# CCAMLR ECOSYSTEM MONITORING AND A FEEDBACK MANAGEMENT PROCEDURE FOR KRILL

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Abstract

The CCAMLR Ecosystem Monitoring Program has been developing a technique which might detect short-term declines in land-based predator performance (e.g., reproductive performance) that may be attributable to loss of prey through fishing activities. The principal fishery in the CCAMLR Convention Area is the krill fishery and this paper examines ways in which the information being obtained from the Ecosystem Monitoring Program might be incorporated into a feedback management strategy for this fishery.

Résumé

Le Programme de contrôle de l'écosystème de la CCAMLR met au point une technique pour déceler des baisses à court terme de performance des prédateurs terrestres (le taux de reproduction, par ex.) qui peuvent être imputées à une perte de proies résultant des activités de pêche. L'auteur examine des moyens d'incorporer les informations provenant du Programme de contrôle de l'écosystème dans une stratégie de gestion par rétroaction de la pêcherie de krill, pêcherie principale de la Zone de la Convention de la CCAMLR.

Резюме

Программа АНТКОМа по мониторингу экосистемы разрабатывает метод, который может выявить краткосрочные снижения в биологической эффективности (напр. эффективность воспроизводства) размножающихся на суше хищников, возможно вызванные потерями пищи в результате промысла. Главным промыслом в зоне действия Конвенции АНТКОМ является промысел криля. В настоящей работе рассматривается каким образом можно включить в стратегию управления этим промыслом с обратной связью информацию, получаемую в рамках Программы по мониторингу экосистемы.

Resumen

El Programa de Seguimiento del Ecosistema de la CCRVMA ha estado desarrollando una técnica que podría detectar la reducción, a corto plazo, en el rendimiento de los depredadores terrestres (por ejemplo, el rendimiento reproductor) y que podría atribuirse a la pérdida de especies presa causada por las actividades de pesca. La pesquería de kril es la

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pesquería de mayor importancia que se realiza en el Area de la Convención de la CCRVMA y este documento examina la manera en que la información obtenida por el Programa de Seguimiento del Ecosistema podría incorporarse en la estrategia de administración interactiva para esta pesquería.

## 1. INTRODUCTION

The need to establish conservation measures on the Antarctic krill fishery to protect both krill and predator populations has been the subject of many recent discussions (see Nicol, 1991 for review) and resulted in the establishment of a Precautionary Catch Limit of 1.5 million tonnes in the Atlantic Sector of the CCAMLR Convention Area at the Tenth Meeting of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR, 1991). The Commission has given a high priority to the establishment of additional precautionary catch limits in the other parts of the Convention Area as well as the establishment of conservation measures to ensure that sufficient krill remain available to meet the needs of predators. Also, the Commission agreed that feedback management should be developed for the krill fishery (CCAMLR, 1991 - paragraph 4.9).

The Working Group on the CCAMLR Ecosystem Monitoring Program (WG-CEMP) has the responsibility of providing advice to the CCAMLR Scientific Committee on the effects that fishing may have on species dependent on or related to the target species. It has been developing a program intended to detect short term declines in land-based predator performance (e.g., reproductive performance) that may be attributable to loss of prey through fishing activities (Anon., 1989; Croxall, 1989).

The development of a useful approach to the maintenance of predator populations, including the recovery of depleted whale populations, by the CCAMLR Convention requires an examination of the design of the CEMP so that advice arising from WG-CEMP will not inadvertently affect other predators and can be utilised in a feedback management procedure by the Commission. This paper examines some of the issues that need to be addressed by the Scientific Committee in evaluating how the CEMP can be utilised to protect predators from adverse effects arising from the krill fishery.

## 2. FEEDBACK MANAGEMENT

Feedback management uses information on the status of the ecosystem to alter the levels of harvesting in order to ensure that the desired state of the ecosystem is sustained (de la Mare, 1991). This process relies on a field program that monitors the status of important features of the ecosystem (such as the krill stocks and predators) as well as the conduct of the fishery (de la Mare, 1986 and 1991). The Scientific Committee uses this information to advise the Commission as to whether the ecosystem or some of its components (krill stocks and/or predators, etc.) are being affected or are likely to be affected by krill harvesting. The Commission then can formulate or alter conservation measures based on options in Article IX of the CCAMLR Convention and dictated by the management procedure (see de la Mare, 1991 for discussion).

The important aspect of feedback management is that the monitoring program can provide information that triggers action by the Commission in sufficient time to ensure that the objectives set out in Article II of the CCAMLR Convention are not contravened.

## 3. APPROACHES TO PREDATOR PROTECTION

Once fishing has begun in a particular area, Article II can be translated, in the case of the predators, to ask the general question "Will fishing for krill at the specified level cause the health of predator populations to decline below an acceptable level?".

There are two issues that arise from this general question. First, the degree of change (decline) in the predator parameters that is considered acceptable (i.e., for which no management action is required) needs to be specified. Second, the approach taken to monitor and assess the status of the ecosystem needs to be one that minimises errors in interpretation and action by the Commission. The above question can be addressed by using either mensurative or experimental approaches.

### 3.1 Specification of Acceptable Changes in Predator Populations

The provision of advice by the Scientific Committee to the Commission on the status of the Antarctic marine ecosystem is contingent on a view established by the Commission as to what is an unacceptable state of either individual predator populations or of the community at large. While some attempts have been made to describe positive and negative aspects of change in predator populations and communities (e.g., Croxall *et al.*, 1988) and the scale at which interactions between different species needs to be considered (e.g., Murphy *et al.*, 1988) there has been no systematic evaluation of the status of predators required to maintain ecological relationships as described in Article II. As a result, the goals in predator protection for the krill fishery are difficult to define.

