

## Development of a Strategy for Ecosystem Monitoring and Management

5.1 The Scientific Committee noted that WG-EMM reviewed its terms of reference (SC-CAMLR-XIII, paragraphs 7.41 to 7.43) and agreed that a useful synthesis of these was:

- (i) to provide advice on an ecosystem assessment combining information from dependent and harvested species and the environment; and
- (ii) to use this assessment to provide advice on management.

5.2 Development of an ecosystem assessment was seen as being fundamental to its role, and WG-EMM had agreed that an ecosystem assessment consisted of two parts:

- (i) an analysis of the status of key biotic components of the ecosystem; and
- (ii) a prediction of the likely consequences of alternative management actions on the future status of these components.

5.3 A simple schematic diagram of the components and linkages involved in monitoring and management of the Antarctic ecosystem is shown in Figure 1. The primary components are the environment, harvested species, dependent species and the fisheries. The system as a whole is completed by a link between these components and management approaches. The ecosystem assessment is conducted using information on the non-management components and linkages between them. The relevance to the components and links in Figure 1 of various ecosystem parameters, including those currently being assessed and reviewed by CCAMLR, is illustrated in Annex 4, Figure 2.

5.4 Strategic modelling is a vital tool in evaluating the procedures involved in an ecosystem assessment and in any system of providing management advice. In the context of the work of WG-EMM, a strategic model incorporates the biological and fishery components, the links between them, the procedures for ecosystem assessment and for the provision of management advice, and the resulting management actions. It is distinguished by explicit consideration of uncertainties and evaluation of the efficacy of management advice from the ecosystem assessment.

5.5 As a first step towards constructing a strategic model, WG-EMM developed a conceptual framework of the system processes in the Antarctic ecosystem. This is shown in Figure 2.

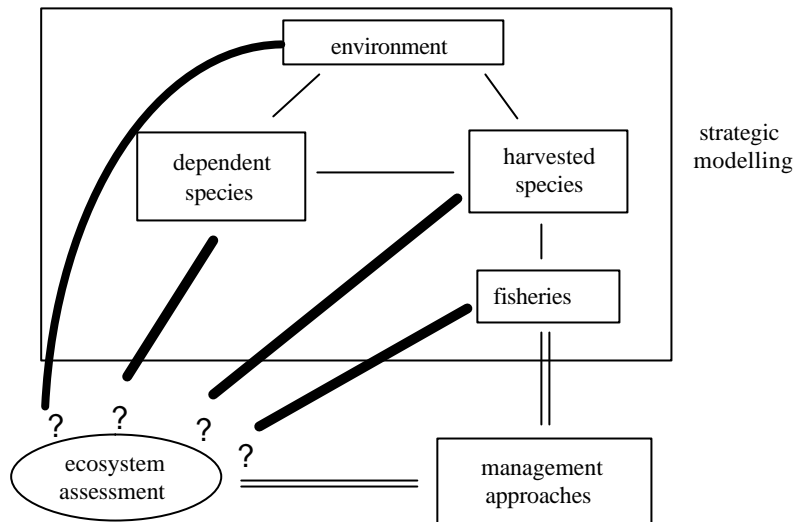


Figure 1: Schematic diagram of the processes involved in ecosystem monitoring and management. The basic ecosystem COMPONENTS are Environment, Dependent species, Harvested species and Fisheries. They interact via ecosystem LINKS (thin lines). They also all have an as yet undefined relationship (thick lines) with an 'ecosystem assessment' which incorporates ecosystem monitoring. Strategic modelling is the process whereby the links between components, and between components and the ecosystem assessment are evaluated. The final step in the scheme is the evaluation of management approaches, and the determination of its links with the ecosystem assessment (double lines).

