MANAGEMENT AND UNCERTAINTY : THE EXAMPLE OF SOUTH GEORGIA

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Abstract

Decisions on fishery management are often made with some degree of uncertainty in scientific advice. Such uncertainty is unlikely to be avoided even though further research should reduce its degree. It seems useful to consider ways in which CCAMLR can improve its ability to take decisions in the face of uncertainty. From an examination of Articles IX 2(f) and XV 2(e, d) of the CCAMLR Convention it follows that a comparison of the immediate and long-term effects of any one proposed measure with those of any other measure (including the effects of doing nothing) could provide a procedure for providing advice that could cope with uncertainty. The question is addressed specifically in terms of the fishery of Notothenia rossii around South Georgia, but the principles examined may be relevant to other management matters.

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AMENAGEMENT ET INCERTITUDE: L'EXEMPLE DE LA GEORGIE DU SUD

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Résumé

Les décisions relatives à l'aménagement de la pêche sont souvent prises dans un climat d'incertitude pour ce qui est des avis scientifiques. Il est difficile de parer à une telle incertitude même si une recherche plus approfondie devrait permettre d'en limiter l'étendue. Il serait utile de déterminer comment la CCAMLR pourrait améliorer son aptitude à prendre des décisions dans un climat d'incertitude. D'après les articles IX 2(f) et XV 2(e,d) de la Convention de la CCAMLR, on déduit qu'une comparaison entre les effets immédiats et à long terme de toute mesure proposée et ceux de toute autre mesure (y compris les effets de l'inaction), devrait permettre de formuler des directives selon lesquelles des avis qui tiendraient compte de l'incertitude pourraient être donnés. Cette question a été étudiée dans le cadre spécifique de la pêche de Notothenia rossii autour de la Géorgie du Sud, mais les principes examinés pourraient également être appliqués aux autres problèmes d'aménagement.

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ADMINISTRACION E INCERTIDUMBRE: EL EJEMPLO DE GEORGIA DEL SUR

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Resumen

Las decisiones sobre administración de pesquería son a menudo hechas con cierto grado de incertidumbre en términos de recomendaciones científicas. Es poco probable que dicha incertidumbre pueda ser evitada aun cuando la investigación adicional debería reducirla. Parece útil considerar maneras en que CCRVMA puede mejorar su capacidad de tomar decisiones frente a la incertidumbre. A partir de un exámen de los Artículos IX 2(f) y XV 2(e,d) de la Convención de CCRVMA se desprende que una comparación de los efectos inmediatos y a largo plazo que resultan de cualquier medida propuesta con aquellos de cualquier otra medida (incluyendo los efectos de no tomar acción alguna), podría proveer un procedimiento para proporcionar recomendaciones que podrían ajustarse con la incertidumbre. La cuestión está dirigida específicamente en términos de la pesca de Notothenia rossii alrededor de Georgia del Sur, pero los principios analizados pueden ser relevantes otros temas de administración.

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УПРАВЛЕНИЕ И НЕОПРЕДЕЛЕННОСТЬ - ПРИМЕР ЮЖНОЙ ГЕОРГИИ

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Резюме

Решения в области управления промыслом часто делаются при наличии некоторой неопределенности в научно обоснованных предложениях. Этой неопределенности вряд ли можно избежать, несмотря на то, что

последующие исследования должны уменьшить ее степень. Представляется полезными рассмотреть пути улучшения процесса принятия АНТКОМ'ом решений при наличии такой неопределенности. Из изучения Статей IX 2 (f) и XV 2 (e,d) Конвенции АНТКОМ'а следует, что сравнение незамедлительного и долгосрочного результатов действия какой-либо одной меры с таковыми любой другой такой меры (включая результат при отсутствии каких-либо действий) может привести к созданию порядка выработки таких предложений, которые будут учитывать эту неопределенность. Этот вопрос ставится конкретно в применении к промыслу Notothenia rossii в районе Южной Георгии, но разобранные принципы могут оказаться применимыми и к другим вопросам управления.

