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Deliverable 2.3 Review of literature about participatory modelling in fisheries management with a focus on the Invest in Fish South West project and the PRONE project

Judgement and Knowledge in Fisheries Involving Stakeholders

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Introduction

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One of the main challenges for the twenty-first century becomes how to link science with our quest for competent and fair governance processes. One of the main objectives of the JAKFISH project is to investigate the potential of *participatory modelling techniques* as a flexible and innovative tool for meeting this challenge by marrying modelling – as a way in which scientific analysis enters the process of decision-support – with stakeholder involvement. The basic idea of 'participatory modelling' is to open up to non-scientists what has conventionally been the exclusive domain of expert modellers (i.e. people with training and experience in the analysis and formal representation of systems) and considered a scientific-technical input into the policy and management process: modelling in general (model building, evaluation, and use) and the construction of models in particular.

In several areas of natural resource governance including fisheries the trend in the past one and a half decades has been to base management decisions to a greater extent on modelling exercises and to aim to develop more complex and sophisticated models for more integrated problem assessments and a broader knowledge basis for decision-making. In the existing literature on natural resource governance and in governance practice as well, there is a general demand for increased public involvement but the specific question of what could be ways to effectively and legitimately combine modelling with public participation is addressed only peripherally. One main argument of the JAKFISH project is, however, that this question deserves increased attention and discussion in view of the increasing importance of models as tools in science informing policies for fisheries management and their alleged potential for contributing to knowledge integration and communication, social learning and consensus building. JAKFISH refers to participatory modelling as the "process whereby scientists and stakeholders *jointly develop* flexible and transparent models" (see JAKFISH self-portrayal poster; emphasis added). It expects this collaboration to have potential to enhance "a common understanding of the current biological, fishery and management issues, of their potential risks for the stock and the fisheries (including socio-economic aspects), and of the way to apprehend them within the current management frame" (Rescan & Clausen 2009). This expectation corresponds to the argumentation in the pertinent literature that participatory modelling can facilitate creating a shared vision of complex environmental or natural resource problems among scientific experts, policy-makers and stakeholders, that it can solicit input from a wide diversity of stakeholders, and that it can help to maintain substantive and structured dialogue between members of these groups (e.g., Costanza and Ruth 1998, p. 185; van den Belt, 2004; Antunes, Santos & Videira 2006; cp. also van Asselt & Rijkens-Klomp 2002, p. 172, for a brief portrayal of participatory modelling as a method of participation).

The main way in which the JAKFISH project seeks to contribute to investigating this potential is by carrying out a set of case studies in which the involvement of stakeholders in the modelling process is explored. That is, the project uses participatory modelling techniques as a method in applied research into participatory fisheries governance. The four case studies[1] do only partly follow a common approach; the respective modelling exercise is opened up to stakeholders in varied ways. This flexible approach has been chosen because relatively little is still known about what might constitute best practice in participatory modelling methods for natural resource governance. The objective of the JAKFISH project

[1] Participatory modelling is being explored in four case studies: North Sea Nephrops fisheries; Herring in Skagerrak, Kattegat and the Western Baltic; Herring in the Baltic Sea; Swordfish in the Medterranean.

is to learn about the variety of possible *options* to involve stakeholders in model-related activities and about *basic requirements* (procedural, structural) to exploit the assumed potential of such participatory practice. The purpose of this Deliverable (D2.3) is to present related insights that the authors have drawn from a review of recent studies that address stakeholder involvement in modelling activities as a promising approach for moving towards strengthened participation in fisheries governance.

The paper is structured into two parts. The *first* part is a brief *overview* of the main results of the literature review. It describes the relevance of participatory modelling as an approach to stakeholder involvement in fisheries governance, sets out some forms of ‘participatory modelling’ (understood in a broad sense) presented in the body of literature reviewed, and highlights those issues that these studies identify as central in regard to further developing and effectively using this participatory method. The *second* part of the Deliverable will focus on *two particular projects* concerned with involving stakeholders in modelling activities in research into fisheries sustainability. There is first, the ‘Invest in Fish South West’ (IiFSW) project, a stakeholder-driven project which was funded by a group of organisations and institutions with a direct stake or interest in England’s South West fisheries. The second project is the EC-funded research project ‘Precautionary risk methodology in fisheries’ (in short: PRONE). The more detailed analysis of these projects will highlight the rationale of the exercises in including stakeholders in modelling activities, the way in which the involvement processes were designed, the results achieved, and insights gained from the analysis of these processes in relation to opportunities and pitfalls of using ‘participatory modelling’ in fisheries governance.

Part 1: Overview of main results of the literature review

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1. Potential and prospects of using ‘participatory modelling’ within fisheries

Stakeholder participation in the construction and use of models applied for the generation of fisheries management advice is a relatively new approach in Europe. It is foremost an object of research, not an approved method. The opaqueness of the knowledge base within the EU fisheries management system to industry and other stakeholders and the black box that the generation of this base means to these actors has been identified as one of the main reasons of the failure of the European Communities Common Fisheries Policy to provide either biological or economic sustainability (cp. Moto & Wilson 2006). Participatory modelling techniques are increasingly discussed as one possible way forward in developing *transparent* procedures for generating and using knowledge in fisheries which incorporate stakeholders’ knowledge and promote a shared understanding of the nature of the resource problem and appropriate management strategies. Various ways in which stakeholders can contribute their knowledge to the modelling process are identified including provision of data, assistance in designing the structure of the model(s), review of choices, assumptions and priorities underlying the model construction, and developing scenarios (Wilson & Pascoe 2006, p. 350). Creation of transparency about the building and use of models and incorporation of stakeholder knowledge into the models are widely understood as basic prerequisites for strengthening the legitimacy of the advice and management system, and eventually, increasing compliance with regulations. This, in turn, the assumption goes, can improve the quality of the information base for knowledge production, e.g. by reduction of the high level of misreporting in the mixed fisheries throughout Europe (cp. Moto & Wilson 2006, p. 425; see also Wilson & Pascoe 2006).

This positive perspective on the participatory modelling approach has been nurtured by recent research on innovative fisheries management systems. Focus group research carried out within the EFIMAS project[2] has shown that stakeholders in the fisheries field view increased accessibility of the overall modelling process as a way to *improve the legitimacy* of modelling results among stakeholders and the wider public (Degnbol et al. 2007, 6). Computer modelling has long been the central analytical method used for producing the scientific advice informing the Common Fisheries Policy. On the side of many stakeholders, however, there has been considerable scepticism towards the validity of the models used, specifically of individual fish stock assessments based on Virtual Population Analysis models (Ibid.). The focus group participants regarded greater access to the modelling process as one way to meet this challenge. Greater access would allow stakeholders to judge the validity of the model themselves and engage in the debate about their usefulness and continued development. Specific suggestions on how to ensure accessibility apparently did not explicitly include direct involvement into the construction and use of models[3]. However, the focus group participants were generally positive towards new approaches of fisheries science to open up for dialogue, for example at the modelling steps of data collection, formulation of basic assumptions, choice of variables, and evaluation of model outcomes (Degnbol 2007, p. 6).

2. On the variety of possible forms of linking modelling with stakeholder involvement

As indicated already above, only few exercises of stakeholder involvement in modelling activities have been carried out in fisheries management up to now. In this section we provide an overview of some of these exercises and highlight how they differ with respect to the main objectives pursued, the modelling approach chosen, the way in which stakeholders shared in the modelling process, and the link (proximity or distance) of the participatory modelling exercise to the policy or management process.

We do not claim to give a comprehensive overview of initiatives that could be referred to as ‘participatory modelling’. Instead, we focus on a set of exercises that can illustrate the various forms that such an approach to stakeholder involvement may take. It is important to note here, that there is no common agreement in the body of literature dealing with stakeholder involvement in modelling-related activities on how to define ‘participatory modelling’. There is also not one best method identified to conduct such an exercise. Rather, participatory modelling appears as a flexible method with several techniques available to guide the process including, for instance, conceptual modelling (such as mental modelling) and formal (computer-based) modelling. Often the term is used specifically to refer to the active involvement of model users or stakeholders in the modelling process *itself*, i.e. in model *construction*. In a broader perspective which views the overall modelling process as

[2] EFIMAS is short for “Evaluating scientific advice and decision-making processes in fisheries management systems” and an EU project funded under the 6th Framework Programme; see http://ec.europa.eu/research/fp6/ssp/efimas_en.htm (EFIMAS 2008). The focus group research was targeted at the commercial fish harvesting sector, the onshore fish processing sector, women in fisheries, marine conservation groups, and local-level government fisheries managers (Degnbol et al. 2007).

