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ECOSYSTEM MONITORING AND MANAGEMENT - SUMMARY OF PAPERS PRESENTED AT THE THIRD MEETING OF THE SCIENTIFIC COMMITTEE

Abstract

This paper is an attempt to summarise and identify agreement of points raised in a number of scientific papers on ecosystem management presented for the consideration of the Scientific Committee at its first three meetings. All points are collated according to the following major questions:

- Interpretation of the objectives of the Convention;
- General concept of Antarctic Ecosystem;
- Present state and existing trends in the ecosystem;
- Management approaches;
- Modelling;
- Indicator species monitoring;
- Plan of action.

CONTROLE ET AMENAGEMENT DE L'ECOSYSTEME - RESUME DES DOCUMENTS PRESENTES A LA TROISIEME REUNION DU COMITE SCIENTIFIQUE

Résumé

Le but de ce document est de récapituler et d'identifier l'accord sur les questions soulevées dans un nombre de documents scientifiques sur l'aménagement de l'écosystème présentés aux trois premières réunions du Comité Scientifique pour examen. Toutes ces questions ont été rassemblées sous les rubriques suivantes:

- Interprétation des objectifs de la Convention;
- Concept général de l'écosystème antarctique;
- Etat actuel et tendances del'écosystème;
- Approches d'aménagement;
- Modèles;
- Contrôle des espèces indicatrices;
- Plan d'action.

МОНИТОРИНГ ЭКОСИСТЕМЫ И УПРАВЛЕНИЕ ЕЮ - ОБЗОР ДОКУМЕНТОВ, ПРЕДСТАВЛЕННЫХ НА ТРЕТЬЕМ СОВЕЩАНИИ НАУЧНОГО КОМИТЕТА

Резюме

Настоящая работа представляет собой попытку суммировать и определить единство мнений в вопросах, поднятых в ряде научных работ по экосистемному управлению, представленных на рассмотрение Научному комитету на его первых трех совещаниях. Все точки зрения сгруппированы по следующим основным темам:

- Интерпретация целей Конвенции;
- Общая концепция антарктической экосистемы;
- Современное состояние и существующие тенденции в экосистеме;
- Подходы к управлению;
- Моделирование;
- Мониторинг с помощью видов-индикаторов;
- План действий.

CONTROL Y ADMINISTRACION DEL ECOSISTEMA - RESUMEN DE DOCUMENTOS PRESENTADOS EN LA TERCERA REUNION DEL COMITE CIENTIFICO

Resumen

El propósito de este documento es resumir e identificar los acuerdos con respecto a los puntos formulados en varios documentos científicos sobre la administración del ecosistema presentados para la consideración del Comité Científico en sus primeras tres reuniones. Todos los puntos se compilan de acuerdo con los siguientes temas:

- Interpretación de los objetivos de la Convención;
- Concepto general del Ecosistema Antártico;
- Estado actual y tendencias existentes en el ecosistema;
- Enfoques administrativos;
- Confección de modelos;
- Control de especies indicadoras;
- Plan de acción.

Interpretation of the Objectives of the Convention

There is an interpretation that the Convention has "a commitment to manage the ecosystem as a whole" (5). It has also been suggested however, (4, 7, 9, 13) that the Convention does not call on the Commission to manage the ecosystem as a whole but to manage the fisheries and conserve the marine living resources from an "ecosystem perspective", i.e. the concept of coupling management of multispecies fisheries and ecosystem conservation (7). The actual objectives are postulated in the three detailed sub-sections under Article II, and, in particular, 3 (a,b and c).

A number of problems are pointed out in interpreting the precise scientific meaning of certain provisions of the text of this Article. Perhaps the main problem is related to the criteria for the protection of any harvested population which "should not be allowed to fall below a level close to that which ensures the greatest net annual increment". It is widely believed that it is not possible to maximize net annual increment of organisms at all levels of the food chain simultaneously (8).

The objective to ensure "the stable recruitment" may also meet difficulties when matched against the actual behaviour of the Antarctic ecosystem. As more is learned about populations of fish, it becomes clearer that stable recruitment is unusual in nature and may be little more than the optimistic simplification of the mathematical modeller (9). It would be surprising if some elements at least of the Antarctic marine ecosystem did not exhibit such instability and changes that are, in the short term, irreversible.

There are other scientific questions on the correct interpretation of the text of Convention, and in view of these difficulties it is proposed that the Scientific Committee be prepared to consider a wide interpretation of the Commission's objectives (9).