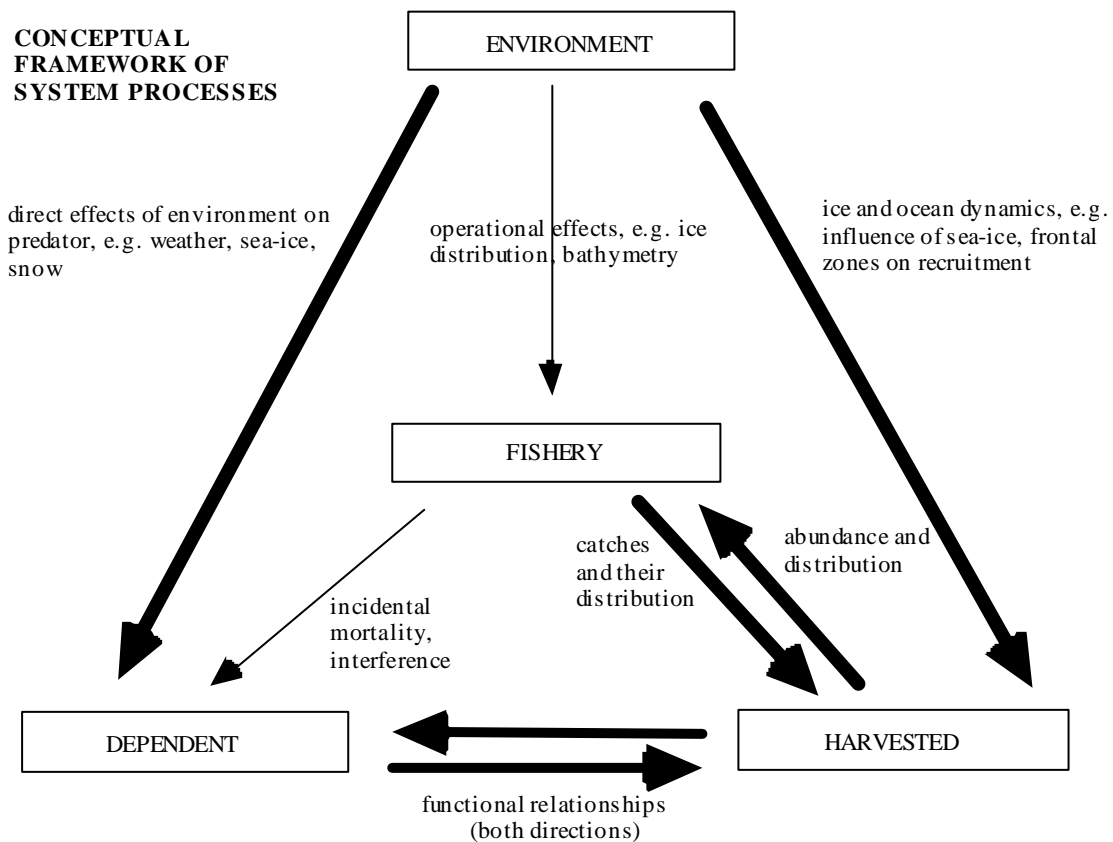


Figure 2: Conceptual framework of system processes. This figure describes the first step in a strategic modelling exercise and demonstrates the relationships between ecosystem components. The direction of arrows indicates the effect of one component on another, and the thickness of an arrow indicates the perceived importance of that link.

5.6 WG-EMM also conducted a preliminary review of the availability of existing models to describe the different components and links in this system, on both small (local) and large (regional) spatial scales. The availability of such models is essential if information on the key components is to be integrated into management advice. This review (Annex 4, paragraphs 7.47 to 7.60 and Figure 4) highlighted the fact that there are important components and linkages between them for which no models currently exist.

5.7 The Scientific Committee noted that this is the first time that a strategy for developing an ecosystem assessment for the Antarctic has been explicitly mapped out. Although clearly this represents only the first step in such a process, the Scientific Committee endorsed the approach taken by WG-EMM as being a very effective way to proceed. It also noted that the approach incorporates many of the components recommended by the FAO/Government of Sweden Technical Consultation on the Precautionary Approach to Fisheries (paragraphs 6.1 and 6.2), and as such it fits in with the latest views.

