

Policy and knowledge in fisheries management: a policy brief^a

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The EU project Policy and Knowledge in Fisheries Management investigated the use of biological knowledge in various parts of the fisheries system, using North Sea cod as a case study. The project examined the way scientific advice was generated from technical and institutional perspectives, as well as the way claims about science appeared in both policy-setting and in public debate through the press. The results suggested that many people involved in the system want a new way to reflect about science in management. People from all major stakeholder groups are calling for a more interactive system of producing a common knowledge base. Such a system could bring uncertainty from its current marginal role as the leftovers of certainty to the heart of the science process. It would require stakeholders to help address uncertainty and to negotiate a more realistic placement of burden of proof.

Keywords: cod, management advice, relative stability, sociology of science, TAC, uncertainty.

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Introduction and historical context

The EU's Policy and Knowledge in Fisheries Management (PKFM) project focused on the scientific knowledge base for the current management system in European fisheries, particularly on systemic weaknesses in the provision of scientific advice from a fisheries system perspective (Degnbol and McCay, 2007), tracing interactions between knowledge and policy decisions among the various actors. Within the project, the management of North Sea cod (*Gadus morhua*) was selected as a case study because many states around the North Sea have vested interests in the stock, and because the stock is now considered to be approaching an all-time low. This choice allowed and focused, but did not necessarily limit, our enquiry into the interface between policy and knowledge in European fisheries management. Although the management of North Sea cod represents a specific case, the analysis may serve also as an example of European fisheries management in general.

The current management system in EU waters is widely acknowledged to be performing poorly in terms of sustainable exploitation (CEC, 2001). In 2003, 22% of the stocks managed under the Common Fisheries Policy (CFP) were outside safe

biological limits (ICES, 2005). A feeling of distrust has developed among all groups of actors, and the overall legitimacy of the CFP has been called into question. Perhaps the most important positive aspect of the situation is that so many people from so many different parts of the fisheries system recognize the need for change. Solutions are being sought within the present stock-based total allowable catch (TAC) system and through an examination of alternative systems. In both cases, it will be important to consider and actively integrate non-biological information, and to consider technological, socio-economic, and political processes. The suitability of a single-species TAC as the main management tool for mixed fisheries, such as those exploiting a suite of demersal species in the North Sea, including cod, is questionable, because of the multispecies, multi-fleet nature of the fishery (Daan, 1997).

The management of marine fisheries and its problems have deep historical roots. The North Sea cod stock has a long tradition as an exploited natural resource, and a highly prized one. In the UK, overfishing was already an issue in the 1850s. Initially, worries were focused on pelagic species, especially herring (*Clupea harengus*) stocks, but over time, the anxiety grew to include demersal species such as the commercially important

^aComments and views expressed in this manuscript are those of the authors and do not necessarily represent the views or opinions of ICES, their employers, or their national Governments, nor do they anticipate future Commission policy in this area.

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cod. Concerns about overexploitation were, in part, the reason for the foundation of the International Council for the Exploration of the Sea (ICES) in 1902, as an intergovernmental organization for scientific investigations of marine fisheries in relation to their management, as well as of the abiotic environment (Rozwadowski, 2002).

The North Sea fishing industry has traditionally depended in part on demersal fish resources, mainly gadoids such as cod, haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*), and the flatfish plaice (*Pleuronectes platessa*) and sole (*Solea vulgaris*). After the Second World War, new technological developments in the fishing fleet led to large catches of all these species. Total landings of cod increased markedly during the late 1960s and 1970s, peaking at 350 000 t in 1972. Similar increases were noted in haddock and whiting, and this period is referred to as "the gadoid outburst" (Cushing, 1984). From the mid-1980s and through the 1990s, the cod stock declined to what is now an all-time low.

As consciousness grew that resources were limited, so did awareness of the political context in which fisheries science operated, and the public roles played by scientists and managers became gradually more prominent (Rozwadowski, 2002: 177–211). Since the CFP was implemented in 1983, scientists and managers have been caught up in a demand for public legitimacy in a way that had not seriously affected them in the decades before. With ever louder voices, industry groups and concerned citizens have claimed their democratic right to have their interests and concerns taken into account in the management system. Organized groups with interests at stake increasingly require a management system that addresses technological, social, and economic questions, as well as biological issues.

