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DETECTION OF POSSIBLE INDIRECT EFFECTS OF HARVESTING AND ASSOCIATED  
ACTIVITIES ON THE ANTARCTIC MARINE ECOSYSTEM

Abstract

The purpose of this paper is to indicate a number of possibilities and to facilitate development of an agreed plan for selecting, assessing and monitoring species, populations, and individual characteristics that will be likely sensitive indicators of possible indirect effects of harvesting and associated activities in the Convention Area. Harvesting is considered as a form of predation which can result in changes in stock status not only of target species but dependent and related species as well. There is a list of criteria to select appropriate indicators of harvest-related changes. Observation of by-catch during fishing operations and sightings of birds and mammals by observers aboard vessels engaged in fishing, research or other activities might be useful as a source of information for assessing possible indirect effects of harvesting and related activities in the Convention Area. It is suggested that penguins and pinnipeds have the greatest potential as possible indicators of krill availability. Some practical steps to identify possible indicator species and necessary research and monitoring programs are proposed.

DETECTION DES EFFETS INDIRECTS EVENTUELS DE L'EXPLOITATION ET DES  
ACTIVITES CONNEXES SUR L'ECOSYSTEME MARIN DE L'ANTARCTIQUE

Résumé

Le but de cet exposé est d'indiquer un certain nombre de possibilités et de faciliter le développement d'un plan convenu et qui aurait pour objet la sélection, l'évaluation et le contrôle d'espèces, de populations et de caractéristiques individuelles susceptibles de constituer des indicateurs sensibles des effets indirects éventuels de l'exploitation et des activités connexes dans la zone de la Convention. L'exploitation est considérée comme une forme d'intervention prédatrice dont le résultat peut être la modification de l'état des stocks non seulement en ce qui concerne les espèces cibles, mais aussi les espèces dépendantes et voisines. Il existe une liste de critères pour la sélection d'indicateurs appropriés des changements relatifs à l'exploitation. L'observation des prises accidentelles au cours des opérations de pêche et celle d'oiseaux et de mammifères effectuées par des observateurs à bord des navires engagés dans des opérations de pêche, de recherche ou d'autres activités pourraient s'avérer utiles en tant que source d'information pour évaluer les effets indirects éventuels de l'exploitation et des activités connexes

dans la zone de la Convention. Il est suggéré que les manchots et les pinnipèdes constituent, potentiellement, les meilleurs indicateurs de la disponibilité de krill. Certaines mesures pratiques pour l'identification d'espèces indicatrices éventuelles sont proposées, ainsi que les programmes de recherche et de contrôle nécessaires.

#### ОБНАРУЖЕНИЕ ВОЗМОЖНЫХ КОСВЕННЫХ ВОЗДЕЙСТВИЙ ПРОМЫСЛА И СВЯЗАННОЙ С НИМ ДЕЯТЕЛЬНОСТИ НА МОРСКУЮ ЭКОСИСТЕМУ АНТАРКТИКИ

##### Резюме

Целью данного документа является выявление ряда возможностей и облегчение создания согласованного плана отбора, оценки и мониторинга тех видов, популяций и специфических характеристик, которые смогут послужить чувствительными индикаторами возможных косвенных воздействий промысла и связанной с ним деятельности в зоне действия Конвенции. Промысел рассматривается как вид хищничества, который может вызвать изменения в состоянии запасов не только промысловых, но и зависимых от них и связанных с ними видов. Предлагается ряд критериев для отбора соответствующих индикаторов связанных с промыслом изменений. Регистрация побочного вылова во время промысловых операций и наблюдение за птицами и млекопитающими, осуществляемое наблюдателями на борту судов, ведущих промысел, исследования и прочая деятельность могут явиться полезным источником информации для оценки возможных косвенных воздействий промысла и связанной с ним деятельности в зоне действия Конвенции. Высказывается мнение о том, что пингвины и ластоногие обладают наибольшим потенциалом для возможного использования в качестве индикаторов наличия криля. Предлагаются некоторые практические меры для определения возможных видов-индикаторов, а также необходимые исследования и программы мониторинга.

