15, as previously introduced, provided a draft template and work plan for the 'Report on Bottom Fisheries and Vulnerable Marine Ecosystems' that was requested by WG-FSA last year. The Working Group agreed that the draft template was useful and well structured, and made a number of suggestions that will be incorporated into the draft template. The Working Group noted that much of the content of the template can be populated based on the WG-EMM and WS-VME reports, as well as several tables from WG-EMM-10/7.

3.58 The Working Group further agreed that the Report on Bottom Fisheries and VMEs could be split into two documents. The first document could contain the status of ecological knowledge relating to VMEs across the CAMLR Convention Area. It is expected that this document would change slowly with time as new information becomes available. The second document would contain information that is updated annually by the Secretariat and the Scientific Committee working groups, akin to Fishery Reports.

Protected areas

3.59 In 2009, the Scientific Committee identified a set of milestones designed to lead to the establishment of a representative system of MPAs (RSMPA) by 2012 (SC-CAMLR-XXVIII, paragraph 3.28).

3.60 The Scientific Committee agreed to, as identified in Milestone (i), 'by 2010, collate relevant data for as many of the 11 priority regions as possible (and other regions as appropriate), and characterise each region in terms of biodiversity patterns and ecosystem processes, physical environmental features and human activities'.

Circumpolar scale

3.61 WG-EMM-10/34 illustrated the application of a methodology for systematic conservation planning at the circumpolar scale. A circumpolar habitat classification of the Antarctic marine ecosystem was developed using the following datasets: (i) bioregional outputs of the 2006 Hobart Workshop (Grant et al., 2006); (ii) geomorphological features (O'Brien et al., 2009); and (iii) depth biomes based on GEBCO data. MARXAN was used as a decision-support tool to identify areas of conservation priority. Several results are presented in order to demonstrate a proof of concept that conservation planning can be applied at the Southern Ocean scale.

3.62 The Working Group observed that this approach added to past efforts, but noted that biological datasets were currently available that could be included in future bioregionalisation efforts, although this may be area-specific. For example, the 2010 Census of Antarctic Marine Life workshop (Villefranche CAML Biogeographic Synthesis Workshop, 18 to 21 May 2010) considered a strategy for studying large-scale biogeographic patterns of benthic and pelagic organisms, including fish and top predator species using data found in SCAR MarBIN. Such data sources could be used to inform future bioregionalisation efforts.

3.63 The Working Group questioned whether some of the inputs used in WG-EMM-10/34 were independent or confounded. For example, outputs from the Hobart Workshop and depth biomes are both strongly influenced by depth. Caution was therefore advised in interpreting the results of the analysis described in WG-EMM-10/34. It was also suggested that separate benthic and pelagic bioregionalisations would be useful, consistent with the advice of the CCAMLR Bioregionalisation Workshop (SC-CAMLR-XXVI, Annex 9).

3.64 The Working Group noted that presentation of results will need to be compatible with the spatial scales of the input data but recognised that outputs in WG-EMM-10/34 were intended to show levels of heterogeneity at the circumpolar scale.

3.65 The Working Group also noted that the early results of the analysis showed some correspondence with the 11 CCAMLR priority areas (SC-CAMLR-XXVII, paragraph 3.55(iv) and Annex 4, Figure 12). It agreed that this kind of analysis will provide an interesting and useful perspective on bioregionalisation and systematic conservation planning at the circumpolar scale. The authors were encouraged to continue their work, making improvement where appropriate, and to report progress to future workshops and meetings.

3.66 The Working Group provided the following specific suggestions to assist the authors in their work:

(i) generate separate bioregionalisations for the pelagic and benthic environments;

(ii) carefully select a limited number of environmental variables for use in the bioregionalisations, to avoid false resolution arising from the intersection of too many variables;

(iii) avoid the selection of multiple variables that are themselves highly correlated;

(iv) segregate the bioregionalisation outputs into separate biogeographic provinces, on the basis of known oceanographic or ecological boundaries;

(v) use biological distributions to represent areas of particular priority for conservation, represented as separate overlays;

(vi) clearly define conservation objectives with reference to both bioregionalisations and to separate biological layers, such that different areas represent different value levels for protection.

Eastern Antarctica

3.67 To date, there has been no consideration by CCAMLR of an RSMPA in Eastern Antarctica. Recognising the paucity of data for the region, WG-EMM-10/26 compiled relevant available data and developed a proposal for an RSMPA between 30°E and 150°E and from the coast to 60°S. The proposed RSMPA contains seven areas selected for their respective contributions to the protection of differing pelagic and benthic values. Covering 37% of the region, it aims to achieve low fragmentation of areas, develop efficient boundaries for management purposes, and provide reference areas, particularly for CEMP and for evaluating climate change impacts on Antarctic marine ecosystems. The authors identified that the proposal would be unlikely to impede rational use within the region, including for *E. superba* and *D. mawsoni*. A process for updating the boundaries as new information becomes available is suggested in the paper. The data layers used in the analyses will be available from the Secretariat.

3.68 WG-EMM-10/26 assessed the comprehensiveness of the RSMPA by considering the pelagic and benthic bioregionalisations as well as regional ecological barriers that structure Eastern Antarctica. Bioregionalisation methods described by Grant et al. (2006) were employed. For the pelagic bioregionalisation, data for depth, SST and sea-ice cover were used. For the benthic bioregionalisation, data for depth and geomorphological feature types were incorporated. The ecological barriers considered in the definition of large-scale biogeographic provinces included the oceanographic fronts of the Antarctic Circumpolar Current, the gyres in coastal waters, the near-surface winds and sea-ice movement. The adequacy of the RSMPA was assessed by considering the location of resources, scales of food webs and variability and long-term trends. The representativeness of the RSMPA was also considered. In considering comprehensiveness, adequacy and representativeness (CAR) the paper explored the underlying ecological principles that are necessary to meet these requirements.

3.69 The Working Group noted that the RSMPA detailed in WG-EMM-10/26 had been developed in line with the principles of systematic conservation planning. The proposed RSMPA is based on a scaled approach that has the potential to help CCAMLR understand the effects of fishing and other human impacts, and in maintaining the importance of CAR values (SC-CAMLR-XXIV, Annex 7, paragraph 14) in the regions, providing information in a structured manner both within and outside fished areas.

3.70 The Working Group noted that the nine pelagic ecotypes and 12 benthic ecotypes described in WG-EMM-10/26 had been selected because this number provided large-scale habitat proxies that were considered to be representative of Eastern Antarctica and were analogous to scales selected in comparable analyses elsewhere (e.g. at Heard Island). The Working Group recognised that it was difficult in practice to place boundaries around ecosystems, as the edges of habitats are often characterised by gradients and the biogeographical ranges of species do not necessarily match the boundaries described by habitat proxies. The Working Group noted that scale was important and that the analyses of Eastern Antarctica attempted not to over-interpret the available data.

3.71 The Working Group noted that the hierarchical analytical methods presented in WG-EMM-10/26 could allow a greater number of pelagic and benthic ecotypes to be selected than the numbers finally used. However, the authors considered that an RSMPA based on a greater number of areas would have a high probability of producing similar results, as greater heterogeneity would lead to greater numbers of smaller areas that may need to be included in an RSMPA in order to achieve the CAR principles. The authors also noted that in order to meet the monitoring requirements for CEMP and to measure climate change impacts, large areas would be needed to encompass the ecosystem processes and these would best be achieved in reference areas where fishing does not occur.

3.72 The authors of WG-EMM-10/26 explained that the RSMPA incorporated ecological boundaries that were determined using environmental components including wind, oceanographic circulation and sea-ice, all of which are processes that delineate oceanographic boundaries characterised by gradients. Despite spatial uncertainty associated with these ecological boundaries, they are thought to reflect known regional biological distributions in Eastern Antarctica. Different biogeographic provinces are known to exist in Eastern Antarctica; however, existing biological data remain inadequate to precisely position boundaries between the different provinces. The boundaries used in the RSMPA were positioned using the best available data, but further data would help to more precisely locate their positions.

3.73 The Working Group recalled that differences between local populations could be substantial; for example, differences between the benthos in adjacent marine canyon systems were known to be considerable in some situations. However, such small-scale biological diversity might not be reflected in habitat proxies for species distributions, such as in sea-surface temperature. Consequently, it is likely that smaller-scale heterogeneity will be present within the regions identified in the paper.

3.74 The Working Group recognised that the proposed RSMPA was developed to satisfy the principles of CAR and utility and then evaluated for its impact on rational use, including research, shipping and fishing. It agreed that ecosystem values satisfying CAR and utility might not necessarily be eroded by some human activities, but that other activities might impact on those values. Where ecological values were not eroded, there was no reason to limit those human activities. However, if ecological values were eroded by human activities, it would potentially compromise the utility of the RSMPA as a reference for understanding the ecosystem effects of fishing or the consequences of climate change to Antarctic marine ecosystems.

3.75 The Working Group noted that the RSMPA comprised 37% of the region in Eastern Antarctica. It recognised that the areal extent was not predetermined as a target but that it was the emergent cumulative consequence of satisfying the principles of CAR and the requirements for ensuring that the reserve system would have utility as reference areas. The Working Group recognised that this was consistent with previous discussions SC-CAMLR-XXIV, paragraphs 3.54(i) and (iv.a) (iv.b).

3.76 The Working Group noted that krill stocks in Prydz Bay and elsewhere in Eastern Antarctica were of potential interest to fishing operators (paragraph 2.18), but that these stocks had not been exploited for some years. Further, the authors noted that the proposed RSMPA is unlikely to limit access to these krill stocks given the structured design of the RSMPA and the oceanography of the region. The design of the RSMPA was such that it provided for matching open and closed areas that could be used to monitor the effects of fishing.