Since the early 1980s, the system of single-species TAC with fixed shares by country has dominated the array of available management measures within the CFP. The principal tools used to provide the annual scientific advice have been age-structured population models (Virtual Population Analysis, VPA) and associated methods developed by fisheries biologists (Rozwadowski, 2002; Skagen and Hauge, 2002; Ulltang, 2002). In the PKFM project, we came to use the notion of "the TAC machine" to describe the annual cycle of stock assessment and advice on catch options by ICES, the proposed TAC by the Commission of the European Community (CEC), and the final decisions by the Council of Ministers (Holm and Nielsen, 2004). This metaphor offered a useful perspective from which the different elements of the current management system could be explored and evaluated, with an emphasis on science–policy interactions. The TACs occupy a central position in the management and advisory system developed in the EU and ICES. First, key management decisions come in the form of a set of legally binding single-stock TACs, which represent the main instrument for controlling fishing mortality (F). Second, scientific advice is based on data collection and produced through assessment methodologies, resulting in a catch forecast that facilitates management decisions in terms of TACs. The allocation of fishing opportunities among countries is based on fixed shares of the TAC, which themselves are based on historical catches; surveillance and control efforts are largely, but not exclusively, focused on enforcement of the TAC.

We summarize and draw on the findings emerging from the PKFM project. First, we address the methodology (quality, selection, and use of assessment models and their products) used by fisheries biologists to produce scientific advice, mainly through

retrospective analyses of the results. Second, we examine institutional influences on fisheries science, focusing on the pressures to expand the range of issues that science can legitimately resolve ("inflation of the science boundary"), and the implications this has for how scientists carry out their work amid high uncertainty. Next, the science–policy interface is discussed from the perspective of why the TAC machine is so difficult to stop. Finally, we consider the public debate around North Sea cod, and whether this has had an influence on decision-making.

Production of scientific advice

The annual scientific advice produced as the TAC machine grinds away is a core element of the management of the cod fishery. We evaluate cod advice through a historical analysis of the work done within the relevant ICES assessment working groups (WG) up to and including 2002 (see Reeves and Pastoors, 2007, for details).

The principal tools used are some form of VPA, coupled with a short-term catch forecast. The VPA is used to reconstruct the stock history and to determine the recent state of the stock in comparison with past trends. The forward projection is used to evaluate the effects of different management options for the next year. Evaluation of the technical basis for scientific advice has focused on these two components of the advisory process. For the VPA part, the evaluation addressed the consistency between annual estimates of F and those obtained from subsequent assessments (historical analysis). This approach has limitations, notably insofar as even the time-series obtained during the most recent assessment is affected by any bias in the annual data over the entire historical period. Nevertheless, any inconsistencies observed will still indicate assessment problems (particularly in relation to the tuning of the VPA), but diagnosing their cause may not be straightforward. The forecast requires assumptions about F , recruitment, and growth of the fish in the stock during the current year. Thus, the forecasts can be evaluated through comparison with equivalent calculations using estimates of recruitment, growth, etc., which become available from subsequent sampling and assessments.

The evaluation indicated a methodological development phase characterized by frequent changes in the tuning models used before 1987, followed by a period of more stability in model choice (1987–1995), during which the VPA performed quite consistently (Reeves and Pastoors, 2007). However, assessments since 1997 have been characterized by substantial bias, mean F in the most recent year being underestimated by some 30% compared with the most recent estimates for the same years, and stock numbers overestimated. Retrospective patterns of this form have been noted in assessment of other stocks (ICES, 1991; Mohn, 1999; Jónsson and Hjörleifsson, 2000) and may arise from changes in catch data, abundance indices, or model assumptions. Although the analysis for North Sea cod indicates that this bias was first manifest in the 1997 assessment, it did not become apparent until the 2000 assessment. The reasons for the bias are not currently understood, but such a pattern could emerge as a result of industry-related factors (e.g. misreporting) or from changes in biological processes (e.g. an increase in natural mortality), or perhaps from a combination of the two. The assessment model introduced after 2002 and currently in use allows for either possibility through estimation of removals that are not accounted for in the landings, such as discards, illegal landings, or losses through increased natural mortality.

Although the VPA part of the assessment performed well during part of the whole period considered, short-term forecasts have always been overly optimistic. This has been caused primarily by overestimating recruitment in the current year and the year ahead, although in some years this has been exacerbated by overestimating weights-at-age, and also by the bias in VPA stock numbers during recent years (Reeves and Pastoors, 2007).

