ANNEX 4

REPORT OF THE WORKING GROUP ON ECOSYSTEM MONITORING AND MANAGEMENT
(Christchurch, New Zealand, 17 to 26 July 2007)

CONTENTS

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INTRODUCTION

Opening of the meeting

1.1 The thirteenth meeting of WG-EMM was held at the Latimer Hotel, Christchurch, New Zealand, from 17 to 26 July 2007. The meeting was convened by Dr K. Reid (UK). In addition, a Workshop on Fisheries and Ecosystem Models in the Antarctic was held jointly by WG-EMM and WG-FSA on 16 July 2007 (SC-CAMLR-XXVI/BG/6; paragraphs 7.6 to 7.21).

1.2 Meeting participants (manuhiri, or visitors) were welcomed with a karakia (traditional Maori blessing) conducted by Apanui Skipper representing the tangata whenua (hosts). This was followed by a waiata (traditional song) performed by staff from the Christchurch office of the National Institute of Water and Atmospheric Research (NIWA).

1.3 The meeting was opened by the Rt Hon. Winston Peters, Minister of Foreign Affairs, who welcomed the participants and thanked them for their contribution to the conservation of Antarctic marine living resources. Dr Reid thanked the Rt Hon. Minister and the local organisers for their warm hospitality and for hosting the meeting.

1.4 Dr Reid extended his welcome to the participants, and outlined the program of work for the meeting. This work included:

- a Workshop to Review Estimates of B_0 and Precautionary Catch Limits for Krill (section 2 and Appendix D);
- further development of management procedures to evaluate options for subdividing the krill catch limit among SSMUs in Area 48 and consideration of the advice from WG-SAM (paragraphs 6.35 to 6.47; Annex 7);
- discussion of the core business of the Working Group.

Adoption of the agenda and organisation of the meeting

1.5 The provisional agenda was discussed by WG-EMM and adopted without change (Appendix A).

1.6 The meeting participants are listed in Appendix B. The documents submitted to the meeting are listed in Appendix C.

1.7 The report was prepared by Drs A. Constable (Australia), D. Demer (USA), M. Goebel (USA), Mr J. Hinke (USA), Drs R. Holt (USA), C. Jones (USA), S. Kawaguchi (Australia),

S. Nicol (Australia), M. Pinkerton (New Zealand), D. Ramm (Data Manager), C. Reiss (USA), E. Sabourenkov (Science and Compliance Officer), V. Siegel (Germany), C. Southwell (Australia) and W. Trivelpiece (USA).

WORKSHOP TO REVIEW ESTIMATES OF B_0 AND PRECAUTIONARY CATCH LIMITS FOR KRILL

2.1 The Working Group recalled that the Scientific Committee had agreed that a workshop to review estimates of B_0 and precautionary catch limits for krill should be held in conjunction with the 2007 Working Group meeting (SC-CAMLR-XXV, paragraphs 3.26 and 3.27).

2.2 The workshop would consider the following points:

(i) review of parameters used in the assessment of krill, including growth and recruitment variability;

(ii) examine whether integrated modelling approaches could be used to estimate recruitment variability and *M* from long-term datasets;

(iii) consider the level of krill escapement to provide for predators in the decision rule;

(iv) consider alternative methods for estimating catch limits for krill according to the CCAMLR decision rules and how the different methods might be compared and evaluated for providing advice;

(v) consider sources of uncertainty that may not be able to be included specifically in the estimation of B_0 or the assessment process generally.

2.3 The Scientific Committee had also requested SG-ASAM and WG-SAM to provide input to the workshop on what is the most appropriate method for estimating B_0 from survey data, considering design-based versus model-based estimation methods. It also requested SG-ASAM to review the method for estimating CV for the biomass estimate provided by Demer (2004) and consider whether this is sufficient to determine the uncertainty in B_0 more generally.

2.4 The Convener of the workshop (Dr Nicol) and the WG-EMM Convener (Dr Reid) had solicited contributions from Members on the three major themes of the workshop:

(i) Estimating B_0 –

(a) spatial coverage and timing of surveys, acoustic protocols (e.g. target-strength model, target identification) and error estimation.

(ii) Key parameters used in assessment –

(a) estimates of growth, recruitment, mortality as well as spatial and temporal variability in those parameters.

(iii) Desired escapement levels and approaches to estimation of precautionary catch limits for krill –

(a) Are there alternative methods for estimating catch limits for krill, according to the CCAMLR decision rules, and how might the different methods be compared and evaluated for providing advice?

(b) Are there sources of uncertainty that are not currently included in the estimation of B_0 or the assessment process generally?

2.5 Two papers (WG-EMM-07/30 Rev. 1 and 07/33) submitted for consideration at the workshop addressed the first theme, and one paper (WG-EMM-07/P6) addressed the second theme. The reports of SG-ASAM (Annex 8) and WG-SAM (Annex 7) were relevant to all three themes. The papers were discussed under the individual themes.

Background

2.6 The Working Group recalled that the need for the workshop arose out of discussions on the new target-strength formulations for krill, then incorporated strategic issues, such as the need to achieve consistency in approaches across time and between areas, and the general issues associated with the assessment of B_0 and the calculation of precautionary catch limits.

2.7 Consistency includes the setting of appropriate catch levels across the CCAMLR Convention Area using agreed protocols as well as common measures, such as trigger levels, in each area to be fished. The trigger level in Area 48 was set using historical fisheries data at what was perceived to be a low-risk catch level and was intended to be independent of the catch limit which was calculated from survey results.

2.8 The basic biological information required for the calculation of precautionary yield includes:

- estimate of biomass (B_0)
- estimates of natural mortality
- estimates of recruitment
- estimates of growth rates.

2.9 The current precautionary catch limits for krill are:

- Area 48: 4 million tonnes
- Division 58.4.1: 440 000 tonnes
- Division 58.4.2: 450 000 tonnes.

2.10 All precautionary catch limits have been set using the Greene et al. (1991) target-strength model which SG-ASAM has recommended be superseded by the SDWBA model (Annex 8, paragraph 8; SC-CAMLR-XXIV, Annex 6, paragraphs 27 and 28). The limits in Area 48 and Division 58.4.1 were set using similar survey designs and methodologies. The limit in Division 58.4.2 was set using data collected in the 1980s. This division was resurveyed in 2006 using a survey design compatible with that in Area 48 and Division 58.4.1

(WG-EMM-07/33), although the precautionary catch limit was not revised. No B_0 surveys have been conducted and no catch limits have been set in any other division/area including Subarea 48.6 and Area 88.

Theme 1 – Estimating B_0

2.11 This theme discussed progress in the estimation of B_0, especially regarding spatial coverage and timing of surveys, acoustic protocols (e.g. target-strength model, target identification) and error estimation.

2.12 Dr Demer provided further context to the discussions under this theme by summarising the previous activities of SG-ASAM related to acoustic surveys of krill biomass (SC-CAMLR-XXIV, Annex 6) and suggested that the work be organised to:

(i) review current protocols as they pertain to the acoustic estimation of krill biomass and its variance for CCAMLR management purposes;

(ii) summarise the major developments in data analysis since the CCAMLR-2000 Survey;

(iii) highlight and resolve any omissions and/or ambiguities in these protocols;

(iv) summarise the subgroup's findings for submission to WG-EMM, either directly or, if any issues of a technical nature remained to be resolved, via SG-ASAM;

(v) evaluate recently submitted biomass estimates (WG-EMM-07/30 Rev. 1, 07/33) for their applicability for CCAMLR management purposes.

2.13 The Working Group agreed that the best advice available for the purposes of the workshop was previous advice provided by SG-ASAM.

2.14 Two fundamental components of biomass estimation were discussed: estimation of transect biomass densities, and extrapolation of densities to the survey area. The first component is highly technical and falls within the remit of SG-ASAM; the second component is more general, and there was considerable general discussion on the merits of obtaining expert advice regarding survey design and the estimation of survey biomass from transect data. SG-ASAM had been asked by WG-EMM to consider this latter component at its 2007 meeting (SC-CAMLR-XXV, Annex 4, paragraph 6.57(xvii)), but had agreed there was insufficient expertise present at SG-ASAM-07 to make any progress (Annex 8).

2.15 The workshop focused on what has changed in terms of acoustic protocols since the CCAMLR-2000 Survey. The workshop addressed the current B_0 estimates and protocols, and considered future improvements that may arise.

2.16 The workshop produced a summary of the major points arising since the CCAMLR-2000 Survey. The aim of this summary was to clarify any potential confusion within the CCAMLR community about the results of subsequent reanalyses of the

CCAMLR-2000 dataset (Demer and Conti, 2005; WG-EMM-07/30 Rev. 1), and reiterate that there are likely to be further developments in this field into the future. This summary is presented in paragraphs 2.17 to 2.19.

Summary of changes in acoustic protocols
since the CCAMLR-2000 Survey

2.17 The SDWBA model, which has been empirically validated, published in the peer-reviewed literature (Demer and Conti, 2005) and endorsed by SG-ASAM, WG-EMM and the Scientific Committee (Annex 8; SC-CAMLR-XXIV, paragraphs 3.10 to 3.13, Annex 4, paragraphs 4.55 to 4.60 and Annex 6; Demer and Conti, 2003), predicts krill target strengths that are generally lower than those of the Greene et al. (1991) model (WG-EMM-07/30 Rev. 1, Figure 1). Therefore, if all else is held equal, the use of the SDWBA will result in an increase in the original 44.3 million tonnes CCAMLR-2000 Survey biomass estimate. This was the finding of the first reanalysis of the CCAMLR-2000 dataset (Demer and Conti, 2005; Conti and Demer, 2006), which estimated between 108.0 million tonnes (CV = 10.4%) and 192.4 million tonnes (CV = 11.7%) depending on the krill orientation distribution used.

2.18 Taking the analyses further, the SDWBA also provides a method for more effective filtering out of non-krill targets (i.e. target classification). The effect of this additional filtering is to improve the acoustically estimated krill biomass. When using the SDWBA to both predict target strength and improve target classification, the combined effect is a reduction in the overall biomass estimate. This was the finding of the second reanalysis of the CCAMLR-2000 dataset (WG-EMM-07/30 Rev. 1), which estimated a krill biomass of 37.29 million tonnes (CV = 21.20%); this was 15.8% lower than the original estimate, but with a larger CV (WG-EMM-07/30 Rev. 1).

2.19 The results of the SDWBA target classification method are likely to be more accurate (i.e. less biased) owing to better rejection of non-krill species. In addition, the patchiness of krill is better elucidated, which results in a higher CV. That is, as non-krill are more effectively filtered, the remaining krill typically become more patchy. Holding sampling constant, higher patchiness and lower biomass results in a higher CV.

2.20 The Working Group emphasised the need to manage the implementation of incremental improvements to acoustic protocols, so that the B_0 and variance estimates in use by CCAMLR at any one time are consistent and comparable:

(i) A consistent set of protocols should be maintained for a period of five years. At the end of this period, any improvements to these protocols should be agreed on and implemented. This would include the reanalysis of existing datasets. However, it was also recognised that mid-period improvements in acoustic protocols will likely be published in the peer-reviewed literature where appropriate.

(ii) Clear guidelines were developed on which protocols currently apply in a CCAMLR context for new data collected (paragraphs 2.21 to 2.26 and Table 1).

(iii) For appropriate comparisons to be made across different surveys, it is implicit that the results need to have been calculated in a consistent way and that reanalyses are required across all datasets whenever protocols are amended (e.g. WG-EMM-07/31).

Current protocols for the acoustic estimation of krill biomass and its variance

2.21 The overall aim of producing agreed CCAMLR survey protocols should be to facilitate the decision-making process so that survey-specific issues can be accommodated and the resulting biomass estimates be as consistent as possible with currently agreed protocols.

2.22 The acoustic protocols of direct relevance to CCAMLR management activities have been extensively documented in the past and do not need to be reiterated in detail here. These are therefore summarised and referenced in the following paragraphs.

2.23 The CCAMLR-2000 Survey, which benefited from extensive planning and coordination across four CCAMLR Members, represented the benchmark for acoustics protocols at that time (e.g. SC-CAMLR-XXIV, Annex 4, paragraphs 4.55 to 4.60, 4.66 and 4.67; Hewitt et al., 2002, 2004).

2.24 Since the CCAMLR-2000 Survey, improvements have been made to the krill target-strength model and target-classification technique (Annex 8; SC-CAMLR-XXIV, Annex 6; Demer and Conti, 2003, 2005). SG-ASAM was established in 2005 to evaluate these improvements and to make recommendations to WG-EMM for possible changes to the CCAMLR-2000 Survey protocols (Annex 8; SC-CAMLR-XXIV, paragraphs 3.10 to 3.13, Annex 4, paragraphs 4.55 to 4.60 and Annex 6). These topics were discussed at the first and third meetings of SG-ASAM (Annex 8; SC-CAMLR-XXIV, Annex 6).

2.25 To date, SG-ASAM has recommended that:

(i) the simplified SDWBA target-strength model with constrained parameters be used to define krill target strength as a function of length, at a given acoustic frequency;

(ii) the range of target strengths from the subgroup's agreed run of the simplified SDWBA (SC-CAMLR-XXIV, Annex 6, Figure 4) be used as a first estimate of the error associated with krill target strength estimates;

(iii) the classification of S_v into krill and non-krill targets be undertaken using the ΔS_v technique, with the ΔS_v windows across three frequencies (38, 120 and 200 kHz) constrained according to SDWBA predictions for the appropriate size range of krill;

(iv) further work be carried out on understanding the orientation distribution, sound-speed contrast, density contrast and animal shape for krill under the surveying vessel;

(v) 70 kHz transducers be used in addition to the previously recommended frequencies (38, 120 and 200 kHz) whenever possible.

2.26 The Working Group agreed that current CCAMLR protocols for the acoustic estimation of krill biomass and its variance should follow those of the CCAMLR-2000 Survey (Trathan et al., 2001; Hewitt et al., 2004), except with regard to target strength and target classification; for these procedures, the recommendations of SG-ASAM should be followed (Annex 8; SC-CAMLR-XXIV, Annex 6).

Clarifying current acoustic protocols

2.27 The Working Group identified a number of potential omissions and/or ambiguities in the current acoustic protocols used to estimate krill biomass and its variance for CCAMLR purposes. To clarify, a table was produced listing these protocols and providing specific advice for each (Table 1). The protocol descriptions follow those suggested in Figure 1 of the SG-ASAM-07 report (Annex 8).

Estimates of B_0

2.28 The Working Group agreed that the methods described in WG-EMM-07/30 Rev. 1 were consistent with currently agreed acoustic protocols, as defined in paragraphs 2.21 to 2.26. Therefore, the B_0 estimate of 37.29 million tonnes and CV estimate of 21.20% represents the most current information for krill in Area 48 from the CCAMLR-2000 Survey.

2.29 The Working Group agreed that the methods in the Australian survey of Division 58.4.2 presented in WG-EMM-07/33 were consistent with those outlined for the CCAMLR-2000 Survey (Hewitt et al., 2004) and that the data could also be used to estimate a revised value of B_0 using the new simplified SDWBA target-strength model. The effects of any protocol deviations on the final B_0 and CV estimates from this survey should be quantified so that their importance can be better assessed by the CCAMLR community.

2.30 All future surveys intended to produce estimates of B_0 should first be presented to WG-EMM for its consideration and approval. The Working Group encouraged continuous and timely communication with CCAMLR regarding acoustic survey and analysis methods for all future CCAMLR surveys, to ensure that any deviations from the recommendations outlined here can be accounted for to the satisfaction of the CCAMLR community. This review task might be facilitated if the effect of any protocol deviations could be quantified with respect to the final estimates of B_0 and CV.

2.31 Dr T. Jarvis (Australia) agreed to produce a paper to be presented to WG-EMM next year that explicitly details data collection and analysis protocols for CCAMLR surveys.

2.32 The Working Group recommended that the following be considered when SG-ASAM meets next:

(i) all new measurements of krill density and sound-speed contrasts, shape and orientation beneath survey vessels relative to Table 1 in the SG-ASAM-05 report (SC-CAMLR-XXIV, Annex 6);

(ii) how krill density and sound-speed contrasts, shape and orientations beneath survey vessels should best be measured;

(iii) how krill length distributions should be considered to assure they are representative of the survey strata;

(iv) the efficacy of the three- versus two-frequency method for target identification; specifically, how the sensitivity of krill target strength at 200 kHz, due to changes in krill orientation and the stochastic nature of sound scatter, affects the three-frequency method for target identification and range limitations at 200 kHz;

(v) methods for integrating the information obtained from direct sampling (e.g. target trawls) into the acoustic species-identification procedure.

Theme 2 – Key parameters used in assessment

2.33 The Working Group recalled that in 2000 it was agreed that more work was still required before the recruitment more recent than 1994 could be used in the GYM (SC-CAMLR-XIX, Annex 4, paragraph 2.98). Currently for the estimation of γ, recruitment variability is assumed to be a stochastic event (SC-CAMLR-XIX, Annex 4, Table 1). Since reproduction and survival of krill is known to be closely linked to environmental factors in relation to the cycle of their life history (Siegel and Loeb, 1995; Quetin and Ross, 2001), the Working Group recommended exploration of ways of incorporating these features in the estimation of γ within the GYM.

2.34 Spatial variation in M will have to be investigated at appropriate scales to account for environmental variability and seasonal differences in predation pressure in Area 48. For example, Subarea 48.3 is thought to have a higher M (possibly resulting from high predation pressure) compared to Subareas 48.1 and 48.2, and therefore one option may be to set a different M for Subarea 48.3 from Subareas 48.1 and 48.2 and to have M vary with time associated with periods of peak predator demand.

2.35 The growth rate of krill is also known to vary in time and space in relation to environmental conditions (temperature, food availability). Recent findings further indicate that there is differential growth and mortality between sexes (WG-EMM-07/P6). It would also be desirable that the growth model to be used in the GYM be capable of taking into account environment variability and seasonal patterns.

2.36 The Working Group noted that the growth trajectory generated by the instantaneous growth rate (IGR) model (Candy and Kawaguchi, 2006) takes into account seasonal trends in temperatures based on direct field measurement.

2.37 The Working Group, however, acknowledged that the KYM and the GYM were not designed as spatially resolving models and used average values for the various parameters which were assumed to apply to the whole population in an area. The modelling work being conducted for the subdivision of the catch limit into SSMUs is the best way to capture regional differences in the key parameters. This would require an assessment of the parameter sets required for each SSMU. It is also uncertain how movement of krill would affect any regional differences in population parameters.

2.38 The currently used γ for Area 48 was estimated using the KYM (SC-CAMLR-XIX, Annex 4, paragraphs 2.96 to 2.101). As the Working Group had some revised parameters which were available at the 2007 meeting, two sets of runs of the GYM were conducted using these parameters. These included a re-run of the current parameter settings using the GYM (Table 2). The runs were:

Run 0 (re-run): Using the original parameters but using the GYM. This resulted with almost same γ as that estimated by the KYM.

Run 1: Using the original parameters but with an updated CV (21.20%) from WG-EMM-07/30 Rev. 1 in the GYM.

Although Run 1 resulted in a slightly lower γ for the recruitment criterion, according to the decision rules, γ was set at 0.093 which is the same as that from Run 0.

2.39 The Working Group noted the currently agreed γ based on the KYM is 0.091. Using the same data inputs as that calculation but using the GYM, the Working Group agreed that this could be updated to 0.093.

2.40 The Working Group agreed that because of the potential change in γ that could result from changes in the growth trajectory, further intersessional work was required to update parameter values for the next meeting.

2.41 The Working Group agreed that, using the revised B_0 and CV, and the updated γ, the precautionary catch limit for Area 48 could be updated to 3.47 million tonnes (Run 1).

2.42 The GYM runs during the meeting also indicated the impact (24% increase) that an alternative growth model has on the estimate of γ.

2.43 The Working Group agreed to the following plan for the intersessional period to be able to provide advice to the next meeting of WG-EMM:

(i) review the currently available growth models
(ii) investigate ways to handle recruitment indices and mortality
(iii) investigate implications of spatial and temporal scale variability on parameter settings in the estimate of γ.

Theme 3 – Approaches to estimation of precautionary catch limits for krill

Escapement levels

2.44 The Working Group recalled the history of the development of the 75% escapement rule for CCAMLR as being halfway between the escapement appropriate for a single-species decision rule (50%) and for a decision rule that preserved all krill for predators (100%), until further research could clarify the actual level of escapement required for predators (SC-CAMLR-XIII, paragraph 7.22; CCAMLR-XIII, paragraph 3.10).

2.45 One attempt has been made in the past to estimate an escapement level directly in a krill–predator model (Butterworth and Thomson, 1995; Thomson et al., 2000). Since then our ability to characterise predator responses to krill densities and the associated uncertainties has improved and has been incorporated into the ecosystem dynamic models currently being developed by CCAMLR (FOOSA, SMOM, EPOC).

2.46 Within the staged approach being considered for determining appropriate catch limits for SSMUs, Stage 1 (a risk-based approach), as specified by WG-SAM, should allow investigation of the likely impact on predator performance (Annex 7, paragraph 5.48(ii)) of using different levels of escapement in the decision rule, including the current level of 75%, through simulating different levels of harvest as proportions of γ (Annex 7, paragraph 5.37(v)).

2.47 The Working Group requested that in order to examine the effect of adopting escapement proportions lower than 75% of B_0, the range of harvest rates that should be examined in the models should include 1.25 times γ.

2.48 The Working Group noted that decreasing the escapement level may not lead to a change in γ, depending on whether krill population depletion ($\gamma1$) or escapement ($\gamma2$) becomes limiting with the decision rule.

2.49 The Working Group recognised that in Stage 1 above only three options for the relative distribution of krill catch between SSMUs will be examined. In Stage 2 other options (including feedback approaches) will be developed, and these could lead to a situation where the sum of the SSMU catch levels is greater than the total catch level for Area 48. Although counter-intuitive, this is not inconsistent with the decision rules: the total Area 48 catch limit would still be based on the decision rules accounting for area-wide krill and predator dynamics, but local SSMU catch limits would be allowed to vary from the relative distribution in Options 2–4 depending on the local situation with predators. In the event that the Area 48 catch limit was reached, the Area 48 fishery would be closed whether or not all the SSMU catch limits had been reached.

2.50 In Stage 2 there may be some possibility of investigating whether different levels of escapement should be used in response to locally observed conditions as part of the development of feedback management. In the interim, a range of specific studies might be conducted to address escapement.

