ANNEX 7

REPORT OF THE MEETING OF THE WORKING GROUP FOR THE DEVELOPMENT OF APPROACHES TO CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES (WG-DAC)

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The Commission's Working Group for the Development of Approaches to the Conservation of Antarctic Marine Living Resources (WG-DAC), chaired by Australia, held its meeting at CCAMLR-IX on 21 October 1990.

2. The Convener had written to Members on 8 August 1990 (COMM CIRC 90/36) suggesting that the Working Group concentrate on two issues in 1990;

- the development of approaches to achieve the conservation objective in Article II 3 (b); the restoration of depleted populations to levels which ensure stable recruitment; and

- what constitutes the 'best scientific evidence available' that Article IX 1 (f) requires the Commission to use as the basis for formulating, adopting and revising Conservation Measures.

The Working Group adopted the agenda prepared by the Executive Secretary which provided for consideration of these two items.

3. Two papers were submitted in response to the Convener's letter, both by Australia; 'Refinements to the Strategy for Managing Depleted Fish Stocks based on CCAMLR Objectives' also submitted as SC-CAMLR-IX/BG/14 (Appendix 1), and 'The Making of Management Policy Decisions' (WG-DAC-90/5) (Appendix 2).

4. Australia presented SC-CAMLR-IX/BG/14 (Appendix 1). The paper gave some specific illustrations which show that the Commission's current policy of basing fishing mortality on $F_{0.1}$ is not appropriate for depleted stocks. It outlined a possible extension to the Commission's policy for managing depleted stocks. This extension involved setting TACs (which in practice would usually be by-catch limits) which would be in accord with the general objectives given in Article II for restoring depleted stocks to levels near those giving 'greatest net annual increment' within two or three decades. The paper illustrated in principle how these catch limits could be calculated for specified levels of probability of achieving the requisite stock recovery. One of the features of the method is that it takes uncertainty in stock assessments into account. The paper included a number of technical details which were expected to be discussed in the Scientific Committee.

5. The paper addressed some implications of the method for operational definitions of ‘depletion’ and ‘target levels for recovering stocks’. These were questions which WG-DAC had requested the Scientific Committee to consider, and it was intended that the paper would provide a basis for further development of responses to these questions. The illustrative calculations showed that uncertainty in stock assessment and the relationship between stock-size and recruitment were both very important in determining by-catch limits.

6. WG-DAC concluded that the approach outlined in the paper was worth further development as a means for providing an objective basis for determining by-catch limits for depleted stocks. It was recognised that considerable further developments were required before the procedure was complete. WG-DAC and the Commission will need to give further consideration to operational definitions of the type illustrated in the paper which take uncertainty into account. WG-DAC reiterated the importance of the Scientific Committee working towards operational definitions for ‘depletion’ and ‘target levels for recovery’ and providing further advice as soon as possible. It was further recognised that refinement of the Commission’s policy for managing the recovery of depleted stocks would be assisted by operational procedures for determining the level of ‘greatest net annual increment’. Article II 3 (a) specifies the level above which stable recruitment is deemed to occur as ‘a level close to that which ensures the greatest net annual increment’. An operational definition for the words ‘close to’ will also be required.

7. Australia then presented WG-DAC-90/5 (Appendix 2), outlining the relative responsibilities of the Commission and Scientific Committee in relation to the collection and analysis of scientific information and the adoption of Conservation Measures, as provided for under the Convention, and noting the comments of the Convener of the Working Group for Fish Stock Assessment (WG-FSA) in his personal statement to CCAMLR-VIII (CCAMLR-VIII, Annex F) on the issue.

8. It was argued that the Commission must make two judgements in meeting its obligation under Article IX 1 (f) to formulate, adopt and revise Conservation Measures on the basis of the best scientific evidence available; what is the best scientific evidence, and what management action it indicates. Guidance to the Commission on how to make the second of these judgements is contained in Article II of the Convention. The only guidance the Convention gives in relation to the first is that the Commission should take full account of the decisions and recommendations of the Scientific Committee.

9. Examples of the decision making process in the Commission and the process of formulating advice in the Scientific Committee were given, some of which showed where no management action had been taken despite available evidence indicating the need for it. It was noted that the direction to act on the best scientific evidence available suggests that it does not matter to what degree of

certainty the available evidence indicates a particular action, if it is the best scientific evidence available the Commission is obliged to act on it, and that instances such as those described could be seen as the Commission failing to meet its obligations under Article IX.

10. WG-DAC considered these issues and recommended that the Commission acknowledge that it regards the Scientific Committee as the source of the best scientific evidence available, and that it would not therefore be appropriate for management decisions to be based on data and information which had not been provided to the Scientific Committee in a timely fashion. This would highlight the importance of Members meeting their obligation under Article XX to provide necessary data and information. WG-DAC further suggested that, if the Commission finds itself unable to act on the Scientific Committee's advice, it should make clear what evidence it is acting on.

