USE OF INDICES OF PREDATOR STATUS AND PERFORMANCE IN CCAMLR FISHERY MANAGEMENT

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Abstract

This paper investigates how data on, or related to, reproductive performance of seabird and seal predators, collected as part of the CCAMLR Ecosystem Monitoring Program (CEMP) could be used in the management, by CCAMLR, of commercial fisheries. It reviews reasons why it is important for CCAMLR formally to use such data in its fishery management operations and discusses the constraints inherent in the CEMP data, both from predator monitoring and harvesting perspectives. An outline of a specific approach is provided, involving an assessment procedure and recommendations for management action. The three elements of the assessment are determining the magnitude and significance of changes in individual parameters, evaluating overall patterns of change within species, sites and areas and reviewing factors potentially influencing or correlated with the changes. The relative merits and feasibilities of recommendations for restrictions on the magnitude, timing and location of harvesting are reviewed, taking account of likely operational constraints on fisheries.

Résumé

Ce document étudie la manière dont la CCAMLR pourrait se servir, dans la gestion des pêcheries commerciales, des données relatives ou ayant rapport à la performance reproductive des oiseaux de mer et des phoques prédateurs, recueillies dans le cadre du Programme de contrôle de l'écosystème de la CCAMLR (CEMP). Il examine les raisons pour lesquelles il est important que la CCAMLR utilise officiellement de telles données dans ses opérations de gestion des pêcheries et traite des contraintes internes des données du CEMP, tant du point de vue du contrôle des prédateurs que de celui de l'exploitation. Les grandes lignes d'une méthode d'attaque spécifique sont fournies; cette dernière nécessite une procédure d'évaluation et des recommandations de gestion. Les trois éléments de l'évaluation sont : la détermination de l'ampleur et de la portée des changements des paramètres individuels, l'évaluation des tendances générales des changements au sein d'espèces, de sites et de régions, et l'étude des facteurs qui risquent d'influer sur ces changements, ou qui sont en correlation avec eux. Les mérites et les applications pratiques de recommandations relatifs, aux restrictions sur l'ampleur, à la période appropriée et à l'emplacement de l'exploitation sont examinés, compte tenu des contraintes opérationnelles probables sous lesquelles opèrent les pêcheries.

Резюме

В настоящем документе рассматривается вопрос о том, каким образом собранные в ходе работ по Программе АНТКОМа по мониторингу экосистемы (CEMP) данные по эффективности воспроизводства хищных морских птиц и тюленей, и связанные с ними данные, могут быть использованы АНТКОМом при управлении коммерческим промыслом. В документе рассматриваются причины, по которым АНТКОМу следует в официальном порядке использовать такие данные при управлении промыслом. В документе также рассматриваются ограничения применимости данных CEMP как при мониторинге хищников, так и при управлении промыслом. Предлагается обзор конкретного подхода, включающий процедуру оценки и рекомендации в отношении управления. Процедура оценки состоит из трех элементов, которые определяют величину и значение изменений отдельных параметров, оценивают общие закономерности процесса изменения видов, участков и районов и рассматривают факторы, оказывающие потенциальное воздействие или связанные с изменениями. Рассматриваются относительные преимущества и пригодность рекомендаций по ограничению объема, времени ведения и места ведения промысла, при этом во внимание принимаются вероятные оперативные ограничения промысла.

Resumen

Este documento investiga como los datos acerca de, o relacionados con, la acción reproductora de las aves marinas y focas depredadoras, recopilados como parte del Programa de Seguimiento del Ecosistema de la CCRVMA (CEMP) podrían ser utilizados en la administración de pesca comercial por la CCRVMA. Este examina las razones por las cuales es importante que la CCRVMA use estos datos oficialmente en sus operaciones de administración de pesca y debate las obligaciones intrínsecas en los datos del CEMP, según las perspectivas de pesca y también del seguimiento de animales depredadores. Se provee un resumen de un enfoque específico, incluyendo un procedimiento de evaluación y recomendaciones para la administración. Los tres elementos de esta evaluación determinan la magnitud e importancia de los cambios en parámetros individuales, interpretación de los patrones generales de los cambios en ciertas especies, localidades y factores de análisis que potencialmente influyen o son correlacionados con estos cambios. Los méritos relativos y viabilidad de las recomendaciones para las limitaciones impuestas en la magnitud, coordinación y localidad de la pesca son examinados, tomando en cuenta las posibles restricciones operacionales a las pesquerías.

