

## ECOSYSTEM MONITORING AND MANAGEMENT

### General comments

3.1 Dr Hewitt, Convener of WG-EMM, reported that the 2004 meeting of WG-EMM was held from 12 to 23 July 2004 in Siena, Italy. Intersessional activities had been conducted by correspondence groups on preparations for this year's workshop, on the design of land-based krill predator surveys, and on the subdivision of CCAMLR statistical areas into ecologically-based harvesting units. During the meeting the following groups met:

- Workshop on Plausible Ecosystem Models for Testing Approaches to Krill Management
- Advisory Subgroup on Protected Areas
- Subgroup on CEMP Methods
- Ad hoc subgroup on subdividing the krill catch among SSMUs
- Steering Committee for the 2005 Workshop on Management Procedures
- Correspondence group on predator surveys
- Ad hoc subgroup on data collection on board fishing vessels
- Ad hoc subgroup on possible CCAMLR-sponsored activities during the International Polar Year (IPY).

3.2 These activities were summarised in three documents for consideration by the Scientific Committee:

- (i) report of WG-EMM-04 (Annex 4) containing a listing of 'Key Points for Consideration by the Scientific Committee' at the end of each major agenda item, as well as the Report of the Workshop on Plausible Ecosystem Models for Testing Approaches to Krill Management (Annex 4, Appendix D);
- (ii) synopses of working papers (SC-CAMLR-XXIII/BG/9) considered at the meeting, each containing an abstract and a summary of the findings and/or conclusions as they relate to a particular agenda item;
- (iii) report of the Convener of WG-EMM-04 to SC-CAMLR-XXIII (SC-CAMLR-XXIII/BG/18) containing appropriate references to paragraphs in the report of WG-EMM-04.

3.3 Similar to recent years, the agenda of WG-EMM-04 was structured to consider the status and trends in the krill fishery (Annex 4, section 3), the status and trends in the krill-centric ecosystem (Annex 4, section 4), and the status of management advice arising from these considerations (Annex 4, section 5). The information presented here is drawn from the report of WG-EMM-04 but is organised according to the agenda of SC-CAMLR-XXIII.

3.4 In particular, the Working Group drew the attention of the Scientific Committee to the highlights of the meeting, which will be discussed under several agenda items:

- (i) the need for a consistent level of international observer coverage on krill fishing vessels (Agenda Item 2);
- (ii) the need to establish an advisory subgroup on acoustic surveys (Agenda Item 3);
- (iii) advice regarding protected areas (Agenda Item 3);
- (iv) specification of plausible ecosystem models for testing management procedures (Agenda Item 3);
- (v) 2005 Workshop on Management Procedures to evaluate options for subdividing the krill catch limit among SSMUs (Agenda Item 3);
- (vi) publication of the CCAMLR-2000 Survey and representation of CCAMLR at the Fourth World Fisheries Congress (Agenda Item 12);
- (vii) the need to develop plans for possible CCAMLR-coordinated activities during the IPY in 2007/08 (Agenda Item 15).

#### Status and trends in the krill-centric ecosystem

3.5 The Working Group reviewed information submitted on the status of krill predators, the krill resource and environmental influences (Annex 4, paragraphs 4.1 to 4.61).

3.6 The Working Group noted that the chinstrap penguin population monitored at Cape Shirreff, South Shetland Islands, continued to decline as it has over the past four seasons; however, all other breeding and foraging indices indicated that 2004 was an average year for the chinstrap and gentoo penguins at this site. Populations of gentoo, macaroni and eastern rockhopper penguins and Crozet shags continued to decrease at Marion Island in 2003/04. The decreases are thought to be due to a reduced availability of prey to birds foraging near the island (Annex 4, paragraphs 4.8 and 4.9).

3.7 The Working Group noted the potentially important influence of input from the Weddell Sea on the composition of the krill stock in the Scotia Sea and at South Georgia, which may vary considerably between years. The Working Group concluded that the role of the Weddell Sea warranted further consideration (Annex 4, paragraphs 4.17 to 4.20).

3.8 The density of krill in the Lazarev Sea (east of the Weddell Sea), observed in April 2004, was less than that observed in the South Shetland Islands. However, recruitment variability (high for the 2002 year class and low for the 2003 year class) was similar to that observed in the South Shetland Islands. Estimates of krill recruitment from observation in the vicinity of the South Shetland Islands indicate strong 2000, 2001 and 2002 year classes, which resulted in a substantial increase in the local krill population abundance, and poor recruitment from spawning in 2003 (Annex 4, paragraphs 4.29 to 4.33).

3.9 The Working Group noted a growing body of evidence suggesting that large-scale climatic variability has a potentially profound effect on the dynamics of the marine ecosystem in the southwest Atlantic Ocean (Scotia Sea). Variations in krill recruitment and reproductive success of krill predators have been linked to environmental variations (e.g. sea-surface temperature and extent of wintertime sea-ice). Questions remain, however, as to whether these variations represent propagation of ENSO signals from the Pacific Ocean, or a more immediate and broad-scale shift in baseline conditions corresponding to the postulated regime shift that affected conditions across the Pacific Ocean basin following the 1998 El Niño (Annex 4, paragraphs 4.34 and 4.42 to 4.49).