The problems that have arisen cannot be attributed to lack of expertise or time, although workloads have increased (Reeves and Pastoors, 2007). Rather, they may be attributed, at least in part, to the form of advice required. In particular, systematic overestimation of incoming year classes in recent forecasts is linked to a series of below-average year classes, which may in itself be partly the consequence of a reduced spawning stock associated with the high rate of exploitation. Therefore, the assessment/advisory system appears to become less effective when the stock is in greatest trouble. The results also suggest that scientific resources could have been deployed more effectively if there had been more reflection, i.e. more regular monitoring of assessment quality and forecasts to detect and respond to problems as they occurred. Perhaps the WG also had a tendency to address mainly the mathematical aspects of problems, where more biological input might have been useful (Reeves and Pastoors, 2007).

Institutional impacts on fisheries science

The TAC machine has a tremendous impact on the way fisheries science is conducted and on the professional lives of scientists. We observed nine WG and committee sessions related to the production of scientific advice. In addition, 29 formal in-depth interviews with fisheries scientists and close observers of the advisory process were carried out, as well as a random-sample attitude survey of European fisheries scientists, with a total of 465 (51% response rate) valid responses (Wilson and Delaney, 2005; Wilson and Hegland, 2005). Here, we summarize the main results.

Scientists were found to be under systematic pressure to "inflate the natural science boundary", by which we mean various efforts to expand the range of issues that can be resolved legitimately through the methods and investigations available to them. Fisheries scientists are being asked more and more to expand their models to deal explicitly with allocation problems, and to address problems and concepts more directly suited to the social and economic sciences, such as requests for fisheries-based rather than stock-based advice. The scientists are resisting these pressures because they prefer to stick to questions that they are well suited to answer, given their scientific and methodological training. The drivers behind the inflation of the science boundary are the large and real problems faced by managers in trying to identify objective grounds on which to base politically sensitive decisions. Based particularly on our investigation of the communications between the CEC and ICES, the needs of managers might best be characterized as "flexible advice with no room for interpretation". This need is real even if paradoxical. Managers require flexibility to be able to make politically acceptable decisions, but they cannot justify their decisions with scientific advice if that advice can be interpreted in different ways.

These tensions take institutional form, for example, in the situation where the same scientists are employed to provide advice under the separate rubrics of ICES and STECF (Scientific, Technical and Economic Committee for Fisheries of the EU). In one specific case, STECF, in response to a request from the CEC to produce mixed-fishery advice, used data that ICES had

considered to be insufficient as a basis for providing advice. STECF scientists also declined to give mixed-fishery advice, but were prepared to give mixed-species advice. In other words, they were willing to move further in the direction of fulfilling the needs of the CEC, but not to the point of basing their analysis on the partly technical, partly biological, and partly social units distinguished within that fishery.

The TAC machine has negative effects on the scientists involved. Fisheries scientists, on average, scored their job satisfaction well above the mean of our survey's scale. However, assessment scientists, while still scoring above the mean of the scale, scored significantly lower than other scientists. The lower satisfaction is linked to the great demand to travel and to frustrations about their chances to produce peer-reviewed scientific publications. Stock assessment work is seen by many as repetitive and boring, "engineering" more than science. The large uncertainty they have to deal with in making the best possible assessment also spills directly over into their working hours, because they often have no objective way of knowing when their work is completed. Scientists at assessment meetings have been known to work all night to make one more small change that improves their results only marginally or not at all.

Perhaps the most serious observation was a growing belief among scientists that their activities are far from their understanding of what science is. This point may be illustrated by quoting a scientist discussing North Sea cod during a WG: "[instead of] adding another rinky-dink, we should stop pretending we know how many fish there are". In our survey, 16% stated that they sometimes, and 60% that they often or very often, feel like they are being asked to create certainty that is not really there, whereas 14% and 56%, respectively, similarly described their feeling about being asked to answer impossible questions. Many scientists in the advisory system see themselves as being asked to play a difficult role under sometimes trying conditions, then having the results of their efforts changed by the management system into a decision that they no longer see as based on scientific knowledge. The survey data show that experience with assessment work has a significant negative impact on job satisfaction.

Uncertainty is compounded because data gathering is unevenly distributed, often politically charged. The problem begins with incidents of poor cooperation with the fishing industry. Some scientists are concerned that if they pushed this issue, they would get even less support. The problem exists at the level of member states as well. Data on discards and bycatch are both particularly sensitive, and some member states are not prepared to submit all their information. Fisheries data also raise questions of confidentiality and control. The agreement between CEC and ICES about the use of community fisheries inspection data for scientific use requires ICES to restrict access, and requires that these data be analysed only for assessing catch statistics that are restricted in terms of geographical resolution, and without any reference to individual member states.