[3] The EFIMAS focus group report mentions these specific suggestions: “not making the models more complex than necessary, being transparent about the research process, basic assumptions, variable etc., and mediating this in ways that are intelligible to outsiders and relate to everyday life” (Degnbol et al. 2007, p. 6).

composed of model construction and model *use* (Bots & van Daalen 2008), or as comprising a third basic modelling stage, namely model *evaluation* (Dreyer & Renn 2009), ’participatory modelling’ may also refer to the *indirect* involvement of model users or stakeholders in the modelling process. Ways of indirect involvement include inviting stakeholders to: review the model’s design in a process which would correspond to what has been called an extended peer review, denoting a process whereby the quality of the knowledge inputs to policy issues are assessed (Functowicz & Ravetz 1990; van der Sluijs 2002); provide inputs for model use in form of scenarios or policy/management options (co-)developed by the stakeholders themselves, or in form of knowledge to test the causal logic of these inputs; share in decision-making on management or policy measures being informed by the results and interpretations of the model runs. The basic modelling stages and their sub-components to which stakeholders can make a contribution are summarised in *table 1* below. The distinctions proposed in this table are a result of a literature review of participatory modelling in river basin management and water resources management (cp. JAKFISH Deliverable 2.4).

Direct Involvement	Indirect Involvement	
Model construction	**Model evaluation**	**Model use**
Provide inputs (data, conceptual considerations) for model construction	Review choices, assumptions and priorities underlying model construction (extended peer review) either only after the model has been built, or at each sub-step of the main modelling process	Provide inputs for model use (scenarios and/or policies)
Make decisions on model design		Interpret outputs from simulation runs
		Co-decide on policy/ management measures

Table 1: Forms of stakeholder involvement in modelling
(drawing on and extending the distinctions proposed by Bots & van Daalen 2008[4])

3. Selected cases: Different types, purposes and political roles of participatory modelling

In the cases that formed part of our literature review various modelling approaches have been used as the basis or instrument of stakeholder involvement (cp. Hegland & Wilson 2009). These include:

[4] A useful differentiation of modelling stages and sub-activities to which stakeholders can make a contribution is proposed by Bots & van Daalen (2008). The authors limit themselves to the basic distinction between model construction and model use (p. 397) to which we have added a third distinction which is model *evaluation*. Inspired by Gottschick (2005), they distinguish between five modelling sub-activities (inform model construction; make modelling decisions; provide inputs for model use; use computer model; act in gaming simulation; Ibid.) which have basically informed the distinction of sub-activities that we propose in table 1.

- *mental modelling* which was used in the PRONE project (2006-2008) for identifying the diversity of stakeholder perceptions of risks related to the fisheries sector; stakeholder representatives constructed individual mental models and were given the opportunity to revise these models in view of 'comprehensive' mental models that the project researchers had developed for each of the stakeholder groups from the results of a pilot survey (see case study by Drakeford & Borodzicz as part of this Deliverable);
- simple *stock assessment models* which were used jointly by members of the Pelagic Regional Advisory Council (in short: Pelagic RAC) and invited scientists for developing a long-term management plan for Western horse mackerel; the process took place in the Pelagic RAC in 2006 and 2007 (Hegland & Wilson 2009);
- *bio-economic fisheries models* for the evaluation of different management options which were co-designed and used by stakeholders in the stakeholder-driven project Invest in Fish South West (2003-2007; see the IiFSW-case study by Dreyer & Renn as part of this Deliverable); in the EU-funded research project EFIMAS (2004-2008) stakeholders provided input to the use of bio-economic fisheries models (through scenario development) (EFIMAS 2008; cp. fn 2);
- and *Bayesian networks (BNs)* which are used in the (ongoing) JAKFISH project itself as a basis for participatory modelling of Baltic Main Basin herring (Haapasaari et al. 2009)[5].

The PRONE, EFIMAS and JAKFISH projects have used (resp. use) participatory modelling techniques foremost as a ***method in applied research*** into participatory fisheries governance. In the PRONE project, representatives of eight groups of stakeholders were directly involved in the *construction* of individual mental models, i.e. conceptual models. They also shared in model *use* when the project researchers presented to them the group mental models that the researchers had developed for the eight stakeholder groups. This exercise served to increase awareness and understanding of other stakeholder viewpoints. The rationale for using the mental modelling approach in this project was that it may facilitate communication about risk between the various stakeholders in each of the case study countries. Involving stakeholders in modelling in the PRONE project served mainly as a *method of research* into stakeholder risk perception and besides this as a method of research into the potential of mental maps for facilitating mutual exchange among stakeholders about group-specific viewpoints on risk in the fisheries sector (see the PRONE case study by Drakeford & Borodzicz in Part 2).

In the EFIMAS and JAKFISH projects, the main purpose of involving stakeholders in modelling activities has been (respectively is) to examine and contribute to developing 'participatory modelling' tools for use in fisheries governance. The use of such tools within the projects has served (resp. serves) to *advance scientific understanding* about whether and how the involvement of stakeholders in modelling can prove useful in benefitting the knowledge base of fishery and enhancing understanding and consensus within fishery management. More specifically, it shall provide information about what are important practical and procedural issues which require consideration when designing and performing participatory modelling activities.

[5] We included this case study in the review – although ongoing and being part of the JAKFISH project – because the major part of the participatory modelling exercise has already been completed and has been presented and discussed at the October 2009 meeting of ICES Working Group on Fishery Systems (Haapasaari 2009).

In the (still ongoing) JAKFISH Baltic herring case study, the Bayesian networks approach is being used as the basis of 'participatory modelling'. Within this approach, stakeholders are viewed as experts and the objective is to include all of the expert views in the model-building process (cp. Mäntyniemi et al. 2009). Like in the PRONE project, the individual stakeholders (six stakeholders from four Baltic Sea countries were engaged) have taken all the modelling decisions (i.e. were directly involved in model *construction*), and a modelling expert, acting also as process facilitator, has built the models according to these decisions. That way, six different biological system models of Baltic Main Basin herring representing the views of the six stakeholders have been constructed. In accordance with the Bayesian approach these six stock assessment models are understood as alternative hypotheses about what constitutes an appropriate model structure. Information about how the stakeholders evaluate the modelling exercise has been elicited through questionnaires. A preliminary analysis has shown that there are indicators that communication of the alternative models to the stakeholders involved in the modelling exercise can increase awareness and understanding of other stakeholders' viewpoints (Haapasaari 2009). The next steps will be to compare the individual models, build a meta-model using the Bayesian networks approach, update the meta-model according to stakeholders' feedback to it, and consider what kind of management actions the revised model would suggest (Haapasaari et al. 2009).

The EFIMAS project has defined participatory modelling for its research purposes as an approach that "uses scenario-based models to evaluate different options" (EFIMAS 2008). In this project, stakeholders were involved in the *use* of models developed for simulation and evaluation of alternative management scenarios as an aid to decision-making. Industry and conservation groups shared in the selection of management options, mainly through contributions to scenario development, e.g. through specific "stakeholder scenarios" of effort allocation (Ibid.). Model development and use was based on FLR, a common modelling framework for evaluating management strategies. The EFIMAS project has identified this framework as a key tool for participatory modelling. It would facilitate collaboration across disciplines and detail how to implement a variety of fishery, biological and economic models and software in a common framework so that alternative management strategies and procedures can be evaluated for their robustness to uncertainty before implementation (Ibid.). A key characteristic of the management strategy evaluation (MSE) approach in a participatory context is that it confronts the stakeholders with *choices* to explore rather than 'optimal' solutions in the form of unitary policy advice highlighting a single or very small sub-set of possible courses of action (for instance a recommend catch level or technical measure; Motos & Wilson 2006, p. 426). What constitutes the 'best' way forward is made a subject of deliberation. This deliberation is informed by the outcomes of the simulations of alternative management scenarios which allow for the evaluation of trade-offs between the performance of different strategies relative to the pre-agreed management objectives (Ibid.[6]; see also Mapstone et al. 2008[7]).

[6] Management strategy evaluation frameworks are relatively new tools to manage fisheries in Europe. They are likely to gain increasingly in importance because the current European Union's Common Fisheries Policy recommends that multi-annual recovery plans should be applied for depleted fish stocks. Use of such plans requires the explicit choice of definite harvest control rules designed to reach pre-agreed management objectives (Motos & Wilson 2006, p. 427; cp. the Pelagic RAC case). Moreover, the comparison of the simulation outcomes shall allow for testing the robustness of the fisheries system to the various sources of uncertainty. In the view of fisheries management analysts this makes the use of these frameworks consistent with the precautionary approach to fisheries management (Ibid; cp. also Aranda & Motos 2006; Kell et al. 2006).