3.77 The Working Group also noted that *D. mawsoni* stocks in Eastern Antarctica were of interest to fishing operators and that the stocks have been exploited for some years through the exploratory fisheries in Divisions 58.4.1 and 58.4.2. The authors further noted that there was no known stock structure in the toothfish population; also, that given the mobility of individual toothfish, the proposed RSMPA is unlikely to limit access to the stock. The Working Group noted that the design of the RSMPA may allow CCAMLR to undertake a structured experiment to compare fished areas and unfished areas. It recognised that an experimental approach could be helpful in managing fish stocks as this may provide information that would otherwise be difficult to collect. The Working Group also recognised that refining the boundaries of the RSMPA (e.g. so boundaries better coincide with those of the SSRUs in Eastern Antarctica) may assist with such comparisons but the potential consequences for achieving the CAR principles would also need to be considered.

3.78 The Working Group noted that socio-economic issues and rational use may need to be considered further for this region (paragraphs 3.117 and 3.121).

3.79 The Working Group recognised that MPAs are often established with multiple objectives. At the time that a representative system of MPAs is established, there may be a hierarchy of conservation objectives, with specific objectives for the wider system and other smaller-scale objectives for individual MPAs.

3.80 The Working Group accepted that the purpose outlined in WG-EMM-10/26 was to satisfy the principles of CAR but also to achieve regional utility for CEMP and monitoring climate change impacts. To determine whether the latter objective might be achievable, the Working Group suggested that the authors of the paper, and other authors developing proposals for MPAs in the future, better characterise options for the spatial and temporal extent of monitoring throughout the region of interest.

3.81 The Working Group thanked the authors of WG-EMM-10/26 for their valuable contribution, acknowledging that the approach outlined in the paper had enabled WG-EMM to enhance its understanding of issues involved in establishing an RSMPA in CCAMLR waters by 2012.

The Ross Sea

3.82 The Working Group reviewed two separate contributions to characterise biodiversity patterns, develop bioregionalisations and conduct other scientific work to support the establishment of an RSMPA in the Ross Sea and the south Pacific sector of the Southern Ocean. One of these focused on Priority Area 11 and was presented in a set of three papers (WG-EMM-10/11, 10/12 and 10/P11); the other considered a region including portions of Priority Areas 10 and 11 and was presented in WG-EMM-10/30. Both contributions represented collaborative work by many different scientists.

3.83 Information on environmental and biodiversity patterns is presented in WG-EMM-10/11. This covers physics, mainly geology, glaciology, water mass circulation, sea-ice and climate change effects. Information on lower trophic levels is also presented, including information on microbial communities and benthic communities; information on mid-trophic levels includes data on zooplankton and fish; while information on upper trophic levels includes data on squid, *D. mawsoni*, cetaceans, seals (Ross seals (*Ommatophoca rossii*), crabeater seals (*Lobodon carcinophagus*), leopard seals (*Hydrurga leptonyx*) and Weddell seals (*Leptonychotes weddellii*)), penguins (Adélie penguins (*Pygoscelis adeliae*) and emperor penguins (*Aptenodytes forsteri*)) and other seabirds (petrels and albatrosses). The authors attempted to synthesize the patterns of distribution in Table 2 on page 50 of the paper.

3.84 The Working Group thanked the authors for their valuable compilation of data and suggested that it would be useful if the data layers could be made available to other Members if requested. It noted that the compilation of data was only feasible because of the long and diverse history of scientific endeavour in the Ross Sea, and that this will facilitate the work of systematic conservation planning. The Working Group also noted that much of the data described in WG-EMM-10/11 originated from sources not generally available to CCAMLR, including from university-based researchers.

3.85 The Working Group noted that many of the data layers described in WG-EMM-10/11 were comparable to a number of the data layers described in WG-EMM-10/30, but that there was not a complete overlap. It recommended that the authors of both papers correspond intersessionally, and consider whether it was possible to develop integrated data products and a further level of synthesis for the CCAMLR 2011 MPA Workshop (paragraphs 3.119 to 3.130). The Working Group noted that more recent data on some species were available for endemic finfishes that might be incorporated in time for 2011.

3.86 WG-EMM-10/12 reported on the results of analyses describing the niche occupancy of various predators in the Ross Sea region, considering three important components: (i) their projected spatial distribution and overlap; (ii) their capacity to utilise different parts of the water column (foraging depth); and (iii) diet. Species for which distributions were modelled included cetaceans (Antarctic minke whale (*Balaenoptera bonaerensis*) and Ross Sea killer whale (*Orcinus orca*) – ecotype C), seals (crabeater seal and Weddell seal), penguins (Adélie penguin and emperor penguin) and other seabirds (light-mantled sooty albatross (*Phoebetria palpebrata*), Antarctic petrel (*Thalassoica antarctica*) and snow petrel (*Pagodroma nivea*)). Leopard seals and killer whale ecotype A/B, were not included because of their rarity and lack of adequate sightings data. Adequate data for modelling Arnoux's beaked whales (*Berardius arnuxii*), *D. mawsoni* and colossal squid (*Mesonychoteuthis hamiltoni*), which are also important predators, were not available. Predator distribution patterns were modelled at a resolution of 5 km^2, using environmental data and species presence data. A machine learning, 'maximum entropy' modelling algorithm (MAXENT) was used to model spatial patterns of the probability of species' occurrence. These data were then used to identify areas of importance to species in a conservation prioritisation framework. Data on diving depth and diet were taken from the literature.

3.87 WG-EMM-10/12 reported that three patterns of spatial use in the Ross Sea were apparent: (i) use of the shelf break, which includes the outer continental shelf and slope; (ii) full use of both the shelf and the slope; and (iii) use of the Marginal Ice Zone (pack-ice surrounding the Ross Sea post-polynya). Diet composition overlapped extensively, but the use of foraging space was partitioned by dive depth.

3.88 The authors noted that the suite of predators studied used the entire shelf and slope in a mosaic, although not necessarily during the same season. Spatial modelling of species richness indicated that the outer shelf and slope, as well as the deeper troughs in the Ross Sea shelf and in the vicinity of Ross Island, were particularly important to the upper trophic level taxa of the Ross Sea.

3.89 The Working Group recognised that the authors of WG-EMM-10/12 had accomplished a considerable amount of complex spatial modelling that could be very valuable for informing a systematic conservation planning process. It agreed that further development would be very valuable and encouraged further submissions to the Working Group. The Working Group also noted that there were various technical issues that would be valuable to address, in particular regarding the use of additional or alternate input variables, assessing model sensitivity to various input parameters, and validation of spatial predictions. The Working Group noted that similar issues had been addressed in the development of WG-EMM-10/P14, and encouraged intersessional correspondence between the relevant authors (see also paragraph 3.82).

3.90 WG-EMM-10/30 presented the outcomes of a 'Bioregionalization and Spatial Ecosystem Processes of the Ross Sea Region' expert workshop hosted by New Zealand and attended by 21 international scientists with a wide range of relevant expertise. The region within which outputs are bounded is defined as 150°E–150°W, and north to 60°S, which includes most of CCAMLR MPA Priority Area 10 and all of Priority Area 11. Analytical methods for the bioregionalisation were as in Grant et al. (2006) and SC-CAMLR-XXVI, Annex 9, i.e. automated environmental classification using cluster analyses of environmental datasets, iteratively selected and validated with reference to expert knowledge and spatial biological data. Outputs from the Ross Sea workshop include the following:

(i) a fine-scale benthic bioregionalisation, with 17 benthic bioregions;

(ii) a fine-scale pelagic bioregionalisation, with 18 pelagic bioregions;

(iii) a list and map of 27 spatially bounded ecosystem processes of particular importance for conservation of the regional ecosystem, including areas containing: spatially fixed oceanographic processes (3); flexible pelagic processes related to ice dynamics (4); concentrations of dominant pelagic middle trophic species supporting higher trophic levels (3); spatially constrained top predator foraging areas (4); processes/areas of particular importance for *D. mawsoni* (4); processes/areas of particular importance for other fish (3); and benthic processes/areas of particular importance (6).

3.91 The Working Group noted that WG-EMM-10/30 illustrated an approach to support spatial planning in a region with abundant scientific data available. In particular, the authors of WG-EMM-10/30 made direct use of a large amount of biological data, both to validate the bioregionalisations and as separate overlays to depict ecosystem processes which may constitute areas of particular importance in their own right. The Working Group noted that this is one of the strengths of the regional-scale bioregionalisation approach, allowing approaches and methods to be tailored as appropriate to each region, to fully utilise available data.

3.92 The Working Group noted that the pelagic and benthic bioregionalisations benefitted from the availability of more than 60 environmental data layers, including multiple alternate depictions of important dynamic ecosystem drivers (e.g. sea-ice) and custom-generated layers to depict particular variables deemed most important for influencing spatial biological patterns. The selection, retention and transformation of environmental data layers to drive the bioregionalisation was iteratively adjusted with reference to available biological data until bioregionalisation outputs accurately depicted important ecological patterns in areas where patterns were known, at as fine a resolution as possible without depicting false resolutions.

3.93 The pelagic bioregionalisation utilised variables representing three main drivers: depth, water mass characteristics and sea-ice dynamics. The benthic bioregionalisation utilised variables representing five main drivers: depth, seafloor water temperature, factors affecting substrate (current speed and benthic rugosity), deposition of pelagic production (ice cover, as a proxy for available light) and iceberg scour.