3.10 Dr M. Naganobu (Japan) noted the importance of examining ecosystem change, particularly in the Antarctic Peninsula region with a well-documented increase in temperature over past decades. He highlighted the need for more research on ecosystem change and variability through field projects, in particular, those which will be developed for implementation during the IPY.

3.11 Dr Constable noted that if ecosystem change is occurring, changes to existing models might be warranted. The assessment of krill may also need revision to take account of these changes.

3.12 Following last year's work on interpreting CEMP data, the Working Group reviewed the analysis by the Secretariat of data from Subarea 48.3. The Working Group agreed that ordination of variables according to functional groupings was a useful way to summarise and interpret variability in CEMP data and encouraged similar analyses for other regions. The Working Group also agreed that work should continue on describing the statistical properties of the CEMP parameters and combined indices, as well as procedures for making decisions based on summaries of CEMP data (Annex 4, paragraphs 4.50 to 4.61).

3.13 The Working Group reviewed a paper expressing concern with regard to exploitation of *D. eleginoides* and minke whales in the Ross Sea shelf ecosystem. The paper noted that this system was relatively unaffected by anthropogenic activities and that expansion of these fisheries could (i) prejudice scientific research programs designed to understand fundamental processes, such as the effect of climate change on the system; and (ii) create unforeseen effects on components of the ecosystem that are not currently monitored. Some participants took exception to the paper and expressed concern that conservation issues are given greater emphasis than the maintenance of sustainable fisheries. Other participants agreed with the conclusions of the paper and noted the need to coordinate conservation and management initiatives between CCAMLR and the IWC. The more general question was also raised as to how ecosystem changes due to natural causes can be separated from those due to fishing, if fisheries are occurring everywhere (Annex 4, paragraphs 4.68 and 4.79).

3.14 Dr Naganobu reported that Japan plans to conduct a research cruise focusing on environment–Antarctic krill–whale interactions in the Ross Sea and adjacent waters during a survey in 2004/05. The survey is intended to provide data which will contribute to an understanding of the Ross Sea ecosystem.

3.15 Dr Kock (IWC Observer) noted that Japan is currently engaged in scientific whaling in the Southern Ocean (Whaling Areas IIIe, IV, V, VIw), taking 440 minke whales each year.

3.16 Dr Constable noted that in general, the potential ecosystem effects of all fishing should be considered, including the potential effects of bottom longlining on benthic habitats. Dr V. Sushin (Russia) suggested that additional data should be collected and comparisons with the Atlantic sector should be made, prior to reaching conclusions on the state of the Ross Sea. Prof. C. Moreno (Chile) cautioned that the issue is not with the amount of data, but that if fishing results in habitat damage, a precautionary approach should be implemented.

3.17 The Working Group reviewed submitted information on land-breeding predators foraging on fish and squid. The Working Group requested the Scientific Committee to reconsider how it wishes to treat matters relating to ecosystem interactions involving fish and squid (Annex 4, paragraphs 4.80 to 4.84).

3.18 The Scientific Committee indicated that it wished to defer advice on this topic until:

- (i) modelling initiatives involving food chains with considerable dependence on fish and squid are developed;
- (ii) data time series with potential utility to assist in contributing to CEMP initiatives had been fully evaluated, especially taking account of the recommendations in the CEMP review.

3.19 In the meantime, it noted the proposed development of work on icefish might offer an appropriate focus for relevant work and the Scientific Committee endorsed the request to Members undertaking relevant research to support these initiatives, including by submitting appropriate papers to both WG-EMM and WG-FSA.

#### Subgroup on Acoustic Surveys and Analysis Methods

3.20 The Working Group reviewed a reanalysis of the CCAMLR-2000 Survey data using previously published refinements to the expected acoustic target strength of krill. The Working Group noted that while it requested this analysis, it had insufficient expertise at the meeting to comment on the results. The Working Group further agreed that it is important to develop a process by which such methodological advances are incorporated into the work of the group and that this should not become a protracted process where there is inactivity in the absence of appropriate feedback (Annex 4, paragraphs 4.87 to 4.91).

3.21 The Working Group also noted that WG-FSA had similar difficulties in interpreting acoustic surveys of icefish and recommended that a standing Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) be established to advise the Scientific Committee in a timely fashion on protocols in acoustic surveys and analyses (paragraphs 3.94 to 3.96).

3.22 The Working Group recommended the following terms of reference:

To develop, review and update as necessary, protocols on:

- (i) the conduct of acoustic surveys to estimate biomass of nominated species;

- (ii) the analysis of acoustic survey data to estimate the biomass of nominated species, including estimation of uncertainty (bias and variance) in those estimates;

and that the immediate issues to be addressed by this subgroup are the acoustic protocols for assessing Antarctic krill in Area 48 and *C. gunnari* in Subarea 48.3 (Annex 4, paragraphs 4.90, 4.92 and 4.93).