5.8 Both at WG-EMM (Annex 4, paragraphs 9.9 and 9.10) and subsequently in a paper to this meeting (SC-CAMLR-XIV/8), Dr Kock had proposed the preparation of a high quality booklet describing in non-specialised language the CCAMLR approach to ecosystem monitoring and management. This would not only be a useful guide for the CCAMLR community, but it would also assist in raising the profile of CCAMLR in international scientific and fisheries management communities.

5.9 The Scientific Committee endorsed this proposal and recommended that a subgroup (Dr Agnew, Prof. D. Butterworth (South Africa), Drs de la Mare, Everson, Miller, Naganobu and Miss R. Thomson (South Africa)) work with Dr Kock by correspondence in the intersessional period, with a view to presenting a first draft of the booklet for consideration at the next meeting of the Scientific Committee. It also agreed that the work of WG-EMM should be communicated to the wider scientific community through a WG-EMM newsletter to be written by the Convener (Dr Everson).

#### Review of Current Knowledge on Dependent Species, Harvested Species and the Environment

5.10 Considerable time was devoted by WG-EMM to reviewing current knowledge on the status of dependent and harvested species and on the environment, with particular emphasis on interactions amongst them. Detailed discussion of these topics is found in sections 4, 5 and 6 of Annex 4, with further information on linkages being given in paragraphs 7.16 to 7.19 of Annex 4. The findings

directly relating to krill were discussed under Agenda Item 4 and dependent species under Agenda Item 3 of the Scientific Committee (see paragraphs 4.1 to 4.31). A brief summary of discussions on environmental variables and of the findings on linkages is given below.

## Environment

5.11 The value of a review of historical data on water mass distribution was emphasised. Issues of access to such data and the facilitation of analyses should be reviewed (Annex 4, paragraphs 6.2 to 6.4). The acquisition of comprehensive bathymetric and sea surface temperature (SST) data by the Secretariat should also be pursued.

5.12 Dr Marín advised the Scientific Committee of plans to develop a database as part of a Geographic Information System (GIS), which would include digitised bathymetric data for the region north of the South Shetland Islands. Notice of a related workshop on the use of information technology and GIS is given in SC-CAMLR-XIV/BG/33. It may be possible to arrange the extraction of relevant data for submission to CCAMLR. The Scientific Committee encouraged dialogue on this, believing that the provision of such information could greatly facilitate the work of WG-EMM.

5.13 Dr Siegel emphasised the importance of analysing data that allowed the detection of both interannual and decadal changes. He reported preliminary plans for a workshop to analyse such data and advised that a more formal proposal will be tabled at the next meeting of WG-EMM.

5.14 The Scientific Committee noted that a number of prey-based analyses of environmental data, which investigated the effects of large-scale and continental shelf water circulation, sea-ice and climate on krill and krill flux, had been discussed at WG-EMM (Annex 4, paragraphs 6.8 to 6.21). Other papers had reported results of integrated ecosystem analyses of environmental data (Annex 4, paragraphs 6.22 to 6.32).

5.15 In relation to sea-ice, a task group to be convened by Dr Miller was set up by WG-EMM to facilitate the formulation of specific hypotheses on the potential effects of sea-ice on components of the Antarctic marine ecosystem (see Annex 4, paragraph 6.49 for membership and terms of reference). This group is to work intersessionally and report to the next meeting of WG-EMM.

## Relationships Between Dependent Species and Other Ecosystem Components

5.16 The Scientific Committee noted that progress has been made in modelling functional relationships between krill and several dependent species (black-browed albatross, fur seals and Adélie penguins - see Annex 4, paragraphs 5.104 to 5.112). Final calculations for the albatross and fur seal models should be completed by the 1996 WG-EMM meeting. Work on the Adélie penguin model may take longer to complete.