3.94 The Working Group noted that the bioregionalisations will inform the design of a system of MPAs to meet the objective of representativeness, but the 27 ecosystem process areas are depicted as separate overlays, and may constitute conservation objectives in their own right within a systematic conservation planning framework. The Working Group further noted that some areas will be more important than others, and that setting appropriate protection levels for different areas should consider the ecological importance of the processes in the area and the size or precision with which the area is defined.

3.95 The Working Group noted that many of the identified ecosystem processes or areas of importance overlie the Ross Sea shelf and slope. The authors noted that this probably reflects the ecological importance of the shelf and slope area relative to other areas, but also the availability of scientific data.

3.96 The Working Group observed that the bioregionalisation described in WG-EMM-10/30 included both Priority Areas 10 and 11 and questioned why these areas were grouped together, especially since datasets available for each area were quite different. The authors responded that the bioregionalisations themselves were each executed in an imposed hierarchical fashion, with a first-order split defined at the continental shelf break to capture this dominant ecological contrast, and subsequent classifications carried out separately for the shelf environments and for the deeper northern environments. Subsequent identification of important ecosystem properties were depicted for the whole region to illustrate the connectivity of ecosystem function between shelf/slope and areas further north. It was noted that the CCAMLR statistical area scheme already identified the larger area.

3.97 The Working Group noted that the Ross Sea shelf and slope are preferentially utilised by fish, seabirds and marine mammals, which exhibit different utilisation patterns in different seasons and at different life-history stages but that specific top predator foraging areas are depicted in WG-EMM-10/30 only for those areas where predators are spatially constrained during the nesting/pupping season (penguins and Weddell seals), and/or where the potential exists for trophic overlap with the toothfish fishery (Weddell seals and Type C killer whales). The Working Group noted that important foraging areas for unconstrained predators are represented separately as generic ecosystem processes influencing productivity (e.g. the Ross shelf front, the Ross Sea polynya edge) or as concentrations of key pelagic prey species (silverfish and krill).

3.98 The Working Group noted that WG-EMM-10/30 identified several areas on the shelf and shelf slope that are thought to be particularly important for *D. mawsoni*. Toothfish are the target of the Ross Sea longline fishery but are also ecologically important in their own right, e.g. as a principal finfish predator, such that these areas may be used to inform both spatial protection objectives and rational use objectives simultaneously.

3.99 The Working Group noted that WG-EMM-10/30 depicted only ecological patterns without reference to human activities, but that the systematic conservation planning process is explicitly designed to consider cost-benefit trade-offs between protection and rational use. The question arose as to the potential of catch or CPUE data being used in the current bioregionalisation process. The authors noted that spatially explicit fishing effort distributions are available for the entire history of the Ross Sea toothfish fishery, and distribution modelling for demersal fish species, including *D. mawsoni*, is being progressed. Fishery-independent data would also be of great assistance when considering the species.

3.100 The Working Group thanked the authors of WG-EMM-10/30 for their valuable contribution, and encouraged them to build on this work in the development of a spatial management proposal in advance of the CCAMLR MPA Workshop in 2011 (paragraphs 3.119 to 3.130).

3.101 In considering systematic conservation planning efforts in the Ross Sea Region, the Working Group recommended that it would be valuable if collaboration and integration between the research teams currently supporting separate efforts to characterise patterns of biodiversity and ecosystem processes occurred prior to the development of any proposal for area protections. The Working Group agreed that a synthesis of the separate efforts presented this year would be expected to support the development of a comprehensive and effective spatial management plan to achieve CCAMLR objectives.

Other areas

3.102 A new initiative by France is now under way to develop marine spatial planning options for both Kerguelen and Crozet Islands. This initiative will consider environmental and biological data through a bioregionalisation analysis. It is envisaged that both benthic and pelagic species will be included in analyses across a range of trophic levels. Data describing human activities will also be incorporated. Having developed a set of spatially resolved data layers, different decision-support tools will be used to develop a spatial management framework.

3.103 A similar initiative by the UK is also under way for Subarea 48.3. This initiative will also consider a range of data, including data describing environmental and biological processes and human activities in a systematic conservation planning framework.

3.104 A project by the US AMLR Program is also under way for the Antarctic Peninsula region. This initiative will also consider a range of data to develop a spatial management framework.

General discussion on MPAs

Terminology relevant to the bioregionalisation and systematic conservation planning process in CCAMLR

3.105 The Working Group recalled that the whole CAMLR Convention Area is managed and protected, but that there are areas within the Convention Area that require further special consideration. Such areas were considered by the CCAMLR MPA Workshop in 2005 and endorsed by the Scientific Committee (SC-CAMLR-XXIV, paragraphs 3.54 and 3.55).

3.106 The Working Group also recalled that the ideas, concepts and terminology used by CCAMLR to describe the spatial planning process and any level or levels of protection afforded by CAMLR conservation measures were to fulfil the objectives of CCAMLR as specified in Article II of the Convention and may not relate to terminology used elsewhere.

Using common ecological terminology in relation to systematic conservation planning

3.107 The Working Group noted that the terms 'Representative Systems of MPAs' and 'Representative Network of MPAs' have been used interchangeably in past reports of the Scientific Committee, WG-EMM and various workshops. This history has caused some confusion and the Working Group noted its preference for the term 'Representative System of MPAs'. This preference was based on noting that the word 'network' implies MPAs will be connected in space and this is not necessarily required to achieve the objectives for the CCAMLR system.

3.108 The Working Group recognised that it was currently not feasible to develop a single set of terms that would adequately and accurately describe the classification of ecosystem components, processes and properties across all scales in all spatial systematic conservation planning projects, because different projects are likely to apply different methodologies consistent with available data. However, the Working Group agreed that it would help increase understanding amongst the CCAMLR community if practitioners of spatial systematic conservation planning could, to the extent possible, utilise a common set of terms in relation to ecosystem components, processes and properties, and clearly define whatever terms are used. It also agreed that it would further increase understanding if common terminology could be used in relation to scale-based ecological components and if such terminology made it evident whether biological and/or physical components were being considered. Examples of useful hierarchical terminologies include those recently developed by Last et al. (2005). The Working Group recommended that practitioners should always be careful to ensure that adopted terms accurately correspond to the actual methodologies or outputs to which they are applied.

Issues related to bioregionalisation

3.109 The Working Group recognised that as CCAMLR developed experience with spatial systematic conservation planning it would be able to develop advice for new practitioners and details of good practice. At present much of the good practice used within the CCAMLR community was the result of experience developed at the Hobart Bioregionalisation Workshop in 2006 (Grant et al., 2006), the CCAMLR Bioregionalisation Workshop (SC-CAMLR-XXVI, Annex 9) and in efforts undertaken by Members within EEZs or at a regional scale (e.g. Lombard et al. (2007); CM 91-03; SC-CAMLR-XXVIII/14; WG-EMM-10/26 and 10/30).

3.110 The Working Group reviewed submitted approaches to date and agreed that Members planning to undertake bioregionalisation and systematic conservation planning in the CAMLR Convention Area could:

(i) where biological data is lacking, use bathymetric, oceanographic or climatological data indicative of biogeographic boundaries to define large-scale biogeographic provinces within which spatial planning will occur separately (as in WG-EMM-10/26);

(ii) where biological and other spatial data are available, use appropriate datasets to locate areas containing ecosystem processes that may constitute conservation objectives in their own right and represent these areas as separate spatial overlays (as in WG-EMM-10/30);

(iii) generate separate pelagic and benthic bioregionalisations (as in WG-EMM-10/26 and 10/30);

(iv) for pelagic bioregionalisations, consider the selection of the following three large-scale environmental drivers: (a) depth, (b) water mass characteristics, and (c) dynamic ice behaviour (as in WG-EMM-10/26 and 10/30).

Appropriate use of decision-support tools

3.111 The Working Group recalled that the Scientific Committee had endorsed the use of MARXAN as one tool that was considered appropriate for use in systematic conservation planning (SC-CAMLR-XXVII, paragraph 3.55(iii)). Further, that the use of MARXAN had been deemed appropriate in the development of the recently adopted South Orkneys Southern Shelf MPA (SC-CAMLR-XXVIII, paragraph 3.19). However, The Working Group recognised that MARXAN had limitations (as described in Ardron et al., 2008) and therefore may not be appropriate for use in all conservation planning situations. The Working Group also recognised that all planning tools probably had analogous sets of limitations.

3.112 The Working Group noted that the systematic conservation planning process is designed to be a transparent method by which costs and benefits associated with different spatial planning proposals can be evaluated. The Working Group noted that so long as objectives and constraints are explicitly defined with reference to spatially explicit layers, then alternate solutions can be evaluated objectively relative to one another without the use of decision-support tools such as MARXAN.

3.113 The Working Group noted that CCAMLR was focused on developing a system of MPAs that would protect areas with specific characteristics (SC-CAMLR-XXIV, paragraphs 3.54 and 3.55). It recognised that it was the ecological properties within such areas that were the key focus, rather than the size of the area *per se*. The Working Group recalled that for the South Orkneys MPA, a sensitivity analysis had been used and this was a valuable process in setting reserve size. However, it noted that the size of an area may be important where resilience to a changing environment was a key issue.

3.114 In determining the size of a reserve or protected area, the Working Group noted that objective criteria provided a useful starting point, but that more subjective considerations based on expert knowledge may need to be made to take account of uncertainty.

Systematic conservation planning in relation to climate change

3.115 The Working Group noted that monitoring of ecosystem components and processes within an individual MPA, including stocks of fish and krill, may not increase CCAMLR's ability to respond to climate change processes if done in isolation. Further, it recognised that a system of MPAs may not help with conserving ecosystem components, if climate processes changed rapidly and the areas are small. However, the Working Group considered that larger areas may be more resilient than smaller areas, particularly if they were also protected from harvesting. A structured system of protected areas would have an additional benefit, in that it could provide an opportunity to examine, in a systematic way, the impacts of fishing in the context of environmental change. It was also noted that a system of undisturbed areas around the Southern Ocean could be used to monitor the effects of climate change impacts on Southern Ocean marine ecosystems while taking account of regional differences in those impacts.