2.51 A feedback management scheme, such as regular reassessments, should also be able to deal with long-term shifts in the Antarctic ecosystem and climate change. It will be important to continue monitoring of both krill and predators to detect such changes. At the moment, the only long-term surveys monitoring the krill population in Area 48 are the surveys conducted by BAS, US AMLR and LTER. Structured fishing provides another potential way that the effect of climate change on appropriate SSMU limits and krill escapement might be investigated (Annex 7, paragraphs 5.13 and 5.14).

Alternative assessment methods

2.52 The Working Group welcomed the consideration of integrated krill assessments by WG-SAM. It noted that such methods may allow estimation of recruitment variability, relative abundance by area and movement between areas. The assessments would, however, remain restricted to the target species (krill) and would not be developed to explicitly include ecosystem dynamics. The latter would remain the role of the ecosystem dynamic models.

2.53 Integrated assessments may also allow more frequent and less costly estimates of krill population status than the current reliance on occasional synoptic surveys. Regular surveys will be increasingly important as the krill fishery develops and the krill population departs from B_0. It is not anticipated that the CCAMLR decision rule would change, but its method of application would become closer to that used currently for toothfish. This would mean that rather than estimating a γ to be applied to B_0, a long-term yield consistent with the decision rules would be directly calculated whenever a new assessment was undertaken. MSE work can be used to identify the most cost-effective methods for collecting data to help in this process (Annex 7, paragraph 6.16)

2.54 The Working Group encouraged participants to continue investigations into integrated assessments for krill and to provide advice to WG-SAM in its work on developing feedback management procedures for krill.

Consistency of approaches to management in the Convention Area

2.55 The Working Group noted that there are currently no SSMUs defined in areas other than Subareas 48.1, 48.2 and 48.3, although there has been some consideration of this matter (SC-CAMLR-XX/BG/24). Furthermore, catch limits have not been set in Area 88 nor Subarea 48.6.

2.56 In considering the existing trigger levels, the Working Group recalled the advice of the Scientific Committee and response by the Commission in 2000:

- As a precautionary step, the Commission agreed that krill catches should not exceed a set (i.e. 'trigger') level in Area 48 until a procedure for division of the overall catch limit into smaller management units has been established. This is consistent with the current Conservation Measure 51-01 which sets such a trigger level at 620 000 tonnes – slightly above the historical maximum annual catch in Area 48 to date (CCAMLR-XIX, paragraph 10.11).

- The Commission noted that the Scientific Committee had proposed two options for setting a trigger level in Area 48 (CCAMLR-XIX, paragraph 10.12):
  - retain the level of 620 000 tonnes, which approximates the historical maximum annual catch; or
  - set the level at 1 million tonnes, which approximates the harvest level suggested for each of the subareas in Area 48 and derived from the CCAMLR-2000 Survey results.

2.57 The Secretariat advised that, for consistency with other fisheries, Conservation Measure 51-01 may not result in it implementing the trigger level as intended by the Commission (CCAMLR-XIX, paragraph 10.11).

2.58 With respect to data reporting and the management of catch limits, the Secretariat routinely forecasts closures in fisheries, management areas and SSMUs using a regression model and data submitted in accordance with the Catch and Effort Reporting System (Conservation Measures 23-01 to 23-03). The regression is based on data from a minimum of three reporting periods, and most forecasts are based on data from four reporting periods.

2.59 In most finfish fisheries, Contracting Parties are required to submit five-day catch and effort reports and the deadline for the submission of these reports is two working days following the end of the reporting period (Conservation Measure 23-01). Given these time intervals, the earliest a forecast can be made is approximately 17 days after the start of fishing (three five-day periods and a deadline of two working days), and closures are forecast up to five days in advance.

2.60 In krill fisheries, Contracting Parties are required to submit monthly catch and effort reports and the deadline for the submission of these reports is the end of the following reporting period (Conservation Measure 23-03). Given these time intervals, the earliest a forecast can be made in a krill fishery is 120 days after the start of fishing (three 30-day periods and a 30-day deadline), and closures are forecast up to one month in advance. In some subareas the fishing seasons are relatively short (four months during the winter in Subarea 48.3, five months during the summer in Subarea 48.2) and the Secretariat would not have sufficient data to close the fishery before the catch limit is exceeded.

2.61 Given the above, the Working Group recommended that the Scientific Committee:

(i) recall its advice on the trigger level in 2000 (SC-CAMLR-XIX, paragraphs 7.21 to 7.24), noting that the Secretariat may not be able to administer its intent with the current conservation measures;

(ii) note and comment on the possibility that the current monthly reporting periods may not be sufficient to ensure that the catch limits for a subarea are not significantly exceeded in the situation where the krill fishery is capable of taking more than 1 million tonnes per season.

Uncertainty

2.62 It was recognised that the current assessment process incorporates parameter (fishery and ecosystem) uncertainty, and structural (model) uncertainty to the extent that there are multiple models being developed. The Working Group felt that known current uncertainties are incorporated reasonably well in the risk-based Stage 1 approach to setting SSMU catch limits. Stage 2 should further investigate the robustness of the management system, both the γB_0 method of setting catch limits and the distribution of catches between SSMUs, to uncertainties.

2.63 Uncertainties, such as long-term changes to parameters, particularly those caused by changes in krill/predator distribution and climate/environmental/exogenous change are difficult to accommodate in decision-making frameworks at present. Continued monitoring is required, and will probably be required in areas currently not being monitored, to identify and update harvest strategies in the future.

2.64 Another aspect of uncertainty that is not currently incorporated in the assessment and decision rules is implementation uncertainty. The Commission has previously requested that the Scientific Committee assume perfect implementation of catch limits. Implementation uncertainty, caused by IUU fishing for krill or spatial/temporal misreporting, may also be important, and may be either minimised by putting appropriate control measures in place or explicitly represented in models.

Conclusion of the workshop

2.65 The Convener of the workshop, Dr Nicol, thanked all participants for their assistance in producing valuable advice to the Scientific Committee in all three themes. In particular, he thanked Drs D. Agnew (UK), Demer and Kawaguchi who coordinated discussions under the three themes and contributed substantially to the writing of the report.

2.66 The Working Group thanked Dr Nicol for achieving an ambitious work program in the short time available.

Advice to the Scientific Committee

2.67 The Working Group advised the Scientific Committee that the most appropriate method for estimating B_0 from survey data was still the Jolly and Hampton (1990) method as has been used for all CCAMLR B_0 surveys to date (paragraph 2.13).

2.68 The Working Group recommended that current CCAMLR protocols for the acoustic estimation of krill biomass and its variance should follow those of the CCAMLR-2000 Survey (Trathan et al., 2001; Hewitt et al., 2004), except with regard to target strength and species identification; for these procedures, the recommendations of SG-ASAM should be followed (paragraph 2.26 and Annex 8; SC-CAMLR-XXIV, Annex 6).

2.69 The B_0 estimate of 37.29 million tonnes and CV estimate of 21.20% presented in WG-EMM-07/30 Rev. 1 represent the best advice on the biomass estimate for krill in Area 48 from the CCAMLR-2000 Survey (paragraph 2.28).

2.70 The Working Group agreed that, using the revised B_0 and CV, and the updated γ, the precautionary catch limit for Area 48 could be updated to 3.47 million tonnes (paragraph 2.41).

2.71 The Working Group agreed that the methods in the Australian acoustic survey for krill in Division 58.4.2 presented in WG-EMM-07/33 were consistent with those outlined for the CCAMLR-2000 Survey (Hewitt et al., 2004). A new estimate of B_0 using the new simplified SDWBA model for target strength and species identification should be produced in time for the next meeting of the Scientific Committee (paragraphs 2.29 and 5.39).

2.72 All future surveys intended to produce estimates of B_0 for krill should follow agreed protocols and be first presented to WG-EMM for its consideration and approval (paragraph 2.30).

2.73 The Working Group reviewed the parameters used in the assessment, including growth and recruitment variability, and examined whether integrated modelling approaches could be used to estimate recruitment variability and M from long-term datasets, but was unable to produce new formulations of the key parameters. A work program has been initiated to incorporate the most recent information into the assessment process (paragraphs 2.33 to 2.36 and 2.52 to 2.54).

2.74 The Working Group noted that in order to examine the effect of adopting escapement proportions lower than 75% of B_0, the range of harvest rates that should be examined in the models should include 1.25 times γ (paragraph 2.47).

2.75 The Working Group strongly emphasised the importance of the long time series of krill data collected as part of the BAS, US AMLR and LTER programs for the work of CCAMLR and the continuing need to collect and submit these data to the Working Group into the future (paragraph 2.51).

2.76 The Working Group drew the Scientific Committee's attention to the fact that there are currently no SSMUs defined in areas other than Subareas 48.1, 48.2 and 48.3. Although there has been some consideration of this matter (SC-CAMLR-XX/BG/24), catch limits have not been set in Area 88 nor Subarea 48.6 (paragraph 2.55).

2.77 The Secretariat advised that, in being consistent with other fisheries, Conservation Measure 51-01 may not result in it implementing the trigger level as intended by the Commission (CCAMLR-XIX, paragraph 10.11; paragraph 2.57).

2.78 The Working Group drew the Scientific Committee's attention to the possibility that, with the current monthly reporting periods, the Secretariat may not be able to close the fishery before the catch limit is significantly exceeded, should the krill fishery be capable of taking more than 1 million tonnes of krill (paragraphs 2.60 and 2.61).

2.79 As the krill fishery develops, it will be important to apply the ecosystem-based management principles developed in Area 48 to other areas. It was noted that like toothfish, krill fisheries are likely to be possible wherever krill is found. There is currently sufficient knowledge of where krill fishing might be possible, but insufficient knowledge about the impacts of such fisheries on krill and dependent predators for many areas. An orderly development would mean that:

(i) the development of fishing in Area 88 or Subarea 48.6 should be considered exploratory fisheries, since only limited information exists on the distribution and abundance of krill or predators;

(ii) the requirements for developing an exploratory fishery should be to undertake a B_0 survey prior to the fishery developing and that:

  (a) notification of the survey should be in sufficient time for the Scientific Committee and WG-EMM to consider the research plan and the likely stock definition for an effective B_0 survey;

  (b) the large size of these statistical areas may require some consideration by the Scientific Committee of their subdivision prior to any survey taking place;

  (c) the survey is undertaken according to the standard protocols developed in paragraphs 2.21 to 2.26, and an assessment includes application of CCAMLR decision rules. This would not preclude such surveys being undertaken by commercial vessels;

(iii) based on a consideration of the risk of krill fishing to predators and the possible requirements for SSMUs, trigger levels should be developed for each krill fishing area to manage the orderly development of the fishery (see also paragraph 6.35).

2.80 The Working Group drew the Scientific Committee's attention to an aspect of uncertainty that is not currently incorporated in the assessment and decision rules – implementation uncertainty. Implementation uncertainty, caused by IUU fishing for krill or spatial/temporal misreporting, may also become important, and may be either minimised by putting appropriate control measures in place or explicitly represented in models (paragraph 2.64).

FEEDBACK FROM THE 2006 MEETINGS OF THE SCIENTIFIC COMMITTEE AND THE COMMISSION

3.1 At the 2006 meetings of the Scientific Committee, SCIC and/or the Commission, the following items were identified for consideration by the Working Group. They were addressed under the appropriate agenda item indicated below.

Agenda Item 4.3 (key points in paragraphs 4.84 to 4.89) –

(i) The need to review the priorities of the observer program to ensure that the expectations and workloads of observers remain achievable (SC-CAMLR-XXV, paragraph 2.21; CCAMLR-XXV, paragraph 10.11).

(ii) The need to collect standard scientific observations on krill fishing and the provision of information from krill fishing nations on fishing methodologies, technology and fishing operations. In particular, operational data were needed on fishing selectivity, total mortality and vessel observer coverage (SC-CAMLR-XXV, paragraphs 4.18 and 11.13; CCAMLR-XXV, paragraphs 4.30 and 10.1 to 10.11).

Agenda Item 4.4 (key points in paragraphs 4.80 to 4.83) –

(iii) To obtain early notification of all fishing activity for krill, the Commission agreed to implement a notification procedure for krill fisheries (Conservation Measure 21-03) which requires Contracting Parties intending to participate in a krill fishery to notify the Secretariat of their intent not less than four months in advance of the Commission's regular annual meeting. The deadline of four months was chosen to allow sufficient time for notifications to be considered by the Scientific Committee and WG-EMM during their regular annual meetings (CCAMLR-XXII, paragraphs 4.37 to 4.39).

Agenda Item 5 (key points in paragraphs 5.87 to 5.94) –

(iv) Members to provide to the next meeting of WG-EMM submissions on what the potential effects of climate change on the Antarctic marine ecosystems might be, and how this knowledge could be used to advise the Commission on management of the krill fishery. The Scientific Committee also requested that Members consider how the effects of fishing might be distinguished from the effects of climate change. For example, could a program of experimental fishing be used to help quantify these effects and/or how might simulation studies using ecosystem models be used to understand what the potential effects might be (SC-CAMLR-XXV, paragraph 3.7).

Agenda Item 6.1 (key points in paragraph 6.51) –

(v) The status of review for CEMP site protection under Conservation Measure 91-01 (2004) in respect of Conservation Measures 91-02 and 91-03 (protection of Cape Shirreff and Seal Islands respectively) should be clarified and, if appropriate, reviewed at the earliest opportunity (SC-CAMLR-XXV, paragraph 3.17).

Agenda Items 2 and 6.2 (key points in paragraphs 2.71 and 6.55 to 6.57) –

(vi) To provide an update of the precautionary catch limit for krill in Division 58.4.2, and other elements of the conservation measure including subdivision of the catch, the placement of scientific observers and the utilisation of VMS in order to facilitate the orderly and precautionary development of the fishery (SC-CAMLR-XXV, paragraph 3.18; CCAMLR-XXV, paragraphs 12.65 to 12.69).

Agenda Item 7.3 (key points in paragraph 7.29) –

(vii) To review the use of bottom trawling gear in high-seas areas of the Convention Area, including with respect to relevant criteria for determining what constitutes significant harm to benthos and benthic communities in the Convention Area; and to begin developing a policy on destructive fishing practices by identifying vulnerable deep-sea habitats, including deep-sea corals, which may require protection from fishing (CCAMLR-XXV, paragraphs 11.27 to 11.33 and 12.28).

STATUS AND TRENDS IN THE KRILL FISHERY

Fishing activity

Season 2005/06

4.1 The total catch of krill reported from the fishery in Area 48 in the 2005/06 season, based on STATLANT data, was 106 589 tonnes. The Republic of Korea reported the largest catch of krill with a total of 43 031 tonnes. Japan also reported a large catch (32 711 tonnes). Ukraine, Norway and Poland reported catches of 15 206, 9 228 and 6 413 tonnes respectively.

4.2 The Working Group noted that, with the exception of the Republic of Korea and Poland, all Contracting Parties had submitted complete sets of fine-scale haul-by-haul data for 2005/06 in accordance with Conservation Measure 23-06.

4.3 The Secretariat advised that it had been in contact with the relevant authorities in the Republic of Korea and Poland, and it was hoped that the overdue data would be submitted to CCAMLR as soon as possible.

4.4 Most vessels fished in Bransfield Strait and the catch reported from the two Bransfield Strait SSMUs within this area showed the highest value compared to the historical catches from these SSMUs. This coincided with the low krill abundance which was recorded by the scientific survey conducted by the US AMLR Program in the South Shetland Islands area (WG-EMM-07/31).

4.5 It was unclear whether this distribution of fishing effort is a result of low krill density in the established fishing ground north of the South Shetland Islands, or is simply part of historically observed variations of catch distribution within Area 48.

Current season (2006/07)

4.6 Five vessels from three Contracting Parties (Japan, Republic of Korea and Norway) are fishing for krill in Area 48. Norway is employing the continuous fishing system. There was no information available on whether Vanuatu, which had notified its intent to fish in 2006/07, had been fishing this season.

4.7 A total catch of 70 832 tonnes of krill was reported by the time of WG-EMM-07. Based on the monthly catch and effort reports, 15 762 and 55 070 tonnes were reported from Subareas 48.1 and 48.2 respectively.

4.8 The preliminary projected estimate of the total krill catch for the 2006/07 fishing season is approximately 111 700 tonnes (WG-EMM-07/5). This compares with 106 589 tonnes of krill reported in the STATLANT data for the previous season (2005/06).

Time series

4.9 The total catch of krill has remained relatively constant since the 1999/2000 season (between 104 425 and 127 035 tonnes), however, there were marked changes in the balance of catches between Contracting Parties, including recent new entrants (Norway and Vanuatu).

4.10 During the past 10 seasons, the maximum catch in any SSMU occurred in one of three SSMUs (SGE, SOW and APDPW).

Fine-scale data arising from the continuous fishing system

4.11 In 2006, problems with the reporting of data on appropriate spatial and temporal scales from the continuous fishing system were identified. Norway had advised that a 'flow scale' instrument would be fitted to the vessel in 2007 to improve the collection of accurate catch data (SC-CAMLR-XXV, paragraph 4.16).

4.12 Analysis of the latest fine-scale data suggest that catches reported from the Norwegian-flagged vessel and taken from both conventional trawling and continuous fishing systems are still being estimated only once per day, and then divided into two-hour intervals. This approach fails to capture the variability in catch rates and precludes the accurate estimation of catch taken in each SSMU when more than one SSMU is traversed during a single continuous tow (WG-EMM-07/5).

4.13 The Working Group urged Norway to implement the proposed 'flow scale' instrumentation in 2007 and to report measured catches at two-hour time intervals (SC-CAMLR-XXV, paragraph 4.16).

Notifications for 2007/08
(table from WG-EMM-07/6 Rev. 2)

4.14 The total krill catch notified for the 2007/08 season was 764 000 tonnes, and was expected to be taken by 25 vessels from nine notifying countries. Ten vessels from three countries notified that they would be using a pumping system (Cook Islands, Russia and Ukraine) (WG-EMM-07/6 Rev. 2). However, at WG-EMM it was clarified that the pumping method notified by Russian vessels did not refer to continuous fishing, but rather to a method used to clear the codends of conventional trawls without hauling the net onto the deck.

4.15 It remained unclear whether the other notifications proposing the pumping method (Cook Islands and Ukraine) will be using the continuous fishing system, and the Working

Group asked the Secretariat to contact the relevant authorities to clarify the fishing method. It was also noted that although Norway has not specified its fishing method, the *Saga Sea* is known to be employing the continuous fishing system.

4.16 WG-EMM noted that the Secretariat has been seeking further information from Vanuatu authorities on the activities of vessels notified at the Scientific Committee meeting in 2006 but has not yet received an answer. No catch from Vanuatu has been reported so far in 2006/07.

4.17 The Working Group listed a number of issues regarding the notifications:

(i) the large number of notifications by non-Members;

(ii) for the first time, the total notified catch (764 000 tonnes) was greater than the trigger level in Area 48 (620 000 tonnes);

(iii) the increasing numbers of notifications for fishing using the continuous fishing system;

(iv) some notifications were incomplete on submission and/or revised after the deadline for submission;

(v) the varying quality of the notifications.

4.18 Regarding paragraph 4.17(iii), WG-EMM still does not have an adequate method to describe catch and effort data in the continuous fishing system. The Working Group urged Norway to undertake the studies proposed by the Scientific Committee in 2006 (SC-CAMLR-XXV, paragraph 4.16) to address this problem (paragraphs 4.11 to 4.13).

4.19 Regarding paragraph 4.17(iv), it was noted that it is essential to have all information submitted prior to the meeting of WG-EMM because notifications and revisions received after the meeting of WG-EMM would preclude management advice from WG-EMM on those notifications.

4.20 Regarding paragraph 4.17(v), suggestions were made to modify the notification form in Conservation Measure 21-03 (Annex 21-03/A) to provide information that would better assist WG-EMM in evaluating the notifications (paragraphs 4.77 and 4.78).

Deployment of observers

4.21 Five scientific observer (four international and one national) datasets were submitted for the 2005/06 season. These data were collected by CCAMLR scientific observers on board the vessels *Niitaka Maru* (Japan), *Konstruktor Koshkin* (Ukraine) and *Saga Sea* (Norway). At present, the CCAMLR database holds scientific observer data from 35 trips/deployments between 1999/2000 and 2005/06 in Subareas 48.1, 48.2 and 48.3, most of which were from Subarea 48.3 (WG-EMM-07/5, Appendix 1).

4.22 Two CCAMLR scientific observers have been deployed in the current season (2006/07) by the time of the WG-EMM meeting, both of them on the *Saga Sea* which is employing the continuous fishing system (WG-EMM-07/5).

By-catch

4.23 The incidental mortality of one Antarctic fur seal was observed in the krill fishery in Area 48 in the 2005/06 season.

4.24 Only 12.8% (7 234 hauls) of the total hauls in the krill fishery were observed for by-catch between 1999/2000 and 2005/06. The dominant by-catch species differed between SSMU groups, showing *Pleuragramma antarcticum* dominant in the Antarctic Peninsula region, *Champsocephalus gunnari* at South Georgia, and *Lycodapus* spp. at the South Orkney Islands. *Electrona* spp. were abundant in catches in both the South Georgia and South Orkney Island regions (WG-EMM-07/5).

Description of the fishery

4.25 The status of the krill fishing ground in Subarea 48.2, as determined from information collected by a Ukrainian national observer in the 2005/06 fishing season, was characterised by very low recruitment and density, and was not profitable for the fishing vessel involved (WG-EMM-07/9). On the other hand, Subarea 48.1 formed good fishing grounds, especially near Elephant Island and in Bransfield Strait. WG-EMM-07/9 further suggested that krill density of 280–300 g m^{-2} was the threshold density required for the Ukrainian fleet.

4.26 WG-EMM-07/27 used haul-by-haul data to identify whether there are simple signals in CPUE patterns that indicate when vessels move between SSMUs in different subareas. The mean CPUEs showed decreasing trends about 1–2 days before the vessels moved from an SSMU, suggesting that the captains were allowing over one day to determine if the factory supply can be maintained before moving. The authors suggested that vessel-specific information, e.g. capacity and rates of processing, determines the captains' decisions and searching time. The best way of achieving uniform reporting of high-quality data on such movements would be through the deployment of international CCAMLR observers trained in reporting these types of data.

4.27 The Working Group also drew attention to the questionnaire (SC CIRC 06/39) on fishery dynamics. It was noted that there has been no reply so far from fishing nations. WG-EMM urged Members to reply to this questionnaire to help gather fishery information to make progress in a fleet dynamics model.

