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THE ASSESSMENT OF EXPLOITED ANTARCTIC FISH STOCKS

Abstract

Comments on the status of exploited fish stocks in Antarctica are provided in the context of assessing the methodology used by Kock et al (1984). Attention is drawn to the problems of interpreting the management guidelines of Article II of the Convention for the Conservation of Antarctic Marine Living Resources, that is to ensure that stocks should not fall below the level at which their net productivity is at maximum. The yield per recruit relationship may be viewed as a possible indicator of net productivity. However, attempts to manage on the basis of this relationship have an associated risk of recruitment decline. Some possible solutions to this problem are considered including the Kock et al (1984) approach to adopt $F_{0.1}$ as a target fishing mortality. The stochastic nature of recruitment makes the problem more complicated. In general all of these imply the need for a conservative management policy aimed at ensuring stable recruitment.

The usage of catch per day fishing as unit of CPUE adopted by Kock et al (1984) is duscussed. Catch per fishing hour is more likely to reflect the changes in stock abundance than catch per day. Separate analyses of CPUE by target species would be more desirable.

Certain results of the Kock et al analyses seem clear regardless of whatever methodology might be used. The biomasses of the spawning stocks of several species, particularly Notothenia rossii, Dissostichus eleginoides and Pseudochaenichthys georgianus, have been reduced to levels where their stable recruitment must be in doubt. The status of the nototheniids gives most cause for concern, as Kock et al report on a number of studies which indicate that there is a substantial by-catch of juvenile nototheniids taken in the krill fishery around South Georgia.

Accordingly it is clearly necessary on the basis of available evidence to consider the immediate adoption of conservation measures for certain stocks in the convention area.

EVALUATION DES STOCKS DE POISSONS EXPLOITES EN ANTARCTIQUE

Résumé

La condition des stocks de poissons exploités en Antarctique est discutée dans le contexte de l'évaluation de la méthodologie utilisée par Kock et ses confrères (1984). Sont également soulevés les problèmes d'interprétation des directives de gestion données par l'Article II de la Convention pour la Conservation de la Faune et la Flore Marines de l'Antarctique, c'est-à-dire de faire en sorte que les stocks ne périclitent pas jusqu'à un niveau au-dessous duquel la productivité nette de ces stocks est à son maximum. La relation rendement-par-recrue peut éventuellement être interprétée comme un indice possible de la productivité nette. Toutefois, des tentatives de gestion sur la base de cette relation sont liées à un risque de déclin du recrutement. Des possibilités de solutions à ce problème sont examinées, y compris l'approche de Kock et ses confrères (1984) adoptant $F_{0.1}$ comme mortalité-cible par pêche des poissons. Le caractère stochastique du recrutement rend le problème plus compliqué. En général, tout ceci implique le besoin d'une politique conventionnelle de gestion dont l'objectif est d'assurer un recrutement stable.

L'utilisation de la prise par jour de pêche comme unité de la CPUE adoptée par Kock et ses confrères (1984) est discutée. La prise par heure de pêche est davantage susceptible de traduire les changements survenant dans l'abondance des stocks que la prise par jour. Des analyses séparées de la CPUE par espèce-cible serait plus souhaitable.

Certains résultats des analyses de Kock et ses confrères semblent clairs quelle que soit la méthode utilisée. Les biomasses des frayères de plusieurs espèces, notamment Notothenia rossii, Dissostichus eleginoides et Pseudochaenichthys georgianus, ont été réduites à des niveaux n'assurant pas forcément le recrutement stable de leur espèce. La condition des nototothénides est la plus préoccupante, ainsi que Kock et ses confrères le démontrent dans de nombreuses études indiquant que la prise secondaire de jeunes nototothénides constitue une capture importante des opérations de pêche de krill aux alentours de la Géorgie du Sud.

En conséquence, en se fondant sur l'évidence disponible, il est clair qu'il est nécessaire de considérer l'adoption immédiate de mesures de conservation de certains stocks dans la zone de la Convention.

