ANNEX 4

REPORT OF THE WORKING GROUP ON
ECOSYSTEM MONITORING AND MANAGEMENT
(Fiskebäckskil, Sweden, 2 to 11 July 2001)

CONTENTS

REPORT OF THE WORKING GROUP ON ECOSYSTEM MONITORING AND MANAGEMENT

(Fiskebäckskil, Sweden, 2 to 11 July 2001)

INTRODUCTION

Opening of the Meeting

1.1 The seventh meeting of WG-EMM was held at the Kristineberg Marine Research Station, Fiskebäckskil, Sweden, from 2 to 11 July 2001. The meeting was convened by Dr R. Hewitt (USA).

1.2 Participants were welcomed by Admiral C. Tornberg (President of the Kristineberg Marine Research Station Board), Mrs D. Edmar (former Swedish CCAMLR Commissioner) and Ambassador E. Kettis (CCAMLR Commissioner, Swedish Foreign Ministry). Reflections were made on the work of CCAMLR and developments since the 1990 meeting of WG-CEMP in Stockholm. It was noted that 2001 is an important year in the history of CCAMLR and Antarctica: CCAMLR will be celebrating its 20th annual meeting; it is the 40th anniversary of the Antarctic Treaty; and it is the 100th anniversary of the 1901–1903 Swedish Antarctic Expedition.

1.3 Prof. J. Rydzy (Italy) recalled last year's meeting of WG-EMM in Taormina, Italy, and hoped that progress made at that meeting would be successfully extended at the 2001 meeting.

1.4 Dr Hewitt welcomed participants and outlined the program for the meeting. He noted that the Scientific Committee had endorsed a plan by WG-EMM to change the format of its meetings in an effort to address both short-term and long-term issues in the provision of management advice (SC-CAMLR-XIX, Annex 4, paragraphs 4.127, 4.128 and 7.14; SC-CAMLR-XIX/6 and SC-CAMLR-XIX, paragraphs 13.4 to 13.6).

1.5 The new format is a hybrid one, consisting of a plenary session where the core work of WG-EMM will be developed and a short symposium or workshop on a specific topic will be held. The rationale is that sessions on the core work would allow WG-EMM to address the requests of the Scientific Committee, while workshops would allow the Working Group to focus more energy on a specific problem, and symposia would expose the work of WG-EMM to a broader community as well as expose the Working Group to fresh ideas and approaches.

1.6 At its 2000 meeting the Scientific Committee reiterated that WG-EMM should consider as its core business (SC-CAMLR-XIX, paragraph 13.5):

- reviewing the status and trends in krill fisheries;
- assessing the krill-centric ecosystem; and
- developing management advice.

1.7 The Scientific Committee also highlighted two issues of high priority for consideration by WG-EMM:

(i) Subdividing krill potential yield. The Scientific Committee acknowledged the statement made by WG-EMM-00 that it may take 5 to 10 years to develop a management scheme for krill that would take into account local as well as regional-scale processes. In the meantime, the Scientific Committee reiterated its request that WG-EMM investigate methods for subdividing the potential yield as a precautionary measure to avoid concentrating fishing effort (SC-CAMLR-XIX, paragraphs 5.15 and 5.27).

(ii) Development of a unified regulatory framework. A key element of this framework would be a Fishery Plan, envisioned as a comprehensive summary of information on each fishery. This would include notifications to fish, harvest controls, fishing activity, data collection plans etc. (SC-CAMLR-XIX, paragraphs 7.2 to 7.20). The Secretariat had been asked to develop a draft plan for the krill fishery in Area 48 and WG-EMM was asked to provide comments and advice.

1.8 The workshop described in paragraph 5.1 was devoted to the development of a multi-year agenda for the future work of WG-EMM. The goals were to: review earlier discussions and consensus within CCAMLR regarding the development of an ecosystem approach to management of the krill fishery; outline the major issues relevant to the work of WG-EMM that require focused attention; and develop a list of prioritised topics. A subset of topics will then be selected and a plan developed to address each of them.

1.9 Implementing the new format does not necessarily mean that a distinction must be drawn between those issues that require immediate comment and those that can be best resolved through a concentration of effort or iteratively over time. There is a large overlap between the core business of WG-EMM and potential symposium/workshop topics. The expectation is that short-term advice will be modified by improvements in the management scheme. It is also expected that these improvements will be developed over several years as a consequence of ideas and information exchanged at the symposia and workshops.

Procedure for Electronic Submission of WG-EMM Papers

1.10 In recent years the increase in the number of meeting papers submitted at the beginning of WG-EMM meetings has meant that participants have not had sufficient time to give papers the full consideration required. At last year's meeting, WG-EMM agreed on a new set of rules which stipulated that papers must be submitted in electronic form to the Secretariat at least two weeks before the meeting. This would allow the placement of documents on the CCAMLR website (SC-CAMLR-XIX, Annex 4, paragraphs 9.4 to 9.7).

1.11 The intention was to allow meeting participants sufficient time to download and read the documents prior to the meeting. In anticipation of increased traffic to the CCAMLR website, the Secretariat had improved its access to the internet during the intersessional period. Initial discussions indicated that the procedure had been successful, and that 69 documents for the 2001 meeting had been submitted by the deadline. Of these papers, 70% were received in the last few days before the deadline. Several papers were received without the requested proforma synopsis.

1.12 A number of problems were encountered. The most common were problems with inappropriate file types, large files, multiple files for single papers, incorrect email address specified, papers submitted as hard-copy form only (published papers), incomplete papers (abstract only) and late arrival of papers.

1.13 The Secretariat indicated that as a result of receiving the majority of papers near the deadline and the effort required to overcome problems relative to file formats, not all papers were available on the CCAMLR website until one week after the deadline. This only allowed one week for participants to download papers prior to the meeting.

1.14 The Working Group noted it was not feasible to move the deadline for paper submission forward to three weeks prior to the start of the meeting because it would be extremely difficult for the participants whose native language was not English to translate their documents in time for an earlier deadline. In addition, an earlier deadline was difficult for those Members submitting numerous papers because the process of assembling and posting documents is currently very time consuming.

1.15 The Working Group reaffirmed its policy that papers not received by the agreed deadline would not be considered. In addition, papers received as abstract only would not be considered because it was not possible to evaluate statements made in the abstracts.

1.16 Working Group members were pleased to learn that meeting documents would remain on the CCAMLR website for the foreseeable future.

1.17 The Secretariat agreed that it would be possible to add zip files every two or three days as papers were placed on the website and that the date of doing so would be indicated. In addition, the Secretariat will, soon after the deadline has passed, provide on the website information on how many papers were received and when it was anticipated they would be available for downloading. This information was provided to participants at the 2001 meeting.

1.18 The Working Group agreed that the proforma synopsis need not include the paper's abstract, but should continue to include a summary of findings as they pertain to particular agenda items. This will allow more room, if required, on the one-page proforma for a summary of findings and eliminate the need to reproduce the abstract which should be on the first page of the paper.

1.19 The Working Group thanked the Secretariat for its efforts to make this a productive exercise and agreed to continue the policy in future years.

1.20 Dr A. Constable (Australia) suggested that all papers may not require in-depth analyses at the meeting. Some might serve as background papers, while others would serve as core papers addressing specific agenda items. This would create two classes of papers (such as presently employed by the Scientific Committee). Dr Hewitt agreed to provide guidelines which might be used by authors to determine the appropriate category. These will be reviewed at the next meeting.

1.21 Dr Hewitt suggested that participants adopt two guidelines to their work at the meeting:

- remain focused on issues that will lead to resource management advice; and

- structure the report such that it leads to a set of well-referenced paragraphs that clearly summarise the advice, requests, notations and comments that the Working Group wishes to bring forward to the Scientific Committee.

1.22 In order to achieve these results it will be necessary for both contributors and rapporteurs to recognise their responsibilities:

- contributors should provide a synopsis of each working paper containing an abstract and a summary of findings as they relate to specific agenda item(s); and

- rapporteurs will organise summaries, present an overview of key points to the Working Group and summarise discussion.

1.23 In this regard WG-EMM considered the fate of four papers that had been submitted after the deadline (WG-EMM-01/70 to 01/73). WG-EMM-01/70 contained data submitted to the Secretariat but was not received on time because of ship-to-shore email problems; it was agreed to consider this document during the meeting. WG-EMM-01/73 was submitted as a complement to an invited presentation at the workshop; it was agreed to consider this document as well. It was agreed to acknowledge receipt of the remaining two papers but not to consider them at the meeting.

1.24 WG-EMM also considered four abstracts which had been submitted by the deadline, but for which detailed papers had not been submitted, or had been submitted after the deadline. It was agreed that the details of these papers would not be considered at the meeting, and that information presented in the abstracts would be given limited consideration.

1.25 Finally, WG-EMM noted that a number of papers had been submitted without a complete synopsis. It was also noted that this placed an extra burden on both participants and rapporteurs in their effort to draw out the relevance of the document to the agenda of WG-EMM, resulting in a disservice to both the contributors and the work of CCAMLR. WG-EMM urged contributors to submit full papers, including complete synopses, at future meetings.

Key Points for Consideration by the Scientific Committee

1.26 The Working Group noted that the electronic submission of papers had, despite some initial difficulties due to the volume of near-deadline submissions, been most successful in facilitating the conduct of the Working Group's business (paragraphs 1.10 to 1.13).

1.27 The Working Group reaffirmed its policy in respect of not considering papers submitted after a deadline of two weeks before the start of its meeting. It also resolved that papers received as abstract only would not be considered (paragraph 1.15).

Adoption of the Agenda and Organisation of the Meeting

1.28 The Provisional Agenda was discussed and adopted without change (Appendix A).

1.29 The List of Participants is included in this report as Appendix B and the List of Documents submitted to the meeting as Appendix C.

1.30 The report was prepared by Dr A. Constable (Australia), Prof. J. Croxall (UK), Dr I. Everson (UK), Prof. B. Fernholm (Sweden), Mr M. Goebel (USA), Drs R. Holt (USA), D. Miller (South Africa), S. Nicol (Australia) and D. Ramm (Data Manager), Mr K. Reid (UK), and Drs E. Sabourenkov (Science Officer), V. Siegel (Germany), W. Trivelpiece (USA) and P. Wilson (New Zealand).

STATUS AND TRENDS IN THE FISHERY

Fishing Activity

1999/2000 Season

2.1 A total of 104 259 tonnes of krill was caught by 14 vessels between July 1999 and June 2000, of which 69 954 tonnes were taken from Subarea 48.1, 28 649 tonnes from Subarea 48.2, 4 671 tonnes from Subarea 48.3, and 985 tonnes from within Area 48 (subarea not specified) (WG-EMM-01/7).

2.2 essels fished for krill in Subarea 48.1 in all months except July 1999. Vessels fished in Subarea 48.2 in July, August and December 1999 and January, March, May and June 2000. Fishing occurred in Subarea 48.3 in June 2000.

2.3 Compared to fishing levels reported over the past 10 years, levels of catch and effort in 1999/2000 were high in Subarea 48.1, low in Subarea 48.2, and the lowest reported in Subarea 48.3.

2000/01 Season (intermediate period, July to November 2000)[1]

2.4 The total catch of krill reported during the intermediate period was 30 175 tonnes, caught by 11 vessels. Fishing only took place in Area 48. The following Member countries reported fishing: Poland (5 vessels, 4 360 tonnes); Japan (4 vessels, 23 931 tonnes); Republic of Korea (1 vessel, 1 816 tonnes); and the USA (1 vessel, 70 tonnes).

2000/01 Season

2.5 Reports were available only for December 2000, and January–April 2001. The total krill catch reported to 17 June 2001 was 45 223 tonnes (WG-EMM-01/7). Fishing has only been reported in Area 48. The following Member countries are known to have been fishing in 2000/01: Poland (3 vessels, 5 072 tonnes reported to end of April); Japan (3 vessels,

[1] From 2000 the fishing season has been brought into line with other CCAMLR fisheries. The 2000/01 fishing season for krill began on 1 December 2000 and ends on 30 November 2001. The intermediate period covers that period between the end of the old reporting period (June 2000) and the start of the new reporting period (December 2000).

39 057 tonnes reported to end of May); Republic of Korea (1 vessel, 1 095 tonnes reported to end of April); Ukraine (1 vessel, started fishing in April, no reports); and the USA (1 vessel, started fishing in May, no reports).

2.6 Information on the US krill fishing venture indicated that it was in a developmental phase whilst the vessel was being brought into full operational mode and its operators were becoming familiar with the operations of the krill fishery. The single US vessel was likely to be joined by a second over the next year and the operation would be producing products for human consumption and meal.

2.7 Other nations indicated that their operations would be at approximately the same level as last year (Japan, 3 vessels catching ~65 000 tonnes; Republic of Korea, 1 vessel catching ~8 000 tonnes; Poland, 3 vessels).

2.8 There were indications that the fishery had been moving south in recent years. WG-EMM-01/52 analysed fine-scale catch data which showed that catches in the Antarctic Peninsula area started to be taken in autumn 1996 and in winter 1997. This trend has continued since. This could be a result of environmental conditions; sea-ice has been absent from the South Orkney Islands in recent years and this has been a favoured fishing area for vessels from a number of nations. There may also be economic reasons for vessels fishing in certain areas or avoiding other areas.

Earlier Years

2.9 In the 1999/2000 split-year four Japanese krill fishing vessels operated in Area 48. In Subarea 48.1 the operation started in December and lasted until June. In Subarea 48.2 fishing took place in December, March and May to June. In Subarea 48.3 fishing took place only in June. Two types of CPUEs were calculated for each 10-day period: catch per tow (tonne/tow) and average catch per towing time (kg/min). These measures fluctuated over the season; from 8–20 tonnes/tow, and from 200–700 kg/min (WG-EMM-01/36).

2.10 The Working Group recognised the importance of the growing dataset on CPUE from the Japanese krill fishing fleet and considered that re-examining the use of such fisheries indices should be a priority task for a future meeting. The Working Group also noted that further information on the spatial and temporal distribution of the fishery from all participants would be very useful for its future work and encouraged the submission of such data.

2.11 Information on the distribution, density and length composition of krill in concentrations from a Polish commercial vessel in the summers of 1997, 1998 and 1999 in the Atlantic sector indicated that concentration densities varied with area and season (WG-EMM-01/13).

2.12 The highest krill densities in 1997 were found near South Georgia and the South Orkney Islands and the lowest near the South Shetland Islands. Commercial krill concentrations generally occurred at depths of 125–250 m but depth varied regionally: at Elephant Island ~125 m, at South Georgia ~150 m, at the South Shetland Islands ~175 m, and at the South Orkney Islands ~250 m. The density of night concentrations of krill was several

times lower than the density of day concentrations but there were no systematic patterns of vertical migration. The average density of krill concentrations increased between February and April–May and then it decreased.

2.13 An analysis of data on the Soviet krill fishery from 1977 to 1992 in Subareas 48.1, 48.2 and 48.3 (WG-EMM-01/57) indicated that the fishing effort could be divided into three types:

> Type I: 1981 and 1982, partly 1979/80. Effort was concentrated in Subarea 48.1 in January–April, then moved to Subarea 48.3 via Subarea 48.2.
>
> Type II: 1983–1986. Effort was mostly in Subarea 48.2; after 1985 the role of Subarea 48.3 increased.
>
> Type III: 1987–1989. Effort was mostly in Subarea 48.3, from March–April to September–November.

The distribution of fishing effort corresponds to the spatial and temporal variability of the zonal and meridional atmospheric processes.

2.14 A total of 16 Soviet vessels operated during this period and the CPUE varied according to vessel type, crew experience, fleet ownership and product, amongst other factors. The maximum fishing effort did not always correspond to the maximum catch: the maximum catch of krill was obtained in 1982 (368 182 tonnes from 3 212 days of fishing), whereas the maximum fishing effort occurred in 1988, resulting in only 262 736 tonnes.

2.15 Three main factors influenced the Soviet fishing fleet distribution in Area 48:

(i) the presence of available krill aggregations of certain quality. Quality was determined by size and feeding intensity: very small and intensively feeding krill may only be processed into meal. For this period the highest priority for the Soviet fleet was maximal catches, krill quality was generally not important;

(ii) ice and weather conditions; and

(iii) operational factors: bunkers and supplies, political changes, changes from krill to other target species etc.

2.16 A revised analysis of the Japanese fishery described the relationship between commercial trawling positions and bottom topography in the Antarctic Peninsula area (WG-EMM-01/35). Trawling positions seemed to be primarily governed by the distribution of larger mature krill, especially at the beginning of the operation each season. The trawling positions followed a pattern of movement from the outer shelf towards on shelf from high summer onwards. Whenever salp densities are high, the fisheries operation may shift towards the shelf to avoid salp by-catch.

Krill Fishery Operation

By-catch

2.17 Scientific observations on fish incidentally caught during commercial krill fisheries by the FV *Niitaka Maru* (3 910 tonnes) were made from 16 December 2000 to 26 January 2001 in the vicinity of the South Shetland Islands (WG-EMM-01/50). Fish by-catch was found in 41 out of 103 trawl catches. *Lepidonotothen larseni* was the most abundant fish in number and weight and occurred in 20.4% of hauls sampled for by-catch. *Pleuragramma antarcticum* and *Champsocephalus gunnari* were the second in number and weight respectively. There was a negative correlation between by-catch of fish and the krill CPUE.

Conversion Factors

2.18 Three papers addressed the Scientific Committee's request for information on CFs from the krill fishery (SC-CAMLR-XIX, paragraphs 2.7 to 2.9). There was, however, little new information available and no information on CFs from modern processing machinery.

2.19 Reviews of published information on CFs were provided indicating that there is a large degree of variation resulting from the type of processing plant, size of krill and probably the operators (WG-EMM-01/39 and 01/ 44).

Processed Product	Yield (%)	CF
Whole	80–90	1.11–1.25
Peeled (attrition)	10–25	4–10
Peeled (roller)	10–16	10–6.25
Meal	10–15	10–6.67

2.20 In order to estimate total removals, the total catch and the quantity of discards need to be quantified. Two methods are currently used to estimate the total catch in trawl fisheries. The first is by direct estimation where the catch is estimated by the length of the codend filled and by its distension. The second is to use a scaling factor to convert product mass to total mass of species caught.

2.21 The scientific observer on board a Japanese krill fishing vessel provided information on the product types and quantities during the fishing operations (WG-EMM-01/38).