General Concept of Antarctic Marine Ecosystem

There is a conception that the Antarctic ecosystem is relatively simple or simpler than others (4, 8). The food chain is short. A traditional explanation for energy pathways in the Southern Ocean has been linear : plankton (diatoms - E. superba → krill consumers. Krill is the major prey species. It is the main food for Baleen whales, seals, sea birds, fish and squid. However, there are a number of problems in assessing any affects of interactions between the elements of the ecosystem in spite of this natural simplification (8). It is now increasingly clear that the Antarctic marine system is much more complex. Changes in our understanding of interactions between marine organisms have taken place, in particular, at the low levels of the ecosystem (11).

The papers refer to the Antarctic ecosystem but reference to "management areas", "semi-discrete systems", "effectively closed subsystems", "geographic components", "pelagic ecosystem of Ross Sea" (1, 4-6), suggests that there is an acceptance that the entire Antarctic ecosystem is subdivided into discrete or semi-discrete systems. For example, the analysis of the distribution of the Antarctic marine living resources in relation to the environmental conditions shows that it is possible to distinguish two separate biological communities (1).

1. Community of the open water
2. Community of pack ice area

The gyres maintained within circumpolar water circulation concentrate krill into semi-discrete systems and at least for the baleen whales, there are indications that they tend to feed each year on the same krill concentrations rather than to range freely around Antarctic waters (5). There is also an indication that there are relatively independent trophic relationships : copepods-mesopelagic and bathypelagic fishes-squids-sperm whales. (1,5).

There is some agreement that fish might not be in such direct competition as other major consumers because the larger stocks of demersal fish occur on banks on the outer edge of the ecosystem. Thus, fish might be considered separately for management purposes (5, 8). There appears to be general agreement that the key interaction in the ecosystem is between baleen whales and krill.

It is generally accepted that the major limiting factor within an ecosystem is the availability of food. Krill is the staple food of key resource species in the Antarctic ecosystem. Therefore, variations in krill abundance will have a direct impact on the major consumers in the Antarctic and vice versa.

Some populations of birds may have a limited area in which to breed and to feed themselves and their young. Certain seals may also be limited by available breeding sites on sub-Antarctic islands.

Present State and Existing Trends in the Ecosystem

There are three main assumptions concerning the present status of the Antarctic marine ecosystem (7) :

(i) as a result of reduced baleen whale stocks, krill availability has increased;

(ii) non-exploited krill predators responded functionally and numerically to the increase in krill availability;

(iii) a new carrying capacity and community composition has developed.

These assumptions are considered in various details in a number of papers.

As a result of depletion of baleen whales in Antarctica, a "krill surplus" may have occurred. With increased food availability, krill predators such as some pinnipeds, seabirds, fish and squid presumably experienced increased growth rates and population size. In general, there is an opinion that krill consuming groups "benefited in various ways from reduction of baleen whale stock".

The significance of sperm whale depletion, though smaller than that of baleen whales in terms of biomass, may be comparable in its affect on the ecosystem because of their high trophic level (8).

Important evidence for the so called "competition release" in the Antarctic was thought to be found in data on demographic parameters of some species of marine mammals, in particular, crab-eater seal and minke whale. However, recent studies have shown that the method of analysis may be fundamentally flawed (8). The important point of this consideration is that we do not have clear indication of the nature and extent of competition between krill predators in the Antarctic (8).

The manner in which current whale stocks are being affected by altered abundance and behaviour of their prey and competitors remains unknown (11). The present community composition of the Antarctic marine ecosystem is substantially different to that existing before commercial fishing began. Obviously, there is far less baleen whale biomass now than before. It is also likely that in some areas the biomass of seals, birds, and perhaps squid and fish is much higher than prior to whaling. The effect that a change from a whale-dominated system to a seal/bird-dominated system has had on ecological processes in the system is unclear. Current population trends of unexploited populations of whales and seals in the Antarctic are uncertain (7).

Thus we find ourselves in the situation where the system to be managed has been significantly perturbed and our information about the effects of the perturbation is not sufficient to give quantitative insight into the effects of various management actions (8, 13).

Management Approaches

Two possible approaches are proposed to achieve the objectives of Article II of the Convention, so called "passive" and "active" approaches (6).

The "passive" approach is to curtail all harvesting. There is a hypothesis that such a "passive" approach may lead the Antarctic ecosystem to the restoration of its pre-exploited state or to the conservation of the ecosystem at the present level or with changes which may occur as a result of natural factors (6, 13). From the large volume of recent literature on the stability of ecosystems (9) however, it is clear that there can be more than one stable state. Once perturbed, the system would not necessarily return to its original position even if all exploitation ceased (6, 9).