1. INTRODUCTION

1.1 Background

An important part of the uniqueness of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) is the concern that exploitation of resources should not be detrimental to natural consumers (see Article II, paragraph 3(b)). This obligation has led the Commission for the Conservation of Antarctic Marine Living Resources to develop, through its Scientific Committee, an Ecosystem Monitoring Program (CEMP) whose aims are "to detect and record significant changes in critical components of the ecosystem, to serve as the basis for the conservation of Antarctic Marine Living Resources. The monitoring system should be designed to distinguish between changes due to the harvesting of commercial species and changes due to environmental variability, both physical and biological" (SC-CAMLR-IV, paragraph 7.2). The program's terms of reference are set out in SC-CAMLR-III, paragraph 9.27.

The approach followed has been to start a system of regular recording of selected ecologically-orientated parameters of the populations of selected species of seals and seabirds and to try to develop schemes for monitoring harvested species and relevant environmental variables. This paper is concerned chiefly with the monitoring of predator species.

The choice of predator species has been based on reasonably objective criteria whose definition has evolved over several years (see SCAR 1979, p. 306; BIOMASS 1980, p. 16; BIOMASS 1982, p. 6; SC-CAMLR-IV, p. 172; SC-CAMLR-V, p. 149) and were most recently summarized by Croxall et al. (1988) as:

"(a) important components (in terms of prey consumption) of the Southern Ocean system;

(b) specialist predators on harvestable prey, especially krill;

(c) have broad geographical breeding ranges including sites near to and far from areas likely to be subject to intensive fishing;

(d) readily accessible at breeding sites and tolerant of human presence and activity."

Only very recently has attention started to focus on the objective selection of parameters according to criteria of accuracy (feasibility of repeatedly making accurate and precise measurements), relevance (closeness of linkage to and degree of dependence upon harvestable resources) and detectability (sensitivity of parameter to changes in food availability) (see Croxall et al. 1988, pp. 277-278).

So far, however, no attention has been directed to arguably the most important point of all, how the data resulting from the monitoring program are to be used by CCAMLR in its management of the commercially exploited resources. This paper reviews why we should be trying to do this and suggests some approaches that might facilitate constructive progress towards realistic goals.

1.2 Why Does CCAMLR Need to Use Results from the CEMP in its Fishery Management Strategies?

I believe that there are at least two main reasons for doing this. First, in the eyes of many participants in and perhaps most observers of CCAMLR work, the main positive

element of this Convention is its explicit concern that exploitation of resources should not adversely effect natural consumers.

It is this that chiefly distinguishes CCAMLR from conventional fishery management agreements. Dissatisfaction with the latter stems from their repeated failure in the past to prevent gross over-exploitation, to the detriment of exploited stock and natural consumer alike, often despite the existence of appropriate scientific data and/or advice. By the time such over-exploitation was officially recognized (i.e. accepted by all parties), it usually proved impossible adequately to restore either the harvestable stock or the depleted population of natural consumers - especially in situations where there is pressure for continuing exploitation.

From many vantage points, the success of CCAMLR rests on whether it can provide more sensitive, balanced and effective management policies than most existing fishery management agreements. A particular issue, not explicitly addressed in Article II, is where the "burden of proof" rests. It is apparently implicit at present that detrimental changes to predators must be proved to result from harvesting before action can be taken. It would be equally logical, however, to assert that commercial harvesting should only continue as long as it can be proved that it has no significant adverse effect on natural predators.

Second, there is limited point in Members of CCAMLR making the substantial commitments of time and money necessary to carry out the CEMP unless CCAMLR has specific plans for using the results in a constructive way.

It would surely be a serious mistake for CCAMLR to be seen to wait until a proven crisis for predator populations is identified before instituting any protective measures. This applies irrespective of whether harvesting is a direct or indirect contributor to the situation. What is needed is (a) to develop contingency plans now, and (b) to ensure that action (i.e. some restriction on harvesting) is taken when the first danger signals appear.

2. GENERAL APPROACH TO THE USE OF PREDATOR INDICES

2.1 Introduction

What would seem to be required is the development by CCAMLR of a balanced and flexible way of using the results of the CEMP predator studies to influence CCAMLR's management (including short-term policy) of commercial fisheries. It is crucial that this aim be achieved with the active support of those involved in current and prospective harvesting and that it is developed in a way that is sensitive to the commercial and logistic constraints which such operations entail. Any scheme will involve compromise. Thus it will obviously include provision for restraint on harvesting under some circumstances; conversely it will inevitably provide less than absolute protection for all consumers under all foreseeable circumstances.

