

REPORT OF THE JOINT MEETING OF THE WORKING GROUPS ON KRILL AND CEMP

7.1 The second joint meeting of WG-Krill and WG-CEMP was held in Cape Town, South Africa between 27 July and 2 August 1994. It was chaired by the Chairman of the Scientific Committee, Dr K.-H. Kock. The report of the meeting is attached as Annex 7.

7.2 The objectives of the meeting were set out at last year's Scientific Committee meeting (SC-CAMLR-XII, paragraph 15.4) and its primary objective was to facilitate interaction between WG-Krill and WG-CEMP on matters of common concern. Specific items chosen by the Scientific Committee for consideration are contained in SC-CAMLR-XII, paragraphs 8.14, 8.22 and 15.5. These include the development of models to evaluate various aspects of experimental harvesting regimes, a review of the scope of CEMP monitoring with respect to predators and prey, fine-scale fisheries data obtained within predator foraging ranges, indices of krill availability and year-class strength, the incorporation of predator-derived indices into the development of approaches to manage the krill fishery and the future organisation of the work of WG-Krill and WG-CEMP.

PREY MONITORING (Annex 7, paragraphs 3.1 to 3.18)

7.3 The Scientific Committee endorsed the joint meeting's deliberations set out in Annex 7, paragraphs 3.1 to 3.18.

7.4 In particular, it was noted that with respect to the availability of krill biomass estimates within the Integrated Study Regions (ISRs), the boundaries for each of the three ISRs enclose a large area. These were originally chosen, *inter alia*, as regions where krill harvesting has taken place, krill surveys have been undertaken, and which were presumed to encompass important foraging areas for predators to be monitored (SC-CAMLR-V, Annex 6, paragraphs 11 and 12).

7.5 The Scientific Committee endorsed the joint meeting's conclusion that these boundaries were useful in the above context, but added that it may not be necessary to conduct surveys of krill biomass over the regions in their entirety (Annex 7, paragraph 3.10).

7.6 It also accepted that there are problems in comparing biomass estimates from different sized areas and that krill density is a more appropriate measure for such comparisons.

PREDATOR MONITORING (Annex 7, paragraphs 3.19 to 3.23)

7.7 The Scientific Committee noted the review of the important work being undertaken within CEMP.

ECOSYSTEM INTERACTIONS (Annex 7, paragraphs 4.1 to 4.40)

Distribution of Krill Fishing and Predators (Annex 7, paragraphs 4.1 to 4.13)

7.8 The Scientific Committee welcomed the work undertaken by Japanese scientists as the most detailed attempt so far to investigate interactions between penguins, fisheries and krill at an appropriate scale.

7.9 In respect of the reservations expressed about the above work, particularly the interpretation of the results (Annex 7, paragraph 4.3), the Scientific Committee welcomed the joint Japanese/US initiative, planned for the forthcoming austral summer, to investigate further potential interactions between predators, the fishery and krill in the Elephant Island region (Subarea 48.1).

7.10 The Scientific Committee further agreed that pursuing the question of potential predator-fisheries interactions at various scales is of great importance to CCAMLR (Annex 7, paragraph 4.4).

7.11 It is equally important that the collection of any data to examine such interactions should be accompanied by theoretical work aimed at establishing how such data can be used in management. Also, both theoretical work and data collection should proceed jointly. In particular, it is essential that data collection be evaluated in respect of additional observations necessary to resolve ambiguities in the interpretation of current data (Annex 7, paragraph 4.5).

7.12 The continuation of modelling studies at scales which examine the combined effects of fishing and krill flux on krill availability within predator foraging areas (Annex 7, paragraphs 4.6 and 4.37 to 4.39) was encouraged.

7.13 The Scientific Committee noted that further breakdown of flux calculations at finer scales more relevant for predators may be required. The importance of refining estimates of krill flux at the scales currently being used and through the acquisition of new data sets (Annex 7, paragraph 4.13), particularly at finer scales than at present, was recognised.

7.14 The Scientific Committee endorsed the joint meeting's suggestion that studies of predator foraging should be continued in order to investigate behavioural interactions between krill predators and their prey (Annex 7, paragraph 4.8). Such studies are also likely to be useful in improving quantitative definitions of predator-prey interactions.

