ICES STATUTORY MEETING 1993 CM1993/D:70 Session P



# RISK ANALYSIS IN FISHERIES MANAGEMENT: THE FALKLAND ISLANDS SQUID FISHERY AS AN EXAMPLE

by
Marinelle Basson
Renewable Resources Assessment Group
Imperial College of Science, Technology and Medicine
LondonSW7 1NA
UK

## ABSTRACT

Although risk analysis is usually viewed in the context of fields such as engineering, the definitions of the relevant terms are also applicable to the management of renewable resources. There has been increasing interest and debate on how risk management should be conducted and four sets of opposing views in this debate are considered here. The Falkland Islands squid fishery is used as an example to explore where in the spectrum of views fisheries management approaches might fall. The opposing views tend to be associated with two quite different approaches to risk management. The implications and applicability of these different approaches to fisheries management in general are considered.

**Risk analysis in fisheries management: the Falkland Islands squid fishery as an example.**

## Introduction

Risk analysis and risk management are usually viewed in the contexts of fields such as engineering, technology and health. The hazards are, predictably, almost always defined in terms of potential direct effects on human life. If we look at some of the definitions of terms such as risk management, we find that they are also applicable to the management of renewable resources.

In a recent report of a Royal Society Study Group on risk management, the term risk assessment is defined as the study of decisions subject to uncertain consequences (Anon 1992). Risk management is defined as the process of making of decisions concerning risks and the subsequent implementation of those decisions. When comparing fisheries management and risk management in its purest form there are, of course, some distinct differences. There is therefore a need to re-interpret some of the concepts in the context of fisheries management.

In the rest of this paper the management approach for the Falkland Islands squid fishery is used as an example. Four sets of opposing views that recur in the debate on how risk management should be approached, are considered with regard to this example. In the last section, I briefly look at fisheries management in general and consider what can be learnt from risk management approaches in other areas.

## The Falkland Islands squid fishery

A brief outline of the management approach used in the fishery for *Illex argentinus* around the Falkland Islands is necessary. A more detailed description can be found in Beddington et al (1990). The main stock characteristics that affect management are the annual nature of this squid species (a single cohort is fished each year) and the large degree of variability in recruitment. The management goal is to ensure that the number of spawners at the end of the fishing season (absolute escapement) does not fall below a target or threshold level. The basic assumption is that a spawning stock above the threshold level has a high probability of producing viable recruitment in the following season. Below the threshold, however, there is a high probability of very low recruitment and possible stock collapse. In the rest of the text I distinguish between threshold and target: threshold is used for the 'true' but unknown critical level of spawning biomass and target refers to the management goal for absolute escapement. Target escapement should ideally be at or above the threshold and can, in that sense, be seen as an estimate of the threshold. Basson et. al. (in press) present a commonsense approach to estimating target escapement.

The fishery is regulated by effort controls whereby vessels are issued licences to fish in the Falkland Islands Interim Conservation Zone (FICZ) for a fixed period. The majority of vessels are from foreign, distant water fleets. The appropriate effort level and hence the number of licenses has to be determined before the start of the fishing season, when the stock size is not yet known. At that stage the effort can only be limited to ensure a given level of proportional escapement (the ratio of spawning stock under that level of effort to spawning stock under no fishing) or absolute escapement conditional on assumptions about recruitment. If

recruitment is particularly low, even high proportional escapement may not ensure a high enough spawning stock. There is therefore a need for supplementary control when assessments during the season indicate that the target level of absolute escapement may not be met. The supplementary control takes the form of an early closure of the licensed fishing season, leading to a reduction in effort. The assessment method is based on the Leslie-Delury method and is described in Rosenberg et. al. (1990) and Basson et. al. (in press).

It is convenient to refer to two phases in the control of effort: licensing prior to the season and monitoring during the season. With regard to the first phase, the decision that needs to be made is what harvesting level to allow. The outcomes for each level of effort are uncertain but expected escapement can be estimated from knowledge (or assumptions) about the mean and variance of recruitment. Given a target escapement, the probability of having to close the fishery early can also be estimated for different levels of effort (Basson & Beddington, in press). With regard to the second phase, the decision that needs to be made is whether there is a need for a closure or not. If assessments and projections of escapement indicate that the target may not be met, decisions have to be made about the duration of a closure. Again, the outcomes are uncertain but they can be identified and evaluated under different assumptions or scenarios.

**Viewpoints in risk management**

Risk assessment or analysis in fisheries management, as seen from the fisheries scientists' point of view, most often focuses on ways of quantifying probabilities of outcomes, and on ways of fixing acceptable levels for these probabilities. There are, however, wider issues in the debate on how risk management should be handled that are of great relevance to fisheries scientists.

