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RISK ASSESSMENT OR MANAGEMENT STRATEGY EVALUATION:

WHAT DO MANAGERS NEED AND WANT?

by

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ABSTRACT

Risk assessment in the narrow sense has been used in fishery assessment to mean estimating the probability that a given management decision or strategy will exceed some defined management threshold. Management strategy evaluation in the broad sense involves assessing the consequences of a range of management strategies or options and presenting the results in a way which lays bare the tradeoffs in performance across a range of management objectives. MSE also evaluates outcomes across a range of uncertainties, but generally deals with a wider range of objectives than risk assessment. The role for the assessment scientist adopting an MSE approach is to:

* elicit and clarify objectives;
* turn objectives into specific attributes and criteria;
* identify a range of strategy choices;
* identify and quantify uncertainties;
* evaluate outcomes;
* communicate the results to the decision maker.

The main challenges are to identify an appropriate set of management strategies, decide which sources of uncertainty to include and how to quantify them, and establish effective lines of communication with the decision makers.

Introduction

In the context of providing scientific advice for fishery management, risk assessment is a currently fashionable term to describe one of the ways in which uncertainty can be allowed for in framing that advice. Taking a fairly narrow view, Francis (1992) defines risk as "the probability of 'something bad' occurring within a given time period". This definition has the distinct advantage that it accords well with the popular interpretation of the term. However it has the disadvantage that measures of risk are not the only criteria on which managers will base decisions about managing fisheries, and more importantly uncertainty must equally be taken into account in providing scientific advice relative to these other criteria.

A broader framework for provision of scientific advice is provided by decision theory, under the rubric of "decision making under uncertainty" (see, e.g., Raiffa, 1968). The advantage of this approach is that it focuses on the main issue for managers, which is making a choice between alternative possible courses of action. This approach has a long pedigree in the fisheries literature (e.g Walters, 1977) and has recently been reviewed extensively (Hilborn and Walters, 1992). The term "management strategy evaluation" (MSE) describes an approach which involves assessing the consequences of a range of management strategies or options and presenting the results in a way which lays bare the tradeoffs in performance across a range of management objectives. This approach also takes full account of the uncertainties in predicting the consequences of alternative strategies. However the final output of this approach is a decision table (see Table 1) rather than a probability or measure of risk.

The contrast between "risk assessment" (in the narrow sense) and "management strategy evaluation" is drawn a little more starkly than is often in practice the case. Both attempt to predict consequences of management actions in the face of uncertainty. Minimizing "risk" in the narrow sense may be one of the objectives against which options are evaluated in MSE. There is also some confusion engendered by the use of the term "risk function" in decision theory (also called objective function or loss function - see Berger, 1985). Both approaches fall short of the full blown decision theoretic approach which involves complete specification of an objective function (involving weighted preferences or "utilities" across alternative objectives), and therefore the ability to specify a "best" decision. In MSE the decision is left to the decision maker.

The minimal requirements for management strategy evaluation are the following:

* a clearly defined set of objectives;
* attributes related to the objectives;
* a set of alternative management strategies or options;
* a means of predicting attribute outcomes for each strategy.

The role of the scientist / analyst in this process is to:

* elicit and clarify objectives;
* turn objectives into specific attributes and criteria;
* identify a range of strategy choices;
* identify and quantify uncertainties;
* evaluate outcomes;
* communicate the results to the decision maker.

The role of the decision maker is to:

* specify the objectives of management;
* evaluate the results and weight the objectives;
* make the decision.

The above is a highly idealised view of the problem. In practice the situation is rarely this straightforward. The rest of this paper will explore briefly some aspects of this complexity, particularly with regard to the role of the MSE analyst.

The role of the MSE analyst

With regard to eliciting and clarifying objectives, the first problem may be to identify who or what is the decision maker. For different fisheries or jurisdictions the decision maker might be a council of ministers, treaty commissioners, the minister of fisheries, a management council or advisory committee, or a fishery manager. The accessibility of the decision maker for questioning about specific management objectives will vary greatly across this range.

In some jurisdictions management objectives may be enshrined in legislation, but such objectives rarely provide an unambiguous basis for management decisions. For example the fishery management objectives of the Commonwealth of Australia are to ensure conservation of the resource, maximize economic efficiency of exploitation, and charge fishermen for use of the community resource (DPIE, 1989). These objectives provide little guidance on how quickly and by how much TACs should be reduced for a currently depleted resource.

Turning vague objectives into specific attributes and criteria requires skill and judgement on the part of the MSE analyst. Obviously the attributes chosen must in some way quantify the underlying objectives, but it is also important that they be intuitively easy to grasp. For example, minimizing changes in TAC from year to year may be an important objective but the variance in TAC for a given decision rule or management strategy is a poor attribute to choose to quantify this objective. As noted above, the Francis definition of risk is a useful one because it is easily understood and seems to correspond to every day usage of the term. If the "something bad" in Francis' definition is unacceptibly low stock size, then stock size is better expressed in relative terms (e.g. relative to unfished stock size) rather than as absolute biomass, which has little meaning to fishermen or managers.

Perhaps the most creative role for the MSE analyst is in identifying a suitable range of management strategies to evaluate. In this respect, the ubiquity of the host of "F" strategies has tended to limit the range of options considered for harvest strategies. At least two alternative classes of harvest strategy are the constant catch and constant escapement strategies. These can perform better or worse than constant F strategies depending on the objective (see Table 1). In practice, a mixed strategy may perform better than any "pure" strategy. For example, in considering strategies for fishing new resources, Smith (1993) evaluates a constant effort strategy during the fishing down phase followed by a constant escapement strategy. These strategies are mediated by a rule which limits the extent of changes in TAC from one year to the next. However the latter constraint can be over-ridden if the cv on the estimate of biomass is sufficiently low.