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MANAGEMENT AND UNCERTAINTY : THE EXAMPLE OF SOUTH GEORGIA

INTRODUCTION

The stocks of fish round South Georgia have been greatly reduced by heavy fishing since 1969, and the stock of Notothenia rossii is at an extremely low level. Proposals have been made in both the Scientific Committee of CCAMLR and the Commission for drastic action, including the closure of South Georgia to all fishing for a period, but these have not been adopted. There are several reasons for this, but an important one is the degree of uncertainty in the scientific advice. If the scientists could say with absolute certainty that a complete closure for x years would rebuild the stocks to a level at which they could provide sustained yields of y thousand tons per year, and that any other, weaker, measure would fail to rebuild the stocks, then it should be much easier to agree to a closure. Such certainty is unlikely ever to be achieved, even though further research should reduce the degree of uncertainty.

Since the difficulties of making definite assessments are likely to increase when questions arise that are more complex than the state of the Notothenia stock e.g. the impact of krill fishing on whales, it seems useful to consider ways in which the Commission can improve its ability to take decisions in the face of uncertainty. The question is addressed specifically in terms of the fishery round South Georgia, but the principles examined may be relevant to other management matters.

Article IX 2 (f) states that the Commission shall "formulate, adopt and revise conservation measures on the basis of the best scientific evidence available ...", while Article XV requires that the Scientific Committee shall (paragraph 2 (e)) "transmit assessments, analyses, reports and recommendations ... regarding measures ...". These cover the simplest situation in which, first, the Committee can determine that, for example, a mesh size of 140 mm would give a greater long-term yield than any other mesh size and transmits a report to this effect in accordance with Article XV 2 (e), and second the Commission adopts a minimum mesh size of 140 mm in accordance with Article IX. This procedure is fine if the scientists can identify clearly a particular action (i.e. the use of 140 mm mesh) as being the best, but this is not the common situation. It is not however the only procedure that is consistent with the Convention.

Article XV 2 (d) states that the Committee shall "assess the effects of proposed changes in the methods or levels of harvesting and proposed conservation measures." Though not very explicit on what is included the comparison of the immediate and long term effects of any one proposed measure with those of any other measure, including the effects of doing nothing. If these comparisons are made not only for the "best", or most probable assessment of the state of the stock, but also for a range of other views of its state, this could provide a procedure for providing advice that could cope with uncertainty. The rest of this paper explores the use of this approach to the South Georgia Notothenia rossii fishery.

THE STATE OF THE STOCK

The stock of Notothenia rossii has been severely depleted. This is perhaps most clearly shown by the statistics. 399,704 tons were caught in 1969/70, 101,558 in 1970/71, and only 59,032 tons in the following 14 seasons. The more detailed analyses in the BIOMASS report (1985), and in the report of the fish stock assessment working group (Anon 1985) confirm the general picture but open some questions. From the working party report it appears that the current low abundance is due to a high mortality rate and low recruitment. From Figure 2 of the working party report it appears that mortality has increased from 0.11 to 0.76, i.e. at present M=0.11, F=0.65. Annual recruitment, as numbers at 3 years old, has fallen from some 20 millions before 1965, to some 3 to 6 millions for the 1967 to 1975 year-classes, to possibly only 40,000 in the 1980 year-class (paragraph 20 of the report).

Accepting that the decline in recruitment is due directly to fishing, with the very low recruitment in the most recent years being due to the second burst of relatively high catches in 1979/80, management policy must be to rebuild the spawning stock (see paragraph 48). It may be that the form of the stock-recruitment relation is such that it is impossible to combine significant fishing with a spawning stock big enough to give the high gross recruitment of the pre-exploitation perid. A more reasonable expectation is that a low rate of exploitation, perhaps F=0.05, could be sustained with a recruitment around that of the 1970's i.e. around 5 million fish. This would give a yield per recruit of around 350-500 gms (paragraph 23), or a sustainable annual yield of 1.75-2.5 thousand tons. Rebuilding the spawning stock from its present very low level would probably take two whole generations i.e. about 10 years (BIOMASS report Table 2).