7.15 In this connection, the Scientific Committee noted the Data Manager's development of a generalised index to describe overlap between predators and fishery and agreed that this work has been taken as far as possible at this stage (Annex 7, paragraphs 4.9 to 4.11). The Secretariat was requested to continue to calculate the catch of krill taken within the critical foraging period-distance.

7.16 The Scientific Committee further agreed that discussion of the full implications of studies of predator-fishery interactions should be carried forward.

Effect of Potential Precautionary Measures (Annex 7, paragraphs 4.14 to 4.17)

7.17 Reviewing the joint meeting's deliberations, the Scientific Committee commended the Data Manager on his efforts to develop a model setting out the perceived consequences of various management measures on the krill fishery. It agreed that further development of this model is unnecessary at this stage, but interested parties were encouraged to proceed with validation of the model and develop proposals for parameter re-definitions. The development of alternative models was also encouraged.

7.18 The Scientific Committee noted the concerns expressed about the relationship of the model to the operational requirements of fishing (Annex 7, paragraph 4.16). It recollected its request that fishing Members provide some indication of how they perceive some of the implications identified by the model in relation to their fishing operations (SC-CAMLR-XII, paragraphs 8.42 to 8.44). Fishing nations were therefore requested to submit their views on this matter to the next meeting of the Working Group.

Krill/Predator Functional Relationships (Annex 7, paragraphs 4.18 to 4.40)

7.19 The Scientific Committee noted that the joint meeting had focused its attention on refining the Butterworth/Thomson model (WG-Krill-93/43 and 24) which aims to describe krill-predator functional relationships. Suggested improvements include refinement of input parameters (e.g., survival of juvenile krill), discussion of the mathematical formulation for functional relationships

between predator survival and krill biomass in modelling density-dependence, mechanisms to deal with modelling error, possible effects of prey size selectivity on age-dependent natural mortality of krill and appropriate levels of krill escapement necessary to meet predator needs (Annex 7, paragraphs 4.21 to 4.32).

7.20 The Scientific Committee noted that work on most of these aspects of the Butterworth/Thomson model will be carried out during the forthcoming intersessional period.

7.21 The Scientific Committee noted that placing nominal bounds on the acceptable levels of escapement had proved to be useful in developing management advice. Usually this level is taken to be about 0.5 of the spawning population in a single species fishery context. However, this ignores dependent and related species within the provisions of Article II.

7.22 In the absence of quantitative assessment of predator responses to different levels of escapement, the Scientific Committee noted that the joint meeting had proposed a target escapement level of 0.75 which is intermediate between the 0.5 (traditional single species fishing level) and 1.0 (no fishing) 'extremes'. It agreed this target value could be revised in the light of new information both from the models currently being developed and from predator data (paragraph 5.18 and Annex 7, paragraph 4.32).

7.23 Particular note was taken of the possible effects of prey selectivity by predators on age-dependent natural mortality of krill along with the need for further investigation of the effects of predator consumption on the 2+ krill year class (Annex 7, paragraphs 4.34 and 4.35).

7.24 The Scientific Committee noted various other approaches to the modelling of predator/prey fisheries interactions considered by the joint meeting, particularly insofar as these attempt to relate prey flux with predator foraging demands at a local level (Annex 7, paragraphs 4.36 to 4.40), and in one case with environmental variability (position of the ice edge) as well. Further development of these models was encouraged in the interests of improving the capacity for comparing results from different modelling approaches.

ECOSYSTEM ASSESSMENT (Annex 7, paragraphs 5.1 to 5.34)

7.25 Having endorsed the joint meeting's deliberations on this topic, and on the development of prey, predator and fishery indices in particular, the Scientific Committee noted the difficulties identified by the meeting in this regard (Annex 7, paragraphs 5.1 to 5.22). Despite recent advances in the submission of fisheries data (Annex 7, paragraph 5.8), there was still a number of unresolved

issues, particularly with regard to analysing fine-scale catch data from the former Soviet fleet (Annex 7, paragraph 5.9).

7.26 Although the Scientific Committee recognised that some expressions of CPUE, such as catch per towsing time, may be useful in providing information about local concentrations of krill abundance, it acknowledged that it is not possible to use currently submitted CPUE data as one of the indices for assessment of prey abundance/availability in comparisons with predator indices derived from CEMP (Annex 6, paragraph 5.15). Consequently, the Scientific Committee agreed to encourage further development of fishery-based indices using catch information.