Scientific observation

4.28 WG-EMM-07/P5 examined how current data collection through the fishing operation can contribute to a greater understanding of krill biology. It pointed out that the type of information available from the fishery is different from that usually available from research surveys, including complete seasonal coverage and high sampling frequencies from a single population. It pointed out future priorities for fishery-related research, including the effective use of the CCAMLR Scheme of International Scientific Observation to collect scientific information.

4.29 WG-EMM-07/16 provided an updated analysis of the *Saga Sea* catch data using both the continuous fishing system and conventional trawls, extending the initial analysis (WG-FSA-06/57) to include data collected up to May 2007. International observers covered 100% of the days fished in the current season.

4.30 A total of 1 721 hauls were conducted by the *Saga Sea* during the fishing period. Of these, 469 trawls (27% of the total) were sampled for krill and 146 trawls (8% of the total) were sampled for by-catch. By-catch was observed by using the newly developed interim protocol (WG-EMM-07/25).

4.31 The Working Group noted that comparison of krill length frequencies showed no differences between the size of krill caught by conventional and continuous trawls deployed by the *Saga Sea*.

4.32 Although the new protocol for the collection of data on fish larvae by-catch worked well, sampling coverage of larval fish was still not sufficiently comprehensive to allow a robust analysis of larval fish by-catch data. The results to date suggest that catch rates of larval fish from continuous trawls conducted by the *Saga Sea* are similar to those reported for conventional trawls.

4.33 WG-EMM-07/25 presented an interim protocol developed in response to the recent requests by the Scientific Committee to develop a standardised protocol for the quantitative assessment of fish in krill catches for use by observers on board krill fishing vessels (SC-CAMLR-XXV, paragraph 4.10). This manual was distributed to all krill fishing nations for use in the 2006/07 fishing season.

4.34 WG-EMM-07/26 assessed the workload of the tasks required in the *Scientific Observers Manual*. The total time needed for the minimum amount of daily routine tasks was above the capacity of a single observer if all the tasks listed in the manual were pursued as required. It was recommended that the instructions in the manual be revised so that the observer can systematically collect the various types of information across vessels and fishing methods by following the instructions (paragraphs 4.61 to 4.72). In order to accomplish the task, the Secretariat should consult with Dr Kawaguchi (Convener of the Subgroup on Fisheries) and technical coordinators.

4.35 WG-EMM-07/32 presented a field key to early life stages of Antarctic fish caught in the krill fishery. The key includes eight families and 28 species mainly from the Atlantic sector of the Southern Ocean and uses distinguishing characteristics which permit rapid field identification. This key has been used by national observers in the Japanese krill fishery for a number of years.

4.36 The Working Group thanked Japan for developing such a useful key to species identification, and suggested that it be submitted to WG-FSA for advice on its use as a guide for CCAMLR scientific observation.

4.37 WG-EMM encouraged all identification guides of the early life stages of fish currently used by Members be reviewed by WG-FSA to make a common identification guide for use by scientific observers on krill fishing vessels.

Scientific observer coverage

4.38 At the 2006 meeting of the Scientific Committee, three questions of priority in the krill fishery were highlighted (SC-CAMLR-XXV, paragraph 2.15):

(i) understanding the differences in selectivity between different krill fishing gear configurations;

(ii) determining the level of by-catch of fish larvae in the krill fishery;

(iii) determining the level of warp strikes by seabirds and incidental mortality of seals.

4.39 WG-SAM further identified a need for high-quality length-frequency data from the fishery from several years in advance of implementing an integrated assessment, and recommended that the fishery start providing length-frequency data now, given the coverage by the research surveys is not likely to be sufficient for all regions (Annex 7, paragraph 3.13).

4.40 The Working Group recognised that the requirements (precision, resolution etc.) for observer data collection may vary depending on the purpose, objectives or the questions that are being addressed.

4.41 It was suggested by the Working Group that, at some stage, a CCAMLR accreditation system for scientific observers may need to be introduced to ensure the quality and standard of the data when the number of observers increases (see also SC-CAMLR-XXV, paragraph 2.11).

4.42 The Working Group discussed the kinds of data needed from the fishery, the data available from other sources, and the spatial and temporal coverage required.

4.43 The Working Group noted that the size selectivity of commercial nets is subject to gear types and fishing method (WG-EMM-07/28) and advised that it is important that the length-frequency data are accompanied by this information.

Options for observer coverage

4.44 The Working Group focused on the question: ‘What data are required to provide reliable answers to each of the Scientific Committee’s priorities in respect of the krill fishery?’ (SC-CAMLR-XXV, paragraph 2.15).

4.45 The Working Group endorsed two strategic objectives for scientific observations in the krill fishery:

(i) to understand the overall behaviour and impact of the fishery
(ii) to undertake routine monitoring of the fishery to inform population and ecosystem models.

4.46 The Working Group noted that it will only be possible to design the spatial and temporal level of coverage required for (ii) once (i) has been completed. A full investigation of (i) would require a systematic coverage by scientific observers across SSMUs, seasons, vessels and fishing methods.

4.47 The rationale behind this two-stage approach is that fisheries monitoring effort does not necessarily have to have indefinite maximum coverage if a reduced observation effort is sufficient to fulfil management requirements. There is, however, an expectation that there will be a long-term need for systematic data collection from the fishery.

4.48 The Working Group agreed that there are a number of ways to collect the required scientific data from the krill fishery. For example, the most comprehensive coverage, and the most rapid way to achieve objective (i), could be either of the following alternatives:

- 100% coverage by international observers
- 100% coverage by international and/or national observers.

4.49 The Working Group noted that reduced levels of observational effort would significantly delay the achievement of objective (i) but this reduced effort could include:

(i) systematic but <100% coverage by observers;

(ii) different levels of coverage for different fleets, for example, 100% coverage for new vessels with unknown characteristics and a lesser level of coverage on established vessels for which data are already available;

(iii) random systematic allocation of observers plus regular quality checks, and systematic coverage by international observers until the fishery is established for vessels from which data suitable for the purposes described in paragraph 4.47 are not available.

4.50 The Working Group noted that not only would these approaches delay the data collection effort, they could also introduce bias into the data.

4.51 The Working Group further clarified that:

(i) 'systematic coverage' means coverage that ensures data collection across all areas, seasons, vessels and fishing methods, which leads to the provision of consistent high-quality data for assessment in multi-vessel multi-nation fisheries (Annex 7, paragraph 4.16);

(ii) to obtain the required information, either international or national observers would be acceptable, provided the data and reports are consistent with the CCAMLR scheme and are of a sufficiently high quality to be of use for the proposed analyses.

4.52 The Working Group acknowledged that each of the options for obtaining the priority data required by the Scientific Committee would have consequential issues of implementation and time scale of delivery.

4.53 Dr M. Naganobu (Japan) expressed his disagreement to the compulsory 100% deployment of international scientific observers and/or national observers on krill fishing vessels since he understands that: (i) deployment of scientific observers through bilateral agreement is sufficiently effective and has provided scientific data, (ii) compulsory 100% observer deployment has significant financial implications, and (iii) in relation to larval by-catch, Japan and Norway have already observed the level of by-catch in the krill fishery, and there are no recent reports on incidental mortality of seabirds and seals.

4.54 The Working Group noted, however, that answering the questions posed by the Scientific Committee would require systematic observation and it welcomed any proposals for the alternative methods to achieving systematic and consistent collection of the required scientific data without 100% observer coverage.

4.55 In noting that arguments against 100% coverage have in the past been made in relation to the level of depletion of the krill resource (CCAMLR-XXV, Annex 5, paragraph 5.4), the Working Group emphasised that the requirement for observer coverage is in no way related to the level of depletion of the krill resource, but results from requirements for scientific information on the ecosystem effects of the krill fishery.

4.56 Members of the Working Group expressed their frustration that the collection of these data, which have been granted a high priority by the Scientific Committee, is being impeded by non-scientific arguments.

Scientific observer data

4.57 The Working Group discussed the use of CCAMLR scientific observer cruise reports as potential means for assessing accuracy and completeness of data collected by observers (WG-EMM-07/22). It was agreed that the main purpose of observer cruise reports should remain the provision of summary information on observations conducted and data collected, including detailed description of fishing gear and general comments of observers on the use of the *Scientific Observers Manual* and observer logbooks and any difficulties encountered during observation. Information contained in observer cruise reports has been used by the Secretariat, when required, as an additional source of information for the verification of data collected by observers and submitted in observer logbooks.

4.58 The Working Group recommended that the Secretariat be requested to prepare a summary of the data collected by scientific observers on board krill fishing vessels during the 2006/07 season, similar to the summaries of information annually prepared by the Secretariat on observations conducted in finfish fisheries, in particular, for toothfish (e.g. WG-FSA-06/37 Rev. 1 and 06/38), and to submit it to the next meeting of WG-EMM for review and approval.

4.59 The Working Group noted that the analyses of available cruise reports, presented in WG-EMM-07/22, indicated that the quality of summary information recorded by observers in these reports could be improved, in particular, in terms of increasing consistency of completion of all sections of the cruise report by all observers. In addition, the section with gear description could be improved by adding schematic layouts of various types of trawl gear, in particular, for krill fishing to assist observers in recording details of fishing gear used. At present, the cruise report form contains only a schematic layout of longline gear.

4.60 The Working Group requested the Secretariat to look into the issue with technical coordinators of national observer programs and gear experts, prepare the required illustrations and update the cruise report form. Consultations on the issue with experts present at the forthcoming meeting of WG-FSA would also be useful.

Scientific Observers Manual

4.61 The Working Group revisited the observers' priority tasks identified by the Scientific Committee.

4.62 The Working Group recommended that the collection of data to meet the three priorities (SC-CAMLR-XXV, paragraph 2.15) must be undertaken and listed as the highest priorities in the observer tasks. In doing so, the Working Group recognised that this may result in a high workload for the observer to ensure collecting comprehensive information on fish larvae by-catch using the interim fish larvae by-catch protocol (WG-EMM-07/25).

4.63 The Working Group recommended that the way forward was to have some of the biological information (maturity stage, feeding intensity) as lower priority items, but to provide the observers with thorough guidance on how data can be collected without compromising systematic observation coverage in time and space.

4.64 One option is to have the required scientific observation from krill fisheries (SC-CAMLR-XXV, paragraph 2.12) listed by the Scientific Committee as mandatory items, and the other tasks listed as optional. However, this may result in inconsistent coverage in time and space.

4.65 The interim fish larvae by-catch protocol was adopted as the standard protocol for fish larvae by-catch observation after some technical revisions.

4.66 The interim fish larvae protocol instructs the observers to randomly preserve remainders of sorted samples for later analysis by Members. Scientists from the Designating Member of the observers are encouraged to undertake the analysis. A minor technical difficulty was pointed out regarding the large amount of samples that would need to be stored on board the fishing vessels.

4.67 WG-EMM also requested data on the frequency of infected krill with black spots to be included in the *Scientific Observers Manual* (WG-EMM-07/29).

4.68 The Working Group agreed that all suggested revisions of the *Scientific Observers Manual* should be done through close correspondence between the CCAMLR Scientific Observer Data Analyst and relevant experts.

4.69 The Working Group also noted that krill length-frequency data are accumulated through scientific observation and these allow some comparison in selectivity between vessels and between fishing methods, but that these observations were spatially and temporally limited. Coverage in time and space could be improved through systematically increasing observer coverage or through the collection of such data by the fishing vessels.

4.70 The Working Group noted that the conservation measure for the data reporting system for krill fisheries (Conservation Measure 23-06) is the only conservation measure for a CCAMLR fishery that does not have an obligation to collect biological information.

4.71 The Working Group recommended that the requirements for the collection of biological information from the krill fishery should be consistent with the finfish fisheries, which require mandatory reporting of length composition measurements of target species (Conservation Measure 23-05) (paragraph 5.51).

4.72 It was also noted that in finfish fisheries the presence of compulsory scientific observers on vessels takes the reporting burden off the vessel's crew. However, without observers on the fishing vessels, the crew would be required to collect and report these data.

Regulatory issues

Orderly development of the krill fishery

4.73 WG-EMM-07/23 described Australia's position regarding the scientific requirements related to the orderly development of the krill fishery as foreshadowed in the Commission meeting in 2006 (CCAMLR-XXV, paragraph 12.66). It recommended that in keeping with the precautionary approach, steps need to be taken to establish when, relative to the scale of the fishery, different arrangements need to be set in place.

4.74 WG-EMM-07/23 recommended the following for ensuring the orderly development of the krill fishery (as described more fully in the paper):

(i) Undertake krill stock surveys in areas with no precautionary catch limits to set a catch limit before fishing is prosecuted.

(ii) Establish SSMUs to minimise localised impacts on krill predators prior to a threshold being reached, to avoid impacts on the predators dependent on that location for food, and allow for the reasonable development of the fishery.

(iii) Establish a threshold capacity for the fishery relative to the catch limits until the system for managing the catch limits is in place.

(iv) Develop a program to monitor and observe krill catch and by-catch, with methods for minimising by-catch in krill fisheries developed early to achieve low levels of by-catch from the outset.

4.75 The paper concluded that CCAMLR will not be able to meet its objective, including an orderly development of the krill fishery, unless the outlined processes are adopted as integral components of managing the krill fishery.

4.76 The Working Group agreed that a strategic approach to the orderly development of the krill fishery, such as that suggested by Australia, would allow the Commission to better control and mitigate the level of impact by the krill fishery on the krill stocks and on predator populations (see paragraph 2.79).

Notification form

4.77 The Working Group recalled the purpose of the conservation measure on the notification of intent to participate in a krill fishery (Conservation Measure 21-03, Annex 21-03/A). This was to provide, *inter alia*, WG-EMM with projections of the expected catch, and where, when and how those catches may occur, for discussion during the annual Working Group meeting. This allows an improved assessment of interest in the krill fisheries and an examination of potential trends in the fishery.

4.78 WG-EMM noted the usefulness of these notifications and suggested some additions to the notification form (Conservation Measure 21-03, Annex 21-03/A) to improve its utility (Appendix D).

Key points for consideration by the Scientific Committee

4.79 The krill catch for the 2006/07 season in Area 48 was 106 589 tonnes. The Republic of Korea reported the largest catch of krill with a total of 43 031 tonnes. Japan also reported a large catch (32 711 tonnes). Ukraine, Norway and Poland reported catches of 15 206, 9 228 and 6 413 tonnes respectively (paragraph 4.1), and the Working Group noted that with the exception of the Republic of Korea and Poland, all Contracting Parties had submitted complete sets of fine-scale haul-by-haul data for 2005/06 in accordance with Conservation Measure 23-06 (paragraph 4.2).

4.80 The total krill catch notified for the 2007/08 season was 764 000 tonnes, and was expected to be taken by 25 vessels from nine notifying countries. Ten vessels from three countries notified that they would be using a pumping system (Cook Islands, Russia and Ukraine) (WG-EMM-07/6 Rev. 2) (paragraph 4.14).

4.81 The high level of notifications indicated that, if all the projected catches were taken, the trigger level for Area 48 (620 000 tonnes) would be exceeded (paragraph 4.17).

4.82 There were notifications of large catches from non-Member States (Cook Islands, 175 000 tonnes and Vanuatu, 80 000 tonnes) (paragraph 4.17).

4.83 The Working Group suggested some modifications to the notification form (Conservation Measure 21-03, Annex 21-03/A) to provide information for improved assessment of interest in the krill fisheries and an examination of potential trends in the fishery (paragraphs 4.20, 4.77 and 4.78) and to take note of the issues in paragraphs 4.17 to 4.20.

4.84 WG-EMM recommended that the instructions in the *Scientific Observers Manual* be revised (paragraph 4.34), and the interim fish larvae by-catch protocol (WG-EMM-07/25) be included, so that the various types of information urgently needed by the Scientific Committee could be systematically collected (paragraphs 4.64 to 4.72).

4.85 The Working Group agreed on two strategic objectives for scientific observations in the krill fishery (paragraphs 4.45 and 4.46):

(i) to understand the overall behaviour and impact of the fishery
(ii) to undertake routine monitoring of the fishery to inform population and ecosystem models.

4.86 The Working Group considered a number of options and approaches and made recommendations on the deployment of observers in the krill fishery to achieve the objectives in paragraphs 4.44 to 4.56.

4.87 To assess the accuracy and completeness of the data collected by scientific observers in the krill fishery, the Working Group requested the Secretariat to prepare a summary of the data collected by scientific observers on board krill fishing vessels during the 2006/07 season and to submit it to the next meeting of WG-EMM for review and approval (paragraph 4.58).

4.88 The Working Group noted that the conservation measure for the data reporting system for the krill fishery (Conservation Measure 23-06) is the only conservation measure that does not require the collection of biological information, and recommended that the requirements from the krill fishery should be consistent with the finfish fisheries (Conservation Measure 23-05) (paragraphs 4.70 and 4.71).

4.89 The Working Group agreed that a strategic approach to the orderly development of the krill fishery would allow the Commission to better control and mitigate the level of impact by the krill fishery on krill stocks and on predator populations (paragraphs 4.73 to 4.76).

STATUS AND TRENDS IN THE KRILL-CENTRIC ECOSYSTEM

Status of predators, krill resource and environmental influences

Predators

CEMP indices

5.1 Dr Ramm summarised recent submissions of CEMP data, data validation and trends in CEMP indices (WG-EMM-07/4). Data for 2006/07 were submitted by eight Members for 10 sites and 13 different CEMP parameters. The Italian CEMP researchers had reported that their study season at Edmonson Point in 2006/07 had been short and only breeding population and breeding success counts had been undertaken. In addition, CEMP data from Esperanza (Hope Bay) were collected in 2006/07 but were lost in a fire on board the Argentine icebreaker *Irizar*.

5.2 Dr Ramm also reported that routine validation and logic testing of CEMP is now complete for data submitted to June 2007. In general, the quality of the CEMP submissions remains high; however, in recent years there have been some recurring issues which had the potential to reduce the quality of these data. These issues were examined by the Subgroup on Methods (paragraphs 5.69 to 5.76).

5.3 Dr P. Wilson (New Zealand) confirmed that aerial photographs for determining breeding population counts for Adélie penguins (*Pygoscelis adeliae*) at Ross Island had been taken in 2003/04, 2004/05, 2005/06 and 2006/07, and population counts derived from these photographs are currently being undertaken and should be available in 2008.

5.4 The Working Group thanked Dr Ramm for his summary of the CEMP data and noted that, while the number of CEMP parameters and Members submitting data had remained relatively constant, the number of sites from which data had been submitted had declined over the past five years. It was noted that this change may not simply be related to funding, but to a combination of issues including shifting scientific priorities.

5.5 The Working Group noted evidence that the krill fishery may be entering a period of expansion (WG-EMM-07/5) which implies that there may be an increased need for monitoring. It further noted that the ability to effectively manage the fishery in areas with no monitoring data may be restricted compared to those areas with more data. The Working Group felt that data collection now is an investment in the future management of the fishery.

5.6 The Working Group also noted that there are countries doing research of interest to CCAMLR and its work which do not currently contribute to the CEMP database. The Working Group encouraged CCAMLR Members with active research programs to join ongoing and future efforts of importance to the work of CCAMLR.

Predator summary

Winter data from the Antarctic Peninsula region

5.7 WG-EMM-07/10 analysed data from archival temperature tags to investigate the daily time and energy budgets of gentoo penguins (*P. papua*) for the full winter periods of 2005 and 2006 in the South Shetland Islands. In general, the time budget of gentoo penguins tracked the cycle of day length and exhibited diurnal foraging patterns. Foraging trip durations tracked light availability throughout the winter; however, lower variation in trip duration among individuals in early winter suggested that gentoo penguins use all available daylight to maximise time spent foraging prior to the mid-winter period. Increased variability in early spring trips may be related to increased activities associated with courtship. Among environmental parameters that affected the winter time budget, air temperature was consistently identified by statistical models, with warmer days associated with longer foraging trips, and colder days associated with reduced trip frequencies. Future work during winter will benefit from increased sample sizes, geolocation of sample birds and complementary data on the diets to refine estimates of consumption during winter.

5.8 The Working Group welcomed this contribution, noting that little is known about the natural history of any penguin species during the winter period in this region. However, increasingly, it appears to be the major time period affecting adult survival and juvenile recruitment in penguins. Initial estimates of winter energy budgets presented in the paper are also useful but will benefit from concurrent work on diets and local movement patterns of individuals over the winter period.

5.9 The Working Group noted that gentoo penguins, unlike their more numerous congeners, the Adélie and chinstrap (*P. antarctica*) penguins are non-migratory and would therefore serve as year-round samplers of the marine system within discrete SSMUs. The Working Group further noted that while the small population sizes of gentoo penguins in Area 48 may suggest they have relatively little impact on krill resources in the region, their life history characteristics make them particularly good indicators of local prey abundance.

Predator foraging parameters from the Antarctic Peninsula region

5.10 WG-EMM-07/P2 compared the size and sex of Antarctic krill (*Euphausia superba*), taken from chinstrap and gentoo penguin diet samples, to those from scientific net surveys in the adjacent region of the South Shetland Islands from 1998 to 2006. Both penguin diet and net samples revealed a four- to five-year cycle in krill recruitment with one or two strong cohorts sustaining the population during each cycle. Penguin diet samples contained adult krill of similar lengths to those caught in nets; however, penguins rarely took juvenile krill. Penguin diet samples contained proportionately more females when the krill population was dominated by large adults at the end of the cycles; net samples showed greater proportions of males in these years. The authors suggest that these patterns are likely driven by the availability of different sizes and sexes of krill in relation to the colony.

5.11 WG-EMM-07/11 examined the diet of chinstrap penguins at Livingston Island, South Shetland Islands, in relation to their diving and foraging behaviour using time-depth recorders over five seasons from 2002 to 2006. Results revealed that when krill were smaller, chinstrap penguins often exhibited a shift to deep dives after sundown, and then resumed their shallower pattern at sunrise. These night-time dives were unexpectedly deep (up to 110 m) and mean night-time depths sometimes exceeded those from the daytime. The average annual size of krill was negatively correlated to the number of penguins foraging on fish, mean night-time dive depths, and the proportion of foraging trips occurring overnight. Based on these patterns, the authors suggested that when krill were small, penguins foraged more on myctophid fish. In addition, the average krill size was negatively correlated to the time chinstrap penguins spent foraging, which suggests that penguins incurred a cost associated with this switch to fish by spending more time at sea foraging.