ОЦЕНКА ЭКСПЛУАТИРУЕМЫХ РЫБНЫХ ЗАПАСОВ АНТАРКТИКИ

Резюме

Замечания по состоянию эксплуатируемых рыбных запасов Антарктики представлены в связи с оценкой методологии, которая была использована Коком и др. (1984 г.). Внимание привлекается к вопросам интерпретации указаний по управлению, содержащихся в Статье II Конвенции о сохранении морских живых ресурсов Антарктики, то есть обеспечения того, чтобы запасы не сокращались ниже того уровня, на котором их чистая продуктивность максимальна. Отношение величины вылова к единице пополнения можно рассматривать как возможный индикатор чистой продуктивности. Тем не менее, попытки осуществления управления на основе этого отношения вносят сопутствующий этому риск сокращения пополнения. Рассматриваются некоторые возможные варианты разрешения этой проблемы, включая подход, предложенный Коком и др. (1984 г.), состоящий в том, что величина $F_{0.1}$ принимается за целевой уровень промысловой смертности. Стохастическая природа процесса пополнения еще более осложняет этот вопрос. В общем, все вышеупомянутое означает необходимость консервативного подхода к управлению, направленного на обеспечение устойчивого пополнения.

Обсуждается использование величины вылова за день промысла, принятой Коком и др. (1984 г.) за единицу CPUE. Вылов за час промысла более вероятно отразит изменения величины запаса, чем вылов за день. Отдельные анализы CPUE по каждому отдельному виду были бы более желательны.

Некоторые результаты анализов, проведенные Коком и др., представляются ясными, независимо от использованной методологии. Биомассы нерестующих запасов нескольких видов, а особенно Notothenia rossii, Dissostichus eleginoides и Pseudochaenichtys georgianus, сократились до такого уровня, при котором их стабильное пополнение находится под сомнением. Состояние запасов нототениидов дает наибольшие основания для беспокойства, поскольку Кок и др. представляют результаты ряда исследований, которые указывают на значительный побочный вылов молоди нототениидов при промысле криля в районе Южной Георгии.

Учитывая вышеизложенное, ясно, что имеется необходимость на основании имеющихся данных рассмотреть вопрос о незамедлительном принятии мер по сохранению в отношении некоторых запасов в зоне действия конвенции.

EVALUACION DE LAS RESERVAS EXPLOTADAS DE PECES ANTARTICOS

Sinopsis

En el contexto de la evaluación de la metodología usada por Kock et al (1984) se proporcionan comentarios respecto al estado de las reservas de peces explotados en la Antártida. Se observan los problemas de interpretación de las pautas administrativas del Artículo II de la Convención para la Conservación de los Recursos Vivos Marinos Antárticos, destinadas a asegurar que las reservas no deberían bajar del nivel en el cual su productividad neta se encuentra en su punto máximo. El rendimiento por cría puede considerarse como un posible indicador de la productividad neta. Sin embargo, los intentos de administración en base a esta relación representan un riesgo asociado con una disminución en el restablecimiento. Se han considerado algunas soluciones posibles de este problema, incluyendo el enfoque de Kock et al (1984) de adoptar $F_{0.1}$ como una meta de mortalidad de peces. La naturaleza fortuita del restablecimiento hace el problema más complicado. En general todo esto implica la necesidad de una política de administración conservadora, dirigida a asegurar un restablecimiento estable.

Se discute el uso de captura por día de pesca como unidad de CPUE adoptada por Kock et al (1984). Es más probable que la captura por hora de pesca refleje los cambios en la abundancia de reservas que la captura por día. Sería mejor realizar análisis separados de CPUE por especie objetivo.

Algunos resultados de los análisis de Kock et al parecen claros cualquiera que sea la metodología usada. Las biomasas de las reservas en desove de varias especies, especialmente, Notothenia rossii, Dissostichus eleginoides y Pseudochaenichthys georgianus, han sido reducidas a niveles en los cuales su restablecimiento estable deber ser puesto en duda. La situación de los nototheniids es causa de la mayor preocupación, según lo informan Koch et al en una serie de estudios que indican que se pescan accidentalmente nototheniids jóvenes de manera considerable durante la pesca de krill en el área de Georgia del Sur.

Por lo tanto, en base a la evidencia disponible es obviamente necesario considerar la adopción inmediata de medidas de conservación para ciertas reservas en el área de la Convención.

The Assessment of Exploited Antarctic Fish Stocks

J.R. Beddington & I. Everson

Submitted by the United Kingdom Delegation

Introduction

Until recently the main source of information on the exploited fish stocks of the Southern Ocean was the Report of the Second Workshop on Antarctic Fish Biology (BIOMASS, 1980). In its deliberations last year, the Scientific Committee agreed to review this document and to seek comments from scientists from member states on the status of Antarctic fish stocks. The Scientific Committee is fortunate this year in having available from BIOMASS a comprehensive review of the problem which extends and updates the earlier work (Kock, Duhamel and Hureau, 1984). Here we will comment on the status of the fish stocks largely in the light of this second document.