3.23 Specifically, the Working Group requested that the subgroup consider whether a new model of krill target strength should replace the current CCAMLR-endorsed standard and provide their comments in time for the 2005 meeting of WG-EMM (Annex 4, paragraph 4.123; see also paragraphs 3.79 and 3.80).

#### New surveys

3.24 The Working Group reviewed announcements by Australia for a survey of krill in Division 58.4.2 (southwest Indian Ocean) and Japan for a survey of krill in Area 88 (Ross Sea). The Working Group noted that the recommendations of SG-ASAM with respect to krill target strength would be relevant to the analyses of data from these surveys (Annex 4, paragraphs 4.112 to 4.115).

3.25 Members welcomed these surveys, and noted the importance of a reassessment of acoustics methods. Dr Nicol further noted that the Australian survey was designed to provide data to CCAMLR to allow for a new estimate of the krill biomass to revise the catch limit, rather than relying on data collected in 1981.

#### CEMP methods

3.26 The Working Group reviewed a series of recommendations with respect to the CEMP standard methods that were developed during an informal workshop held at the Secretariat during February 2004 (Annex 4, paragraphs 4.109 to 4.111, Table 2).

#### Management of Protected Areas

3.27 Following consideration by the Subgroup on Protected Areas and recommendations of the Working Group (Annex 4, paragraphs 5.1 to 5.37), the Scientific Committee recommended that the Commission approve:

- (i) the revised Conservation Measure 91-01, Annex 91-01/A 'Information to be included in Management Plans for CEMP Sites' (WG-EMM-04/19);
- (ii) the Management Plan for ASPA No. 149, Cape Shirreff and San Telmo Island, Livingston Island, South Shetlands Islands, which is currently undergoing review by the ATCM (WG-EMM-04/8);

- (iii) the Management Plan for ASPA No. 145, Port Foster, Deception Island, South Shetland Islands, which is currently undergoing review by the ATCM (SC-CAMLR-XXII/BG/14). Notwithstanding approval, the Scientific Committee also wished to transmit advice for substantive improvements to the originators of this plan (Annex 4, paragraph 5.14).

3.28 In respect of the subgroup's term of reference relating to MPAs, Prof. Croxall:

- (i) noted that CCAMLR had important responsibilities, as an organisation with the attributes of an RFMO, but with a wider conservation mandate, for participating in the international discussion on the development and implementation of MPAs as management tools for the world oceans;
- (ii) introduced two papers, previously submitted to WG-EMM, which he believed provided important background information for CCAMLR's work in this area. SC-CAMLR-XXIII/BG/30 discussed the applicability of international conservation instruments to the establishment of MPAs in Antarctica and SC-CAMLR-XXIII/BG/28 listed current and proposed Antarctic MPAs within the Antarctic Treaty System.

3.29 Prof. Croxall noted that the UK had indicated, through an intersessional document placed on the CCAMLR website, its belief that more effective and coordinated progress was needed on this topic. The UK document suggested the need to:

- (i) acquire and synthesise relevant background information;
- (ii) create frameworks and mechanisms for addressing the topic in general and for examination of specific proposals.

3.30 In respect of the first suggestion, the UK believed there was merit in developing links with IUCN which, particularly through its Global Marine Program, was well placed to advise on the nature of current international initiatives of particular relevance to the Convention Area.

3.31 In respect of the second suggestion, the UK hoped that the subgroup could develop approaches which encourage the development and review of case studies relevant to proposals for different types of MPA, *inter alia*:

- (i) areas within EEZs;
- (ii) areas adjoining or linking existing EEZ MPAs;
- (iii) areas surrounding islands or archipelagos of exceptional marine biodiversity;
- (iv) large-scale areas of (or including) unique characteristics, perhaps particularly where management of harvestable marine resources coexists with extensive scientific research programs;
- (v) seamount and canyon habitats with unique and/or highly diverse biological assemblages.

3.32 In respect of the last category (paragraph 3.31(v)), Prof. Croxall drew attention to the review paper, SC-CAMLR-XXIII/BG/29, on the biology, ecology and vulnerability of seamount communities and to the recent publication 'Seamounts: Biodiversity and Fisheries' (*Fisheries Centre Research Reports*, 2004, Vol. 12, No. 5) which contained a global review of potential seamount locations, indicating that there were at least 900 such sites within the Convention Area.

3.33 Prof. Croxall noted that although the topic of MPAs is a management tool available to CCAMLR and is an important element of the work of the Subgroup on Protected Areas, there has been insufficient time and expertise available during subgroup meetings at WG-EMM to make real progress. He recommended that a workshop should be held to review current principles and practices in this field, to assess how these would be best applied to the Convention Area and to consider existing and forthcoming proposals relating to MPAs in the Convention Area.

3.34 Dr Constable supported consideration of MPAs to improve conservation of biodiversity in the Southern Ocean. One way forward might be to conduct an inventory and risk assessment of various habitats; however, it was likely to take a very long time for this analysis to lead to management advice. He suggested that in the interim of this work being concluded, the use of open and closed areas in new and exploratory fisheries could provide the best opportunity for the Commission to protect future options for the conservation and rational use of Antarctic marine living resources.