7.27 The Scientific Committee noted that, at least in the near future, the provision of prey abundance and availability indices relevant to the CEMP Program will depend extensively on fishery-independent information (Annex 6, paragraph 5.16).

7.28 The Scientific Committee reiterated that as far as CEMP prey monitoring surveys are concerned, a minimum requirement is for annual surveys of at least part of each ISR.

7.29 The Scientific Committee noted that the above conclusions indicate that evaluating changes in predator populations in relation to changes in prey, taking due account of environmental variability, and how together these may affect predators, prey, or both within the ISRs, may be more difficult than previously envisaged.

7.30 The Scientific Committee agreed that this topic should be reviewed at the earliest opportunity by WG-EMM (see paragraphs 7.40 and 7.41 below). It will be necessary to address questions of whether it is best to proceed in future by (Annex 7, paragraph 5.23):

- (i) attempting to increase the number and frequency of prey surveys in ISRs and to facilitate the acquisition of complementary environmental data;
- (ii) defining and developing more appropriate prey indices;
- (iii) developing a suite of different approaches to management measures involving predator/prey interactions, which do not necessarily require the close linkage of data from predators, prey and environment in the same way as hitherto attempted; or
- (iv) some combination of (i) to (iii) above.

7.31 The Scientific Committee agreed that to improve the development of an ecosystem-based management approach, it is necessary to improve current understanding of both the structure and dynamic functioning, including temporal and spatial variability, of the Antarctic marine ecosystem (Annex 7, paragraph 5.24).

7.32 Members were urged to submit proposals aimed at identifying variables most likely to indicate trends in important ecosystem components, especially for prey, hydrography and weather, on various spatial (e.g., areas/subareas, ISRs, fishing grounds) and temporal scales (e.g., interannual, intraseasonal).

7.33 WG-CEMP's past progress in addressing this issue specifically for predators was noted and the Scientific Committee agreed that it offers a useful basis on which to proceed (Annex 7, paragraph 5.26).

7.34 With respect to integrating predator, prey, environmental and fishery indices into ecosystem assessments and, ultimately, the formulation of management advice, the Scientific Committee acknowledged progress reported by both WG-CEMP and WG-Krill (Annex 7, paragraph 5.27).

7.35 In terms of CEMP Experimental Approaches (Experimental Fishing Regimes) as a means of investigating cause/effect relationships between the potential impact of fisheries and predator performance, the Scientific Committee agreed that these should not proceed without formalising the precise objectives of any experiment and thoroughly evaluating its feasibility. It was noted that Members had been requested to undertake such tasks, but no proposals or evaluations had been forthcoming (Annex 7, paragraphs 5.28 and 5.29).

7.36 The Scientific Committee also noted that continuing to measure and evaluate annual variations in predator, prey and environmental parameters increases the possibility of formulating well defined hypotheses to be tested by future experimental perturbations. Such measurements also serve to establish baselines against which to assess any detected changes in selected parameters. In the meantime, sharp fluctuations in the natural variability of various parameters (e.g., local krill availability) can be considered as a form of natural experiment which may facilitate the development of suitable hypotheses for future work (Annex 7, paragraph 5.30).

7.37 The Scientific Committee concurred with the joint meeting's conclusion that given the difficulties which have become apparent in developing assessments using some combination of predator, prey and environmental data from those submitted to the CEMP database, and the likelihood that the situation will not improve markedly in the near future, greater priority should be given to considering how assessments of predator population status, trends, reproductive

performance, diet and demography can contribute to the formulation of management recommendations for the krill fishery (Annex 7, paragraph 5.31).

7.38 The Scientific Committee noted that papers addressing the general issue of incorporating ecosystem assessments into management advice have been tabled at past CCAMLR meetings and encouraged Members to present these and other suggestions at the next meetings of the appropriate Working Groups.

ORGANISATION OF FUTURE WORK (Annex 7, paragraphs 6.1 to 6.12)

Re-organisation of the Scientific Committee's Working Groups
(Annex 7, paragraphs 6.1 to 6.9)

7.39 The Scientific Committee had requested the joint meeting's advice on re-organisation of the Committee's work (SC-CAMLR-XII, paragraph 15.16).