The "active" approach involves harvesting of some species (6). The following options were proposed for consideration as "active" management strategies :

- Low harvest of krill only;
- High harvest of krill only;
- Low (or zero) harvest of krill + sustainable catch of crabeater seals;
- High harvest of krill + sustainable catch of crabeater seals;
- Low (or zero) harvest of krill + sustainable catch of crabeater seals + sustainable catch of minke whales.

The hypothetical consequences upon the ecosystem arising from each of the management options were considered (5, 7, 8). The degree to which various krill consumers would be affected by krill fishing would depend on the species and its natural history. A major difficulty with this approach is there is not sufficient data at present to assess quantitatively the relationships between various components of krill-dominated food webs. Without more information it is not possible to devise specific management strategies for simultaneous harvest of krill and its predators (7, 8).

Modelling

It is obvious that mathematical modelling could be one of the most useful approaches in future study to achieve the goal of a rational utilization and management of the Antarctic ecosystem (4, 5, 6, 8, 9, 12). There are several classes of models (theoretical, estimation and strategic simulation models) each of which have their particular uses and shortcomings (8).

The theoretical models give us insight into the system. They make predictions on what kinds of phenomena might be observed and provide a means of reconciling the observations to give a starting point for refined models. In general, such models do not give quantitative predictions about specific aspects of the system. The estimation models give us quantitative estimates about the system such as yield or demographic parameters of particular species. Such models are designed to incorporate few parameters and may not always be applicable in a particular set of circumstances. This class of models is important for management purposes. The strategic simulation models can be used to evaluate strategies for the acquisition of information about a system and hence management decisions.

Thus, the theoretical models give guidance as to what sort of phenomena to look for, the strategic simulation models indicate how to look for them and the estimation models are the tools which summarise the observations for practical purposes.

An ability to manage rationally implies an ability to predict the effect of perturbing the system. Such quantitative predictions require the construction of a model in which "species-species" as well as "men-species" interactions are taken into account - that is a "multi-species" model (6, 12, 13). One of the anticipated shortcomings of such models is the great difficulty to decide or to assign adequate values for too many parameters (12, 13). Possible future improvements of such models were mentioned taking into account interaction with neighbouring system (13) and the seasonal variations within the system (12). Meanwhile, the utility of the single-species models was emphasised as a research tool for the development of the multispecies models and the strategy for ecosystem management (6, 9, 13).

Several models have already been applied to marine living resources of the Antarctic. The pelagic ecosystem of the Ross Sea has been simulated, the so-called "heuristic" models have been used to investigate behaviour of biological systems exploited simultaneously at two or more trophic levels (e.g. baleen whales and krill) and there have been numerous modelling investigations associated with assessment and management of whale stocks (2, 8, 12). These models take into account the different parameters of the ecosystem from the simple prey-predator relationship to much more complex interactions covering up to thirteen species or components (12). It is possible to consider these models as the first stage of the development of a multi-species model to match the needs of CCAMLR.

Our present knowledge of the actual behaviour even of the same "major" components of the Antarctic ecosystem is however extremely limited and in general, the existing data base is insufficient to meet the aims and goals of Antarctic ecosystem management. Available data from the Convention area are not adequate to reliably predict or to detect the effects of harvesting, particularly of Antarctic krill (E. superba), and on dependent or related populations.

Indicator Species Monitoring

There appears to be consensus that many species of higher trophic levels are predominantly dependent on krill as a food source. There is a suggestion that monitoring of krill would provide us with very useful information on the status of dependent species and hence with some knowledge on the status of the whole ecosystem (2, 5-8). There are problems however in monitoring changes in krill abundance (7, 6) :

- Krill is distributed over a very large area, presenting a logistic problem;

- Its patchy distribution creates a sampling problem;

- Its swarming behaviour complicates abundance estimates;

- There is a limited understanding of the physical and biological factors affecting krill population dynamics.

Given these and other difficulties, the use of indicator species has been suggested as a method to indirectly monitor ecological interactions (2, 7).

The "ideal" indicator species should (2, 7) :

(i) be predators, prey or competitors of Antarctic krill;

(ii) occur in areas where krill are found and are being harvested;

(iii) be sensitive to changes in krill availability, but relatively insensitive to natural fluctuations in physical environmental conditions;

(iv) have perturbation response times that are relatively short;

(v) have variables which can be measured relatively simply and inexpensively at accessible locations.