3.35 Dr Shust agreed that these issues would require focused attention and that future considerations should take into account the whole ecosystem. For example, the Ross Sea has been discussed from a variety of viewpoints, but not in a holistic manner. The Scientific Committee should develop a plan to move forward, such as a workshop with submitted papers addressing all of the issues, including science, management, legal jurisdiction etc.

3.36 Dr E. Barrera-Oro (Argentina) agreed that a framework for discussion was required in order to make progress. In particular, he highlighted the importance of seamounts as marine habitats and their vulnerability to bottom trawling.

3.37 Dr E. Fanta expressed Brazil's strong support for the establishment of MPAs as an important tool for the maintenance of biodiversity and the targeted resources.

3.38 Dr Naganobu noted that the consideration of MPAs in the Convention Area should include not only conservation but also rational use according to Article II of CCAMLR.

3.39 Dr H.-C. Shin (Republic of Korea) observed that MPAs are one of a suite of management tools and that the application of MPAs should not restrict future management options.

3.40 Dr Fanta (SCAR Observer) reported that at the 2004 SCAR Life Sciences Standing Scientific Group (LSSSG) meeting in Bremen, Germany, the importance of MPAs was discussed, as well as procedures related to protected areas with a marine component. Dr Fanta noted that LSSSG might be conducting an exercise to identify areas to be protected for their outstanding values. SCAR could then decide on a plan that would be submitted to the ATCM and to CCAMLR in the case of an MPA. This topic will remain as a permanent agenda item in the LSSSG.

3.41 Dr Kock observed that the 1994 designation of the Southern Ocean Whale Sanctuary by the IWC was based on political considerations, rather than science. At its 2004 meeting, the IWC extended the sanctuary designation for an additional 10 years, while noting that designation of sanctuaries should be based on solid scientific rationale in the future.

3.42 Several Members stressed the urgency to make progress, noting that the depleted stocks of the past have not yet risen to pre-unregulated fishing levels even after several decades.

3.43 Dr Penhale suggested that an ad hoc group be convened during the Scientific Committee meeting in order to formulate a recommended plan of action for making progress, rather than waiting another year for the next meeting of the subgroup. She noted that additional expertise would be advisable to augment the expertise of those who attend the subgroup meetings during WG-EMM.

3.44 The Chair of the Scientific Committee appointed Dr Penhale to convene an ad hoc group to formulate a plan of action and to report back to the Scientific Committee before the end of its meeting.

3.45 The ad hoc subgroup met with the goal for furthering the discussion of MPAs as one of a suite of management tools available to support the goals of CCAMLR.

3.46 Early in the discussion, the group identified a workshop as a means to bring together various points of view and expertise in a focused manner. While many enthusiastically endorsed a workshop on MPAs, others cautioned that a workshop must be grounded in the goals of CCAMLR, including rational use as well as conservation. This was endorsed unanimously. The worldwide activity on MPAs in various government and intergovernmental organisations was cited, along with the need and opportunity for CCAMLR to apply its expertise in the Convention Area to a discussion of MPAs.

3.47 It was suggested that a workshop should deal with principles and practices involved in the establishment of MPAs and should address the pros and cons of different approaches. Several Members noted the importance of clearly addressing the rationale for MPAs versus other management tools as well as the level of protection required in a particular area, along with a description of the values to be protected and the extent of available scientific data. Others noted that once established, a scheme for period review of MPAs would be desirable. Some Members promoted the precautionary approach, including the importance for helping restore depleted fish stocks and assisting in the maintenance of ecological function and sustainable stocks in regulated fisheries.

3.48 Other potential topics for such a workshop included consideration of the relevant areas/scales of different types of potential MPAs (e.g. in relation to water mass movement and its effect on organisms within an MPA), the concepts of connectivity and corridors, the value of seamounts as marine habitats, conservation of biodiversity, and 'lessons learned' from established MPAs in other parts of the ocean.

3.49 Another suggestion was to consider discussion papers on proposals currently under development or in a conceptual phase that related to MPAs in the Convention Area. Examples given were the South African plan for the Prince Edward Island EEZ (CCAMLR-

XXIII/BG/22), a revision of Antarctic Specially Managed Area No. 1 at Admiralty Bay by Brazil and Poland, the Balleny Islands plan under development by New Zealand, and ongoing discussions regarding the value of the least modified ecosystem of the Ross Sea.

3.50 Another desirable goal would be to start to evaluate needs for marine habitat conservation through a comprehensive review of the whole Convention Area, including defining the principal marine habitats involved and assessing the scientific data available in each area.

3.51 Members noted that while CCAMLR scientists were the experts in the Convention Area, scientists in governmental, intergovernmental and non-governmental organisations have long-established expertise in the development and management of MPAs. It was recommended that the workshop include invited experts, to take advantage of the large body of MPA knowledge that could be used to promote the goals of CCAMLR. Prior to the workshop, a paper could be produced to place existing MPA material in the context of CCAMLR's goals.