Krill Product Type	Fresh/Frozen	Peeled/Frozen	Meal	Total
Estimated green weight (kg)	2 062 500	231 000	2 077 000	4 370 500
Percentage of catch (%)	47.19	5.29	47.52	
Assumed product recovery rates*	1:1	1:10	1:10	
Round green weight (kg) from fishpond scale				4 248 000

* Maximum values

This paper noted a good agreement between total weight estimated from fishpond scale and total weight estimated from products using a CF of 10 for peeled and meal products.

2.22 The proportion of each product is a result of a number of factors. If the frozen krill are required for aquaculture, the vessel does not have to target non-feeding krill. As krill undergo rapid enzymatic autolysis once they are caught, they must be processed (i.e. frozen or boiled) within about 60 minutes after they enter the factory or they are sent to the meal plant. The Japanese krill fishery rarely discards krill as lower quality catches are sent to the meal plant and any discards are recorded by the vessel's crew. Discards are included in the total catch reported.

2.23 The Working Group reiterated that it required more information on krill processing factors, particularly from modern processing machinery and from all Members fishing for krill.

Economics

2.24 Information on the economics of the krill fishery was produced in response to the Scientific Committee's request (SC-CAMLR-XIX, paragraph 2.6). WG-EMM-01/44 drew attention to the International Market Insight Paper from the US Department of Commerce (USDC), 'Krill Market' (www.csjapan.doc.gov/imi0011/krill.html), and to a website highlighting difficulties in marketing krill (www.foreview.com/frame.shtml, www.foreview.com/magazine/articles/Nunaat_to_Enter_NAFTA.html).

2.25 Production of krill meal alone is still thought to be uneconomic (WG-EMM-01/44). Current (2001) market prices for krill meal range from 60–90% of break-even production cost depending on the pigment, protein and general quality standards. There is no established market price for krill meat but an ex-vessel price of US$3.50/kg or less was suggested and it was expected that a market price will be established in the next two years.

2.26 The current ex-vessel market price for whole frozen krill can be inferred from the USDC document referenced in paragraph 2.24 at the upper range of the figure reported at US$0.08–0.21/lb of frozen krill. A general ex-vessel price of US$500/tonne for whole frozen krill was estimated.

2.27 WG-EMM-01/44 indicated that the US fishing vessel (FV *Top Ocean*) is capable of processing more than 150 tonnes of green krill per sea day. Such well-equipped vessels complying with all safety and crew regulations set down by the IMO are expensive to operate (~US$23 000 per sea day).

2.28 The Working Group repeated its request for more information on the economics of the krill fishery and on the market developments that might affect the development of the fishery.

Information from the CCAMLR International Scheme of Scientific Observation

2.29 Despite the presentation of standard methods for measurement of length, maturity and feeding status in the *Scientific Observers Manual*, there are differences in the standard methods that are used by researchers (WG-EMM-01/16). This topic was discussed further under agenda item 3.5 (see paragraphs 3.97 to 3.100).

2.30 The Working Group agreed that it was necessary for information to be collected from the fishery in a systematic and comparable way. This information would not only include length and maturity information from the krill catch, but also information on CPUE that could be used to explore patterns of the fishery in space and time.

2.31 It was pointed out that fine-scale catch and effort data was available from other fisheries in the Convention Area and that this had provided useful information in their management. Additionally, to date, Japan had provided considerable information from its krill fishery, yet other Members fishing have provided little information on their operations (see also paragraph 2.10).

Fishing Strategies

2.32 The first examples of completed questionnaires on krill fishing strategies were received from the Polish krill fishery (WG-EMM-01/70). The Working Group thanked the master of the vessel (*Acamar*) for supplying the completed questionnaires and for the effort that had gone into them.

2.33 The Working Group noted that the completed questionnaires contained a wealth of information which would enable an analytical examination of fishing activities and encouraged further regular submissions by other nations' fisheries.

2.34 Members were encouraged to examine the questionnaires and to provide feedback on any difficulties they saw in using the form, on the uses to which such information might be put and any modifications to the form that might make it more useful. The Working Group acknowledged that some of the information on the questionnaire might be commercially sensitive. Fishing operators should examine the forms and indicate the areas where such sensitivities might occur. The Working Group also suggested that in future some sections of the forms might be completed by scientific observers so reducing the burden placed on the vessels' crews.

2.35 The Working Group recommended that the Scientific Committee adopt the questionnaire and incorporate it into the *Scientific Observers Manual* with some clear instructions on its completion, recognising that the questionnaire may require modification for different fishery operations.

Key Points for Consideration by the Scientific Committee

2.36 The Working Group noted that there was increasing fishing activity in Subarea 48.1 during austral autumn and winter since 1996. A combination of factors may influence the location of the fishing fleet in any one year but the Working Group recognised that easier access through reduced sea-ice extent was a major factor contributing to this trend (paragraph 2.8).

2.37 The Working Group recognised the importance of the growing dataset on CPUE from the Japanese krill fishing fleet and considered that re-examining the use of such fisheries indices should be a priority task for a future meeting (paragraph 2.10).

2.38 The Working Group also noted that further information on the spatial and temporal distribution of the fishery from all participants would be very useful for its future work and encouraged the submission of such data (paragraphs 2.10 and 2.30).

2.39 The Working Group reiterated that it required more information on krill processing factors, particularly on modern processing machinery and from all Members fishing for krill (paragraph 2.23).

2.40 The Working Group repeated its request for more information on the economics of the krill fishery and on the market developments that might affect the development of the fishery (paragraph 2.28).

2.41 The Working Group recommended that the Scientific Committee adopt the questionnaire on krill fishing strategies and incorporate it into the *Scientific Observers Manual* with some clear instructions on its completion, recognising that the questionnaire may require modification for different fishery operations (paragraph 2.35).

STATUS AND TRENDS IN THE KRILL-CENTRIC ECOSYSTEM

CEMP Indices

3.1 Updated information on the status and trends of CEMP indices was reported in WG-EMM-01/05. WG-EMM expressed its appreciation for the new data and updates which had been submitted to the CEMP databases since the 2000 meeting. The Working Group also thanked Dr Ramm for a comprehensive report and presentation of the CEMP indices.

3.2 WG-EMM reviewed the various developments which the Secretariat had undertaken this year, including (SC-CAMLR-XIX, Annex 4, Section 3):

- flagging data conformity with standard methods; and
- investigating ways to include summary data in the CEMP database.

3.3 All CEMP dataforms now include a box which data providers should tick to indicate that data have been collected according to the CEMP standard methods. In addition, a flag had been added to the right margin of the CEMP indices data report (WG-EMM-01/05, Appendix) to indicate conformity with standard methods. WG-EMM recognised that in order to implement this flag, data providers will have to indicate whether or not standard methods were followed for all data previously submitted to the Secretariat. The issue of data conformity was referred to the Subgroup on Methods for further consideration (see section 3.5).

3.4 Discussion was also held on the reasons for including summary data, or data collected using methods other than the CEMP standard methods, in the CEMP database. Summary data for Index A5a had been added as a trial (WG-EMM-01/05, Appendix, Table 4.04). The Working Group recalled that the CEMP database was designed to hold raw data submitted in accordance with the CEMP standard methods. It was noted that summary data may be included in the CEMP database on a case-by-case basis. However, the current structure of the

database would need to be modified substantially so as to allow the general inclusion of summary data. This matter was referred to the Subgroup on Methods for further consideration (see section 3.5).

3.5 WG-EMM also reviewed a new rule for selecting core colonies used in the calculation of Index A3 (WG-EMM-01/05). This new rule (select colonies where data are available >80% of the years of the study) made greater use of data than was possible under the existing rule (select colonies where data are available over all years of the study) (see WG-EMM-01/05, Table 7). WG-EMM agreed that the new rule was an improvement and should be used in future calculations of Index A3. It also noted that this dataset could be used to determine how many core colonies are required to estimate the trend in the overall population.

3.6 In reviewing trends and anomalies in the CEMP indices, the Working Group returned to discussions initiated at previous meetings regarding the interpretation of CEMP indices and their usefulness in addressing management issues. For example: What methods should be used to identify anomalies? Should baseline periods be established? How long should such a period be? What constitutes a good year, or a bad year? What action should be taken when an anomaly is detected? These types of issues were further considered in the workshop sessions (section 5).

3.7 Based on WG-EMM-01/05 the Working Group concluded that both overall, and in respect of individual indices, 2000/01 had been an average year in comparison with the time series of data available to WG-EMM. In Area 48 there were no particular indications of important differences between the subareas in 2000/01.

3.8 The Secretariat's review of CEMP indices and the development of ecosystem assessments (WG-EMM-01/9), which had been requested last year (SC-CAMLR-XIX, Annex 4, paragraph 3.55 and Table 3), was considered under section 7.

CCAMLR-2000 Survey

3.9 WG-EMM considered the report of the recent workshop convened by Dr J. Watkins (UK), and held in Cambridge, UK (WG-EMM-01/60). This workshop assessed the status of a set of papers arising from the CCAMLR-2000 Survey of Area 48. The Working Group noted that this set of papers would be aimed at a special issue of *Deep-Sea Research*. That journal had been contacted and had agreed in principle that the suggested topic and set of papers would be suitable for publication.

3.10 WG-EMM also noted that a letter to *Nature* describing the estimate of krill biomass in the Scotia Sea had been turned down by the editors of *Nature*. The CCAMLR-2000 Steering Committee now planned to amplify the paper by explaining how the information from the survey had been used by CCAMLR to set revised catch limits. That manuscript would be submitted to *Science*. The Working Group suggested that an accompanying letter should link the CCAMLR-2000 Survey with the forthcoming CCAMLR-XX meeting.

3.11 WG-EMM noted that the collaboration between CCAMLR and the IWC had been productive, and had extended the analyses of data from the CCAMLR-2000 Survey. WG-EMM agreed to encourage further collaboration between scientists from CCAMLR and the IWC.

3.12 Finally, WG-EMM noted that the papers arising from the CCAMLR-2000 Survey demonstrated the breadth of science associated with the survey. WG-EMM congratulated Dr Watkins and other participants on the success of the workshop.

Regional Surveys associated with the CCAMLR-2000 Survey

3.13 The Working Group noted that the International Coordination Subgroup, led by Prof. S. Kim (Republic of Korea), had arranged four vessels from Japan, Republic of Korea, Peru and the USA to conduct five hydroacoustic surveys in Subarea 48.1 from December 1999 to March 2000 (WG-EMM-01/68). These surveys had been conducted in conjunction with the CCAMLR-2000 Survey, and had used the acoustic protocols agreed for the synoptic survey. Acoustic data from the coordinated surveys were analysed at a three-day workshop held in Seoul, Republic of Korea, in June 2001. The subgroup appreciated the financial support for this workshop provided by the Korea Ocean Research and Development Institute (KORDI).

3.14 The Working Group noted the extensive analyses conducted at the workshop, and the usefulness of the data collected during the five surveys. WG-EMM congratulated participants and thanked Prof. Kim for taking on the responsibility of coordinator. WG-EMM endorsed further work outlined in WG-EMM-01/68 (see paragraph 3.22).

Krill Resource

3.15 The Working Group confined its discussion to new information on the ecology of krill relevant to making an ecosystem assessment.

Krill Distribution and Abundance

2000/01 Season

3.16 Results from an RMT net survey in January–February 2001 around Elephant Island, Subarea 48.1, from the FRV *Polarstern* and reported in WG-EMM-01/10, indicated that krill density was high relative to previous recent surveys. This was mainly due to the presence of large numbers of juvenile krill. Two US AMLR surveys in January and February–March 2001, reported in WG-EMM-01/45, noted that the krill density was higher than in 1996 but lower than in 1998. Moderate numbers of small krill were present in the catches from both these surveys although small krill were absent from the samples in February–March. In discussion it was noted that during this season the smaller krill were found down to 63°S, beyond the southern limit of the US AMLR surveys.

3.17 The results of a series of three acoustic surveys conducted near South Georgia were reported in WG-EMM-01/15. These represent an extension of the annual surveys in the existing BAS Core Programme and are designed to examine temporal variability in krill biomass in relation to the assessment of intra-annual variability and relationships with response variables of dependent species. In the area to the northwest of Bird Island, krill density was low (3.5 gm^{-2}) in October, had increased by January (34.7 gm^{-2}) and had decreased again by March (7.7 gm^{-2}). Given these differences it was concluded that the interpretation of interannual variability of krill density may be strongly dependent on the timing of surveys.

1999/2000 Season

3.18 Following analysis of the results from the CCAMLR-2000 Survey reported last year by WG-EMM (SC-CAMLR-XIX, Annex 4, paragraphs 2.84 to 2.95) several papers reported further analysis of the data. In addition, papers were tabled reporting work on small-scale surveys associated with the CCAMLR-2000 Survey.

3.19 Using the same analytical protocols as had been used to identify krill targets from the acoustic survey (SC-CAMLR-XIX, Annex 4, Appendix G), data from Subarea 48.4 had been analysed to indicate the distribution of krill and myctophids. These results were presented in WG-EMM-01/61. The results indicated that the bulk of the krill were present in Weddell Sea water whilst myctophids were restricted to waters to the north in Antarctic Circumpolar Current (ACC) water.

3.20 A further analysis of these data, reported in WG-EMM-01/42, indicated that 64% of the krill biomass present during the survey in Subarea 48.4 was present in swarms and that the bulk of the krill were present in only 14% of the area. These high-density locations were also identified as the only major localities suitable for commercial trawling. The predicted catch rates were low, of the order of approximately two tonnes per hour towing, but the locations were more or less congruent with the traditional trawling grounds in the area.

3.21 Results from net hauls made during the CCAMLR-2000 Survey were compared with those from similar studies from Soviet mesoscale surveys in seasons 1983/84, 1984/85 and 1987/88 and presented in WG-EMM-01/28. The density estimates were similar from which it was concluded that there had been little change in standing stock over the period.

3.22 Based on the results from the workshop referred to in paragraph 3.13, acoustic data from a series of surveys to the north of the South Shetland Islands undertaken by Japan, Republic of Korea, Peru and the USA were reported in WG-EMM-01/68. Prof. Kim gave a brief presentation outlining the key findings. The study had been conducted as five survey legs with the first starting on 14 December 1999 and the last ending on 26 February 2000. Excluding the results from the second survey leg, during which the acoustic results were thought to have been compromised by electronic problems, the density estimates were broadly similar over the period (39–68 gm^{-2}). The transects were aligned perpendicular to the shelf break and the net sampling indicated that the larger krill were present offshore and smaller krill on the shelf.

Krill Demography

3.23 Central to many studies of krill demography is information on size frequency. Such information is available from scientific and commercial nets as well as from food samples from dependent species and had been discussed at WG-EMM last year (SC-CAMLR-XIX, Annex 4, paragraphs 2.58 to 2.60). Each of these sources of information has its own attendant bias but since the general shape of the distributions derived from sampling by different methods at the same time and location appeared small, the error caused by these biases was thought to be small relative to other sampling errors. The Working Group noted that attention needs to be given to methods for comparing length-frequency samples obtained using methods for which the data cannot be transformed to length densities.

Growth

3.24 An examination of the length of krill in the diet of Antarctic fur seals at South Georgia between October and December for four years, reported in WG-EMM-01/18, indicated consistent changes in the modal size from c. 42 mm to c. 54 mm. The growth rate required to achieve this change was higher than reported for other regions but was consistent with the work of Mackintosh (1972) from an examination of the 'Discovery' samples from the Scotia Sea.

3.25 It was noted that krill growth rates had recently been reviewed by Siegel and Nicol (2000). To achieve the reported size at age for some of the krill around South Georgia, growth rates would have to be at the higher end of the reported values. The implications of incorporating different growth rates into yield models was discussed. Whilst it was accepted that this would be possible for local assessment models it would be very difficult currently to incorporate more than one growth function into the GYM.

3.26 Some members of the Working Group expressed the opinion that there were other possible explanations for the observed changes in size structure, such as variable meridional transport and influx into the western South Georgia area or that the krill might originate from different regions; for example, Weddell or Bellingshausen Sea.

3.27 Comparisons of krill length-frequency distributions from net samples collected in January and February 2000 at South Georgia were presented in WG-EMM-01/40. These showed greater differences between the locations and smaller differences with time. These differences were attributed to a different origin and not due to growth.

3.28 WG-EMM-01/53 presented a model of krill population structure that examined the rôle of changes in krill demography in generating variability in the South Georgia ecosystem. Comparison of the model output with data on krill size structures in the diet of Antarctic fur seals showed good congruence and demonstrated the importance of biologically based recruitment failures in generating the observed variability. The analysis indicates that mortality rates for the South Georgia region may be relatively high ($M = 1.25\ y^{-1}$). It was noted that this value is not necessarily inconsistent with that currently used for a whole krill population ($M = 0.6\ y^{-1}$).

3.29 If the interpretation of growth rates is realistic, then there are implications for other demographic factors. It was noted that a higher growth rate would most likely be associated with a higher rate of natural mortality. In turn, this would have some effect on the value of γ to be used in yield models.

Recruitment

3.30 WG-EMM-01/10 reported values for recruitment indices in Subarea 48.1. This indicated that recruitment from the 1999/2000 year class had been high and was a major factor in the high standing stock reported above. WG-EMM-01/10 and 01/45 also reported spawning had been early and extensive in the 2000/01 season and both papers forecast that recruitment from spawning in 2000/01 would most likely be high. In WG-EMM-01/45 this conclusion was supported by the observed status of salps and copepods in the region.

3.31 In discussion it was noted that the recruitment indices were strongly affected by the area from which the samples were obtained. Bearing in mind that it is impractical to sample adequately over the whole range of krill, it was agreed that sampling should be representative of the local region. In the Elephant Island region it was suggested that, to ensure this, the surveys should extend south to 63°S around that meridian to prevent underestimation of R1 recruits. Due to logistic constraints this would be likely to affect other sampling programs and the extent to which this might be achieved needs to be incorporated into survey plans. The Working Group agreed that the recruitment series in this region needs to be reviewed in light of this recent survey.

3.32 It was also noted that the small krill encountered at the southern portion of the survey could have arisen from another source (i.e. Weddell or Bellingshausen Sea).

