ECOSYSTEM MONITORING AND MANAGEMENT

Report of WG-EMM

6.1     In its discussions leading to an ecosystem assessment, WG-EMM considered trends in harvested species, dependent species and the environment and interactions between them. Trends in harvested species were discussed under Agenda Item 2 and trends in dependent species under Agenda Item 4.

        General Items

6.2     As directed by the Scientific Committee during its last meeting (SC-CAMLR-XV, paragraph 5.8), the Subgroup on Statistics met just prior to the WG-EMM meeting.

6.3     The Scientific Committee noted that the subgroup and WG-EMM had difficulty with the use of the term 'anomaly' to describe noteworthy values in the CEMP indices because the term anomaly is commonly used to describe events that occur with low probability.  However, events of interest may be fairly common, for example occurring once every four or five years. The important consideration may be whether the frequency of these events is changing over time.  The Scientific Committee noted that the term 'Ecologically Important Value' (EIV) (referred to by the Subgroup on Statistics as 'Value Outside the Generally Observed Norm') had been agreed to describe a value of an index which is extreme relative to the distribution of values which are deemed to be unlikely to lead to substantial changes in the status of dependent, related and harvested species (Annex 4, paragraph 6.6).

6.4     The Scientific Committee noted that WG-EMM had completed preliminary studies using multivariate analysis, including principal component analysis, which led to the development of combined indices that summarise a large number of indices into a smaller set which can be more easily examined (Annex 4, paragraph 6.7).

6.5     The Scientific Committee also noted the desirability of having access to this methodology prior to the planned workshop to investigate Area 48, which will be held in June, 1998.  Dr de la Mare indicated he would endeavour to work with the Secretariat to ensure its availability by March, in time for use by workshop participants.

6.6     WG-EMM noted the importance of being able to detect not only extreme values in the indices, but also changes in variability, trends and shifts in the values, and changes in the frequency of extreme events.  In addition, as with any such analysis, the quality of the output depends critically on the input data.  Contributors to CEMP indices were requested to check the validity of their data and to inform the Secretariat of any changes which might be required (Annex 4, paragraphs 6.8 and 6.9).

6.7     The Scientific Committee was pleased to note that subsequent to the WG-EMM meeting, the UK had completed and validated all of their CEMP data and submitted to the Secretariat appropriate changes.

6.8     The Scientific Committee agreed with WG-EMM's Subgroup on Statistics that the causes of values being missing in the database of CEMP indices need to be documented as part of the database.  These might arise for several reasons such as:  no observation made; or the observer was unable to make an observation due to some constraint; or an unrecorded zero value; or an error in data entry.  These might have different interpretations in analysis.  The

Data Manager agreed to prepare a circular seeking relevant information (Annex 4, paragraph 6.11).

Environment

6.9    The Scientific Committee noted that information on water circulation, water mass distribution, position of fronts and sea-ice cover was discussed at WG-EMM and that a significant contribution to this section came from the results of the Workshop on International Coordination, which had taken place just prior to the meeting of WG-EMM (Annex 4, paragraphs 5.1 to 5.5).

6.10    WG-EMM also reported on additional studies which investigated the location and variability in the position of frontal zones and the water movement over the deep ocean and residence times over the shelf.  In addition, topics which are relevant to understanding krill flux were discussed (Annex 4, paragraphs 5.6 to 5.13).

Environmental Parameters

6.11    The Scientific Committee noted that as part of CEMP, the Secretariat currently produces four environmental indices (Annex 4, paragraph 8.92).  These are:

F2a – sea-ice percentage cover in a subarea in September;

F2b – sea-ice retreat past a CEMP site:  number of ice free days;

F2c – sea-ice distance to a CEMP site:  weeks sea-ice is within 100 km of site; and

F5 – summer sea-surface temperature adjacent to a CEMP site.

6.12    Further standard methods have been prepared by the Secretariat, however these are currently in draft form:

F1 – sea-ice cover viewed from a CEMP site;

F3 – local weather at a CEMP site; and

F4 – snow cover at a CEMP site.

6.13    The Scientific Committee agreed that further review of the draft environmental indices was necessary before formal data submissions could proceed (Annex 4, paragraphs 8.93 to 8.103).

Interactions between Ecosystem Components

Harvested Species and the Environment

6.14    The Scientific Committee agreed that the krill haul-by-haul fishery data are providing

valuable information on the location of krill concentrations relative to local bathymetric features (Annex 4, paragraph 6.21).