Scotland, in particular, has been a place of contention about discard information. It was the first country to establish an observer programme to gather such data. Once made available, these data drew attention from both the EU and local conservation NGOs, resulting in increased pressure on the industry to reduce discarding. This led to a feeling among Scottish fishers that the data they were helping to provide were being used against them in a way that penalized them more than fishers from other countries who had not made information available. A scientist

working directly with the Scottish observer programme reported that, at that time, it was becoming more difficult to solicit cooperation from the industry. The most extreme expression of industry refusal to cooperate with data collection has taken place in Northern Ireland, where fisheries officers were kept from sampling landings through threats of violence. A scientist reported that this attitude affected Irish Sea stock assessments.

In response to all these experiences, fisheries scientists throughout the advisory system are calling for increased dialogue between science and management. They recognize that they are not the only experts in the process, and that given the uncertainty about many processes operating in the marine environment, no single form of expertise can produce the right, or even adequate, answers. A growing group feels that advice needs to be produced in a much more interactive manner with managers and other stakeholders. They also seek institutional expression of their criticisms of the current system, which is difficult for ICES to provide, given its official advisory role. To address professional problems and advocate alternative policies, fisheries scientists in Europe need an institutional forum separated from the advisory system within ICES.

The mainstream view of the role of science in the provision of advice, a view that has been articulated by the CEC in official documents and by many other actors in the process, is that science is to be a neutral provider of objective advice to guide the overall political process of fisheries management. This, however, is a utopian view, because fisheries science is not separate from the politics involved, but sits at the centre of the process while trying to deal with great uncertainty. Therefore, the view of the role of science needs to be adjusted. If the exclusive role of scientists is to offer up to this political process the "objective reality" for all to see and to make decisions about, then fisheries scientists will continue to be forced to create something in which they do not believe.

The science-policy interface

The poor performance of North Sea cod management is an indication of systemic weaknesses in the management system as such, and in the policy subsystem in particular. We came to this conclusion after conducting and analysing 30 interviews with key participants and observers in the management processes of North Sea cod from EU Member States and Norway, and detailed examinations of relevant policy documents (see Wilson and Delaney, 2005, for details).

The TAC machine has been constructed to solve political problems, particularly in relation to the principle of relative stability (Holden, 1994). The TAC is a consequence of the strong commitment within the EU to allocate resources among member states. Relative stability is operationalized as fixed percentage shares of the TAC for single species. Although relative stability can be translated, in principle, into other regulatory mechanisms (e.g. effort control), such transformations are bound to be contestable because of their inherent complexity, for example in the context of mixed-fisheries issues. The TAC machine constitutes an instrument to control the effects of all fisheries combined on individual stocks, and also to provide suitable measures for political negotiation, especially for achieving compromises on resource allocation. These factors have contributed to the apparent institutional success of the TAC machine (Holm and Nielsen, 2004).

Despite its institutional success, the capacity of the TAC system to adapt to an unpredictable but continuously changing ecosystem within which the fisheries operate is extremely limited. The situation would have been less severe if the recipients of the advice had been

able to respond to the warning signals embedded in the advice, particularly to frequently repeated reminders that the agreed TAC was failing to control fishing mortality sufficiently. Within the mixed-fisheries context, the reliance on catch forecasts as the diagnostic tool and on single-stock TAC as the intervention instrument has obvious and foreseeable weaknesses. The combination of these weaknesses with large overcapacity of fleets and inadequate monitoring, control, and surveillance creates a system prone to failure.

A related second-order weakness is the system's limited capacity to learn from, and to respond adequately to, first-order failures. When put under pressure, for instance by a resource crisis, the effectiveness of the TAC machine in controlling exploitation deteriorates further. Scientists and policy-makers often misinterpret each other's roles and develop mutually contradictory expectations about their actions. The system as a whole contains remarkably few evaluation procedures that can identify and respond to the problems described above. In the most general and non-technical meaning of the term, the TAC machine works fundamentally in a non-precautionary manner in the case of North Sea cod. Although it might work well when the stock is healthy and fishing pressure is low, it breaks down when needed most: when fishing pressure is heavy and the stock is threatened.

Although the record of the TAC machine in sustaining utilization of marine resources has been particularly poor for demersal species, the system has been impervious to attempts at major reform and continues to dominate the CFP in the face of massive criticism. Its resistance to criticism and attempted reform is explored as a case of path dependence in Holm and Nielsen (2004). Interdependence between elements generating resistance towards attempts to reorganize a system can be conceptualized as a "lock in" mechanism (David, 1985).