### 3.2 The Mensurative Approach to Ecosystem Monitoring

The current approach used by WG-CEMP to determine the effects of fishing is to construct models of the predator-prey system in the area in which harvesting occurs and examine the possible effect that a reduction in prey availability may have on predator performance. These models are based on knowledge of the diets of predators and estimates of predator and prey abundances and life history parameters. Although a study of penguins off the Antarctic Peninsula has indicated that the recent decline of their populations may be attributed to a shortage of krill (Anon., 1991), the interpretation of short-term changes in predator parameters are still uncertain due to the inability to relate these directly to changes in krill abundance (Croxall, 1989) or environmental features, such as ice conditions (e.g., Trivelpiece *et al.*, 1990).

Additional to the problems of understanding how environmental and biological factors may influence predators is the lack of knowledge on what may have happened to these predator populations had there been no fishing. Consequently, predictions of future changes in predator performance in response to fishing pressure are difficult to make.

The uncertainty in these models highlighted by Croxall (1989) has led WG-CEMP and the Scientific Committee to agree that "analysis and evaluation of submitted CEMP data and developments of recommendations based thereon did not require, and should not await, the determination of the precise quantitative nature of predator/prey/environmental relationships." (SC-CAMLR, 1990 - paragraph 5.4). While this provides an important opportunity to give advice on predator status there has been no indication by the Commission of the required precision of such advice before it will be used to formulate conservation measures for the krill fishery.

### 3.3 The Experimental Approach to Ecosystem Monitoring

Monitoring of the impact of krill harvesting on predators using a controlled fishing regime may avoid many of the problems associated with the elaboration of ecosystem models

fundamental to the current approach in the CEMP (Nicol and Constable, 1991). The development of experimental fishing regimes to clarify the effects of fishing on the Antarctic marine ecosystem has been advocated for many years (e.g., Beddington and de la Mare, 1985; de la Mare, 1986 and 1991; SC-CAMLR, 1991 - paragraph 11.13). The principle approach that has been proposed is to identify management areas based on biological characteristics (e.g., Chittleborough, 1987; de la Mare, 1991) and to monitor the performance of predators in selected areas that are within the proximity of fishing (such as the current CEMP areas) and compare this to predator performance in control areas that are far from the effects of fishing.

The rationale for spatial and temporal replication of monitoring programs has been developed mostly for non-fishing human impacts on marine systems (see Green, 1979; Stewart-Oaten *et al.*, 1986; Underwood, 1990 and 1991, for background and discussion). However, the principles are easily transferred to fisheries. In the context of the krill fishery, these designs focus on the question of whether changes in predator performance in areas being fished are likely to be different from changes that may have occurred in the absence of fishing. To do this, these authors specify that a number of replicate control areas are required in addition to the experimental areas (even if only one experimental area is being used). They also recommend that unambiguous interpretation of changes in predator performance in the experimental areas is facilitated by having the monitoring program proceed in all experimental and control areas before fishing begins as well as after it has begun. This is known as the 'Before-After-Control Impact' (BACI) design. Here, the prediction is that, if fishing affects the predators, the naturally occurring differences between experimental and control areas in the absence of fishing will alter (become smaller or larger) after fishing begins.

Further, the ability to determine the effects of fishing could be facilitated by attempting to control for environmental parameters, such as ice conditions, and prey abundances.

An elaboration of this approach was discussed briefly at the 1991 Meeting of the Scientific Committee (SC-CAMLR, 1991 - paragraph 11.13) indicating that control and experimental sites may be able to be established in the near future.

## 4. DISCUSSION

There are considerable differences of opinion in the ecological literature as to which method (mensurative or experimental) is more appropriate. However, the method that is chosen and the resulting design in the monitoring program should meet the following criteria:

(i) the program has sufficient power to signal that action needs to be taken by the Commission to prevent the fishery from negatively affecting the predators (or, in the case of testing the effectiveness of conservation measures, that the predators are no longer being affected by the fishery) (Peterman, 1990);

(ii) its cost is commensurate with the value of the fishery (de la Mare, 1991); and

(iii) it is feasible.

WG-CEMP now has the data available to begin examining, using analytical and simulation techniques, the potential designs and analyses of monitoring programs that meet these criteria. While the mensurative approach has been the focus of WG-CEMP so far this should not preclude an examination of the experimental approach, despite the existing CEMP sites being concentrated mostly within only a few areas from which most of the krill catch is taken.

Further, the WG-CEMP needs to examine the long-term implications of recommendations it gives to the Scientific Committee. For example, its suggestion that it may be desirable to prohibit fishing from the foraging range of land-based predators during their reproductive

season in the Atlantic sector, where a high proportion of the krill catch is taken currently (SC-CAMLR, 1991 - paragraph 6.34), may impact on the capacity for the WG-CEMP to provide management advice derived from predator performance in these areas. Similarly, the potential impact of a shift in fishing effort to unmonitored areas, such as whale feeding grounds, would need to be addressed.

In summary, two important issues need to be addressed by WG-CEMP and WG-Krill:

(i) the status of predators required to maintain ecological relationships as described in Article II of the CCAMLR Convention; and

(ii) the design of CEMP that ensures a low probability of errors in interpretation on the status of the ecosystem and consequent action by the Commission.

In the event that no design of the CCAMLR Ecosystem Monitoring Program is able to meet the above criteria, the Scientific Committee and Commission will need to examine other methods for protecting land- and sea-based predators from adverse effects that may arise from the krill fishery.

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