11. In considering this issue, WG-DAC recalled earlier discussions and emphasised the need for the Scientific Committee to present advice to the Commission which takes account of the uncertainty in the evidence on which it is based and which clearly indicates the implications of the adoption of different management responses. The implications for the Scientific Committee in attempting to take account of uncertainty in their advice were discussed, and it was pointed out that there were two main reasons for uncertainty in this context; lack of necessary data, and divergent, or imprecise conclusions from analyses of available data. The Working Group concluded that both sources of uncertainty must be addressed.

12. At CCAMLR-VII, WG-DAC had agreed that information on plans for fishery development and descriptions of operational tactics applied to fishing activities were important in the development and evaluation of approaches to conservation. WG-DAC reiterated the value of this information for this purpose and in formulating future management and research work programs.

13. At CCAMLR-VIII, WG-DAC had identified the approach to be taken in relation to new and developing fisheries as a key topic for consideration by the Commission (CCAMLR-VIII, paragraph 66), and the Commission referred questions which had arisen from consideration of the issue to the WG-FSA (CCAMLR-VIII, paragraph 123). WG-DAC noted that the WG-FSA had responded and that their response would be examined by the Commission under Item 9 of its Agenda.

APPENDIX 1

REFINEMENTS TO THE STRATEGY FOR MANAGING DEPLETED FISH STOCKS BASED ON CCAMLR OBJECTIVES

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Abstract

A method of calculating fishing mortalities which will allow depleted fish stocks to recover to levels near those giving greatest net annual increment within two to three decades is illustrated. These fishing mortalities are based on probabilistic descriptions of the future states of a depleted stock, and take into account uncertainty in assessments. Sample calculations show that applying a policy of $F_{0.1}$ will not always lead to stock recovery in two to three decades, and hence that additional management policies are required for depleted stocks. The implications of these studies for defining the terms 'depleted' and 'target levels for recovery' are briefly discussed.

In 1988, the Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources (WG-DAC) suggested that the interpretation of Article II of the CCAMLR Convention would be assisted by the development of operational definitions for depletion and for target levels for recovery of depleted populations (CCAMLR-VII, paragraph 140). In 1987, the Commission adopted the yield-per-recruit fishing mortality $F_{0.1}$ as the appropriate management strategy for fish stocks (CCAMLR-VI, paragraph 61). The studies in this paper explore an approach to calculating values of fishing mortality (F) other than $F_{0.1}$ which are more appropriate in terms of the requirements of Article II of the Convention for fish stocks which have been reduced to low levels. This approach represents a starting point for extending the management strategy to the case of depleted fish stocks, and points to factors to consider in formulating operational definitions of depleted and target levels for recovery.

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2. The part of Article II directly applicable to harvesting objectives states:

> '3 Any harvesting and associated activities in the area to which this Convention applies shall be conducted in accordance with the provisions of this Convention and with the following principles of conservation:
>
> (a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment;
>
> (b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in sub-paragraph (a) above; and
>
> (c) prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the direct and indirect impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem and of the effects of environmental changes with the aim of making possible the sustained conservation of Antarctic marine living resources.

3. From these general objectives, several key concepts relevant to the management of depleted stocks stand out:

(i) depleted populations are below levels near to the population level giving greatest net annual increment (GNAI);

(ii) the minimum population level posited to ensure stable recruitment is equated with GNAI; and

(iii) the effects of exploitation should be compatible with potential reversibility in two or three decades, taking into account the state of available knowledge of, *inter alia*, the direct and indirect impact of harvesting.

4. The general objectives need to be supplemented to render their meaning more precise for the purposes of formulating advice in the Scientific Committee. It is very unlikely that in the near term

that levels of GNAI for various stocks will be able to be estimated directly. Thus, levels will probably be chosen on the basis of conventional fisheries models. Similarly, identifying stock-recruitment (S–R) relationships will also be extremely difficult, and some form of model will have to be selected which is compatible with the concepts (i), (ii) and (iii) above.

5. A further factor to take into consideration is some practical way is the state of available knowledge about the stocks. Inevitably assessments of the state of a stock will include uncertainty, for example, due to sampling variability. This uncertainty needs to be taken into account when formulating management advice.

6. A framework which integrates the elementary concepts above can be formulated as follows. An assessment is made of a fish stock, using whatever methods and data are available, to estimate the current stock level and the mean stock level which would exist without fishing. If the 'best' estimate of current stock level is substantially below GNAI (expressed as a fraction of the unfished mean stock level) then it is deemed to be depleted and hence fishing mortality must be set at levels which should not preclude stock recovery to GNAI (or other target level) within two or three decades. A 'best' estimate would be the mean or median of a probability density function which incorporates the uncertainty in the quantities estimated. Using this information, the following fishing mortalities are calculated using a stock projection computer program:

(i) the fishing mortality which results in a specified subjective probability that the stock will be above the current level in 20 years;

(ii) the fishing mortality which results in a subjective probability of 0.5 that the stock is at or above GNAI (or other target level) in 20 years;

(iii) the fishing mortality which results in a specified subjective probability that the stock is above GNAI (or other target level) in 30 years; and

(iv) the fishing mortality corresponding to $F_{0.1}$.

