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Biological Uncertainties in Fish Stock Management — A Discussion

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Abstract

Fish stock assessments and the derived biological advice, e.g. total allowable catches, are subject to uncertainties. These uncertainties originate from limitations in amount and quality of data, from misinterpretations of these data and from limited theoretical understanding of the biological, economical/technical and social systems affected by the fishing operations. Biological uncertainties play a role in management. That role is described in this paper by considering the process leading to management decisions.

Introduction

All assessments of fish stocks and the derived biological advice, e.g. total allowable catch (TAC), are subject to uncertainties. These uncertainties originate from limitations in amount and quality of data, from misinterpretations of these data and from limited theoretical understanding of the biological, economical/technical and social systems affected by the fishing operations.

For the formulation and interpretation of any biological advice we must understand how our models function. Among other things, we must understand how variability and biased data may affect the advice. We must, for a given assessment have some guess of the likelihood that a particular type of uncertainty occurs.

How variability, biases or theoretical misconceptions may affect the biological advice can, to some extent, be studied through computer simulations. But such studies can only help as long as we are able to specify the variability of the data or alternative to the population dynamics model in question. The unexpected reaction of the system or misinterpretation of data are much more difficult to study. Case studies provide a "lookback" at the history and may provide some insight as to the type of unexpected reactions of the ecological systems and how often such reactions occur. Similarly, types and frequencies of misinterpretations of data may be studied looking at past performances.

Thus it is quite apparent that biological uncertainties play a role in management. It is the thesis of this paper and that this role is best understood by considering the process leading to management decisions.

The questions raised by this symposium obviously cannot be addressed without interaction between both fishery managers and fisheries biologists. Also when it comes to discussing the decision making processes it is partly outside the professional competence of many fisheries biologists. Even so, the following discussion is offered with the hope of better understanding the processes.

Providing Biological Advice

Fisheries management affects the livelihood of people dependent on fisheries. Management is by no means a unique situation and exists elsewhere in modern society, e.g. restrictions on chemical usage (pesticides, mercury, chlorine, etc.) and environmental considerations affecting agriculture, etc. Management however originates at the scientific level. Through scientific evaluation, fisheries biologists suggest management actions. In an assessment of a fish stock it is necessary to distinguish the unbiased from the biased data, and to distinguish accurately the stock indicators which reflect stock changes from those indicators which are severely influenced by changes in environment or in fishing practices. It is necessary to guess how precisely the theoretical models will account for the reactions of the fishing system.

Analysis of a suggested management action by fisheries biologists may indicate its likely effects, but the actions suggested are good only if the projections are considered to be **reasonably accurate**. Only then can advice be provided. But when are we **reasonably certain** that the outcome of these analyses indicates the real effects? The "reasonably certain" condition depends on how grave the biological situation is assessed to be, how large the potential benefits are, what the likely effects on the involved groups are and how serious adverse effects could be.

If the situation is assessed incorrectly, we cannot specify a generally applicable precision requirement. Unexpected reactions by the ecosystem introduce additional uncertainties. Similarly, unexpected reactions can occur in the fishing systems because of possible miscomprehension of the system. The level of uncertainty in the analysis is anybody's guess.

When biological assessments are presented, the tendency is to transmit the results of the projections together with a description of the uncertainties. Much time, energy and ingenuity is then spent by the fisheries biologists in formulating advice for the management of the fish stock and many words and careful formulations are laid down to adequately reflect the analyses and the judgements on the uncertainties.

The effects of some types of uncertainties on the advice can sometimes be analyzed using computer simulations while other types are not easily tractable. To get some insight into the problem a classification of the uncertainties is given below.

Sources of Uncertainties in a TAC Advice

The effect of TAC advice varies depending on which class of uncertainty a particular assessment is confronted with. Everybody involved should have a clear idea of how the advice is affected by each class of uncertainty and they should be aware of the likelihood of a particular uncertainty being important.

The data items considered in a fish stock assessment are:

- Catches, how much, when and where.
- Biological samples of the catches.
- Abundance estimates or abundance indicators (e.g. catch rates from the commercial fisheries, hydroacoustic surveys or trawl surveys).
- technical description of the fisheries (e.g. mesh sizes used in a trawl fishery, discard practices, etc.).