The justification for this decision is obvious as the second document contains much new material. However it is clear that like the earlier BIOMASS report the review by Kock et al suffers from a lack of data from the main commercial fisheries. To that extent the results may be viewed as provisional. Nevertheless there is sufficient consistency in the available data to warrant confidence in the results.

Management Guidelines

The main guideline to the management of the living resources of the Southern Ocean is in Article II of the Convention. The relevant portion of this article may be paraphrased as indicating that harvesting should be regulated to ensure that stocks should not fall below the level at which their net productivity is at a maximum. There are some problems in interpreting this article for top predators such as fish because their productivity may be expected to be closely related to the abundance of their main food supply (May et al 1979, Edwards and Heap 1981). Nevertheless, at present levels of exploitation of krill it is unlikely that the productivity of the fish stocks has been eroded although the problem of the by-catch of the young of certain species, referred to by Kock et al, could be eroding that productivity and is considered below.

At this point it is pertinent to raise the question: what is the stock level at which net productivity is maximised? Conventional fisheries theory offers some guidelines. The yield per recruit (Y/R) may be viewed as a possible indicator of net productivity; this varies with the level of fishing mortality (F), and the age specific pattern of recruitment to the fish ry. If for the purposes of discussion we assume knife edge recruitment at a certain optimum age (t_c) or length (l_c) then the picture is as illustrated in Figure 1. In Figure 1a yield per recruit is maximised at some finite value of fishing mortality (Fmax). Associated with that level of fishing mortality is an equilibrium spawning stock biomass level (S_{max}). The degree of deple-

tion of the spawning stock biomass may be conveniently represented by the ratio of S_{max} to the unexploited spawning stock biomass level (S_0).

In Figure 1b yield per recruit is not maximised at any finite value of F and no convenient spawning stock size is associated with the maximum yield per recruit. Mathematically, maximum yield per recruit occurs at infinite fishing mortality and zero stock size. This is clearly biologically absurd, but the absurdity highlights a problem of the approach. Even in the situation depicted in Figure 1a the degree of depletion of the spawning stock may be sufficient to affect the recruitment. Examples abound where severe reduction in spawning stock biomass is associated with much reduced recruitment. Hence attempts to manage on the basis of a maximum yield per recruit will have an associated risk of recruitment decline. This implies that the overall productivity will not be maximised.

It is possible to treat such a problem formally by incorporating a stock recruitment relationship into the analysis. Maximum net productivity (MNP) is then found at the stock level where the product of expected recruitment and yield per recruit is maximised. Such an approach does not at present seem advisable in the Southern Ocean context. The relationship between stock and recruitment for the fish stocks of the Southern Ocean is unknown and other studies indicate that in the vast majority of cases elsewhere recruitment is only loosely linked to spawning stock size. Yet it is also clear from such studies that significant reduction of the spawning stock to below some 20 to 30 per cent of the unexploited level has been associated with dramatic reductions in recruitment.

A pragmatic approach to the problem has been proposed by Kock et al, who suggest that an adoption of a target fishing mortality of $F_{(0.1)}$ might be appropriate. The choice of a particular target fishing mortality is clearly arbitrary and it is appropriate to consider what level of spawning stock reduction is associated with this level of fishing mortality.

Another option is to manage under the constraint that spawning stock biomass is not reduced below some arbitrary percentage of the unexploited level, say 20 or 30 per cent.

Whatever choice is made it will be to some extent an arbitrary one. Nevertheless the guidelines for the choice are clear. The stock should not be reduced to a level below which its stable recruitment is threatened. Indeed that is part of the wording of article II of the convention.

An important rider to this discussion is that the question of random variation in stock size has not been addressed. The stochastic nature of recruitment implies a variable stock even in the absence of fishing. Hence the deterministic concepts of unexploited stock size, equilibrium stock level S_{max} etc need refining. Beddington & Cooke (1984) outline the way in which such considerations can be incorporated. In general they imply a more conservative management if policy is aimed at ensuring stable recruitment.

Methods for assessing the changes in abundance of exploited stocks

There are three basic sources of information on changes in stock abundance that are currently available; Catch Per Unit Effort (CPUE), direct abundance estimates (swept area methods) and mark recapture. Kock et al use the two former techniques for a variety of species and Burchett and Ricketts (1984) used mark recapture methods to estimate abundance of Notothenia rossii around South Georgia.

Another method of assessing stock size and status is via direct estimates of fishing mortality. Unfortunately such estimation techniques critically depend on estimates of natural mortality which themselves are highly uncertain. This is particularly so in the present case as age/length samples are unavailable for the early stages of the fishery where fishing mortality would have been a small component of natural mortality. We do not consider them further in this paper other than to remark that the review by Kock et al indicates reasonable agreement between such estimates and other techniques.