5.12 WG-EMM-07/P1 summarised results from penguin studies at Cape Shirreff in the South Shetland Islands undertaken by US AMLR researchers in the 2006/07 season. Both gentoo and chinstrap penguin populations experienced average years with breeding success and chick fledging weights slightly below the 10-year mean for gentoo penguins, while both of these parameters were slightly above the mean for chinstrap penguins. Diet samples contained the highest proportion of fish in the 10 years of study and both species had significant amounts of juvenile krill (<35 mm in length) in their diet samples. The small krill and increased percentage of fish in the penguins' diets in 2006/07 were very similar to diet data from the 1997/98 and 2002/03 seasons. In addition, the mean foraging trip durations during chick rearing were significantly longer than in the previous season.

5.13 The Working Group discussed the female bias in krill found in penguin diets reported in the latter years of each krill recruitment cycle. It noted that this bias may be related to spatial segregation of non-breeding females inshore with males located offshore; however, several other explanations were suggested, including:

(i) local effects could be influencing the krill population at Cape Shirreff as krill distributions are very dynamic, particularly in poor years;

(ii) vertical stratification in krill could account for the female bias;

(iii) older krill are female-biased due to differences in growth and survival between males and females (WG-EMM-07/P6);

(iv) penguins may be selecting large female krill for their higher energy value.

5.14 The Working Group noted the high incidence of fish in the penguin diets in years dominated by small juvenile krill and the concurrent increase reported in foraging trip duration in those years. The authors added that in addition to longer foraging trips, years with a high proportion of fish included foraging trips 30 to 40 km offshore, to the shelf break and beyond. Years where large krill dominated the penguin diets were characterised by short foraging trips within 10 km of the colony.

Indian Ocean sector

5.15 WG-EMM-07/21 investigated the relationship between sea-ice and Adélie penguin reproductive performance at Béchervaise Island. Sea-ice influences penguin populations through a variety of processes operating at different spatial and temporal scales. To further understanding of the relationship between sea-ice and penguin biology, the authors examined annual breeding success in relation to three sea-ice attributes: (i) winter sea-ice cover; (ii) offshore summer sea-ice cover; (iii) near-shore summer ice cover. Results indicated that the relative importance of sea-ice cover on reproductive performance differs according to the spatial scale and timing of sea-ice presence and magnitude. In particular, the analyses presented here highlight the importance of the influence of near-shore January ice cover on reproductive performance for Béchervaise Island Adélie penguins.

5.16 The Working Group noted that there is mounting evidence of the effects of climate change in the Antarctic ecosystem and that it is therefore important to continue the assessment of the linkage between penguins and their ice environment. Such understanding will aid in interpreting results from the CEMP monitoring program and in predicting changes in krill-dependent predator populations.

5.17 The Working Group cautioned that the Antarctic ecosystem should not be regarded as a single system operating in a uniform manner; rather it is increasingly evident that the Antarctic Peninsula, East Antarctica and the Ross Sea regions are responding to environmental change in differing ways and at different rates. The linkages between sea-ice, krill and predators that have been reported in the Antarctic Peninsula region may not hold for other regions.

5.18 The Working Group further noted that, given the different responses in the system to environmental change, it will be important to have monitoring sites in regions that have different ice regimes. The design of future monitoring studies should include not only what is measured, but also include a consideration of where measurements are made, so that fishery–predator interactions will be assessed over a broad range of environmental conditions.

Ross Sea region

5.19 WG-EMM-07/7 reported on a joint survey of the RV *Kaiyo Maru* and the Japanese Whale Research Program that examined the interactions between oceanographic conditions, the distribution of krill and baleen whales in the Ross Sea region during the austral summer of 2004/05. Results indicated close interactions between the thermal conditions, krill and baleen whale distributions. Humpback whales (*Megaptera novaeangliae*) were mainly distributed in ACC waters with high density around 0°C near the southern boundary of that current. Antarctic minke whales (*Balaenoptera bonaerensis*) were mainly distributed in Antarctic surface water and shelf water with a high density around –1°C in the continental shelf slope frontal zone. The interaction between distributions and abundance of krill and baleen whales and oceanography, relating water mass and circulation pattern of the oceanic surface layer, was summarised in a conceptual model.

5.20 WG-EMM-07/P4 summarised observations of Weddell seals (*Leptonychotes weddellii*) feeding on Antarctic toothfish (*Dissostichus mawsoni*) in McMurdo Sound from the 2001 to 2003 austral summers. In addition to past reports of isolated toothfish captures, the frequency of these observations, and the quantity of toothfish captured, suggest that this species is a significant prey item for Weddell seals, and that the recent development of a toothfish fishery in the Ross Sea may have broad ecosystem impacts.

5.21 The Working Group noted the importance of behavioural data in predator studies, as identifiable hard-part remains (otoliths) of toothfish seldom appear in Weddell seal scats, yet toothfish may be important to this species' foraging ecology. It further noted that new innovative techniques, such as critter-cams, might be very helpful in improving our knowledge of the potential overlap between predators and the toothfish fishery.

5.22 Dr Nicol suggested that new molecular techniques may allow prey items to be identified when hard parts are missing, and may also be useful to investigate prey consumed by predators at times of the year when access to them is difficult. Improved data on diets of predators are of great importance for models to be used in calculations of predator demand.

5.23 Dr Wilson noted that the Ross Sea region has several sites where monitoring-type data have been collected for 20+ years, and suggested it would be important to determine how WG-EMM might encourage the submission of these data to CCAMLR. Data from the Italian program were of particular interest, given a recent finding suggesting that the program is monitoring in an important transition area in the Ross Sea (WG-EMM-07/7).

5.24 The Working Group further noted the proposal for a new monitoring parameter on Weddell seals (WG-EMM-07/13).

5.25 The Working Group discussed the need for, and development of, a monitoring program for the Ross Sea region. Some participants felt there was an urgency to proceed along this path, given the rapid development of the toothfish fishery in recent years and the lack of any monitoring data of relevance to this fishery in the region. However, there were several concerns, including that:

(i) it would be counter productive to begin collecting data without first developing a monitoring design that was both theoretically sound and pragmatic;

(ii) it will be important to distinguish between what must be collected to have a viable monitoring program and what would be additional information to assist in better understanding the ecosystem;

(iii) to be helpful, a monitoring program would have to have a long-term funding commitment.

5.26 The Working Group expressed its appreciation for the work presented from the Ross Sea region and encouraged future contributions that would assist in providing advice to CCAMLR regarding the toothfish fisheries in Subareas 88.1 and 88.2.

Krill resources

Survey results

5.27 WG-EMM-07/8 reported on a krill net sampling survey along three transects in the southern part of Subarea 48.6 during winter 2006. During this period the survey area was completely covered by seasonal pack-ice. Antarctic krill was caught in most of the 54 RMT samples. Krill abundance estimates for the current winter survey in the Lazarev Sea resulted in 13.9 krill 1 000 m^{-3}. This was a significant increase compared to the mean numerical density observed during an early summer survey carried out in the same season, which resulted in a density estimate of 3.15 krill 1 000 m^{-3}. Size composition in winter was dominated by 1- and 2-year-old krill; however, the proportion of the juvenile group was relatively low, indicating only a moderate abundance of the 2005 year class.

5.28 It was argued in the paper that a quantitative evaluation of the other Euphausiacea species seems to be essential, because they not only overlap with Antarctic krill in the same area, but they can also occur in similar numerical densities and, depending on the area, in similar size classes. This may cause problems in species delineation during the acoustic surveys for krill biomass estimates. Therefore, the study also covered the distribution of other euphausiids and their abundance.

5.29 Ice krill (*E. crystallorophias*) was found exclusively on the narrow shelf and along the slope stations of the continent. Numbers were relatively low and densities did not exceed 2 krill 1 000 m^{-3}. *Thysanoessa macrura* was distributed across all stations of the survey grid. Densities were one order of magnitude lower in winter than in the preceding summer when *T. macrura* outnumbered the density of *E. superba* five times. However, samples from the multiple RMT in winter indicated substantially higher densities of *T. macrura* in deeper depth strata down to 400 m. This would point to a seasonal vertical migration of the species to deeper waters in winter.

5.30 The analysis of *E. superba* larvae resulted in an average density of 6.8 furcilia m^{-2}. Compared to historic data of the FIBEX 1982 survey or the CCAMLR-2000 Survey, the density of larvae in the Lazarev Sea was relatively low. However, due to the lack of time-series data from Subarea 48.6 it is impossible to identify whether 2006 was an unusually poor year for krill larvae in that area or whether the situation reflects the common situation in the Lazarev Sea.

5.31 WG-EMM-07/7 presented results of a survey to the Ross Sea in 2004/05 to study the interactions between oceanographic conditions, and the distribution of krill as prey and baleen whales as predators in the Ross Sea. The oceanography of the surface layer was summarised as an oceanographic environmental index that integrated the mean temperature from 0 to 200 m in depth (ITEM-200). Distribution of ITEM-200 was used as background information to compare distribution patterns of species. *Euphausia superba* was mainly distributed in the Antarctic surface water area (ITEM-200 between 0° and –1°C). *Euphausia crystallorophias* did not occur in the Antarctic surface water, but was distributed in the colder shelf water on the continental shelf south of the –1°C isopleth of ITEM-200 which approximately coincides with depths shallower than 1 000 m.

5.32 The survey area was divided into two strata to estimate the biomasses of the two krill species based on their distribution patterns. Biomass densities of *E. superba* and *E. crystallorophias* were estimated to be 5.36 g m^{-2} and 3.44 g m^{-2} respectively. The total biomass of *E. superba* and *E. crystallorophias* in the study presented here were estimated to be 2.04 and 1.26 million tonnes respectively.

5.33 The Working Group noted that the ITEM-200 index might be a helpful tool to delineate areas of different krill distribution patterns or for bioregionalisation purposes. It was suggested that the general appropriateness of the index should be tested for other areas, because the temperature range described for krill distribution in the Ross Sea is obviously different in areas such as the Antarctic Peninsula or the Scotia Sea.

5.34 The Working Group encouraged further oceanographic and sighting studies in the Ross Sea and other high-latitude areas around the continent, such as the one presented in WG-EMM-07/7 (see discussion in paragraphs 6.28 to 6.30). It was noted that the segregation between *E. superba* and *E. crystallorophias* has also been observed in other high-latitude areas, such as the southern Weddell Sea and the Prydz Bay region, but not in the Lazarev Sea and the Bellingshausen Sea, where the two species co-occur on the shelf. This can be important for subdividing subareas and the setting of future precautionary catch limits.

5.35 WG-EMM-07/30 Rev.1 reviewed the estimation of krill biomass of the international acoustic CCAMLR-2000 Survey across the Scotia Sea (Subareas 48.1 to 48.4) (see paragraphs 2.17 to 2.19). A detailed discussion of the new methods and the recommendations can be found in the report of SG-ASAM (Annex 8) and the discussion of the krill acoustic subgroup during the WG-EMM workshop (paragraphs 2.11 to 2.32).

5.36 WG-EMM-07/33 updated the survey estimate for Division 58.4.2, which was first presented to WG-EMM in 2006 (WG-EMM-06/16). A reanalysis of the data has resulted in amendments to the acoustic estimates of krill mean biomass density, biomass and variance. The methods are clearly described in the paper. The volume-backscattering bins at 120 kHz were classified into krill and non-krill, where krill are defined by the algorithm S_v 120–38 kHz = 2–16 dB and S_v >–80 dB. The analysis also applied the Greene et al. (1991)

TS:length model at 120 kHz to convert the krill areal-backscattering values to an areal measure of biomass density. In general it can be realised that the post-processing of the raw echosounder data was consistent with the acoustic protocol applied for the original CCAMLR-2000 Survey analysis (see paragraph 2.29 and Hewitt et al., 2004).

5.37 Krill were widely distributed at relatively low densities throughout the survey area; only 13% of the 2-km-alongtrack echo-integration intervals were devoid of krill, 50% of intervals registered densities of 1 g m^{-2} of krill or less. The mean acoustic biomass density of krill, integrated to 250 m depth across the entire survey stratum of Division 58.4.2 (1.31 million km^2), was 9.48 g m^{-2}. B_0 was estimated to be 12.46 million tonnes with a CV of 15.15%.

5.38 The krill distribution was considered in the context of the physical oceanography, from which a case is presented for the subdivision of Division 58.4.2 into smaller, more biologically homogeneous, areas. The paper suggested that Division 58.4.2 be divided into four ecologically distinct harvesting units. The simplest subdivision is longitudinally at 55°E, which acknowledges the dominant influence of the Weddell Gyre and the Prydz Bay Gyre. A further latitudinal subdivision at 65°S would take into account both the krill demography and the southern boundary of the ACC, and would also reflect the influence of the Antarctic Slope Current (see also paragraphs 6.18 to 6.24).

5.39 Drs Nicol and Jarvis informed the Working Group that they will provide the biomass estimate results as well as the revised potential yield estimates for the subdivided harvesting units of Division 58.4.2 to the Scientific Committee using the newly agreed acoustic protocols (Annex 8; see also paragraph 3.1(vi)). They further indicated that the biomass estimate of the 1996 survey of Division 58.4.1 will be revised according to the agreed protocols for the next meeting of WG-EMM, so that a consistent set of biomass estimates will be available to revise the existing precautionary catch limits.

5.40 WG-EMM-07/31 presented krill biomass trends in the South Shetland Island region of Subarea 48.1. Only daytime data were used in the analysis due to possible bias from diurnal vertical migration. All previous data from 1996 to the present were reanalysed using the simplified SDWBA target-strength model and a dynamic ΔS_v krill delineation model. Krill are delineated from other scatters by use of a three-frequency ΔS_v method instead of using a constant range of ΔS_v (i.e. $2 \leq S_v120\text{ kHz} - S_v38\text{ kHz} \leq 16$ dB). This is in conformity with the agreed protocol currently accepted by SG-ASAM (Annex 8).

5.41 In 2007 krill was distributed in dense layers all across the survey area. The biomass was 294, 129 and 43 g m^{-2} for the Elephant Island, the South Shetland Islands and Bransfield Strait areas respectively. The total biomass exceeded 19 million tonnes. This increase from <500 000 tonnes in 2006 represents the largest biomass recorded in nearly 20 years. One-year-old krill were poorly represented in the net samples in 2006, but more than 60% of the biomass of krill collected in 2007 was composed of two- and three-year-old krill. This suggests that either a large recruitment event was not captured in surveys conducted in 2006 or 2005, or that in 2007 advection from elsewhere is responsible for the recent increase. The paper discussed the observation that anomalously high temperatures and high chl-*a* conditions in 2006 may have affected distribution of krill in that year.

5.42 The Working Group observed that the biomass time series shows that the biomass during the year of the CCAMLR-2000 Survey was in the lower range of the biomass estimates. It further noted that in 2007 krill biomass around Elephant Island and north of the South Shetland Islands was substantially higher than in Bransfield Strait. This is in contrast with the observer report from the *Saga Sea*, which indicated that in the 2006/07 season major krill fishing activities in Subarea 48.1 have moved from outside to inside Bransfield Strait (WG-EMM-07/16). However, final conclusions about the behaviour of the fishing fleets can only be made after the complete catch and effort data for 2006/07 will have been submitted to the CCAMLR Secretariat.

5.43 The Working Group further noted that the biomass estimates in Subarea 48.1 from acoustic and net sampling data show very similar trends across the long-term time series, which was very encouraging. It stressed the importance of continuation of collecting krill density and recruitment indices for this area, since these are important input parameters for the GYM to calculate precautionary catch limits.

Biological information

5.44 WG-EMM-07/P6 consisted of two parts: (i) krill sex ratio across length classes was examined using field survey data; and (ii) model simulation was performed to explore the model structure and parameter settings that best explain the trends observed from the field. The field data show that the proportion of males was consistently high in the smallest adult size class (30–35 mm). The proportion of males was always low in medium-sized krill (38–42 mm), but showed higher values in larger krill (45–50 mm), and the values again decreased in the largest animals.

5.45 The outcome of the simulation model indicated that the trend of male proportions with length is a result of the combined effects of differential growth rates and mortality rates between the sexes, the age composition of the population, the life span and the degree of mortality acceleration at the end of the life span.

5.46 Results suggested that a higher proportion of males tends to be associated with good recruitment. The authors argue that, as the population ages with little recruitment, and thus little input of new males, the population becomes dominated by the longer living females. With a high recruitment in some years, combined with higher proportion of males than females at birth, the ratio becomes skewed towards males. Overall, it appears that the pattern of proportion of males across size is mainly dictated by the life span of males (3–4 years) in relation to females (7 years). An assumed 3–4 year male life span, or accelerated mortality above age 3, compared to the female 7 years' lifespan, seemed to best reproduce the pattern observed from the field data. This may explain interannual differences in male:female ratios. The discussion mentioned that the consequences would be obvious, accelerated mortality in above age 3 in males means that if the number of years with poor recruitment increases, then there would be a major reduction in surviving productive males, and restoring the population would become more difficult than it would be in a population with males and females of the same age structure.

5.47 The Scientific Committee and WG-EMM have commented extensively on the implications of new technologies in the krill fishery (SC-CAMLR-XXIV, paragraphs 4.4 to 4.10; SC-CAMLR-XXV, Annex 4, paragraphs 3.28 to 3.31 and 3.48 to 3.61; WG-EMM-06/27). In particular, concerns have been expressed that the new continuous fishing system may capture different components of the krill population and may have a higher ecosystem impact than conventional trawls. However, even for the conventional trawl, very limited information is available on catchability or selectivity. WG-EMM-07/28 presented information on selectivity and vulnerability of krill in conventional trawling, by comparing length-frequency data of krill from RMT1, RMT8 and a pelagic trawl.

5.48 WG-EMM-07/28 reported that krill smaller than 20 mm were underestimated by roughly 60% in the catches from the RMT8. Depending on the surveys, the RMT8 selection curve showed a selectivity inflection point (L_{50}) between 16 and 19 mm. It was discussed that length classes below this inflection point are usually below the size range of krill present in summer when surveys usually take place and when krill reach a mean length well above 20 mm. From this it can be concluded that mesh-size selection for the RMT8 has little effect on the estimation of the density of the 1+ age group.

5.49 The comparison of length-frequency data from the RMT8 and commercial trawl samples showed a shift to larger size classes in the commercial trawl by 3 mm on average. The turning point of the net selection curve was calculated as L_{50} = 42.2 mm. However, data from a year with a much higher proportion of small krill present in the stock resulted in an L_{50} selection point of 32 mm. It is hypothesised that, due to clogging effects, length-frequency distributions and the location of selection curves obtained from the commercial trawl are highly dependent on the actual stock composition in a given year and area. This makes the estimation of recruitment indices less reliable.

5.50 A preliminary study on krill damaged during commercial trawling operations indicated an effect of trawling duration and total catch per haul. It is interesting to note in this regard that the damage rate of krill in the commercial trawl was not size dependant or related to sex of krill. This can be important, because it can be assumed that at least 5 to 25% or even more of those krill passing through the meshes are also lethally damaged after long trawling times or high catches.

5.51 The Working Group noted that krill length-frequency data from the fishery are important for the interpretation of the stock composition, because the fishery covers larger areas over a longer time and can collect data which are not available from surveys. Consequently, a standardisation of data will be essential. It was therefore recommended that information on gear type and mesh size shall be reported by scientific observers together with biological data.

5.52 WG-EMM-07/29 described a black-spot disease found on *E. superba*, sampled by a scientific observer on board a krill fishing vessel in the South Shetland and the South Georgia regions during winter 2003 and 2006. Approximately 2–5% of sampled krill showed this infection. The black spots were most often found on the cephalothorax. Three bacteria were isolated from these black spots. Histological observations showed that the black spots were melanised nodules and that these nodules often contained more than one type of bacteria. The melanised nodules were almost always accompanied by tumour-like cells, which seemed to be derived from a gonad tissue. These results suggest that the bacterial infections of krill were likely to be secondary and that the development of the tumour-like cell mass in the gonad may be the primary cause for the disease.

5.53 The Working Group recognised the importance of the results and noted that a similar kind of shell disease is well known from shrimp species in the North Atlantic, where pollution, effects of fishing gear, predator interaction and level of organic enrichment are discussed as potential reasons, although the reasons for infections in Antarctic waters are probably different.

5.54 Dr Siegel noted that, despite the authors' observation that krill specimens were recovering at least from the bacterial infections, an unknown proportion of the infested population may have already been subject to mortality. Even if the disease does not directly cause mortality in the krill, the development of such a tumour-like cell mass in the gonad can affect reproduction of the organism. This has been observed in shrimp populations in the North Sea where, over a period of several years, the reproductive rate of female shrimp had decreased by 50 to 90% leading to an overall decline in the shrimp stock biomass.

5.55 Predation is usually the primary mortality component in food-web models. This study provided insights into other potential sources of mortality. In order to consider the potential consequences of this condition on krill reproductive performance and mortality, the Working Group requested that observations on the frequency of occurrence of such black spots be recorded by scientific observers on krill fishing vessels. The analysis of intra-annual and interannual time series of occurrence of this condition might provide insights into its impacts on the dynamics of krill populations.

5.56 No other diseases are currently reported for krill in the published literature which would require further monitoring.

Environment

5.57 WG-EMM-07/P8 presented an exhaustive summary and review of the Scotia Sea ecosystem. It summarised how the influence of the eastward-flowing ACC and waters from the Weddell–Scotia Confluence dominates the physics of the Scotia Sea, leading to a strong advective flow, intense eddy activity and mixing. The paper reviewed the impact of the strong seasonality, including irradiance and sea-ice cover, which leads to shorter summers in the south and impacts the strength and timing of summer phytoplankton blooms, probably as a result from the mixing of micronutrients into surface waters through the flow of the ACC over the Scotia Arc. It also reviewed the importance and influence of interannual variability in winter sea-ice distribution and SST that is linked to southern hemisphere-scale climate processes such as ENSO. The paper summarised the importance of this climate link in relation to regional primary and secondary production and biogeochemical cycles and importantly to krill population dynamics and dispersal. It also reviewed how this ecosystem has been perturbed by resource harvesting over the last two centuries and significant ecological changes owing to climate change. The authors concluded that these changes suggest that the Scotia Sea ecosystem is likely to show significant change over the next two to three decades, which may result in major ecological shifts.

5.58 The Working Group noted the extensive amount of work summarised in WG-EMM-07/P8. Discussion revolved around the different mechanisms that could result in coherences in age structure of krill between the South Shetland Islands and the South Georgia area of Area 48. The Working Group also noted that the summary section of the review article provided a series of ideas from which to formalise hypotheses for testing in the future.