5.17 Progress has also been made on the evaluation of krill selectivity by predators (Annex 4, paragraphs 5.114 to 5.118). This is an important input to the krill yield model. The principal problem is still the ability to obtain fully representative length frequency distributions of krill, given the effects of different spatio-temporal scales of sampling. It was believed, however, that for most major predators diet and scat samples do provide representative samples of the length frequency of krill consumed by them. Progress is also being made on other approaches to this problem, as indicated in Annex 4, paragraphs 5.119 to 5.124.

## Overlap Between Krill Harvesting and Dependent Species Foraging Areas

5.18 The nature and significance of the overlap between the location of krill fisheries and the foraging areas of krill-dependent predator species during the breeding season is a vital link in the Antarctic ecosystem. This interaction is currently assessed through the critical period-distance (CPD), which at present is taken to be a range of 100 km from breeding sites over the period December to March inclusive. Data on the overlap between the location of krill fishing and predator CPDs were provided to WG-EMM by the Data Manager (Annex 4, paragraphs 5.88 to 5.91).

5.19 At WG-EMM, the Data Manager reported that in 1995 there had been a substantial increase in the catch of krill by Ukraine in Subareas 48.1, 48.2 and 48.3. Paper SC-CAMLR-XIV/BG/3 analysed data on the overlap between krill fishing and predator CPDs. This demonstrated that most of the increased catch in 1995 was taken in Subarea 48.2 outside predator CPDs, and that overall the degree of overlap was similar to that in 1994. Further information on Ukrainian krill fishing in 1995 is given in SC-CAMLR-XIV/BG/29.

5.20 A number of potential difficulties associated with the use of the CPD were identified by WG-EMM, and different views were expressed as to whether application of the CPD concept under- or over-estimates the extent of overlap between predators and krill fishing (Annex 4, paragraphs 7.25 to 7.34). The interaction is complex, and it is very important that more empirical studies be

undertaken. The Scientific Committee agreed that the concept and details of the CPD needed further critical re-examination. It noted that this topic will be considered further at the next meeting of WG-EMM.

#### Taking Account of Land-based Predator Populations when Setting Precautionary Catch Limits

5.21 A proposal was made at WG-EMM that local precautionary catch limits for krill should be set taking into account the krill requirements of land-based predators (WG-EMM-95/17). The aim was to develop methods that would produce management advice designed to meet the aims of Article 2 of the Convention. Extensive discussion of this proposal is reported in Annex 4, paragraphs 7.61 to 7.76.

5.22 The Scientific Committee endorsed the following conclusions of WG-EMM:

- (i) there is a continuing need to ensure that krill catches are not concentrated in such small areas and over such short periods of time that local populations of dependent species may be adversely affected;
- (ii) when determining precautionary catch limits, and subdividing precautionary limits set for larger areas, as much relevant environmental and biological information as possible should be used; and
- (iii) the approach in WG-EMM-95/17, which makes use of extensive predator food consumption data, represents a valuable new thrust towards achieving these goals.

5.23 The Scientific Committee noted that a small subgroup, coordinated by Drs Everson and Boyd, was to carry out further work intersessionally on the incorporation of information on predator demand in the calculation of precautionary catch limits and their allocation to subarea in Area 48 (Annex 4, paragraphs 7.77 to 7.80 and Appendix H).

#### Other Interactions

5.24 Several other interactions between dependent species, harvested species and the environment were noted. These include links between sea-ice, krill abundance and penguin breeding (Annex 4, paragraphs 7.7 to 7.9); penguin chick starvation at Béchervaise linked to poor krill

availability (Annex 4, paragraphs 7.10 to 7.11); the effect of krill flux and other factors on local krill availability (Annex 4, paragraphs 7.12 to 7.15); patterns of breeding success of birds at Bird Island and the South Orkneys linked to krill and the environment (Annex 4, paragraphs 7.16 to 7.19); and the small numbers of albatross breeding linked to snowfall (Annex 4, paragraphs 7.20 to 7.22).