What are some of the obvious problems and considerations involved in the development of such a scheme? I advance below some views, from the different perspectives of predator monitoring and commercial harvesting, which need to be taken into account.

2.2 Predator Monitoring Perspective

The possible aims of CEMP predator monitoring might include any or all of the following.

(i) To detect changes in indices of the status (in either demographic or physiological (e.g. condition) respects) and/or reproductive performance of seabirds and seals.

(ii) To relate these changes to indices of prey (at present krill) abundance and availability (to the predators).

(iii) To use predator indices, on the basis of relationships between predators and prey developed above, as a measure of (a) prey availability (to the predators) and (b) prey stock abundance.

(iv) To use the predator indices to detect changes in food availability that result from commercial harvesting as distinct from changes due to natural fluctuations in the biological and physical environment.

In my judgement a realistic assessment of these aims is that:

(i) should be possible for many species, sites and circumstances;

(ii) may be possible for certain species at certain sites under favourable circumstances;

(iii) (a) might be possible under optimum conditions;

(b) is unlikely to be possible even under optimum conditions; and

(iv) is unlikely to be possible, unless under exceptional circumstances.

We should accept that proof, in terms of scientific evidence which would pass rigorous scrutiny, of commercial harvesting causing detriment to predators, is very unlikely. Even if it were obtained, it would probably come so long after the start of the causal problem as seriously to prejudice reversal of the situation within two to three decades (as required by Article II of the Convention).

We should also accept that, with our present knowledge of the dynamics of predator-prey interactions in the marine environment, evidence for short-term changes (year-to-year differences or trends over three to five years) will rarely be available even at 90%, let alone 95% levels of statistical significance (Croxall et al., 1988).

In addition, not all predator indices are equally important because not all parameters fulfil equally the criteria of relevance, accuracy and detectability. Furthermore, as more knowledge accumulates and/or more parameters are added to the CEMP, the relative importance of indices may change. Also, as more CEMP data become available there is likely to be a better chance of meaningful trends being detected. Important though such results may be, they will not replace the need for some kind of short-term assessment, permitting a finer-scale tuning of management policy.

Finally, it might not be too difficult (in theory) to incorporate predator indices into the management approaches being developed for fisheries directed at existing target species, where there are adequate data available to CCAMLR coming from the fishery itself. A fishery starting for a completely new target species would be a different matter, because there will be few, if any, data on which to base rational management. It is, therefore, not unreasonable to plan to take greater note of changes in relevant predator indices concurrent with the start of a new fishery.

2.3 Harvesting Perspective

Commercial harvesting, especially in the Southern Ocean, is a difficult and costly operation, where, nowadays, profit margins are usually small. Restrictions on the timing, location, or permitted catch levels of fishing may interfere with sensible, safe or effective fishing practice to the point where the fishery becomes uneconomic and therefore unsustainable. This may also eliminate one of the main sources of data for monitoring future trends in the prey.

Indices of predator status/performance derived from study sites on the Antarctic Continent and perhaps Antarctic Peninsula are likely to be as much, if not more, affected by changes in the physical, rather than biological, environment (Croxall et al., 1988). Resulting difficulties in interpretation may, therefore, reduce their direct relevance to fisheries management.

Even if we accept that predator indices can theoretically reflect prey abundance/availability, in practical terms they do so over areas that are often not congruent with those for which prey stock assessments are carried out. Furthermore, prey abundance/availability and predator status/performance are unlikely to be coupled in linear fashion. Therefore, predator indices may be a poor guide to prey abundance/availability, except perhaps at more extreme values.

There is evidence that some predator populations in the Southern Ocean are currently increasing in numbers. If, as is likely, density-dependent factors ultimately limit population size (Croxall and Rothery, in press), indices of status and performance may show a negative trend when this happens. Uncritical interpretation could easily attribute such a trend to adverse effects of harvesting.

Finally, climatic trends have already been detected in the Antarctic and are likely to be an important feature of the next decades. The responses of predators and prey are likely to involve changes in abundance and reproductive performance. This will significantly complicate detecting any effects which might be ascribed to harvesting.