7. A TAC (which might be a by-catch limit in practice) would be set using whichever of these fishing mortalities was lowest. The assessments would be revised as new data became available. Once the procedure has been put into effect the target years for recovery become fixed at 20 and 30 years after the procedure is first put into effect. Thus, the fishing mortalities specified above have to be calculated using shorter projections as time progresses. The fishing mortalities would also be revised as more information accrues about the status of the stock.

8. The underlying process in calculating the probabilities is illustrated in Figure 1. In year 0 an estimate is available of the biomass relative to the average unexploited biomass. Around this point estimate will lie some distribution expressing degrees of belief in alternative values for the estimate. Calculating the subjective probability of the state of the stock at a given time in the future could be done with population projections. Each interval, such as A, B or C in the probability distribution in the current assessment of the stock, can be projected forward with given values of F. However, because recruitment is stochastic, (and also because of uncertainty in the population dynamics) there will be a distribution of final population sizes for each current population size projected forward, shown as A', B' and C'. The probability distribution at year 20 is the sum of the projected distributions, for the set of current stock states in the distribution associated with the current assessment, weighted by their subjective probabilities.

9. These calculations will most likely have to be carried out numerically, using multiple simulation projections with some parametric or empirical model for generating variability in recruitment. In addition, some form of stock-recruitment model will be required. The starting point for the projections would be the centres of a range of intervals in the distribution of the current stock status. The weight to be applied to the distribution of the projections is the area of the respective starting interval.

10. A computer program implementing this algorithm has been used to generate some approximate results to illustrate some of the properties of the fishing mortalities defined above. A modified version of the CCAMLR stochastic population projection program (PROJ) was used to set a deterministic initial age-structure for hypothetical fish stocks. The same model was then used with stochastic recruitment for the projections, however, using catches-by-weight, rather than applying fishing mortality. The catches-by-weight were calculated using the biomass from a deterministic projection (i.e., no recruitment fluctuation) of the median of the current stock assessment. This series of catches was applied for each interval selected from the distribution about the current stock estimate. 100 projections with recruitment fluctuation were made from 20 intervals. Other sources of uncertainty, for example, in the population dynamics parameters such as natural mortality (M) and growth rates, could also in principle be taken into account in the assessment and in the stock projections, but this has not been attempted here.

11. Calculations were made for two hypothetical fish stocks with different levels of production, one relatively high, the other relatively low. The population dynamics parameters for the two stocks are given in Table 1. Two current stock states are examined, one with the population at 30% of average pre-exploitation biomass, and the other at 5%. GNAI is taken to be 50% of the average pre-exploitation biomass. Two stock recruitment relationships are used, one with the recruitment constant (independent of stock size, denoted C in the table) and the other with recruitment declining

linearly to zero for stock sizes less than 50% of the unexploited level (denoted L). These particular forms were chosen because they represent the bounds of the plausible S–R relationships which might apply below GNAI. Stochastic variation in recruitment is drawn from a lognormal distribution with median determined by the S–R relationship and a coefficient of variation of 0.4. The subjective probability distribution of the estimate of the current status of the stock is taken to be normal, with median equal to the true value of the stock assessment. CVs of 0.1 and 0.3 are used for this distribution. This leads to a total of 16 cases, with results shown in Table 2.

12. The fishing mortalities given in the table are those which would result in:

(i) $F_{0.1}$;

(ii) 95% confidence in the stock being above the current level in year 20 (denoted $P_{L,20}$>0.95 in the table);

(iii) 50% confidence in the stock being above GNAI in year 20 (denoted $P_{GNAI,20}$=0.5 in the table); and

(iv) 95% confidence in the stock being above GNAI in year 30 (denoted $P_{GNAI,30}$=0 95 in the table).

13. There are several points worth noting about the results. In most cases, the fishing mortalities required to meet all of the three criteria relating to projected outcomes in two to three decades are less than $F_{0.1}$. This has clear significance for applying $F_{0.1}$ for stocks below GNAI, in that it will not necessarily lead to fulfilment of the basic objective of reversibility in two to three decades. This suggests that an operational definition of depletion for fish stocks would involve the concept that the stock state is such that the application of the normal policy for applying $F_{0.1}$ will not lead to the stock being restored to at or near GNAI within two to three decades.

14. In all these cases, the fishing mortality which gives 95% probability of exceeding GNAI is the limiting value. The value is lower for the more uncertain estimate of current stock status. A population recovery level different from GNAI might be selected for this particular criterion in light of the language of Article II 3(a) which is couched in terms of levels ‘close to that which ensures’ GNAI; the definitions and calculations given here are illustrative. However, the calculations point to the selection of the level to be used in such a criterion as having a significant effect on the level of fishing allowed on recovering stocks.