5.59 WG-EMM-07/P10 presented the results of a circumpolar lagrangian modelling study that includes interactions with sea-ice to examine the importance to krill distribution. The paper used outputs from the OCCAM project together with satellite-derived sea-ice motion vectors to examine the potential roles of the ocean and sea-ice in maintaining the observed circumpolar krill distribution. It showed that the ACC is likely to be important in generating the large-scale distribution of krill and that sea-ice motion can substantially modify the ocean transport pathways, enhancing retention or dispersal depending on location. Within the Scotia Sea, the authors showed that variability in sea-ice motion increases variability of influx to South Georgia, at times concentrating the influx into pulses of arrival. This variability has implications for the ecosystem around the island. The inclusion of sea-ice motion leads to the identification of source regions for the South Georgia krill populations additional to those identified when only ocean motion is considered. This study indicated that the circumpolar oceanic circulation and interaction with sea-ice are important in determining the large-scale distribution of krill and its associated variability.

5.60 The Working Group noted that considerable variability in particle arrival and particle distribution was found in the model outputs and such data indicate the utility of these modelling approaches to provide information regarding the transport and retention in the Southern Ocean.

5.61 WG-EMM-07/14 extended the time series of the DPOI (the sea-level pressure difference between Rio Gallegos, Argentina, and the Esperanza Base) to 2006. It further correlated the annual DPOI and the integrated temperature of the water column over the upper 200 m in the South Shetland Islands region. The data are likely to be useful in examining the relationship between atmospheric changes and krill abundance and recruitment (Naganobu et al., 1999).

5.62 There was considerable discussion regarding the broader use of the DPOI to infer transport variability of the ACC. The Working Group noted that the DPOI has now been linked with the integrated temperature of the upper water column and that this index may provide a stronger link to atmospheric forcing. It was also noted that, as the DPOI extends into the past more than 50 years, it should provide an important link to other atmospheric and oceanographic time series. The authors were encouraged to continue development and exploration of this index.

5.63 WG-EMM-07/15 proposed a method to forecast the fishing conditions across Area 48 through examination of the relationship between solar activity (indexed by the mean annual Wolf sunspot number), the variability in the rotation of the earth (the index was not described) and net-based catch rates across Area 48. The proposed mechanism is increased eddy activity, and increased zonal atmospheric interactions that may aggregate animals in the nearshore environments. The paper also proposed that this relationship could be used to forecast catch rates over the next three years.

5.64 The Working Group noted that the development of environmental indices to forecast fishing should be pursued.

5.65 WG-EMM-07/12 presented a first-order analysis of 18 years of hydrographic data from the Elephant Island region of the South Shetland Islands and examined their relationship to atmospheric tele-connections (principally El Niño) and both water column properties and phytoplankton biomass. The authors developed an index of the influence of upper circumpolar deepwater (UCDW) and found a negative correlation between their index and the strength of the El Niño 3.4 (EN34) index. No linear secular trend was observed in the temperature at 27.6 σt, however, a significant unimodal pattern was found suggesting that long-term decadal scale variability was also captured in the study. Phytoplankton biomass (inferred from chl-*a*) was not correlated to the influence of the UCDW, although a high EN34 index was related to low phytoplankton biomass. Chlorophyll *a* was positively correlated with both upper mixed layer (UML) temperature and the UML depth, and a further stepwise regression showed that UML temperature, not UML depth, was more important in explaining the variability in mean phytoplankton biomass over the 18-year time series. The authors concluded that both ENSO event scale forcing and long-term trends in atmospheric forcing influence UCDW in the vicinity of the Elephant Island region of the South Shetland Islands and show that the collapse of the UML shoaling (associated with low SST) leads to the lack of a bloom during El Niño.

5.66 The discussion around the importance of this paper centred around the chl-*a* data, and the high values observed in 2006. The Working Group discussed the relationship between the warm water column temperature and the chl-*a* concentration as it related to the lack of krill observed in 2006.

Other prey species

5.67 The Working Group welcomed work on epipelagic macrozooplankton distribution in the Ross Sea conducted on board the RV *Kaiyo Maru* (Japan) (WG-EMM-07/10).

5.68 The Working Group noted that different groups of zooplankton may be affected to different extents by climate change (e.g. ocean acidification is likely to particularly affect pteropods).

Methods

5.69 The Subgroup on Methods met to review issues relating to CEMP methods. There were five issues that were discussed and brought to the attention of the Working Group.

5.70 The first issue regarded the CEMP Standard Method A7, fledging weights of penguins. At WG-EMM-06 it was agreed that the standard method be modified for gentoo penguins to reflect the difference in fledging behaviour noted at Admiralty Bay (SC-CAMLR-XXV, Annex 4, paragraph 4.52) compared to other pygoscelid penguins. However, no proposed modification was tabled at WG-EMM-07 and it was agreed that progress on this issue would be made intersessionally and presented at the next meeting of WG-EMM. Dr Trivelpiece agreed to coordinate this work.

5.71 The second issue was a suggestion that CCAMLR species codes used in CEMP be reviewed. It was pointed out that the scientific name of the black-browed albatross had been changed from *Diomedea melanophrys* to *Thalassarche melanophrys*. The species code used by CEMP, DIM, was based on the former name and was no longer intuitive for some data submitters.

5.72 It was noted, however, that the three-letter species codes are FAO species codes. Consistency in the use of data codes was essential in maintaining the integrity of the CCAMLR databases. However, the Secretariat agreed to look into the utility of an alternate CEMP code that could be cross-referenced to the FAO species codes.

5.73 The third issue, raised by the Secretariat, concerned CEMP data forms. It was noted that some Members were using old data forms to submit data and that there were some inconsistencies in reporting. The Working Group made the following recommendations:

(i) Members should be encouraged to use the most current data forms available, which are found on the CCAMLR website;

(ii) Members should be encouraged to use comment sections of data forms and to send extra information that they believe may be useful in data validation or interpretation of the data.

5.74 WG-EMM noted that the Secretariat sends an annual circular to Members, with email copy to regular submitters of CEMP data, advising on the deadline for the submission of CEMP data and any changes to data forms.

5.75 The fourth issue, related to CEMP data, was a request from the Secretariat for guidance from WG-EMM on the implementation of the ordination method for presenting trends in CEMP indices, specifically:

(i) which CEMP indices should be used, as not all have complete series or have been collected annually;

(ii) how to address missing values in the time series;

(iii) what sort of ordination method to use;

(iv) what approach should be taken when dimensions are limited for a particular region.

5.76 It was suggested that a 'scoping' paper that outlined the issues above, and further defined what is needed, be tabled with WG-SAM for consideration. Further it was noted that a combined approach with WG-SAM and data providers working together might prove more fruitful. It was suggested that the report of the Subgroup on Statistics (SC-CAMLR-XVI, Annex 4, Appendix D) and subsequent commentary of this Working Group be used as a basis for such a scoping paper.

5.77 WG-EMM-07/13 contained a proposal to monitor Weddell seal population numbers in the Ross Sea along the Victoria Land coast using aerial census techniques and aerial photography. It noted that Weddell seals are potentially important predators of Antarctic toothfish and may be impacted by the longline fishery, though the level of predation is not yet clear.

5.78 The Working Group noted that it would be premature to approve the Weddell seal as a CEMP species because it was not clear how monitoring of these seals would be used in the context of CEMP to signal the impacts of fishing on dependent and related species. An important prerequisite is that CEMP species are responsive to changes in targeted species and therefore signal potentially wider ecosystem effects of fishing. Nevertheless, the Working Group agreed that establishing time-series monitoring of important species in different areas will help document the variability in the system as baseline data and, in particular, will help identify when the system is changing. It was also noted that species need to be chosen carefully to achieve these aims.

5.79 The Working Group encouraged further work on determining the role of the Weddell seal in the Ross Sea ecosystem and whether it was a sufficiently sensitive species to monitor for ecosystem variability and change and whether it could be a suitable indicator species in CEMP. It agreed that large-area surveys of Weddell seals would be useful in this baseline task, as they would complement existing long-term localised biological monitoring of Weddell seal populations at Ross Island. It encouraged submission of results of this work in the future.

Future surveys

5.80 Plans for proposed krill and krill predator surveys, and associated surveys in parts of the Convention Area, were reviewed.

Methods and protocols for future acoustic surveys

5.81 The report of the third meeting of SG-ASAM was considered (Annex 8). The meeting focused on the development of methods for acoustic surveys of mackerel icefish and reviewed the acoustic sampling protocols for Antarctic krill for use by CCAMLR-IPY projects.

5.82 Regarding future CCAMLR acoustic surveys to estimate krill B_0, SG-ASAM recommended that:

(i) the SDWBA model with constrained parameters be used to define krill target strength as a function of length at a given frequency;

(ii) the minimum and maximum TS values from the subgroup's agreed run of the simplified SDWBA (SC-CAMLR-XXIV, Annex 6, Figure 4) be used as a first estimate of the error associated with krill target strength;

(iii) the classification of S_v to filter out non-krill targets should be undertaken using the ΔS_v technique, with the ΔS_v windows constrained for the appropriate size range of krill;

(iv) further research be conducted during future surveys on the distributions of orientation and shape, and sound-speed and density contrasts for krill under the surveying vessel;

(v) 70 kHz echosounders be used in addition to 38, 120 and 200 kHz to improve krill detection, classification and estimation of B_0, whenever possible.

5.83 Regarding future CCAMLR surveys of icefish, SG-ASAM recommended that:

(i) multiple frequencies, including 38, 70 and 120 kHz, be used in acoustic surveys of icefish and krill whenever possible to improve echo classification. The utility of higher and lower frequencies should also be investigated;

(ii) the efficacy of the current Δ120–38 kHz S_v dB difference method of target identification be further evaluated in relation to discrimination of icefish from associated species;

(iii) the target strength of icefish and associated species continues to be studied using a variety of methods including *in situ* measurements, *ex situ* experiments on individuals and aggregations, and physics-based and empirical models;

(iv) data be collected on icefish orientation, including changes in orientation due to vertical migration or in response to survey vessels;

(v) icefish behaviour should be further investigated, including vertical distribution and response to survey vessels, as they impact on survey design, fish orientation, target strength determination and species delineation;

(vi) a library of echograms with associated target strength, catch and biological data for icefish and associated species should be archived with, and made available from, the CCAMLR Secretariat. This library should be incorporated into the existing CCAMLR acoustic database;

(vii) the Secretariat investigate the feasibility of archiving data in the HAC[1] (or other suitable) format, and that other types of data, such as calibration parameters, should be archived by the Secretariat.

Planned IPY surveys

5.84 The CCAMLR-IPY Steering Committee met in May 2007, and held a joint session with SG-ASAM on 2 May 2007 to discuss acoustic sampling protocols for CCAMLR-IPY surveys. The meeting was convened by Mr S. Iversen (Norway). The report of the meeting (SC-CAMLR-XXVI/BG/3) was circulated in SC CIRC 07/26 in order that appropriate acoustic and sampling protocols can be implemented in the coming Antarctic field season. Further reference to the use of acoustic protocols by Members carrying out IPY surveys may be found in paragraph 5.98.

5.85 The following surveys are planned during IPY (SC-CAMLR-XXVI/BG/3):

(i) Norway – The research vessel *G.O. Sars* will conduct pelagic studies including an acoustic survey in the northern region of Subarea 48.6 for krill and icefish. This study has adopted an ecosystem approach to look at the ecology of the

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[1] A global standard being developed for the storage of hydroacoustic data.

region, including zooplankton and phytoplankton, and to quantify the prey available to land-based predators. The *G.O. Sars* will perform acoustic target strength studies on krill and icefish near South Georgia in Subarea 48.3.

Provisionally, the fishing vessel *Saga Sea* will also be used as an observation platform in Area 48. A range of new environmental sampling systems will be used in the Norwegian survey, including the MESSOR and MUST plankton and environmental samplers and midwater trawl for macrozooplankton.

(ii) Germany – The research vessel *Polarstern* will work in the southern region of Subarea 48.6 and conduct a SYSCO benthic survey for CAML and a SCACE physical oceanography and climate survey. Opportunities exist for the collection of acoustic data and RMT samples (December–January).

(iii) New Zealand – The research vessel *Tangaroa* will conduct a CAML survey of the Ross Sea (Subarea 88.1) to measure and describe key elements of species distribution, abundance and biodiversity. A wide range of taxonomic groups will be studied, with an emphasis on the biodiversity of benthic, demersal and mesopelagic species, and on by-catch associated with the toothfish (*Dissostichus* spp.) fishery in Subarea 88.1.

(iv) Japan – The research vessel *Umitaka Maru* will conduct a survey near Syowa Station (JARE Survey Area A; Division 58.4.2) and a CEAMARC survey near Dumont d'Urville for CAML (Division 58.4.1). This work will include pelagic sampling with RMT8 nets and the collection of acoustic, physical and chemical oceanographic data. The *Umitaka Maru* is a university vessel and the survey will be conducted in cooperation with the Australian Antarctic Division; Dr G. Hosie is the CAML IPY contact at the AAD.

(v) UK – The research vessel *James Clark Ross* will conduct Discovery 2010 and BIOFLAME surveys of the West Antarctic Peninsula and Scotia Sea, South Georgia and South Shetland Islands region (Area 48). All trophic levels will be studied at fixed and reactive stations, using RMT and other nets, and a full suite of acoustic data.

(vi) CAML – CAML surveys will be conducted around Antarctica to provide a bench of current biodiversity and describe the associated processes. CEAMARC surveys in eastern Antarctica will use the Japanese vessel *Umitaka Maru* (pelagic and mesopelagic sampling), the Australian vessel *Aurora Australis* (physical and chemical oceanography, demersal and benthic sampling) and the French vessel *l'Astrolabe* (with supplementary inshore pelagic sampling). In addition, a circum-Antarctic CPR survey will be conducted with some 14 vessels likely to be involved.

(vii) ICED Program – ICED is investigating the interactions of physical oceanography, biogeochemical cycles and the food web. This is a long-term project which will start in the IPY. ICED will provide circum-Antarctic sampling opportunities similar to CAML, and seeks to develop links with other IPY projects. Closer links could be developed between ICED, CCAMLR and CAML.

5.86 The Working Group noted that a synoptic survey for krill in Area 48 (i.e. similar to the CCAMLR-2000 Survey) is not planned under the auspice of IPY in 2008.

Key points for consideration by the Scientific Committee

Status of predators, krill resource and environmental influences

Predators

5.87 The Working Group noted that the ability of the krill fishery to develop in areas with no monitoring data may be restricted in relation to those areas with more data, and that data collection now is an investment in the future management of the fishery (paragraph 5.5).

5.88 All Members conducting research of interest to CCAMLR are encouraged to contribute to the CEMP database and to the work of the Working Group (paragraph 5.6).

5.89 The Working Group expressed its appreciation for the work presented from the Ross Sea region and encouraged future contributions that would assist in providing advice to CCAMLR regarding the ecosystem effects of the toothfish fishery in Subareas 88.1 and 88.2 (paragraph 5.26).

Krill resources

5.90 The Working Group encouraged further studies on the segregation of *E. superba* and *E. crystallorophias* in the Ross Sea and other high-latitude areas around the continent, for the purpose of subdividing subareas and setting future precautionary catch limits (paragraph 5.34).

5.91 The Working Group noted that the revised estimate of krill B_0 in the survey stratum of Division 58.4.2 (12.46 million tonnes, CV = 15.15%) will be further revised using the agreed CCAMLR methods for target strength estimation and target identification (Annex 8) and submitted to the Scientific Committee to revise the existing precautionary catch limits (paragraph 5.39).

5.92 The Working Group encouraged Members to continue to collect krill density and recruitment indices for Subarea 48.1 and to submit these to the Working Group, as these are important input parameters for the GYM to calculate potential yield (paragraph 5.43).

5.93 The Working Group recommended that krill length-frequency data from the fishery, which cover larger areas and periods than are available from surveys, are standardised and reported with information on gear type and mesh size to allow optimal interpretation of the stock composition (paragraph 5.51).

Environment

5.94 The Working Group noted that the results of a comprehensive review of the structure and operation of the Scotia Sea ecosystem indicated that a combination of historical exploitation and the effects of climate change could lead to significant and rapid changes over the next two to three decades (paragraph 5.57).

Methods

5.95 Members are encouraged to submit data on the most up-to-date forms which are available on the CCAMLR website (paragraph 5.73).

5.96 The Working Group recommended that issues relating to methods for the ordination of CEMP data be the subject of a scoping paper submitted to WG-SAM for its advice (paragraphs 5.75 and 5.76).

Future surveys

5.97 The Working Group recommended that, regarding acoustic surveys of krill and icefish, all CCAMLR-adopted acoustic protocols and guidelines for krill surveys be collated into a single document (paragraph 2.31).

5.98 The Working Group recommended that, regarding methods and protocols for CCAMLR-IPY surveys, Members carrying out IPY surveys refer to, and follow, the acoustic protocols for data collection provided in Table 3 of Annex 8 (paragraph 5.84).

5.99 The Working Group suggested that the CCAMLR Secretariat contact all CAML investigators via Dr V. Wadley (AAD, Australia), Secretary of CAML, and request that they adhere to CCAMLR-IPY protocols when conducting their respective IPY surveys, and that the Secretariat produces a summary of all IPY acoustic data and related metadata submitted to CCAMLR, and report to SG-ASAM by April 2009 (SC-CAMLR-XXVI/BG/3, paragraph 22).

STATUS OF MANAGEMENT ADVICE

Protected areas

6.1 The Advisory Subgroup on Protected Areas met during WG-EMM-07 to review and present advice on the following topics.

CEMP site protection

6.2 The Working Group considered a request of the Scientific Committee that the requirements to review CEMP site protection under Conservation Measure 91-01 in respect of

Conservation Measures 91-02 and 91-03 (protection of Cape Shirreff and Seal Islands CEMP sites respectively) should be clarified and, if required, reviewed at the earliest opportunity (SC-CAMLR-XXV, paragraph 3.17).

6.3 The Working Group agreed that management plans for the Cape Shirreff and Seal Islands CEMP sites had been modified in 2004 (CCAMLR-XXIII, paragraphs 10.26 and 10.27), therefore, a formal review of the two relevant measures (Conservation Measures 91-02 and 91-03 respectively) would not be required until 2009.

6.4 However, the Working Group recognised that all CEMP-related work on the Seal Islands had ceased in 1997 (WG-EMM-07/4, Table 1) and that the USA had indicated that it has no plans to conduct such work in the future. Therefore, the Working Group suggested that the protection of the Seal Islands CEMP Site under Conservation Measure 91-03 should be discontinued.

CEMP site maps

6.5 The Working Group noted that the USA had submitted a map depicting the study site on Admiralty Bay where CEMP data are collected annually. The map was a subset of the one prepared for ASMA No. 01 encompassing the entire Admiralty Bay area and including ASPA No. 128. The map shows the locations of seabird colonies and topographical features at the CEMP site. The location of the 'US summer field camp' known locally as Copacabana Field Camp (also known as Pieter J. Lenie Camp) is shown.

6.6 The Working Group was informed by Dr Holt that the last time CEMP data had been collected and submitted for the Anvers Island site was in 1999 and that no data would be submitted in the future. Therefore, no new maps would be submitted for the site.

6.7 The Working Group noted that the last time CEMP data were submitted for the Elephant Island (Stinker Point) CEMP site was in 1992 by Brazil. Dr E. Fanta (Brazil) indicated that there will be a project at Elephant Island during 2008. She indicated that more information on the project will be available at the time of SC-CAMLR-XXVI and she would inquire if CEMP work might be resumed and if an updated map could be prepared for the site.

Bioregionalisation

6.8 The Working Group noted that the Scientific Committee had provided detailed terms of reference for a steering committee to facilitate collaboration with CEP to organise a workshop to establish a bioregionalisation of the Convention Area and to consolidate advice on a system of protected areas (SC-CAMLR-XXV, paragraphs 3.30 to 3.55).

6.9 The Working Group noted that the Bioregionalisation Workshop is scheduled to be held from 13 to 17 August 2007 in Brussels, Belgium. Attendance is expected to number approximately 33 participants, representing 10 Members, the Secretariat, and invited experts.

6.10 The objective of the workshop is to advise the Scientific Committee and Commission on a bioregionalisation of the Southern Ocean, including, where possible, advice on fine-scale subdivision of biogeographic provinces. The 2007 workshop is viewed as a next step in the progression of endeavours leading to the establishment of a system of MPAs harmonised for the protection of the Antarctic marine environment across the Antarctic Treaty System (SC-CAMLR-XXV, paragraph 3.32).

ATCM draft management plans for protected areas
with marine components

6.11 The USA submitted to the Commission, and requested the Working Group to provide comments on, the Draft Management Plan for ASMA Number X: Southwest Anvers Island and Palmer Basin (CCAMLR-XXVI/BG/3 (as submitted to ATCM XXX (2007) WP5)). As indicated by the title, the proposed ASMA contains a marine component.

6.12 The Working Group noted that it is not within its remit to approve or disapprove of a proposed management plan but to provide advice to the Scientific Committee according to the procedure nominated by the Commission (CCAMLR-XX, paragraph 11.17). In this regard, the Working Group also noted that:

(i) in 2001 (CCAMLR-XX, paragraph 11.17) and again in 2006 (CCAMLR-XXV, paragraph 6.1), the Commission reaffirmed its support of the ATCM (as expressed now in ATCM Decision 9 (2005)) that those ASMAs and ASPAs with a marine component that need the approval of CCAMLR are those:

   (a) in which there is actual harvesting or potential capability of harvesting of marine living resources which might be affected by site designation; or

   (b) for which there are provisions specified in a draft management plan which might prevent or restrict CCAMLR-related activities;

(ii) when such a proposal is submitted to CCAMLR, the Commission requests advice from the Scientific Committee as to the impact of a management plan with respect to these two points, although other scientific advice may be provided as well (CCAMLR-XX, paragraph 11.17).

6.13 The Working Group noted that the site:

(i) contains the US Palmer Station which has been for many years, and continues to be, the site from which year-round research is conducted. It includes both marine and land-based research and includes all aspects of ecosystem research (seabird, finfish, oceanographic etc.);

(ii) is included in the US LTER area in which a study has been conducted since 1990. This research, which occurs in an area without commercial harvesting, has the potential to provide information which can be compared to the US AMLR research, located directly adjacent to the north, to investigate krill fishing effects;

(iii) the proposed marine component represents a small proportion of the fishable area in Subarea 48.1 (approximately 0.5% of the total surface area – 3 275 km^2 in the ASMA (CCAMLR-XXVI/BG/3) versus 672 000 km^2 in Subarea 48.1 (*CCAMLR Statistical Bulletin*));

(iv) has not been subjected to sustained commercial harvesting (less than 4 tonnes of krill has been taken from the proposed ASMA during 2002/03 (*CCAMLR Statistical Bulletin*, in CCAMLR-XXVI/BG/3)).

