The ecosystem approach to fisheries – science driven or issue driven?

Kjellrun Hiis Hauge

The ecosystem approach to fisheries (EAF) represents a multi-objective aiming at 1) broadening the management perspectives from single species to including ecosystems considerations, 2) maintaining a precautionary approach and 3) increasing the involvement of stakeholders. ICES, as a science community and provider of advice, has a particular responsibility in these respects, but developing advice in accordance with the EAF has proven difficult and time consuming. In this paper, I discuss the role of science for the EAF in terms of applied versus basic research and in terms of type-I, II and III errors. I argue that the science community augment two problems in our demand for political attention to knowledge gaps, often in our own field of interest. First, the managers are implicitly advised to postpone the EAF until the knowledge gaps are filled, which is in contradiction with the precautionary approach. Second, this may take attention away from more urgent ecosystem issues. One solution to this problem is to consider scientists as stakeholders and involve all interested parties when deciding what should be the present priority of ecosystem issues. As ICES is not in power to arrange this, an alternative is that ICES carries out this exercise itself among its own scientists. I briefly discuss how this can be done.

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Kjellrun Hiis Hauge: Institute of Marine Research, P.O. 1870 Nordnes, N-5817 Bergen, Norway [tel: (+ 47) 55 23 85 90, fax: (+ 47) 55 23 86 87, e-mail: kjellrun@imr.no].

Background

The ecosystem approach has been defined as a strategy to reach a balance between ecosystem conservation, sustainable use and equity of the benefits of the resources (UNEP, 2000; FAO, 2003). Three factors have been closely linked to the ecosystem approach: a cross-sectoral approach, the precautionary approach and participatory processes (FAO, 2001; UN, 2002; FAO, 2003).

The ecosystem approach to fisheries management (EAF) aims for “sustainable fisheries management taking into account the impacts of fisheries on the marine ecosystem and the impacts of the marine ecosystem on fisheries” (FAO, 2001). The declarations and agreements on the ecosystem approach reflect a common understanding of a necessity of broadening the traditional fisheries management to sector-crossing management and acknowledging the multiple uses of the marine ecosystem. This requires a shift in the knowledge production supporting management decisions (FAO, 2001; UN, 2002; FAO, 2003). An improved understanding and assessments of the ecosystem is called for with emphasis on ecosystem structure, functioning and variability (FAO, 2001; UN, 2002).

ICES, as a science community and provider of fisheries advice, has a particular responsibility in the ecosystem approach to fisheries. ICES responds to these multiple objectives by declaring an incremental approach in implementing the ecosystem approach into advice, increasing stakeholder interactions and by aiming at expanding the number of the ecosystem components in the advice (ICES, 2006). ICES' aim of the stakeholder interaction is so far concentrated on a one-way interaction: to let the stakeholders get better insight into the advisory process (ICES, 2006).

On the question whether ICES has managed to serve the ecosystem approach to fisheries, it is no doubt that issues have been debated, study groups and working groups have been created to meet the needs of an EAF, and individual scientists at research labs have carried out research to support the EAF. ICES gets requests from its clients on a broad set of ecosystem issues, it evaluates indicators for OSPAR and HELCOM, prepares a range of reports and tries to implement environmental effects in stock assessments in various ways. There is a tendency, however, to treat the EAF issues separately, and turning the knowledge into applicable advice has shown to be a rather slow process. The Working Group for Regional Ecosystem Descriptions (WGRED) has pointed to this and concludes that to improve the existing quota advice by incorporating more environmental information will be immensely time demanding (ICES, 2007a). The WGRED report also suggests that incorporating environmental drivers in stock assessment may be less significant than pointing to some other fisheries related issues like trying to get the grasp of the total fishing mortality (including illegal fishing and discards). Perhaps even more demanding is the struggle, within ICES and outside, with making the concept of measuring "ecosystem health" operational or useful.

The Study Group of Risk Assessment and Management Advice, SGRAMA (ICES, 2007b), suggests a framework for risk management that is quite different from the above processes in ICES. Instead of focussing on gaining knowledge of the ecosystems and environmental impacts on fish stocks, the framework implies to invite stakeholders to decide what the main issues are for the EAF. This is more or less in line with what the Australian managers and scientists do (Fletcher, 2005).