15. As might be expected, the S–R relationship plays a major role in determining the critical value of the fishing mortality. A constant S–R relationship is an implausible choice for stocks depleted substantially below GNAI. Where a more suitable form of S–R is unknown, it may be appropriate to use the linear model given here, in order to determine fishing mortalities at a likely lower bound with regard to uncertainty in the S–R relationship.

16. Interestingly, the degree of uncertainty in the estimate of current stock status does not have a great effect on the levels of fishing mortality which would prevent further decline over 20 fishing years or lead to median recovery to GNAI by year 20. However, the 95% probability of being above GNAI by year 30 is sensitive to the degree of uncertainty in the current stock status estimate. This uncertainty would be reduced as further data accrued, and consequent recalculation of the various fishing mortalities could lead to increased TACs, at least in cases where the fishing mortality for 95% recovery by year 30 is binding.

17. The final column in the table shows the median value to which the stocks would be expected to recover under the lowest of the fishing mortalities calculated (i.e., 95% probability of being above GNAI in three decades). In many cases it can be seen that these levels are not greatly above GNAI, and the form of calculation suggests a procedure for selecting target levels for exploited stocks which takes into account uncertainty in estimates of stock status. This would entail managing the stocks by choosing a stock target level so that there is a given level of confidence that the stock will be maintained above GNAl (or other nearby selected value).

CONCLUSION AND DISCUSSION

18. There are more important details to sort out for methods of estimating the status of the stock with respect to the average pre-exploitation biomass, and in particular how to formulate a subjective probability distribution about such estimates. Consideration needs to be given to procedures to apply in cases where the available data are too sketchy to calculate subjective probability distributions for the current assessment, or to assess variability in recruitment. The routine application of the calculations presented in this paper will require the development of a more sophisticated computer program than that used to make the illustrative calculations here.

19. The calculation of fishing mortalities which lead to assessments of the subjective probability of a depleted stock being in a state conformable with the basic objectives of the Convention seems to be a promising line of enquiry for further refining the Commission's management policy for finfish stocks. It is shown that the current strategy of applying $F_{0.1}$ would not always be sufficient for restoring depleted populations to the levels envisaged in the Convention. The approach outline here

gives an objective basis for basing scientific advice on fishing mortalities which will be expected to achieve management goals with selected levels of probability. The selection of the probability level to apply is not a purely scientific question, and hence guidance from the Commission will be required. However, this will be most easily obtained if further analyses on the properties of these or other suggestions for definitions and procedures can be carried out so that the Commission has an objective and quantitative bases for selecting management policy parameters.

ACKNOWLEDGMENT

20. The authors are indebted to Dr Larry Jacobson and Matt Perchard, the authors of the PROJ simulation program used as a component in the computer program for the calculations presented in this paper.

Table 1: Population parameters used for the two hypothetical fish stocks.

Lower yielding stock		
Natural Mortality	=	0.15 $year^{-1}$
Von Bertalanffy K	=	0.12 $year^{-1}$
Von Bertalanffy W_8	=	2 500 grams
Age at first fishing	=	5 years (knife-edge)
Age at first spawning	=	5 years (knife-edge)
Pooled age-class	=	20 years
Higher yielding stock		
Natural Mortality	=	0.40 $year^{-1}$
Von Bertalanffy K	=	0.20 $year^{-1}$
Von Bertalanffy W_8	=	1 000 grams
Age at first fishing	=	3 years (knife-edge)
Age at first spawning	=	3 years (knife-edge)
Pooled age-class	=	10 years

Table 2: Fishing mortality rates consistent with each of the three criteria for managing stocks below the putative level giving greatest net annual increment. (See text for explanation of terms.)

S/R	CV	Current Stock	$P_{L,20}$>0.95	$P_{GNAI,20}$=0.5	$P_{GNAI,30}$=0.95	Stock at 30 years
			Lower yielding stock ($F_{0.1}$ = 0.123)			
C	0.1	0.30	0.210	0.139	0.130	0.63
L	0.1	0.30	0.044	0.041	0.029	0.75
C	0.3	0.30	0.103	0.112	0.074	0.63
L	0.3	0.30	0.012	0.041	0.008	0.92
C	0.1	0.05	0.318	0.106	0.071	0.62
L	0.1	0.05	0.044	0.	0.	0.23
C	0.3	0.05	0.197	0.104	0.067	0.65
L	0.3	0.05	0.011	0.	0.	0.23
			Higher yielding stock ($F_{0.1}$ = 0.336)			
C	0.1	0.30	0.304	0.340	0.150	0.69
L	0.1	0.30	0.073	0.117	0.057	0.88
C	0.3	0.30	0.302	0.340	0.150	0.69
L	0.3	0.30	0.032	0.120	0.031	0.94
C	0.1	0.05	<1.0*	0.367	0.150	0.75
L	0.1	0.05	0.087	0.	0.	0.83
C	0.3	0.05	<1.0*	0.355	0.149	0.70
L	0.3	0.05	0.011	0.	0.	0.83

* Approximate values – current version of computer program failed to converge on more accurate solutions.