[7] The paper by Mapstone et al. (2008) presents the use of MSE for line fishing in the Great Barrier Reef in Australia. In this case stakeholders were involved in model use for development of fisheries management

In contrast to the PRONE, EFIMAS and JAKFISH projects, the co-operation of stakeholders and scientists in modelling activities in the Pelagic RAC and Invest in Fish South West initiatives served foremost the purpose of ***influencing fisheries management and policy***. In the first instance, participatory modelling was aimed at assisting in joint evaluation and selection of management respectively policy options to be recommended to the respective management or policy making bodies for consideration, further development, and implementation. Both initiatives also served the purposes of collective learning. One objective of the IiFSW project was to learn about opportunities and challenges that characterise the fishing situation in the south-west of the UK and about the advantages and challenges of cooperation between stakeholders and scientists in modelling endeavours. One objective of the Pelagic RAC initiative was to explore ways to develop management plans by stakeholder consensus, rather than following the CFP standard procedure of having it developed within the International Council for the Exploration of the Sea (ICES). These objectives were, however, of secondary importance in comparison with the primary objective of influencing policy (this point will be addressed in more detail in the IiFSW case study by Dreyer & Renn in Part 2).

In the IiFSW project, stakeholders were directly involved in the *commissioning, development and use* of a *bio-economic modelling tool*. Stakeholders used this tool for their own negotiations and decision-making on recommendations for policy makers. As in the EFIMAS project, the stakeholders provided their input to a policy option comparison process based on the use of computer intensive modelling techniques. The main *political role* that the IiFSW project has played so far is that of a promoter of a climate of cooperation among key actors in fisheries governance in the south-west of the UK through procedural and structural devices that proved helpful in reaching consensus on a package of policy options for sustainable fisheries. According to the knowledge of the authors of this Deliverable, the policy making bodies did not (yet) formally respond to the recommendations that were addressed to them. Hence, the political role of this project is (at this point in time at least) rather an *indirect* one.

In the Pelagic RAC process, stakeholders were involved in model *building* aimed at evaluating long-term management plans for Western horse mackerel. They agreed to not include recruitment pulse in the model. They were also involved in model *use* for developing the plan. The Pelagic RAC process had a more *direct* political effect in so far as it led to the first step of the implementation of the management plan from 2008 (Hegland & Wilson 2009). The final draft of the management plan was passed on to the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE) with a request to have it submitted to ICES for evaluation. In the autumn of 2007, ICES found it to be in accordance with the precautionary principle, initially for a period of three years (Ibid.). The analysts of the participatory modelling process view it as an illustration of "both the ability of the RAC – under the right circumstances and with the right allies – to shape the CFP agenda as well as the power of a consensus in later decision-making" (Ibid.).

Table 2 below provides a summary of the features of the five cases described above.

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strategies. They collaboratively specified the objectives against which the performance of the management alternatives were assessed as well as the performance indicators used for those assessments.

Features / *Cases*	Modelling approach	Objective of modelling exercise	Main purpose(s) of involving stakeholders in modelling	Modelling activity in which stakeholders were involved	Political role
PRONE	Mental modelling	Identification of the diversity of stakeholder risk perceptions	Advance scientific understanding on diversity of stakeholder risk perspectives and potential of mental models as communication tools	Model development and use	none
Pelagic RAC	Stock assessment modelling	Development of a long-term management plan for Western horse mackerel	Bottom-up fisheries management secondary: collective learning about participatory modelling as a way of bottom-up management plan development	Model development and use	Direct: led to the first step of the EU's 2008 management plan implementation
EFIMAS	Bio-economic modelling, management strategy evaluation	Evaluation of fisheries management options	Advance scientific understanding (on potential of participatory modelling)	Model use	none
Invest in Fish South West	Bio-economic modelling for policy option comparison	Agreement on preferred fisheries management options for the English Channel, Irish Sea and Western Approaches	Influence fisheries policy secondary: collective learning about the fisheries situation in the UK's south west	Model development and use	Indirect: promoted cooperative climate among key stakeholders
JAKFISH (Baltic herring)	Bayesian networks	Incorporation of stakeholders' knowledge into stock assessment	Advance scientific understanding (on potential of participatory modelling)	Model development	none

Table 2: Five cases of involving stakeholders in modelling activities

4. Some insights: Direct benefits and basic challenges of engaging stakeholders in modelling

In the cases that we have presented above, the linkage of modelling and stakeholder involvement occurs in a variety of forms and for different purposes. The different forms include engaging stakeholders in the process of *model development* in which they build conceptual qualitative models or contribute to the construction of formal, computer-based models; and they include involving stakeholders in the processes of *using models* for evaluating and selecting policy or management options. The main purpose of stakeholder involvement in modelling is either to investigate participatory modelling as an emerging approach in Europe or to influence actual fisheries policy or management. A secondary purpose of participatory modelling in all of the presented cases is to initiate or foster processes of collective learning about the nature of the resource problem and possible solutions and about practical and procedural issues of cooperative modelling.

Documentation of these cases has highlighted direct benefits from stakeholder involvement in modelling activities. Increased awareness of other stakeholders' viewpoints has been identified as a direct benefit from making conceptual models (representing the variety of individual or group perspectives and built by stakeholders or from stakeholder input) the subject of communicative exchange between stakeholders (Haapasaari et al. 2000; see also the PRONE case study by Drakeford & Borodzicz in Part 2). Involvement of stakeholders in model use for the evaluation and selection of management options can have the direct benefit that stakeholders are forced to clarify their objectives and explicitly address the trade-offs implied by various management strategies (EFIMAS 2008; see also Hegland & Wilson 2009).

A major challenge that the documentation of the Invest in Fish South West project has identified in relation to involving stakeholders in the development and use of bio-economic models is the *complexity* of these models. Within the IiFSW project, the complexity of the bio-economic modelling tool would have placed an "onerous burden on partners and other stakeholders who may have a steep learning curve to be able to use such tools effectively but also manage their development (IiFSW 2007, p. 74). There is a general trend within fisheries science to build increasingly large, complex computer-based models integrating biological and economic models and software in a common framework for evaluation of alternative management strategies. Such complex models and evaluation frameworks appear to enjoy also widespread support by policy makers. Partly for this reason, the Invest in Fish South West project partners – all key actors in fisheries and fisheries governance – resorted to such highly technical modelling science. The assumption was that this would increase chances that policy makers accept the project's conclusions as legitimate (Ibid.). Experiences gained within this project suggest that more intensive reflection is required about the questions of whether such complex models are suited for the involvement of non-modelling specialists and what procedural and structural devices may facilitate such involvement and decrease the risk of generating or nurturing stakeholders' reluctance to engage in modelling processes (cp. Wilson & Pascoe 2006, p. 344). In regard to the experiences of the IiFSW project it has been proposed, for instance, to consider the potential of science communications for 'translating' the technical matters throughout the modelling processes so that they become comprehensible to non-experts in modelling (Squires 2009).

Another suggestion in the light of the experiences made in this project is that such complex models are not well suited if the purpose (or one of the purposes) of 'participatory modelling' is to initiate or foster a process of 'collective learning' about the nature of the resource problem and appropriate solutions. The IiFSW bio-economic modelling tool served a dual purpose: to legitimise the Steering Group's conclusions *and* support multi-stakeholder discussions and decision making through encouraging common understandings of the problems, opportunities and challenges that characterise the fishing situation in the south-west of the UK. However, the level of complexity of the modelling tool turned out to be not really suited to serve the second purpose. One conclusion drawn from this experience is that a 'simple' model was likely to be a more instrumental tool in creating a supportive learning environment for stakeholders (IiFSW 2007, p. 74). A simpler model might also be beneficial to keeping a high level of commitment and motivation of the stakeholders throughout the overall process of model development and use. This assumption is put forward by Sandker et al. (2008, p. 2) who warn against building and using models so complex that they are disincentives to stakeholder involvement and opt for "simpler models with more engaged participants”. The experiences gained in the IiFSW project suggest at least that the chances of achieving the objectives of a ‘participatory modelling’ exercise are higher if the level of model complexity is *matched* with the purposes of modelling and involving stakeholders in modelling.

Implementation of the management strategy evaluation approach in particular faces the problem that the great complexity of the modelling tools reduces their comprehensibility and accessibility (e.g. Kell et al. 2006; Aranda & Motos 2006; Smith et al. 1999). Even if stakeholders contribute to the model-building process, they might develop only little understanding of the way in which the various types of data drive the assessment outcomes. Hence, the modelling procedure might remain a black-box problem *despite* stakeholders sharing in the tasks of model development and use (Aranda & Motos 2006, p. 414; de Oliveira & Butterworth 2004; Hilborn 2003). The very potential of these tools to model at a very detailed level can drive the building of ever more complex models when those involved in model building have different views on what constitutes an appropriate level of detail in modelling. One challenge that the EFIMAS project faced was finding a level of detail that seemed to fit everyone’s needs and that still allowed interpretation and communication of the modelling results in a management context (EFIMAS 2008).

The experiences of the Pelagic RAC initiative suggests that the *composition* of the group of stakeholders involved in the modelling exercise is highly related to the chances to reach a consensual agreement on specific management measures. The analysts of this process have identified as important factors for the success that this ‘participatory modelling’ exercise constituted in the view of the participants: the high degree of homogeneity of the Pelagic Regional Advisory Council as a whole (in comparison to the other RACs) and of the group of stakeholders that was active in relation to the management plan for horse mackerel in particular. Conservation groups did not take part in the management plan development process and the active group was composed of stakeholders of the catch sector with most of them representing large-scale fishing enterprises (Hegland & Wilson 2009).