6.15    It also noted that the krill fishery in Area 48 does not target the whole Scotia Sea area but is almost certainly able to target the regular high concentration regions.  As these traditional fishing grounds are in the vicinity of some of the largest predator colonies in the area, this highlights the usefulness of the fishery data in considering interactions between predators, prey and fisheries.  As with all of the prey and predator datasets, the need for careful interpretation of such data was emphasised.  The Working Group noted the value of analyses of individual trawl-based fishery data and encouraged further development of analyses of the fishing operation (Annex 4, paragraph 6.22).

6.16    The Scientific Committee noted WG-EMM discussions on the strategic modelling exercise for the management of the ecosystem derived at WG-EMM in 1995 (SC-CAMLR-XIV, Annex 4, paragraphs 7.46 to 7.60 and Figures 3 and 4) and was encouraged by progress made by this year's WG-EMM meeting (Annex 4, paragraphs 6.30 to 6.34).  It agreed with the suggestion that the various hypotheses being proposed should be developed so that they could be tested using the indices being compiled by WG-EMM.  In addition, WG-EMM was encouraged to investigate whether the hypothesised relationship between winter sea-ice conditions and krill recruitment in the Elephant Island area was valid for other Southern Ocean localities.


Interactions between Krill and Dependent Species

        Fur Seals

6.17    The Scientific Committee noted WG-EMM's report that biochemical analysis of samples of milk from lactating fur seals has demonstrated that the fatty acid composition can be used to provide an index of the major food components, fish and krill, in the diet.  Further progress was reported in developing an energy budget for fur seals (Annex 4, paragraphs 6.39 to 6.42).


        Seabirds

6.18    The Scientific Committee noted several reports to WG-EMM which investigated the interactions between krill and seabirds (Annex 4, paragraphs 6.43 to 6.48).  It also noted that the insights into diet variation provided by these studies, and particularly the varying ability of species that are generally dependent upon krill to switch to other prey in the absence of krill.   There is a continuum of species in terms of the extent to which fecundity, fledging/weaning mass and reduced survival of adults and young are affected by variations in krill abundance.

Minke Whales

6.19    WG-EMM reviewed results of several studies of minke whales which had been carried out in Division 58.4.1 and Subarea 88.1. Specifically these considered the girth of minke whale as an index of condition. Also raised was the relationship between minke whale condition, krill availability and the extent of ice cover (Annex 4, paragraphs 6.49 to 6.55).

6.20    The Scientific Committee endorsed the principle of developing standard methods for minke whales, but agreed with WG-EMM that there remained sufficient uncertainty about the spatial and temporal scales represented by such a monitoring parameter that their reintroduction as a CEMP monitoring species could not be justified at this stage.

6.21    The Scientific Committee also noted that to re-establish minke whales as a CEMP monitoring species would require methods capable of generating long-term data which involved non-invasive techniques such as photogrammetry (paragraph 4.9).

Dependent–Harvested Species Interactions

6.22    The Scientific Committee endorsed WG-EMM's view that it was advantageous to examine krill–predator interactions using both empirical and mechanistic models (Annex 4, paragraphs 6.58 to 6.72). At a broad scale, the empirical model being developed by Prof. D. Butterworth's group provides a useful foundation for the provision of management advice. Mechanistic modelling, still largely under development, will provide the necessary link between prey abundance and distribution and predator behaviour, which is measured in the form of CEMP parameters. This can be used to characterise better the functional relationship between krill abundance and predator demographic parameters.

6.23    The Scientific Committee agreed that the empirical model be developed further to ensure that in future there is a basis upon which management advice can be taken forward to the Scientific Committee. It also endorsed the mechanistic approach by inviting the submission of papers addressing this subject at future meetings.

Interactions between Dependent Species

6.24    The Scientific Committee noted that potential interactions between dependent species was relevant to WG-EMM's ability to discriminate between the effects of krill fishing and the effects of competition between predators (Annex 4, paragraphs 6.74 to 6.76), and agreed that it is an issue that should be incorporated within assessments of the reasons underlying changes in predator abundance.

Fisheries–Dependent Species Overlap

6.25    The model of dependent species and fisheries overlap, the Agnew–Phegan Model, was discussed by the Subgroup on Statistics and by WG-EMM (Annex 4, paragraph 6.10). The subgroup found that the model was not a direct measure of overlap, but rather was related to

the total amount of krill removed from the foraging area during the critical period. WG-EMM agreed that the use of a new standardised index, the Schroeder index, which gives a measure of the spatial overlap between the dependent species and the fishery in a given time, was more appropriate. The Scientific Committee requested the Secretariat to report results obtained using the new index to the next meeting of WG-EMM.

6.26    The Scientific Committee also noted that an additional index is required to give some measure related to the possible impact on dependent species of the quantities of harvested species taken by the fishery (Annex 4, paragraph 6.10).