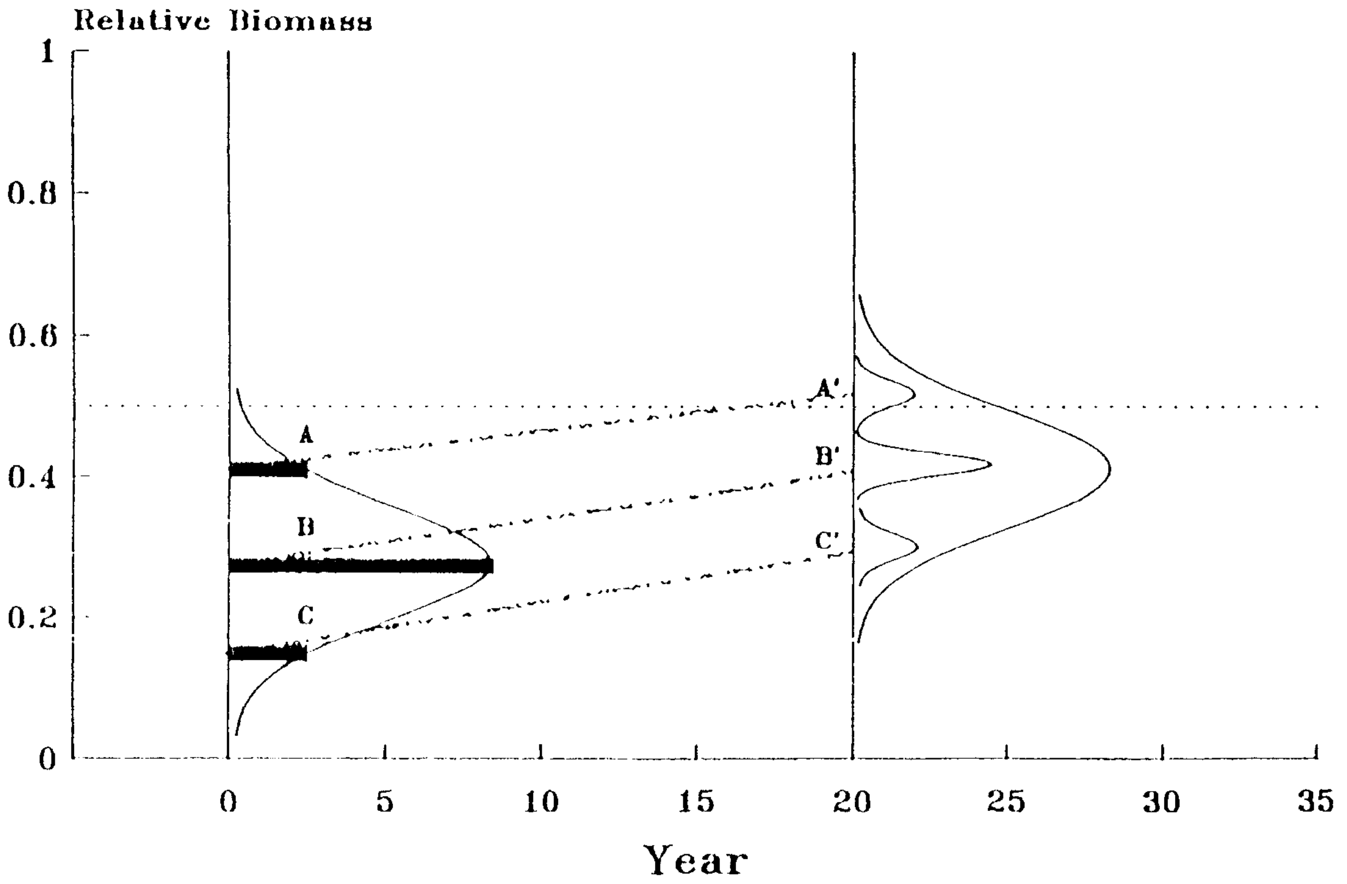

Figure 1: Schematic illustration of the method of calculating subjective probabilities of future states of a fish stock by stochastic forward projection of the subjective probability distribution associated with the current stock assessment.

APPENDIX 2

THE MAKING OF MANAGEMENT POLICY DECISIONS

An examination of the ways in which scientific evidence is
being used by the Commission to aid its decision-making

INTRODUCTION

The Convener's letter to Members of the Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources (WG-DAC) suggested that at CCAMLR-IX the Working Group could consider what constitutes 'the best scientific evidence available' that Article IX 1 (f) of the Convention requires the Commission to use as the basis for formulating, adopting and revising Conservation Measures.