A major challenge that the IiFSW project faced in relation to stakeholders sharing in the tasks of model development were methodological difficulties with regard to integrating resource users’ practical and experiential non-scientific knowledge into the model (Squires 2009). The literature about knowledge production in fisheries management has identified this technical barrier as one of the main challenges in using models developed for simulation and evaluation of alternative management options in a participatory setting (Aranda & Motos 2006; Baelde 2003; Smith et al. 1999). The need to find “more creative ways of embracing alternative hypotheses and data, including fishermen’s perceptions and experience” (Smith et al. 1999, p. 976), that was pointed out already 10 years ago, clearly deserves to be a subject of future research on the potential and pitfalls of ‘participatory modelling’.

References

Antunes, P., Santos, R., Videira, N. (2006). Participatory decision making for sustainable development – the use of mediated modelling techniques. *Land Use Policy*, 23, 44-52.

Aranda, M., Motos, L. (2006). Management Strategy Evaluation (MSE) and Management Procedure (MP) implementations in practice: A review of constraints, roles and solutions. In: L. Motos, D.C. Wilson (eds.), *The Knowledge Base for Fisheries Management* (Vol. 36 of Developments in Aquaculture and Fisheries Science), Amsterdam et al.: Elsevier, pp. 409-421.

Baelde, P. (2003). Using fishers' knowledge goes beyond filling gaps in scientific knowledge-analysis of the Australian experience. In: *Putting fisher's knowledge to work*. Conference Proceedings, 78-86.

Bots, P.W.G., van Daalen, C.E. (2008). Participatory model construction and model use in natural resource management: A framework for reflection. *Systemic Practice and Action Research*, 21, 389-407.

Costanza, R., Ruth, M. (1998). Using dynamic modeling to scope environmental problems and build consensus. *Environmental Management*, 22 (2), 183-185.

Degnbol, D., Eustace, B. , Frangoudes, K., Hatchard, J., Hegland, T.J., Pitchon, A., Jacobsen, R.B., Stead, S.M., Wilson, D.C. (2007). *Stakeholder perspectives on fisheries science and modelling. Focus group discussions in Spain, Greece, UK, Denmark and Ireland*. Research report of the EFIMAS project (Operational evaluation tools for fisheries management options), funded under the 6th Framework Programme.

Dreyer, M., Renn, O. (September 2009). Findings from water resources and river basin management. In: Drakeford, B., Borodzicz, E., Dreyer, M., Renn, O., Review of literature about participatory modelling in natural resource governance: Findings from forestry management (Part 1) and water resources/river basin management (Part 2). *Deliverable 2.4 of EU project JAKFISH* (contract no. 212969). Stuttgart: DIALOGIK.

EFIMAS (2008). Operational Evaluation Tools for Fisheries Management Options. EFIMAS. *Policy Brief* (September 2008). Project funded under the 6th EC Framework Programme, project no.: SSP8-CT-2003-502516. Available for download at www.efimas.org.

Funtowicz, S.O., Ravetz, J.R. (1990). *Uncertainty and Quality in Science for Policy*. Dordrecht: Kluwer Academic Press.

Gottschick, M. (2005). Participatory material flow analysis for production chains. *Abstracts 3rd international conference of the international society for industrial ecology*, Stockholm, pp. 230-232.

Hegland, T.J. (2009). The Common Fisheries Policy and Competing Perspectives on Integration. *Publication Series Department of Development and Planning*, No. 2009-6. Aalborg: Aalborg University; accessed on 13 November 2009 at: http://www.ifm.dk/reports/194.pdf.

Haapasaari, P. (2009). *Participatory modelling to enhance understanding and consensus within fishery management*. Presentation at the Meeting of the ICES Working Group on Fisheries Systems, October 2009, Copenhagen.

Haapasaari, P., Mäntyniemi, S., Kuikka, S. (2009). Participatory modelling to enhance understanding and consensus within fisheries management: The Baltic herring case. *ICES Working Group on Fishery Systems Report* 2009.

Hegland, T.J., Wilson, D.C. (2009). Participatory modelling in EU fisheries management: Western Horse Mackarel and the Pelagic RAC. *Journal of Maritime Studies*, 8 (1), 75-96.

Hilborn, R. (2003). The state of the art in stock assessment: Where we are and where we are going. *Scientia Marina*, 67 (1), 15-20.

Investinfish South West. *Setting a Course for Sustainable Fisheries in South-West England*. June 2007.

Kell, L.T., de Oliveira, J.A.A., Punt, A.E., McAllister, M.K., Kuikka, S. (2006). Operational Management Procedures: An introduction to the use of evaluation frameworks. In: L. Motos, D.C. Wilson (eds.), *The Knowledge Base for Fisheries Management* (Vol. 36 of Developments in Aquaculture and Fisheries Science), Amsterdam et al.: Elsevier, pp. 379-407.

MacGarvin, M., Jones, S. (2000). *Choose or Lose: A recovery plan for fish stocks and the UK fishing industry*. WWF-UK report, December 2000.

Mäntyniemi, S., Haapasaari, P., Kuikka, S. (2009). Incorporating stakeholders’ knowledge to stock assessment: how? *ICES CM* 2009/O:12.

Mapstone, B.D., Little, L.R., Punt, A.E., Davies, C.R., Smith, A.D.M., Pantus, F., McDonald, A.D., Williams, A.J., Jones, A. (2008). Management strategy evaluation for line fishing in the Great Barrier Reef: Balancing conservation and multi-fishery objectives. *Fisheries Research*, 94, 315-329.

Motos, L., Wilson, D.C. (2006). The role of science within modern management processes with the development of model-based evaluation tools. In: L. Motos, D.C. Wilson (eds.), *The Knowledge Base for Fisheries Management* (Vol. 36 of Developments in Aquaculture and Fisheries Science), Amsterdam et al.: Elsevier, pp. 425-436.

De Oliveira, J.A.A., Butterworth, D.S. (2004). Developing and refining a joint management procedure for the multispecies South African pelagic fishery. *ICES Journal of Marine Science*, 56, 1432-1442.

Rescan, C.U., Clausen, L.W. (2009). Background document for January 2009 presentation to Pelagic Regional Advisory Council, DTU Aqua.

Sandker, M., Campbell, B., Suwarno, A. (2008). What are participatory scoping models? *Ecology and Society* 13 (1): r2; accessed on 1 October 2009 at http://www.ecologyandsociety.org/vol13/iss1/resp2/.

Smith, A., Sainsbury, K., Stevens, A. (1999). Implementing effective fisheries-management systems-management strategy evaluation and the Australian partnership approach. *ICES Journal of Marine Science*, 56, 967-979.

Squires, H. (2009). *Participatory Modelling and Invest in Fish South West*. Presentation at the JAKFISH WP2 International Expert Workshop on “Participatory Modelling in Natural Resource Governance: Promises, Pitfalls, Improvement Opportunities”, Haigerloch, Germany, 18 June 2009.

Van Asselt, M.B.A., Rijkens-Klomp, N. (2002). A look in the mirror: reflection on participation in Integrated Assessment from a methodological perspective. *Global Environmental Change*, 12, 167-184.

Van den Belt, M. (2004). *Mediated Modeling. A System Dynamics Approach to Environmental Consensus Building*. Washington et al.: Island Press.

Van der Sluijs, J.P. (2002). A way out of the credibility crisis of models used in integrated environmental assessment. *Futures*, 34, 133-146.

Wilson, D.C., Pascoe, S. (2006). Delivering complex scientific advice to multiple stakeholders. In: L. Motos, D.C. Wilson (eds.), *The Knowledge Base for Fisheries Management* (Vol. 36 of Developments in Aquaculture and Fisheries Science), Amsterdam et al.: Elsevier, pp. 329-353.

Part 2: The Invest in Fish South West and PRONE cases

A. Involvement of stakeholders in modelling activities in the Invest in Fish South West project

Contents

A. Involvement of stakeholders in modelling activities in the Invest in Fish South West project[8]

Marion Dreyer & Ortwin Renn

1. Introduction – IiFSW, a multi-stakeholder partnership project

Invest in Fish South West was a multi-stakeholder project in England's south west with a mandate to reach agreement on preferred fisheries management options for the English Channel, Irish Sea and Western Approaches through recourse to modelling science and participatory processes. The project was performed in a period of four years. While the project was officially launched in April 2004, it had already started in 2003 through a founding partnership of WWF-UK, National Federations of Fishermen's Organisations (NFFO) and Marks & Spencer (plus regional partners) which stemmed from the WWF-UK report 'Choose or Lose' (MacGarvin & Jones 2000). This founding partnership brought other organisations to the table and initiated the South West Cost-Benefit Analysis of Stock Recovery project (SW CoBAS) which was soon after renamed the Invest in Fish South West (IiFSW) project.