Rational use

3.116 The Working Group reiterated that it is important to be clear about objectives for spatial management design, with reference to conservation goals and effects on rational use, and to clearly identify how achievement of the objectives will be assessed, taking account of uncertainty. It is important that the underlying rationale for spatial management be transparent.

3.117 The Working Group agreed that it was important for both the Scientific Committee and Commission to provide guidance on how to address the topic of rational use in the development of an RSMPA. It requested that the topic of rational use be discussed at the 2010 meetings of the Scientific Committee and Commission.

3.118 The Working Group recommended that a paper be developed for the Scientific Committee following a framework similar to that in WG-EMM-10/26, but considering, in particular, how scientific issues relating to rational use may be considered in this process. Such a framework could be applicable to a broad range of regions. Ideally, this paper would be developed through a collaborative process that involved interested Members so that a paper would be presented for broader discussion at the Scientific Committee. Dr A. Constable agreed to facilitate this process.

MPA workshop in 2011

3.119 WG-EMM-10/31 presented a preliminary proposal, developed by the MPAs Special Fund Correspondence Group, for a CCAMLR workshop on MPAs to be convened in 2011 and supported by the MPA Special Fund. This workshop will fulfil Milestone (ii) in the list of agreed milestones and provide information to assist Members in achieving other milestones contributing towards the development of an RSMPA by 2012 (SC-CAMLR-XXVIII, paragraph 3.28). The workshop proposal includes terms of reference, suggested outputs, required expertise and logistical/financial considerations for discussion by WG-EMM.

3.120 The workshop output may be a report for consideration by SC-CAMLR (and possibly by WG-EMM depending on workshop timing and venue). The report may include a summary of progress to date on existing and proposed MPAs in the Convention Area, advice on the use of specific tools, methodologies or datasets appropriate to the work, recommendations on draft MPA proposals that might be submitted to the workshop and a work program for the identification of MPAs in priority regions and other regions.

3.121 The Working Group considered the scope of the MPA workshop, specifically whether or not the terms of reference should include a consideration of socio-economic aspects of MPA designation. It was acknowledged that while policy aspects of the establishment of MPAs were most appropriately addressed at the Commission, characterising trade-offs to meet multiple objectives, including objectives for protection and rational use, are an integral part of the process of developing an RSMPA at the WG-EMM and Scientific Committee levels. It was concluded that there are technical aspects in the development of MPAs that involve socio-economic issues so the topic should be incorporated into the terms of reference at an appropriate level.

3.122 The Working Group recalled discussion of the approach used in the development of the East Antarctica proposed system of MPAs (WG-EMM-10/26). The series of questions used to ensure CAR was achieved were viewed as a useful framework in which to discuss goals that might seem in conflict, such as conservation and rational use. The framework of questions could facilitate a discussion of cost-benefit trade-offs, which are an integral part of systematic conservation planning. The authors were encouraged to submit these questions to the next meeting of the Scientific Committee for further consideration.

3.123 Whilst discussing the principles of CAR, the Working Group noted that WG-EMM-10/26 had helped clarify many of the issues related to the development of an RSMPA in the Convention Area. It therefore endorsed this approach for future use by others as one approach, among others, which could be useful in developing an RSMPA (SC-CAMLR-XXVII, Annex 4, paragraph 3.59).

3.124 In discussing whether a system of MPAs was likely to be representative, the Working Group considered that a focus at the level of ocean basins is appropriate. The Working Group agreed that the CCAMLR statistical areas would be satisfactory in the first instance. This would enable CCAMLR to better understand whether the biological diversity was adequately represented within the CAMLR Convention Area.

3.125 The Working Group discussed the utility of monitoring as a tool for understanding whether an RSMPA was achieving the goal of protecting identified values. Monitoring has the potential to not only provide data required to evaluate success, but also to provide data that can be used in revising management plans over time should changes in an MPA be observed, or changes in values for which protection was provided. For example, monitoring can provide data that can help address the current uncertainty with regard to climate change.

3.126 The Working Group reviewed the proposed terms of reference in WG-EMM-10/31 and recommended that the terms of reference be:

(i) To review progress on the development of a representative system of Marine Protected Areas (RSMPA) in the CAMLR Convention Area, including consideration of:

  (a) recently designated MPAs and other spatial protection/management measures;

  (b) proposals for new MPAs and other spatial protection/management measures.

(ii) To share experience on different approaches to the selection of candidate marine sites for protection, including consideration of:

  (a) types of scientific information that could be used for the identification of areas of conservation importance;

  (b) use of bioregionalisation and other data compilations, e.g. characterisations of priority regions in terms of biodiversity patterns and ecosystem processes, physical environmental features and human activities; and representation of particular biological distributions and ecosystem processes as separate overlays;

  (c) identification of conservation objectives appropriate to different regions; with reference to particular data layers and metrics against which achievement of objectives might be assessed;

  (d) identification of the value of particular areas for rational use;

  (e) methods for identifying and prioritising candidate marine sites for protection, including the means by which conservation and rational use objectives might be addressed;

  (f) use of decision-support tools or approaches.

(iii) To review draft proposals for MPAs or an RSMPA in the CAMLR Convention Area, submitted for this purpose, such that Members developing proposals can incorporate feedback from the workshop and revise their proposals accordingly in advance of SC-CAMLR in 2011.

(iv) To develop a work program for further developing an RSMPA in each statistical area, including consideration of:

(a) regions in which further work to identify MPAs is now required, based on current progress and considering the 11 priority regions and other regions as appropriate;

(b) collaboration with the Committee on Environmental Protection towards a harmonised approach to the development of RSMPAs south of 60°S.

3.127 The Working Group recommended the following list of workshop outputs:

(i) Summary of progress on developing an RSMPA, which could include:

(a) the current status of existing and proposed MPAs in the Convention Area;

(b) updated consideration of priority regions in which further work to identify MPAs could be focused;

(c) recommendations on draft MPA proposals.

(ii) Work program for finalising recommendations on an RSMPA for the Commission meeting in 2012.

3.128 The Working Group discussed practical aspects of the workshop, including the length of time required for a successful outcome, as well as timing and location of the workshop. The Working Group agreed that a five-day workshop would be necessary to address the terms of reference and produce a final report. It was noted that a factor which contributed to the success of the two previous stand-alone MPA workshops for the Convention Area was the ability of participants to prepare and focus on just one theme. Alternatively, holding the workshop in conjunction with WG-EMM and WG-SAM would allow for savings in travel costs for participants and the Secretariat.

3.129 Difficulty in setting a date for the MPA workshop in 2011 will result from other planned meetings or workshops scheduled for the same year (paragraphs 6.4 to 6.7). The Working Group recognised that the Scientific Committee will need to address this difficulty at its 2010 meeting. It was recommended that the MPA Correspondence Group produce a circular to the Scientific Committee to identify issues related to holding the MPA workshop so that Members would be fully prepared for a discussion at the 2010 meeting of the Scientific Committee.

3.130 The Working Group recognised the value of inviting technical experts to participate in the MPA workshop. Representation from amongst a broad range of CCAMLR Members was considered to be important. The Working Group agreed that organisations with appropriate experience for this workshop could be invited, including SCAR, CEP and the IUCN. Also, experts providing scientific papers submitted to the workshop to address elements of the terms of reference could be invited, subject to the Scientific Committee Rules of Procedure. Another recommendation was to include those with expertise in bioregionalisation, systematic conservation planning and the development of high-seas MPAs. It was suggested that key material documenting CCAMLR's progress in the development of an RSMPA be provided prior to the workshop. This would be particularly useful for those coming from a non-CCAMLR background. The Working Group recommended that the MPA Correspondence Group engage in a discussion to identify potential experts for discussion at the 2010 meeting of the Scientific Committee.

Cape Shirreff ASPA

3.131 A revised management plan for ASPA No. 149, Cape Shirreff and San Telmo Islands, Livingston Island, South Shetlands Islands, was presented for consideration by the Working Group (WG-EMM-10/21). Protection to this area, which includes a site at which CEMP data have been collected since 1994, is afforded through the Antarctic Treaty. The management plan, which is undergoing its required periodic review, includes updated information on biological communities and provides greater protection with the addition of a preferred air access zone.

3.132 Values to be protected under the original Antarctic Treaty designation in 1966 included the diversity of fauna and flora, particularly marine mammals. The area was subsequently afforded protection by CCAMLR through its designation as a CEMP site in 1994 under the provisions of CM 91-01 (CM 91-02 (1994)). In an effort to harmonise protection under the ATS and to avoid duplication of management plans, protection under CCAMLR was rescinded with the lapse of CM 91-02; protection continues under the ATS with the management plan of ASPA No. 149 (SC-CAMLR-XXVIII, Annex 4, paragraph 5.29).

3.133 Due to CCAMLR interest in continued protection of a site where CEMP data are collected, the proponents of the ASPA (Chile and the USA) requested comments from CCAMLR prior to submission to the ATCM for approval of the revised management plan.

3.134 The Working Group welcomed the opportunity to review the revised management plan for Cape Shirreff and recommended that the Scientific Committee approve the revised plan for ASPA No. 149.