Predator Interactions with Fish and Squid

6.27    As demonstrated in papers submitted to previous meeting, Antarctic blue-eyed shags rely heavily on a range of inshore fish species. Many of these have historically been subject to heavy exploitation. (For further information, refer to paragraph 4.12.)

6.28    The Scientific Committee noted that WG-EMM had considered the potential impact of a fishery for *M. hyadesi* on predators and concluded that there was generally insufficient information to conclude how the development of such a fishery was likely to influence predators. It appeared that most predators were taking small squid and there was little indication that they were feeding on spent squid. Moreover the most accurate information about squid consumption came from the predator species which accounted for the smallest proportion of the estimated predation of squid in Area 48 (Annex 4, paragraph 6.83).

6.29    Last year, the Commission set a precautionary catch limit at 1% of the estimated predator demand. The Scientific Committee concurred that determining a more accurate estimate for the precautionary yield would require more information on estimates of the natural mortality rate of squid from one to two years of age, on variability in recruitment and on the appropriate level of squid escapement after fishing to meet predator requirements (Annex 4, paragraph 6.85).

6.30    The Scientific Committee recognised that only limited information was available on seasonal distribution and migration of *M. hyadesi* and that more information could be obtained by spreading the fishing season over the entire year. However, it also recognised that the fishing season should take into account the lack of sufficient data to assess how the development of a fishery would affect predators dependent on *M. hyadesi* (Annex 4, paragraphs 6.86 and 6.87).

6.31    The Scientific Committee agreed with the results of a workshop to consider the management of exploitation in the Heard Island area (Annex 4, paragraph 6.88). Detailed interactions had been considered and distilled into more simple views of the system. As a general rule such simplification attempts to account for the interactions which involve about 80% of the prey consumed by the predators.

Ecosystem Assessment

### Estimates of Potential Yield

6.32    The Scientific Committee noted that refinements in the krill yield model to correct for bias would not greatly change the current value of $\gamma$ used to calculate precautionary catch limits.  The Working Group agreed that revised calculations of precautionary catch limits should be deferred until additional information becomes available (Annex 4, paragraphs 7.1 and 7.2).

6.33    The Scientific Committee noted that the GYM used by WG-FSA can duplicate results provided by the krill yield model and agreed that once validated it should replace the existing krill yield model (Annex 4, paragraph 7.3).

### Precautionary Catch Limits

6.34    At present the precautionary catch limit for Area 48 has not been subdivided among subareas.  An estimate of the biomass of krill for the vicinity of South Georgia based on an estimate of predator demand in that region was provided at the meeting (Annex 4, paragraph 7.4).

6.35    The Scientific Committee accepted WG-EMM's view that there was no need to make a subarea subdivision of the precautionary catch limit for Area 48 and that consideration of subdivision should be deferred until the results from the planned synoptic survey in Area 48 became available (Annex 4, paragraph 7.7).

### Assessment of the Status of the Ecosystem

6.36    The Scientific Committee noted the following assessments of the status of the ecosystem provided by WG-EMM.

#### Subarea 48.1

6.37    Overall, in the Antarctic Peninsula region in 1996/97, absolute krill recruitment was close to historical averages.  Around Elephant Island in 1996/97 there was a prolonged krill spawning season, a delayed spawning peak and a massive salp bloom.  This followed below average sea-ice conditions in winter 1996.  Excellent recruitment success was observed for the 1994/95 year, but lower recruitment success was observed for the 1995/96 year class. These observations confirm predictions made at last year's meeting (Annex 4, paragraph 6.38) and support the hypothesised relationships between recruitment success and winter sea-ice conditions (Annex 4, paragraphs 7.12 and 7.13).

6.38    In addition, the Scientific Committee noted WG-EMM's observation that low larval krill densities and high salp concentrations observed during this year suggest poor krill

reproductive success. Poor recruitment of the 1996/97 krill year class is predicted (Annex 4, paragraph 7.14).

6.39 The Scientific Committee noted WG-EMM's view that there appeared to be an encouraging degree of coherence in CEMP indices across sites within Subarea 48.1 (Annex 4, paragraph 7.19). Specifically, Adélie penguin fledging success and fur seal pup production were higher than in recent years.

Subarea 48.2

6.40 At Signy Island, breeding success of Adélie, chinstrap and gentoo penguins were all at above average levels in 1996/97. This suggests a degree of coherence in predator indices with those in Subarea 48.1 (Annex 4, paragraph 7.20).

Subarea 48.3

6.41 Bird Island was the one CEMP site for which a combined index for dependent species had been developed (Annex 4, Appendix D, Figure 1). This indicated that there had been a steady improvement in predator reproductive success since the last poor year in 1993/94.