The IiFSW project was directed by a Steering Group which was a partnership drawn from a wide range of major interest groups with a direct stake in fisheries sustainability, and included: commercial fishing interests (South Western Fish Producers Organisation, Cornish Fish Producers Organisation); recreational sea anglers (Bass Angler's Sportfishing Society, National Federation of Sea Anglers); statutory conservation agencies (Natural England); environmental non-government organisations and conservation organisations (WWF-UK, The Wildlife Trust); fish processors (FALFISH); regional development (South West Regional Development Agency); restaurateurs (Moshi-Moshi) and retailers (Marks & Spencer). The project received financial support from most of these organisations and some other organisations[9]. The stakeholder bottom-up approach is one of the innovative hallmarks of the IiFSW project which describes itself as a "stakeholder-driven and defined process" (IiFSW 2007, p. 22). Notable is also the breadth of the multi-stakeholder engagement, particularly the inclusion of the marketing and the consumer element through retailers and restaurateurs.

The broader political context in which the IiFSW project emerged was the 2002 reform of the European Communities Common Fisheries Policy (CFP) which called for enhanced stakeholder involvement in European fisheries management. The main objective of the project was to rebuild and maintain sustainable fish stocks in the south-west of England and to reach agreement about the steps to get there among the major stakeholder groups. In the oceanographic region covered by the project a significant part of fish stocks are considered as being currently outside safe biological limits. The project's approach of testing long-term management options corresponded with the reformed CFP's focus on long-term management plans. More specifically, the project aimed at exploring biological, environmental and economic impacts of different policy options for fisheries and, based on these assessments, seek agreement among the stakeholder groups on the most appropriate

[8] The following exposition draws on the Invest in Fish South West project report of 2007 (IiFSW 2007) and a presentation of the project's scientific manager at the JAKFISH WP 2 expert workshop on participatory modelling which was held in June 2009 in Haigerloch, Germany (Squires 2009).

[9] The funding organisations included: Cornish Fish Producers Organisation; Cornwall County Council; Esmee Fairbairn Foundation; EU Financial Instrument for Fisheries Guidance; Defra; Marks & Spencer; National Federations of Fishermen's Organisation; Natural England; Sea Fish Industry Authority; South Western Fish Producers Organisation; South West Regional Development Agency; The Worshipful company of Fishmongers; and WWF-UK.

management options. This broader view on impacts was a direct consequence of the WWF-UK report ‘Choose or Lose’ (MacGarvin & Jones 2000). This report had emphasised that a long-term focus on fisheries sustainability could generate a more profitable industry, and that societal support vis-à-vis short-term transitional aid could be a useful tool to help get there.

2. Using complex modelling science to inform stakeholder deliberation and decision-making

The IiFSW project was made up of two major components. The first was a systematic effort to collect and synthesise the impacts of a set of alternative management options on the marine environment and on the economic situation of the fishing and related industries. This effort was undertaken by using highly sophisticated scientific modelling. The second component consisted of processes of deliberation among the Steering Group members around these modelling results with the shared task to find a consensus on the most preferred policy options on the basis of a joint evaluation of the different options. There was general agreement among the project partners that option evaluation and selection required not only a technical discussion, but discussion around how to deal with uncertainty, risk and divergent viewpoints.

The use of complex modelling science as a tool for the stakeholder debates oriented towards agreement on policy recommendations is another innovative hallmark of the IiFSW project. In this project stakeholders were directly involved in the commissioning and the development of a bio-economic modelling tool, and they were also directly involved in using this tool for their negotiations and decision making about what constitutes appropriate management options. The development of the bio-economic modelling tool was assisted by leading scientists from centres for research on fisheries and the environment, economics and management of aquatic resources, and local and regional economic analysis[10]. The integrated assessment tool can be used to simulate the interactions between fish stocks, the size and effort of the fishing fleet, the regional economy, employment and other factors within the south-west.

The IiFSW project report emphasises that the bio-economic modelling tool is an “’option comparison’ model” (IiFSW 2007, p. 41) and not a model suited for providing actual predictions or forecasts. The model compares what could happen if a particular policy option is varied while all other factors remain the same. The impact is then considered against a baseline where all these variables are held constant over time (for instance, the number of vessels and their fishing activity). The creation of a ‘standard baseline’ required a number of fundamental assumptions which can be expected to become increasingly unrealistic over time. However, as stressed by the project report, the baseline is not a simulation of reality but a standard benchmark against which to assess the different policy options. Hence, what the model does allow for is the comparison of the relative merits of different options against the baseline and between each other (Ibid., p. 41).

Within the IiFSW project a set of alternative policy options were assessed against a created standard baseline. The effects of all options were evaluated against a number of key parameters which included: the level of spawning stocks; overall impact on the environment; the value of revenue for each major south-west port; profitability (overall for the UK south-west fleet and by different fishing methods); the value of recreational sea

[10] Foremost scientific and technical contributions were provided by CEFAS (Centre for Environment, Fisheries & Aquaculture Science); CEMARE (Centre for the Economics and Management of Aquatic Resources of the University of Portsmouth); and CLREA (Centre for Local and Regional Economic Analysis).

angling expenditure; and regional economic output and employment. For each option a standardised set of results was produced, shown as graphs. The Steering Group members used these graphics as a starting point in their explorations of the strengths and weaknesses associated with the options.

The Steering Group produced a shortlist of priority options which was refined in response to the results of a number of additional participatory processes. These included (amongst others) small group stakeholder discussions with a special focus on modelling and other outputs in an accessible format and three days of workshops with the environmental, commercial fishing, and recreational sea angling sectors to discuss the short listed options in detail. The results from these exercises formed an input into the final deliberations of the Steering Group, as did the public sector responses[11].

3. Procedural and practical issues

IiFSW can be considered a pioneering project because it used two innovative tools for fisheries management – a stakeholder bottom-up approach and a complex bio-economic modelling tool – and because it directly involved stakeholders in the commissioning, development and use of the scientific model. The project report describes "the first project of its kind in Europe" (IiFSW 2007, p. 73) as a success in several dimensions. First and foremost, its procedural and structural devices would have proved helpful in creating a climate of cooperation among major interest groups with a direct stake in fisheries sustainability and in reaching conclusions commonly agreed by the project's partnership (the Steering Group) drawn from this wide range of stakeholders (Ibid., p. 36). All members of the Steering Group finally agreed on a package of policy options for sustainable fisheries and recommended them to the respective policy making bodies for consideration, further development and implementation. Overall, the recommendations of the Steering Group encompassed a mission statement; recommendations on preferred management options; recommendations on governance and marketing; and recommendations on required research. Amongst others it was recommended that the IiFSW bio-economic model, which was developed for the project, is maintained and updated by CEFAS for the use of decision making bodies within Defra (UK's Government Department for Environment, Food and Rural Affairs) and beyond. There is also the expectation of the IiFSW partnership that the model will assist the North Western Waters RAC in its task of advising on long-term management options. Another benefit, stated by the report, is that the IiFSW project encouraged common understandings among the stakeholders of the problems, opportunities and challenges that characterise the fishing situation in the south-west of the UK. This obviously facilitated the process of reaching consensual conclusions (Ibid.).

The project report also offers a number of reflections about procedural and practical issues that emerged from the chosen multi-sector and participatory approach (IiFSW 2007, pp. 67-75). In the following subsections we will refer to those issues which are linked to the use of participatory modelling techniques.

3.1 The need for modelling and facilitation expertise

In the body of literature dealing with participatory modelling there seems to be general agreement that there is a need for both in processes involving stakeholders in modelling activities: modelling expertise and facilitation expertise. There are different views, however, on whether expert modellers should and could serve a both modellers *and* facilitators. One

[11] The IiFSW project also tested the shortlisted policy options the general public, through staged information and consultation events with a representative sample of south-west residents.

view is that successful facilitation requires special expertise in modelling. Therefore expert modellers are seen as particularly qualified to perform this task subject to the condition that they remain neutral and avoid overly influencing the outcome by restricting themselves to acting as a catalyst for joint problem thinking. There is also acknowledgement in this view that certain skills are required for acting as a mediator, such as conflict handling and communication, but these could be developed by practice (van den Belt 2004). A contrasting view stresses the specialised expertise that a good facilitator can bring to a process and that the skill sets for modelling and facilitating are very different. While the facilitator is mostly concerned with the process (collaboration), the modeller primarily cares about the product (the model itself and/or the working of the model); in that sense the modeller is also a stakeholder. In this view, the facilitator and modeller roles should be segregated and fulfilled by different individuals (Cockerill 2005).