#### DETECCION DE LOS POSIBLES EFECTOS INDIRECTOS DE LA RECOLECCION Y ACTIVIDADES AFINES EN EL ECOSISTEMA MARINO ANTARTICO

##### Resumen

El propósito de este documento es indicar una serie de posibilidades y facilitar el desarrollo de un plan

acordado para seleccionar, evaluar y controlar las especies, poblaciones y características individuales que posiblemente constituyan indicadores sensibles de los posibles efectos indirectos de la recolección y actividades afines en el Area de la Convención. Se considera que la recolección es una forma de depredación que puede dar como resultado cambios en el estado de la existencia, no sólo de las especies objetivo, sino también de las especies dependientes y afines. Existe una lista de criterios para seleccionar los indicadores adecuados de los cambios relacionados con la recolección. La observación de la captura accidental durante las operaciones de pesca y las observaciones de aves y mamíferos efectuadas por los observadores a bordo de las naves dedicadas a la pesca, investigación u otras actividades podrían constituir una útil fuente de información para evaluar los posibles efectos indirectos de la recolección y actividades afines en el Area de la Convención. Se sugiere que los pingüinos y los pinnípedos tienen la mayor capacidad de servir como posibles indicadores de la disponibilidad del krill. Se proponen algunas medidas prácticas para identificar las posibles especies indicadoras y los programas de investigación y control necesarios.

The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) requires that harvesting of marine living resources in the Convention Area be conducted so as to maintain the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources, as well as to prevent the depletion of harvested species and populations. Available data and ongoing research and monitoring programs in the Convention Area are not adequate to reliably predict or to detect the effects of harvesting, particularly of Antarctic krill (*Euphausia superba*), on dependent or related species and populations of Antarctic marine living resources. Moreover, it would be prohibitively costly, if not impossible, to assess and monitor each species and population that might be affected indirectly by harvesting of krill or other Antarctic marine living resources. It follows, therefore, that one of the tasks of the Scientific Committee, established pursuant to Article XIV, will be to determine and recommend programs for assessing and monitoring those species, populations, or individual characteristics that most likely will be affected indirectly, in detectable ways, by harvesting of Antarctic krill or other species of Antarctic marine living resources.

The United States has proposed (see SC-CAMLR-II/INF.1) that identification of possible indicator species and necessary research and monitoring programs be initiated as a matter of priority during the second meeting of the CCAMLR Scientific Committee. The purpose of this paper is to indicate a number of possibilities and to facilitate development of an agreed plan for selecting, assessing and monitoring species, populations, and/or individual characteristics that likely will be sensitive indicators of the possible indirect effects of harvesting and associated activities in the Convention Area.

#### General Considerations

Harvesting is a form of predation which can result in changes in the productivity and behavior, as well as the distribution and density (abundance), of the target species. Such changes, including changes in behavior, can affect the distribution, productivity, survival and behavior

of dependent or related species - i.e., species that prey upon, are eaten by, or compete with the target species. As an example, harvesting of Antarctic krill conceivably could result in fewer or smaller krill swarms, or changes in swarming behavior, that would make it more difficult for certain krill predators to locate and effectively catch krill. Conversely, the same harvest-caused changes in krill swarms could result in more food, space, or other limiting resources being available to one or more herbivore species that compete with E. superba.

To function as an indirect indicator of harvest-caused changes in the demography of target species or populations, the indicator species or population must be a consumer (predator), prey, or competitor of the target species, occur in or near areas where the target species is being harvested, and be sensitive to changes in the distribution, density, productivity or behavior of the target species, but relatively unresponsive, or predictably responsive, to natural environmental fluctuations. In addition, the responses should be relatively rapid (i.e., not subject to substantial time lags), monitoring programs needed to detect responses should be simple, inexpensive, and not subject to large sampling errors or bias, and adequate baseline information should already exist or should be relatively simple to collect. Data collection ideally could be accomplished during fishing operations and/or from shore stations or vessels engaged in other activities - i.e., there ideally would be little or no need for dedicated vessels to carry out assessment and monitoring of selected indicators.

#### Potential "By-Catch" Indicators

One or more species caught incidentally during fishing operations may be consumers, prey or competitors of the target species. The distribution, density or vital rates of these by-catch species may be sensitive to changes in the distribution, density, productivity or behavior of the target species such that they could serve as an indirect indicator of harvest-caused changes in the target species or population.

Catch, effort, and related biological information collected during commercial and experimental fishing operations and the First International BIOMASS Experiment (FIBEX) may provide a basis for determining whether and what by-catch species might function as useful indicators of harvest-caused changes in target species or populations. It would be desirable, therefore, to compile and evaluate available catch, effort and related biological information to determine whether and what by-catch species might serve as useful indicators of harvest-caused changes in various target species.