6.14 The Working Group noted that the information provided above constitutes the only quantitative advice with respect to these issues and therefore is the best scientific advice available for the Commission to consider.

6.15 Dr Naganobu stated that he cannot support the proposed ASMA, which includes a large marine area for the following reasons:

(i) Article II of the Convention includes rational use and this needs to be ensured in this case;

(ii) the marine component of the proposed ASMA does have the potential for commercial krill harvesting, as shown by the commercial catches taken in the past;

(iii) krill spatial fishing patterns have been variable in recent years and areas in Bransfield Strait, similar in size and location to the proposed area in this ASMA, were commercially fished during 2007.

6.16 Dr V. Bizikov (Russia) indicated that because the proposed ASMA contains a sizable marine area with some potential for commercial fishing, the management plan should not restrain any possible fishing activity which might yield research data. He also emphasised that the proposed ASMA should not contradict the principles of conservation as stated in Article II of the Convention.

6.17 Others noted that, in addition to the advice in paragraph 6.13 that:

(i) such a small area in the region is unlikely to contribute to the economic viability of a krill or other fishery;

(ii) on the basis of our understanding of the dynamics of krill, should the fishery be dependent on this area alone in Area 48, or even Subarea 48.1, then the state of the krill stocks will be such that the fishery should probably be closed;

(iii) if the western Antarctic Peninsula is an important area for reproduction and recruitment of krill for the entire southwest Atlantic (WG-EMM-07/P8) then maintaining the area free of fishing would be of benefit to the population as a whole.

Harvesting units

6.18 The Working Group further considered procedures to subdivide large CCAMLR statistical areas into ecologically based harvesting units. The Scientific Committee had suggested that advice on this topic should await the results of the Australian survey of Division 58.4.2, which could provide an example of using environmental data to assist in the subdivision process (SC-CAMLR-XXV, Annex 4, paragraph 5.21).

6.19 WG-EMM-07/33 provided details on the results of the Australian survey of Division 58.4.2, which included an assessment of whether the division could be divided into regions that were ecologically distinct. The paper indicated that the division could be split in two along the 55°E line of longitude, reflecting the oceanographic influence of the Weddell Gyre in the west and the Prydz Bay Gyre in the east. A further subdivision was suggested along the 65°S line of latitude, which separated the oceanic krill populations from those in more coastal areas. A four-way subdivision of Division 58.4.2 would also reflect the population structure of krill observed on the survey.

6.20 The rationale for the latitudinal subdivision of Division 58.4.2 is to ensure that any precautionary catch limits established in this region recognised the existence of both oceanic and coastal krill populations. This would ensure that a krill fishery operating in Division 58.4.2, which, based on historical data would most likely occur in the coastal zone, would not take the catch limit that resulted from an assessment of krill across the entire division from only the coastal zone.

6.21 Some members felt that the further subdivision of Division 58.4.2, separating the krill population in the waters to the north of 65°S from those to the south, was not justified.

6.22 The Working Group agreed that dividing Division 58.4.2 along the 55°E line of longitude was ecologically appropriate and would also reflect differences in krill stocks in this area.

6.23 In considering the issue of subdividing other large statistical areas, the Working Group agreed that there were a wide range of options available in the absence of recent survey data. Many of these approaches had been presented to the Scientific Committee in 2001 (SC-CAMLR-XX/BG/24) but they included:

- data from oceanographic surveys
- information on bathymetry and the presence of island groups
- information from the upcoming bioregionalisation workshop
- use of arbitrary subdivisions, such as the SSRUs developed for the toothfish fishery.

6.24 The Working Group sought advice from the Scientific Committee on its preferred approach(es).

Small-scale management units

6.25 The Working Group noted that WG-SAM was asked by the Scientific Committee to further develop approaches to subdividing the Area 48 catch limit for krill amongst SSMUs (SC-CAMLR-XXV, paragraph 13.12). The deliberations and advice from WG-SAM are contained in Annex 7, paragraphs 5.7 to 5.51.

6.26 The Working Group recalled the options for subdividing the catch limit among SSMUs (Annex 7, paragraph 5.12) and endorsed 'structured fishing' as a useful elaboration of the meaning of Option 6 (Annex 7, paragraphs 5.13 and 5.14). This is considered further below.

6.27 The Working Group noted that WG-SAM-07/12 and 07/14 were available for consideration, along with three additional papers addressing issues relevant to the deliberations on SSMUs and management procedures for krill. The additional papers are presented here first before the general discussion on this issue.

6.28 Dr Naganobu introduced WG-EMM-07/7, which reported on survey work carried out to study the interactions between oceanographic conditions, and the distribution of krill as prey and baleen whales as predators in the Ross Sea and its adjacent waters, in the austral summer of 2004/05. The distribution of each species was compared to the distribution of ITEM-200 (see also paragraph 5.31). Antarctic krill was mainly distributed in the Antarctic surface water area (ITEM-200 = 0° to –1°C) compared to ice krill, which was clearly distributed in the shelf water but not Antarctic surface water. Humpback whales were mainly distributed in the ACC waters with highest densities near the southern boundary of that current. Antarctic minke whales were mainly distributed in the eastern part of the Ross Sea in the continental shelf slope frontal zone. The paper summarised a conceptual model of interaction between oceanography, relating water mass and circulation pattern of the oceanic surface layer with ITEM-200, and the distribution and abundance of krill and baleen whales.

6.29 The Working Group noted the distinction in the distribution of Antarctic and ice krill and the distributions of whales. In relation to the development of a Ross Sea ecosystem model, the following points may need to be taken into account:

(i) What is the distribution of killer whales in relation to these other species?
(ii) Why were the minke whales not found in the same location as Antarctic krill (their highest densities being in areas where few krill were observed)?

6.30 Dr Constable also noted that the conclusions of the paper were based on the physical and biological oceanography and the visual surveys of whales. This work was very useful for characterising the Ross Sea ecosystem. He concluded that the addition of data from individual whales was unnecessary for developing those conclusions.

6.31 WG-EMM-07/17 was presented by Dr Bizikov on behalf of the authors. This paper analysed variability of krill transport and distributions in two local areas, one each in the SSMUs of SOW and SGW. Repeated small-scale acoustic surveys were accompanied by trawls and CTD casts. The data were compared to geostrophic flows predicted from oceanographic models. The results indicated that temporal and spatial changes of krill abundance through krill transport need to be accounted for in the development of management procedures for the krill fishery, particularly in considering the catches that could be taken from within SSMUs. It was recommended that such work be based on actual data describing annual and seasonal variability of krill biomass and characteristic distribution patterns in SSMUs under the impact of transport processes.

6.32 The Working Group welcomed this paper and encouraged the authors to continue quantifying the spatial and temporal variability of krill in SSMUs. It noted that the spatial coverage of such work needs to be comparable to the scales of the SSMUs and the oceanographic processes being investigated. The scale of the study reported in this paper is useful for investigating temporal variability of abundance at the scale of the operation of a fishing vessel; however, the investigation of processes occurring at the scale of SSMUs would require studies over larger areas. As such, analyses of the sort reported here could assist with developing models of the dynamics of fishing fleets. It was noted that mesoscale studies, such as the US AMLR surveys around the Antarctic Peninsula, show a greater stability in relative abundances among SSMUs, even though there may be small-scale variability within SSMUs as to the location of the aggregations. The Working Group encouraged further work on these issues and requested that fuller explanations of the research design (acoustic transect details and integration intervals, number and depth of CTD samples and so on) be submitted along with the additional work.

6.33 WG-EMM-07/P7 was presented by Dr Constable, who noted that this paper is part of a very useful book on top predators in marine ecosystems and their importance in monitoring and management (Boyd et al., 2006). This particular chapter examined how goals and reference points might be set in quantitative terms for higher trophic levels – such as marine mammals, birds and fish. In terms of the work of CCAMLR, it discussed how to operationalise Article II by exploring the general characteristics of objectives for higher trophic levels within the context of ecosystem-based management, but noting that the emphasis for managing the effects of human activities on higher trophic levels is often biased towards fisheries-based approaches rather than approaches that take into account the maintenance of ecosystem structure and function. Following this, the precautionary approach developed in CCAMLR for taking account of higher trophic levels in setting catch limits for target prey species is described. The last section considered indicators of the status of predators with respect to establishing target and limit/threshold reference points that can be used directly for making decisions in a feedback management system, noting the value of closed areas to monitoring ecosystem processes and for evaluating the effects of fishing. Indicators are described that include univariate indices summarising many multivariate parameters from predators, known as composite standardised indices, as well as an index of predator productivity directly related to lower trophic species affected by human activities.

6.34 Dr Constable noted that the chapter summarised some of the issues that could be addressed in the evaluation of management strategies for the krill fishery, taking account of the small-scale requirements of predators.

Process for implementing a subdivision of Area 48 catch limit amongst SSMUs

6.35 The Working Group endorsed the process recommended by WG-SAM that the implementation of a subdivision of the Area 48 catch limit among SSMUs could be undertaken in stages based on the best scientific advice available at each stage (Annex 7, paragraphs 5.10, 5.11 and 5.49 to 5.51). Stage 1 can be delivered next year based on models and data currently available, and would involve the provision of advice on a total catch limit in Area 48 combined with catch limits in each SSMU. The advice would be couched in terms of risks to predators, krill and the fishery. It is intended that this would help provide for the orderly development of the krill fishery beyond the current trigger level of 620 000 tonnes, in advance of improved data and models and evaluation of structured fishing approaches, and a feedback management procedure.

6.36 While agreeing with the process to proceed to Stage 1 advice, Dr Naganobu noted that consideration needs to be given to how trends and variability in spatial distribution of krill could impact on whether a subdivision of the krill catch limit among SSMUs, once established, would remain appropriate in the future. He was also concerned that a subdivision might impede the ability of the fishery in some years to move to other areas because of substantial redistributions of krill that can sometimes occur.

6.37 Dr Bizikov noted that, taking account of the considerable variability in the distribution of krill, subdivision of krill catch limits among SSMUs should be necessarily re-evaluated annually based on the data obtained from scientific surveys and the fishery.

6.38 The Working Group noted a number of important points in this case:

(i) the staged approach provides for updating the advice on the SSMU subdivision after Stage 1, particularly after the acquisition of more data and reassessment of the subdivision as further work is undertaken (in the same manner as stock assessments are updated for toothfish);

(ii) the initial subdivision and an associated catch limit are not intended to unnecessarily impede the flexibility of the fishery;

(iii) there is an expectation that information and modelling will improve over the coming years and that the strategy for managing the fishery in terms of catch limits within SSMUs will evolve to provide better and updated advice on the subdivision;

(iv) there is also an expectation that the full management strategy will include feedbacks from the fishery (catches, fishery performance) as well as fishery-independent monitoring (krill, predators and/or environment) to help:

  (a) redistribute catches among SSMUs based on an assessment model and decision rules;

  (b) overcome issues of trends and interannual variability in abundance of krill and responses of predators by using such indicators in an assessment model that appropriately predicts future harvest strategies (over, say, one or two years);

(v) the process of evaluating these feedback management strategies in Stage 2 and subsequent stages if needed can be used to identify the impacts of different harvest strategies (catch and effort distribution among SSMUs) on krill and its predators;

(vi) the proposal to have a structured fishing program during the development of the fishery aims to obtain data necessary for refining the management strategy, including data acquisition programs, assessment models and decision rules governing the distribution of catches among SSMUs.

Scenarios to be evaluated in Stage 1

6.39 The Working Group noted the consideration by WG-SAM of the models that can be used to evaluate scenarios for Stage 1 advice (Annex 7, paragraphs 5.28 to 5.35), including advice (Annex 7, paragraph 5.36) that catch limits will be represented in the models as proportions of the harvest rate, γ, with;

(i) the trigger level of 620 000 tonnes corresponding to 0.15 x γ;

(ii) the subdivision applying to the aggregate catch for Subareas 48.1, 48.2 and 48.3 of 3.168 million tonnes, which is based on the proportion of area in those subareas compared to the combined area of Subareas 48.1, 48.2, 48.3 and 48.4, would correspond to 0.8 x γ.

6.40 The Working Group endorsed the model scenarios considered essential by WG-SAM (Annex 7, paragraphs 5.37 and 5.38) but noted that some consideration of the spatial impact of the subdivision options on the krill fishery should be essential in the risk assessment, rather than optional.

6.41 In considering this further, the Working Group noted that the following would be important to consider in the risk assessment, although this need not require detailed implementation of models of fleet dynamics in Stage 1:

(i) the potential for the catchability of krill to be different in coastal and shelf areas compared to oceanic areas and how this might impact on the performance of the krill fishing vessels and therefore could be a cost to the fishery;

(ii) the potential for sea-ice to impact on performance of the fishery.

6.42 The issue of catchability could be addressed in the first instance by comparing the relative ‘performance’ of the fishery in the different SSMUs in model outputs. Other observations (external to the models) would be used to determine if krill are likely to be more difficult to catch in some SSMUs compared to others, and these differences would be applied to the relative performance data to adjust the risk assessment.

6.43 The Working Group agreed that data requested from the fishery in the past on what influences the performance of a fishing vessel, the basis on which vessels move between fishing grounds (SC-CAMLR-XXV, Annex 4, paragraphs 3.67 to 3.71) and haul-by-haul data from the fishery will be important for these analyses. It also noted that spatial patchiness of krill could be derived from existing survey data. The Working Group encouraged analyses leading to an understanding of how catchability and fishing performance may vary between coastal and oceanic SSMUs.

6.44 The Working Group agreed that not all scenarios need to be explored by each model but that there needs to be sufficient overlap in scenarios between models to understand the relative model performance.

6.45 The Working Group noted the importance of using field and other data in the models to establish that the relative differences amongst SSMUs in the models reflect reality. It noted and endorsed the process of using data outlined by WG-SAM (Annex 7, paragraphs 5.17 to 5.27). The data suggested by WG-SAM for validating the models (Annex 7, paragraphs 5.24 and 5.26) were considered by the Working Group, as requested by WG-SAM, and WG-EMM noted the following for using these data:

(i) the strongest signals in empirical data are those for penguins and seals;

(ii) variability in krill abundance can be documented from the US AMLR, BAS and LTER survey series;

(iii) changes in krill abundance prior to these survey series are less well supported by data, particularly when the errors in the estimates of abundance are considered;

(iv) trends in whale populations are unclear and very much dependent on which species is considered.

Risk Assessment for Stage 1

6.46 The Working Group endorsed the approach of WG-SAM to the performance measures and risk assessments to be undertaken in Stage 1 (Annex 7, paragraph 5.48). It noted that the 'benchmark levels' indicated by WG-SAM are really 'reference levels', which are quite distinct from the benchmark data used to validate the models.

Developing approaches beyond Stage 1

6.47 The Working Group endorsed the further development of feedback management approaches (Option 5) and structured fishing (Option 6) after the work for Stage 1 is completed (Annex 7, paragraph 5.16), noting that structured fishing (Annex 7, paragraph 5.13) could provide useful results to assist, during the development of the fishery, in the elaboration of a feedback management in the longer term (Annex 7, paragraph 5.14).

Analytical models

6.48 The Working Group noted:

(i) the work of WG-SAM at its first meeting, particularly its work on integrated assessments for krill and the subdivision of the krill catch limit among SSMUs;

(ii) the name and terms of reference of WG-SAM (Annex 7, paragraph 8.18) and the recommended process for reviewing quantitative assessment methods, statistical procedures and modelling approaches that lead to advice when the Working Group cannot agree on the appropriateness, implementation or interpretation of results from a quantitative method (those defined in the terms of reference of WG-SAM) proposed for use by the Working Group (Annex 7, paragraph 8.19);

(iii) KPFM is now to be known as FOOSA (Annex 7, paragraph 8.20);

(iv) a desirable process for interaction between WG-SAM and other working groups on issues referred to in (ii) would be through the development of tasks using scoping papers (Annex 7, paragraph 6.9).

Existing conservation measures

6.49 The Working Group thanked the Secretariat for its updated krill fishery report (WG-EMM-07/5). It noted the conservation measures in force and considered what might be required for this fishery in addition to what is contained within existing measures. In so doing, it discussed WG-EMM-07/23, provided by Australia according to the undertaking made to the Commission last year (CCAMLR-XXV, paragraphs 12.65 and 12.66). The outcomes of these discussions and recommendations are summarised in paragraphs 4.73 to 4.76. These will have implications for all conservation measures for krill fisheries.

6.50 More specifically, the Working Group noted the advice that will need to be considered with respect to conservation measures this year:

(i) the recommended change in the yield of krill in Area 48 (Conservation Measure 51-01) (paragraph 2.41);

(ii) the need for the Commission to clarify the implementation of the trigger level in Conservation Measure 51-01 (paragraphs 2.56 and 2.57);

(iii) as a result of work at the B_0 workshop, a revised yield will be available for krill in Division 58.4.2 (Conservation Measure 51-03), including a subdivision of that yield into two smaller areas (paragraphs 2.29, 2.53 and 6.22);

(iv) the need to clarify the notification procedure for krill (Conservation Measure 21-03), including the proposed change to the form contained in Annex 21-03/A of that conservation measure (paragraphs 2.79, 4.20, 4.77 and 4.78 and Appendix D);

(v) the need to report biological information from the krill fishery, requiring the application of Conservation Measure 23-05 to the krill fishery and to include reference to biological information in Conservation Measure 23-06 (paragraphs 4.70 to 4.72);

(vi) the recommendation to consider krill fishing in Subarea 48.6 and Area 88 as exploratory fisheries (with reference to Conservation Measure 21-01), and the need to undertake B_0 surveys before the fishery expands in those areas (paragraph 2.79);

(vii) the recommendation to remove the Seal Island CEMP site from Conservation Measure 91-03 (paragraphs 6.3 and 6.4);

(viii) with respect to the request in Conservation Measure 22-05 for the Scientific Committee to review the use of high-seas bottom trawling gear in high-seas areas, the discussion by the Working Group is in paragraph 7.29.

Key points for consideration by the Scientific Committee

Protected areas

6.51 The Working Group agreed that management plans for the Cape Shirreff and Seal Islands CEMP sites and the two relevant measures (Conservation Measures 91-02 and 91-03 respectively) would not need to be reviewed until 2009 (paragraph 6.3). However, the Working Group suggested that the protection of the Seal Islands CEMP site under Conservation Measure 91-03 should be discontinued (see rationale in paragraph 6.4).

6.52 No new maps would be submitted for the Anvers Island site, as CEMP data will no longer be collected at the site (paragraph 6.6).

6.53 The Working Group noted the progress towards the Bioregionalisation Workshop, scheduled to be held in August 2007 in Brussels, Belgium (paragraphs 6.8 to 6.10).

6.54 The Working Group wished to refer the Scientific Committee to the discussion and advice on the submission by the USA to the Commission of the Draft Management Plan for ASMA Number X: Southwest Anvers Island and Palmer Basin, which contains a marine component (paragraphs 6.11 to 6.17).

Harvesting units

6.55 The Working Group recommended subdividing Division 58.4.2 along the 55°E line of longitude to reflect differences in krill stocks in this area (paragraph 6.22).

6.56 The Working Group sought advice from the Scientific Committee on its preferred approaches to considering the subdivision of other large statistical areas in the absence of recent survey data (paragraphs 6.23 and 6.24). This would facilitate designing surveys of krill populations for the purposes of estimating B_0. Many of these approaches had been presented to the Scientific Committee in 2001 (SC-CAMLR-XX/BG/24) and they included:

- data from oceanographic surveys
- information on bathymetry and the presence of island groups
- information from the upcoming bioregionalisation workshop
- use of subdivisions, such as the SSRUs developed for the toothfish fishery.

Small-scale management units

6.57 The Working Group wished to draw the attention of the Scientific Committee to its deliberations on SSMUs (paragraphs 6.25 to 6.47), paying particular attention to:

(i) its endorsement that 'structured fishing' is a useful elaboration of the meaning of Option 6 (paragraph 6.26);

(ii) its endorsement of the process recommended by WG-SAM that the implementation of a subdivision of the Area 48 catch limit among SSMUs could be undertaken in stages based on the best scientific advice available at each stage (paragraph 6.35);

(iii) that Stage 1 advice can be delivered next year based on models and data currently available, and would involve the provision of advice on a total catch limit in Area 48 combined with catch limits in each SSMU and that the discussion surrounding this advice is provided in paragraphs 6.35 to 6.38;

(iv) its endorsement of the model scenarios for delivering Stage 1 advice, and the need to consider the implications for the fishery of potential differences in catch rates in shelf versus oceanic SSMUs (paragraphs 6.39 to 6.44);

(v) the importance of using field and other data in the models to establish that the relative differences among SSMUs in the models reflect reality, and its endorsement of the process of using data outlined by WG-SAM (paragraph 6.45), including consideration of the benchmark data suggested by WG-SAM for validating the models, noting:

    (a) the strongest signals in empirical data are those for penguins and seals;

    (b) variability in krill abundance can be documented from the US AMLR, BAS and LTER survey series;

    (c) changes in krill abundance prior to these survey series are less well supported by data, particularly when the errors in the estimates of abundance are considered;

    (d) trends in whale populations are unclear and very much dependent on which species is considered.

(vi) its endorsement of the approach of WG-SAM to the performance measures and risk assessments to be undertaken in Stage 1, noting that the 'benchmark levels' indicated by WG-SAM are really 'reference levels', which are quite distinct from the benchmark data used to validate the models (paragraph 6.46);

(vii) its endorsement of the further development of feedback management approaches (Option 5) and structured fishing (Option 6) after the work for Stage 1 is completed, noting that structured fishing could provide useful results to assist, during the development of the fishery, in the elaboration of a feedback management in the longer term (paragraph 6.47).

Existing conservation measures

6.58 The Working Group wished to refer the Scientific Committee to its consideration of the important scientific requirements for the orderly development of krill fisheries (paragraph 6.49).

FUTURE WORK

Predator surveys

7.1 The Working Group considered progress towards a workshop in 2008 on the estimation of land-based predator abundance (SC-CAMLR-XXV, paragraphs 3.25 and 10.1(k)). WG-EMM-07/20 summarised recent intersessional deliberations of the land-based predator correspondence group prior to WG-EMM-07.

7.2 The Working Group agreed to the following terms of reference for the workshop:

(i) consider candidate procedures for deriving abundance estimates for priority land-based predator species in the southwest Atlantic region between 70°W and 30°W;

(ii) identify the minimum data requirements to satisfy the preferred candidate procedures;

(iii) examine available existing datasets to determine the degree to which the minimum requirements are met, and identify inadequacies or gaps in existing data;

(iv) where feasible, apply preferred candidate procedures to existing data to derive abundance estimates;

(v) identify and prioritise gaps in existing data as a basis for assessing where and how any future survey work would be conducted;

(vi) develop a plan for work beyond the workshop, including the use of diet and energetics data to convert estimates of abundance to consumption.