3.52 Draft terms of reference for the workshop were developed during the meeting:

- (i) to review current principles and practices related to the establishment of Marine Protected Areas;
- (ii) to discuss how the use of Marine Protected Areas could be used to contribute to furthering the objectives of CCAMLR;
- (iii) to consider proposals that are currently under development or in a conceptual phase that relate to Marine Protected Areas in the Convention Area;
- (iv) to discuss the types of scientific information that may be required for the development of Marine Protected Areas to further the objectives of CCAMLR, including the identification of biophysical regions across the Convention Area.

3.53 Practical issues addressed included the potential venue and timing of a workshop and financial support for such an endeavour. While Members recognised that these practical issues might not be resolved during the meeting, the Scientific Committee endorsed in principle the concept of a CCAMLR workshop on MPAs, and requested that the Chair of the Subgroup on Protected Areas act as Convener of the workshop. Intersessional tasks would include the creation of a steering committee to develop the agenda and suggested background papers, as well as identifying the appropriate venue and timing of the workshop.

3.54 Dr Penhale introduced a topic arising from WG-EMM-04 regarding the review of protected area management plans containing marine areas which are referred by the ATCM to CCAMLR for review and approval. WG-EMM recommended that CCAMLR devise a 'general rule' for proposals in coastal areas so that CCAMLR only focuses on protected areas with marine components that are of central interest to CCAMLR, rather than addressing areas only metres offshore or only containing a minimal area (Annex 4, paragraph 5.31).

3.55 The Scientific Committee agreed that such a mechanism would be welcome in that it would focus only on those protected areas that have potential impact on the goals of CCAMLR and would increase the efficiency of interactions between the ATCM and

CCAMLR. It noted that such a scheme would need to be transparent, so that any Party would have the opportunity to call for review of a management plan that was proposed for 'non-discussion'. It requested that WG-EMM advise on what such a general rule might be.

3.56 Dr Sullivan noted that New Zealand planned to continue work on a revised Balleny Islands management plan, which will have a solid scientific basis.

3.57 Dr Fanta reported that Brazil had undertaken three years of environmental monitoring research in Admiralty Bay in order to provide new scientific data for the revision of the plan.

#### Edmonson Point proposed ASPA

3.58 Dr Hewitt provided background information on the status of a proposed new ASPA at Edmonson Point, Woods Bay, Ross Sea (CCAMLR-XXIII/41). The management plan, which requires approval by CCAMLR due to the inclusion of a marine area in the site, was received too late for consideration at WG-EMM. This will result in a one-year delay in consideration by the Scientific Committee and the Commission, and a further delay in being available for approval by the ATCM whose own intersessional review will be reported to their June 2005 meeting. Under these circumstances, some Members at WG-EMM wished to make allowances for the late submission and to permit the subgroup to review the plan. It was agreed that the subgroup could continue to work intersessionally, pending a decision by the Scientific Committee as to whether it would accept advice on the Edmonson Point management plan directly from the subgroup (Annex 4, paragraphs 5.27 to 5.37).

3.59 Dr Penhale (Chair, Subgroup on Protected Areas) summarised the intersessional review of the Edmonson Point plan. The consensus of the few Members who provided comments was support of the plan, which was viewed as well written and scientifically sound, with a clear description of the values to be protected.

3.60 The Chair stated that his concern, which had nothing to do with the merits of the management plan, was that if the rules of procedure were not upheld in this case, other exceptions would be sought in the future. He reiterated that the normal course of action is for the Subgroup on Protected Areas to report to WG-EMM, and for WG-EMM to report to the Scientific Committee which formulates advice to the Commission.

3.61 At the request of the Chair, Dr M. Vacchi (Italy) provided some background on the plan. He noted that the values to be protected focused on the diverse terrestrial and freshwater components of the ecosystem, which provide an excellent site for climate change research. Years of research at an Adélie penguin colony within the site have contributed to the goals of CEMP. The marine component consists mostly of an area extending only 200 m offshore.

3.62 A discussion followed which focused on various aspects of the situation. Members were strongly supportive of the plan itself, citing the high quality of the plan, including the maps, and the solid scientific research that has been conducted at the site. There was some concern that a delay could have negative implications, if increasing pressures to the site were to emerge. All agreed that the inclusion of the small marine component would not affect the goals of CCAMLR, as it was extremely unlikely that any fishing activities could be conducted within the site.

3.63 Despite the positive support for the proposed management plan, a consensus could not be reached as to whether the Scientific Committee should review the plan. Some Members felt that the need for protection, particularly with the reality of at least one year's delay, warranted making an exception to the rules. Others felt that the rules and procedures should be strictly adhered to and that the plan should be referred to the 2005 meeting of the subgroup at WG-EMM. In the absence of consensus, the plan was referred to the subgroup for formal discussion at the 2005 meeting of WG-EMM. Despite this lack of a formal positive recommendation, many Members recommended that the Commission indicate to the ATCM that, based on the existing informal review, there appeared to be no objections to the plan.