EU fisheries management is a complex interlocking system in which the reform of some subsystems, without parallel reforms in others, will prove difficult, especially if they are incompatible with the principle of relative stability. Unfortunately, as most potentially effective reform plans—such as effort management, long-term management, mixed-fisheries management, regional management, and ecosystem management—may appear to challenge relative stability, the adaptive capabilities of the CFP seem to be severely restricted. Instead, the system, when put under pressure, tends to focus most on minimizing short-term losses and maintaining agreed quota shares.

Public debate on North Sea cod

Of course, the critical situation of North Sea cod has found its way into the news media, where many stakeholders—fishers, management representatives, biologists, and the general public—have argued about causes and effects, but have struggled to find a solution. Three studies were conducted as part of the PKFM project, and the main results are recapitulated here. In a first study, as yet unpublished, an analysis was made of "buck-passing" in the Danish public media among the parties involved. A second study, also unpublished, mapped the topics of the national debates in five different countries. Finally, Delaney *et al.* (2007) investigated the impact of public debate within the EU and Norway on decision-making. All three studies were based on qualitative analyses of written documents (e.g. newsletters, web-discussion fora, minutes from meetings from 2001 to 2004) and on interviews with key informants.

In exploring the complex relations between knowledge and politics in Denmark, the Danish study argued the importance of

three factors: (i) knowledge regarding fisheries has to be understood as politicized and positioned; (ii) in democratic societies, the idea exists of a separation between knowledge and opinion, leaving a close linkage between "being right" and "having a right"; (iii) the combination of (i) and (ii) leads to repeated conflicts between fishers and authorities, because everyone believes him/herself to be right. These three claims were based on an analysis of "buck-passing" in the media, i.e. an analytical category for the action of blaming somebody else for the situation (Herzfeld, 1993). Buck-passing is one of the mechanisms for maintaining oneself, because it compensates for the mismatch between the ideals of a democratic and egalitarian community and the reality of wrongdoing that unavoidably takes place where humans manage humans. This mechanism cannot be seen solely as passing on the blame; buck-passing also has to be seen as explanation. From this perspective, debaters view the situation differently, both in terms of defining the situation and of finding proper solutions to deal with it. When seen as rejected explanations, repetitive buck-passing would indicate a more general reluctance among the parties involved to recognize the other party's arguments as valid. The cod has been taken hostage, so to speak, in a political setting, authorities and fishers agreeing that the cod stock has declined, but not on the causes of the decline or appropriate measures to address the situation.

Presumably, everyone in the public debate does his/her job. Politicians make the best possible decisions, seen from their perspective, to ensure that fisheries are sustainable, by balancing socio-economic factors against biological conditions. Fisheries scientists provide the best possible stock assessments and advice under the given conditions. EU sceptics use the depleted cod stock to illustrate their concerns about the CFP. Local politicians hold up to the fishers the prospect of looking after their interests in parliament. The political opposition ensures that the government stays awake. Fishers communicate their disagreement on fisheries issues, both as citizens and as knowledgeable experts with defined interests at stake. All participants deal with the cod case according to their position in the debate. In other words, everybody believes him/herself to be right. Hence, the conflicts between fishers and authorities are reproduced over time, because giving in regarding an explanation also means giving up the right to decide how the problem can be resolved best.

In a second study, as yet unpublished, a comparative analysis was made across Europe, including UK, the Netherlands, Denmark, Norway, and France, of the articulation of knowledge in the public debate on the North Sea cod situation. The analysis was conducted as a mapping of the debate based on three categories of perception: of nature, science, and the management system. The mapping showed the differences and similarities among countries. The intensity of the debate varied: it is most vociferous in countries where cod is important to the industry, such as Denmark and Scotland, and less so in other countries. Few indications of an active debate across national borders were found. The influence on policy is channelled mainly through national channels running from the member states to their representatives in the Council of Ministers.

Differences also seem to be related to the culture of acceptance or contestation of natural-science knowledge in the policy-making process beyond the specific context of fisheries management. In general, our analysis revealed that fishers often see cod in a broader context, whereas politicians rely heavily on the biologists and their single-stock approach. At the core of the public debate

is the question of "fishing vs. other factors" as being responsible for the stock decline. Only considering fisheries impact, they claim, is incomplete or unbalanced: too much emphasis is put on fishing and too little or none on other ecological processes, such as rising temperature, water quality issues, and habitat destruction. This lack of minimum consensus adds to the mistrust of scientific advice. Fishers assert that considering their experience-based knowledge of fish, the fishery, and the ecosystem would improve the knowledge base of the management process. Uncertainty (i.e. the perception that stock assessment is not an exact science) is also another important focus of the debate. Fishers frequently contest the results of assessments, the data, and the models used, and are critical of scientific surveys. Scientists respond by explaining their methods, what is known, and what is assumed, often in rather technical terms. The lack of a common language increases the communication gap between scientists and the "fishing" public.