EAF creates a situation that demands new science approaches as it embraces applied, multidisciplinary research and multiple societal values. In this paper I first present some general discussions on science for policy from the academic literature on what kind of research should be prioritised and how to ensure relevance and quality in science. These form the background of my discussion on why the process of defining or developing tools for the EAF has been slow. I define two positions of defining the ecosystem approach to fisheries where one is science-driven and the other is issue-driven. I argue that the EAF would benefit from a shift in national/international research strategies combined with a more issue-driven EAF than today. And finally I sketch a way forward for ICES and discuss its benefits and drawbacks in relation to the role of science, its relevance and accountability.

Science for Policy

Stokes argues that national strategies for supporting science have been built on the assumption that basic research will eventually be picked up later somewhere else and made applicable (Stokes, 1997). He opposes to this simple, one-dimensional model and argues that this is not how science necessarily has become applied. To illustrate his point of view, he divides research into 4 quadrants by what research is inspired by (see Fig. 1). These are defined by two axes: *Quest for fundamental understanding* and *Considerations of use.* While Bohr's science illustrates that basic science can later be applied, Pasteur's science shows that science can both be basic science and solving practical problems at the same time. Edison's engineering demonstrates that basic research is not always necessary for great inventions (Stokes, 1997). Stokes further denotes the three essential quadrants as Bohr, Pasteur and

Edison and argues that it may be fruitful to also fund research within Pasteur's and Edison's quadrants to solve problems or create essential innovations (Stokes, 1997).

Funtowicz and Ravetz takes the discussion one step further and argue that basic science may not even be suitable for solving the urgent policy questions today when stakes are high and facts are uncertain (Funtowicz and Ravetz, 1993). Knowledge production in basic research is built on controlled experiments while claims about the natural environment are often based on non-tested assumptions. Furthermore, they argue that while basic research aims at reducing type-I error (the error of rejecting a null hypothesis (no change or no danger) when it is actually true), the precautionary principle, in practice, is to reduce type-II error (the error of accepting a null hypothesis when the alternative hypothesis is true). Funtowicz and Ravetz also address problem framing in science for policy as a crucial issue, and use the concept of type-III error. Dunn defines type-III error as assessing the wrong problem by incorrectly accepting the false meta-hypothesis that there is no difference between the boundaries of a problem, as defined by the analyst, and the actual boundaries of the problem (Dunn, 1997). Funtowicz and Ravetz argue that the risk of making type-II and type-III errors gives reason for an increased and new focus on uncertainty in science for policy. Also, they argue that extended peer review (by stakeholders or lay persons) of science for policy is necessary to try to avoid problems related to relevance (type-III error) and societal values (type-II and -III error). They denote this new way of doing science as *post-normal science*, where *normal* refers to the Kuhnian term of normal science (Funtowicz and Ravetz, 1993).

On the practical solutions to environmental problems, Wynne argues that the predictive paradigm should be about solving the problems upstream, meaning solving the problem at its origin (human impact), rather than downstream: waiting for a statistically significant effect, when it's often too late to solve the problem (Wynne 1992). Both Wynne and Funtowicz and Ravetz agree that science can no longer be seen as the only provider of the right answers to environmental problems, and that stakeholders should have a more significant role. Still they accentuate the necessity of research for solving the urgent policy questions that continuously arise.

The Ecosystem Approach to Fisheries

In what quadrants do we place research for the EFA and how do they relate to the type-I, II and III errors? As the EAF covers a considerable number of topics, I have chosen three quite distinct categories to discuss my points: technical/practical EAF problems, quota advice and ecosystem health.

There is a range of research issues supporting the EFA that suits the applied quadrants of Pasteur and Edison (Fig. 2). This kind of research solves policy questions directly, like the development of scaring devices to avoid bird by-catch or the mapping of corals to define areas not allowed for bottom-trawling. The policy questions associated with this research are formulated rather precisely and are relatively easily translated to practical problem solving.

Implementing environmental drivers in quota advice have shown more difficult. Although there may have been a common understanding (maybe among managers?) that this would be in line with Edison's quadrant, the related research effort may rather belong to Bohr's quadrant. This research aims at incorporating environmental effects on stock assessment parameters (recruitment, growth etc), defining regime shifts to explain/predict productivity or quantifying stock interactions. Although it is more or less taken for granted that such projects are in the spirit of the EAF, I still think it would be useful to rethink their intention: increase accuracy in advice or produce a different kind of advice. A specific research effort may create more correct assessments or refined reference points, but if unreported catches are substantial it may not contribute to improving advice, but may even move the attention away from other sources of uncertainty, like illegal catches. To avoid making type-III errors, there should be a continuous discussion on what should be defined as an issue within the EAF (for example discarding) and on how the different issues impact the stock and the assessment uncertainty.