3.64 In the discussion that followed, two general themes emerged. One was that the Edmonson Point plan provided a concrete example of the need to develop criteria by which management plans referred to CCAMLR by the ATCM could be initially categorised into two groups: those which are of interest to CCAMLR (thus requiring review) and those containing such minor marine areas that formal review would be unwarranted (paragraph 3.55).

3.65 The second point was the recommendation that the rules and procedures of the subgroup should be reviewed in order to increase operational efficiency and to facilitate interactions with both WG-EMM and WG-FSA, two groups with interests in many of the topics referred to the subgroup.

#### Management advice on allocation of the krill catch limit among SSMUs

3.66 As part of its long-term work plan, the Working Group indicated that it would forward a recommendation in 2004 for the subdivision of the precautionary catch limit of krill in Area 48 among SSMUs adopted by the Commission in 2002. The Working Group considered five options (see Hewitt et al., 2004, for a description of these options). However, consensus on a recommendation was not achieved. Instead, the Working Group agreed to use the modelling framework outlined at this year's workshop to evaluate the various assumptions underlying each of the options (Annex 4, paragraphs 5.39 to 5.60).

3.67 Drs Sushin and Naganobu noted that the krill catch currently shows a decline in Subarea 48.3, suggesting that allocation of precaution catch limit of krill by SSMU is not an extremely urgent matter at this time.

3.68 Other Members reaffirmed that, irrespective of the interpretation of current trends in krill fishing effort, recommendations for the subdivision of the precautionary catch limit for krill among SSMUs have been required by the Commission. This subdivision is essential to the management of krill fishing in Area 48 and the development of appropriate recommendations is proceeding according to a process and plan endorsed by all Members of the Scientific Committee (Table 1).

## Workshop on Plausible Ecosystem Models for Testing Approaches to Krill Management

3.69 During the first week of the 2004 meeting of the Working Group, a workshop was held to specify plausible operating models of the krill-centric ecosystem that could be used to test alternative management procedures. This was the third workshop in the long-term work plan of WG-EMM to develop a revised krill management procedure (Table 2).

3.70 In developing its long-term plan, the Working Group and the Scientific Committee agreed that the revised krill management procedure should be based on ecosystem monitoring. These observations can then be used as a basis for an assessment of the state of the system. In a parallel fashion, specified management objectives can be used as a basis to define the desirable states of the system. The difference between the observed state and the desired state triggers decision rules. These decision rules act on the only part of the ecosystem amenable to control – that is, the fishery (Figure 1).

3.71 In order to test the performance of alternative management procedures, the Working Group agreed to specify an operational model that would simulate the krill-centric ecosystem. The management procedure that performs best with respect to achieving the objectives of conservation and rational use, and is the most robust with respect to errors in specifying and observing the system, would be the preferred alternative (Figure 2).

3.72 The Workshop on Plausible Ecosystem Models for Testing Approaches to Krill Management, an element in the Scientific Committee's long-term program of work for WG-EMM, was convened by Dr Constable during the first week of the 2004 meeting of WG-EMM. Abbreviated terms of reference were:

- (i) to review the approaches used to model marine ecosystems;
- (ii) to consider plausible operating models for the Antarctic marine ecosystem;
- (iii) to advance a program of work to develop and implement operating models that could be used to investigate the robustness of different management approaches to underlying uncertainties in the ecological, fishery, monitoring and assessment systems.

3.73 The report of the workshop is included as Appendix D in the WG-EMM-04 report (Annex 4). Discussion of the workshop report is recorded in Annex 4, paragraphs 2.1 to 2.31. The workshop report was organised around six general headings:

- (i) review of intersessional activities
- (ii) desirable attributes of ecosystem models
- (iii) conceptual representation of ecosystem models
- (iv) plausible scenarios for the Antarctic marine ecosystem
- (v) model formulation and specification
- (vi) future work.

3.74 A steering committee coordinated intersessional work in preparation for the workshop. These activities included consultation with ecosystem modelling experts, review of relevant literature, review of available software, consideration of data requirements, and preliminary specifications of model components.

3.75 Dr Fulton was invited to the workshop in recognition of her expertise in developing models used to evaluate management strategies. She provided background on management strategy evaluation, steps for developing ecosystem models, and case examples of two management regimes that she has evaluated. She also provided guidance to workshop participants as they laid out the conceptual design and specification of various components of a model of the Antarctic marine ecosystem. Her contributions were critical to the success of the workshop.

3.76 The general attributes required of an ecosystem model used to evaluate management procedures were reviewed and agreed. These include the incorporation of fishing effects, specification of observations and monitoring programs, flexibility in the degree of aggregation possible among taxonomic groups, use of multiple spatial and temporal scales, flexibility in how interactions between components are simulated, and incorporation of external conditions and processes.