#### Preliminary Ecosystem Assessment

5.25 The Scientific Committee noted that for an ecosystem assessment, it was essential that integrated data be available on population size, adult survival rate, reproductive rate and recruitment of dependent species. At present, such data are only available for:

- Subarea 48.3 - Antarctic fur seal (South Georgia)  
Black-browed albatross (South Georgia)
  
- Subarea 48.1 - Adélie and gentoo penguin (King George Island)  
Adélie penguin (Palmer)
  
- Division 58.4.2 - Adélie penguin (Béchervaise).

Historical data covering all these variables are available for Adélie penguins at Cape Crozier and crabeater seals in Subarea 48.1.

5.26 WG-EMM attempted to draw together into a preliminary ecosystem assessment the information presented to it on the status of krill populations and the krill fishery, the status of dependent species, and the interactions amongst dependent species, harvested species and the environment (Annex 4, paragraphs 7.81 to 7.93). Discussions centred around summary tables of this information, which were similar to those previously used by WG-CEMP for dependent species only (Annex 4, Tables 3.1 to 3.10).

5.27 A lack of time during the meeting to complete some sections of these tables and the subjective nature of the interpretation of trends led WG-EMM to conclude that it was not yet possible to use this information to develop an ecosystem assessment. WG-EMM then identified a number of steps that needed to be taken urgently to improve the usefulness of the information and the tables. These are listed in Annex 4, paragraph 7.96. These topics were referred for consideration by the ad hoc intersessional Subgroups on Statistics and Methods.

## Interactions with WG-FSA

5.28 WG-EMM discussed several research topics relating to fish-based dependent species/harvested species interactions. These included: the continuing status of *Pleuragramma antarcticum* as a CEMP species; the use of the diet of blue-eyed shags for providing local indices of abundance for *N. rossii* and *G. gibberifrons*; and the species and amounts of fish in the diets of king penguins and fur seals (see Annex 4, paragraphs 5.129 to 5.135).

5.29 The growing importance of considering such fish-based interactions in the deliberations of WG-EMM was recognised. This highlights the need for coordination of studies and evaluation of results between WG-EMM and WG-FSA.

5.30 The Scientific Committee noted that WG-FSA had also discussed several topics of relevance to WG-EMM, including some that arose directly from the report of the intersessional WG-EMM meeting. It had also directly posed some questions for consideration by WG-EMM. These are discussed in Annex 5, paragraphs 6.1 to 6.15.

5.31 A topic of particular relevance to both Working Groups is the by-catch of fish in the krill fishery. Two papers tabled at WG-EMM had been referred to WG-FSA for further consideration, and a further analysis of data in one of these papers was also tabled at WG-FSA. These are discussed in Annex 5, paragraphs 6.16 to 6.22. WG-FSA had concluded that it was still unable to provide a clear indication of the likely impact of krill harvesting on juvenile fish.

5.32 Dr Yakovlev suggested that, since the topic had been under discussion for several years, it was now time to indicate a by-catch limit for fish in the krill fishery.

5.33 The Scientific Committee noted that there were four components to the problem: the fish species, the location of hauls, the time of year and the amount of by-catch taken. All of these would need to be considered by the Scientific Committee in developing its management advice.

5.34 The Scientific Committee noted that a correspondence group coordinated by Dr E. Sabourenkov (Secretariat) planned to work intersessionally on this topic (Annex 5, paragraph 6.24), and that fish by-catch would be allocated a specific agenda item at next year's meeting of WG-FSA.

5.35 Mr Ichii welcomed the constructive criticism that had been made of the studies of fish by-catch on Japanese krill vessels in relation to the extent of their coverage in space and time. He noted, however, that four studies have now been completed and reported by Japanese and US



scientists (e.g., WG-EMM-95/56 and SC-CAMLR-XIV/BG/10 Rev. 1), and that despite difficulties in interpretation, the results all suggest that the by-catch in areas where Japanese vessels fish is low. He also pointed out that Japanese krill trawlers will avoid areas where a high level of fish by-catch occurs in order to ensure good quality product. He advised that these studies will continue. The Scientific Committee welcomed this and looked forward to receiving the results.

5.36 The Scientific Committee welcomed the interaction that was taking place between the two Working Groups.