Stock Identity

3.33 WG-EMM-01/12 presented a progress report on a study on krill mitochondrial DNA. The study had shown that there were significant genetic differences between samples of *Euphausia crystallorophias* taken within one region, whereas samples from other localities of the Antarctic indicated a high degree of homogeneity. Arising from this it was noted that, to assess genetic variability between samples, future sampling strategies for examining stock structure of krill should, at a minimum, consist of 10 samples of at least 100 individuals from each region.

Predators

3.34 Prof. Croxall summarised recent work on foraging ranges and distribution of Antarctic fur seals, macaroni penguins and black-browed and grey-headed albatrosses at South Georgia, studied using satellite-tracking techniques (WG-EMM-01/19, 01/22, 01/26 and 01/67).

3.35 WG-EMM-01/19 addressed seasonal variation in macaroni penguin foraging and reported larger foraging ranges during the incubation phase of the breeding cycle, which contracted to more inshore areas during chick rearing. In the former period, ranges extended well into the Antarctic Polar Frontal Zone to the northwest of South Georgia.

3.36 WG-EMM-01/22 examined overlap in foraging areas between fur seals and macaroni penguins. Although there was a large potential overlap between species with similar trophic niches, at-sea foraging distributions showed significant spatial segregation. However, the implications of this with respect to potential interspecies competition still depends critically on the distribution, abundance and movements of the krill population in the area.

3.37 WG-EMM-01/67 used a new approach (kernel estimation) to quantify habitat use within the overall foraging ranges of black-browed and grey-headed albatrosses. This technique revealed that the mean foraging areas of these two albatross species are very distinct.

3.38 WG-EMM-01/26 presented data on the satellite tracking of foraging by female Antarctic fur seals from Bird Island, South Georgia. These were used to derive a foraging density map of Antarctic fur seals at South Georgia which was combined with energetic requirements and indicates that female Antarctic fur seals have the ability to locally deplete prey resources during the lactation period. Therefore, in some years, the reproductive success may be food-limited.

3.39 WG-EMM-01/26 also presented the first information on the distribution of female Antarctic fur seals during the over-winter period. At the end of lactation females dispersed from South Georgia to areas of high productivity associated with the Patagonia Shelf and the northern boundary of the sea-ice zone. The availability of prey in these areas may have an important influence on subsequent survival and reproductive output.

3.40 All these papers illustrated how satellite-tracking data can be used to delineate the foraging ranges of krill-dependent predators and to define the areas of priority use within these ranges. WG-EMM-01/26 also provided a new approach to the generalisation of foraging ranges and habitat use at larger scales based on extrapolation from data collected at smaller scales. In the case of fur seals, foraging range and habitat use data from two sites at South Georgia were used, in conjunction with bathymetric characteristics and the known distribution and size of fur seal breeding populations around South Georgia, to produce an overall density-distribution map of foraging range and habitat use for the whole South Georgia population.

3.41 WG-EMM-01/23 examined changes in Adélie penguin populations breeding on Ross Island, in the Ross Sea region. Annual changes in Adélie penguin population growth were best explained by the extent of sea-ice five years earlier. The authors suggested that extensive sea-ice in winter negatively affects subadult survival and that this is expressed five years later, when these birds, on average, return to breed for the first time. The recent increases in Adélie populations in this region imply that sea-ice extent has changed significantly over recent decades.

3.42 WG-EMM-01/32 reported declines in Adélie penguin populations at King George Island in the Antarctic Peninsula region that were best described by a piece-wise linear regression model that suggested two periods of population stability (1978–1988 and 1991–2000) separated by a dramatic decline in population in the late 1980s. This decline was driven by a 50% reduction in cohort survival between the earlier and later periods. The Adélie penguin population decline occurred concurrently with a significant reduction in krill biomass estimates in the adjacent marine region.

3.43 WG-EMM-01/23 and 01/32 concur that the winter period is of vital importance in influencing predator population dynamics and both papers suggest that sea-ice extent is the primary variable affecting these populations. However, reduced sea-ice in the Ross Sea region has positively affected Adélie populations, through affording better access to productive winter habitat in the eastern Ross Sea, while reduced sea-ice in the Antarctic Peninsula region has negatively affected Adélie populations via reductions in krill biomass.

3.44 WG-EMM-01/32 further examined gentoo penguin population changes and found no correlation between changes in gentoo population size and either sea-ice extent or krill biomass estimates. Gentoo penguins experienced several rapid changes in the number of breeding pairs, interspersed with decadal periods of population stability. Demographic data suggest that gentoo populations are strongly affected by rare, strong cohorts that arise and dominate the population for 10–12 years, then decline as birds from the cohort die.

3.45 WG-EMM-01/32 also reports the results of the winter distributions of Adélie and chinstrap penguins as determined by satellite tracking. Adélie penguins from the Admiralty Bay colony left the breeding grounds and spent February to June of 1999 and 2001 close to the western shore of the Antarctic Peninsula and in the upper Weddell Sea basin. Chinstrap penguins spent the winter of 2000 distributed off the northern coast of the South Shetland Islands. The winter distribution of chinstrap penguins overlapped extensively with the krill fishery during the March to May period.

3.46 These studies from South Georgia, the South Shetland Islands and the Ross Sea identify important habitats for adult land-based predators, both during the period of rearing offspring and in the post-fledging/weaning winter periods. As more demography data become available, it is increasingly apparent that the winter period is critical for the survival and recruitment of predators to their respective populations. For penguins, the post-fledging period is a time of increased predator demand as young enter the marine environment and adults spend two to three weeks at sea in preparation for their annual moult. The identification of critical periods outside of the breeding season and the potential for overlap with krill fisheries warrants further investigation.

3.47 WG-EMM-01/43 presented a general overview of pinniped research at Cape Shirreff by the US AMLR Program and gave a brief synopsis of conditions for fur seals at Cape Shirreff in the 2000/01 season. It reported that pup production had increased 6.8% over the last year for an area that represents approximately one third of total pup production on the Cape. The mean trip duration for adult females was 2.7 days; significantly shorter than in previous years. The proportion of krill in the diet was higher than in previous years and the mean length of krill increased over the last year. Return rates and natality were 90.4% and 87.2% respectively.

3.48 WG-EMM-01/46, 01/47, 01/48 and 01/59 presented data on the incidence of *Brucella* and herpes virus antibodies in Antarctic fur seals and Weddell seals from Cape Shirreff. There is no direct evidence for the presence of *Brucella* or herpes in this area, or that these pathogens have influenced pinniped numbers in the Antarctic. However, these four papers serve to heighten awareness that predator abundance can potentially be influenced by pathogens.

3.49 The Working Group recommended that, until evidence of the effects of disease at levels potentially relevant to population trends and performance became available, further submissions on this topic would be more appropriately directed to the Committee for Environmental Protection of the ATCM.

3.50 WG-EMM-01/49 presented the latest estimates of fur seal pup production for Cape Shirreff. It provided confidence limits for the most recent count and reported a 3% decline in pup production for SSSI No. 32 over the last year. However, the overall decline can be attributed to the San Telmo Island portion of the SSSI, and when only counts of Cape Shirreff are considered there was an increase in pup production of 1% over the previous year. There was a request for more information on how the carrying capacity, presented in the paper, was derived and for confidence limits for this parameter to be provided in the future.

Environmental Influences

3.51 WG-EMM-01/11 compares SST obtained from satellite data and krill catches in the years around 1990 and 10 years later in the South Georgia area. During the positive SST anomaly of +0.7°C in 1990/91 the krill catch was 123 562 tonnes while during the negative anomaly of –0.6°C in 1999/2000 the krill catch was only 4 671 tonnes.

3.52 While acknowledging that there were more fishing vessels in the fishery in 1990 than in 2000, the paper explains that the absence of predictable krill concentrations in 1999/2000 is due to an intensification of the Weddell Sea water advection. This increased inflow of Weddell Sea water causes lowering of the SST and, through interaction with the ACC, also results in a weakening of the eddies typically associated with predictable krill concentrations around South Georgia. The author suggests that SST data from early in the summer season can be used to predict the potential of the krill fishery for the coming year.

3.53 The Working Group noted the limitation of drawing conclusions from two points in time separated by 10 years.

3.54 Vertical distribution of temperature, salinity, density and flow down to a depth of 1 000 m were recorded in the Drake Passage (WG-EMM-01/30). Knowledge of the physical characteristics of the Drake Passage is important because it is a narrow passage for the ACC and also because north of the South Shetland Islands there is an important fishing ground for krill. In that area the data indicate upwelling of warm deep water. The Polar Front was identified by a steep temperature gradient between 58 and 59°S. The water flow was eastward along the whole transect with a maximum speed of 30 cm/s at the Polar Front.

3.55 WG-EMM-01/34 used satellite image data of sea-ice concentrations to calculate polynia extent per day from 1978 to 1998. These data were converted into yearly means for the whole of the Antarctic Ocean. The time series of yearly means in the whole of the Antarctic show an increasing trend from the latter half of the 1980s (Figure 4 in the paper). The time series of the yearly means of polynia extent around the Antarctic Peninsula show a pulsating pattern with peak years in 1980, 1987, 1991 and 1995 (Figure 5 in the paper) while for the whole of the Antarctic Ocean, the peak years were 1980, 1987, 1991, 1995 and 1998 (Figure 4 in the paper).

3.56 In the discussion, attention was drawn to similarities to other Antarctic cyclical events and also to the conspicuous anomalies seen in 1987 for the monthly means of sea-ice cover of ±50% coverage as demonstrated by WG-EMM-01/34, Figures 6 and 7.

3.57 The Working Group concluded that WG-EMM-01/11, 01/30 and 01/34 demonstrate the increasing usefulness of satellite data and also provide valuable baseline information of relevance to the work of the group and encourages further work on elaborating oceanographic conditions using remote sensing.

Further Approaches to Ecosystem Assessment and Management

3.58 Last year the Working Group initiated a reappraisal of its approaches to ecosystem assessment (SC-CAMLR-XIX, Annex 4, paragraphs 4.86 to 4.117). Three papers were provided to guide and develop discussion (WG-EMM-00/22, 00/43 and 00/60); these are still very pertinent to the work of WG-EMM.

3.59 These papers:

(i) characterised the main elements of the approach to ecosystem assessment as:

(a) identification and monitoring of key processes governing krill recruitment and transport, and those controlling the viability of krill predator populations;

(b) elaboration of resource management rules based on monitoring results; and

(c) research activities designed to reduce uncertainty, monitor performance and improve the management scheme;

(ii) conceptualised a potential decision-making process, based on addressing four simple, fundamental questions:

(a) Is the availability of krill changing?
(b) Are populations of dependent species in decline?
(c) How much krill is required by the dependent species?
(d) What is the extent of overlap between krill fishing and foraging by dependent species?

(iii) developed the potential for a set of decision rules, designed to achieve conservation objectives for krill-dependent species, based on specified target levels of the production of the species.

3.60 The Working Group recognised that substantial data were available for providing quantitative answers to the questions in 3.59(ii)(a) to (d). Similarly, considerable data were available on key processes relating to the demography of krill and dependent species; however, further work on processes governing krill recruitment and transport was required.

3.61 Nevertheless, little, if any, practical progress had been achieved in developing potential decision rules (based, for example, on critical values of key processes) in relation to spatial scales of relevance to dependent species; this would be an important topic for the discussion workshop developing the future work plan for WG-EMM (see section 5).

3.62 Several submitted papers contributed to the development of further approaches to ecosystem management. The Working Group regretted that it had insufficient time to evaluate these at the present meeting but indicated that this should be an important element of its future deliberations on this topic. In the meantime the meeting provided some preliminary comments on the papers concerned.

3.63 WG-EMM-01/25 reported an application of the approach developed in WG-EMM-00/14 for combining CEMP data into simple indices (CSIs). The data used comprised up to 27 variables measured over 22 years for three krill-dependent CEMP indicator species (gentoo penguin, macaroni penguin and Antarctic fur seal) at Bird Island, South Georgia.

3.64 The variables used were either CEMP indices, part of CEMP indices or used data submitted to CEMP, except for timing of breeding, number of pups born and pregnancy and survival rates for Antarctic fur seals. Data for these additional variables are collected annually by standard methods but, as yet, no formal standard method has been developed for their submission to CEMP.

3.65 The paper also addressed some methodological issues (including two which were identified last year as needing further work (SC-CAMLR-XIX, Annex 4, paragraph 3.51)), showing that:

(i) sensitivity analysis indicated that missing values substantially effect the CSI but this effect is reduced if variables are highly correlated; and

(ii) the influence on the CSI of individual variables differs widely but, in general, those with longer time series have greater influence.

3.66 WG-EMM-01/25 concluded that:

(i) variables representing offspring growth explained the greatest proportion of the variability in the CSI, followed by those representing diet;

(ii) variables representative of changing population size indicated a statistically significant decline between 1977 and 1998;

(iii) variables representing foraging conditions during the breeding season showed no overall trend;

(iv) the CSI showed extreme and significantly low values in three years. (These are those frequently exemplified in past WG-EMM discussion as reflecting very poor predator performance in years of very low krill biomass); and

(v) there was a non-linear functional relationship between the overall CSI and krill biomass and this was also the case when each species was treated individually.

3.67 Prof. Croxall indicated that further work was in progress to refine the approach in this paper, particularly in respect of examining the inter-relationships within and between variables representing processes at similar spatial and temporal scales and more critical examination of variables relating to population size and demography. In addition, there are methodological issues, particularly in respect of indices of offspring growth, where WG-EMM-01/20 suggested that the existing formulation of the CEMP index may be inappropriate.

3.68 Part of WG-EMM-00/27 developed this approach further, by means of an illustration of how the relationship between a predator performance index (the Bird Island, South Georgia CSI derived in WG-EMM-01/25) and krill biomass might be used to manage levels of krill fishing. If the management objective was to minimise the chances of below-average predator fitness (predator performance index of 0 or less), then no or reduced fishing would be allowed in years when the krill biomass was below 24 gm^{-2}. The paper noted that this would require estimating or predicting krill biomass in advance of exploitation and also raised issues concerning the relationship between recruitment and population levels of krill. It would also imply, in the illustrative example, potential closure (or substantial reduction in level) of the fishery at South Georgia every two to three years.

3.69 In considering this paper the Working Group raised the following points:

(i) further development of management approaches, especially decision rules, based on the above illustration, requires careful consideration of the nature and magnitude of the errors in estimating both CSI and krill biomass;

(ii) an approach based solely on a predator performance index averaged across variables for several different species might be insufficiently precautionary in circumstances where one or more of the species showed a significant population decrease and for which management objectives might include the desire to restore depleted populations as provided for under Article II of the Convention; and

(iii) in the illustrative example, the krill biomass data came from the western acoustic survey box at South Georgia (that in closest proximity to Bird Island), whereas the main fishing grounds for krill have usually been associated with the eastern acoustic survey box. Knowledge of the oceanography in the region, at scales relevant to inter-relationships between the krill survey boxes and at larger scales relevant to krill advection, would be important in addressing the implications of this and related issues. In addition, the authors of WG-EMM-01/57 suggested that oceanographic data, especially in relation to meridional transport, might even assist in predicting likely levels of krill biomass.

3.70 Several members noted that given the current low level of krill fishing, particularly in relation to estimates of overall krill biomass, management decision rules that could invoke closure of fishing every two to three years were unnecessary and inappropriate. It was recollected that some time ago the Commission had indicated a desire to maintain approximately consistent levels of krill fishing and to avoid substantial interannual variations in this.

3.71 However, other members indicated that:

(i) most of the fishing, at least in some subareas, is concentrated in relatively small areas, which overlap extensively the core foraging areas of key krill-dependent predators at potentially critical times of year. Indeed, the results of the CCAMLR-2000 Survey suggested that two thirds of the krill biomass is outside the areas currently subject to fishing (SC-CAMLR-XIX, Annex 4, Appendix G);

(ii) a time when fishing levels are low might be very appropriate for developing mechanisms designed to limit the uncontrolled expansion of krill fishing;

(iii) at least in some subareas, substantial interannual variation in krill biomass is a characteristic feature which has already produced similar magnitudes of variation in catches. Furthermore, the Commission had agreed that fishing in years of low krill biomass should not be at levels likely to exacerbate the effects on dependent predators (CCAMLR-XIII, paragraphs 3.9 and 3.10);

(iv) avoiding unnecessary dislocation to the krill fishery would, hopefully, be achieved by employing adaptive management strategies, in particular by devising and implementing appropriate management frameworks at scales smaller than statistical areas and subareas; and

(v) precedents exist in fisheries management for the inclusion, either implicitly or explicitly, of 'exceptional circumstance rules', which strive to balance conservation needs against potential disruption of fishing.

3.72 WG-EMM-01/21 used data on body mass at arrival to breed and at offspring independence, and aspects of the reproductive performance of Antarctic fur seal, macaroni and gentoo penguin and black-browed albatross at Bird Island, South Georgia, together with data on population sizes for these species and data on krill demography (previously presented in WS-Area48-98/15 and WG-EMM-99/37), to provide an overview of potential changes in the South Georgia region of the Southern Ocean marine system over the last 23 years.

3.73 The paper concluded that:

(i) there has been a change from a situation with a relatively large krill supply compared to the predator demand, linked to a krill population structure that effectively buffered predators against the underlying variability in krill recruitment;

(ii) a distinct change occurred around 1990, since when the supply of krill appears to have been sufficiently close to the level of predator demand to cause the local mortality rate of krill and, consequently, the local krill population structure to be substantially altered; and

(iii) predator-induced mortality of krill has effectively removed the buffering that previously existed with a consequently significant increase in the frequency of

years when the amount of krill is insufficient to support predator demand and results in reduced predator performance and, concomitantly, declines in populations.

3.74 The Working Group welcomed review work such as in WG-EMM-01/21 and noted:

(i) that careful attention needs to be given to the methods underpinning such analyses;

(ii) the potential relevance of contemporaneous changes in oceanographic processes, for example, the relatively abrupt change in the meridional transport signal around 1990, as indicated in WG-EMM-01/57;

(iii) the possibility that krill transported to South Georgia before and after 1990 represent different, or a different balance of, source stocks;

(iv) that account may need to be taken of the apparent paradox that for predator consumption rates to influence krill population structure, the krill population must be resident around South Georgia for a considerable time, whereas to sustain the South Georgia predator population requires a consumption of krill of 8 to 10 times the instantaneous estimate of standing stock (implying a relatively rapid accumulation and/or turnover of krill); and

(v) that urgent attention needs to be given to appropriate fishery-management frameworks that can account for long-term changes in the relationship between krill and its predators.