It is a main procedural feature of the IiFSW project that it involved technical experts and consultants[12] and also process experts. Professional facilitators were enlisted to support the overall process. In particular, the comparative evaluation process in the Steering Group was led by these process experts. The professional facilitation support was experienced as positive in the IiFSW project. It proved to be helpful in providing a structured process for dialogue between the Steering Group members. Moreover, it supported day-to-day-conflict management within the group (IiFSW 2007, p. 75). The project report underlines how important it is that this resource is accessible and trusted by the stakeholder group (Ibid.). At a wider scale, the process facilitators' work was supported by a 'community liaison officer' who was a member of the project team and worked as a bridge between the interest groups from which the Steering Group was drawn and the technical experts. He could assist stakeholders (Steering Group members and their constituencies) with their articulation of preferred options.

3.2 The need for matching the level of model complexity with the purpose of 'participatory modelling'

Depending on how familiar stakeholders are with the logic and techniques of modelling and thinking in terms of dynamic systems more or less efforts in capacity building are required. A core issue framing many concerns about using models in natural resources management is that the models become increasingly complex. The construction and use of computer models is identified as a special challenge as they require often more than only basic computing and quantitative skill. They require so much skill and background knowledge that even despite stakeholders' participation in model building, the model to some extent remains a black box.

This corresponds with the experiences of the IiFSW project. A major challenge that the documentation of the project has identified in relation to involving stakeholders in the development and use of a highly sophisticated bio-economic modelling tool is the *complexity* of these models. This complexity would have placed an "onerous burden on partners and other stakeholders who may have a steep learning curve to be able to use such tools effectively but also manage their development (IiFSW 2007, p. 74). Although the development and use of the model was aided by an external advisory committee, a permanent technical consultant and overall project management (see fn 15), "the burden on the individual steering group members was still immense" (IiFSW 2007, p. 74). Within fisheries science, as in others scientific areas related to natural resource governance, there is

[12] Technical expertise was provided from outside and inside the project. Research centres were commissioned to provide scientific-technical input, and the project work was assisted by a Technical Consultant (who was a member of the project team) and by a an Advisory panel and Technical support group.

a trend to build increasingly large, complex computer-based models integrating biological and economic models and software in a common framework for evaluation of alternative management strategies. Such complex models and evaluation frameworks appear to enjoy also widespread support by policy makers. Partly for this reason, the Invest in Fish South West project partners – all key actors in fisheries and fisheries governance – resorted to such highly technical modelling science. The recourse to bio-economic modelling was viewed as critical to being taken seriously by the scientific and policy making community. The assumption was that this would increase chances that policy makers accept the project's conclusions as legitimate (Ibid.)[13].

Experiences gained within this project suggest that more intensive reflection is required about the questions of whether such complex models are suited for the involvement of non-modelling specialists and what procedural and structural devices may facilitate such involvement and decrease the risk of generating or nurturing stakeholders' reluctance to engage in modelling processes (cp. Wilson & Pascoe 2006, p. 344). In regard to the experiences of the IiFSW project it has been proposed, for instance, to consider the potential of science communications for 'translating' the technical matters throughout the modelling processes so that they become comprehensible to non-experts in modelling (Squires 2009).

Another suggestion in the light of the experiences made in this project is that such complex models are not well suited if the purpose (or one of the purposes) of 'participatory modelling' is to initiate or foster a process of 'collective learning' about the nature of the resource problem and appropriate solutions. The IiFSW bio-economic modelling tool served a dual purpose: to legitimise the Steering Group's conclusions *and* support multi-stakeholder discussions and decision making through encouraging common understandings of the problems, opportunities and challenges that characterise the fishing situation in the south-west of the UK. However, the level of complexity of the modelling tool turned out to be not really suited to serve the second purpose. One conclusion drawn from this experience is that a 'simple' model was likely to be a more instrumental tool in creating a supportive learning environment for stakeholders (IiFSW 2007, p. 74) [14]. The experiences gained in the IiFSW project suggest that the chances of achieving the objectives of a 'participatory modelling' exercise are higher if the level of model complexity is *matched* with the purposes of modelling and involving stakeholders in modelling.

3.3 The need for creative ways of including non-scientific knowledge

Significant efforts were made in the IiFSW project to collect both scientific and non-scientific 'data' which were (as far as possible) fed into the modelling databasis (IiFSW 2007, p. 71). Additional, 'non-modellable' information was collected internally or via externally commissioned research. A major challenge that the IiFSW project faced in relation to stakeholders sharing in the tasks of model development were methodological difficulties with regard to integrating resource users' practical and experiential non-scientific knowledge into the model (Squires 2009). The literature about knowledge production in fisheries management has identified this technical barrier as one of the main challenges in using models developed for simulation and evaluation of alternative management options in a participatory setting (Aranda & Motos 2006; Baelde 2003; Smith

[13] This assumption corresponds with the observation by Smith Korfmacher (2001, p. 172) that model complexity was often equated with the legitimacy of model results.

[14] A simpler model might also be beneficial to keeping a high level of commitment and motivation of the stakeholders throughout the overall process of model development and use. This assumption is put forward by Sandker et al. (2008, p. 2) who warn against building and using models so complex that they are disincentives to stakeholder involvement and opt for "simpler models with more engaged participants".

et al. 1999). The need to find "more creative ways of embracing alternative hypotheses and data, including fishermen's perceptions and experience" (Smith et al. 1999, p. 976), that was pointed out already 10 years ago, clearly deserves to be a subject of future research on the potential and pitfalls of 'participatory modelling'.

The main political role that the IiFSW project has played so far is that of a promoter of a climate of cooperation among key actors in fisheries governance in the south-west of the UK. According to the knowledge of the authors of this Deliverable, the policy making bodies did not (yet) formally respond to the recommendations that were addressed to them. Hence, the political role of this project is (at this point in time at least) rather an *indirect* one. Another indirect political role that the project has intended to play is to serve as a "test case" (IiFSW 2007, p. 23) for applying a participatory approach to modelling for collective learning and decision-making purposes from which some interesting lessons in regard to main issues of process design can be drawn. It needs to be seen whether these lessons will find any resonance in the North Western Waters RAC or any of the other Regional Advisory Councils of which some are currently engaged in efforts to find new ways of stakeholder-science cooperation in developing management advice.

References

Aranda, M., Motos, L. (2006). Management Strategy Evaluation (MSE) and Management Procedure (MP) implementations in practice: A review of constraints, roles and solutions. In: L. Motos, D.C. Wilson (eds.), *The Knowledge Base for Fisheries Management* (Vol. 36 of Developments in Aquaculture and Fisheries Science), Amsterdam et al.: Elsevier, pp. 409-421.

Baelde, P. (2003). Using fishers' knowledge goes beyond filling gaps in scientific knowledge-analysis of the Australian experience. In: *Putting fisher's knowledge to work*. Conference Proceedings, 78-86.

Cockerill, K. (2005). Book review: M. van den Belt, Mediated Modelling: A System Dynamics Approach to Environmental Consensus Building, Island Press. *Ecological Economics*, 55 (1), 135-137.

Investinfish South West. *Setting a Course for Sustainable Fisheries in South-West England*. June 2007.

MacGarvin, M. & Jones, S. (2000). *Choose or Lose: A recovery plan for fish stocks and the UK fishing industry*, WWF-UK report, December 2000.

Sandker, M., Campbell, B., Suwarno, A. (2008). What are participatory scoping models? *Ecology and Society* 13 (1): r2; accessed on 1 October 2009 at http://www.ecologyandsociety.org/vol13/iss1/resp2/.

Smith, A., Sainsbury, K., Stevens, A. (1999). Implementing effective fisheries-management systems-management strategy evaluation and the Australian partnership approach. *ICES Journal of Marine Science*, 56, 967-979.

Smith Korfmacher, K. (2001). The Politics of Participation in Watershed Modelling. *Environmental Management*, 27 (2), 161-176.

Squires, H. (2009). *Participatory Modelling and Invest in Fish South West*. Presentation at the JAKFISH WP2 International Expert Workshop on "Participatory Modelling in Natural Resource Governance: Promises, Pitfalls, Improvement Opportunities", Haigerloch, Germany, 18 June 2009.

Van den Belt, M. (2004). Mediated Modeling. A System Dynamics Approach to Environmental Consensus Building. Washington et al.: Island Press.

Wilson, D.C., Pascoe, S. (2006). Delivering complex scientific advice to multiple stakeholders. In: L. Motos, D.C. Wilson (eds.), *The Knowledge Base for Fisheries Management* (Vol. 36 of Developments in Aquaculture and Fisheries Science), Amsterdam et al.: Elsevier, pp. 329-353.

B. Overview of participatory methods in fisheries management: A review of the EU 6th Framework PRONE project

Contents

Overview of participatory methods in fisheries management: A review of the EU 6th Framework PRONE project

Ben Drakeford & Edward Borodzicz

1. Overview the EU fishing fleet and current management systems

Commercial fishing has long been an important activity in the EU, generating foreign exchange earnings, supporting fishing communities and maintaining a traditional way of life for many EU citizens. In 2005, the total output of fish products in the EU was around 7 million tonnes. This now makes the EU the second largest fishing power behind China, with one of the largest markets for fish products in the world. While the fishing industry has seen significant changes in recent years, the sectors contribution to gross national product remains negligible (< 1 percent), although socioeconomic benefits continue to increase. Debate regarding fisheries management in the European Union has intensified in recent years. However, what is not in debate is that further advances are required in the fisheries management process to safeguard stocks while maintaining benefits to fishing dependant communities.