2.4 Conclusions

Taking both sets of perspectives into account, what might be a reasonable set of conclusions for a sensible general approach?

First, if we wish to use indices of predator status/performance to influence fishery policy on a year-to-year basis, we need to develop a system that takes notice of changes where the likelihood of correctness is less than 95%, provided the required responses make appropriate allowance for our reduced certainty.

Second, it may be most profitable initially to develop a policy for incorporating predator indices into CCAMLR fisheries management for sub-Antarctic and Antarctic Peninsula areas. This may avoid much of the problem concerning the relative importance of physical and biological influences and would also concentrate on locations where significant harvesting is regularly occurring at present.

Third, the initial focus of attention should be on krill and krill-eating predators. This interaction is the most closely coupled of those available and must offer the best chance of developing a sensible policy. Doing this would facilitate extending the policy to less closely linked trophic interactions (e.g. between seabirds/seals and fish), including those hitherto largely unstudied (e.g. involving squid).

Fourth, it is important that estimates of prey abundance/availability to predators be forthcoming as soon as possible and that these be as congruent as possible with the areas generating the predator indices. There is a particular need to ensure that broad-scale data (e.g. at the "stock" level) are complemented by fine-scale data (e.g. $1° \times {}^1/_2°$ squares), because it is the latter which are of greater relevance in assessing predator-prey interactions.

Fifth, until the nature of relationships between predator indices and prey abundance/availability are established, we need to be prepared to proceed on the assumption that changes in predator indices are reflecting changes in food availability, unless there is clear evidence to the contrary. Evidence from a wide variety of marine ecosystems provides examples of indices of predator population status and reproductive performance correlating with various indices of prey stock availability and abundance (see reviews in Croxall, 1987; Furness and Monaghan, 1987; Croxall and Rothery, in press). Such relationships certainly need investigating in more detail and there may be special problems where physical and environmental factors regularly exert stronger influences than biological ones, but the above assumption is probably a suitably conservative one from which to proceed.

Sixth, we should accept that there is a need to avoid harvesting exacerbating a situation where predator indices tell us that populations are performing poorly - even when there is no evidence that harvesting is, or has been, a contributory factor. The logic for this is that if predator populations are in trouble, any level of harvesting, if conducted at critical times and places, may have significant adverse effects.

3. SPECIFIC APPROACHES

It is not intended to develop here a detailed formal scheme. Rather, the aim is to suggest one possible approach, which can then serve as a basis for discussion and development.

Consideration is confined to krill-eating predators and, inevitably, the perspective is chiefly that gained from work at Bird Island, South Georgia over the last 14 years. The emphasis is entirely on the detection and evaluation of short-term change.

3.1 Outline of Approach

3.1.1 Preparation

(i) Rank or group parameters according to relevance criteria.

(ii) Also, using information on accuracy and detectability criteria, define the lowest level of significance that would constitute evidence of change for each parameter or group of parameters.

The process of formal ranking of parameters and definition of level at which changes would be regarded as significant will inevitably be somewhat arbitrary, especially in the present state of our knowledge. One alternative would be to take into account the information on relevance, accuracy and detectability at the assessment stage.

(iii) For each parameter, calculate magnitude of change, compared with last year and with average(s) of previous years. Determine level of statistical significance of change.

3.1.2 Assessment

(i) For each species at each site, examine magnitude (and direction) of all significant changes and determine overall nature of predators' response to that years environmental circumstances.

(ii) For each species at all sites (particularly within the same general area) and for all species monitored at each site, review overall pattern of responses.

3.1.3 Recommendations

Make recommendations for appropriate management action. This, and the preceding assessments, will obviously need to take into account additional information on:

(i) the biological environmental background (e.g. current/recent diet of monitored species, current/recent prey stock assessments and level of commercial catches in each subarea);

(ii) the physical environmental background (weather and climate prevailing during monitoring period); and

(iii) the current status of the monitored species (e.g. population trend, latest demographic information, etc.).

3.2 Evaluation of Parameters

The approach outlined here requires that, at some stage, parameters be evaluated. Croxall et al. (1988, pp. 278-281) assessed a variety of parameters, including all those currently selected by CCAMLR (1988). Based on this, parameters might be classified, in relation to their potential for detecting short-term changes, as follows.

(i) Potentially high relevance and of appropriate accuracy and detectability

(a) foraging trip duration;
(b) offspring growth rate and/or weight at independence (fledging/weaning).