To be of practical use such a species would also have to be land-based and thus relatively easily monitored and to respond to a depletion of a shared food supply in a way similar to the oceanic predator (8).

Last year the Committee considered in brief the matter of indicator species. It was decided to address a list of special questions to the BIOMASS Working Party on Bird Ecology and SCAR Group of Specialist on Seals (see Annex 10 to the Report of the Second Meeting of the Scientific Committee). The Secretariat received the answers and distributed them to the members in advance of this meeting. The summary of these answers is in SC-CAMLR-III/BG/9. The main conclusions of these answers as well as other papers (2, 7) that the use of indicator species to indirectly monitor ecological trends in the Antarctic marine ecosystem appears promising. However, there is only the barest foundation of information upon which to build a monitoring program. The limited knowledge of the characteristics of indicator species in Antarctica does not allow for estimating how long it is likely to take to establish suitable baselines.

As possible indicator species the crabeater seal, Antarctic fur seal, Adelie and Chinstrap penguin are suggested.

Plan of Action

There seems to be agreement on several activities which may be collected together into a plan of action.

(i) Commercial and Scientific data collection;

(ii) Development and Use of Models;

(iii) Design and Implementation of experimental fishing and monitoring program;

(iv) Commencement of a program of monitoring dependent and related species.

Some progress has been made with data collection and the subject has been included in the agenda of this meeting. The papers emphasise the need to ensure the scientific utility of the Commercial data.

Most authors refer to the need to develop multi-species models. Three directions of investigation are outlined :

(i) Selection of the major components of the system.

(ii) Estimation of the population sizes and growth rates for these components.

(iii) Carrying out of carefully designed so-called "perturbation experiments".

The idea of perturbation experiments was considered in various details (6, 8, 10). Such experiments include the special "control" areas in which there would not be any human activities. A detailed proposal for a major phased study in the Prydz Bay area is put forward (10).

In the meantime, as interim measures on the basis of single-species models, it was proposed to determine or to allocate so-called "target levels" for the major components of the ecosystem (6). In this connection, the following actions were suggested (13) :

(i) To maintain the exploitation of krill at current levels, taken as a maximum.

(ii) To establish an adequate program for the controlled culling of crabeater seals.

(iii) To maintain a monitoring programme on the populations of other secondary consumers at the same time as numbers of crabeater seals are decreased.

(iv) To reduce fish catches to a minimum.

In relation to the use of indicator species, it is proposed that to develop a strong program upon which management decisions can be based, the following steps must be taken now to begin laying the groundwork for a monitoring network and database :

(i) consultations among scientists to begin planning and coordinating monitoring efforts;

(ii) evaluation of baseline data that may be available and initiation of pilot projects to begin the acquisition of baseline data at monitoring sites;

(iii) begin monitoring studies on selected indicator species.

8. References

First meeting :

1.	Number not allocated	"Ecological Peculiarities, Stocks and Role of E. Superba in the Trophic Structure of the Antarctic Ecosystem" 1982, Lubimova T.G. et al.

Second Meeting :

2.	SC-CAMLR-II/6	Detection of Possible Indirect Effects of Harvesting on the Antarctic Marine Ecosystem
3.	SC-CAMLR-II/INF.3	Trends in Crabeater Seal's Age at Maturity : an Insight into Antarctic Marine Interaction?
4.	SC-CAMLR-II/INF.4	Modelling : The Application of a Research Tool to Antarctic Marine Living Resources

Third Meeting :

5.	SC-CAMLR-III/BG/1	"An Approach to a Management Strategy for the Antarctic Marine Ecosystem" (This paper was intially presented at the second meeting).
6.	SC-CAMLR-III/BG/3	Antarctic Ecosystem Management
7.	SC-CAMLR-III/BG/5	Monitoring Indicators of Possible Ecological Changes in the Antarctic Marine Ecosystem.
8.	SC-CAMLR-III/BG/7	Marine Mammal Fishery Interactions : Modelling and the Southern Ocean
9.	SC-CAMLR-III/BG/8	Comments and Questions on Ecosystem Management

10.	SC-CAMLR-III/7	Ecosystem Management : Proposal for Undertaking a Coordinated Fishing and Research Experiment at selected sites around Antarctica.
11.	SC-CAMLR-III/BG/13	Review of Antarctic Marine Fauna
12.	SC-CAMLR-III/INF.6	A Review on the Antarctic Ecosystem Models Published by Japanese Scientists and Some Comments
13.	SC-CAMLR-III/BG/12	Conservation and Management Strategy for the Antarctic Marine Ecosystem