A management objective that is yet more complex is the "ecosystem health" objective stated by OSPAR, HELCOM and the Norwegian white paper on integrated management in the Barents Sea (The Royal Ministry of Environment, 2006). While it is easy to agree that we want healthy ecosystems, this is an objective that does not translate easily to research problems. How do you define health? How do you translate health to a set of criteria? What is considered sufficient representation of an ecosystem? Can we measure this representation? On a local or global scale? Is it possible to regulate "health" in a meaningful way? How many person-months of research will it take to get there? These unanswered questions demonstrate that this research belongs to Bohr's quadrant as the idea is basically to support research and we will eventually know how we will make use of the knowledge.

There are potentially another two problems with an objective connected to measuring ecosystem health. One is that it is against the precautionary principle. History has shown that when you eventually are able to detect that something is wrong, then it is often too late to handle the problem (Wynne, 1993). The other is that such a broad and open-ended issue, creates an opportunity for all marine and fisheries scientists to declare that an ecosystem approach is impossible without more funding within their particular field of interest, whether it is on tools for stock assessments or understanding the role of bacteria in the marine ecosystems. (It is quite understandable, though, since scientists need to apply for funding regularly.) This kind of argument puts that research in Bohr's wait-and-see quadrant and may contradict the precautionary approach. But above all, it defines the scientists as a stakeholder to the EAF.

In this section, I divided the research for the EAF in three categories, 1) to solve specific practical problems, 2) to improve quota advice and 3) to define ecosystem health. The first group supports what I denote an *issue-driven* EAF as it calls for solutions for specific issues. The third group I call *science-driven* EAF, because the underlying idea is that science will eventually be able to define the EAF. While regulating a fishery is a specific management issue, I would denote stock assessment related research as one or the other depending on whether it can changes the characteristics of advice. If the contribution of including an environmental driver in an assessment is insignificant compared to the These categories are naturally too coarse and too general, but will hopefully serve to clarify my points. A science-driven EAF is an implicit promise to support a management objective, but can we guarantee that our research will be possible to make operational and improve management? In our obligation to produce useful science are we at risk of making type-III errors? In addition, a science-driven EAF may move focus away from more urgent issues and slow down the process of solving problems. (The managers may even be satisfied with this if the urgent issues are politically more contentious). For these reasons, I think it would have been more fruitful to separate the research with the two different justifications: one to support the EAF (issue-driven, the quadrants of Pasteur and Edison) and the other to strengthen the research basis, which is important for cultural reasons but can turn out useful for the EAF at a later stage (Bohr's quadrant).

ICES and the Ecosystem Approach to Fisheries

Given the present situation where the managers have only partly defined what an operational EAF is and we, the scientists, argue that our specific field of interest is of crucial importance to the EAF, what role can ICES play in this game? I will now suggest how ICES can contribute to make the science and advice making for the EAF issue driven, and some thoughts on how they can be presented.

ICES today covers a broad spectre of ecosystem related tasks; it answers to requests on specific issues related to the ecosystem, evaluates OSPAR indicators and tries to implement ecosystem effects in stock assessment. However, ICES tends both to handle these questions separately and to present them separately in the annual ICES report on advice. This has the effect that the importance of each issue compared to others looks somewhat arbitrary. The ICES annual quota advice, for example, may include a couple of sentences on environmental effects and maybe on discarding or damage to the bottom habitat. But concerns presented by a single sentence, and that does not seem to have any effect on the advice, appear insignificant. This generates a chance of making a type-III error.

An issue-driven EAF would help preventing management and ICES from assessing the wrong problems. Who then should decide the issues and make priorities? The Australian way (Fletcher, 2005), which also is recommended by SGRAMA (ICES, 2007), is to include managers, scientists and (other) stakeholders to decide the issues. This recognizes that the EAF is about multiple values and therefore the relevance of issues and is in line with Funtowicz and Ravetz (1993) and Wynne (1992). Since it is not in ICES' power to arrange the necessary management bodies and decide what stakeholders should participate, ICES can only recommend such a management process. But ICES can also make influences by initiating a similar process with ICES scientists from different disciplines and research areas. ICES is about to reorganize in a way that may suit an issue-driven management very well. Instead of having ACFM and ACE separate, an advisory committee for each eco-region is suggested to give advice more in line with the ecosystem approach. These advisory committees, consisting of representatives from different science disciplines and expertise, would be competent to evaluate and suggest the most important and urging issues. An ICES defined region may not be a sufficient scale to operate on as some issues are fisheries specific while others are state or regional specific. The EAF would therefore need to be defined for different scales. The ICES regional advisory committees could decide what issues to recommend for each fishery or stock and each region.