The more optimistic view would be to accept the general conclusions, but to believe that a higher rate of exploitation (e.g. F=0.1) could be sustained, and that this could be consistent with a higher recruitment (e.g. 10 million) - giving a Y/R of 500 to 800 gms, and a total yield of 5-8 thousand tons. It might also be hoped that recovery would be quicker, perhaps taking only 5 years.

The more pessimistic view would be to challenge the general interpretation, and look at some of the inconsistencies of detail. (There does not seem to be a fundamentally different interpretaion of the data that leads to an optimistic view i.e. one of a high sustained yield, other than the view that the decline of the stock is nothing to do with fishing, and that catches of 400,000 tons in a season will occur again whatever is done. There is no support for this).

The inconsistencies chiefly concern the age data, or results arising from those data. The age-composition for 1970/71 (Figure 2 of the report) is unusual in indicating little mortality up to age 8, then a low rate until 12, but few fish over 12 years old. The age composition for 1984 and 1985 are more typical of age samples from other stocks, but the indication of a high and apparently uniform fishing mortality (as indicated by the good fit to a straight line) is not consistent with the catches being concentrated in a few years (1969/70, 1970/71 and 1980/81). Some of these features could be explained by year-to-year changes in recruitment. They might also be explained if catches had not in fact been so highly concentrated in two short periods. This might be the case if there were errors in the reports of catches, for example in the species identification, some other species being included in the peak catches of Notothenia, and some Notothenia in the catches of Champsocephalus in other years.

The detailed pattern of recruitment shows variations that are not due simply to changes in spawning stock. Thus although the spawning stock must have been high until fishing started in 1969, recruitment declined from the 1966 year-class onward, and in fact those from 1970 to 1976 were no lower than those of 1967 to 1969. Similarly, although the spawning stock presumably underwent the second big drop during the second period of high catches in 1980/81, year-class strength dropped further from 1978 onwards.

Some of these inconsistencies might be reduced if there had been errors in the age-determinations, especially if the fish were older than believed. There is a common belief that Antarctic fish are relatively long-lived, but the Notothenia rossii data does not support this. A maximum age of 13 in an unexploited stock is, if anything somewhat low for temperate water fish of comparable sizes. Nikolsky (1965 Table 52) examined the life span of 104 species of fish, mostly of temperate waters. 46% had maximum ages over 10 years and 19% over 20 years. The short lived fish were mostly small fish like anchovy.

If Notothenia had in fact a long life span comparable to the longer-lived species of northern cold-waters, such as Sebastes, the unexploited stock in 1969 might well have consisted of thirty or more year-classes. The average contribution of each year-class would have been correspondingly smaller, and the small numbers from the 1966 to 1969 year-classes observed in later years would not be inconsistent with the earlier year-classes. Revisions to the estimated age-compositions in accordance with a longer life span might remove several of the inconsistencies remarked on previously. In particular such revisions might give a pattern of decreasing recruitment that matches the decrease in adult stock in a more satisfactory fashion than the pattern indicated in the working group's report, and a pattern of mortalities that are more consistent with apparent changes of fishing effort.

It must be stressed, however, that this hypothesis of a long life-span is based almost entirely on the wish of the mathematical modeller to have a tidy quantitative explanation of the dynamics of the fish stocks since exploitation started. There are no suggestions in the literature (e.g. Biomass 1982) that the determination of ages for Notothenia raises particular problems and there is fair agreement between the results obtained by different people (c.f. Table 14 of the Biomass Report). At the same time there has, almost inevitably, been no independent check on ages, e.g. from long-term tag recaptures. It may also be noted that most ages have been determined from scales, which in some other species have given lower ages than otoliths. The only growth rate based on otolith readings in Table 15 of the Biomass report indicates a lower value of the parameter K, which is often inversely related to life-span. The evidence from age determination studies may be said not to be sufficient to completely reject the hypothesis.