7.40 The Scientific Committee agreed that in order to integrate better the work currently being undertaken by WG-Krill and WG-CEMP, these two Working Groups should be combined into a single group under one convener. The new Working Group will be called the 'Working Group for Ecosystem Monitoring and Management' (WG-EMM).

7.41 Recalling that Article II of the Convention requires the conservation of harvested populations, the maintenance of ecological relationships between harvested, dependent and related populations, the restoration of depleted populations and the minimisation of the risk of irreversible changes in the Antarctic marine ecosystem, the Scientific Committee agreed that the terms of reference for WG-EMM are to:

- (i) undertake assessments of the status of krill;
- (ii) undertake assessments of the status and trends of dependent and related populations including the identification of information required to evaluate predator/prey/fisheries interactions and their relationships to environmental features;
- (iii) undertake assessments of environmental features and trends which may influence the abundance and distribution of harvested, dependent, related and/or depleted populations;

- (iv) identify, recommend and coordinate research necessary to obtain information on predator/prey/fisheries interactions, particularly those involving harvested, dependent, related and/or depleted populations;
- (v) liaise with WG-FSA on matters related to stock assessment;
- (vi) develop further, coordinate the implementation of, and ensure continuity in the CCAMLR Ecosystem Monitoring Program (CEMP); and
- (vii) taking into account the assessments and research carried out under the terms of reference (i) to (v) above, to develop management advice on the status of the Antarctic marine ecosystem and for the management of krill fisheries in full accordance with Convention Article II;

Pursuing these terms of reference will require, *inter alia*, that WG-EMM:

- (a) develop assessment methods, including survey methods for predators and prey, and standard methods for monitoring dependent and related species together with environmental conditions;
- (b) continue efforts aimed at utilising the best available technology and at developing standard methods for the collection, recording, reporting and analysis of biological, environmental, fishery and other data pertinent to fulfilling the terms of reference;
- (c) develop models for predator and prey populations, their direct interaction with each other, and their potential interactions with fisheries and the environment;
- (d) coordinate relevant research activities; and
- (e) develop and evaluate approaches to managing krill fisheries, taking account of current and future patterns of harvesting.

7.42 The Scientific Committee also identified the following priority activities to be undertaken by WG-EMM (Annex 7, paragraph 6.10):

- further work on the determination of krill flux in Statistical Area 48, especially in relation to predators (Annex 7, paragraph 4.7) and with consideration of temporal as well as spatial variation;

- investigation of options for decision rules (in addition to those implicit in the bullet following) for the calculation of appropriate levels, distribution and timing of krill harvesting (Annex 7, paragraph 4.33);
- further work on the functional relationship between predators and prey, especially involving further determination of the parameters for and formulation of the Butterworth/Thomson model (Annex 7, paragraphs 4.25 to 4.30);
- further evaluation of the significance of localised interactions between krill harvesting and krill-dependent predators and identification of suitable approaches for further research initiatives and management measures; and
- review of the links between prey, predator and environmental data within the scope of the CEMP Program (Annex 7, paragraphs 5.22 to 5.25).

7.43 The Scientific Committee agreed that the important ongoing intersessional tasks and submission of data requirements identified by WG-CEMP (Annex 6) and WG-Krill (Annex 5, Tables 3 and 4), as well as those listed by the joint meeting (Annex 7, paragraph 6.8), should be carried out by WG-EMM. Tasks requiring work by *ad hoc* groups during the 1994/95 intersessional period include:

- (i) evaluation of proposals for new CEMP methods;
- (ii) evaluation of new statistics and methods of analysis of CEMP data;
- (iii) evaluation of any new proposals for CEMP site protection;
- (iv) development of standard methods for measurement of foraging performance of predators;
- (v) continuation of the analysis of krill flux;
- (vi) estimation of krill biomass and evaluation of acoustic methods, and
- (vii) continuation of work on yield and functional relationship models.

7.44 The Scientific Committee noted that in order to address effectively the diverse range of tasks, WG-EMM will require wide participation by scientists in a variety of specialist fields (Annex 7, paragraph 6.9).

7.45 To facilitate the efficient and ongoing development of its advice to the Commission on krill harvesting and ecosystem assessment the Scientific Committee recommended that WG-EMM should meet in 1995 for about 10 days.