2. The evidence on which the Commission's management decisions are based is a key consideration in the development of possible conservation approaches for achieving the objectives of the Convention and therefore an appropriate question for the Working Group to consider. Until CCAMLR-VIII, the Working Group has largely worked to define the best approaches to conservation in the abstract, but at CCAMLR-VIII, Australia proposed that the Working Group consider the approach that should be taken to the management of new and developing fisheries. This issue has now been taken up by the Commission. As a further step, examination of an aspect of the Commission's decision-making process could prove useful both in improving current decision-making and in defining more refined and effective approaches to conservation. This paper therefore examines how the Commission has obtained and used the evidence on which it bases its decisions, giving particular attention to the role of the Scientific Committee and its subsidiary groups.

THE ROLE OF THE COMMISSION

3. Under the Convention (Article IX) the Commission's role is to 'give effect to the objective and principles set out in Article II'. Article IX 1 spells out how it is to achieve this by requiring it to:

- *facilitate research into and comprehensive studies of Antarctic marine living resources and of the Antarctic marine ecosystem*, paragraph (a);

- *ensure the acquisition of, compile, analyse, disseminate and publish … information, including the reports of the Scientific Committee, on the status of and changes in populations of Antarctic marine living resources and on factors affecting the distribution, abundance and productivity of harvested species and dependant or related species or populations*, paragraphs (b), (c) and (d);

- *identify conservation needs*, paragraph (e);

- *formulate, adopt and revise conservation measures on the basis of the best scientific evidence available*, paragraph (f): and

- *analyse the effectiveness of conservation measures*, paragraph (e).

4. In exercising these functions, the Commission must (under Article IX 4) 'take full account of the recommendations and advice of the Scientific Committee'.

THE ROLE OF THE SCIENTIFIC COMMITTEE

5. The Scientific Committee is established under Article XIV as a consultative body to the Commission made up of suitably qualified Members' representatives assisted by other experts and advisers. The Scientific Committee may also seek the advice of other scientists and experts as required to meet its obligation under Article XV to 'provide a forum for consultation and cooperation concerning the collection, study and exchange of information with respect to the marine living resources to which (the) Convention applies and to encourage and promote cooperation in the field of scientific research in order to extend knowledge' of these resources. It is required under Article XV to 'conduct such activities as the Commission may direct in pursuance of the objective of the Convention' and under Article XV 2 to:

- *establish criteria and methods to be used for determinations concerning … conservation measures*, paragraph (a);

- *regularly assess the status and trends of the populations of Antarctic marine living resources, analyse data concerning the direct and indirect effects of harvesting on these populations, and assess the effects of proposed changes in the methods or levels of harvesting and proposed conservation measures*, paragraphs (b), (c) and (d); and

- *transmit assessments, analyses, reports and recommendations to the Commission as requested or on its own initiative regarding measures and research to implement the objective of (the) Convention,* paragraph (e).

6. To assist in producing this information for the Commission the Scientific Committee has established specialist working groups on fish, krill and the CCAMLR Ecosystem Monitoring Program. As the Commission has so far adopted Conservation Measures relating to fish only, this paper looks at the Working Group on Fish Stock Assessment (WG-FSA) rather than the other working groups.

7. The WG-FSA was established as an *ad hoc* group at CCAMLR-III in 1984 with the following terms of reference:

- to identify those fish stocks which might appear to be heavily fished and for which conservation action might be necessary; and

- to indicate the options for Conservation Measures in respect of these stocks.

THE DECISION-MAKING PROCESS

8. In undertaking its role to 'formulate, adopt and revise Conservation Measures' the Commission must act 'on the basis of the best scientific evidence available'. For this obligation to be met the Commission must make two judgements; what is the best evidence and what management action does it indicate. The guidance given by the Convention on how the Commission is to make the second of these judgements is contained in Article II. The only guidance in relation to the first is that the Commission should take full account of the advice and recommendations of the Scientific Committee.

9. During the period of CCAMLR's operation, the WG-FSA, the Scientific Committee and the Commission have all, on occasion, had trouble reaching consensus on each of these matters. The issues have become more confused as advice is passed from one body to the other and made it difficult to ensure that the Commission is meeting its obligation under Article IX 1(f). It has, in particular, led to some occasions where no action has been taken despite available evidence indicating the need for action. This would appear to be contrary to Article IX. The direction to act on 'the best scientific evidence available' suggests that it does not matter to what degree of certainty the available evidence indicates a particular action; if it is the best evidence available, the Commission is obliged to act on it.