To briefly remind the spectre of issues an EAF can address, they may be a) effects on the fish stocks by the fishing practice, b) effects on the ecosystem by fishing practice, c) environmental effects on the fish stock and/or d) effects on the fish stock by other sectors. This means that the issues can be anything from the destruction of bottom habitat to animal welfare and pollution. Part of the problem today is the way concerns are expressed. To really emphasize the important issues, each fishery or stock presentation should start with the essential issues (see Table). These must be placed up front so that ICES clients and others expect to find them at the beginning of every assessment each year. Visual effects are no doubt crucial in communication. Who hasn't heard the complaint about managers only reading the tables?

A criterion for choosing an issue should be that it has an effect on what is advised, either on TACs or related to the fishing activity. How one issue affects the others should be included in the report to emphasize and communicate its considered importance, and solutions should be suggested when appropriate. For example how illegal catches or discarding affect future stock size and catches or how fishing affects the environment. Solutions to several likely problems lie outside the scope of ICES, so often they cannot be other than sketched.

Deciding the “most important” issues is easier when the impact associated with the different issues is possible to quantify. Obviously, many, or most, impacts are not possible to quantify to a “satisfactory” degree. Qualitative and judgment based evaluations should be used more commonly and more systematically to avoid neglecting non-quantifiable issues. Although this may be perceived as non-scientific, it can be justified by the precautionary principle. This does not mean that ICES will produce one single statement on each issue. Rather, the underlying uncertainties should be accentuated and how they affect results and advice related to the issue in question. As ecosystem issues may be urgent and the knowledge basis is uncertain, the issues falls well under the concept of post-normal science, developed by Funtowicz and Ravetz (1993). I believe that with the EAF, we need to move away from the thought that exact numbers are necessary for high quality advice. Objectivity in applied science, previously defined as neutral, credible, transparent and accountable through precise numbers, can be redefined as credible, transparent and accountable through assessing the real problems and including more comprehensive uncertainty assessments than today.

This will change ICES’ role in the advisory process as it may leave answers to management questions more open. This may create uneasiness about how the managers will respond. However, loss of trust in science is a trend in society today, and it is time to rethink how this trust is recaptured, also in relation to ICES and its role within the EAF. In this paper I have suggested that one way to go is to redefine and separate what is applied research for the EAF and what is basic research, to suggest or define the most urgent EAF issues related to different scales or units and to define uncertainty communication as a necessary part of objective science.

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Figures and tables

Ecosystem issues related to Stock X

Status of stock	*Illegal catches*	*Bottom habitat*	*Pollution*
- Estimated status - Explain how the other issues affect the estimated state	- Estimated or described impact on stock status	- Estimated or described impact on habitat	- Estimated or described impact on stock
Advice			
- Scenario based advice (may be based on harvest control rules) including how the issues may affect the stock and showing how the issues influence the advice (quota/effort etc). - Advice directly related to all issues - Quality of information - Extended uncertainty assessment			

Table 1. *Issue-driven ICES advice.* This is a suggestion on how each presentation of fish stock should start in the advisory report. (Issues may be destruction of bottom habitat, bycatch, diseases, lack of prey, changes in the physical environment that will affect recruitment or distribution, considerable increase in predators, quotas, effort regulation, illegal catches, discards, animal welfare and destruction of habitat in spawning areas or nursery areas from other sectors, pollution…)

Considerations of use?

Quest for fundamental understanding?	no	yes
yes	Pure basic research (Bohr)	Use-inspired basic research (Pasteur)
no		Pure applied research

Figure 1. Stokes' quadrants for research

Considerations of use?

Quest for fundamental understanding?	no	yes
yes	*Pure basic research* -Defining ecosystem health -Understanding ecosystem functions	*Use-inspired basic research* -Multispecies modelling? -Recruitment/maturity?
no	-Mapping ecosystem components without knowing how it is going to be used	*Pure applied research* -Stock Assessments -Mapping of coral reefs -Scaring devices -Illegal catches and discards -Bycatch

Figure 2. Suggestions for how research for the EAF fit the quadrants. Several topics are likely to be at the border of two quadrants (multi-species modelling, mapping of coral reefs, mapping of ecosystem components etc).