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The Use of Personal Knowledge in Stock Assessment

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Abstract

The focus on the precautionary approach, sustainable fisheries and ecological management requires knowledge about the uncertainty of stock assessments. An increasing number of working groups in the ICES system include uncertainty estimates, and new reference points are being developed. When it comes to the quality or the uncertainty of uncertainty estimates and reference points, this is communicated by scarce comments in ACFM reports or working group reports. Uncertainty is difficult to estimate, and to get a picture of the quality of assessments it might be fruitful to study not only the data and models used, but also *how* the models are used by the participants of the ICES working groups. It seems that personal knowledge plays an important role when results from each run are evaluated and the program package is rerun with new options or other data. In this paper I discuss the role personal knowledge plays in stock assessment and how this can reflect the quality of the assessment.

Keywords: fish stock assessment, uncertainty, precautionary approach, personal knowledge, quality

Introduction

The precautionary principle is about decision making founded on values beyond the economics and based on uncertain knowledge. A consequence of the principle is that the burden of proof is reversed; more uncertainty requires more cautious management action. The principle is usually associated with situations including possible risks of severe outcomes: the ozone layer, toxic waste etc. Within fisheries, a more moderate term is adopted, the precautionary approach. To manage in accordance with the precautionary approach, uncertainty in biological advice is crucial. Much effort has been put into meeting these new demands in advice; tools have been developed to calculate risk in stock predictions (Francis and Shotton 1997) and new reference points to suit precautionary harvest control rules have been discussed and calculated (Serchuk *et. al.* 1997, NN 1998). However, calculations of both risk and reference points are strongly dependent on uncertainty estimates. The main models ICES use in stock assessments, either do not estimate uncertainty (XSA) or the uncertainty estimate reflects only a part of the total uncertainty (ICA (Patterson and Melvin 1996), ADAPT (Gavaris 1988)). To include every source of uncertainty, in catch statistics, in age reading, indices and every model assumption is a demanding task and would make a very complex model. Complex models need quality data to give good uncertainty estimates and, not to forget, to maintain robustness and stability.

To get an impression of the uncertainty in stock assessment, it might be useful to study discussions in working groups.

Personal Knowledge

An assessment is carried out by running a computer model and the results carefully studied afterwards. Not seldom the assessment model is rerun where maybe parameters are adjusted or data points left out. No wonder, there are many examples of index series pointing in different directions, and parameters, e.g. natural mortality, may not be founded on sound scientific reasons. This means that controlling and evaluating output of such computer models is necessary, which again means that some people must have knowledge about the stock that is not included in the computer program.

Within philosophy of science, the importance of personal knowledge or intuition has been discussed the last few decades. The physicist and philosopher Polanyi was the first to use the term *tacit knowledge* (1958) and claimed that this kind of knowledge is not possible to articulate in such a way that the person having this knowledge is able to describe exactly what he does. Consequently, this knowledge would not be possible to write down in computer language. The role of tacit knowledge in science has been discussed both in connection with practical and theoretical aspects of research (Holton 1987, Keller 1983, Popper 1972).

Members of ICES' working groups have claimed that intuition is important in stock assessment. In my opinion, the discussions in working groups can show that the uncertainty in an assessment may be greater than what is communicated in the reports. The Norwegian Spring Spawning herring has shown to be a rather hard stock to assess. On the working group in 1997, the output from several runs of the assessment model, which is seen in Table 1, was discussed. The final result was chosen to be 5.6 mill. tonnes with an uncertainty estimate of 30 %. When discussing what run to choose, some of the arguments would be : - this doesn't resemble what we got last year, - I trust this or that survey, - this is an outlier, or the arguments could be of more technical character: - This data point makes the model unstable or - this catchability doesn't seem right. Such arguments can be difficult to confirm, and may be grounded on personal knowledge. The decision on what run to choose may thus be based on non-quantified arguments. My question is then, is this knowledge precise, or is 30% uncertainty too low? I find it hard to believe that even experienced fishery scientists have such precise intuition on quantities like abundance, even though I strongly believe that qualified assumptions are necessary since assessment computer models can be quite unstable or fail in discovering new trends in stocks. Fishery scientist may however have knowledge that is hard to document, on whether stock abundance is increasing or decreasing compared to previous years.

Another interesting uncertainty related aspect is how the confidence about an assessment of a working group member can slightly grow with time after the working group. The nervous atmosphere you sometimes have before the final assessment, is more or less forgotten or maybe just not communicated. While the common view is that science is about searching for the truth, Latour (1987) claims that something becomes true when enough of the "right" people believe it's true. Maybe this can explain the increasing confidence of working group members. When every member of the working group has given their approval of the assessment, it is easier to be convinced about the quality of the assessment.