10. Early in CCAMLR's operation the basis for this problem was largely lack of data. For example, at CCAMLR-III in considering the work of the WG-FSA, the Scientific Committee noted that 'there are insufficient data available to specify a detailed management program' (SC-CAMLR-III, paragraph 7.48). The lack of data led different Members of SC-CAMLR to different conclusions about the appropriate management response. At SC-CAMLR-IV available data indicated that a particular stock was in a very serious state and one Member proposed that 'in the absence of adequate data to determine the effectiveness of other measures, there should be an indefinite closure of the South Georgia region until enough data had been received by the Commission to estimate safe levels of yield' (SC-CAMLR-IV, paragraph 4.37). Some other Members supported such a course of action. Another Member suggested that 'if there were deficiencies in the supply of data, the proper course would be to postpone decisions to encourage data submission, and discuss the matter further next year when better data should be available' (SC-CAMLR-IV, paragraph 4.44). This view also drew support. The discussion was summarised by noting that 'the Scientific Committee strongly urged the Commission to take action to conserve and protect' the depleted stocks 'but could not agree on additional management measures necessary to ensure the conservation of the species'.

11. The Commission's reaction mirrored this divergence of views. Some delegations emphasised that the Scientific Committee's advice 'should always be based on the results of carefully conducted scientific research … . Other delegations … pointed out that … according to the advice of the Scientific Committee there was a need to institute management measures immediately and the Commission … had to base its decisions on currently available information' (CCAMLR-IV, paragraphs 33 to 34).

12. This led Australia to suggest in the Commission that an item be included in the CCAMLR-V agenda 'structured towards defining a conservation and management strategy for Antarctic marine living resources' (CCAMLR-IV, paragraph 42) and to the formation of the Working Group for the Development of Approaches to the Conservation of Antarctic Marine Living Resources (WG-DAC).

13. In past meetings some Members of the WG-DAC, including Australia, have suggested that the best means to ensure that Conservation Measures were introduced when the need for them was indicated would be to define 'decision rules' which would enable the practical application of the objectives of the Convention. Such rules would designate what application or variation of Conservation Measures would be appropriate for any given assessment of the state of a particular stock. The development of such rules has been envisaged as an iterative process in which information from fisheries and other sources about the state of stocks would be used to set rules

which progressively more accurately allow the maximum sustainable harvest consistent with the conservation objectives of the Convention and the interest of all the Members of the Commission.

14. The developments within the WG-DAC have been paralleled in the work of the Scientific Committee and its Working Groups. At CCAMLR-V, the WG-FSA suggested that, in the face of uncertainty inherent in determining the status of stocks in relation to the conservation objectives contained in Article II, the Scientific Committee 'might discuss the possibility of introducing some relatively easily measurable criteria for bringing into effect different management measures' (SC-CAMLR-V, paragraph 4.10). While consideration of this suggestion was deferred pending the outcome of the Commission's consideration of the work of WG-DAC, the WG-FSA's report led SC-CAMLR to present a number of options for management action in Subarea 48.3 (SC-CAMLR-V, paragraph 4.49).

15. The Commission however 'was unable to agree upon additional measures to limit fishing' in this area as 'there was divergence of views' over what measures were appropriate. 'Members carrying out fisheries in this area took the position that … limitations of catch for the 1986/87 season should be fixed at the level of catch for the 1985/86 season' while 'a number of other Members took the view that such a catch level was inconsistent with the advice of the Scientific Committee' (CCAMLR-V, paragraph 51). 'In these circumstances, the Commission could not reach agreement on a limitation of catch' for the area (CCAMLR-V, paragraph 52). In lieu, it was agreed that such measures or their equivalent should be introduced at CCAMLR-VI (Conservation Measure 7/V) and that the Scientific Committee should work in the intersessional period to improve the content and presentation of their advice. One delegate's reaction to these decisions was 'to record his delegation's concern that Conservation Measures be based on the best scientific evidence' and that, 'although he was not objecting to Conservation Measure 7/V, which had been adopted after careful deliberation', the measure should not in any way be interpreted as prejudging the results of future analyses by the Scientific Committee' (CCAMLR-V, paragraph 56).

16. This reaction is worthy of further consideration in this context. As there is no clear statement in the CCAMLR-V Report about the evidence on which the adoption of Conservation Measure 7/V is based, it is unclear as to whether the Commission's obligations under Article IX 1 (f) of the Convention to 'formulate, adopt and revise Conservation Measures on the basis of the best scientific evidence available' is being met in this case.

17. CCAMLR-VIII provided further examples of this difficulty. In the Scientific Committee's consideration of the advice of the WG-FSA's report in formulating general management advice for the Commission on fish stocks in Subarea 48.3, all Members except the USSR considered that a stock by stock approach to management of fish stocks was no longer adequate to ensure

conservation of the fish resources. In the face of advice that the status of stocks in the subarea was either unknown due to lack of data, uncertain due to wide differences in the results of different analyses or depleted and in need of protection, the majority opinion was that the efficiency of a stock by stock approach was currently low.