ADVICE TO THE SCIENTIFIC COMMITTEE AND ITS WORKING GROUPS

4.1 The Working Group provided advice to the Scientific Committee and other working groups on the following topics:

(i) Krill –

  (a) in-season catch and effort reporting in krill fisheries (paragraph 2.14);

  (b) notifications for krill fisheries in 2010/11 (paragraphs 2.20 and 2.21);

  (c) field studies to investigate krill escape mortality (paragraph 2.38);

  (d) scientific observer coverage in krill fisheries (paragraphs 2.49 to 2.52);

(e) use of SDWBA in estimating B_0 (paragraph 2.56);

(f) revised estimate of B_0 in Subareas 48.1 to 48.4 (paragraph 2.62);

(g) revised precautionary catch limit for krill in Subareas 48.1 to 48.4 (paragraphs 2.68 to 2.71);

(h) further consideration of the three-stage decision rule for determining precautionary catch limits for krill (paragraph 2.78).

(ii) VMEs –

(a) terminology relevant to the management of VMEs (paragraphs 3.3 and 3.5);

(b) summary of notifications made under CMs 22-06 and 22-07 (paragraphs 3.7 and 3.8);

(c) access to VME data (paragraph 3.9);

(d) development of impact assessments (paragraphs 3.20 to 3.22);

(e) deployment of camera systems by scientific observers for collecting data on benthic habitats and associated communities (paragraph 3.26);

(f) development of assessments of vulnerable habitats (paragraphs 3.40 and 3.41);

(g) VMEs notified under CM 22-06 (paragraphs 3.46 to 3.49);

(h) report on bottom fisheries and VMEs (paragraph 3.58).

(iii) Protected areas –

(a) terminology in relation to bioregionalisation and systematic conservation planning (paragraphs 3.105, 3.106 and 3.108);

(b) approaches to bioregionalisation and systematic conservation planning (paragraph 3.110);

(c) rational use (paragraphs 3.116 to 3.118);

(d) MPA Workshop in 2011 (paragraphs 3.126 to 3.130);

(e) revised management plan for ASPA No. 149, Cape Shirreff and San Telmo Islands (paragraph 3.134).

(iv) Future work –

(a) format, duration and timing of the meeting of WG-EMM in 2011 (paragraphs 3.126 and 5.3);

(b) three- to five-year science plan (paragraphs 5.5 to 5.8, 5.11 and 5.12).

(v) Other matters –

(a) consideration of the Global Environment Facility (GEF) capacity building in CCAMLR-related science (paragraph 6.3);

(b) five-day catch and effort reporting for research activities notified under CM 24-01 (paragraph 6.13);

(c) succession planning (paragraph 6.14).

FUTURE WORK

5.1 The Working Group considered the following draft agenda for its meeting in 2011 (WG-EMM-10/1):

2. MPA Workshop
3. Ecosystem effects of fishing for krill
   - 3.1 The krill fishery and scientific observation
   - 3.2 Krill-dependent predators (standard methods, STAPP, CEMP Review)
   - 3.3 Climate impacts
   - 3.4 Feedback management strategies for the krill fishery
   - 3.5 Tasks resulting from the CCAMLR Performance Review
4. Ecosystem effects of fishing for finfish.

5.2 Dr Watters presented a series of options for the structure of the Working Group meeting in 2011 (Table 4) that addressed the current priorities for the Working Group and the desire to restrict the duration of the meetings.

5.3 The Working Group agreed that the choice of the format and duration of its meeting next year should be considered by the Scientific Committee and that such considerations should identify the standing item that there is a requirement for WG-EMM to provide advice to the Scientific Committee on an annual basis, as well as those items where advice is not required each year.

5.4 Given the proposed agenda for 2011, the Working Group agreed that WG-EMM-10/P1 to 10/P5, 10/P15 and 10/P16 on higher predators at the Prince Edward Islands, as well as WG-EMM-10/22 and 10/P7 on the myctophid fish in the South Georgia area, would be carried forward to 2011, pending consideration of the agenda by the Scientific Committee.

5.5 The Working Group discussed the development of mechanisms to increase the effectiveness of its meetings and to ensure that it can deliver the science required to provide advice requested by the Scientific Committee in a timely manner. This included developing both a strategic plan that identified the science areas that would need to be delivered over the next 3–5 years, as well as a tactical strategy to ensure that the science objectives in the strategic plan were delivered. This tactical strategy would include identifying groups or individuals, including the Secretariat, that could undertake to deliver the required work in the timeframe described in the strategic plan.

5.6 Such a plan would facilitate the work of scientists progressing different areas of work and would also assist the Secretariat in allocating time and resources to support that science.

5.7 The Working Group agreed that providing greater clarity in the rationale for the science priorities of the Working Group and the Scientific Committee would help in increasing engagement in the work and would also be helpful in developing a greater understanding of the work of CCAMLR.

5.8 The following items of future work were identified during the current meeting:

(i) Krill issues –
  (a) Escape mortality experiments and manual (e.g. paragraph 2.32)
  (b) Recruitment variation and decision rules (paragraph 2.78)
  (c) Integrated assessment (e.g. paragraph 2.3)
  (d) B_0 and precautionary catch limits for Divisions 58.4.1 and 58.4.2 (paragraph 2.71).

(ii) VME issues –
  (a) Review Risk Areas and notifications from research cruises (paragraphs 3.40 and 3.48)
  (b) Triggers for light and heavy taxa (paragraphs 3.36 to 3.39)
  (c) Spatial scales (e.g. paragraph 3.30)
  (d) Parameterisations for models and impact assessments (paragraphs 3.54 to 3.56).

(iii) MPA issues –
  (a) Further synthesis for the Ross Sea (paragraphs 3.85 and 3.101)
  (b) Progress science to support other proposals (e.g. paragraphs 3.102 to 3.104)
  (c) Prepare for MPA workshop (e.g. paragraphs 3.129 and 3.130).

The Working Group recommended that these items be included in the considerations of the Scientific Committee while addressing the issues raised in paragraphs 5.1 to 5.3.

5.9 Prof. D. Butterworth (South Africa) indicated that, based on recent experience with anchovy fisheries in South Africa, he may be able to provide work to address the issues identified in paragraph 5.8(i.b), although he noted that this would be dependent on obtaining appropriate resources to undertake this work.

5.10 In response to a request from Dr R. Crawford (South Africa), the Working Group noted that data from predators, other than those species currently included in CEMP, may be very useful in the proposed review of CEMP, as well as in monitoring to detect the effects of climate change.

5.11 The Working Group agreed that the following items should be considered for inclusion on the agenda for the meeting of WG-EMM in 2012, contingent on the discussion of priorities and the progress made on other items during 2011 and encouraged Members to contribute to this work:

(i) MPAs –

(a) by 2011, submit proposals for areas for protection to the Scientific Committee;

(b) by 2012, submit proposals on an RSMPA to the Commission.

(ii) Krill and krill predators –

(a) integrated assessment
(b) feedback and spatial management
(c) decision rules and climate change.

5.12 The Working Group requested that the Scientific Committee consider whether various spatial management approaches, including inter alia, MPAs, VMEs, ASPAs and ASMAs, could be integrated.

OTHER BUSINESS

6.1 Dr A. Naidoo (South Africa) advised the Working Group that South Africa had approached the GEF for advice on accessing GEF funding to support capacity building in science in the Southern Ocean and the Antarctic. The areas of initial interest to South Africa included climate change, conservation planning, particularly in relation to MPAs, oceanographic processes and fishery monitoring and building capacity to engage more fully in science processes in CCAMLR. It was noted that South Africa is about to acquire a new research vessel that will be deployed to support South African research effort in the Southern Ocean, and that this effort could foreseeably involve other countries with a mutual interest in such research.

6.2 The Working Group welcomed a presentation by Dr D. Vousden (South Africa/UNDP) that described how GEF considered the South African approach to be compatible with the strategy for funding support under Objectives 3 and 4 of the GEF International Waters Focal Area within the fifth replenishment cycle of GEF. GEF had provided advice to South Africa concerning elaboration of the concept for further consideration. GEF noted that other CCAMLR Members, including Argentina, Chile, India, Namibia and Uruguay, would be eligible for GEF funding support within a multilateral initiative to build capacity in Antarctic and Southern Ocean science. South Africa advised its intention to engage these developing countries and other potential partners in further developing this draft concept.

6.3 The Working Group considered that, while there is a need to consider the proposal in the context of CCAMLR's priorities, GEF resources could be utilised for broadening participation of GEF-eligible countries in the work of CCAMLR. Management of the krill fishery in the South Atlantic Ocean, climate change and ecosystem monitoring are among areas of the proposal of direct relevance to WG-EMM while other components would involve other working groups. How funding might be allocated would be considered during further development of the project. The Working Group expressed general support for the concept and looked forward to further information being presented to the next meeting of the Scientific Committee.

Planned workshops associated with the work of WG-EMM

6.4 Dr J. van Franeker (European Union) informed the Working Group of a workshop entitled 'Antarctic Krill in a Changing Ocean' to be hosted in The Netherlands, funded by the European Union, in April/May 2011. The Working Group noted the broad aims of the proposed workshop. It suggested that a useful item for consideration would be an update of the analyses of the relationship between krill and sea-ice in order to better understand the trends presented in Atkinson et al. (2004). The Working Group requested the workshop organisers to provide an update of plans for the Scientific Committee this year.

6.5 Dr Watters informed the Working Group of ongoing discussion with the Lenfest Foundation in respect of two workshops designed to contribute towards the development of feedback management of krill. It is proposed that the first of these workshops would examine how krill dynamics and variability are linked across Area 48 with the second examining the monitoring of the consequences of this variability in krill.

6.6 Dr Constable informed the Working Group of two workshops being planned by ICED, the first of which, on monitoring the effects of climate change, was scheduled for September 2011, while the second, on model development, was scheduled for the first half of 2012.