3.77 Conceptual models were developed for the following system components: physical environment, primary production, pelagic herbivores and invertebrate carnivores, harvested species (krill and icefish), mesopelagic species, marine mammals, birds and fisheries. The aim was to provide a flexible framework for considering how each taxon might be influenced by the rest of the ecosystem. Schematic diagrams and tables were developed to describe key population processes and interactions with other components of the system. These specifications can now be used by programmers to produce a modelling framework. The performance of plausible models developed within this framework can then be tested with respect to underlying structural assumptions and observation errors.

3.78 Discussion of plausible scenarios that need to be considered in evaluating the robustness of krill management procedures to structural uncertainties of the model focused on two broad topics. The first was concerned with the plausibility of the model and the second was concerned with questions of ecosystem dynamics. Of several possible scenarios, the following were accorded the highest priority:

- (i) behaviour of the model system in response to artificial (i.e. known) forcing functions in order to better understand the properties of the model;
- (ii) effects of alternative formulations of krill transport on ecosystem dynamics;
- (iii) effects of climate change on primary production and/or ocean circulation.

The Working Group also requested guidance from the Scientific Committee with regard to the priorities for exploring realistic scenarios and future work.

3.79 With respect to model formulation and specification, the Working Group agreed that it would be desirable to develop an ecosystem model as a series of connected modules rather than a single large piece of software. The Working Group also agreed that particular attention should be paid to how interactions between taxa are simulated, how time and space are resolved, and how peripheral processes and boundary conditions are incorporated.

3.80 The Working Group agreed that future work will entail validating and refining the conceptual models developed during the workshop as well as the specification of additional

ones. In this regard it requested WG-FSA review the fish, squid and fisheries components, and provide component details for toothfish and demersal species. This request is described in more detail in paragraph 7.2 of the workshop report (Annex 4, Appendix D).

3.81 Dr Hanchet (WG-FSA Convener) reported that the Working Group had insufficient time to address this topic during its 2004 meeting, but would conduct a review prior to the 2005 meeting.

3.82 Dr Constable noted that it was important to consider the interactions between krill, icefish and the respective fisheries in Subarea 48.3 in the development of operating models. The development of an icefish-related monitoring program is a separate issue. It could be considered later in the development of management procedures for either fishery. He suggested that papers to underpin modelling efforts should be directed to WG-EMM and papers related to icefish monitoring be directed to WG-FSA. He observed the overlap between the two Working Groups in the areas of modelling, monitoring and acoustics and recommended streamlining the work effort.

3.83 With respect to next year's Workshop on Management Procedures, the Working Group noted that initial exploration of management options could be achieved using spatially structured krill population models that allow exploration of the interactions between:

- the krill population
- spatial catch limits and the fishery
- krill predators
- transport of krill.

3.84 The Working Group agreed to establish a steering committee to further the development of plausible ecosystem models and established terms of reference that include coordination of further development of the modelling framework, publication of work, input from the Secretariat, and support of future WG-EMM workshops. The Working Group requested that Members consider representation on the steering committee, and that the structure of the committee, including its convener, be determined by the time of the meeting of the Scientific Committee. To that end, the Chair of the Scientific Committee agreed to coordinate the process, with assistance from Dr Constable, during the 2004/05 intersessional period (Annex 4, paragraphs 5.62 to 5.64).

#### Future Work of WG-EMM

3.85 The Working Group agreed that plans for conducting synoptic surveys of land-based predators should continue. In particular, the planning will consider field methods, survey design, logistical requirements and methods of data analysis. The Working Group recommended that this work should initially be done through intersessional correspondence. The Working Group further directed the correspondence group for land-based predator surveys to develop a work plan, including financial implications, in time for the 2004 meeting of the Scientific Committee. Subsequently, the correspondence group developed the work plan which includes a workshop in 2006 (Table 1; Annex 4, paragraphs 6.1 to 6.11).

3.86 The Working Group agreed that the objective for the 2005 Workshop on Management Procedures should be to evaluate options for the subdivision of the precautionary catch limit of krill in Area 48 among the SSMUs. These options include subdivisions developed according to (Annex 4, paragraphs 6.12 and 6.13):

- (i) spatial distribution of catches by the krill fishery;
- (ii) spatial distribution of predator demand;
- (iii) spatial distribution of krill biomass;
- (iv) spatial distribution of krill biomass minus predator demand;
- (v) spatially explicit indices of krill availability that may be monitored or estimated on a regular basis;
- (vi) pulse-fishing strategies in which catches are rotated within and between SSMUs.

3.87 Dr Constable noted that the Commission had requested this work be undertaken and that it was prudent to be able to provide advice concerning the options involving the establishment of SSMUs before catches reach critical levels. Some Members expressed support for the continuation of this work, while other Members expressed negative views on the concept of SSMUs. The Chair of the Scientific Committee reiterated that the Scientific Committee's role is to provide the Commission with advice solely based on scientific principles.

3.88 The Working Group further agreed that these candidates should be evaluated by quantifying the degree to which they are robust or sensitive both to a range of assumptions about the structure and function of the predator–krill–fishery system and to the data or conditions that are used to initialise the candidate procedures. Robustness and sensitivity will be determined by measures of performance of important attributes of the krill–predator–fishery system, which could include factors such as catch rates and predator survival (Annex 4, paragraph 6.14).