In my opinion, the use of personal knowledge in relation to uncertainty estimates is a topic that deserves more attention.

Quantifiable and non-quantifiable uncertainties

Several papers characterize the different sorts of uncertainty in fisheries management (Fogarty et. al. 1992, Hilborn and Peterman 1996, Garcia 1996, Francis and Shotton 1997 etc.). Francis and Shotton have the following suggestion:

- *Process uncertainty*: uncertainty from natural variability.
- *Observation uncertainty*: uncertainty in the process of data collection.
- *Model uncertainty*: ignorance in biological knowledge.
- *Estimation uncertainty*: how precise parameters can be estimated with the given data.
- *Implementation uncertainty*: in implementing management uncertainty
- *Institutional uncertainty*: e.g. the lack of well-defined social, economic and political objectives in fisheries management.

While fisheries scientist have paid attention to the first two categories and worked on estimating these uncertainties, and the last two categories are not essential to assessments, estimation uncertainty and especially model uncertainty are rarely treated and difficult or maybe impossible to estimate.

Risk calculations and precautionary reference points are chosen to be the solution on how to include the uncertainty in stock assessments and predictions. But what about the uncertainty in the uncertainty estimates? After all, you can't be certain that the total estimated uncertainty will dominate the uncertainty that is not possible to estimate. In my opinion, since the quality of uncertainty estimates will vary from stock to stock, there is a need to communicate the quality of the assessment. With the great success and dominance of the science of physics the last decades, which in contrast to the science of fisheries is a precise science, the society will think of scientific advice as something precise. Assessments are based on many assumptions which are hard or not possible to test, the data is insufficient and experiments might be impossible to carry out, thus, the uncertainty is uncertain.

Communicating uncertainty

Management is about making rational decisions on, among other things, uncertain information on fish stocks. The society's increasing demand for sustainable fisheries and precautionary management, puts the uncertainty in focus, which not only requires uncertainty estimates but also information on the quality of the uncertainty estimates. The precision of a complex assessment and predictions cannot be compared to the determination of a physical constant. Within traditional science (in contrast to science for policy), simplified systems are studied and uncertainty under these conditions is estimated. Funtowicz and Ravetz (1991) point out that research traditionally has been limited to relatively well known systems and short time scales. Now, however, the number of policy related projects dealing with topics on a global scale and on a long time scale is increasing. This new kind of science puts uncertainty in focus. Funtowicz and Ravetz stress the importance of communicating uncertainty and have developed a system to make this possible; the NUSAP-system (Numeral Unit Spread Assessment Pedigree), (Funtowicz and Ravetz 1990). In addition to the traditional way of presenting research results with spread and percentiles, they suggest a way to present the quality of the research; a pedigree matrix. This matrix is supposed to evaluate research results (See table 2). Different matrices are developed for different purposes, e.g. to evaluate data or to evaluate computer models. None of their matrices suits assessments sufficiently, but form a basis for further development. This could enable the fisheries scientists to communicate uncertainty in an assessment more entirely.

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Table 1: Results from assessment model for Norwegian Spring-Spawning Herring (Anon. 1997)

Run no.	Description	Mean F (Ages 5-12)	Yield/ Biomass	SSB Mill. t	Residual Variance
1	Baseline	0.33	0.23	5.28	390
2	As 1, new tagging data	0.34	0.23	5.20	389
3	As 2 + new December survey without outlier	0.37	0.32	3.69	493
4	As 3 with outlier	0.18	0.18	5.56	3800
5	As Run 3, + Barents Sea Juvenile survey	1.15	0.52	2.32	52031
6	As 3 + fill in missing values in catches at age	0.36	0.33	3.68	488
7	As 6, change from lognormal to gamma error	0.29	0.28	4.40	496
8	As 7, include 1991 yc in Feb/Mar and Jan Surveys	0.10	0.10	12.08	809
9	As 6, flat selection pattern	0.15	0.17	6.99	805
10	As 9, include weak cohorts in surveys	0.45	0.47	2.53	3461
11	As run 7, flat selection pattern 8-13, linear 5-8	0.36	0.51	5.48	703

Table 2: Research pedigree matrix in the NUSAP-system
(Funtowicz and Ravetz 1990)

Code	Theoretical phase Quality of model	Empirical phase Quality of data	Social phase Degree of acceptance
4	Established theory	Experimental data	Total
3	Theoretical model	Historical/field data	High
2	Computational model	Calculated data	Medium
1	Statistical processing	Educated guesses	Low
0	Definitions	Uneducated guesses	None