6.7 The Working Group agreed that there is a need for coordination of the increasing number of workshops being planned in order to maximise the potential synergies for the work of CCAMLR.

Southern Ocean Observing System

6.8 The Science Officer informed the Working Group of correspondence from the Executive Director of SCAR seeking input from CCAMLR scientists in the development of the scientific rationale and strategy for the Southern Ocean Observing System (SOOS) (www.scar.org/soos/) and encouraged all interested parties to provide feedback (soos@scar.org) before 1 October 2010.

CCAMLR Science

6.9 The Working Group agreed that the ranking of *CCAMLR Science* as 16 out of the 42 journals in the Fisheries subject category of the Thomson Reuters Journal Citation Reports (WG-EMM-10/13) was a reflection on the quality of science undertaken in CCAMLR.

6.10 In response to comments from the Science Officer about the need to delay publication of some papers by a year because of the annual publication cycle of the journal, the Working Group considered whether greater flexibility in the publication of the electronic version of the journal might be possible if it was not tied to the publication of a hard-copy volume. The Secretariat agreed to examine the implications of changing the publication cycle of both the electronic and hard-copy versions.

Working Group papers

6.11 The Working Group discussed the potential for making working group papers publicly available, noting that this would contribute to the transparency of the CCAMLR decision-making process. While there was support for the principle of making papers more available, there was recognition that it was important to have clarity in the process of how working group papers are to be dealt with in order to maintain the current high standard of work submitted to the working groups. The Secretariat undertook to prepare a discussion paper for consideration by the Scientific Committee on this subject.

6.12 The Working Group welcomed the proposed single Document Submission Form (WG-EMM-10/13, Appendix 1) proposed by the Secretariat (as a replacement for the two separate forms currently required).

Conservation Measure 24-01

6.13 The Working Group noted that currently CM 24-01 requires the notification of very small catches taken during research surveys and that such reporting is not the intention of the measure. The Working Group suggested that, in order to address this issue, the existing conservation measure should be modified.

Succession planning

6.14 The Convener informed the Working Group that he intended to continue in the role for two more years in order that there was sufficient time to identify a replacement. The Working Group agreed that the following items would be useful for discussion by the Scientific Committee in respect of the convenership of working groups:

(i) fixed terms for conveners of working groups would allow for more effective successional planning;

(ii) a mentoring role, including a hand-over year when the incumbent and the incoming convener shared the role;

(iii) the development of clear instructions on the role of conveners that could be made available to new conveners, and broader distribution of this material to meeting participants would provide a greater understanding of the conduct of the meeting.

ADOPTION OF THE REPORT AND CLOSE OF THE MEETING

7.1 The report of the meeting of WG-EMM was adopted.

7.2 In closing the meeting, Dr Watters thanked the participants for their contributions to the meeting and their work during the intersessional period, Dr Parker for facilitating the subgroup discussions on VMEs, and the rapporteurs for bringing together a short focused report. He also thanked Dr Mayekiso and his local organising team for providing a beautiful venue and excellent facilities for the meeting, and the Secretariat for its support.

7.3 Dr Trathan, on behalf of the participants, thanked Dr Watters for his work in preparing for, and convening the meeting, and leading the discussions, including the subgroup discussions on krill.

7.4 The meeting was closed.

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Table 2: Sensitivity of harvest rates to increasing the overall CV in the estimate of B_0 (based on 10 001 iterations for each CV). The CV in recruitment is fixed at 12.6% in all cases.

CV survey	CV methodological	CV total	γ	Harvest rate
12.8%	0%	12.8%	γ_2	**0.093**
			γ_1	0.121
12.8%	22.2%	25.6%	γ_2	**0.094**
			γ_1	0.114
12.8%	49.6%	51.2%	γ_2	0.098
			γ_1	**0.094**

Table 3: Sensitivity of harvest rates to increasing levels of recruitment variability. The overall CV in the estimate of B_0 is fixed at 12.8% in all cases.

CV recruitment	γ	Harvest rate
12.6%	γ_2	**0.093**
	γ_1	0.121
17.0%	γ_2	0.092
	γ_1	**0.072**

Table 4: Proposed options for the meeting of WG-EMM in 2011.

1 week that includes MPA Workshop[1]	1 week but separate MPA Workshop[1]	2 weeks that include MPA Workshop	2 weeks but separate MPA Workshop
MPA Workshop	Krill-dependent predators (Standard Methods, STAPP, CEMP Review)	MPA Workshop	Full agenda from preliminary draft (SC CIRC 10/31)
Review data from krill fishing season and notifications[2]	Tasks from CCAMLR Performance Review OR Climate Change	Items from second column	More krill (e.g. integrated assessment, recruitment and decision rules)
Review VME Risk Areas and notifications	Review data from krill fishing season and notifications[2]		
	Review VME Risk Areas and notifications		

[1] Would require two additional days to prepare and adopt report.
[2] Would limit discussion to review of summary papers prepared by the Secretariat.

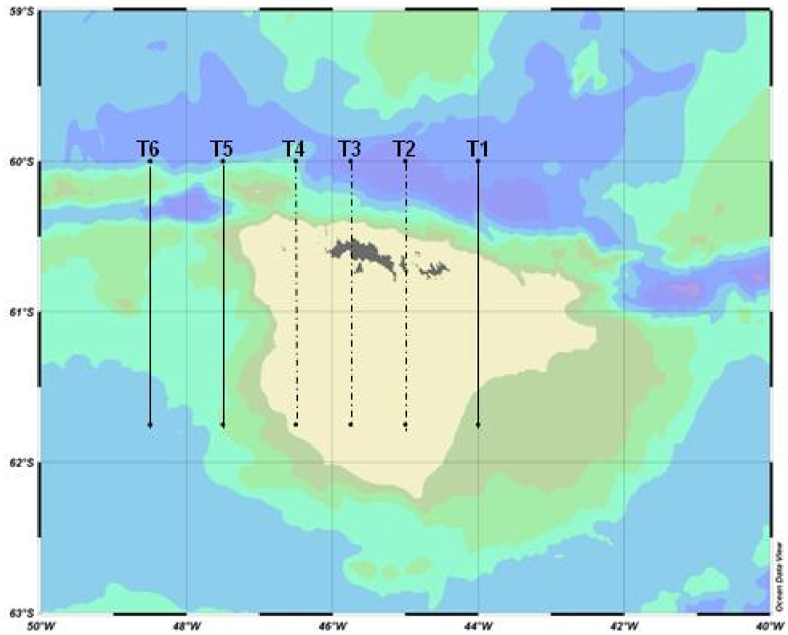

Figure 1: Bathymetry of the South Orkney Islands with transect locations used by the US AMLR Program during an acoustic survey conducted in 2008 and presented as a potential sampling design for a proposed survey by the Norwegian krill fishing vessel *Saga Sea*. Dashed lines represent transects that may have to be altered to transit around islands. All transects have northernmost waypoints at 60°S and southernmost waypoints at 61.75°S. Longitudes for Transects 1 (T1) through 6 (T6) are, respectively, at 44°W, 45°W, 45.75°W, 46.5°W, 47.5°W and 48.5°W.

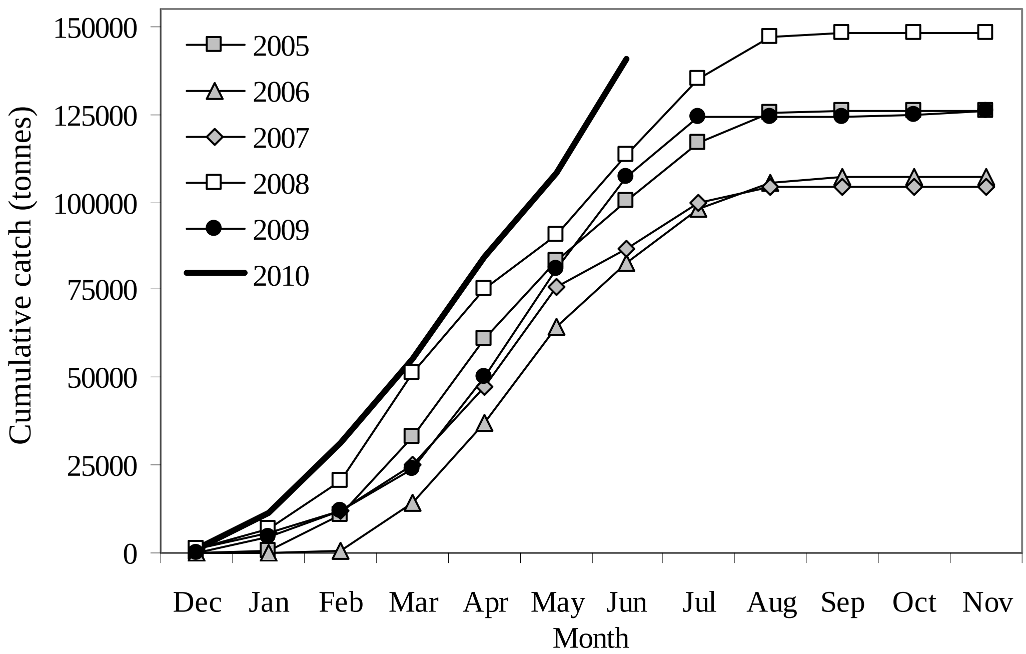

Figure 2: Monthly cumulative catch of krill in Area 48 in each season since 2004/05. Source: monthly catch and effort reports to June 2010.