3.75 The authors of WG-EMM-01/21 indicated that:

(i) system changes of this magnitude would involve, if not originate in, substantial changes in oceanographic conditions and processes. However it was unlikely that a switch in source krill stocks was responsible;

(ii) regardless of the underlying ultimate causal factors, the proximate effect on krill and predator populations was a real one, which supported the urgent need to develop and implement appropriate fishery-management frameworks and practices; and

(iii) current ideas on the krill population at South Georgia are that it reflects complex interactions between large-scale oceanographic transport of krill into the region, associated with the Southern Antarctic Circumpolar Current Front and its retroflexion north of the island, and local-scale processes in which krill may be retained for extended periods.

3.76 WG-EMM-01/66 represented the culmination of a modelling exercise initiated at the joint meeting of WG-Krill and WG-CEMP in Chile in 1992. Earlier developments and elements of this model were presented as WG-Krill-93/43 and 94/24 and as WG-EMM-95/39, 95/42 and 97/70. The objective of this exercise is to investigate the extent to which the

current value (75%) of the median escapement of the unexploited krill biomass, which, when incorporated into the KYM gives a value for the proportion of the biomass estimate (γ) of 0.116, is sufficient to meet the needs of predators.

3.77 The dataset used in this model is that for Antarctic fur seals at South Georgia. After an extensive review, involving several candidate species, this was the only species with data comprising a sufficiently long time series, adequate data on survival rates and reproductive performance and without significant potential biases from krill-independent effects on predator demography, to be suitable for the purpose.

3.78 The paper's conclusions were that the level of krill fishing intensity (γ) that would reduce the fur seal population to half its equilibrium size in the absence of krill fishing (γ_{half}) lies between 0.03 and 0.18, which includes the level currently recommended by CCAMLR. While this large range results primarily from the sensitivity of the model to the maximum growth rate parameter, use of plausible values for this produces estimated (γ_{half}) values of 0.04 to 0.23. Although stochastic calculations (to take account of interannual fluctuations in krill abundance due to recruitment variability) yield higher estimated (γ_{half}) values, simulation tests indicated that these values are biased upward. A potential implication of these results is that the current value of median krill escapement might be insufficient to provide a krill catch limit which is sufficiently precautionary in accounting for the needs of krill-dependent predators.

3.79 In its discussion the Working Group noted that:

(i) WG-EMM-01/66 was the result of very extensive collaborative research generated and sustained within WG-EMM. It thanked the authors for their work in investigating this approach to potential decision rules to ensure that CCAMLR's management of krill takes sufficient account of the needs of dependent species;

(ii) the approach is complementary to other initiatives in progress within the Working Group (see section 5);

(iii) in order to save simulation time, the model used an abbreviated version of the KYM rather than a version of the current GYM (which was not available at the time);

(iv) the model incorporates no feedback with respect to the effect of predator consumption;

(v) a considerable volume of data is necessary to undertake such an assessment and even in cases where this is possible, substantial uncertainties in the underlying model remain. Nevertheless, the results suggest that decision rules underpinning estimates of γ could be based on explicit objectives for predators; and

(vi) any recent new data which could improve estimates for variables considered uncertain in the paper should be incorporated into future analyses to assess further the implications of this approach for accounting for the needs of krill-dependent predators.

3.80 Taking into account the information presented in a number of papers submitted to this and previous meetings of WG-EMM, there was a recognition of an increasing body of evidence suggesting that a substantial change had occurred in aspects of the dynamics of the krill-based system, perhaps most noticeably in relation to processes operating in Subareas 48.1 and 48.3.

3.81 The ultimate origin of these changes probably reflects changes in physical environmental conditions in the Southern Ocean system, including endogenous ocean–atmosphere processes and possibly also even teleconnections with analogous process originating outside the Southern Ocean system (e.g. ENSO effects).

3.82 The proximate effects of these changes are almost certainly mainly mediated through changes in food-web processes leading to consequent changes in abundance of krill and krill-dependent species, and to changes in the dynamics of these predator–prey interactions.

3.83 The Working Group reiterated the importance of developing appropriate fishery-management frameworks that can account for long-term changes in the relationships between krill and its predators.

Other Prey Species

3.84 In respect of data relating to predator–prey interactions and processes not involving the krill-centric system, both of this year's contributions relate mainly to myctophid fish.

3.85 WG-EMM-01/58 reported the results of the analysis of 153 stomach lavage samples collected from southern elephant seals at King George Island in six years between 1994 and 2000. Overall frequency of occurrence of cephalopods and fish was 98% and 14% respectively. Within the fish element, myctophids, chiefly *Gymnoscopelus nicolsi*, represented 76.5% of items and the nototheniid *P. antarcticum* comprised 12% by numbers and 31% by frequency of occurrence. Myctophids were inferred to be taken close to the seal hauling out sites on King George Island with *P. antarcticum* taken at higher latitudes during post-breeding southward migrations.

3.86 The Working Group noted that these results were broadly consistent with studies at other sites. It noted that, after squid, myctophids are of considerable importance in the diet of southern elephant seals. Sustaining the energy requirements of this species implied that a considerable biomass of myctophids must be available.

3.87 Further support for the importance of myctophids in the Southern Ocean system was provided by WG-EMM-01/61, reporting aspects of the results of multi-frequency echosounder surveys in Subarea 48.4 in January–February 2000 (see also paragraph 3.19). Analysis of the existing samples identified as nektonic organisms indicated that 90% of samples were in the ΔMVBS (38–120 kHz) range of -5 to +2 dB, regarded as characteristic of myctophid fish.

3.88 Dr Miller noted that the myctophid species involved had not been identified (e.g. from net hauls targeted at appropriate acoustic signals) and indicated that the correct identification of net-caught specimens of myctophids remains a highly specialised task.

Methods

3.89 Prof. I. Boyd (UK) and Dr Siegel had informed WG-EMM that they were unable to continue as members of the Subgroup on Methods. It was agreed that the membership and relevant expertise of the subgroup be as follows: Dr Constable (statistics), Mr Goebel (dependent species – seals), Dr S. Kawaguchi (Japan) (krill), Dr E. Murphy (UK) (environment), Mr Reid (convener), Dr Trivelpiece (dependent species – birds).

New CEMP Standard Methods and Proposed Revisions to Existing Methods

3.90 There were no proposed new standard methods, or revisions of existing standard methods, for parameters collected as part of the CEMP program.

3.91 WG-EMM-01/20 outlined the potential for misinterpretation arising from the use of the growth rate of Antarctic fur seals following Standard Method C2.2. Assumptions of linearity of growth were not supported by the data and biases associated with cross-sectional sampling produced counter-intuitive results when compared with other indicators of environmental conditions. A new index is proposed that is not dependent on the same assumptions and has a more logical relationship in comparison with other parameters.

3.92 In the discussion of WG-EMM-01/20 the Working Group noted that the collection of data on fur seal growth rates at Cape Shirreff submitted to CEMP was not initiated 30 days after the median date of pupping and that samples were collected at two-week, rather than at 30-day intervals in accordance with Standard Method C2.2B. It was noted that the sampling regime was implemented because in some years researchers were not present at the site long enough after the first sampling to get more than just two samples if they used a 30-day interval. The Working Group felt that the decreased sampling interval was not a concern; however, it was stressed that only those data collected in accordance with the CEMP standard methods should be submitted on the CEMP dataform. Mr Goebel agreed to examine the relevant part of Standard Method C2.2 to clarify issues related to timing of sampling and selection of animals to weigh. The subgroup agreed to correspond intersessionally with a view to presenting a revised standard method at the next meeting.

Consideration of Non-CEMP Parameters

3.93 It was noted that there are no CEMP standard methods relating to indices of prey abundance. Protocols for the collection of data using analogue echosounders and integrators had been produced for the FIBEX Survey (BIOMASS, 1980) and for digital systems for the CCAMLR-2000 Survey (www.ccamlr.org). It was agreed that the sampling protocols for the CCAMLR-2000 Survey should be considered as the CEMP standard method for collection of acoustic data.

3.94 The Working Group agreed that in order to develop functional relationships between krill and dependent species it was necessary to provide information not just on standing stock but also on krill availability. This would need to be addressed through studies on vertical distribution and spatial structure that are relevant to the foraging behaviour of the dependent

species. This topic has been addressed initially at the WG-Krill Subgroup on Survey Design (1991), but improvements in technology and current ideas on predator foraging highlighted the need for further consideration of this topic.

3.95 WG-EMM-01/14 described the use of an autonomous underwater vehicle (AUV), fitted with an EK500 scientific echosounder, to assess krill avoidance of survey vessels. The acoustic determination from the AUV and from the research vessel detected the same amount of krill, indicating that no detectable avoidance of the vessel was taking place. Although these observations were made at slow speed, evidence was presented which indicated that, arising from the noise spectrum of the ship, the results would be valid at the normal speed under which acoustic surveys are conducted. The use of this platform was recognised as an exciting new development and opened a number of new possibilities for krill research.

3.96 WG-EMM-01/41 reported on the analysis of the Subarea 48.4 data from the CCAMLR-2000 Survey according to the survey protocol and also by a method as close as practical to the FIBEX protocols. During FIBEX most acoustic data were collected using analogue systems with no thresholding, high signal saturation and target classification from a visual examination of echocharts taking account of catches in targeted net hauls. The multi-frequency digital acoustic sampling and processing systems using Simrad© EK500 and SonarData© software in use during the CCAMLR-2000 Survey meant that target identification was made according to a rigorous protocol. Also the increased dynamic range of digital systems meant that bias due to thresholding and saturation was minimised. The analysis indicated that improvements in acoustic survey methodology could have a considerable influence on the biomass estimate. It has been demonstrated that application of different methods to krill species identification realised by single-frequency algorithms could cause a marked difference in krill biomass estimates. The analysis indicated that the FIBEX methodology gave a biomass figure approximately 1.8 times greater than that from using the CCAMLR-2000 Survey methodology. This result highlights the need for caution when comparing the results of historical surveys.

3.97 WG-EMM-01/16 presented a synopsis of the response to a series of questions regarding the methods used to determine the length, maturity/sex stage and colour of krill. While a number of different methods exist to measure krill length the most widely used is the measurement of total length. The subgroup considered that biases introduced by the different measurement methods currently used were unlikely to be significant. Methods used in the determination of maturity and sex were related to the types of samples collected and the level of detail required. There were considerable difficulties in the assessment of colour, using the guide in the CCAMLR *Scientific Observers Manual*.

3.98 It was recognised that the instructions for CCAMLR krill fishing observers in the *Scientific Observers Manual* required clarification, particularly in relation to the methods used to assess the status of krill. It was agreed that it was important to recognise the operational constraints on observers, in terms of facilities and time, and that the expectation of data deliverable from observers should reflect this.

3.99 WG-EMM recommended that, as a minimum requirement, data on the total length of fresh samples, be collected from 100 krill from up to three separate hauls per day. The data on krill length were agreed to be mandatory; additional information on maturity/sex stage and colour was considered as desirable, depending on available expertise and facilities. A number

of issues related to potential biases associated with access of observers to samples of krill were discussed. The importance of potential bias, both in terms of krill length and assessment of by-catch, of the restrictions imposed on observers from sampling krill directly from the factory fishpond was discussed.

3.100 Dr Kawaguchi agreed to investigate these issues further and clarify the methods in the *Scientific Observers Manual*.

Future Role of the Subgroup

3.101 WG-EMM-01/17 described the existing role of the Subgroup on Methods and outlined a proposal for how the remit of this subgroup might develop in the future. WG-EMM agreed that the subgroup should:

(i) consider new, and revisions to existing, CEMP standard methods;
(ii) advise on and review new techniques for the analysis of parameters; and
(iii) develop criteria to evaluate the methods used in the collection of non-CEMP parameters identified by WG-EMM as relevant to its work.

3.102 In respect of paragraph 3.101(iii), the Working Group requested the Subgroup on Methods to prepare intersessionally a questionnaire for the Secretariat to circulate to Members concerning the availability of non-CEMP time-series data on predator, prey and environment of particular relevance to WG-EMM, together with information on the methods used to acquire such data.

3.103 There was a recognition that, in order for the subgroup to consider some issues, there is a need to identify sources of expertise and to develop a suitable timetable for relevant experts to be included in the work of the subgroup.

Future Surveys

3.104 The Working Group considered two proposals for future surveys: aerial surveys of land-based predators at South Georgia (WG-EMM-01/24) and an acoustic survey of krill in the Ross Sea (WG-EMM-01/64).

3.105 The proposal for aerial surveys of land-based predators at South Georgia was submitted in response to a request of the Scientific Committee (SC-CAMLR-XIX, paragraphs 6.24 to 6.26). WG-EMM agreed that this proposal was an important development in improving estimates of the population size of land-based marine predators dependent on krill. The proposal was considered further under item 5.2.

3.106 WG-EMM was pleased to note further development of the proposal for an acoustic survey of krill in the Ross Sea in 2002. Last year WG-EMM had requested that plans for the survey be brought forward for approval at the 2001 meeting for a standardised survey design in the Ross Sea (SC-CAMLR-XIX, Annex 4, paragraphs 2.77 and 2.78). Unfortunately, WG-EMM-01/64 contained only an abstract, and the detailed paper was not available at the meeting. WG-EMM was unable to evaluate the survey design.

3.107 Correspondence with Dr M. Azzali (Italy) during the meeting indicated that the survey would be postponed one year. Dr Azzali had advised that details of the survey would be presented at the next meeting of WG-EMM.

Key Points for Consideration by the Scientific Committee

3.108 A specially convened workshop to prepare and publish a set of papers describing the pelagic ecosystem of the Scotia Sea, arising from analysis of data collected during the CCAMLR-2000 Survey, had made good progress (paragraphs 3.9 to 3.12).

3.109 Collaboration with the IWC for the CCAMLR-2000 Survey had been productive and had extended the scope of the survey. WG-EMM encouraged further collaboration between scientists from CCAMLR and the IWC (paragraph 3.11).

3.110 A productive workshop had been held in June 2001 for the analysis of data from surveys conducted by the International Coordination Subgroup in 2000 in conjunction with the CCAMLR-2000 Survey; the future work plan of the subgroup was endorsed (paragraph 3.13).

3.111 Based on data collected on predators and environment as part of CEMP and submitted to the CCAMLR database (paragraph 3.7), and on standard annual surveys for krill in Subareas 48.1 and 48.3 (paragraphs 3.16 and 3.17), 2000/01 had been an average year in comparison with the time series of data available to WG-EMM.

3.112 Based on krill spawning surveys conducted in Subarea 48.1 in 2000/01 it was predicted that recruitment in 2002/03 (from spawning in 2000/01) would be high (paragraph 3.30).

3.113 There was increasing potential use to WG-EMM of satellite-derived environmental data (paragraph 3.57).

3.114 The Working Group recommended that, until evidence of the effects of disease at levels potentially relevant to population trends and performance became available, further submissions on this topic would be more appropriately directed to the Committee for Environmental Protection of the ATCM (paragraph 3.49).

3.115 In respect of the development of further approaches to ecosystem assessment and management, the Working Group recognised that it needed to set aside more time for detailed evaluation of relevant approaches and analyses (paragraphs 3.62, 3.74(v) and 3.83).

3.116 There were increasing indications, based on reviews and analyses of scientific data, that a substantial change may have occurred over the last 20 years in aspects of the dynamics of the krill-based system in Area 48 (paragraphs 3.80 to 3.82). The basis and implications of this need further investigation.

3.117 The WG-EMM Subgroup on Methods was reconstituted with the terms of reference as set out in paragraph 3.101.

STATUS OF MANAGEMENT ADVICE

Small-scale Management Units

4.1 In response to a request from the Scientific Committee (SC-CAMLR-XIX, paragraph 5.15), WG-EMM considered methods for the subdivision of the krill potential yield into small-scale management units. The primary aims are to avoid concentrating fishing effort in small but critical areas and also to consider the level at which appropriate 'trigger levels' might be set.

4.2 Conservation Measure 32/XIX states that when the total catch within Area 48 exceeds 620 000 tonnes, precautionary catch limits appropriate to small-scale management units would be applied. The Working Group agreed that it would be prudent to consider as many options as possible to achieve this so that when the 620 000 tonne threshold is reached, there can be a smooth transition to a more closely defined management regime.

4.3 The Working Group examined two papers discussing methods to subdivide CCAMLR areas into small-scale management units. The first paper (WG-EMM-01/29) was originally submitted to WG-Krill in 1992 and published in *SC-CAMLR Selected Scientific Papers* (Watters and Hewitt, 1992). It discussed trade-offs between different approaches of subdivision. The favoured approach in that paper was to consider providing protection to critical zones and/or critical periods. This may require adjustment of current fishing patterns.

4.4 WG-EMM-01/52 examined the issue of small-scale management units in principle. It defined two types of management units: 'harvesting units' which are defined as areas in which the CCAMLR objectives will need to be achieved, and 'predator units' which are potentially smaller-scale units within harvesting units that are used to subdivide the catch (in space and/or time) and will help (i) to reduce the potential for undesirable local effects on predators; and (ii) to ensure undesirable effects do not arise.

4.5 A conceptual model for the South Atlantic illustrates how predator units can be used to subdivide the catch limit in the harvesting unit (Area 48). As well, these units can be used to provide strategic advice on the potential effects of fishing as intended through CEMP. The paper suggests that these units should be established in the early phases of a fishery, integrating knowledge of local populations of harvested species, predator foraging density (number of predators, location and foraging areas) and fishing grounds. Predator units do not have to be self-contained ecosystems but should be sufficiently self-contained such that fishing in that unit does not inadvertently affect predators being monitored in other units.

4.6 Analyses of predator foraging areas around South Georgia (WG-EMM-01/19, 01/22 and 01/26) and around the Antarctic Peninsula (WG-EMM-01/32) suggest that a subdivision following the approach set out in paragraph 4.4 is tractable.

4.7 A number of papers on the South Georgia system suggest that spatial differences in the requirements of krill by predators and how this relates to the productivity and flux of krill in foraging areas need to be accounted for in subdividing the overall catch limit for krill in Area 48. These papers included WG-EMM-01/18, 01/21, 01/27 and 01/53.