The EU fleet comprises some 88,000 vessels ranging from small inshore boats to larger open water trawlers. Different segments of the fleet are managed through varying levels of legislation, some of which can be cumbersome and complicated. Legislation measures are administered through the Common Fisheries Policy (CFP), which has been subject to reform since its inception in 1983. In part, reform was deemed necessary to meet the original objectives of the policy but also to meet new objectives. The most notable include the overexploitation of stocks, aiming to ensure sustainable development of fishing activities from an environmental, economic and social viewpoint. The reform in 2002 also aimed to improve the basis of the decision-making process through sound and transparent scientific advice and increased participation of stakeholders. In fact, the involvement of stakeholders in fisheries management is thought to be key to the success of future management strategies. For example, the participation of the industry itself in policy formulation is essential to its success, as any piece of legislation can only effective if it is complied with.

Perceptions of the viability and quantities of fish stocks have been subject to increasing controversy and debate in recent years. Most notable, is the ever widening perception of fish stocks between fishermen and scientists. This may result, in part, from the often complicated data that stock assessments generate and the way that this information is communicated to stakeholders. The way in which information is communicated impacts on the overall effectiveness of the management policy because if fishermen do not understand the policy it is unlikely they will comply with it.

Fishing methods have changed significantly over time and today's highly sophisticated vessels are able to catch fish almost anywhere in the poorest of conditions. While technological advances have increased catches over time, they may have also given the impression that stocks are larger than can be harvested sustainably. The latter is estimated by scientists and provides a large input into policy formulation. It appears that a key issue in the strained relations between fishermen and scientists is the question that stock assessments set out to answer. In short, a scientist views a fish stock in terms of biological sustainability, while a fisherman views the same stock as a source of economic revenue and livelihood.

Compliance with management measures has been at the forefront of recent discussions in EU fisheries management. There is a growing school of thought that stakeholder involvement in policy formulation is required to achieve high levels of compliance in the fishing industry. Certain types of illegal fishing activity have been almost eradicated from the industry in recent years but compliance is thought to be a key factor regarding the success of the Common Fisheries Policy beyond the 2003 reform. A key component of the 2003 reform is stakeholder involvement in fisheries policy formulation. For example, Regional Advisory Councils (RACs) were born in the 2003 reform where stakeholders from the industry are invited to participate in the various stages of policy formulation. Ultimately, if stakeholders are involved in policy formulation they are more likely to comply with regulations. Therefore, stakeholders have the potential to contribute to the overall success of fisheries management, which to date is widely considered to have failed, as stocks become ever more depleted. Furthermore, fishermen have vast knowledge and experience of the resource they obtain their livelihood from. They can, therefore, provide valuable information in the modelling process that stock assessments and policy are derived from.

2. The PRONE project[15]

The EU PRONE Project commenced in January 2006 in response to the increasingly intensified debate regarding fisheries management in the European Union. The underlying reason appears to be the ever increasing difference in perception of stock levels between stakeholders, especially between the catching sector and scientists. The rationale behind the project ultimately lies with the need for improved qualitative and quantitative information on the biological, economic and social consequences of current and alternative actions and tools available to fisheries managers to better manage the risks inherent in EU fisheries.

The overriding aim of the PRONE project was thus to improve the assessment, management and communication of risk and to provide an integrated approach including biological, economic and social objectives. In each of these respective fields, progress has been made and is ongoing. For example, work undertaken by Kell et al (2006) that evaluates management systems using simulations. Further effort is currently being made to integrate economic aspects into simulation models. However, what is lacking is a method that incorporates biological, economic and social aspects that is required in European fisheries management. The main rationale for the PRONE project was that as part of such an integrated framework, a strategic approach to risk management is clearly needed. In line with this, the main tasks undertaken in the PRONE project were to:

- Review the current state of the art, identify weaknesses within the current fisheries science and management framework (assessment, management and communication of risk information) and identify potentially useful approaches being used elsewhere (economics, engineering, food safety, toxicology, etc).

- Identify the knowledge requirements for existing fisheries management systems and link these to the ability to reach management objectives using the available control tools.

- Identify the key controllable elements in different management systems and their ability to manipulate the system to achieve management objectives.

[15] This section is largely taken from the PRONE technical annex.

- Improve risk assessment and management tools to develop, implement and run appropriate risk management strategies in fisheries.
- Provide an executive summary of the elements required within differing fisheries management systems to meet management objectives.
- Link together the biological, social and economic elements to be used in fisheries advice.
- Evaluate the understanding and interest to use information in alternative management schemes.
- Create a risk framework, where risk classification is used to communicate risks and show the responsibilities of actors and their dependencies.
- Suggest a risk framework for European fisheries management and advice of the adaptation of it to advisory systems and international agreements.

The general objective was to investigate how risk theories can be adapted to European fisheries management, embracing the full process from stock assessment, projection and advice, via management decisions, to the practical implementation of the management measures, including control. Many risk theories have been developed in numerous fields and the PRONE project attempts to test their applicability to fisheries management.

The objective of this report is to discuss the role of stakeholders in the above processes, with particular emphasis on stakeholder engagement in the two surveys that were carried out during the project.

2.1 How risk is currently dealt with in fisheries management

In the EU, risk is currently dealt with under the guise of the precautionary approach. The precautionary approach applied in EU fisheries management has rules for both risk management and risk assessment (FAO, 1995a). Generally, the rules of the precautionary approach are that a conservative approach to management should be followed until there is compelling evidence that a less conservative approach would pose no additional risk (FAO, 1995b).

Risk in fisheries is generally defined as the probability of something bad happening (e.g. probability of stock collapse). To prevent stock collapse being a product of chance, exploitation patterns should be related to the probability of achieving management objectives. However, the acceptable probability of not achieving the objectives must be decided by stakeholders using probabilities estimated by experts in the relevant disciplines. Thus, future fisheries management in the EU must fully engage relevant stakeholders in a stakeholder led process. Further, the framework must include the biological, economic and social elements in the fishery. The rationale behind the PRONE project ultimately lies with the need for improved qualitative and quantitative information on the biological, economic and social consequences of current and alternative actions.

2.2 How did PRONE propose to involve stakeholders?

In terms of the participatory process, stakeholders were engaged in the PRONE project in two phases. The first aimed to identify the perceptions of risk in the fishing industry through engaging stakeholder groups with an interest in the fishing industry. The second phase, again through stakeholder participation, seeks to review the risk communication process in fisheries management.

The rationale for stakeholder involvement be will discussed followed by the process of engaging stakeholders for both elements of the survey work undertaken (i.e. risk perception and identification and then communication).

2.3 How were stakeholders engaged in the Risk perception and identification process[16]?

Eight categories of stakeholder groups were identified for the 2007 risk identification and perception work undertaken in the UK. These were:

(1) inshore/small-scale fishermen
(2) offshore/large-scale fishermen
(3) fishing organisations
(4) scientists
(5) government employees
(6) non-governmental organisations (NGO's)
(7) consumers – fishing aware
(8) consumers - fishing unaware

The desired sample size in the UK was set at between 5 to 10 interviews per stakeholder group depending on the type of group being interviewed. A target of 5 interviewees was set for all groups except fishermen (both groups 1 & 2) and consumers (both groups 7 & 8) where the target was 10 interviews. This reflected the fact that the pool of potential fishermen and consumers was much larger than for the other stakeholder groups. In the UK, this led to the inclusion of 64 individuals from 8 stakeholder groups. The characteristics of the stakeholders are given in table 1.

Table 1: Key characteristics of mental modelling interviewees by stakeholder group

	Number of interviews	Male (%)	Age (mean)[1]	Notes
Inshore fishermen	8	100	53	Mostly targeting whitefish and shellfish.
Offshore fishermen	17	100	49	Mostly targeting whitefish and *Nephrops* (prawns).
Fishermen's organisation representatives	4	75	47	Representing range of inshore and offshore fishermen.
Scientists	5	80	39	Government research and University-based scientists.
Government/managers	5	100	39	Local and national managers and enforcers.

[16] Information in this section is largely taken from Tingley, D, Drakeford, B and Palmieri, G. (2008).

Non-governmental organisations (NGOs)	6	100	32	Range of NGOs with both local and national interests.
Consumers - fishing aware	10	n/a[2]	n/a	Interviewed in specialist fish wholesale outlet which is open to general public.
Consumers - fishing unaware	10	n/a	n/a	Interviewed in general supermarkets.
Total	64			

2.4 Overview of case study countries engaged in the project

The methodology used in the PRONE project was applied to four case studies. The four countries (Faroe Island, Greece, Iceland and the UK) were chosen reflecting differences in the current fisheries management techniques applied. The case study interviews were fundamental to the objectives of the PRONE project in allowing current risk methodologies to be tested and compared to alternative methods. In turn, the interviews were also used to ensure that the outputs of risk assessment are adequately understood by stakeholders (risk communication).