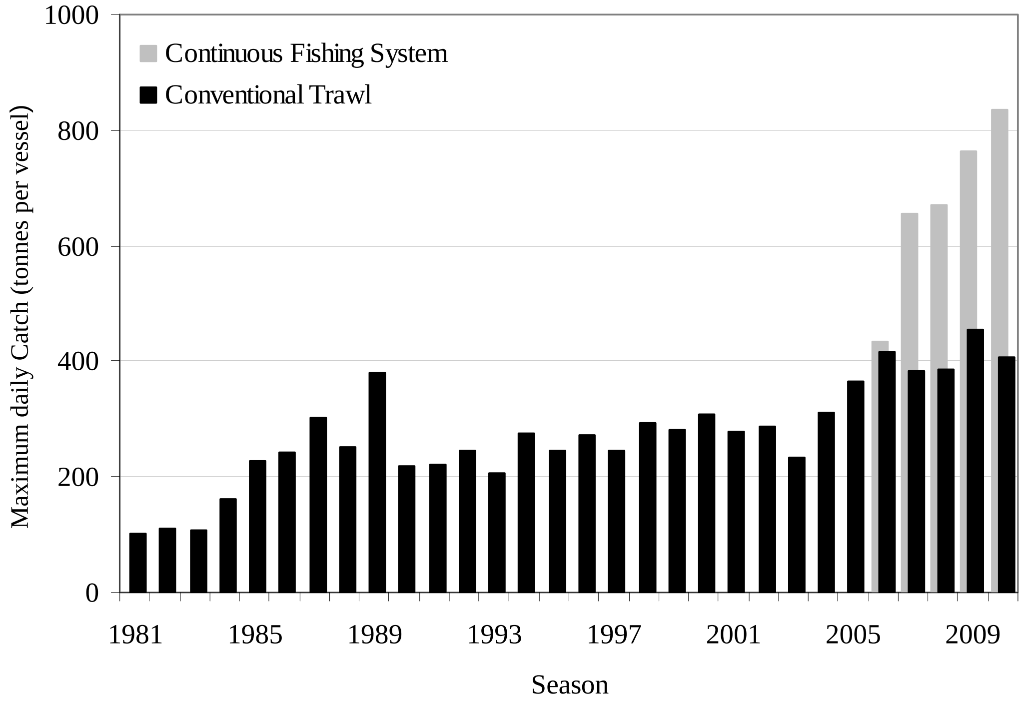

Figure 3: Maximum daily catch of krill (tonnes per vessel) reported from Area 48 since 1980/81. Source: C1 data.

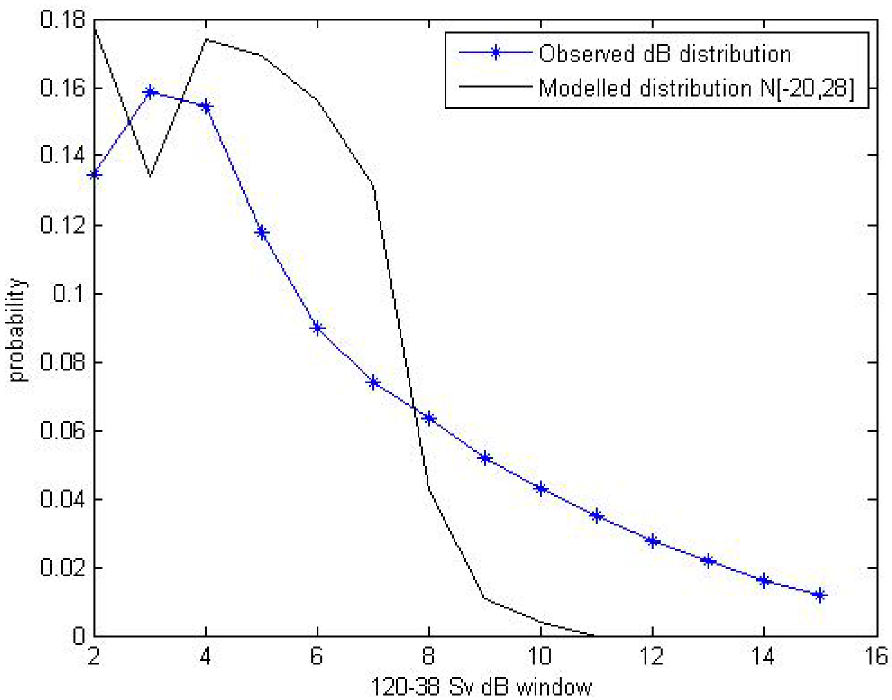

Figure 4: Observed and modelled dB-difference distributions for the best-fitting krill orientation distribution. The observed distribution is derived from the difference in acoustic backscatter for 120 and 38 kHz from the entire synoptic survey. The modelled distribution is generated from the SDWBA model with an orientation distribution with a mean of –20° and a standard deviation of 28°.

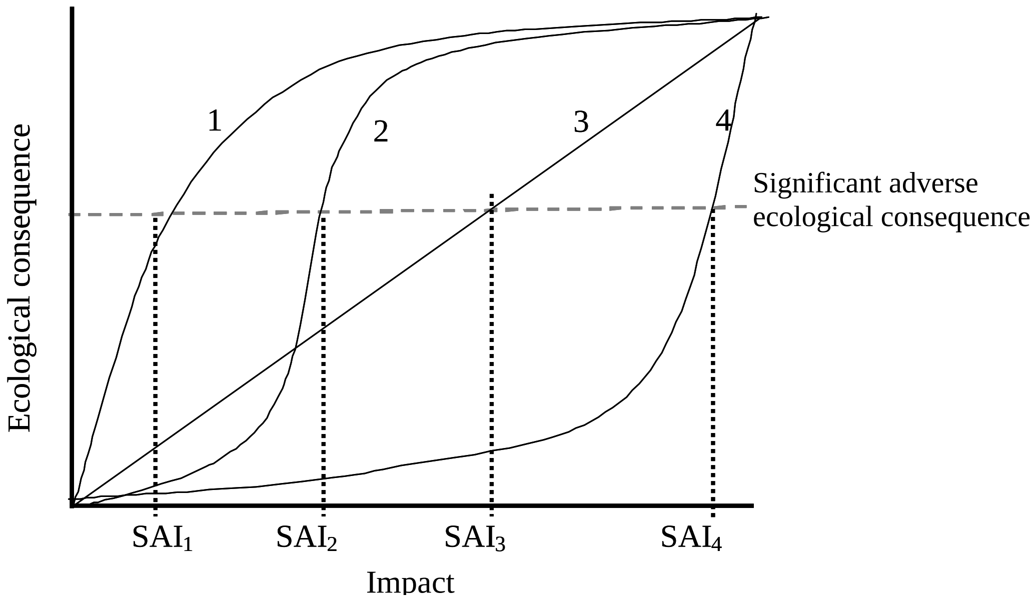

Figure 5: Alternative hypothetical forms of the relationship between impact and ecological consequence. 'Significant adverse impact' (SAI) refers to the level of impact that would constitute a significant adverse ecological consequence.

APPENDIX A

LIST OF PARTICIPANTS

Working Group on Ecosystem Monitoring and Management
(Cape Town, South Africa, 26 July to 3 August 2010)

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APPENDIX B

AGENDA

Working Group on Ecosystem Monitoring and Management
(Cape Town, South Africa, 26 July to 3 August 2010)

1. Introduction
   1.1 Opening of the meeting
   1.2 Adoption of the agenda and appointment of rapporteurs
   1.3 Review of requirements for advice and interactions with other working groups

2. Ecosystem effects of fishing for krill
   2.1 Krill
   2.2 The krill fishery and scientific observation of the fishery
   2.3 Estimates of B_0 and precautionary yield for krill

3. Spatial management to facilitate the conservation of marine biodiversity
   3.1 Vulnerable marine ecosystems
   3.2 Protected areas

4. Advice to the Scientific Committee and its working groups

5. Future work

6. Other business

7. Adoption of the report and close of the meeting.

APPENDIX C

LIST OF DOCUMENTS

Working Group on Ecosystem Monitoring and Management
(Cape Town, South Africa, 26 July to 3 August 2010)

WG-EMM-10/1	Draft Preliminary Agenda for the 2010 Meeting of the Working Group on Ecosystem Monitoring and Management (WG-EMM)
WG-EMM-10/2	List of participants
WG-EMM-10/3	List of documents
WG-EMM-10/4	Summary of observations aboard krill trawlers operating in the Convention Area Secretariat
WG-EMM-10/5	Krill fishery report: 2010 update Secretariat
WG-EMM-10/6	Summary of notifications for krill fisheries in 2010/11 Secretariat
WG-EMM-10/7	Summary of VME notifications made under Conservation Measures 22-06 and 22-07 Secretariat
WG-EMM-10/8	Results of krill fishery in Subarea 48.2 in the 2009 season based on data of the Russian vessel *Maxim Starostin* S.Yu. Gulyugin, V.E. Polonskiy and S.M. Kasatkina (Russia)
WG-EMM-10/9	The importance of obtaining annual biomass information in CCAMLR Subarea 48.2 to inform management of the krill fishery N. Jensen (Norway), R. Nicoll (Australia) and S.A. Iversen (Norway)
WG-EMM-10/10	On the need to determine the level of krill escapement mortality in the Antarctic krill fishery L. Pshenichnov and G. Milinevsky (Ukraine)
WG-EMM-10/11	Ross Sea Biodiversity, Part I: validation of the 2007 CCAMLR Bioregionalisation Workshop results towards including the Ross Sea in a representative network of marine protected areas in the Southern Ocean D.G. Ainley, G. Ballard and J. Weller (USA)
WG-EMM-10/12	Ross Sea Bioregionalisation, Part II: Patterns of co-occurrence of mesopredators in an intact polar ocean ecosystem G. Ballard, D. Jongsomjit and D.G. Ainley (USA)