18. In the Commission, most Members agreed that all available evidence indicated that restoration of significantly depleted stocks would best be achieved by a complete closure of the statistical area, especially Subarea 48.3, to finfishing. The Soviet Union reiterated its opinion that an approach which examined individual stocks is adequate to ensure conservation of fish resources. The Commission therefore continued to adopt a stock by stock approach in the absence of consensus to the contrary (CCAMLR-VIII, paragraphs 90 to 92). The WG-FSA Convener made a personal statement commenting on this response. The essence of his statement was that he considered the advice given by the WG-FSA and endorsed by the Scientific Committee to be the best scientific advice available and that he could not accept that the Commission could discredit or ignore this advice without indicating what level of certainty is necessary for such advice to be acceptable.

19. Another instance involved the setting of a TAC level for *Champsocephalus gunnari* in Subarea 48.3 for the 1989/90 season. The Scientific Committee was presented with two vastly different estimates of the stock and the Scientific Committee could not reach agreement on the reliability of the results. ‘A number of delegations expressed the view that … any compromise position, e.g., the setting of a TAC based on the average value of the two assessments … will lead to (either) a substantial depletion of the stock … (or) … ‘the stock will increase substantially’. The Commission agreed on a TAC of 8 000 tonnes, ‘being a TAC based on the lower biomass … plus an addition for the area not covered in the survey which provided that biomass estimate’.

20. An even more striking example is the refinement of mesh size regulations. The Commission’s general fisheries management strategy, first stated at CCAMLR-VI, and largely reiterated at CCAMLR-VIII (CCAMLR-VIII, paragraph 77) included the protection for small fish by means of, among other measures, establishing a minimum mesh size that will allow small fish to escape. Mesh size regulations had first been introduced at CCAMLR-III (Conservation Measure 2/III). Conservation Measure 4/V supplemented Measure 2/III. At CCAMLR-VI, the Commission requested the Scientific Committee to provide advice, for *Champsocephalus gunnari* and other species, on the appropriate mesh size to protect young fish, and in particular noted that mesh selectivity studies should be conducted and reported to the Commission as soon as possible. The Scientific Committee provided advice on this issue at CCAMLR-VII. There was considerable discussion on the background to and interpretation of this advice and suggestions that further analysis of data that had been submitted (Polish and Spanish) and data of which Members were aware

(USSR) was required. The Commission noted with some concern that some of the views expressed were not clearly reflected in the advice of the Scientific Committee and therefore asked the Scientific Committee to complete the evaluation of the whole topic taking into account the Commission's management strategy.

21. At CCAMLR-VIII, the Scientific Committee provided detailed advice and recommended that the Commission consider introducing new minimum mesh sizes and associated measures. The Commission noted the advice the Scientific Committee had provided. The Commission also expressed the view that after five years of operation (the mesh size regulation was adopted in 1984) the point should have been reached where it might be reviewed on the basis of completed selectivity experiments, and new measures adopted as recommended by the Scientific Committee (CCAMLR-VIII, paragraph 82). The Soviet Union indicated that it was unable to agree to new mesh size requirements, thus no consensus could be reached on the implementation of the Scientific Committee's recommendations; a failure regretted by other Members of the Commission.

CONCLUSION

22. While continuing its work towards operational definitions of the conservation objectives of the Convention, the Working Group might also consider ways in which the Commission could ensure that it meets, and can be seen to meet, its obligation to formulate, adopt and revise Conservation Measures on the best scientific evidence available. The Working Group might also consider ways in which the Scientific Committee can assist the Commission in meeting this objective.

23. While it is up to the Commission to satisfy itself that no better scientific evidence exists, it has not often sought evidence from sources other than the Scientific Committee, and has acted on the basis of the Scientific Committee providing it with the best evidence. The examples above show that while this is assumed, the relationship between the Scientific Committee's advice and the Commission's decisions is not always clear in its deliberations and reports. If, in its deliberations, the Commission finds itself unable to act on the advice of the Scientific Committee, it should be prepared to make clear what evidence it is acting on, and on what basis it has determined that this evidence is the best available, particularly why it is better than that provided by the Scientific Committee. It should be recalled that the Commission is obliged to act on the best evidence available no matter to what degree of certainty it indicates action.

24. At the same time the Scientific Committee, as CCAMLR's principle scientific advisory body, could possibly assist the Commission in meeting the requirements of Article IX 1(f) if it accepts more fully the responsibility for providing the best available evidence. In presenting a number of options in

its advice, the Scientific Committee has sometimes left the Commission to make decisions on scientific matters as well as management policy matters. This role is within the scope of the Commission's responsibilities under Article IX 1, but the Commission is not well equipped to take on such a role when the time constraints of its annual meetings are considered, nor has it indicated its desire to do so.

25. There may also be scope for assumption of greater responsibility by the Scientific Committee for indicating what conservation action the evidence provided indicates, being aware of the Commission responsibility for judgements and decisions on management policy.

26. There will be varying degrees of scientific uncertainty in the conclusions of the Scientific Committee, but the obligation of the Commission is to act on the best available evidence. If the Scientific Committee's advice were presented in such a way as to make clear the Commission's options in relation to management policy, but to leave no doubt about the scientific validity of the evidence, the Commission may find it easier to meet its obligation.