CPUE

The basic unit of CPUE adopted by Kock et al is the catch in tonnes per days fishing. Data were available only for Polish trawlers. These were obtained either from direct sources or from the FAO Statlant 08B forms. The Statlant 08B forms also give information on the number of hours spent fishing. This latter measure would be preferable as a unit of effort as it avoids periods of stop catch. CPUE measured as catch per fishing hour is therefore more likely to affect changes in stock abundance rather than catch per day. Kock et al present analysis of CPUE for only one species Champsocephalus gunnari. Their data indicate marked changes in availability of the stock by month which in any assessment of changes over seasons needs to be taken into account.

A further problem is that the Statlant 08B forms indicate a range of species caught with the same unit of effort. In the absence of further information it is difficult to assess correctly the way in which the fishing operation has targeted on different species during different periods.

The appropriate way of dealing with monthly variation when investigating trends in abundance is via an analysis of variance. Although the data are unreplicated and confounded in statistical design, it is possible to produce an approximate analysis. As an example of this type of analysis we have calculated the trend in CPUE measured as the deviation from the monthly means catch per trawling hour. Data were obtained from the Statlant 08B forms for Polish vessels around South Georgia. Initially, in order to avoid the problem of changing target species, the analysis was performed for all fish species combined. The results indicated a significant decline in biomass ($P < .01$) of around 46% from 1977 to 1981. Separate analyses by species type indicated a highly significant decline in the species Pseudochaenichthys georgianus ($P < .001$) to around 2.3% of its initial abundance in the period 1977-81 although in other species showed no significant

change. However, since exploitation begain in 1968 and peaked in 1970 (Everson 1977) the total decline from the initial unexploited stocks will have been much greater.

Swept area methods

Kock et al present results from trawl surveys of estimates of trawlable biomass for the period 1975-81 for seven different species. The confidence regions around the estimates are large, but the picture of declining biomass for all species around South Georgia seems clear. It is also worth noting that there is a decline in Pseudochaenichthys although not as great as the estimate from the CPUE analysis described above.

Mark Recapture

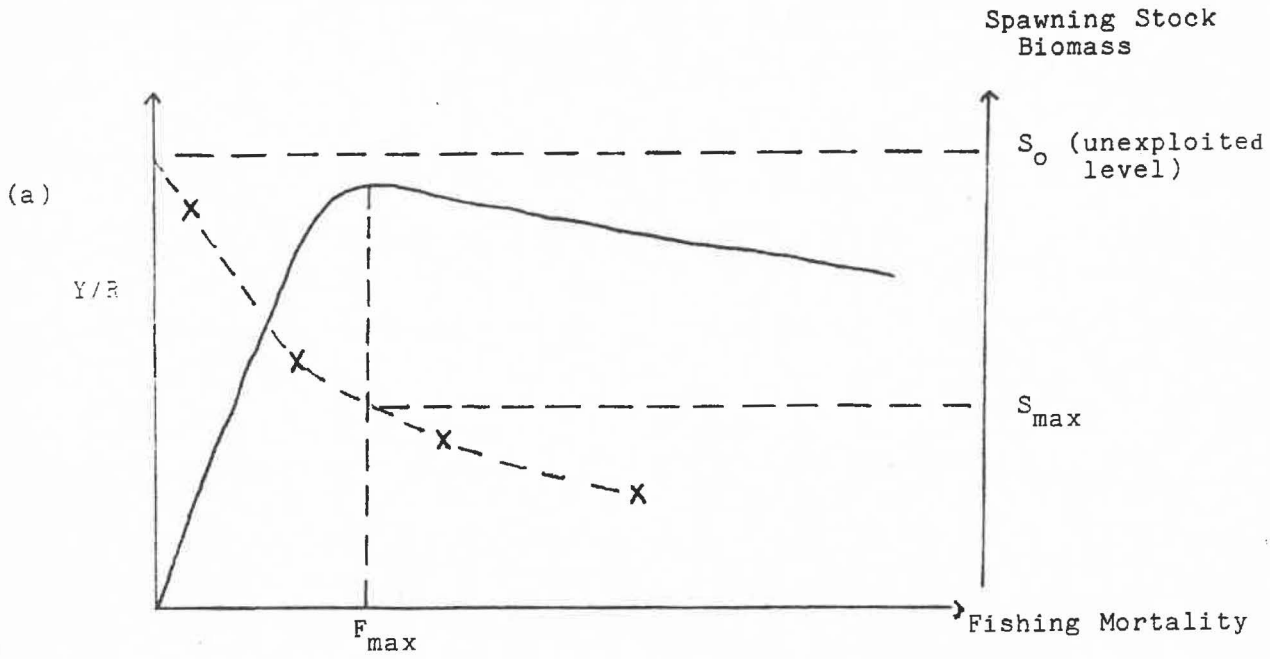
Burchett and Ricketts (1984) used a mark recapture technique to estimate the abundance of nearshore Notothenia rossii around South Georgia in the season 1978/9. This estimate was then extrapolated to the offshore adult population. The total biomass estimated was some 117,000 tonnes of which 54% was calculated to represent the nearshore population. There are some problems with these calculations as the estimated mortality rates seem rather high. However the general picture of a stock well below its original pre-exploitation abundance is clear. Catches in 1969/70 were some four times the estimate of abundance in 1978/9.