WG-EMM-10/13	*CCAMLR Science*: an update and suggested changes to document handling/submission Secretariat
WG-EMM-10/14	High densities of pterobranchs and sea pens encountered at sites in the South Orkney Islands (Subarea 48.2): two potential VMEs S.J. Lockhart and C.D. Jones (USA)
WG-EMM-10/15	Report on bottom fisheries and vulnerable marine ecosystems: draft template and workplan WG-FSA Subgroup on VMEs
WG-EMM-10/16	Distribution and size-age composition of Antarctic krill in the South Orkney Islands region (CCAMLR Subarea 48.2) D.O. Sologub and A.V. Remeslo (Russia) (*CCAMLR Science*, submitted)
WG-EMM-10/17	Interannual variability of standardised index of krill abundance in Area 48 according to CCAMLR fishery statistics database P.S. Gasyukov and S.M. Kasatkina (Russia)
WG-EMM-10/18	Recommendations on estimating krill escape mortality during fishing operations: the problems and approaches V.K. Korotkov and S.M. Kasatkina (Russia)
WG-EMM-10/19	Review of Russian investigations of krill escape through the meshes of commercial trawls: approaches to estimating gross removal at krill fishery S.M. Kasatkina (Russia)
WG-EMM-10/20	Monitoring krill larvae at the Weddell-Scotia confluence E. Marschoff, N.S. Alescio, D. Gallotti and G. Donini (Argentina)
WG-EMM-10/21	Revised Management Plan for Cape Shirreff ASPA 149 P.A. Penhale (USA) and V. Vallejos Marchant (Chile)
WG-EMM-10/22	Annual changes in species composition and abundance of myctophid fish in the north of South Georgia (CCAMLR Subarea 48.3), Antarctica, during austral winter from 2002 to 2008 T. Iwami, M. Naganobu, K. Taki and M. Kiyota (Japan) (*CCAMLR Science*, submitted)
WG-EMM-10/23	Update on the 'Demersal interactions with marine benthos in the Australian EEZ of the Southern Ocean: an assessment of the vulnerability of benthic habitats to impact by demersal gears' project G.P. Ewing, D.C. Welsford and A.J. Constable (Australia)

WG-EMM-10/24	Using compact video camera technology for rapid deep-sea benthic habitat assessment G.P. Ewing, R. Kilpatrick, A.J. Constable and D.C. Welsford (Australia)
WG-EMM-10/25	Quantitative assessment of benthic fauna and assemblages in the Heard Island and McDonald Islands region T. Hibberd, D.C. Welsford, A.J. Constable, K. Moore and S. Doust (Australia)
WG-EMM-10/26	Elaborating a representative system of marine protected areas in eastern Antarctica, south of 60°S A.J. Constable, B. Raymond, S. Doust, D. Welsford and K. Martin-Smith (Australia)
WG-EMM-10/27	Is toothfish catch correlated with the catch of vulnerable benthic invertebrate taxa? S.J. Parker and M.H. Smith (New Zealand) (*CCAMLR Science*, submitted)
WG-EMM-10/28	Spatial scales of benthic invertebrate habitats from fishery by-catch and video transect data in the Ross Sea region S.J. Parker, R.G. Cole and S.M. Hanchet (New Zealand)
WG-EMM-10/29	A glossary of terms relevant to the management of Vulnerable Marine Ecosystems (VMEs) in the CCAMLR Area B.R. Sharp and S.J. Parker (New Zealand)
WG-EMM-10/30	Bioregionalisation and spatial ecosystem processes in the Ross Sea region B.R. Sharp, S.J. Parker, M.H. Pinkerton (New Zealand) (lead authors) also B.B. Breen, V. Cummings, A. Dunn (New Zealand), S.M. Grant (United Kingdom), S.M. Hanchet, H.J.R. Keys (New Zealand), S.J. Lockhart (USA), P. O'B. Lyver, R.L. O'Driscoll, M.J.M. Williams, P.R. Wilson (New Zealand)
WG-EMM-10/31	Proposal for a CCAMLR Workshop on Marine Protected Areas (2011) MPA Special Fund Correspondence Group
WG-EMM-10/32	Proposal for GEF (Global Environment Facility) funding to support capacity building and training to the GEF-eligible countries with Antarctic interests South Africa
WG-EMM-10/33	Preliminary assessment of the potential for the proposed bottom fishing activities to have significant adverse impact on vulnerable marine ecosystems United Kingdom

WG-EMM-10/34	Demonstrating proof of concept of the application of systematic conservation planning at the circumpolar scale D. Beaver, R. Nicoll, G. Llewellyn, P. Harkness, C. Hellyer and J. Turner (ASOC-WWF)

Other Documents

WG-EMM-10/P1	Recent trends in numbers of four species of penguins at the Prince Edward Islands R.J.M. Crawford, P.A. Whittington, L. Upfold, P.G. Ryan, S.L. Petersen, B.M. Dyer and J. Cooper (*Afr. J. Mar. Sci.*, 31 (3) (2009): 419–426)
WG-EMM-10/P2	Recent trends in numbers of Crozet shags breeding at the Prince Edward Islands R.J.M. Crawford, P.G. Ryan, B.M. Dyer and L. Upfold (*Afr. J. Mar. Sci*., 31 (3) (2009): 427–430)
WG-EMM-10/P3	A tale of two islands: contrasting fortunes for sub-Antarctic skuas at the Prince Edward Islands P.G. Ryan, P.A. Whittington and R.J.M. Crawford (*Afr. J. Mar. Sci*., 31 (3) (2009): 431–437)
WG-EMM-10/P4	Recent population estimates and trends in numbers of albatrosses and giant petrels breeding at the sub-Antarctic Prince Edward Islands P.G. Ryan, M.G.W. Jones, B.M. Dyer, L. Upfold and R.J.M. Crawford (*Afr. J. Mar. Sci*., 31 (3) (2009): 409–417)
WG-EMM-10/P5	Estimates of numbers of kelp gulls and Kerguelen and Antarctic terns breeding at the Prince Edward Islands, 1996/97–2008/09 P.A. Whittington, R.J.M. Crawford, B.M. Dyer and P.G. Ryan (*Afr. J. Mar. Sci*, 31 (3) (2009): 439–444)
WG-EMM-10/P6	Larval development and spawning ecology of euphausiids in the Ross Sea and its adjacent waters in 2004/05 K. Taki, T. Yabuki, Y. Noiri, T. Hayashi and M. Naganobu (*Plankton and Benthos Res*., 4 (4) (2009): 135–146)
WG-EMM-10/P7	Linking predator and prey behaviour: contrasts between Antarctic fur seals and macaroni penguins at South Georgia C.M. Waluda, M.A. Collins, A.D. Black, I.J. Staniland and P.N. Trathan (*Mar. Biol.*, 157 (1) (2009): 99–112)

WG-EMM-10/P8	Krill population dynamics at South Georgia: implications for ecosystem-based fisheries management K. Reid, J.L. Watkins, E.J. Murphy, P.N. Trathan, S. Fielding and P. Enderlein (*Mar. Ecol. Prog. Ser.*, 399 (2010): 243–252)
WG-EMM-10/P9	Swarm characteristics of Antarctic krill *Euphausia superba* relative to the proximity of land during summer in the Scotia Sea T. Klevjer, G.A. Tarling and S. Fielding (*Mar. Ecol. Prog. Ser.*, (in press))
WG-EMM-10/P10	Variability and predictability of Antarctic krill swarm structure G.A.Tarling, T. Klevjer, S. Fielding, J. Watkins, A. Atkinson, E. Murphy, R. Korb, M. Whitehouse and R. Leaper (*Deep-Sea Res. I*, 56 (2009): 1994–2012)
WG-EMM-10/P11	Responding to climate change: Adélie penguins confront astronomical and ocean boundaries G. Ballard, V. Toniolo, D.G. Ainley, C.L. Parkinson, K.R. Arrigo and P.N. Trathan (*Ecology*, 91 (7) (2010): 2056–2069)
WG-EMM-10/P12	AMLR 2009/10 Field Season Report: objectives, accomplishments and conclusions A. Van Cise (Editor) (*AMLR 2009/2010 Field Season Report: Objectives, Accomplishments and Conclusions*. NOAA Technical Memorandum, NOAA-TM-NMFS (in press))
WG-EMM-10/P13	Mean circulation and hydrography in the Ross Sea sector, Southern Ocean: representation in numerical models G.J. Rickard, M.J. Roberts, M.J.M. Williams, A. Dunn and M.H. Smith (2010) (*Ant. Sci*. (2010): doi: 10.1017/S0954102010000246)
WG-EMM-10/P14	Spatial and seasonal distribution of adult *Oithona similis* in the Southern Ocean: predictions using boosted regression trees M.H. Pinkerton, A.N.H. Smith, B. Raymond, G.W. Hosie, B. Sharp, J.R. Leathwick and J.M. Bradford-Grieve (*Deep-Sea Res. I*, 57 (2010): 469–485)
WG-EMM-10/P15	Summer survey of fur seals at Prince Edward Island, southern Indian Ocean M.N. Bester, P.G. Ryan and J. Visagie (*Afr. J. Mar. Sci*., 31 (3) (2009): 451–455)

WG-EMM-10/P16 Intra-archipelago moult dispersion of southern elephant seals at the Prince Edward Islands, southern Indian Ocean
W.C. Oosthuizen, M.N. Bester, P.J.N. de Bruyn and G.J.G. Hofmeyr
(*Afr. J. Mar. Sci.*, 31 (3) (2009): 457–462)