3.89 In preparation for the workshop, three intersessional correspondence groups were established to identify appropriate data, define alternative assumptions, and specify performance measures with respect to the krill resource, the krill fishery and krill predators. Members were also requested to develop models that would be able to explicitly consider alternative structural assumptions and produce identified performance measures (Annex 4, paragraphs 6.15 to 6.24)

3.90 The Working Group noted that the workshop planned for 2005 should be viewed as the first workshop to evaluate management procedures for the krill fishery (i.e. the subdivision of the krill catch limit among SSMUs). The Working Group further noted that it may be useful to convene a workshop in 2006 that considers CEMP in the context of an operating model of the Antarctic ecosystem. This workshop would be the second evaluation of management procedures for the krill fishery (Annex 4, paragraphs 6.25 to 6.27).

3.91 The Working Group updated its long-term work plan and asked for endorsement by the Scientific Committee (Table 1).

3.92 The Working Group also noted the need to (i) consolidate work that overlaps with WG-FSA and WG-IMAF, (ii) review information that is of interest to the Working Group but due to time constraints receives limited consideration, (iii) make available quantitative expertise, (iv) respond to broader conservation issues, and (v) establish new subgroups to consider specific issues. Furthermore, it noted the increased demands on the Secretariat in support of the Working Group and recommended that the Scientific Committee, in consultation with the Secretariat, consider how to best coordinate and structure the work of its working groups and subgroups (Annex 4, paragraphs 6.28 to 6.30).

3.93 Members endorsed the plan of work and noted that the strategic planning activity was the venue in which to merge appropriate activities of WG-EMM and WG-FSA.

3.94 Dr Hanchet called attention to the WG-FSA advice to the Scientific Committee summarised in SC-CAMLR-XXIII/BG/27, paragraphs 10.23 to 10.26. These recommendations include the establishment of SG-ASAM in conjunction with WG-EMM, coordinated work on icefish-centred ecosystem monitoring in conjunction with the krill-centred monitoring program, and encouragement for Members to conduct ecosystem-based research in areas where icefish populations occur, using the data collected for ecosystem modelling.

3.95 Some Members supported the establishment of SG-ASAM, but noted that there is a critical lack of expertise among those attending either WG-EMM or WG-FSA. It was suggested to bring in experts from groups such as the ICES-FAST group. Obtaining assistance from those already focused on the topic could result in a more efficient means to bring best practices to the working groups.

3.96 Other Members felt that outside experts might be too busy to focus on CCAMLR's issues. Asking others to solve CCAMLR's issues would be unproductive. It was noted that expertise is to be found among Member countries which could provide acoustic experts to address the tasks.

3.97 Dr Fanta reported that she is chairing, in conjunction with Dr Kock, an ad hoc subgroup of WG-FSA on ecosystem interactions. The goal of the subgroup is to discuss how an ecosystem monitoring program centred on icefish could be established and what would be needed to build an ecosystem model of such a system. A preliminary search revealed that there is a great amount of data available in CCAMLR documents, as well as in publications outside the CCAMLR arena. An action plan will be developed and circulated intersessionally. Members are asked to contribute with papers on icefish biology and interactions with other elements of the ecosystem.

3.98 The Chair of the Scientific Committee reiterated the need for experts to participate in the working groups and in workshop activities in order to make progress.

#### Management advice

3.99 The Scientific Committee called to the attention of the Commission the following items arising from WG-EMM:

- (i) the need to establish an advisory subgroup on acoustic surveys (paragraphs 3.21 and 3.22);
- (ii) specification of plausible ecosystem models for testing management procedures (paragraphs 3.69 to 3.84);
- (iii) 2005 Workshop on Management Procedures to evaluate options for subdividing the krill catch limit among SSMUs (paragraph 3.86);
- (iv) a future workshop on MPAs (paragraphs 3.44 to 3.53);
- (v) a future workshop on large-scale surveys of land-based predators (Table 1);
- (vi) the need for a review of the rules and procedures related to the work of the Subgroup on Protected Areas and to develop additional criteria in reviewing protected areas referred to CCAMLR from the ATCM (paragraphs 3.64 and 3.65);
- (vii) the need for the Scientific Committee to consolidate work that overlaps with WG-FSA and WG-IMAF (paragraph 3.92);
- (viii) the WG-EMM long-term plan of work (Table 1).

3.100 The Scientific Committee recommended that the Commission approve (paragraph 3.27):

- (i) revised Conservation Measure 91-01, Annex 91-01/A 'Information to be included in Management Plans for CEMP Sites';
- (ii) Management Plan for ASPA No. 149, Cape Shirreff and San Telmo Island, Livingston Island, South Shetlands Islands, which is currently undergoing review by the ATCM;
- (iii) Management Plan for ASPA No. 145, Port Foster, Deception Island, South Shetland Islands, which is currently undergoing review by the ATCM, along with advice for improvements to the originators of this plan (Annex 4, paragraph 5.14).