#### Opportunistic Bird and Mammal Sightings as Possible Indicators

Information concerning the presence, absence, abundance, and behavior of marine mammals and birds can be collected opportunistically by observers aboard vessels engaged in fishing, research or support activities. Such information can be used to determine spatial distribution, relationships between distribution and oceanographic conditions, local co-occurrence of groups of competing or predatory species, changes in relative abundance within and between areas, and to estimate absolute abundance.

Scientific technicians presumably have been and will continue to be placed aboard fishing and scouting vessels in the Convention Area in order to collect detailed data about the fishing operations and catches. These technicians could conduct bird and marine mammal sighting surveys when they are not engaged in their principal duties. The several types of data that could be obtained from such surveys would be useful for improving understanding of the relationships among birds, marine mammals, krill, fish and other components of the Antarctic marine ecosystem.

Survey methods and data forms should be standardized to the maximum practical extent. It would be desirable, therefore, to constitute a small working group or workshop to assess procedures that have been and are being used to compile and analyze sighting data and to determine whether and how these procedures might be adapted to facilitate acquisition

of information that might be useful for assessing possible indirect effects of harvesting and related activities on the Convention Area.

#### Penguins as Possible Indicators of Krill Availability

Because of their large numbers, wide distribution, dependence upon Antarctic krill, and accessibility during the breeding season, Adelie and chinstrap penguins may be potentially good indicators of localized or regional changes in the abundance or behavior (availability) of krill. Parameters that presumably could or would change in response to krill availability include colony size, clutch size, time that parents spend away from the chicks searching for food, relative quantity of krill and other species in the diet, fledging success, weight of chicks at fledging, and survival to breeding age. Changes in survival to age at first reproduction and colony size would take a number of years to be manifested and would be difficult to detect unless the changes and/or sample sizes were very large. Changes in time spent feeding, fledging weights, and other similar variables would be less subject to time lags and easier to measure, making them better choices of potential indicators.

No matter what variables are selected for monitoring, the studies likely will be labor intensive and limited in scope unless some system of more or less automatic data collection can be established (see the companion paper by Green-Hammond, et al.). A team of two to four investigators would be required, for example, at each selected indicator colony if traditional study techniques were used. Therefore, at an early stage, it will be necessary to assess and, as possible, adapt and use remote sensing and automatic data recorders to collect data. It would be desirable, therefore, to constitute a working group or to ask the BIOMASS Working Party on Bird Ecology to consider and, as possible, indicate the types of assessment/monitoring programs that might be useful for detecting harvest-caused changes in krill distribution, density or behavior.

Pinnipeds as Possible Indicators of Krill Availability

Of the six pinniped species that occur in the Convention Area, three depend upon Antarctic krill to some extent. The crabeater seal feeds more or less exclusively on krill. The leopard seal eats krill, at least in some areas, and preys upon crabeater seals and Adelie penguins, both of which are dependent primarily upon Antarctic krill. Fur seals on South Georgia Island and elsewhere in the vicinity of the Antarctic Peninsula also eat krill.

Parameters that could change in response to changes in krill availability include: population size; pup, juvenile and/or adult survival; ages at first reproduction; size at birth; growth rate; pupping interval and/or age-specific reproductive rates; blubber thickness; time spent feeding; and proportion of species other than krill that are eaten. Most of the potential indicator variables, other than population size, could be assessed and monitored by periodically collecting representative samples of animals from selected areas, including areas where krill has not and is not being harvested. Sample sizes necessarily would be large (30 to 50 individuals per age class) and sample intervals would have to be selected so as to assure that any observed changes in the selected indicator variables were not caused by the sampling.

As with birds, it would be desirable to establish a working group or to ask the SCAR Group of Specialists on Seals to consider and indicate the types of assessment/monitoring programs that might be useful for detecting indirect effects of krill harvesting on selected pinniped species.

Conclusions

It seems likely that several species groups and types of data might be useful for detecting and monitoring the possible indirect effects of harvesting on dependent and related populations of Antarctic marine living resources. Some species groups and types of data no doubt will be more useful than others and, as a first step toward the development of an

agreed (general) program plan, relevant theory, methodology and biological, ecological and catch/effort data should be examined to determine what combination or combinations of species, populations and individual characteristics have the greatest potential for reflecting the possible indirect effects of harvesting and associated activities in the Convention Area. This task could be accomplished more effectively by one or more working groups than by the committee as a whole. The US therefore proposes that initial efforts in this regard be devoted to development of a work plan and terms of reference for one or more working groups.