The long life hypothesis does not change the conclusion of a heavy effect of fishing, but will change the assessment of the results of management measures. In brief, the conclusion is that a very high proportion of the high 1969-70 catches came from the accumulation of many years' production, and that the sustainable yield is small. A long period of protection, perhaps 20 years, would be needed to restore the stock to the level giving the greatest sustained yield. That yield might be quite small, perhaps a yield per recruit of 500 gms, and an average year-class strength of only 1 million fish, i.e. an annual yield of 500 tons.

COMPARISON OF POLICIES

The preceding section gave three alternative hypotheses about the current state of the stocks, and three views of the measures needed to restore the stocks, and their results. To be complete, advice should also look at the effects, under each hypothesis, of different possible policies. The most relevant is a policy of counting the measures agreed at the 1985 Commission meeting, i.e. a closure of directed fishing for Notothenia rossii, and efforts to keep the by-catch at a minimum. This is not a very exact measure, and there are different interpretations of its effect. On one view the distribution of Notothenia and other species is sufficiently distinct, and the efforts of fishermen likely to be so successful, that the by-catch will be negligible. On that view the results will be virtually the same as complete closure. Another view is given by the working party's report, which in Table 4 indicated fishing mortalities in the years 1976 to 1983 (excluding 1980) of 0.2 to 0.6. The only year during this period in which there appears to have been significant directed fishing was 1980, when the table gives F=2.3. This suggests that even a fishery directed on other species can exert a very significant effect on Notothenia rossii.

A reasonable assessment would be that the stock cannot maintain itself in the face of incidental catches that inflict a fishing mortality of the magnitude caused by recent non-targeted fishing, and that the stock would decline. The catches obtained under a policy that allowed fishing for other species would therefore decline from the recent level of a few hundred tons. The precise sequence of annual catches will depend on the strength of recent year-classes. If they are indeed as weak as the preliminary figures for the 1979 and 1980 year-classes given in the working group's report, then catches in the next few years will be very low, perhaps one or two hundred tons in total over the next 10 years. If recent year-classes are not quite so bad, say no worse than that of 1978, then cumulative catches will be higher, but with the stocks declining, are unlikely to exceed one or two thousand tons in 10 years.

A more optimistic assessment would be that, provided the incidental mortality was small and towards the bottom range in recent years, i.e. no more that F=0.1 or 0.2, then the stock could sustain it, and recruitment would remain at current levels. If average recruitment is 0.5 million (i.e. the average of 1978 and 1979), and Y/R about 500 gms, this would give sustained yields of 250 tons.

The more pessimistic view is that most of the catches have come from an accumulation of many years' production, and that currently abundance is low. Continuation of fishing for other species will not produce much catch, but will not allow any accumulation. Catches will be very small.

In comparing the results of various policies under different hypotheses it must be remembered that the view taken of the long-term dynamics must be consistent with the view of immediate events. It is therefore possible to tabulate the results according to three basic view-points.

	VIEWPOINT		
	Optimistic	Realistic	Pessimistic
MANAGEMENT OPTION			
Closure			
Sustainable yield (tons)	5,000-8,000	1,750-2,500	500
Duration of closure	5 years	10 years	20 years
Transitional yields			
(next 10 years)	25-40,000	Nil	Nil
(years 11-20)	50-80,000	17,500-25,000	Nil
Non-targeted fishing			
Sustained yield	250 tons	Nil	Nil
Transitional yields			
(next 10 years)	2,500	1,000-2,000	100-200
(years 11-20)	2,500	Nil	Nil