The report of the Royal Society study group (Anon. 1992) identifies seven sets of opposing views that recur in the risk management debate. I would like to focus on four of these that are of particular relevance for fisheries (Table 1, below) and consider where management of the Falkland Islands squid fishery falls with regard to these viewpoints.

Preventative versus corrective approach to regulation

The limiting of effort at the licensing stage is aimed at preventing the spawning stock from falling to a level far below that which would occur under no harvesting. This is clearly a preventative measure but, because the stock size is not known at the time, it is conditional on recruitment being above some level. If recruitment is particularly low, for whatever reason, then the allocated level of effort may not be sufficient to ensure that the management goal is met. In this such cases effort can be reduced by shortening the fishing season. This is clearly a corrective approach.

The philosophy behind the scientific advice for this fishery has always been that closures are emergency measures. Early closure of the fishery is costly, disruptive and, if it occurs often, faith in future warnings and in the authorities' ability to manage the fishery is likely to be eroded. The expected number of closures required for a given level of effort has therefore been used to aid decision-making about appropriate levels of effort (Basson and Beddington, in press).

Both approaches, preventative and corrective, are thus used in the management of this squid fishery, though the focus is primarily on the preventative.

Table 1. A summary of four sets of opposing viewpoints in risk management policy (after Anon. 1992).

| Viewpoint | Opposing Viewpoint |
|---|---|
| PREVENTATIVE APPROACH<br>anticipate events through knowledge of the system and use a preventative approach to management | CORRECTIVE APPROACH<br>complex systems are not predictable so resilience to events and a corrective approach are appropriate |
| QUANTITATIVE APPROACH<br>focus on quantified evaluation of risk; quantification promotes understanding and rationality | QUALITATIVE APPROACH<br>focus on more qualitative assessments; inherently unquantifiable factors should be given proper weight |
| GOALS ARE COMPLEMENTARY<br>'safety' of the resource and other goals are complementary in good management | GOALS ARE TRADE-OFFS<br>'safety' of the resource must be explicitly traded off against other goals |
| SPECIFY OUTCOMES<br>the regulatory process should concentrate on specifying the management targets | SPECIFY PROCESSES<br>the regulatory process should concentrate on specifying management processes |

Quantitative versus qualitative approach to risk assessment

There is no doubt that the approach to assessing risks in this case study is primarily quantitative. The problems are such that they lend themselves to quantification even if assumptions have to be incorporated or ranges of scenarios considered. There are, however, important aspects that are difficult, if not impossible, to quantify.

First, take the example where two options for licensing are considered. The one option is to licence, say, 50 vessels to fish for three months each, while the second option, leading to the same level of overall fishing mortality (and hence escapement) is to licence 150 vessels to fish for a month only. From the point of view of monitoring the fishery, the first option is far preferable to the second. A longer time-series of data would be available for stock assessment during the season and this implies a greater chance of detecting the need for a closure in time to take appropriate action. It is, however, very difficult to quantify the associated probabilities for the two options even with extensive simulation studies.

Irrespective of the pattern of effort, there is a still a chance of making a mistake during the monitoring phase. Two types of mistakes are possible: Type I errors (detecting the need for and enforcing a closure when it really is not necessary) and Type II errors (not detecting the need for a closure when it is necessary). In terms of the future survival of the squid stock,

an error of Type II is clearly far more serious than an error of Type I. Again, the probabilities of these errors are very difficult to quantify, mainly because of the uncertainty about the threshold for the spawning stock.

In practice, these unquantifiable aspects have been explicitly stated together with the quantified aspects, and managers have in the past taken these 'warnings' seriously. There is currently no formal way for incorporating qualitative risks into the decision-making process, but they are usually used as arguments for being conservative.

Complementary goals versus trade-off between goals

Rather than consider the rather obvious arguments of sustainability, I would like to focus on two different matters here. First consider the relationship between 'safety' of the stock and stability in the fishery. Effort regulation is more appropriate than catch regulation for this highly variable annual stock. The proportional escapement criterion lends itself to stability in terms of the level of effort in the fishery. It does, however, imply that the annual catch levels may be highly variable. The goals are therefore complementary if one is interested in stability in quantities related to effort though there is a trade-off if the focus is on stability in quantities related to catch.

The second relationship to consider is that between 'safety' and the capability to assess or manage the stock. There is often value in allowing very high levels of effort because this may produce contrast in data which would improve stock assessment. This is clearly possible in the case of a multi-cohort population. In the case of a single cohort population this is a very risky approach! Regarding the distribution of effort within the season, a more cautious approach is again compatible with improved capability to assess the stock.