4.8 The Working Group welcomed the approach described in WG-EMM-01/52 and noted that it provided a potential framework for integrating fishery, predator and prey information,

developing earlier approaches when fewer data were available (WG-EMM-01/29). The Working Group noted that further elaboration of small-scale management units, such as predator units, may need to include details of the behaviour of fisheries, environmental factors, such as interannual variation in the location of gyres and ice, and seasonal (summer–winter) variation in predator foraging areas. As discussed in WG-EMM-01/52, the Working Group recognised that not all predators could be monitored or assessed for the designation of these units. Dr Constable indicated that, as these units do not have to be ecosystem units but are simply units to help management, then many of these issues of large-scale variation could probably be overcome.

4.9 Dr M. Naganobu (Japan) expressed doubt about the need for such subdivisions and that the objectives of the subdivision need to be determined before this work continues.

4.10 In response to the request of the Scientific Committee (SC-CAMLR-XIX, paragraphs 5.14 and 5.15) and the Commission (CCAMLR-XIX, paragraph 10.11), the Working Group agreed to use WG-EMM-01/52 as a guide for further work next year to develop small-scale management units, such as predator units. The program of work for next year is discussed in paragraphs 5.9 to 5.12. It noted that WG-EMM-01/52 included discussion of subdividing the krill catch limit between these units as well as providing other opportunities for the Commission to help achieve the objectives of CCAMLR, such as in the field evaluation of CEMP. The Working Group agreed that the priority at present is to subdivide the catch between units.

4.11 The Working Group noted that the use of the approach by Everson and de la Mare (1996) may help subdivide the catch limit into smaller areas. This method uses estimates of abundance of predators and their consumption requirements. In part, these calculations ensure that uncertainty in estimates of natural mortality of krill is accounted for in the calculations because the same estimate of M used to determine γ is used in these calculations. The Working Group noted that other methods may be available and invited contributions on determining local catch limits in these smaller areas.

4.12 With respect to harvesting units, the Working Group agreed that there is a need to further subdivide some of the large statistical subareas for management purposes. The history of the subdivision of the Southern Ocean into statistical units began with the paper by Everson (1977). When originally designated, the northern boundary for Areas 48, 58 and 88 was 60°S, in line with the northern limit of the Antarctic Treaty zone. Arising from the development of commercial fishing for krill and finfish in the Southern Ocean it was recognised that the Antarctic Polar Frontal Zone was a better ecological descriptor of the Southern Ocean and the northern limit was revised to take account of this (Everson, 1977). The main fishing grounds in the Southern Ocean at that time were known to be associated with the shelf and shelf break. Subarea boundaries were designated by Everson (1977) to delineate these main fishing locations. Since that time, a number of revisions have been made to include finer-scale delimitation of fishing areas based primarily on ecological grounds. The most recent division has been that concerned with SSRUs in exploratory toothfish fisheries (Conservation Measure 200/XIX).

4.13 With respect to harvesting units, WG-EMM-01/52 proposed that a number of CCAMLR statistical areas could be divided on ecological grounds to complete the division of the Convention Area into manageable harvesting units, including Subareas 48.6, 88.1 and 88.2 and Division 58.4.2.

4.14 The Working Group noted that further subdivision would make large-scale krill surveys of these areas, such as Subarea 48.6, more tractable. It agreed that further consideration of subdividing the statistical areas as outlined in WG-EMM-01/52 required a paper to be submitted to the Scientific Committee detailing the ecological justification of such divisions. The authors of WG-EMM-01/52 agreed to provide a more detailed paper to the Scientific Committee this year. The Working Group requested that the authors consider developing a framework that is consistent with the framework adopted in Conservation Measure 200/XIX and asked that suggestions by some members of the Working Group for greater subdivision than proposed in WG-EMM-01/52 be considered.

4.15 Some members noted that it may not be possible to determine appropriate subdivision of statistical areas at this stage. This is because of the difficulty in matching ecological features and statistical units.

Draft Fishery Plan

4.16 WG-EMM noted the Scientific Committee's progress in developing a unified regulatory framework for CCAMLR fisheries (SC-CAMLR-XIX, paragraphs 7.2 to 7.19). At the request of the Scientific Committee (SC-CAMLR-XIX, paragraph 7.20), WG-EMM considered a Fishery Plan for the krill fishery which had been drafted by the Secretariat (WG-EMM-01/7).

4.17 WG-EMM agreed that the draft Fishery Plan was an excellent beginning to the documentation of the development and implementation of management measures in the krill fishery and other fisheries. The plan provided a suitable vehicle for tracking such measures, as well as references to relevant documents and information. The Working Group envisaged that such information would be updated each year.

4.18 WG-EMM noted that the Fishery Plan documented the status of a fishery and was not specifically intended to forecast what may happen to that fishery.

4.19 WG-EMM recognised that, once developed, Fishery Plans may highlight differences in management measures between CCAMLR fisheries. Where this occurred, the rationale for such differences would also need to be documented, or at least referenced to relevant paragraphs of the Scientific Committee or Commission reports.

4.20 WG-EMM recognised the need for consistency in the headings of the plan and that not all of the categories in the plan would be applicable to all fisheries. The Working Group suggested a number of changes to the draft Fishery Plan; these were incorporated in the revised plan given in Appendix D.

4.21 The changes were as follows:

(i) the mandatory data reporting requirements were placed in Section 2;

(ii) the section dealing with requirements for CCAMLR scientific observations was moved out of Section 2 'Data Reporting Requirements' into a new section;

(iii) the heading 'Notification Received by CCAMLR' was moved from Section 6 'Data Reported to CCAMLR' to Section 3 'Notification Requirements'; and

(iv) the types of data reported to the CCAMLR database were summarised in Section 6.

4.22 In further discussion WG-EMM agreed that the concept of the Fishery Plan may be extended, in the long term, to document the management of non-target species. For example, a 'predator summary' could document management measures and data and research requirements for land-based predators.

Designation of Protected Areas

CEMP Site Maps

4.23 The Working Group reviewed CEMP site maps submitted so far to the Secretariat.

4.24 There were still outstanding maps for CEMP sites. These maps should be submitted to the Secretariat as soon as possible. Members are reminded that those maps which are prepared in colour should be readable when reproduced in black and white.

4.25 Last year maps were received from Australia, Japan, New Zealand, Norway and the UK. Maps from New Zealand, Norway and the UK all met the criteria for CEMP site maps. The map provided by Australia was fine when viewed in colour on the website, but found to be difficult to read when printed in black and white. The map from Japan needed minor technical improvements.

4.26 This year, improved maps from Australia and Japan were received and met the criteria. Maps from South Africa and Chile were also submitted for evaluation.

4.27 The Working Group considered that the maps from South Africa met the criteria but suggested changes be made to address possible confusion over shading. The maps from Chile met the criteria; however, since colour was used, the legend is difficult to follow in black and white print. The Working Group commented that titles should be included on maps rather than just included in the accompanying text.

4.28 It was also clarified that where CEMP colonies have moved to another location, merged or split, the principal CEMP researchers should inform the Secretariat so changes can be adequately recorded and tracked in the CEMP database. The Working Group felt that it was not necessary to record these changes on the CEMP site maps unless the colony had moved outside the existing CEMP site.

ATCM Proposals

4.29 The Working Group noted that the Commission had considered the advice of the Scientific Committee regarding the consideration of management plans forwarded by the ATCM (SC-CAMLR-XIX, paragraphs 11.20 to 11.26; CCAMLR-XIX, paragraphs 11.20

and 11.21). It noted a request by the Commission to the Scientific Committee (CCAMLR-XIX, paragraphs 11.20 and 11.21) to develop scientific advice regarding proposals from the ATCM for marine protected areas on steps to be taken to determine:

(i) whether a site proposed for designation as a marine protected area affects actual or potential harvesting of marine resources in relation to Article II of the Convention; and

(ii) whether the draft management plan for the proposed site might prevent or restrict CCAMLR-related activities.

4.30 In order to answer the two questions posed by the Commission (CCAMLR-XIX, paragraph 11.20), and taking into account the agreement of the Scientific Committee on the types of information useful for assessing these proposals (SC-CAMLR-XIX, paragraphs 11.21 and 11.22), the Working Group reviewed the information requirements and general procedure. Following receipt of a proposal by the Commission, the proposal should be assessed by both WG-EMM and WG-FSA with respect to scientific consideration of whether the proposal affects actual or potential harvesting of marine resources or prevents or restricts CCAMLR-related activities (CCAMLR-XIX, paragraph 11.20). WG-EMM would value having the Commission identify any additional questions it has regarding a specific proposal.

4.31 Not all proposals will require the same information. The future assessment of the two questions from the Commission should include an assessment of available information relevant to CCAMLR and its objectives, such as those listed in paragraphs 11.21 and 11.22 of SC-CAMLR-XIX.

4.32 The Working Group agreed that further development of the general procedure is difficult at this stage until a specific proposal is presented. Given the discussion at SC-CAMLR-XIX, the Working Group requested that the Scientific Committee consider whether any further work is required on this matter. In particular, the Working Group asked for advice on whether the values of a proposal need to be assessed with respect to the two questions posed by the Commission.

CCAMLR Article IX.2(g)

4.33 The Commission also requested the Scientific Committee to provide advice on the application of the provisions in Article IX.2(g) of the Convention, 'the designation of the opening and closing of areas, regions or subregions for purposes of scientific study or conservation, including special areas for protection and scientific study' (CCAMLR-XIX, paragraph 11.21).

4.34 With regard to advice on the application of the provisions in Article IX.2(g) of the Convention, the Working Group noted the global interest in the use of marine protected areas (WG-EMM-01/31) and that a major review would be published in the journal *Ecological Applications* later this year. The Working Group requested that this volume be available to participants for review at the next meeting of WG-EMM. The Working Group noted that consideration of Article IX.2(g) could be included in discussions of management options for

fisheries. The Working Group agreed that such consideration will require the development of a framework for assessing the value of different management options in terms of achieving the objectives of the Convention.

4.35 The Working Group wished to convey its thanks to the Subgroup on the Designation and Protection of CEMP Sites for its work, to Dr Wilson for acting as interim coordinator and to Dr Sabourenkov for his valuable contribution.

Generalised Yield Model

4.36 A number of papers on the South Georgia system indicate that some parameters in the krill yield calculations may need to be revised, including growth and natural mortality (WG-EMM-01/18, 01/21, 01/27 and 01/53). The Working Group noted that work over the last 10 years has indicated that the growth rates estimated in the 1980s and used in the krill yield calculations may need updating (see Siegel and Nicol, 2000). There were different opinions expressed about interpretation of changes in the size structure in the krill stock (paragraph 3.26). Therefore, the Working Group requested that work be undertaken intersessionally to analyse available information to provide new estimates of growth and natural mortality for use in estimating krill yield.

4.37 The Working Group welcomed the work of the Secretariat on a web-based description of the history of the KYM and GYM (WG-EMM-01/8). It looked forward to the further documentation of this information as requested by the Scientific Committee last year (SC-CAMLR-XIX, paragraph 5.17). This is discussed further in paragraph 7.1.

4.38 With respect to the coordination between WG-FSA and WG-EMM of the development of the GYM, the Working Group requested that the coordination proposed by the Scientific Committee last year (SC-CAMLR-XIX, paragraph 5.18) be undertaken as soon as possible. Members were requested to communicate with Dr Constable as to their involvement in the coordinated development of the GYM and testing to be carried out on the GYM in future (SC-CAMLR-XIX, Annex 4, paragraph 2.110). In addition, the Working Group encouraged members to become familiar with the GYM and how it is used in assessments.

4.39 The Working Group reiterated its request to undertake intersessionally the following work highlighted last year:

(i) to develop a proforma format for the submission and archiving of any tests of the GYM (SC-CAMLR-XIX, Annex 4, paragraph 2.97);

(ii) to revise the time series of recruitment information for inclusion in the GYM (SC-CAMLR-XIX, Annex 4, paragraph 2.98) and to include new information arising from recent surveys (WG-EMM-01/10); and

(iii) to assess the sensitivity of the estimation of γ to the nominated time of the CCAMLR-2000 Survey (SC-CAMLR-XIX, Annex 4, paragraph 2.107).

Conservation Measures

4.40 WG-EMM reviewed Conservation Measures 32/XIX, 45/XIV and 106/XIX which are in force for krill fisheries in Area 48, Division 58.4.2 and Division 58.4.1 respectively. Conservation measures detailing CCAMLR's catch and effort reporting system (40/X, 51/XIX and 61/XII) and fine-scale data requirements (121/XIX and 122/XIX) were also considered. The Working Group noted for comparison the data requirements specified in a typical conservation measure (194/XIX) for a finfish fishery in the Convention Area.

4.41 The data reporting requirement for krill fisheries, as agreed by the Commission, is that catches shall be reported to the Commission on a monthly basis (e.g. Conservation Measure 32/XIX, paragraph 5). WG-EMM noted that this requirement was open to interpretation because it was not linked to a specific set of requirements, such as those of the catch and effort reporting system (see Appendix D, Section 2). As a result, Contracting Parties had submitted various types of data at varying levels of spatial and temporal resolution (see Appendix D, Section 6).

4.42 All Contracting Parties reported catches of krill at monthly intervals to the Secretariat, and these reports were used to monitor the fishery, and also to forecast, if needed, the closure date for the season. This reporting practice followed the principle set out in Conservation Measure 40/X. Most Contracting Parties also reported data at a finer level of resolution, such as catch by 10-day period and 10 x 10 n mile rectangles.

4.43 Some Contracting Parties report effort; however, these data are neither consistent between parties nor complete.

4.44 WG-EMM advised the Scientific Committee that future work identified during the workshop (section 5) would require detailed catch and effort data from the krill fisheries. This future work would include investigating the behaviour of fishing fleets, characterising predator units and developing indices of abundance based on catch per unit effort. Ideally, data would need to be submitted at the finest scale practicable, and in a consistent format across all fleets. Guidelines set out in Conservation Measure 122/XIX, for example, would suit WG-EMM's requirement for catch and effort data.

4.45 Dr Naganobu advised that Japan's annual submission to CCAMLR of aggregated catch data from the krill fishery was difficult under current domestic rule.

4.46 WG-EMM thanked all parties who had submitted data to the CCAMLR database and at the Working Group meetings. This information had allowed WG-EMM to reach its present understanding of the krill fishery, and develop objectives for future work. WG-EMM continued to encourage all Member countries involved in krill fisheries to submit to the Working Group, and/or bring with them to future meetings and workshops, detailed data and information on krill fisheries.

4.47 Two other elements of the conservation measures in force were considered in relation to the krill fisheries: (i) catch limits in Subareas 48.5 and 48.6; and (ii) the timely provision of data for managing a fishery when catches approached a trigger level or catch limit.

4.48 WG-EMM noted that the Commission had set a catch limit of 4.0 million tonnes of krill in Area 48 (Conservation Measure 32/XIX). Further, this catch limit had been

subdivided into catch limits for Subareas 48.1, 48.2, 48.3 and 48.4 (i.e. the region of the CCAMLR-2000 Survey), and the sum of the catch limits in these four subareas equalled 4.0 million tonnes. To assist in future work, the Working Group sought clarification from the Scientific Committee on the catch limits for krill in Subareas 48.5 and 48.6.

4.49 Some Members of the Working Group noted that the catch limit of 4.0 million tonnes of krill in Area 48 was estimated based on the result of the CCAMLR-2000 Survey which was carried out only in four subareas but not in Subareas 48.5 and 48.6, and reiterated the recommendation for a future krill biomass survey in these subareas (SC-CAMLR-XIX, paragraph 5.28).

4.50 WG-EMM also noted that the agreed regression method for forecasting the closure date of the fishery was based on the last three reporting periods for which all catch data had been submitted. Given that the catch data are reported at monthly intervals in the krill fisheries, a revision of the closure date would require catch data collected over a period of three months. This lengthy period could result in a high risk of overshooting the catch limit. WG-EMM noted that the regression method is regularly applied by the Secretariat to the toothfish and icefish fisheries in Subarea 48.3 where catch and effort reports were submitted every five days in accordance with Conservation Measure 51/XIX.

4.51 The Working Group requested the Secretariat to review the mechanisms that could be used for managing the krill fishery based on reports from the fishery.

4.52 The Working Group noted that the fishing season in Division 58.4.2 (Conservation Measure 45/XIV) is not in accordance with fishing seasons adopted by the Commission in Area 48 and Division 58.4.1.

Key Points for Consideration by the Scientific Committee

Small-scale Management Units

4.53 In response to the request of the Scientific Committee (SC-CAMLR-XIX, paragraphs 5.14 and 5.15) and the Commission (CCAMLR-XIX, paragraph 10.11), the Working Group agreed to use WG-EMM-01/52 as a guide for further work next year to develop small-scale management units, such as 'predator' units (paragraph 4.10). The program of work for next year is discussed in paragraphs 5.9 to 5.12. The Working Group envisaged that a method to divide the precautionary catch limit between such units will be developed in the following year (paragraph 4.11).

4.54 The Working Group noted that a number of CCAMLR statistical areas including Subareas 48.6, 88.1 and 88.2 and Division 58.4.2 could be divided on ecological grounds to complete the division of the Convention Area into manageable harvesting units (paragraph 4.13). The Working Group noted that such subdivision would make large-scale krill surveys of these areas, such as Subarea 48.6, more tractable. The Working Group requested that a paper should be submitted to the Scientific Committee this year by the authors of WG-EMM-01/52 detailing the ecological justification of such divisions, and considering how such subdivisions could be made consistent with the framework adopted in Conservation Measure 200/XIX (paragraph 4.14).

Draft Fishery Plan

4.55 WG-EMM agreed that the draft Fishery Plan was an excellent beginning to the documentation of the development and implementation of management measures in the krill fishery and other fisheries. The plan provides a suitable vehicle for tracking such measures and the references to relevant documents and information. Such information would be updated each year (paragraph 4.17).

4.56 WG-EMM noted that the Fishery Plan documents the status of a fishery, and is not specifically intended to forecast what may happen to that fishery in future years (paragraph 4.18).

4.57 WG-EMM recognised the need for consistency in the headings of the plan, and that not all of the categories in the plan would be applicable to all fisheries. The Working Group suggested a number of changes to the Draft Fishery plan and these are illustrated in Appendix D (paragraph 4.20).

Designation of Protected Areas

4.58 Regarding ATCM proposals, WG-EMM identified a procedure for considering those proposals and would value having the Commission identify additional questions it has regarding a specific proposal (paragraph 4.30).