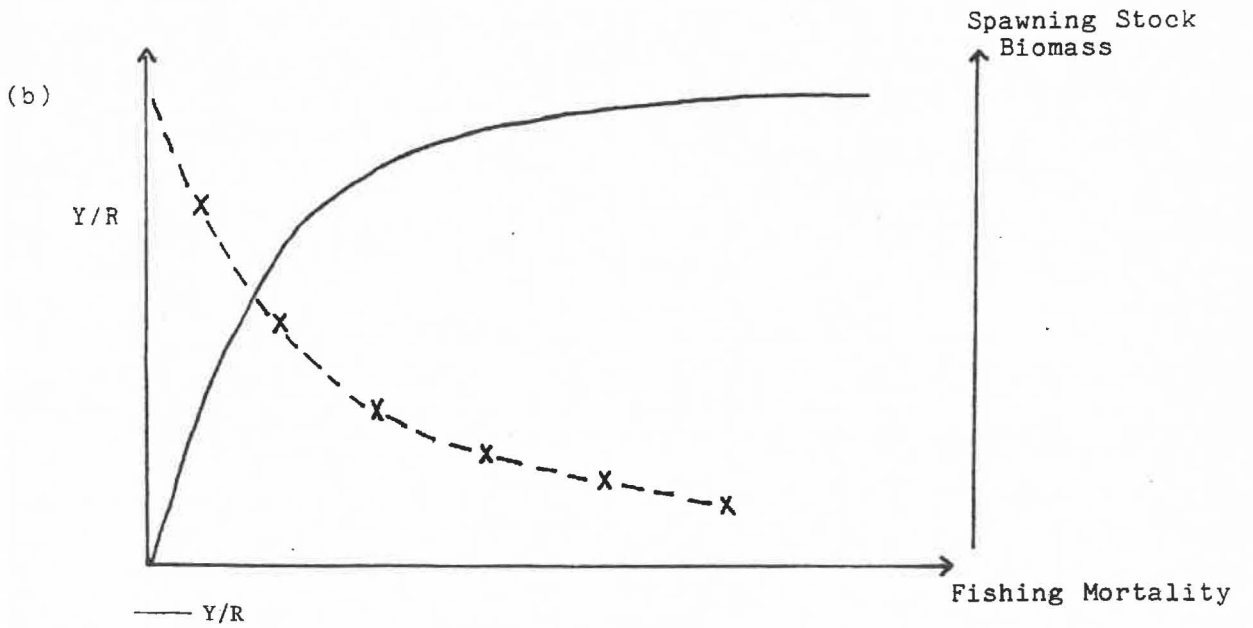
Concluding remarks

Whatever the decision concerning the methodology for assessing the level of maximum net productivity, certain results for the Atlantic sector fish stocks seem clear. The biomasses of the spawning stocks of several species particularly; Notothenia rossii, Dissostichus eleginoides and Pseudochaenichthys georgianus, have been reduced to levels where their stable recruitment must be in doubt. The status of the nototheniids gives most cause for concern, as Kock et al report on a number of studies which indicate that there is a substantial by-catch of juvenile nototheniids taken in the krill fishery around South Georgia.

Accordingly it is clearly necessary on the basis of available evidence to consider the immediate adoption of conservation measures for certain stocks in the convention area.

Fig. I





—— Y/R

---x--- Equilibrium Spawning Stock Biomass
Equilibre de la biomasse du stock reproducteur
Равновесное состояние биомассы нерестового запаса
Equilibrio de la Biomasa de las Existencias de Desove

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