6.42 Krill biomass densities off South Georgia in December 1996 were comparable with those in the previous year and were relatively high for this region (Annex 4, paragraph 7.22).

Subarea 48.6

6.43 The population of chinstrap penguins at Bouvet Island has fallen sharply since 1989/90 whilst that of macaroni penguins has shown a more moderate decline. The population of Antarctic fur seals has grown dramatically over the same period (Annex 4, paragraph 7.23).

6.44 There is considerable interannual variation in the number of Antarctic petrels breeding successfully at Svarthamaren, but 1997 appears to have been quite a good year (Annex 4, paragraph 7.25).

Division 58.4.2

6.45 After two poor seasons, the breeding success of Adélie penguins at Béchervaise Island was high in 1996/97. The breeding population size has remained almost constant (Annex 4, paragraph 7.26).

Subarea 58.7

6.46    At Marion Island, macaroni and gentoo penguins have been monitored for the past three seasons.  The CEMP indices measured in 1996/97 were all within the ranges of previous values and there were no obvious EIVs (Annex 4, paragraph 7.27).

Subarea 88.1

6.47    Although Adélie penguin breeding success was the highest of the three years for which data have been collected at Edmonson Point, no exceptional values of monitored CEMP indices were obtained in 1996/97 (Annex 4, paragraph 7.28).

Format for Presentation of Ecosystem Assessments

6.48    The Scientific Committee noted that it would be helpful if ecosystem assessments could be presented in a more standardised form.  An illustrative example of a possible format, based on that used for fish stocks by WG-FSA, for an ecosystem assessment summary for Subareas 48.1, 48.2 and 48.3 was proposed.  The Scientific Committee agreed that this approach should be considered further at the next meeting of WG-EMM (Annex 4, paragraph 7.30).

Possible Management Measures

6.49    No new management measures were proposed.

Plans for the Area 48 Workshop

6.50    The Scientific Committee agreed that the need for the Area 48 workshop remains and that the terms of reference for the workshop have not changed since last year (Annex 4, paragraph 8.110).  The terms of reference are:

(i)     identify the extent of between-season and within-season variation in key indices of the environment, harvested species, and dependent species over past decades;

(ii)    identify coherence in the indices between sites and clarify understanding of the linkages between Subareas 48.1, 48.2 and 48.3;

(iii)   develop working hypotheses; and

(iv)    provide a summary report for consideration of the 1998 meeting of WG-EMM.

6.51    The Scientific Committee agreed that it would be useful to organise the workshop around the following hypothesis and its alternative:

(i)    $H_0$:  Subareas 48.1, 48.2 and 48.3 are discrete ecosystems and events observed in any one subarea do not reflect what is happening in other subareas; and

(ii)   $H_1$:  area is a homogenous ecosystem and events observed in any one subarea reflect the entire area.

6.52    It was recognised that neither of these hypotheses was likely to be correct.  However, they represent the end points of the spectrum of possibilities and may thus serve a useful purpose for organising the workshop (Annex 4, paragraphs 8.112 and 8.113).

6.53    The Scientific Committee agreed to the following plans for the organisation of the workshop (Annex 4, paragraphs 8.114 to 8.117):

(i)    the workshop should be held at Southwest Fisheries Center, La Jolla, Ca., USA, in June 1998.  It was noted that the meeting venue was small and could accommodate relatively few participants.  Dr Hewitt had agreed to convene the workshop;

(ii)   workshop participants were requested to submit their full sets of data on indices (i.e. without combining similar indices).  Participants were, however, encouraged to undertake analyses of their own data in advance of the workshop and to report their results to it; and

(iii)  the CCAMLR Data Manager should attend the workshop and that secretarial support from the CCAMLR Secretariat should also be requested.  This recommendation is motivated by the nature and scope of the workshop, particularly since diverse sources of data will be used and data in the CCAMLR database are likely to be considered.

Future Work

6.54    The Scientific Committee noted the considerable amount of work identified by WG-EMM which will be required in the future (Annex 4, paragraphs 10.1 to 10.52).  This work covers many aspects of WG-EMM's work including:  fisheries information, harvested species, methods, biomass survey, dependent species standard methods, environment, ecosystem analysis, and collaboration with IWC.

Advice to the Commission

6.55    Advice to the Commission in relation to precautionary catch limits for krill is given in paragraphs 6.33 and 6.34.

6.56    The Scientific Committee recommended that a workshop to consider the coherence of process relating to environment, krill and dependent species between Subareas 48.1, 48.2 and 48.3 be held during the intersessional period.