4.59 The Working Group agreed that further development of the general procedure is difficult at this stage until a specific proposal is presented. Given the discussion at SC-CAMLR-XIX, the Working Group requested that the Scientific Committee consider whether any further work is required on this matter. In particular, the Working Group asked for advice on whether the values of a proposal need to be assessed with respect to the two questions posed by the Commission (paragraphs 4.29 and 4.32).

4.60 With regard to advice on the application of the provisions in Article IX.2(g) of the Convention, the Working Group noted the global interest in the use of marine protected areas (WG-EMM-01/31) and that a major review would be published in the journal *Ecological Applications* later this year. The Working Group noted that consideration of Article IX.2(g) could be included in discussions of management options for fisheries and would require the development of a framework for assessing the value of different management options in terms of achieving the objectives of the Convention (paragraphs 4.33 and 4.34).

Existing Conservation Measures

4.61 WG-EMM advised the Scientific Committee that future work identified during the workshop (section 5) would require detailed catch and effort data from the krill fisheries. This future work would include investigating the behaviour of fishing fleets, characterising predator units and developing indices of abundance based on catch per unit effort. Ideally, data would need to be submitted at the finest scale practicable, and in a consistent format across all fleets. Guidelines set out in Conservation Measure 122/XIX, for example, would suit WG-EMM's requirement for catch and effort data (paragraph 4.44).

4.62 Given the discussion in paragraphs 4.48 and 4.49, WG-EMM requested clarification to assist in its future work on the catch limits for krill in Subareas 48.5 and 48.6.

4.63 WG-EMM also noted that the current method for forecasting the closure date of fisheries would, if applied to the krill fishery, be based on catch data collected over a period of three months. This lengthy period could result in a high risk of overshooting the catch limit (paragraph 4.50).

4.64 The Working Group requested the Secretariat to review the mechanisms that could be used for managing the krill fishery based on reports from the fishery (paragraph 4.51).

4.65 The Working Group noted that the fishing season in Division 58.4.2 (Conservation Measure 45/XIV) is not in accordance with fishing seasons adopted by the Commission in Area 48 and Division 58.4.1 (paragraph 4.52).

WORKSHOP ON FUTURE AGENDA OF WG-EMM

5.1 Following its agreement last year (SC-CAMLR-XIX, Annex 4, paragraphs 4.127, 4.128 and 7.14), WG-EMM held a two-day workshop during the current meeting. This workshop focused attention on reviewing monitoring data and identifying new monitoring requirements and approaches for analysing/integrating information relevant to WG-EMM's work.

5.2 Three invited presentations provided the workshop with information and ideas for discussion. All the presentations focused on the krill-centred component of the Antarctic marine ecosystem.

5.3 The first presentation by Dr Miller reviewed early discussions within, and agreements reached by, CCAMLR concerning the development of an ecosystem approach to management of the krill fishery. Developments during the period 1984 to 1995 were considered and key CCAMLR actions were highlighted. These included the introduction of CEMP and the work undertaken by WG-CEMP, WG-Krill and WG-DAC. Attempts to interpret the Convention's language (particularly Article II) in operational and scientific terms were emphasised.

5.4 The second presentation by Dr Everson also outlined the requirements attached to implementing an ecosystem approach to the management of Southern Ocean resources. The need for information on the fishery and on harvested and dependent species, as well as various interactions between these components was highlighted. CCAMLR's approaches to obtain such information were discussed and a mechanism to bring the various components together as an ecosystem approach to management was suggested.

5.5 The final presentation by Dr Constable outlined the major issues relevant to WG-EMM's work which required additional attention or focus, particularly in relation to the development of procedures for managing the krill fishery using an ecosystem approach. Twelve subject areas were identified and these were divided into topics of a more 'theoretical' nature and those with 'practical' implications as follows:

Theory	Practical
1. Harvested species–environment models	7. Evaluation of candidate management procedures
2. Predator–prey–environment models	8. Utility of CEMP
3. Fishery–prey–environment models	9. Small-scale management units, such as predator units
4. Objectives, decision rules	10. Predator demand
5. Performance measures	11. Ecological division of precautionary catch limit
6. Assessment methods	12. Field test CEMP, precautionary catch limit

These topics were used as a basis for discussing the major issues to be addressed by future WG-EMM workshops in the short to medium term.

5.6 In thanking the three presenters, WG-EMM encouraged them to submit their manuscripts to *CCAMLR Science*. It was felt that the three presentations provided a useful record of where ecosystem management in CCAMLR had come from, the direction it had assumed and where it was likely to go in the future.

Prioritised Topics for Future WG-EMM Workshops and Symposia

5.7 In considering topics for future workshops and symposia, WG-EMM agreed that taking into account the twelve topics set out in paragraph 5.5, the following four topics require priority development to further the work of the group:

- identification of small-scale management units, such as predator units;
- utility of CEMP;
- predator–krill–environment models; and
- fishery–krill–environment models.

5.8 It was recognised that the activities necessary to address these topics may be able to run in parallel. However, it was agreed that their development is likely to be iterative which could involve a stepwise approach. Predator units and the utility of CEMP were afforded top priority for workshops in 2002 and 2003. Dr Constable was tasked with convening an intersessional correspondence group to consider the latter two items above to ensure that the development of the necessary models is carried forward. Key issues:

- status of existing models including data requirements;
- variety of modelling approaches being undertaken; and
- modelling approaches which may be useful in management.

Identification of Small-scale Management Units

5.9 It was recognised that the Scientific Committee (SC-CAMLR-XIX, Annex 4, paragraphs 5.14 and 5.15) and Commission (CCAMLR-XIX, paragraph 10.11) had clearly indicated that, as a matter of priority, WG-EMM should provide guidelines for approaches to divide the krill potential yield in all areas as a precautionary measure to avoid concentrating fishing effort in small but critical areas, and to consider the level at which appropriate 'trigger levels' might be set. The identification of appropriate management units to take account of such considerations therefore is a key area for WG-EMM to address.

5.10 WG-EMM-01/52 discussed the principles required for the development of small-scale management units for the krill fishery, which involves the integration of local krill populations, foraging areas of related predators, fishing ground information and potential influences of the environment (see also paragraphs 4.4 and 4.5).

5.11 WG-EMM agreed that to take account of the types of ideas highlighted by WG-EMM-01/52 and the concerns of the Scientific Committee, it would be appropriate to include a workshop on small-scale management units in the agenda of the Working Group's next meeting. The following key aspects would serve as the terms of reference for such a workshop:

(i) Purpose:
The workshop would collate and compare information on:

(a) fishing fleet behaviour and patterns of fishing;
(b) predator foraging ranges (especially of land-based predators); and
(c) krill abundance and distribution.

Information on the environmental influences affecting (a) to (c) would also be collated. Results from analyses of the information will then be used to determine appropriate boundaries for small-scale management units, such as predator units. The practical steps and considerations attached to implementing such units were identified as a task to be held over until 2003.

(ii) Data Required:
Data on the information requirements outlined in (i) above will be required and WG-EMM made a general call for such data to be provided in good time and in an appropriate format for the workshop to consider. The Data Manager was tasked with coordinating and standardising the data received prior to the workshop.

(iii) Additional Facilities and Resources:
The need for appropriate computer hardware and software to be available at the workshop was recognised. It was also noted that data should be collated into a standardised format (see (ii) above).

(iv) Duration and Format:
Collation of necessary information – two to three days.
Consideration of suitable unit boundaries – one day.
Total duration – four days.

(v) Participants:
Participants with experience in Geographical Information Systems (GIS) and spatial analysis techniques were encouraged to attend the workshop.

(vi) Product:
Demarcated small-scale management units, such as predator units, for consideration at a subsequent workshop in 2003.

5.12 WG-EMM agreed that a steering committee convened by Dr Trivelpiece, and comprising Drs Constable, Hewitt, Kawaguchi, V. Sushin (Russia) and P. Trathan (UK) should operate intersessionally to guide the workshop. The CCAMLR Data Manager would serve on this group to ensure coordination and data standardisation.

5.13 WG-EMM agreed that data presented to the workshop would be considered the 'best available' at the time. The Scientific Committee would be informed of the workshop results at its 2002 meeting.

Review of the Utility of CEMP

5.14 CEMP was established in 1985 to:

(i) detect and record significant changes in critical components of the ecosystem to serve as a basis for the conservation of Antarctic marine living resources; and

(ii) distinguish between changes due to the harvesting of commercial species and changes due to environmental variability, both physical and biological.

5.15 CEMP uses indices derived from data on indicator species and the environment collected by standard methods within the three Integrated Study Regions of the CCAMLR Convention Area and at network sites outside these regions. The indicator species chosen were those which were believed to have the greatest potential for detecting responses to changes in harvested resources (to date specifically krill), or were the subject of a commercial harvest (to date only krill has been considered in this context). At present, the environmental data consist of regional sea-ice distribution and SST.

5.16 The Working Group agreed to consider whether:

(i) the nature and use of the existing CEMP data continued to be appropriate for addressing the original objectives;

(ii) these objectives remain appropriate and/or sufficient; and

(iii) additional data were available which should be incorporated into CEMP or be used in conjunction with CEMP data.

5.17 In addition, the Working Group particularly wished to consider whether useful management advice could be derived from CEMP (and/or CEMP-related) data and, if so, how best to do this.

5.18 The Working Group recognised that a review under the above terms of reference would, in due course, also address most of the key questions posed at last year's meeting of WG-EMM (e.g. SC-CAMLR-XIX, Annex 4, paragraphs 4.14, 4.23, 4.29, 4.41 and 4.62) and that it would be essential to identify which of these questions are important to the development of management procedures.

5.19 It also noted that the outlined work plan in respect of further development of CSIs (SC-CAMLR-XIX, Annex 4, paragraph 3.51) might have relevance to work that would develop within, or arise from, any review of CEMP.

5.20 It was recognised that there would be a need, as part of the overall review process, to develop and link appropriate statistical and ecological models. This would require the involvement of scientists with relevant experience. Expertise of particular importance would include time-series analysis, demographic analysis and modelling and development of assessment frameworks, as well as practical and theoretical experience of research on environment–prey–predator interactions.

5.21 The Working Group agreed that in order to prepare for a workshop whose tasks should include detailed analysis of appropriate data and which could be held in conjunction with the WG-EMM meeting in 2003, a preliminary session should be held at the 2002 meeting of WG-EMM to address the terms of reference and to make detailed plans for such a workshop.

5.22 In order for this session, envisaged to last not more than two days, to be successful, it was essential for appropriate documentation and other relevant materials to be available for the 2002 meeting of WG-EMM.

5.23 Members were invited to submit appropriate reviews, papers and other materials which would assist in addressing the draft terms of reference (paragraphs 5.15 and 5.16) and the key questions developed last year (see paragraphs 5.17 and 5.18) in advance of the next meeting of WG-EMM.

5.24 It was noted that the report of the Area 48 Workshop (SC-CAMLR-XVII, Annex 4, Appendix D) provided considerable relevant background information and, in some cases, examples of appropriate analyses and models. Members with similar data from other parts of the Convention Area were encouraged to provide WG-EMM with the results of similar analyses and investigations.

5.25 Dr Nicol indicated that analysis of CEMP data collected by Australia, principally at Béchervaise Island, would be undertaken intersessionally and the results made available to the next meeting of WG-EMM.

5.26 The Working Group agreed that a correspondence group convened by Prof. Croxall and comprising Mr Goebel, Drs Miller, Naganobu and Nicol and Mr Reid should be established to act as an interim steering committee both for the pre-workshop session in 2002 and to initiate planning for the workshop in 2003. The CCAMLR Data Manager would also serve on this group.

5.27 Dr Sushin indicated that in his view, any future review of CEMP should consider whether predator indices could be used to identify reference points to be applied in the ongoing evaluation of predator performance. Suitable predator reference points also need to be identified.

5.28 WG-EMM agreed that the identification of suitable reference points is an important consideration attached to many indices likely to be used in ecosystem management by CCAMLR. In this respect, the median krill escapement of 75% of its unexploited biomass to

meet the needs of predators used in the GYM provides a reference point with regard to protecting predators. WG-EMM recognised that further implications of reference points for Antarctic fur seals were demonstrated in WG-EMM-01/66 (see also paragraphs 3.76 to 3.78). Acknowledgement was also given to the important role that reference points play in efforts to restore depleted populations to levels consistent with those described in Article II.

5.29 WG-EMM made a general call for submission on 'reference' points to be used in ecosystem management. These will be revised after the review of CEMP's utility.

Survey of Land-based Marine Predators

5.30 The Scientific Committee had requested WG-EMM to review SC-CAMLR-XIX/6 and develop terms of reference for a workshop in 2002 on the feasibility of a synoptic survey, survey methodologies and the need for estimating the circum-Antarctic abundances of land-based predators.

5.31 To facilitate the above work, WG-EMM tasked Dr C. Southwall (Australia) with coordinating a group (comprising Mr Goebel and Drs Trathan, Trivelpiece and Wilson) to consider how marine predator surveys could be undertaken. This group would advise on to what extent surveys of land-based predators are feasible and the priorities for the techniques to be used. It was agreed that if the correspondence group considered that such a workshop was necessary by 1 May 2002, then a one- to two-day workshop could be scheduled in combination with WG-EMM's 2002 meeting.

Key Points for Consideration by the Scientific Committee

5.32 The Working Group has developed a timetable for its future work on major issues (paragraph 5.5) and prioritised topics (paragraph 5.7), including subjects for future WG-EMM workshops and symposia (see also paragraph 6.3).

5.33 The first three topics to be addressed are:

(i) further development of prey–predator–fishery–environmental models for ecosystem management through an intersessional correspondence group (paragraph 5.8);

(ii) define small-scale management units, such as predator units, through a workshop at WG-EMM's meeting in 2002, organised by an intersessional correspondence group (paragraphs 5.11 and 5.12); and

(iii) a review of the utility of CEMP (paragraph 5.16), coordinated by an interim steering committee arranging a preliminary workshop on the matter at the WG-EMM meeting in 2002 and undertaking detailed planning for a second workshop in 2003 (paragraphs 5.21 and 5.26).

5.34 The data considered at the small-scale management unit workshop in 2002 will be considered the best available (paragraph 5.13).

5.35 WG-EMM has made a call for submissions on reference points to be used in ecosystem management (paragraph 5.29).

5.36 With respect to the request of the Scientific Committee (SC-CAMLR-XIX, paragraph 6.26), a task group has been formed to advise on the extent to which surveys of land-based predators are feasible as well as on the priorities for the techniques to be used. If agreed, a short workshop will be scheduled for WG-EMM's 2002 meeting (paragraph 5.31).

FUTURE WORK

Intersessional Work of WG-EMM

6.1 Future work identified by the Working Group is detailed in the relevant sections of this report. This work is summarised in Table 1, together with the persons identified to take the work forward and the references to paragraphs where the task is described. High priority items are shown in the table.

6.2 Attention of the Scientific Committee is drawn to the following task which could have financial implications for the CCAMLR budget: translation and publication in the *Scientific Observers Manual* of a questionnaire on krill fishing strategies (paragraph 2.35).

Planning of Future Meetings

6.3 The Working Group agreed that a notional timeline for the development of management procedures and the elaboration of issues considered in paragraph 5.5 could be the following:

Issues	Year			
	2002	2003	2004	2005
Harvested species–environment models	D	D	W4	
Predator–prey–environment models	S		W4	
Fishery–prey–environment models	S		W4	
Objectives, decision rules	D	D	D	W5
Performance measures	D	D	D	W5
Assessment methods		*W2		
Utility of CEMP	*IW2	*W2		
Small-scale management units, such as predator units	*W1			
Predator demand	D	W3		
Ecological division of precautionary catch limit		W3		
Field test CEMP, precautionary catch limit	D	W3		
Evaluation of candidate management procedures	D	D	D	W5

D – Developments received by WG-EMM; S – Scoping paper; IW – Interim planning for workshop;
W – Workshop; * – Workshops agreed to be held (numbers refer to workshop numbers).

6.4 The development of management procedures requires work on all these issues. The Working Group noted that more than one workshop may be required to satisfactorily investigate some of these issues. The Working Group also noted that this timeline may require revision over the next one or two years as work proceeds on the first two workshops.

6.5 The Working Group recognised that because of planned workshops its annual reports in the next four years are expected to be at least the size of previous reports when, e.g. the Area 48 and B_0 Workshops were held. This should be drawn to the attention of the Scientific Committee as having potential financial implications.

OTHER BUSINESS

Documentation of the KYM and Development of CEMP Indices

7.1 At its 2000 meeting WG-EMM requested the Secretariat to review the historical development of the CEMP indices and ecosystem assessments (SC-CAMLR-XIX, Annex 4, paragraph 3.55 and Table 3) and to compile the documentation of the KYM (SC-CAMLR-XIX, Annex 4, paragraph 2.110 and Table 3). The Secretariat, therefore, prepared WG-EMM-01/9 and 01/8 respectively to address these two topics. These web documents are to be considered as works in progress and have been placed on the CCAMLR website so that members can provide additional advice and suggestions for revisions. The Working Group congratulated the Secretariat for its efforts on these topics and found the documents to be instructive and urged the Secretariat to continue with their development.

Workshop on Krill Culturing Techniques

7.2 Dr Kawaguchi presented WG-EMM-01/37 which provided an announcement that Japan's Port of Nagoya Public Aquarium will sponsor a Workshop on Krill Culturing Techniques during September 2002. The workshop will assemble researchers who are active in this field to address common problems. The Working Group, therefore, recognised that the successful development of these techniques could have positive benefits to the work of CCAMLR. The Working Group encouraged and supported this workshop.

Course on Krill Survey Design and Execution

7.3 Dr B. Bergström (Sweden) presented a proposal (WG-EMM-01/51) to arrange a CCAMLR course in survey design and execution. This proposed course would incorporate the experience gained in planning and executing the CCAMLR-2000 Survey and would illustrate both theoretical and practical aspects of krill surveys. It would also include the execution of a 'miniature survey'. Students from Member countries would be recruited.

7.4 The Working Group recognised the need to recruit and train a core group of young scientists to continue the work of CCAMLR in future years. The proposed course was supported and Dr Bergström was encouraged to continue in his efforts to assemble experienced teachers and students from Member countries.