(ii) Potentially high relevance but with large interannual variation and/or difficult to acquire enough data

(a) diet;
(b) breeding success.

(iii) Potentially lower relevance (because reflects a variety of influences over rather longer timespans) but easy to measure accurately

(a) adult weight (e.g. at arrival).

(iv) Potentially lower relevance (reflects a variety of influences over much longer timespans) and difficult to obtain very accurate data

(a) demographic variables;
(b) breeding population size.

Detailed demographic (including population trend) studies, however, should receive high priority; evidence of statistically significant trends (especially in vital rates) should be considered, in the context of the CEMP, as soon as it is available.

(v) Potentially high relevance, but apparently rather insensitive to environmental change

(a) clutch size;
(b) incubation shift duration (see Davis and Miller, in press);
(c) onshore attendance in fur seals.

An informal use of this, or any other parameter classification would simply give greater weight to changes in some parameters than others, particularly when considering the overall picture at the species and site level. A more formal approach would be to assign levels of significance at which changes in each parameter (or parameter group) would be accepted. Categories (ii) and (iv) above might be best regarded simply as vital background information.

3.3 Recommendations for Management Action

The assessment procedure has three distinct elements. First, the evidence for change in monitored parameters is considered individually. Second, the overall pattern of changes within species, sites and areas is evaluated. Third, factors possibly influencing or correlated with these changes are reviewed.

Recommendations for management action are only likely to follow when there is evidence either of a broad scale general effect or of an acute effect at a more local level. The content of recommendations is likely to involve restrictions on the magnitude, timing and location (or some combination of these, perhaps involving effort limitation) of krill harvesting (Table 1).

Restricting the total catch in an area requires regular reporting of catches by all vessels and a system for informing them of the rate of progress towards the target catch. Checking the accuracy of catch reports is very difficult and imposing a catch limit, even in a subarea, is unlikely to be the most effective way of improving conditions for predators. Limiting the timing and location of fishing is easier to do, easier to monitor and, by avoiding times and places of greater likely impact on predators, more likely to have a significant effect.

Restricting fishing within the foraging radius of breeding fur seals and penguins, or confining fishing to areas downstream of the main predator breeding concentrations in a subarea, would be obvious possible actions. Closing the fishery at particular times could be used to avoid harvesting occurring simultaneously with times of critical energy requirements by predators. One such time might be while adults have dependent offspring. Critical periods for adults may also occur just before breeding starts and for juveniles when they become independent. Winter may generally be a time of reduced food availability. However, most predators are well dispersed at this time and it is difficult to identify any management actions which could be implemented effectively in winter.

Limitations on the timing of fishing may well be the most difficult for commercial operations to cope with. Thus fishing conditions may be better in some seasons than others; also fishing fleets have timetables involving fishing for other resources in other areas at fixed periods. Their capacity for flexibility may be severely limited and more so than in respect of modifying the location of fishing.

The recommendations themselves need to be flexible in terms of the magnitude of the restriction they seek to impose. Some possible examples are shown in Table 2. The degree of restriction would obviously depend on the magnitude of the perceived problem but in many circumstances it would be prudent to start with a relatively modest restriction and adopt more severe ones if there are no signs of a change for the better.

3.4 General

If CCAMLR adopts any strategy involving the evaluation of the results of predator monitoring in order to consider these in the context of fisheries management, then WG-CEMP will need annually to review and evaluate the predator data. They would provide detailed advice for the Scientific Committee to consider, as a basis for making appropriate recommendations to the Commission.

ACKNOWLEDGEMENTS

I thank Inigo Everson, John Gulland, Mike Harris and John Heap for helpful comment and discussion.

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Table 1: Practical considerations relating to applying restrictions on commercial harvesting.

Restriction on Catch	Feasibility of Implementation	Feasibility of Monitoring Compliance	Consequences for Fishery	Probability of Aiding Predators
Size	Moderate-difficult	Difficult	Moderate	Low
Timing	Easy	Moderate	Serious	Moderate
Location	Easy	Moderate	Moderate	Moderate-good

Table 2: Examples of measures of differing degrees of restriction on commercial harvesting.

Restriction on Catch	Increasing Intensity of Restriction		
	1	2	3
Size	30% reduction	60% reduction	Zero
Timing	Not Jan-Mar	Not Dec-April	Closed
Location	Downstream in subarea	Close subarea	Close area

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