Uncertainties originating from several sources are:

- Variability in data, but the data are unbiased.
- Biases in data
  - Incomplete catch statistics, i.e. underestimation of the removals.
  - Incomplete coverage of the stock in surveys or incomplete coverage when sampling the fisheries. Such incomplete coverage is likely to create biases in data.

    A particular example in the NAFO Regulatory Area is vessels flying "flags of convenience". Catches in those vessels essentially have to be guessed, together with length and age compositions and other biological parameters.
- Misjudgment of data on the parts of the scientists. These judgements involve discerning between trends and variability in the stock indicators, identifying biases in the data, interpreting changes in stock indicators as being due to a stock change or a change in fishing technology.
- Incomplete understanding or misunderstanding of the population dynamics and stock structure.

The resulting biological advice is a scientific brew which tries to sort out where each indicator belongs. These reports are transmitted to the managers; in the case of NAFO it is to the Fisheries Commission which is represented by national governments, where the biological advice is weighed together with other considerations of relevance to fisheries before a decision on management measures may eventually be made.

Variability in data and even biases can be analyzed fairly simply if the magnitude of these are known. Computer simulations can provide insight to how much the advice would be affected, and the decisions can be reached with knowledge of the risks and the possible adverse effects. Misinterpretations and deficiencies in the biological models are much more serious. They may lead to management actions which are counterproductive to reaching the objectives. Management actions based on deficient biological models may lead to events which are not foreseen at all, and which may be highly undesirable. The discussion on the effects of a general mesh size change in the trawl fisheries in the North Sea may serve as an example. Here single-species models indicated an increase in the high-value top predators while multispecies models, because of feedback in increased predation on younger age groups, showed none or a much smaller gain from such an action. The discussion of the Grand Bank cod (NAFO Div. 2J+3KL) in Canada (Harris, 1990) was partly based on a misinterpretation of the trawl survey results, which led to too high TACs and delayed management actions, in spite of well defined objectives.

Thus it is easy to see how scientific advice with all its qualifications could easily make a manager despair, and on the other hand the scientific advisor sees with unrest the advice being taken forward with its qualifications toned down or simply forgotten. To account for uncertainties in the biological advice and any other analysis, management decisions are put up to revision regularly. This is done for most catch quota systems where TACs are revised annually.

Decisions on Management Measures

The biological TAC advice with all its qualifications is considered together with economy, social life, fishery technology, etc. by each interested party and compared with that group's objectives. If the problem concerns a stock under international jurisdiction, national priorities have to be agreed before discussions take place in the NAFO Fisheries Commission or through bilateral negotiations. An agreed TAC subsequently has to be implemented and enforced at the national level. And again the actual enforcement scheme may be a matter for consideration when biological advice is formulated.

Fishing is a complex undertaking affecting many different groups. These include:

— Fishing vessel owners.
— Fish processing plant owners.
— Fishing service industries (stevedore, harbours, ice, radio, fish finding equipment, etc.).
— Fishermen.
— Workers in fish processing plants, in harbours, in retail and detail sales of fish, banks, in the service industry.
— Municipalities and government.

Thus the process includes numerous decisions. A study of the decision making process could cast light on how management deals with biological uncertainties.

Two models of how the decision making process could be viewed are discussed below. These two models are:

1. A search for an optimum solution.
2. A search for an acceptable compromise.

Biological uncertainties play a very different role in the two decision making scenarios and this suggests that such studies could be fruitful in understanding the role of biological uncertainties. Under (1) the biological uncertainties contribute to the weight attached to the biological advice. A high degree of uncertainty leads to little weight attached to the biological advice. Under (2) biological uncertainties are arguments which can be used or not used, as the party sees fit in the negotiations. However, a real situation is neither seen as a clear-cut rational nor as a political decision making process. The two models are considered extremes between which a real decision process would actually take place. A decision making process is not static in time and a real situation may in time flip to and fro and between the extremes decribed below.

Decision Scenario I. Rational Model

A search for the optimum solution

The first model is a rational decision making process where everybody agrees on objectives and jointly search for an optimal solution.

This scenario is characterized by:

— Well defined objectives and well defined weighting of conflicting objectives.
— Objectives and weightings shared by all interested parties with a clear understanding by all interested parties of these objectives.
— Common acceptance of applicable management measures.

The decision making process is characterized by:

— Analysis of how the different objectives can be reached using the accepted management measures.
— Weighting the different objectives.
— Calculating the overall optimum and reaching the decision almost mechanically.