7.3 The Working Group noted that the estimation of predator demand will require a considerable program of work up to and beyond the 2008 workshop, and accordingly agreed to elevate the status of the correspondence group to a subgroup (Subgroup on Status and Trend Assessment for Predator Populations (WG-EMM-STAPP)), to be convened by Dr Southwell, with the following terms of reference:

Develop, review and update as necessary, protocols and procedures for:

(i) the analysis of existing data to estimate the abundance of nominated predator species in specified regions of the CCAMLR Convention Area, including estimation of uncertainty in those abundance estimates;

(ii) the analysis of existing data to estimate trends in abundance of nominated predator species in specified regions of the CCAMLR Convention Area, including estimation of uncertainty in those trend estimates;

(iii) the identification of gaps in existing data that constrain abundance and trend estimation;

(iv) the future collection of data, where necessary, for estimation of predator abundance and trends.

7.4 The Working Group considered the timing and location for the workshop, originally planned to be held in conjunction with the 2008 meeting of WG-EMM (SC-CAMLR-XXV, paragraph 10.1(k)). After consideration of several other meetings and workshops planned for 2008, it was agreed that the workshop need not be held in conjunction with WG-EMM, provided there were no budgetary implications. The subgroup was tasked to plan for the workshop accordingly, and indicated that it was likely to be held in Hobart, Australia, in June 2008. The workshop details, when finalised, will be communicated to SCAR.

7.5 The Working Group expressed its thanks to Dr Southwell for undertaking to convene the subgroup and looked forward to a full discussion of the outcomes from the workshop.

Ecosystem models, assessments and approaches to management

7.6 A joint WG-FSA and WG-EMM one-day workshop on Fisheries and Ecosystem Models in the Antarctic (FEMA) was held on 16 July 2007. The FEMA report (SC-CAMLR-XXVI/BG/6), prepared by the Co-Conveners of the workshop, is not an official report of WG-EMM, but was presented to, and discussed at, WG-EMM.

7.7 The Working Group welcomed this report and agreed that WG-EMM should continue to consider scientific information on the ecosystem effects of finfish fisheries in the Convention Area.

7.8 The Working Group noted that the Scientific Committee should benefit from bringing together expertise from WG-SAM, WG-FSA and WG-EMM into a workshop. The workshop considered methods to assess and investigate ecosystem effects of finfish fisheries in the Convention Area. The Working Group noted that in expanding consideration of fishing in the greater ecosystem context, this work should not become fragmented on the basis of considerations of target species.

7.9 A workshop 'Identifying and Resolving Key Uncertainties in Management Models for Krill Fisheries' was organised at the request of the Lenfest Ocean Program and occurred during the week of 21 May 2007 (henceforth referred to as 'Lenfest Workshop'). The Chair of the Scientific Committee conveyed a letter to the Working Group from the workshop conveners (Drs M. Mangel (USA), Nicol and Reid) which provided an overview of the Lenfest Workshop (WG-SAM-07/15), summarised as follows:

(i) The Lenfest Workshop considered the general characteristics of the krill-centric ecosystems of the South Atlantic including the role of physical forces, krill and dependent predators.

(ii) The Lenfest Workshop considered modelling approaches to krill-centric ecosystems. Discussion focused on model validation methods and performance measures. The Lenfest Workshop concluded that the use of models to investigate ecosystem effects of the krill fishery should not be impeded by requiring models to have features and biological realism exceeding that required for the provision of advice.

(iii) The Lenfest Workshop noted the need for a model of fishing vessel behaviour.

(iv) The Lenfest Workshop concluded that the research priorities on krill-specific issues are:

(a) The distribution and abundance of krill at the spatial scale of SSMUs, and its seasonal variation. This requires improved understanding of what constitutes krill habitat and better understanding of current sampling techniques and how effectively they sample different parts of the krill population.

(b) The parameterisation of krill growth, mortality and recruitment functions. The comparison of length-frequency data from different sampling methods was suggested as a useful approach.

(v) The Lenfest Workshop concluded that the research priorities on krill–predator interactions are:

(a) regional and temporal estimates of krill consumption. Improving these estimates will require assessments of predator abundance, diet and movement;

(b) the characteristics of species and locations that are most sensitive to changes in krill abundance.

(vi) The Lenfest Workshop concluded that understanding relationships between the physical environment and biotic components of the krill-based system was a research priority. The key issue was considered to be the relationship between medium- to long-term trends in krill abundance and large-scale climatic processes, especially the regional and temporal relationship with sea-ice.

7.10 The Working Group welcomed workshops on krill-centric ecosystems outside the CCAMLR forum, such as the Lenfest Workshop. Such workshops provide an opportunity for people outside the CCAMLR community to contribute their experience, data and perspectives towards advancing our understanding of these ecosystems. The Working Group highlighted that it is important that CCAMLR continues to keep the wider scientific community informed of its work.

7.11 The Lenfest Workshop suggested using benchmarks to specify how closely models should reproduce key events and trends in the ecosystem to be considered sufficiently realistic for the provision of advice. WG-SAM provided similar suggestions on the necessary realism of models, the use of empirical data in validation, and the development of a calendar of key events and trends in Area 48 (Annex 7, paragraphs 5.17 to 5.27).

7.12 The Lenfest Workshop suggested that aggregate performance measures would be needed to summarise the output of complex models. Appropriate measures to evaluate the performance of management options were considered by WG-SAM (Annex 7, paragraphs 5.39 to 5.47). WG-SAM noted that aggregate performance measures will be sensitive to the particular method of aggregation chosen.

7.13 The Working Group noted that the letter from the conveners had been used in both WG-SAM and this Working Group in formulating advice in the appropriate sections of the reports.

7.14 The Working Group noted that there is broad agreement amongst krill experts, both within and outside the CCAMLR community, about the major issues that need to be addressed in the management of the krill fishery. In particular, recent research on many of the priority issues suggested by the Lenfest Workshop was considered by WG-EMM-07, including:

(i) understanding the status, trends and behaviour of the krill fishery (section 4; WG-EMM-07/10, 07/27, 07/P5);

(ii) understanding the distribution, abundance and seasonal variability of krill at the spatial scale of SSMUs (WG-EMM-07/8, 07/9, 07/17, 07/31, 07/33);

(iii) better understanding of current sampling techniques and how effectively they sample different parts of the krill population (WG-EMM-07/16, 07/25, 07/28);

(iv) appropriate parameterisation of krill growth, mortality and recruitment functions (WG-EMM 07/30 Rev. 1, 07/33, 07/P6);

(v) estimates of the regional and temporal estimates of krill consumption (WG-EMM-07/10);

(vi) characteristics of predator species and locations (WG-EMM-07/4, 07/11, 07/P1, 07/P2);

(vii) interactions between the physical environment and biotic components of the krill-based system (WG-EMM-07/12, 07/21, 07/P8, 07/P10).

7.15 The Working Group recognised the important role that monitoring plays in managing fisheries in the Convention Area (WG-EMM-07/24, 07/P7, 07/P9). Information collected by consistent methods over long periods of time is particularly valuable to the work of WG-EMM. The Working Group noted that consistent, long-term data are available from three study locations/programs in Area 48: US AMLR, BAS and Palmer-LTER. The continuity of data from these programs is extremely valuable for monitoring and understanding changes in krill abundance, and understanding the relationship with large-scale climatic processes, including sea-ice.

7.16 The Working Group encouraged the submission of information on krill population dynamics and the performance of dependent predators from the Palmer-LTER region to WG-EMM.

7.17 The Working Group identified three areas which may play an important role in the krill-centric ecosystem of the South Atlantic, but which are poorly represented in available data at present: Weddell Sea, Bellingshausen Sea and South Orkney Islands. WG-EMM encouraged increased research in these areas. The South Orkney Islands particularly are a focus for fisheries and are central to the SSMUs in Area 48.

7.18 The Working Group noted that there is a potential conflict between rapid expansion of the krill fishery and the ability to answer key scientific questions about the krill-centric system to enable effective management. It will be very important to ensure that the krill fishery does not impact on CCAMLR's ability to answer these key questions. This issue is of particular concern for areas where little research on krill, predators or the environment is currently available.

7.19 The Working Group recognised that the fishery for Antarctic toothfish in the Ross Sea has the potential to affect other ecosystem components, including predators of toothfish, such as Weddell seals, prey of toothfish, and through second-order ecosystem effects. Further work on assessing these threats and on approaches to managing these threats at the present level of understanding is required. In the meantime, the fishery should be managed at a precautionary level with respect to ecosystem effects.

7.20 Mass balance trophic models are recognised as being a valuable starting point for characterising ecosystem structure. The Working Group welcomed progress on a novel method for objectively establishing balance in trophic models based on estimates of the different level of uncertainty between parameters (WG-EMM-07/18).

7.21 The Working Group noted the conclusions of WG-EMM-07/P7 that the revised principles of Mangel et al. (1996) are useful in indicating what needs to be achieved to deliver a precautionary approach to marine ecosystem management, namely:

(i) manage total impact on ecosystems and work to preserve essential features of the ecosystem;

(ii) identify areas, species and processes that are particularly important to the maintenance of an ecosystem, and make special efforts to protect them;

(iii) manage in ways that do not further fragment natural areas;

(iv) maintain or mimic patterns of natural processes, including disturbances, at scales appropriate to the natural system;

(v) avoid disruption of food webs, especially removal of top or basal species;

(vi) avoid significant genetic alteration of populations;

(vii) recognise that biological processes are often non-linear, are subject to critical thresholds and synergisms, and that these must be identified, understood and incorporated into management programs.

Long-term work plan

7.22 The Working Group noted the combined set of tasks arising from its discussions (Table 3) and requested Members to review and participate where possible in this work plan. It noted the increasing volume of work and requested the Scientific Committee consider and advise on the relative priorities for this work plan.

7.23 The Working Group recognised the importance of streamlining the agendas of all working groups and workshops of the Scientific Committee. It noted that it was desirable to maximise the input of scientists to this work and that it would be helpful to manage the agenda of WG-SAM and this Working Group so that scientists could attend both groups for overlapping work but without having to attend both meetings for their entire time. The Working Group agreed that advance notice of the scheduling of key agenda items would be helpful in this regard.

7.24 The Working Group noted the following key points for consideration in the work of the Scientific Committee in the coming year:

(i) the recommended points for consideration by SG-ASAM at its next meeting (paragraph 2.32);

(ii) the need for the Working Group to review parameter settings in the estimate of γ, notably the currently available growth models, recruitment indices and mortality, and the implications of spatial and temporal variability in parameters (paragraph 2.43);

(iii) WG-EMM-STAPP will hold the predator survey workshop next year, probably in Hobart in June prior to WG-EMM, to consider the work plan identified in paragraphs 7.1 to 7.4. The workshop details, when finalised, will be communicated to SCAR.

7.25 Dr Constable summarised the work to date on the planning for the CCAMLR-IWC Workshop to review input data for Antarctic marine ecosystem models (SC-CAMLR-XXVI/BG/5). A Joint Steering Group made up of representatives from both organisations was established in 2006 to plan for the workshop. It developed the following terms of reference to account for the needs identified by both organisations:

(i) for models on the Antarctic marine ecosystem, and in particular predator–prey relationships, that could be developed for providing management and conservation advice relevant to CCAMLR and IWC, consider the types, relative importance and uncertainties associated with input data for those models, in order to understand what is needed to reduce uncertainties and errors in their use;

(ii) review the available input data from published and unpublished sources that are currently available for such models;

(iii) summarise the nature of input data (e.g. abundance estimates, trend estimates, foraging scales, seasonal diet etc.), based on metadata (see definition below), by describing methodology, broad levels of uncertainty, time series and spatial extent and determine the appropriate scale at which those input data are relevant to these modelling efforts;

(iv) identify and prioritise the gaps in knowledge and types of analyses and field research programs needed to reduce important uncertainties in ecosystem models being developed for CCAMLR and IWC, and identify how scientists from the two Commissions can best collaborate and share data to maximise the rate of development and scientific quality of modelling efforts and input data.

7.26 Progress from 2006 to April 2007 was reported to the SC-IWC in SC-CAMLR-XXVI/BG/5. The outcomes of the discussion at the SC-IWC are contained in the report of the SC-CAMLR Observer to the SC-IWC (SC-CAMLR-XXVI/BG/4).

7.27 The Working Group welcomed progress on the planning for the workshop and the importance of increasing cooperation between SC-CAMLR and the SC-IWC. It welcomed the commitment by the SC-IWC for half the budget for the workshop.

7.28 In considering the planning for the workshop, the Working Group noted the following for consideration by the Steering Group and the Scientific Committee:

(i) the preference by the SC-IWC to hold the meeting later in 2008 was acceptable and that some time in August would be appropriate, given the timing of other meetings of the Scientific Committee, noting that translation of the report would not be possible until 2009;

(ii) the budget remains satisfactory but it would be desirable to minimise expenses wherever possible, particularly if experts can become involved voluntarily or funded by individual Members;

(iii) the overall budget should be expended in a way that delivers the best outcomes from the workshop and, as a result, it is expected that the invited experts will comprise mostly expertise not necessarily related to cetaceans;

(iv) the CCAMLR Secretariat remains the preferred location of the workshop;

(v) it is desirable that a more refined budget and work plan be made available to SC-CAMLR for consideration;

(vi) the compilation of data and reviews for mesopelagic and epipelagic predators and the other biological and physical components was likely to be of lower priority than the other groups;

(vii) it is important to hold the workshop in 2008 because of the momentum now gathered for this work and the requirements for the outcomes of this work to be included in consideration of Stage 2 of the work of WG-EMM in 2009 for subdividing the krill catch limit among SSMUs in Area 48;

(viii) the Chair of the Scientific Committee should consult with the Scientific Committee via an SC circular, as soon as practicable, to ascertain whether a request can be made of SCAR by CCAMLR to submit the results of the Antarctic pack-ice seals survey to the workshop, as those results will be very important in future modelling efforts of the Antarctic marine ecosystem.

7.29 The Working Group noted the desire of the Commission for the Scientific Committee to review the use of bottom trawling gear in high-seas areas of the Convention Area, including with respect to relevant criteria for determining what constitutes significant harm to benthos and benthic communities (Conservation Measure 22-05; CCAMLR-XXV, paragraphs 11.25 to 11.38). With respect to this request, the Working Group noted the following:

(i) krill trawling is unlikely to significantly impact on benthic communities as it is a pelagic fishery;

(ii) consideration of the nature of interactions of other fisheries activities would best be addressed within WG-FSA because of its expertise on finfish fisheries;

(iii) future work could be included in this Working Group on how to investigate adverse impacts of fisheries on marine ecosystems, noting the modelling work already under way to address the food-web effects of krill and finfish fisheries;

(iv) the Working Group would welcome submissions from Members providing suggestions on methodologies to be used to review the use of bottom trawling gear in high-seas areas and developing criteria for determining what constitutes significant harm to benthos and benthic communities.

7.30 The Working Group agreed that its priorities for work at its next meeting would be:

(i) the development and provision of advice on Stage 1 of the subdivision of the Area 48 krill catch limit among SSMUs;

(ii) revision, as needed, of estimates of yield for krill;

(iii) considering the outcomes of the work of WG-EMM-STAPP.

7.31 In considering these items, the Working Group noted that the usual workshop period could be used jointly for the work of WG-SAM and WG-EMM on the first priority item.

7.32 The Working Group noted that it would be useful to renew the long-term work plan at its next meeting, forecasting when expertise might be required for workshops or other priority activities of the group, such as is contained in Table 3 of SC-CAMLR-XXIII, Annex 4.

OTHER BUSINESS

8.1 No other business was raised at the meeting.

ADOPTION OF THE REPORT AND CLOSE OF THE MEETING

9.1 The report of the thirteenth meeting of WG-EMM was adopted.

9.2 In closing the meeting, Dr Reid thanked all participants for a successful and convivial meeting, which had advanced the Convention's ecosystem approach to managing the krill fishery. He thanked the New Zealand Delegation for their warm hospitality, and for providing excellent meeting facilities, and in particular noted the outstanding contributions from Miss J. McCabe and Dr S. Mormede. Dr Reid also thanked the Secretariat staff for their dedicated support.

9.3 Dr Reid noted Dr Sabourenkov's retirement early next year. Dr Sabourenkov has had a long-standing involvement in the work of WG-EMM and its predecessors. This contribution included development of the CEMP standard methods. The Working Group presented a small gift to Dr Sabourenkov in recognition of his valuable service to CCAMLR's work as a whole, particularly in ecosystem monitoring and management.

9.4 Dr Holt, on behalf of the Working Group, thanked Dr Reid for his skill and dedication in leading WG-EMM over the past two years. His leadership had greatly facilitated the work of WG-EMM. The Working Group wished Dr Reid every success in his new role in the Secretariat.

9.5 The meeting was closed.

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Table 1: Guidelines on which acoustic protocols currently apply in a CCAMLR context for new data collected (see paragraph 2.27).

Protocol	Recommendations
Ship track (space)	Reference to Jolly and Hampton (1990) should be made for all questions of survey design.
Ship track (time)	Reference to Hewitt et al. (2004) should be made with regard to sampling by day and/or by night.
Transducers	Reference to Hewitt et al. (2004) and SG-ASAM-05 (SC-CAMLR-XXIV, Annex 6) should be made with regard to the transducer frequencies to use.
Calibration	Reference should be made to Hewitt et al. (2004) and Demer (2004) for questions regarding echosounder-system calibration and the survey sound-propagation model.
Resampling	Reference to Watkins and Brierley (2002) and Hewitt et al. (2004) should be made for questions regarding the resampling of S_v samples into bins.
S_v classification	When defining ΔS_v windows, it is recommended that the range of lengths be used that includes ≥95% of the krill length PDF and achieves the smallest ΔS_v windows. Reference to SG-ASAM-07 (SC-CAMLR-XXVI/BG/2) and WG-EMM-07/30 Rev. 1 should be made for further questions regarding the ΔS_v method.
EDSU dimensions	Reference to Hewitt et al. (2004) and MacLennan and Simmonds (2005) should be made for questions regarding the integration of S_v bins into elementary distance sampling units (EDSUs).
$W(L)$ model	In order of preference, define the $W(L)$ model in one of the following ways: • measure W and L directly during the survey • use literature values representative of survey location and time of year • use the $W(L)$ model presented in Hewitt et al. (2004).
Target-strength model	Reference to Siegel et al. (2004) should be made for questions regarding the generation of length-frequency clusters, and to SG-ASAM-07 (SC-CAMLR-XXVI/BG/2) and SG-ASAM-05 (SC-CAMLR-XXIV, Annex 6) for questions regarding the implementation of the SDWBA model.
Calculation of biomass density	The correct equation for calculating C (*aka* CF) is presented in WG-EMM-07/30 Rev. 1 and Reiss et al. (submitted). The equation applied by Hewitt et al. (2004) is not strictly correct for a model that predicts target strength on the basis of target area rather than volume; because the Greene et al. (1991) model relates to target volume, the Hewitt et al. (2004) calculations will not have been significantly affected.
Biomass density to biomass	Reference to Hewitt et al. (2004) should be made for all questions of converting from biomass density to biomass.
Area	Reference to Trathan et al. (2001) should be made for all questions of area estimation.
Parameter and survey error	Reference to Jolly and Hampton (1990) should be made for questions regarding the estimation of survey sampling error. Demer (2004) should be consulted if an estimate of total random error is required.

Table 2: Outputs of the GYM runs conducted during the meeting. See paragraphs 2.38 to 2.42 for details.

	Current	Run 0	Run 1
Survey B_0	44.29	44.29	37.29
Survey CV	11.38	11.38	21.20
γ			
75% predator criterion	0.091	0.093	0.093
10% recruitment criterion	0.118	0.121	0.116
γ which satisfies rule	0.091	0.093	0.093
Area 48 catch limit (million tonnes)	4.03	4.12	3.47

Table 3: List of tasks identified by WG-EMM for the 2007/08 intersessional period. The paragraph numbers (Ref.) refer to this report.