Other considerations in framing harvest strategies are the time frame for evaluation and the extent to which the strategy is adaptive (sensu Walters, 1986). For example, in considering strategies for TAC reduction Francis(1992) considers non-adaptive strategies which specify future TAC trajectories explicitly. Most strategies (such as F strategies) are passively adaptive, in the sense that the actual TAC chosen at each time step is conditional on the latest estimates of biomass. Very few actively adaptive or experimental strategies have been considered in practice, but see Sainsbury (1988) for a notable exception.

Turning to the issue of identifying and quantifying uncertainty, this poses a major problem for the MSE analyst. It is perhaps useful to try to classify the types of uncertainties which can potentially be considered. These include model uncertainty, data uncertainty, bias in estimators, and management implementation uncertainty. Model uncertainty can include uncertainty about structural form, parameter values and/or the nature of process error or noise. Data uncertainty can include sampling error in observations (both random error and bias), as well as the problem of lack of contrast in the data (e.g. Hilborn, 1979). The potential for bias in the estimators used in stock assessment has also been explored in some instances. Management implementation uncertainty refers to the possibility that management decisions will not be achieved (e.g. the true catch will exceed the TAC). This source of uncertainty has only recently been considered explicitly (Rosenberg and Brault, 1993).

A major problem for the MSE analyst is where to draw the line in considering the range of possible sources of uncertainty. There are no clear guidelines here, and in practice the range has been from considering a single source all the way to the very comprehensive and exhaustive evaluations undertaken by IWC scientists in evaluating "management procedures".

In evaluating outcomes, the most common procedure has been to use Monte Carlo simulation techniques. However the same issues arise - how to identify and quantify a plausible range of "operating models" against which to evluate the selected strategies. A further consideration is whether to adopt an explicitly Bayesian approach to uncertainty, or whether to use sensitivity analysis.

The problem of communicating the results to the decision maker is a crucial one for the MSE analyst. The first problem, alluded to above, is the actual accessibility and involvement of the decision maker in the process. Clearly the capacity for effective communication is best where the lines of communication are open, frequent, and operate in both directions. Unfortunately this tends to be the exception rather than the rule, and may well be the main constraint on improving the track record of scientific advice in influencing fishery management.

In presenting the results of management strategy evaluation to the decision maker, the presentation can be at several levels of detail and in several different forms. The basic format for presentation is the decision table (e.g. Table 1). This table should be designed to highlight in the simplest way possible the tradeoffs in performance across the range of options considered. The decision as to whether the outcomes should be expressed qualitatively, as in Table 1, or quantitatively as in Table 2 will depend on the decision maker. The form in Table 2 allows scope for the decision maker to make quantitative tradeoffs between alternative objectives, while the qualitative presentation lends itself to "satisficing" decisions. It should be noted that both tables implicitly present outcomes as expected values across the range of uncertainties considered in the analysis, and to that extent hide the fact that those uncertainties have been explicitly considered. It will therefore generally be appropriate to provide further levels of detail pertaining to each strategy/objective combination in the form of, say, a frequency distribution of outcomes. Further levels of detail can include plots of time streams of variables rather than cumulative or end-of-period statistics.

Where to next?

The title of this paper asks the question what do managers (or decision makers) need and want. The answer at this stage is conditional. In Australia at least, the increasing trend is for the decision maker to be a combination of a government "fishery manager" and an industry-based advisory committee. In the past the fishery managers have generally been sceptical of formalised decision analytic approaches such as MSE, and have been particularly reluctant to articulate specific management objectives. The view of the managers is starting to change, formal management plans are starting to be developed, and some managers at least are specifically requesting stock assessment information in the MSE format. On the industry side, there is a welcoming of consideration of longer term management strategies. A major source of frustration for them in the past has been the way in which, as they put it, the "rules" and advice seem to change from year to year. They welcome more certainty in the process, even if the outcome of applying the procedures (or strategies) still remains somewhat uncertain.

For the Australian stock assessment scientist, one of the main issues at the moment is formalising the process by which advice is delivered. One important aspect of this is that there is increasing dialogue and interaction between scientists, industry and managers. While frequently frustrating for scientists in terms of the amount of time involved, this interaction is leading to a better common understanding both about objectives and about the sources and consequences of the the types of uncertainty which need to be incorporated in the assessments.

Further technical improvements in MSE as applied to fishery assessment can be expected in the areas of: developing a more interesting and appropriate set of harvest strategies or decision rules; incorporating the costs and benefits of research and monitoring in the decision making framework; and undertaking "meta-evaluations" of the performance of the evaluation framework itself.

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Table 1. Performance of strategies against objectives.

STRATEGY	Maximize catch	Minimize variability	Minimize risk
	OBJECTIVE		
Constant catch High	Moderate	Good	Poor
Constant catch Low	Poor	Good	Moderate
Constant harvest rate	Moderate	Moderate	Moderate
Constant biomass	Good	Poor	Good

Table 2. Performance of strategies against attributes.

STRATEGY	Σcatch	S^2_{catch}	P(B<20%B0)
	ATTRIBUTE		
Constant catch High	40	5	0.5
Constant catch Low	25	3	0.3
Constant harvest rate	45	20	0.2
Constant biomass	55	60	0.1