COMPARISON OF POLICIES

This tabulation shows that there are considerable doubts over the effects of alternative measures. It may be, on the pessimistic view, that the economic benefits of severe measures are small, and will not occur for a long time. It is also possible, on the optimistic view, that a complete closure would involve foregoing the catches of a few thousand tons over the next few years. However the doubts over the relative advantages of alternative policies are small, the chief uncertainty being the length of time before the long-term advantages of complete closure become apparent. On the central view, it would take only a year after a 10-year closure for total catches from the more conservative policy to exceed those from a policy of allowing non-directed fishing. Optimistically it might take 6-7 years, but pessimistically it might take more than 20 years.

Put another way, the tabulation shows that a complete closure could result in a significant sustainable fishery within less than ten years. It is possible that, if the stock is slow growing and unproductive that the long-term benefits will be small, but in that case the immediate sacrifices in applying a closure will be small. Also in that case, although the economic benefits are small (but positive), the obligations under Article 2 point clearly to a closure.

DISCUSSION

The results presented here suggest that an exploration of the consequences of alternative management policies, under different hypotheses concerning the state of the stocks, can point clearly to the best policy even when there is considerable uncertainty over the state of the stocks. Before treating the method as a general solution to all problems of uncertainty, or the results as specific for the management of *Notothenia*, some comments are called for.

First, further consideration should be given to the possible range of hypotheses about the Notothenia stock. The central view has been taken largely from the working group's report, together with an analysis of the stock-recruitment relation. The optimistic and pessimistic alternatives are somewhat subjective, and might be considered too extreme or not extreme enough. The point so far as advice from the Scientific Committee to the Commission is concerned is that the extent of the range does not have to be precisely determined, and the choice of range is unlikely to affect the advice much. In practice it may be convenient to consider five hypotheses - three defining the centre and bounds of the range of probable values, within which one hypothesis cannot be distinguished as being significantly more probable than another, and two extreme values, which though unlikely, cannot be rejected entirely.

A second important point is that the present note does not examine the impact on other stocks. The practical objection to a complete closure is the loss of potential catch from other species. The working group's report indicates that these stocks too have been heavily fished, and therefore would be expected to benefit in some way from a period of protection. As in the case of Notothenia the effects will depend on the intensity of exploitation and the life-span. At one extreme, if the stocks are heavily fished and long-lived, a closure for a few years will increase the long-term yield from these species. At the other, a closure for more than a year or two will reduce the total yield from lightly fished or short lived stocks.

Given sufficient information on the other stocks these alternatives can be expressed in the same sort of tabulation as given for Notothenia. These tabulations can be combined to consider the desirable policy, in terms of the fishery as a whole. In doing so it should be remembered that the views of the different stocks are more independent than the short and long-term views of Notothenia. However, if Notothenia is long lived or heavily fished, it would seem more likley than not that the other species are also long lived or heavily fished.

While the information is not sufficient to make a detailed tabulation, it is enough to make a qualitative evaluation of alternative policies under different conditions. On the optimistic view of the *Notothenia* stock, it is likely that a complete closure would rebuild that stock, and allow fishing to be re-opened before there would be any loss of long-term catch of other species, and indeed possibly with some benefit. If the pessimistic view is correct, however, the economic benefits to the *Notothenia* fishery will be so small and take so long to arrive that they would almost certainly be exceeded by the losses to the catches of other species, whatever the state of those stocks.

Finally, it must be noted that the tabulation gives the comparison between policies on the presumption that one or other policy is maintained indefinitely. This is highly unrealistic. In practice the results of any policy should be carefully monitored, and adjusted as soon as events do not follow the expected path. CCAMLR may not go as far as has been suggested by e.g. Walters (1984) in setting policies that, while not necessarily giving the highest yield, would generate information from which improved policies could be determined. It must, however, be recognized that all policies are subject to review. Good management plans will include monitoring and other activities required to make the necessary reviews.