	Task	Ref.	Action Required	
			Members/Subgroups	Secretariat
	Estimation of B_0 and precautionary catch limits for krill			
1.	Implement incremental improvements to acoustic protocols.	2.20	Members to implement	Assist
2.	Use current CCAMLR protocols for the acoustic estimation of krill biomass and procedures developed by SG-ASAM for target strength and species identification.	2.26, 2.66	Members to implement	Assist
3.	Produce a paper for WG-EMM describing details of data collection and analysis protocols for CCAMLR acoustic surveys.	2.31, 5.97	Dr T. Jarvis (Australia)	Remind
4.	Pass on WG-EMM recommendations on krill assessment to SG-ASAM for consideration.	2.32	SG-ASAM Convener	Implement
5.	Plan and conduct intersessional work to incorporate krill recruitment variability and M from long-term datasets into the assessment process.	2.42, 2.73	Members to implement	Assist
6.	Continue investigation into integrated assessment for krill and provide advice to WG-SAM in its work on developing feedback management for krill.	2.54	Members to implement	Assist
7.	Estimation of B_0 for Division 58.4.2 to be produced in time for the 2007 meeting of the Scientific Committee.	2.71, 5.39	Australia	Assist
8.	Update krill parameter values for GYM for the use at next meeting of WG-EMM.	2.40	Members to implement	Remind
9.	Consider advice of WG-SAM in planning future acoustic surveys to estimate krill B_0.	5.82	Members to implement	Remind
	Status and trends in the krill fishery			
10.	Implement ‘flow scale’ method to improve collection of catch data arising from continuous fishing system and undertake studies as proposed by the Scientific Committee in 2006.	4.13, 4.18	Norway	Remind
11.	Requirement to complete the CCAMLR questionnaire on the collection of data on fishery dynamics for krill fisheries.	4.27	Members to implement	Assist

	Task	Ref.	Action Required	
			Members/Subgroups	Secretariat
12.	Seek advice of WG-FSA on the use by CCAMLR observers of a field guide developed by Japan for identification of early life stages of Antarctic fish.	4.36	WG-EMM Convener	Assist
13.	Review other available fish identification guides and develop a common guide for the use of observers on board krill fishing vessels.	4.37	WG-FSA	Assist
	Scientific observation			
14.	Information of gear type and mesh size to be reported by scientific observers together with krill biological data.	5.51	Members to implement	Assist
15.	The frequency of occurrence of krill black-spots disease to be reported by scientific observers.	5.55	Members to implement	Assist
16.	Prepare an annual summary of observer data collected in krill fisheries and submit it to WG-EMM to review and approve its format for the use in the future.	4.58	WG-EMM Convener	Implement
17.	Enhance consistency in completion of Cruise Reports by observers.	4.59	Technical Coordinators	Assist
18.	Update Observer Cruise Report form by including schematic diagrams of trawl gear, e.g. used in krill fisheries.	4.59	Technical Coordinators	Implement
19.	Revise observer instructions based on workload estimates so that the observers can systematically collect the required data.	4.34	Dr S. Kawaguchi (Australia)	Implement
20.	Revise *Scientific Observers Manual*/observer logbooks to include fish larvae by-catch observation protocol and collection of data on krill infected by 'black-spot' disease.	4.65, 4.67	Technical Coordinators Working Group conveners	Implement
	Status and trends in the krill-centric ecosystem			
21.	Encourage Members with active research programs to join CEMP.	5.6	Members to implement	Assist
22.	Continue the assessment of the linkage between penguins and their ice environment to aid interpretation of CEMP results and predict changes in krill-dependent predator populations.	5.16	Members to implement	Remind
23.	Continue collection of krill density and recruitment indices in Subarea 48.1 as important input parameters to GYM to calculate precautionary catch limits.	5.43, 5.58	Members to implement	Remind

	Task	Ref.	Action Required	
			Members/Subgroups	Secretariat
24.	Pursue development of environmental indices to forecast krill fishing.	5.64	Members to implement	Remind
25.	Consider advice of WG-SAM in planning future acoustic surveys of icefish.	5.83	Members to implement	Remind
26.	Further studies on the segregation of *E. superba* and *E. crystallorophias* in the Ross Sea.	5.90	Members to implement	Remind
27.	Standardise krill length data from the fishery collected over large areas and periods, and report them with information on gear type and mesh size.	5.93	Members to implement	Assist
28.	Contact all CAML investigators and request that they adhere to CCAMLR-IPY protocols when conducting their respective IPY surveys.	5.99	Dr V. Wadley (Australia)	Implement
	Status of management advice			
29.	Review status of CEMP works on Elephant Island (Stinker Point).	6.6	Brazil	Assist
30.	Seek advice of the Scientific Committee on the approach to be followed for subdividing large statistical areas into harvesting units in the absence of recent survey data.	6.23, 6.24	SC Chair	Remind
31.	Conduct analyses leading to an understanding of how krill catchability and fishing performance may vary between coastal and oceanic SSMUs.	6.43	Members to implement	Remind
32.	Conduct further development of feedback management approaches.	6.47	Members to implement	Remind
33.	Modify CEMP Standard Method A7 for gentoo penguins to reflect differences in fledging behaviour noted at Admiralty Bay.	5.70	Dr W. Trivelpiece (USA)	Assist
34.	Consider utility of an alternative CEMP code for black-browed albatross that could be cross-referenced to the FAO species code.	5.72		Implement
35.	Ensure that only current CCAMLR forms are used for submitting CEMP data.	5.73, 5.95	Members to implement	Assist
36.	Produce a scoping paper for WG-SAM on the issues surrounding the ordination method for presenting trends in CEMP indices.	5.76, 5.96		Implement
37.	Conduct further work on determining the role of Weddell seals in the Ross Sea ecosystem and submit results of this work in the future.	5.79	Members to implement	Remind

	Task	Ref.	Action Required	
			Members/Subgroups	Secretariat
	Ecosystem models, assessments and approaches to management			
38.	Keep the wider scientific community informed of CAMLR work.	7.10	Members to implement	Assist
39.	Submit to WG-EMM information on the work conducted at the Palmer-LTER site.	7.15	USA	Remind
40.	Conduct work required to establish how research on the interaction between krill, predators and the environment would be affected if the krill fishery expands rapidly.	7.18	Members to implement	Remind
	Long-term work plan			
41.	Prepare and conduct a workshop on estimation of land-based predator abundance.	7.1–7.4	Dr C. Southwell (Australia)	Assist
42.	Prepare and conduct the CCAMLR-IWC Workshop to review input data for Antarctic marine ecosystem models.	7.22–7.32	Dr A. Constable (Australia), Joint Steering Group	Assist
43.	Further work on streamlining the agendas of all working groups.	7.22–7.32	Working Group conveners	Assist
44.	Further work to review the use of bottom trawling gear in high seas of the Convention Area.	7.22–7.32	WG-EMM and WG-FSA	Assist

APPENDIX A

AGENDA

Working Group on Ecosystem Monitoring and Management
(Christchurch, New Zealand, 17 to 26 July 2007)

1. Introduction
   1.1 Opening of the meeting
   1.2 Adoption of the agenda and organisation of the meeting

2. WG-EMM Workshop to Review Estimates of B_0 and Precautionary Catch Limits for Krill

3. Feedback from the 2006 meetings of the Scientific Committee and the Commission

4. Status and trends in the krill fishery
   4.1 Fishing activity
   4.2 Description of the fishery
   4.3 Scientific observation
   4.4 Regulatory issues
   4.5 Key points for consideration by the Scientific Committee

5. Status and trends in the krill-centric ecosystem
   5.1 Status of predators, krill resource and environmental influences
   5.2 Other prey species
   5.3 Methods
   5.4 Future surveys
   5.5 Key points for consideration by the Scientific Committee

6. Status of management advice
   6.1 Protected areas
   6.2 Harvesting units
   6.3 Small-scale management units
   6.4 Analytical models
   6.5 Existing conservation measures
   6.6 Key points for consideration by the Scientific Committee

7. Future work
   7.1 Predator surveys
   7.2 Ecosystem models, assessments and approaches to management
   7.3 Long-term work plan
   7.4 Key points for consideration by the Scientific Committee

8. Other business

9. Adoption of report and close of meeting.

APPENDIX B

LIST OF PARTICIPANTS

Working Group on Ecosystem Monitoring and Management
(Christchurch, New Zealand, 17 to 26 July 2007)

AGNEW, David (Dr) (to 23rd)	Biology Department Imperial College London Prince Consort Road London SW7 2BP United Kingdom d.agnew@imperial.ac.uk
BIZIKOV, Viacheslav (Dr)	Russian Federal Research Institute of Fisheries and Oceanography (VNIRO) 17 V. Krasnoselskaya Moscow 107140 Russia bizikov@vniro.ru
CONSTABLE, Andrew (Dr) (WG-SAM Co-convener)	Antarctic Climate and Ecosystems Cooperative Research Centre Australian Antarctic Division Department of the Environment and Water Resources Channel Highway Kingston Tasmania 7050 Australia andrew.constable@aad.gov.au
DEMER, David (Dr)	Fisheries Resources Division Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla, CA 92037-1508 USA david.demer@noaa.gov
FANTA, Edith (Dr) Chair, Scientific Committee	Departamento Biologia Celular Universidade Federal do Paraná Caixa Postal 19031 81531-970 Curitiba, PR Brazil e.fanta@terra.com.br

GOEBEL, Michael (Dr)	US AMLR Program Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla, CA 92037-1508 USA mike.goebel@noaa.gov
HILL, Simeon (Dr)	British Antarctic Survey Natural Environment Research Council High Cross, Madingley Road Cambridge CB3 0ET United Kingdom sih@bas.ac.uk
HINKE, Jefferson (Mr) (first week only)	US AMLR Program Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla, CA 92037-1508 USA jefferson.hinke@noaa.gov
HOLT, Rennie (Dr)	US AMLR Program Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla, CA 92037-1508 USA rennie.holt@noaa.gov
JARVIS, Toby (Dr)	Australian Antarctic Division Department of the Environment and Water Resources Channel Highway Kingston Tasmania 7050 Australia toby.jarvis@aad.gov.au
JONES, Christopher (Dr) (WG-SAM Co-convener) (first week only)	US AMLR Program Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla, CA 92037-1508 USA chris.d.jones@noaa.gov

KAWAGUCHI, So (Dr)	Australian Antarctic Division Department of the Environment and Water Resources Channel Highway Kingston Tasmania 7050 Australia so.kawaguchi@aad.gov.au
KNUTSEN, Tor (Dr)	Institute of Marine Research Research Group Plankton Nordnesgaten 50 PO Box 1870 Nordnes 5817 Bergen Norway tor.knutsen@imr.no
MORMEDE, Sophie (Dr)	Ministry of Fisheries PO Box 1020 Wellington New Zealand sophie.mormede@fish.govt.nz
NAGANOBU, Mikio (Dr)	Southern Ocean Living Resources Research Section National Research Institute of Far Seas Fisheries 2-12-4, Fukuura, Kanazawa Yokohama, Kanagawa 236-8648 Japan naganobu@affrc.go.jp
NICOL, Steve (Dr) (B_0 Workshop Convener)	Australian Antarctic Division Department of the Environment and Water Resources Channel Highway Kingston Tasmania 7050 Australia steve.nicol@aad.gov.au
PINKERTON, Matt (Dr)	National Institute of Water and Atmospheric Research (NIWA) Private Bag 14-901 Kilbirnie Wellington New Zealand m.pinkerton@niwa.co.nz

PLAGÁNYI, Éva (Dr)	Department of Mathematics and Applied Mathematics University of Cape Town Private Bag 7701 Rondebosch South Africa eva.plaganyi-lloyd@uct.ac.za
REID, Keith (Dr) (WG-EMM Convener)	British Antarctic Survey Natural Environment Research Council High Cross, Madingley Road Cambridge CB3 0ET United Kingdom k.reid@bas.ac.uk
REISS, Christian (Dr)	US AMLR Program Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla, CA 92037-1508 USA christian.reiss@noaa.gov
SIEGEL, Volker (Dr)	Bundesforschungsanstalt für Fischerei Institut für Seefischerei Palmaille 9 D-22767 Hamburg Germany volker.siegel@ish.bfa-fisch.de
SOUTHWELL, Colin (Dr)	Australian Antarctic Division Department of the Environment and Water Resources Channel Highway Kingston Tasmania 7050 Australia colin.southwell@aad.gov.au
TAKAO, Yoshimi (Mr) (first week only)	Fisheries Acoustics Section National Research Institute of Fisheries Engineering, FRA 7620-7 Hasaki Kamisu Ibaraki 314-0408 Japan ytakao@affrc.go.jp

TRIVELPIECE, Wayne (Dr)	US AMLR Program Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla, CA 92037-1508 USA wayne.trivelpiece@noaa.gov
WATTERS, George (Dr) (to 18th)	Southwest Fisheries Science Center Protected Resources Division 1352 Lighthouse Avenue Pacific Grove, CA 93950-2097 USA george.watters@noaa.gov
WEEBER, Barry (Mr)	Antarctic Marine Project 3 Finnimore Terrace Vogeltown Wellington New Zealand b.weeber@paradise.net.nz
WILSON, Peter (Dr)	MFAT Scientific Adviser 17 Modena Crescent Glendowie Auckland New Zealand wilsonp@nmb.quik.co.nz

Secretariat:

Denzil MILLER (Executive Secretary) Eugene SABOURENKOV (Science/Compliance Officer) David RAMM (Data Manager) Genevieve TANNER (Communications Officer) Rosalie MARAZAS (Website and Information Services Officer) Fernando CARIAGA (Information Technology Manager) (first week only) Jacquelyn TURNER (Analytical Support Officer) (second week only)	CCAMLR PO Box 213 North Hobart 7002 Tasmania Australia ccamlr@ccamlr.org

APPENDIX C

LIST OF DOCUMENTS

Working Group on Ecosystem Monitoring and Management
(Christchurch, New Zealand, 17 to 26 July 2007)

WG-EMM-07/1	Provisional Agenda and Provisional Annotated Agenda for the 2007 Meeting of the Working Group on Ecosystem Monitoring and Management (WG-EMM)
WG-EMM-07/2	List of participants
WG-EMM-07/3	List of documents
WG-EMM-07/4	CEMP indices: 2007 update Secretariat
WG-EMM-07/5	Krill fishery report: 2007 update Secretariat
WG-EMM-07/6 Rev. 2	Summary of notifications for krill fisheries in 2007/08 Secretariat
WG-EMM-07/7	Interaction between oceanography, krill and baleen whales in the Ross Sea and adjacent waters, Antarctica in 2004/05 M. Naganobu, S. Nishiwaki, H. Yasuma, R. Matsukura, Y. Takao, K. Taki, T. Hayashi, Y. Watanabe, T. Yabuki, Y. Yoda, Y. Noiri, M. Kuga, K. Yoshikawa, N. Kokubun, H. Murase, K. Matsuoka and K. Ito (Japan) (*CCAMLR Science*, submitted)
WG-EMM-07/8	Demography of Antarctic krill and other Euphausiacea in the Lazarev Sea in winter 2006 V. Siegel, M. Haraldsson, M. Vortkamp, L. Würzberg and S. Schöling (Germany)
WG-EMM-07/9	State of Antarctic krill (*Euphausia superba*) fisheries in Statistical Area 48 (Subareas 48.2 and 48.1) in 2006 V.A. Bibik and N.N. Zhuk (Ukraine)
WG-EMM-07/10	Time and energy budgets during winter for gentoo penguins (*Pygoscelis papua*) in the South Shetland Islands J.T. Hinke (USA)

WG-EMM-07/11	Chinstrap penguins alter foraging and diving behaviour in response to krill size A.K. Miller and W.Z. Trivelpiece (USA)
WG-EMM-07/12	Trends and relationships between atmospheric tele-connections and Upper Circumpolar Deep Water (UCDW) influence on phytoplankton biomass around Elephant Island, Antarctica C. Reiss, O. Holm-Hansen and C.D. Hewes (USA)
WG-EMM-07/13	Protocol for aerial censusing of Weddell seals as an EMM protocol D. Ainley, D. Siniff, R. Garrott (USA) and P. Wilson (New Zealand)
WG-EMM-07/14	Short note on time series of Drake Passage Oscillation Index (DPOI) and its influence on environmental variability M. Naganobu and K. Kutsuwada (Japan)
WG-EMM-07/15	Long-term forecast of the conditions of krill (*Euphausia superba* Dana) fisheries in the Antarctic part of the Atlantic Ocean V.A. Bibik and V.A. Bryantsev (Ukraine)
WG-EMM-07/16	Analysis of scientific observer data from the *Saga Sea* 2006–2007 P. Orr, J. Hooper, D. Agnew, J. Roe, G. Doherty and A. Pryor (United Kingdom)
WG-EMM-07/17	Investigations of krill transport factors in the local areas in the Scotia Sea: variability of krill distribution in the fishing grounds under the transport impact S.M. Kasatkina and V.N. Shnar (Russia)
WG-EMM-07/18	A balanced trophic model of the ecosystem of the Ross Sea, Antarctica, for investigating effects of the Antarctic toothfish fishery M.H. Pinkerton, S.M. Hanchet and J. Bradford-Grieve (New Zealand)
WG-EMM-07/19	Stable isotope analysis of Southern Ocean fish tissue samples to investigate trophic linkages of Antarctic toothfish (*Dissostichus mawsoni*) M.H. Pinkerton, S. Bury, S.M. Hanchet and D. Thompson (New Zealand) (*CCAMLR Science*, submitted)

WG-EMM-07/20	Developments, considerations and recommendations by the land-based predator survey correspondence group: a second summary and update C. Southwell (Australia), P. Trathan (UK), W. Trivelpiece, M. Goebel (USA) and P. Wilson (New Zealand)
WG-EMM-07/21	The relationship between sea-ice cover and Adélie penguin reproductive performance at Béchervaise Island L. Emmerson and C. Southwell (Australia)
WG-EMM-07/22	Information on krill in reports from the CCAMLR scheme of international observation and its utility for management J. Foster, S. Nicol and S. Kawaguchi (Australia)
WG-EMM-07/23	Scientific requirements for an orderly development of the krill fishery A. Constable, G. Slocum and S. Nicol (Australia)
WG-EMM-07/24	Ecological risk management and the fishery for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea, Antarctica M.H. Pinkerton, A. Dunn and S.M. Hanchet (New Zealand)
WG-EMM-07/25	Interim protocol for fish/fish larvae by-catch observation in krill fishery S. Kawaguchi (Australia)
WG-EMM-07/26	CCAMLR scientific observation: tasks, priorities and time budget S. Kawaguchi (Australia)
WG-EMM-07/27	Analysis of krill fishery behaviour in the southwest Atlantic: potential signals for moving fishing activities amongst SSMUs S. Kawaguchi, A. Constable and S. Nicol (Australia) (*CCAMLR Science*, submitted)
WG-EMM-07/28	Size selectivity of the RMT8 plankton net and a commercial trawl for Antarctic krill V. Siegel (Germany) (*CCAMLR Science*, submitted)
WG-EMM-07/29	Histopathology of Antarctic krill (*Euphausia superba*) bearing black spots S. Miwa, T. Kamaishi, T. Matsuyama, T. Hayashi and M. Naganobu (Japan)
WG-EMM-07/30 Rev. 1	CCAMLR 2000 revisited D.A. Demer, A.M. Cossio and C.S. Reiss (USA) (*CCAMLR Science*, submitted)

WG-EMM-07/31	2007 krill biomass update of the South Shetland and Elephant Island regions of Area 48 C.S. Reiss and A.M. Cossio (USA)
WG-EMM-07/32	A guide to identification of fishes caught along with the Antarctic krill T. Iwami and M. Naganobu (Japan)
WG-EMM-07/33	Distribution and abundance of Antarctic krill (*Euphausia superba*) off East Antarctic (30–80°E) in January–March 2006 T. Jarvis, N. Kelly, E. van Wijk, S. Kawaguchi and S. Nicol (Australia)
WG-EMM-07/34 Rev. 1	Community structure of epipelagic macrozooplankton in the Ross Sea Y. Watanabe, S. Sawamoto, T. Ishimaru and M. Naganobu (Japan)

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WG-EMM-07/P3	Insights from the study of the last intact neritic marine ecosystem D. Ainley (to be published as a 'letter' in *Trends in Ecology & Evolution*, autumn 2007)
WG-EMM-07/P4	The Antarctic toothfish: how common a prey for Weddell seals? P.J. Ponganis and T.K. Stockard (USA)
WG-EMM-07/P5	Learning about Antarctic krill from the fishery S. Kawaguchi and S. Nicol (Australia) (*Ant. Sci.*, 19 (2): 219–230 (2007))

WG-EMM-07/P6	Male krill grow fast and die young S. Kawaguchi, L.A. Finley, S. Jarman, S.G. Candy (Australia), R.M. Ross, L.B. Quetin (USA), V. Siegel (Germany), W. Trivelpiece (USA), M. Naganobu (Japan) and S. Nicol (Australia) (*Mar. Ecol. Prog. Ser.*, accepted)
WG-EMM-07/P7	Setting management goals using information from predators A. Constable (Australia) (Constable, A.J. 2006. Setting management goals using information from predators. In: Boyd, I., S. Wanless, C.J. Camphuysen (Eds). *Top Predators in Marine Ecosystems: their Role in Monitoring and Management*. Cambridge University Press, Cambridge: 324–346)
WG-EMM-07/P8	Spatial and temporal operation of the Scotia Sea ecosystem: a review of large-scale links in a krill centred food web E.J. Murphy, J.L. Watkins, P.N. Trathan, K. Reid, M.P. Meredith, S.E. Thorpe, N.M. Johnston, A. Clarke, G.A. Tarling, M.A. Collins, J. Forcada, R.S. Shreeve, A. Atkinson, R. Korb, M.J. Whitehouse, P. Ward, P.G. Rodhouse, P. Enderlein, A.G. Hirst, A.R. Martin, S.L. Hill, I.J. Staniland, D.W. Pond, D.R. Briggs, N.J. Cunningham and A.H. Fleming (United Kingdom) (*Phil. Trans. R. Soc. B*, 362: 113–148 (2007))
WG-EMM-07/P9	Monitoring and management in the Antarctic – making the link between science and policy K. Reid (United Kingdom) (*Ant. Sci.*, 19 (2): 267–270 (2007))
WG-EMM-07/P10	Circumpolar connections between Antarctic krill (*Euphausia superba* Dana) populations: Investigating the roles of ocean and sea ice transport S.E. Thorpe, E.J. Murphy and J.L. Watkins (United Kingdom) (*Deep-Sea Res.*, I, 54: 792–810 (2007))
WG-SAM-07/12	A spatial multi-species operating model of the Antarctic Peninsula krill fishery and its impacts on land-breeding predators É.E. Plagányi and D.S. Butterworth (South Africa)
WG-SAM-07/14	Rationale, structure and current templates of the Ecosystem, Productivity, Ocean, Climate (EPOC) modelling framework to support evaluation of strategies to subdivide the Area 48 krill catch limit amongst small-scale management units A. Constable (Australia)

WG-SAM-07/15	Lenfest Ocean Program Workshop 'Identifying and Resolving Key Uncertainties in Management Models for Krill Fisheries'
CCAMLR-XXVI/BG/3	Draft Management Plan for ASMA No. X: Southwest Anvers Island and Palmer Basin Delegation of the USA (as submitted to ATCM XXX (2007), WP 5)
CCAMLR-XXVI/BG/11	On the scientific research of marine protected area within the bounds of the Argentina Islands Archipelago Delegation of Ukraine
SC-CAMLR-XXVI/BG/2	Report of the Third Meeting of the Subgroup on Acoustic Survey and Analysis Methods (Cambridge, UK, 30 April to 2 May 2007)
SC-CAMLR-XXVI/BG/3	Report of the Planning Meeting of the CCAMLR-IPY Steering Committee (Cambridge, UK, 2 to 4 May 2007)
SC-CAMLR-XXVI/BG/4	Observer's Report from the 59th Meeting of the Scientific Committee of the International Whaling Commission (Anchorage, Alaska, USA, 7 to 18 May 2007) CCAMLR Observer (K.-H. Kock, Germany)
SC-CAMLR-XXVI/BG/5	CCAMLR-IWC Workshop to review input data for Antarctic marine ecosystem models: update on progress since 2006 Co-conveners, CCAMLR-IWC Workshop

APPENDIX D

ADDITION TO THE NOTIFICATION OF INTENT TO PARTICIPATE IN A KRILL FISHERY (CONSERVATION MEASURE 21-03, ANNEX 21-03/A)

Contracting Party: ______________________________

Fishing season: ______________________________

Name of vessel: ______________________________

Fishing technique:

- ☐ Conventional trawl
- ☐ Continuous fishing system
- ☐ Pumping to clear codend
- ☐ Other: Please specify ____________________

Matrix of areas and months to specify the timings of intended fishing activity to be considered by the Scientific Committee and to be agreed by the Commission.