On balance, goals such as stability of the fishery (in terms of effort) and the ability to assess and manage the stock are complementary rather than in direct opposition. Having said that, if viewed from the position of the foreign fishing fleets, there may well be many goals which are not complementary to the safety of the resource.

Outcome specification versus process specification

Management of the squid fishery basically falls into the category of outcome specification. Although there are subtleties in reality, largely because the fishery harvests the same population in the FICZ, the Argentine EEZ and international waters, the management approach in the FICZ has been based on specifying a desirable level of effort and aiming to achieve that. Corrective measures have also been based on specifying a target level of absolute escapement and aiming to achieve that.

The question that arises is how to specify these quantities. I deliberately used the word 'desirable' rather than 'appropriate' above because the latter has been at the heart of many of risk management debates. With regard to nuclear power or the harvesting of whales, there has been increased public concern and debate about 'safe' levels. What is an appropriate level of risk? What may appropriate to scientists may not be appropriate to politicians or to the public. The idea behind 'process specification' is to try and bypass this issue or, at least, minimise its importance, by designing management processes (or procedures) that would be robust to

hazards. This approach can also be interpreted as an integration over a range of possible outcomes. In the fisheries management context, I am reminded of the International Whaling Commission (IWC) management procedure which is discussed in Kirkwood (this meeting).

**Discussion**

Management of the Falkland Islands squid fishery is generally closer to the viewpoints presented in the left hand column of Table 1 than to those in the right hand column. This approach to risk management is in line with what has been called the 'homeostatic' approach (Anon 1992) where the management institution sets determinate goals in advance and converts goals into quantified decision rules which experts can apply to particular cases. By implication, relatively narrow participation and decision-making by a small group of experts is compatible with this approach.

A less widely accepted and less well developed approach which leans towards viewpoints in the right hand column of Table 1, has been termed the 'collibratory' approach (Anon 1992). Here the view is that reliable forecasting is usually limited by ineradicable scientific uncertainties. Furthermore, the large range of different worldviews limit the capacity for setting overall goals to be turned into quantified decision rules in a robust way. Risk management therefore requires the design of 'institutions' on the principle of the desk lamp which is held in balance by systems of springs, continuously in tension. The institutions should explicitly juxtapose rival viewpoints to maintain a constant process of dynamic tension with no pre-set equilibrium. This approach favours resilience, qualitative debates over uncertainties and process specification. It also favours broad participation in management and decision-making.

There are many other possible approaches which fall somewhere between the two extremes discussed above. These extremes do, however, highlight two interesting points. The first is the difference between the 'institutions' associated with a given management approach. In terms of the Falkland Islands fishery, the 'institution' is a very simple one, limited to scientific advisers and members of the Fisheries Department and Government of the Islands. The number of individuals involved are also few. Contrast this with large international bodies such as the IWC or CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources). The components of the management body and the number of people involved will obviously affect communication and the way in which decisions are taken. The design of the management body (or institution) cannot be viewed independently of the general approach to management

The second point is the difference in philosophy. It is worth considering whether one of the two above approaches is more applicable than the other to fisheries management in general, and to what extent the approach depends on the forum within which management takes place. If fisheries and resource management move more towards the 'collibrational' approach, it would be wise to be explicit about it. This may be the only way to ensure that non-scientific arguments are heard and considered, without being disguised as scientific arguments to try and improve their credibility.

**References**

Anon. 1992. Risk: Analysis, Perception and Management. Report of a Royal Society Study Group. The Royal Society, London. pp 201.

Basson, M, and J.R. Beddington. (In Press). Risks and uncertainties in the management of a single-cohort squid fishery: The Falkland Islands *Illex* fishery as an example. Special Publication Series of the Can. Jnl. Fish. & Aquat. Sci.

Basson, M, J.R. Beddington, J.A. Crombie, S.J. Holden, L.V. Purchase, G.A. Tingley. (In Press). Assessment and management techniques for migratory annual squid stocks: The *Illex argentinus* fishery in the Southwest Atlantic as an example. In FAO Special Issue on Cephalopods.

Beddington, J.R., A.A Rosenberg, J.A. Crombie and G.P. Kirkwood. 1990. Stock Assessment and the Provision of Advice for the Short Fin Squid Fishery in Falkland Island Waters. Fisheries Research, 8:351-365.

Rosenberg, A.A, G.P. Kirkwood, J.A. Crombie, J.R Beddington. 1990. The Assessment of Stocks of Annual Squid Species. Fisheries Research, 8:335-350.