Under this scenario, the biological advice is simply the optimum solution to the specified set of objectives and their weightings. In cases where these objectives are not clearly specified, the biological advice is usually (a step towards) MSY. The biological uncertainties contribute to the weight attached to the biological advice. High uncertainty leads to little weight attached to the biological advice. If the knowledge on how the biological system may react is limited, i.e. the advice is given with high uncertainty, then analysis of that system will either have to be left out or be replaced by some rather arbitrary considerations, and the management decisions will be taken by consensus between all interested parties.

Decision Scenario II. Political Model

A search for an acceptable compromise

The second model is a political process where the interested parties have more or less conflicting objectives but where everybody has an interest in reaching a compromise in order to allow fishing to continue. In this case the search for a solution is through negotiations and the compromise involves elements like the importance a party attaches to the problem, political ability to explain a case to the public, and in general, the power base available to each interested party.

This scenario is characterized by:

- Conflicting objectives between interested parties and no accepted weighting between the different objectives.
- No general acceptance of management measures.
- Different importance is attached to the issues by different interested parties.
- Objectives and the importance attached to the problem are not known by other parties.
- Different power base is available to different interested parties.
- An interest among all interested parties to reach a compromise, as it is assumed that management decision is required for the continuation of fishing.

The decision making process is characterized by:

- Establishing, as general knowledge, the objectives of all interested parties and the importance each party attaches to its objectives.
- Analysis of the systems to understand how each interested party's objectives are affected by different management decisions.
- A search for a compromise, both with respect to a subset of management measures which are non-objectionable and to a set of management measures which will to some degree fulfil the objectives of the interested parties.

During the search for a compromise, alliances may be formed and in the end a decision is reached because all parties have an interest in the continuation of fishing operations.

The role of biological uncertainties in this scenario is rather unclear as is the role of the biological advice itself. Actually the biological advice forms the starting point of the negotiations in several fora and, as such, is taken into account when each interested party evaluates its position on the starting point of the negotiation process.

During the negotiation process, not only is the weight of the biological argument evaluated against the biological uncertainties, but also against how much this advice is at variance with the objective of the interested party. Biological uncertainties in this scenario are arguments which can be used or not used as the party sees fit.

Parameters Affecting the Process

While biological uncertainties play a different role depending on the decision making process, it may be pertinent to ask whether biological uncertainties are among the variables which determine how an actual decision making process may evolve.

One element in the rational decision process is the ability to simulate how fish stocks and the fishing industry are affected by management. Under high biological uncertainties these biological effects are not known, hence that element of a rational decision process is not available. So, to reach consensus and apply a rational decision making process involving the biological aspects would require a fairly low degree of uncertainty in our understanding of the biological system.

In the negotiation process the uncertain advice is easily put aside for any party for whom the advice is seen to be in conflict with its legitimate interests. Conversely is it difficult to make a firm stand on very shaky biological evidence.

It is therefore suggested that the type of decision shifts towards the political process with increasing biological uncertainty. Further, in negotiations shaky biological advice is ignored (as it rightly should be).

Discussion

Holden (MS 1990) reviewed at the 7th International Council for the Exploration of the Sea (ICES) Dialogue Meeting in November 1989, why so many fisheries are mismanaged. Mismanagement in this context is overexploitation and dissipation of the resource rent, i.e. the output of the fisheries in biological and economical terms is less than what could have been achieved. He found that the main reason seemed to be that different managers have different objectives and there was no single overall objective in most countries. A further problem was that only rarely is there agreement on how an objective was to be implemented. He suggested that a forum should be established where all parties involved could discuss these questions and try to reach agreement.

The mechanism implied was probably that decision making is done politically, where biological uncertainties (among other types of uncertainties) in fact prevent the management of the fisheries to the extent required, particularly when higher yields and economical benefits may be possible.

This indicates that the aims suggested by macro economy (maximize the resource rent) or fisheries biology (maximize the yield) are, either not shared by the dominating interested parties or that the means to achieve these objectives are not accepted in the short run. A third explanation could be that the uncertainties in the biological advice are too big to allow projections with adequate confidence to the extent that short-term sacrifices are considered worthwhile.

These questions are for the interested parties to answer.

Fisheries biologists should consider if their projections are worthwhile or would the considerable sums of money spent on fisheries research be better invested elsewhere. Such questions can only be answered by identifying the actual degree of accuracy obtained in the predictions and relate these results to management practiced.

References

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