Collaboration between the Global Ocean Observing System (GOOS) and CCAMLR

7.5 WG-EMM-01/54 presented a proposal from Dr A. McEwan (representative of GOOS), to discuss collaboration between his organisation and CCAMLR. GOOS is a

permanent global system for observation, modelling and analysis of marine and ocean variables to support operational ocean services worldwide. It is sponsored by IOC, WMO, UNEP and ICSU. Dr McEwan proposed that he would be willing to make a brief presentation to the Scientific Committee if appropriate. He also suggested it may be appropriate for a CCAMLR observer to attend the next meeting of the GOOS Steering Committee from 15 to 17 May 2002 in Paris, France.

7.6 WG-EMM indicated that some objectives of GOOS appeared to be related to CCAMLR's work but that the Scientific Committee would be the best venue to consider the feasibility of this proposed collaborative effort. The Working Group did, however, note that the proposed work is ambitious and probably will require considerable resources to undertake. It felt a specific plan of work must be presented before it would be possible to fully evaluate its effects on CCAMLR's work.

7.7 As Chair of the Scientific Committee, Dr Holt agreed to write to Dr McEwan and advise that a succinct proposal on cooperation could be submitted by GOOS to the Scientific Committee for further consideration.

Southern Ocean GLOBEC

7.8 Prof. Kim reported briefly that the SO-GLOBEC Program was currently under way. The Working Group noted the common interests with SO-GLOBEC and wished it success in its program of work (www.ccpo.odu.edu/research/globec_menu.html).

Ecosystem Modelling for the Antarctic Krill Fishery
using Ecopath with Ecosim 4.0

7.9 WG-EMM noted that, in a pilot study, Ecopath with Ecosim 4.0 is being used to develop two mass-balance models of the Antarctic ecosystem, one for Subarea 48.1 and another for Subareas 48.2 and 48.3 combined (WG-EMM-01/65). Prof. T. Antezana (Chile) attended the latter portion of WG-EMM and briefed individual attendees as to the preliminary status of the study. Several colleagues expressed their gratitude to Prof. Antezana for information on this study and to Chile for its involvement in the work of WG-EMM.

Key Points for Consideration by the Scientific Committee

7.10 The Working Group wished to bring to the attention of the Scientific Committee the educational materials being developed by the Secretariat to be placed on the CCAMLR website (paragraph 7.1). These materials provide the background instruction, history and details of methods now being used by the Working Group, including the KYM and GYM and approaches used in CEMP. These materials will form the basic archive of the development of assessment methods of the Working Group.

7.11 The Working Group also wished to bring the attention of the Scientific Committee to the initiative to recruit and train young scientists to continue the work of CCAMLR in future years (paragraph 7.4). Such courses are essential for the long-term maintenance of the scientific work of CCAMLR. In addition, the Working Group requested that the Scientific

Committee call on Members to involve specialists on resource assessment, statistics and modelling in the work of WG-EMM. This urgent request is particularly important for the successful implementation of the program of work detailed in paragraph 6.3 and reiterates past requests (SC-CAMLR-XIX, paragraph 13.6).

ADOPTION OF THE REPORT

8.1 The report of the seventh meeting of WG-EMM was adopted.

CLOSE OF THE MEETING

9.1 In closing the meeting, Dr Hewitt thanked all those involved in the meeting for their contributions and discussions which had resulted in the definition of a multi-year agenda and future work for WG-EMM. The Working Group had identified significant areas of new work which would facilitate major advances in ecosystem monitoring and management.

9.2 Dr Hewitt thanked the local meeting organisers, Dr Bergström and Ms M. Thomasson, and their colleagues at the Kristineberg Marine Research Station, for providing such excellent facilities and setting for the meeting. This had greatly contributed to the success of the meeting. Dr Hewitt also thanked Mrs R. Marazas and Ms G. Tanner, and Drs Ramm and Sabourenkov for their significant work in support of WG-EMM, both at the meeting and during the intersessional period.

9.3 Dr Miller, on behalf of the Working Group, thanked Dr Hewitt for his continued leadership and contribution to WG-EMM.

9.4 The meeting was closed.

REFERENCES

BIOMASS. 1980. FIBEX acoustic survey design. *BIOMASS Rep. Ser.*, 14: 15 pp.

Everson, I. 1977. The living resources of the Southern Ocean. FAO GLO/S0/77/1, Rome: 156 pp.

Everson, I. and W.K. de la Mare. 1996. Some thoughts on precautionary measures for the krill fishery. *CCAMLR Science*, 3: 1–11.

Mackintosh, N.A. 1972. Life cycle of Antarctic krill in relation to ice and water conditions. *Discovery Rep.*, 36: 1–94.

Siegel, V. and S. Nicol. 2000. Population parameters. In: Everson, I. (Ed.). *Krill: Biology, Ecology and Fisheries*. Blackwell Science, Oxford: 104–149.

Watters, G. and R.P. Hewitt. 1992. Alternative methods for determining subarea or local area catch limits for krill in Statistical Area 48. In: *Selected Scientific Papers, 1992 (SC-CAMLR-SSP/9).* CCAMLR, Hobart, Australia: 237–249.

Table 1: List of tasks identified by WG-EMM for the 2001/02 intersessional period. The paragraph numbers (Ref.) refer to this report unless stated otherwise. √ – general request, √√ – high priority

	Task	Ref.	Priority	Action Required	
				Members	Secretariat
	Status and trends in krill fisheries				
1.	Submit further information on the spatial and temporal distribution of the krill fishery.	2.10	√	Members	Remind
2.	Re-examine the use of CPUE indices in krill fisheries.	2.10, 2.37	√	Continue data submission	Remind/coordinate
3.	Submit information on krill processing factors, including krill discards.	2.23	√	Continue data submission	Remind/coordinate
4.	Submit information on the economics of the krill fishery and market developments.	2.28	√	Continue data submission	Remind/coordinate
5.	Examine the questionnaires on krill fishing strategies and provide feedback.	2.34	√√	Members	Remind/implement
6.	Incorporate questionnaire and instructions on its completion into the *Scientific Observers Manual*.	2.35	√	Continue data submission	Remind/coordinate, implement
	Status of the krill-centric ecosystem				
7.	Use the agreed new rule for the calculation of Index A3.	3.5	√		Implement
8.	Review the recruitment series taking into account results of surveys conducted in Subarea 48.1.	3.31	√	Members	Remind
9.	Request more information on the derivation of carrying capacity for seal pup production as presented in WG-EMM-01/49.	3.50	√	Chile	Implement
10.	Examine Standard Method C2 to clarify issues related to timing of sampling and selection of animals to weigh; present a revised method to WG-EMM-02.	3.92	√	Mr Goebel (USA), Subgroup on Methods	Remind
11.	Clarify methods detailed in the *Scientific Observers Manual* and used to determine the length, maturity/sex stages and colour of krill.	3.97–3.100	√	Dr Kawaguchi (Japan), Subgroup on Methods	Remind
12.	Prepare a questionnaire for the Secretariat to circulate to Members concerning the availability of non-CEMP time-series data on predators, prey and environment.	3.102	√	Subgroup on Methods	Remind
	Status of management advice				
13.	Revise WG-EMM-01/52 in relation to harvesting units including ecological justification; submit it for consideration by the Scientific Committee.	4.14	√√	Drs Constable and Nicol (Australia), Members	Remind/coordinate
14.	Submit outstanding maps of CEMP sites; place maps on the website.	4.24	√	Members	Remind/implement

(continued)

	Task	Ref.	Priority	Action Required	
				Members	Secretariat
15.	Obtain a copy of the special issue of *Ecological Applications* on marine protected areas; make it available to the next meeting of WG-EMM.	4.34	√√		Implement
16.	Review the mechanisms that could be used for managing the krill fishery based on reports from the fishery.	4.51	√√		Secretariat
17.	Invite the three presenters at the WG-EMM-2001 workshop to submit their manuscripts to *CCAMLR Science* prior to the 2001 meeting of WG-FSA.	5.6	√	Drs Miller (South Africa), Everson (UK) and Constable (Australia)	Implement
	Future work of WG-EMM				
18.	Submit and circulate working group documents by means of the CCAMLR website – add dates of papers' submission, ZIP files of papers, information on the total number of papers received and their availability, revise proforma synopsis.	1.16–1.18	√	Continue the policy	Implement
19.	Prepare guidelines for determining categories of papers to be submitted; review categories at WG-EMM-02.	1.20	√	Convener, Members	Coordinate
20.	Develop further appropriate management frameworks that can account for long-term changes in the relationships between krill and its predators.	3.83	√	Members	Remind
21.	Continue documenting the historical development of CEMP indices and ecosystem assessments.	4.37, 7.1	√		Implement
22.	Coordinate development of the GYM and testing of the GYM to be carried out in future; encourage Members to become familiar with the GYM.	4.38	√	Members	Remind/coordinate
23.	Develop a proforma format for the submission and archiving of the GYM tests.	4.39	√	Members	Implement
24.	Revise the time series of recruitment information for inclusion in the GYM, and include new information from recent surveys.	4.39	√	Members	Remind/coordinate
25.	Assess the sensitivity of the estimation of γ to the nominated time of the CCAMLR-2000 Survey.	4.39	√	Members	Remind/coordinate
26.	Prepare and conduct further thematic workshops and symposia in accordance with the topics agreed (see table in paragraph 6.3).	5.7, 5.8	√	Convener, Members	Coordinate/implement
27.	Convene an intersessional correspondence group to prepare advice to WG-EMM and the Scientific Committee on further development of prey–predator–environment models for ecosystem management.	5.8	√√	Dr Constable (Australia)	Remind

(continued)

	Task	Ref.	Priority	Action Required	
				Members	Secretariat
28.	Prepare and conduct during WG-EMM-02 a workshop on the identification of small-scale management units such as predator units, coordinate submission of data and their standardisation, provide appropriate software and hardware.	5.11	√√	Dr Trivelpiece (Chair, Steering Committee)	Coordinate/ implement
29.	Arrange a workshop on the review of the utility of CEMP at WG-EMM-03, and conduct at WG-EMM-02 a preliminary session to consider submitted review papers and other materials.	5.20–5.24	√√	Dr Trivelpiece (Chair, Steering Committee)	Coordinate/implement
30.	Call for submission of papers on 'reference points' to be used in ecosystem management.	5.29	√	Members	Remind/coordinate
31.	Coordinate a group to consider how marine predator surveys could be undertaken, and consider a planning workshop during the 2002 meeting of WG-EMM.	5.31	√	Dr Southwell (Australia)	Remind
32.	Continue efforts to arrange a CCAMLR course in krill survey design and execution – evaluate availability of lecturers and students.	7.3, 7.4	√	Dr Bergström (Sweden)	
33.	Write to GOOS and advise that a succinct proposal on cooperation could be submitted by GOOS to the Scientific Committee for further consideration.	7.7	√	Chair, Scientific Committee	Coordinate

APPENDIX A

AGENDA

Working Group on Ecosystem Monitoring and Management
(Fiskebäckskil, Sweden, 2 to 11 July 2001)

1. Introduction
    - 1.1 Opening of the meeting
    - 1.2 Organisation of the meeting and adoption of the agenda

CORE BUSINESS

2. Status and trends in the fishery
    - 2.1 Fishing activity
    - 2.2 Description of the fishery
    - 2.3 Regulatory issues
    - 2.4 Key points for consideration by the Scientific Committee

3. Status and trends in the krill-centric ecosystem
    - 3.1 Status of predators, krill resource and environmental influences, Part I
    - 3.2 Status of predators, krill resource and environmental influences, Part II
    - 3.3 Further approaches to ecosystem assessment and management
    - 3.4 Other prey species
    - 3.5 Methods
    - 3.6 Future surveys
    - 3.7 Key points for consideration by the Scientific Committee

4. Status of management advice
    - 4.1 Smaller management units
    - 4.2 Draft fishery plan
    - 4.3 Designation of protected areas
    - 4.4 Generalised yield model
    - 4.5 Existing conservation measures
    - 4.6 Key points for consideration by the Scientific Committee

WORKSHOP

5. Workshop on the future agenda of WG-EMM
    - 5.1 Defining an ecosystem approach to management of the krill fishery
    - 5.2 Major issues to be addressed
    - 5.3 Planning

CORE BUSINESS

6. Future work
7. Other business
8. Adoption of the report
9. Close of meeting.

APPENDIX B

LIST OF PARTICIPANTS

Working Group on Ecosystem Monitoring and Management
(Fiskebäckskil, Sweden, 2 to 11 July 2001)

ANTEZANA, Tarsicio (Dr)	Departamento de Oceanografía Universidad de Concepción Casilla 160-C Concepción Chile antezana@udec.cl
BERGSTRÖM, Bo (Dr)	Kristineberg Marine Research Station S-450 34 Fiskebäckskil Sweden b.bergstrom@kmf.gu.se
CONSTABLE, Andrew (Dr)	Australian Antarctic Division Channel Highway Kingston Tasmania 7050 Australia andrew_con@antdiv.gov.au
CROXALL, John (Prof.)	British Antarctic Survey High Cross, Madingley Road Cambridge CB3 0ET United Kingdom j.croxall@bas.ac.uk
DOMMASNES, Are (Mr)	Institute of Marine Research PO Box 1870 Nordnes 5817 Bergen Norway are.dommasnes@imr.no
EVERSON, Inigo (Dr)	British Antarctic Survey High Cross, Madingley Road Cambridge CB3 0ET United Kingdom i.everson@bas.ac.uk
FERNHOLM, Bo (Prof.)	Swedish Museum of Natural History S-104 05 Stockholm Sweden bo.fernholm@nrm.se

GOEBEL, Michael (Mr)
US AMLR Program
Southwest Fisheries Science Center
PO Box 271
La Jolla, Ca. 92038
USA
megoebel@ucsd.edu

HEWITT, Roger (Dr)
US AMLR Program
Southwest Fisheries Science Center
PO Box 271
La Jolla, Ca. 92038
USA
rhewitt@ucsd.edu

HOLT, Rennie (Dr)
Chair, Scientific Committee
US AMLR Program
Southwest Fisheries Science Center
PO Box 271
La Jolla, Ca. 92038
USA
rholt@ucsd.edu

INOUE, Tetsuo (Mr)
Japan Deep Sea Trawlers Association
Ogawacho-Yasuda Building
6 Kanda-Ogawacho, 3-chome
Chiyoda-ku
Tokyo 101-0052
Japan

KASATKINA, Svetlana (Dr)
AtlantNIRO
5 Dmitry Donskoy Str.
Kaliningrad 236000
Russia
sea@atlant.baltnet.ru

KAWAGUCHI, So (Dr)
National Research Institute of Far Seas Fisheries
Orido 5-7-1, Shimizu
Shizuoka 424-8633
Japan
kawaso@enyo.affrc.go.jp

KIM, Suam (Prof.)
Department of Marine Biology
Pukyong National University
599-1, Daeyeon 3-dong, Nam-gu
Pusan, 608-737
Republic of Korea
suamkim@pknu.ac.kr

KNUTSEN, Tor (Dr)
Institute of Marine Research
PO Box 1870 Nordnes
N-5817 Bergen
Norway
tor.knutsen@imr.no

LÓPEZ ABELLÁN, Luis Jose (Mr)
Centro Oceanográfico de Canarias
Instituto Español de Oceanografia
Apartado de Correos 1373
Santa Cruz de Tenerife
España
lla@ieo.rcanaria.es

LEE, Youn-ho (Dr)
Korea Ocean Research and Development Institute
Ansan PO Box 29
Seoul 425-600
Republic of Korea
ylee@kordi.re.kr

MILLER, Denzil (Dr)
Marine and Coastal Management
Private Bag X2
Roggebaai 8012
South Africa
dmiller@mcm.wcape.gov.za

NAGANOBU, Mikio (Dr)
National Research Institute of Far Seas Fisheries
Orido 5-7-1, Shimizu
Shizuoka 424-8633
Japan
naganobu@enyo.affrc.go.jp

NICOL, Steve (Dr)
Australian Antarctic Division
Channel Highway
Kingston Tasmania 7050
Australia
stephe_nic@antdiv.gov.au

PATERSON, Matthew (Mr)
Antarctic Policy Unit
Ministry of Foreign Affairs and Trade
Private Bag 18-901
Wellington
New Zealand
matthew.paterson@mfat.govt.nz

REID, Keith (Mr)	British Antarctic Survey High Cross, Madingley Road Cambridge CB3 0ET United Kingdom k.reid@bas.ac.uk
RYDZY, Jerzy (Prof. Dott.)	Adviser for Science and Technology General Directorate for Asia, Oceania, Pacific and Antarctica Ministry of Foreign Affairs Piazzale della Farnesina, 1 00194 Roma Italy rydzy@esteri.it
SHUST, Konstantin (Dr)	VNIRO 17a V. Krasnoselskaya Moscow 107140 Russia antarctica@vniro.ru
SIEGEL, Volker (Dr)	Bundesforschungsanstalt für Fischerei Institut für Seefischerei Palmaille 9 D-22767 Hamburg Germany siegel.ish@bfa.fisch.de
SUSHIN, Viatcheslav (Dr)	AtlantNIRO 5 Dmitry Donskoy Str. Kaliningrad 236000 Russia sushin@atlant.baltnet.ru
THOMASSON, Maria (Ms)	Kristineberg Marine Research Station S-450 34 Fiskebäckskil Sweden m.thomasson@kmf.gu.se
TRIVELPIECE, Wayne (Dr)	US AMLR Program Southwest Fisheries Science Center PO Box 271 La Jolla, Ca. 92038 USA (current address: 8759 Trooper Trail, Bozeman, Mt. 59715, USA) waynezt@aol.com

VANYUSHIN, George (Dr)
VNIRO
17a V. Krasnoselskaya
Moscow 107140
Russia
sst.ocean@g23.relcom.ru

WILSON, Peter (Dr)
Manaaki Whenua – Landcare Research
Private Bag 6
Nelson
New Zealand
wilsonpr@landcare.cri.nz

Secretariat:

Eugene SABOURENKOV (Science Officer)
David RAMM (Data Manager)
Rosalie MARAZAS (Information Resources Administrator)
Genevieve TANNER (Coordinator, Publications and Translation)
CCAMLR
PO Box 213
North Hobart 7002
Tasmania Australia
ccamlr@ccamlr.org

APPENDIX C

LIST OF DOCUMENTS

Working Group on Ecosystem Monitoring and Management
(Fiskebäckskil, Sweden, 2 to 11 July 2001)