Delaney *et al.* (2007) examined whether the public debate on North Sea cod has had any influence on decision-making and policy. They conclude that the main purpose of the discourse was to voice dissatisfaction and, thus, to bring about changes in the way the stock is managed. No evidence was found that the public debate had a direct impact on management decisions in terms of setting TAC, but it is argued that the convergence of themes discussed and those considered within developments in the advisory framework point in the direction of an indirect influence. Therefore, the debate may well have affected the decision-making agenda.

Conclusions

Fisheries science is not independent of fisheries management; instead, it is a cog in the TAC machine. Fisheries management is a political system with technical components operating within political constraints. Technical success is not the main criterion for institutional success, at least not before strong political pressures are generated by technical failures. This seems to be the lesson from cod management, first from North America (Sinclair *et al.*, 1999) and now from the North Sea. The situation within the CFP involves particularly severe constraints because of the strong and systemic focus on maintaining relative stability among member states.

The design of a management system directly affects the way science is done. Quota systems are relatively data-intensive and demand the production of precise and accurate estimates rather than alternative approaches, although they also contain incentives for high-grading and misreporting. This makes stock assessment particularly sensitive to bias caused by unreliable landings data. However, other management systems have their own implications and may cause different problems for science.

A striking feature of the TAC machine as it operates for North Sea cod is how poorly it has adapted to new insights. Estimates of the condition of the stock have been consistently overly optimistic in recent years. Non-compliance with quota regulations leads to deterioration in the quality of data required to produce subsequent TAC advice. Therefore, the system performs least well when most urgently needed, i.e. when a stock is depleted. Nevertheless, the cranks have to be turned, year after year.

North Sea cod has assumed centre stage in a political debate. All players in the field agree that the stock has declined, but not on the causes of the decline, the severity of the situation, and on proper remedial actions. The debate is an example of the complex relationship between scientific knowledge, fishers' experience,

and politics, and between concerned citizens and stakeholders, uncertainty playing a leading role. However, the debate does not seem to resolve major issues or to have measurable effects on the decision-making process. The advisory/management framework is undergoing a slow process of change in the direction of more stakeholder participation that may well reflect an indirect response to the recent public debate, which seemed to focus on North Sea cod.

The attempts by managers to use science as a legitimate device for the institutionally strong but technically flawed TAC system result in demoralized scientists who do not believe in what they are doing, in undue demands for flexible advice with no room for interpretation, and in continuous inflation of the science boundary. The Memorandum of Understanding between the CEC and ICES, and the dual role of scientists within the ICES advisory system and STECF, may make it more difficult for scientists to express their professional views and needs. Although scientific journals remain a suitable outlet, a forum that is separate from the advisory system where they can speak out publicly and loudly might resolve part of the problem.

Clearly, a new role has to be developed for science in the fisheries system. People in all major stakeholder groups call for a more interactive system of producing a common knowledge base to address uncertainty. An interactive system could bring uncertainty, from its current marginal position at the loose ends of the "certainty" represented by overly precise catch-option tables to the heart of the science process. Such a system would demand that stakeholders help address uncertainty and negotiate a more realistic placement of the burden of proof. Models exist for such an approach; eco-labelling (and accreditation) schemes such as the Marine Stewardship Council (MSC, 2006), for example, often develop systems of accountability about whether and how an industry can earn the right to be labelled as sustainable. In such a model, concerned citizens also have a role to play in interpreting the science and making its relevance clear to the public and the consumers. Such systems would be better balanced, with concerned citizens rather than direct stakeholders having a meaningful and influential task to fulfil. Scientists are transparency experts: they know what it means to explain how they know what they know. Scientists can, and often do, help facilitate interactions among stakeholders in trying to build an accurate common picture of the marine environment. Given the inherent uncertainty of the marine world and its far-reaching consequences for an ecosystem-based approach to fisheries management, such a role may be more rewarding than playing the role of "experts" who tell managers how large next year's TAC should be. The first step, however, is to demand a system that places as much emphasis on uncertainty and sustainability as it does on allocation rules.

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