WG-EMM-01/1	Provisional Agenda and Provisional Annotated Agenda for the 2001 Meeting of the Working Group on Ecosystem Monitoring and Management (WG-EMM)
WG-EMM-01/2	List of participants
WG-EMM-01/3	List of documents
WG-EMM-01/4	History of development and completion of tasks put forward by WG-EMM (1995–2000) Secretariat
WG-EMM-01/5	CEMP indices 2001: analysis of anomalies and trends Secretariat
WG-EMM-01/5 Appendix	CEMP index data report Secretariat
WG-EMM-01/6	Secretariat work in support of WG-EMM Secretariat
WG-EMM-01/7	Krill fishery information Secretariat
WG-EMM-01/8	From KYM to GYM: the development of the krill yield model Secretariat
WG-EMM-01/9	CEMP indices and the development of ecosystem assessments Secretariat
WG-EMM-01/10	Demography of Antarctic krill in the Elephant Island area (Antarctic Peninsula) during austral summer 2001 V. Siegel (Germany), B. Bergström (Sweden), U. Mühlenhardt-Siegel (Germany) and M. Thomasson (Sweden)

WG-EMM-01/11	Comparison of temperature situation near South Georgia in December–February, 1989–1990, 1990–1991, 1999–2000 and 2000–2001 on satellite data and information about krill catches in Subarea 48.3 G. Vanyushin (Russia) (*CCAMLR Science*, submitted)
WG-EMM-01/12	Sources of variance in studies of krill population genetics S.N. Jarman and S. Nicol (Australia) (*CCAMLR Science*, in press)
WG-EMM-01/13	Distribution and size of Antarctic krill (*Euphausia superba* Dana) in the Polish commercial catches in the Atlantic sector of Antarctica in 1997–1999 E. Jackowski (Poland) (*CCAMLR Science*, in press)
WG-EMM-01/14	An investigation of avoidance by Antarctic krill of RRS *James Clark Ross* using the *Autosub-2* autonomous underwater vehicle A.S. Brierley, P.G. Fernandes, M.A. Brandon, E. Armstrong, D.G. Bone and the *Autosub* Team (United Kingdom)
WG-EMM-01/15	Multiple acoustic estimates of krill density at South Georgia during 2000/2001 reveal significant intra-annual and spatial variability A.S. Brierley, C. Goss, S.A. Grant, J.L. Watkins, K. Reid, M. Belchier, I. Everson, M.J. Jessop, V. Afanasyev and J. Robst (United Kingdom) (*CCAMLR Science*, in press)
WG-EMM-01/16	Notes on methods for measuring and estimating the status of krill I. Everson (United Kingdom)
WG-EMM-01/17	The development of the role of the WG-EMM Subgroup on Methods K. Reid (United Kingdom)
WG-EMM-01/18	Growth of Antarctic krill *Euphausia superba* at South Georgia K. Reid (United Kingdom) (*Marine Biology*, 138: 57–62)
WG-EMM-01/19	Seasonal and interannual variation in foraging range and habitat of macaroni penguins at South Georgia K.E. Barlow and J.P. Croxall (United Kingdom) (*Marine Ecology Progress Series*, submitted)

WG-EMM-01/20	Growth rates of Antarctic fur seals as indices of environmental conditions K. Reid (United Kingdom) (*Marine Mammal Science*, submitted)
WG-EMM-01/21	Environmental response of upper trophic level predators reveals a system change in an Antarctic marine ecosystem K. Reid and J.P. Croxall (United Kingdom) (*Proceedings of the Royal Society Ser B.*, 268: 377–384)
WG-EMM-01/22	Are penguins and seals in competition for Antarctic krill at South Georgia? K.E. Barlow, I.L. Boyd, J.P. Croxall, I.J. Staniland, K. Reid and A.S. Brierley (United Kingdom) (*Marine Biology*, submitted)
WG-EMM-01/23	Adélie penguin population change in the pacific sector of Antarctica: relation to sea-ice extent and the Antarctic Circumpolar Current P.R. Wilson (New Zealand), D.G. Ainley, N. Nur, S.S. Jacobs (USA), K.J. Barton (New Zealand), G. Ballard and J.C. Comiso (USA) (*Marine Ecology Progress Series*, 213: 301–309)
WG-EMM-01/24	Outline details of the proposed aerial photographic survey at South Georgia for estimating breeding population sizes of land-based predators P. Trathan and D. Briggs (United Kingdom)
WG-EMM-01/25	Monitoring a marine ecosystem using responses of upper trophic level predators I.L. Boyd and A.W.A. Murray (United Kingdom) (*Journal of Animal Ecology*, in press)
WG-EMM-01/26	Spatial distribution of foraging by female Antarctic fur seals I.L. Boyd, I.J. Staniland and A.R. Martin (United Kingdom) (*Ecology*, submitted)
WG-EMM-01/27	Integrated environment–prey–predator interactions off South Georgia: implications for management of fisheries I.L. Boyd (United Kingdom) (*Aquatic Conservation: Marine and Freshwater Ecosystems*, in press)
WG-EMM-01/28	Variability of krill biomass estimates in repeated mesoscale surveys in relation to CCAMLR-2000 Survey V.A. Sushin, F.F. Litvinov (Russia) and V. Siegel (Germany)

WG-EMM-01/29	Alternative methods for determining subarea or local area catch limits for krill in Statistical Area 48 G. Watters and R. Hewitt (USA) (In: *Selected Scientific Papers, 1992 (SC-CAMLR-SSP/9)*: 237–249)
WG-EMM-01/30	Distribution of temperature, salinity, density and flow across the Drake Passage in December 1994 M. Naganobu and K. Kutsuwada (Japan)
WG-EMM-01/31	Sources of information on Global Marine Protected Areas (MPAs) WG-EMM Subgroup on Designation and Protection of CEMP Sites
WG-EMM-01/32	Penguin demography and winter distributions in the Antarctic Peninsula region W. Trivelpiece and S. Trivelpiece (USA) (*NSF Progress Report 2000/01*)
WG-EMM-01/33	Seabird research on Cape Shirreff, Livingston Island, Antarctica, 2000/01 M. Taft, I. Saxer and W. Trivelpiece (USA) (*US AMLR Field Season Report 2000/01*, in press)
WG-EMM-01/34	Interannual variability of polynya extent in the Antarctic Ocean M. Naganobu and K. Segawa (Japan)
WG-EMM-01/35	Analysis of krill trawling positions north of the South Shetland Islands (Antarctic Peninsula area), 1980/81–1999/2000 S. Kawaguchi and K. Segawa (*CCAMLR Science*, 8: 25–36 (2001))
WG-EMM-01/36	CPUEs and body length of Antarctic krill during the 1999/2000 season in Area 48 S. Kawaguchi and M. Naganobu (Japan)
WG-EMM-01/37	Preliminary announcement of 'Workshop on Krill Culturing Techniques' Delegation of Japan
WG-EMM-01/38	Final report of scientific observation of commercial krill harvest aboard the Japanese stern trawler *Niitaka Maru*, 13 December 2000–26 January 2001 T. Hayashi, S. Kawaguchi and M. Naganobu (Japan)
WG-EMM-01/39	Krill conversion factors I. Everson (United Kingdom)

WG-EMM-01/40	Changes observed in krill length frequency distribution during repeated sampling on the South Georgia shelf in 2000 January–February V.A. Sushin and F.F. Litvinov (Russia) (*CCAMLR Science*, submitted)
WG-EMM-01/41	On influence of acoustic survey methodology improvement on krill biomass estimation. (A comparison of results of acoustic surveys based on single-frequency and double-frequency algorithms) S.M. Kasatkina and A.P. Malyshko (Russia) (*CCAMLR Science*, submitted)
WG-EMM-01/42	Characteristics of krill aggregations in 48.4 subdivision during January–February 2000 S.M. Kasatkina, A.P. Malyshko, V.N.Shnar and O.A. Berezhinskiy (Russia) (*CCAMLR Science*, submitted)
WG-EMM-01/43	Pinniped research at Cape Shirreff, Livingston Island, Antarctica, 2000–2001 M.E. Goebel, B.W. Parker, A.R. Banks, D.P. Costa and R.S. Holt (USA) (*US AMLR Field Season Report 2000/01*, in press)
WG-EMM-01/44	Krill processing factors D. Rogers (USA)
WG-EMM-01/45	Seasonal and interannual variability of krill, salp and other zooplankton populations in the northwest Antarctic Peninsula region: summer 2001 in relation to the Long-Term AMLR Data Set V. Loeb (USA)
WG-EMM-01/46	Detection of anti-*brucella* antibodies in pinnipeds from the Antarctic Territory P. Retamal, O. Blank, P. Abalos and D. Torres (Chile) (*Veterinary Record*, 146: 166–167 (2000))
WG-EMM-01/47	Withdrawn – see 'Other Documents'
WG-EMM-01/48	Detection of anti-*brucella* antibodies in Weddell seals (*Leptonychotes weddellii*) from Cape Shirreff, Antarctica O. Blank, P. Retamal, P. Abalos and D. Torres (Chile)

WG-EMM-01/49	Antarctic fur seal population dynamics update and assessment of census error at SSSI No. 32, Livingston Island, South Shetlands, Antarctica (2000/2001) R. Hucke-Gaete (Chile)
WG-EMM-01/50	Some notes on by-catch of fishes caught by the fishery vessel *Niitaka Maru* in the vicinity of the South Shetland Islands (December 2000 to January 2001) T. Iwami, S. Kawaguchi and M. Naganobu (Japan)
WG-EMM-01/51	CCAMLR course in survey design and execution – a possible way to assure intellectual continuity and renewal in WG-EMM B. Bergström and M.A. Thomasson (Sweden)
WG-EMM-01/52	Defining smaller management areas within CCAMLR A.J. Constable and S. Nicol (Australia) (*CCAMLR Science*, submitted)
WG-EMM-01/53	Modelling Southern Ocean krill population dynamics: biological processes generating fluctuations in the South Georgia ecosystem E. Murphy and K. Reid (United Kingdom) (*Marine Ecology Progress Series*, in press)
WG-EMM-01/54	Collaboration between GOOS and CCAMLR Secretariat
WG-EMM-01/55	Note on demography of Antarctic seabirds J.P. Croxall (United Kingdom) (*Comité National Français des Recherches Antarctiques*, 51: 479–488)
WG-EMM-01/56	Measurement of ocean temperatures using instruments carried by Antarctic fur seals I.L. Boyd, E.J. Hawker, M.A. Brandon and I.J. Staniland (United Kingdom) (*Journal of Marine Systems*, 27: 277–288 (2001))
WG-EMM-01/57	Soviet krill fishery in 1977–1992, Part 1. Distribution, fishing effort, interannual situation patterns F.F. Litvinov, V.A. Sushin, G.A. Chernega and O.A. Berezhinskiy (Russia) (*CCAMLR Science*, submitted)
WG-EMM-01/58	Predation on fish by the southern elephant seal, *Mirounga leonina*, at King George Island, South Shetland Islands, as reflected by stomach lavage G.A. Daneri and A.R. Carlini (Argentina)

WG-EMM-01/59	Herpes virus antibodies in *Arctocephalus gazella* from Cape Shirreff, Livingston Island, Antarctica O. Blank, J.M. Montt, M. Celedón and D. Torres (Chile)
WG-EMM-01/60	Report of CCAMLR-2000 Special Issue Workshop British Antarctic Survey, Cambridge, 30 May–6 June 2001 J.L. Watkins (Convener)
WG-EMM-01/61	On dispersion of different pelagic organisms, forming Antarctic backscattering in South Sandwich subarea during January–February 2000 S.M. Kasatkina and A.P. Malyshko (Russia)
WG-EMM-01/62	Seasonal relationships in biological parameters and in spatial distribution in the euphausiid populations sampled during the XIIIth and XVth expedition to the Ross Sea M. Azzali, J. Kalinowski, G. Lanciani, I. Leonori and A. Sala (Italy) (abstract only)
WG-EMM-01/63	A three-frequency method to determine the abundance and the size of two euphausiid species (*Euphausia superba* and *Euphausia crystallorophias*) M. Azzali, J. Kalinowksi, G. Lanciani and I. Leonori (Italy) (abstract only)
WG-EMM-01/64	Design of the Italian acoustic survey in the Ross Sea M. Azzali and A. Sala (Italy) (abstract only)
WG-EMM-01/65	Ecosystem modelling for the Antarctic krill fishery T. Antezana, J. Cornejo, E. Bredesen, P. Faundez (Chile), A.W. Trites and T. Pitcher (Canada) (abstract only)
WG-EMM-01/66	Modelling the consequences of Antarctic krill harvesting of Antarctic fur seals R.B. Thomson, D.S. Butterworth (South Africa), I.L. Boyd and J.P. Croxall (United Kingdom) (*Ecological Applications*, 10 (6): 1806–1819 (2000))
WG-EMM-01/67	Quantifying habitat use in satellite-tracked pelagic seabirds: application of kernel estimation to albatross locations A.G. Wood (United Kingdom), B. Naef-Daenzer (Switzerland), P.A. Prince and J.P. Croxall (United Kingdom) (*Journal of Avian Biology*, 31: 278–286 (2000))

WG-EMM-01/68	Report of the Workshop for the International Coordinated Survey in conjunction with CCAMLR-2000 Survey Delegations of Japan, Republic of Korea, USA and Peru
WG-EMM-01/69	Procedure for electronic submission of WG-EMM papers Secretariat
WG-EMM-01/70	Data from krill questionnaire Secretariat
WG-EMM-01/71	Aide memoire: Balleny Islands Delegation of New Zealand
WG-EMM-01/72	Do fish prey size affect the foraging patterns and breeding output of the Antarctic shag *Phalacrocorax bransfieldensis*? R. Casaux and A. Baroni (Argentina)
WG-EMM-01/73	Consideration of major issues in ecosystem monitoring and management I. Everson (United Kingdom)

Other Documents

SC-CAMLR-XIX/5	Regional surveys of land-based predators, and a future synoptic survey of land-based predators report of correspondence on behalf of the SC-CAMLR Working Group on Ecosystem Monitoring and Management Delegation of Australia
SC-CAMLR-XIX/BG/10	Additional data on anti-*brucella* antibodies in *Arctocephalus gazella* from Cape Shirreff, Livingston Island, Antarctica O. Blank et al. (*CCAMLR Science*, 8: 147–154 (2001))

REVISED DRAFT FISHERY PLAN FOR THE KRILL FISHERY IN AREA 48

CCAMLR Fishery Plan – Draft			Closed Fisheries
Fishery details — Species: **Krill**; Area, subarea or division, or subdivision: **Area 48**; Gear types: **Midwater trawl**	CCAMLR Season		
	1999/2000	2000/2001 (expectations)	
Conservation measure adopted?	32/X	32/XIX	
1. Harvest Controls			
Closed areas	None	None	
Open and/or closed seasons	All-year fishing	All-year fishing	
Total allowable catch	Overall 1 500 000 t Trigger level 620 000 t	Overall 4 000 000 t Trigger level 620 000 t Subarea limits 48.1: 1 008 000 t 48.2 : 1 104 000 t 48.3 : 1 056 000 t 48.4 : 832 000 t	
Effort limitation (no. of vessels, Member States etc.)	None	None	
Fish size limits	None	None	
By-catch limits	• Limits for various species of finfish (e.g. CM 95/XIV)		
2. Data Reporting Requirements			
Catch Data			
Monthly reporting (CM 32/XIX)	Yes	Yes	
Catch and Effort Reporting System			
5-day reporting period (CM 51/XIX)	None	None	
10-day reporting period (CM 61/XII)	None	None	
Monthly reporting period (CM 40/X)	None	None	
Fine-scale Data			
Catch and effort data (CM 122/XIX)	None	None	
Biological data (CM 121/XIX)	None	None	
Other Data			
STATLANT data	Yes	Yes	
Scientific observer data	None	None	
Data collection plan	None	None	
Research plan	None	None	
Fishery operations plan	None	None	
2a. Scientific Observer Requirements			
International CCAMLR scientific observer requirements	None	None	
Other observer requirements	None	None	
Any other provisions (specify)	None	None	
3. Notification Requirements			
Notification required?	None	None	
Notification deadline	na	na	
Notifications received by CCAMLR	na	na	
Notification preferences			
(i) Research and fishery operations plan The nature of the proposed fishery including target species, methods of fishing, proposed region.	None	None	

Any minimum level of catches that would be required to develop a viable fishery. Biological information from comprehensive research/survey cruises, such as distribution, abundance, demographic data and information on stock identity. Details of dependent and associated species and the likelihood of them being affected by the proposed fishery. Information from other fisheries in the region or similar fisheries elsewhere that may assist in the valuation of potential yield. Other requirements (specify)?			
(ii) Limits on fishing capacity and effort.	None	None	
(iii) The name, type, size, registration number and radio call sign of each vessel participating.	Required	Required	
(iv) Other notification preferences (specify)?	None	None	
4. Data Collection Plan (in addition to standard CCAMLR reporting requirements)			
Data collection plan required/prepared?	None	None	
Data collection plan contents	na	na	
A description of the catch, effort and related biological, ecological and environmental data required to undertake an evaluation of the status and potential of the fishery, in accordance with Article II. A plan for directing fishing effort during the exploratory phase. An evaluation of the time scales involved in determining the responses of harvested, dependent and related populations to fishing activities.			
5. Fishing Activity			
Total allowable catch	1 500 000 t	4 000 000 t	
Total reported catch	104 259 t (STATLANT data)	45 223 t (STATLANT data)	
No. of vessels	14	9	
Days fished	Incomplete data	Incomplete data	
Period of season	Jul 1999–Jun 2000	Dec 2000–Nov 2001	
Major by-catch species	None reported	None reported	
6. Data Reported to CCAMLR			
Monthly catch reports (CM 32/XIX)	• Reported by all Contracting Parties		
Monthly effort reports	• Reported by some Contracting Parties		
Catch data by fine-scale rectangle or smaller rectangle	• Reported at varying levels of spatial and temporal resolution		
Effort data by fine-scale rectangle or smaller rectangle	• Reported by some Contracting Parties		
Haul-by-haul catch and effort data	• Not reported		
Biological data by fine-scale rectangle or smaller rectangle	• Not reported		
Observer data	One trip	Two trips – data to be submitted	
STATLANT data	Reported by all Contracting Parties	To be submitted	
7. Assessment			
Most recent assessment performed?		B_0 Workshop 2000	
Method of discounting for lapse since last assessment		None	