2.4.1 Current management measures in the case study countries

In the Faroe Islands an effort based fishing day system, along with a range of technical measures and closed areas, is used to manage the fishing fleet. This method is preferred over other types of catch restrictions because many Faroese fisheries are mixed fisheries. Systems that adopt restrictions in terms of the amount of fish that can be landed tend to result in a higher level of discarding. When effort is restricted only by means of days at sea, any species that is caught will be landed as it has an economic value.

Being part of the EU, fisheries management in Greece is directly influenced by the Common Fisheries Policy (CFP) and associated legislation. However, only for bluefin tuna is total allowable catch (TAC) and quota applied. For the rest of the commercial species in Greece, national legislation attempts to control overexploitation through effort restrictions (days at sea) and technical measures (gear restrictions etc). The management of fisheries in Greece seems to be failing, typified with non-compliance and illegal fishing. In contrast to the Faroe Islands, there is a serious lack of reliable data on which to base scientific stock assessments.

An individual transferable quota (ITQ) system operates in Iceland. While a days at sea system may be preferred by industry, an ITQ system is thought to be more efficient in safeguarding stocks, particularly when compared with management systems in other countries, such as Greece. The ITQ system in Iceland has increased the efficiency of the Icelandic fleet, although the policy has been criticised in terms of socioeconomic impacts, mainly loss of employment.

Fisheries management in the UK is complex for a number of reasons, although it is more closely regulated by the CFP than other EU countries, such as Greece. As in Iceland, TAC is divided into quotas, although there is a significant difference in administration. In the UK quotas are not fully and freely transferable and are known as “fixed quota allocations” (FQAs). Some transferability of quota is allowed throughout the year, although permanent transfers are not permitted. Further restrictions are in place for some species backed up with technical measures, fleet capacity reduction and closed areas. The restrictions are most notable for cod in the North Sea. The Scottish fleet, accounting for over 1/3 of the UK catch has recently suggested that it would like to leave the quota system administered under the CFP in the UK and pursue its own form of management.

2.5 Mental modelling – a suitable method for stakeholder engagement?

Mental modelling is fundamentally concerned with the understanding of human knowledge about the world. Mental models have been studied by cognitive scientists to understand how humans know, perceive, make decisions and construct behaviour in a variety of environments (Davidson et al, 1999).

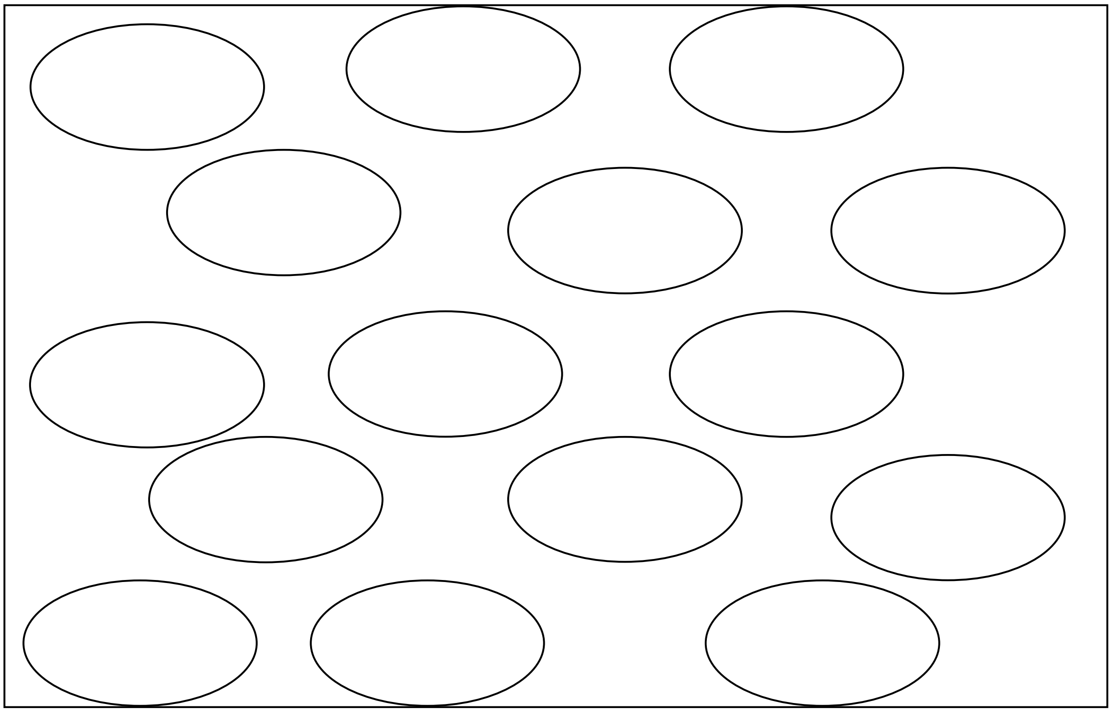
In the PRONE project, the rationale for the mental modelling approach was that an adapted version of the mental modelling methodology (Bostrum, et. al., 1991, 1992) may prove useful in the facilitation of risk communication between the various stakeholders in each of the case study countries.
In 2007, face to face interviews were undertaken with stakeholders from each of the four countries. In total 179 interviews using the mental modelling technique were undertaken in the four case study countries – 26 in the Faroese, 49 in Greece, 39 in Iceland and 64 in the UK.

The adapted version of the mental modelling procedure used in the PRONE project was designed to elicit the identification of risk from the 179 stakeholders interviewed. The methodology was also designed to produce two sets of data (quantitative and qualitative) and followed a 3-step procedure. The project also considered how the presentation of results could enhance communication to stakeholders.

The methodology involved the use of 3 mental models. The first mental model was presented to the respondent (see fig 1) who was asked to write down in each of the "bubbles" a risk that they felt important in the fisheries sector[17].

[17] For no particular reason, the mental models presented are those that were completed by inshore fishermen.

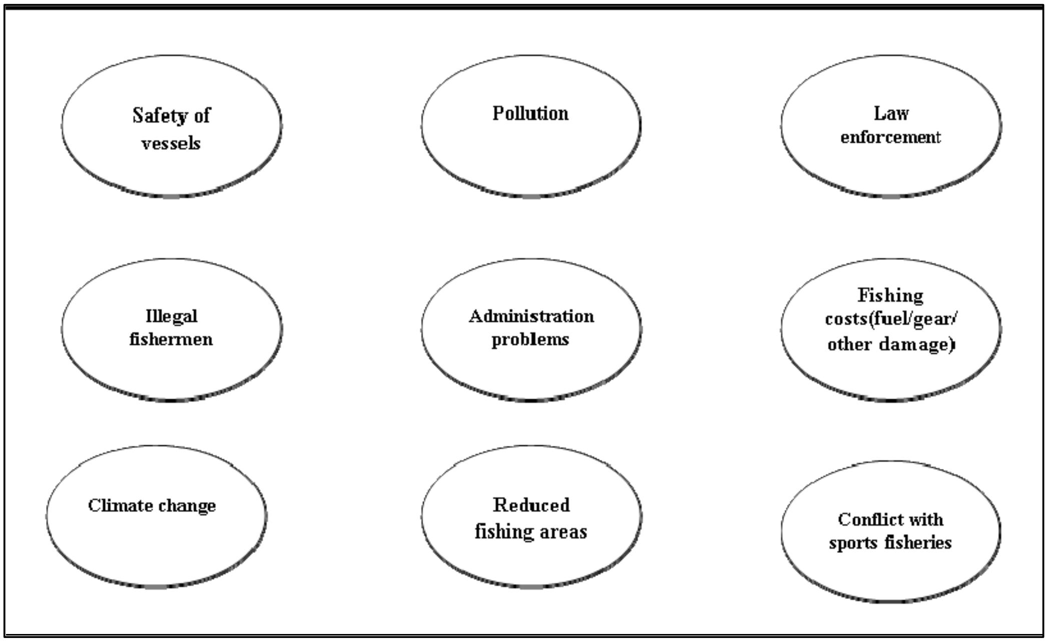
Figure 1- Mental model 1: Blank model (inshore fishermen)



After using mental model 1 to demonstrate their perception of risk, the respondents were asked to rank risks numerically (i.e. in order of importance) and indicate if they thought any relationships or "linkages" exist between the risks identified. Respondents were also asked to state the reasons why they ranked risks as they did and why they thought, if any, relationships and linkages occur. For example, a fisherman may think that there is a link between science and policy, but that the science underlying the policy decisions is the more important risk. This enables both qualitative and quantitative data to be collected for analysis – although this phase of the PRONE project was primarily concerned with the collection and analysis of qualitative data.

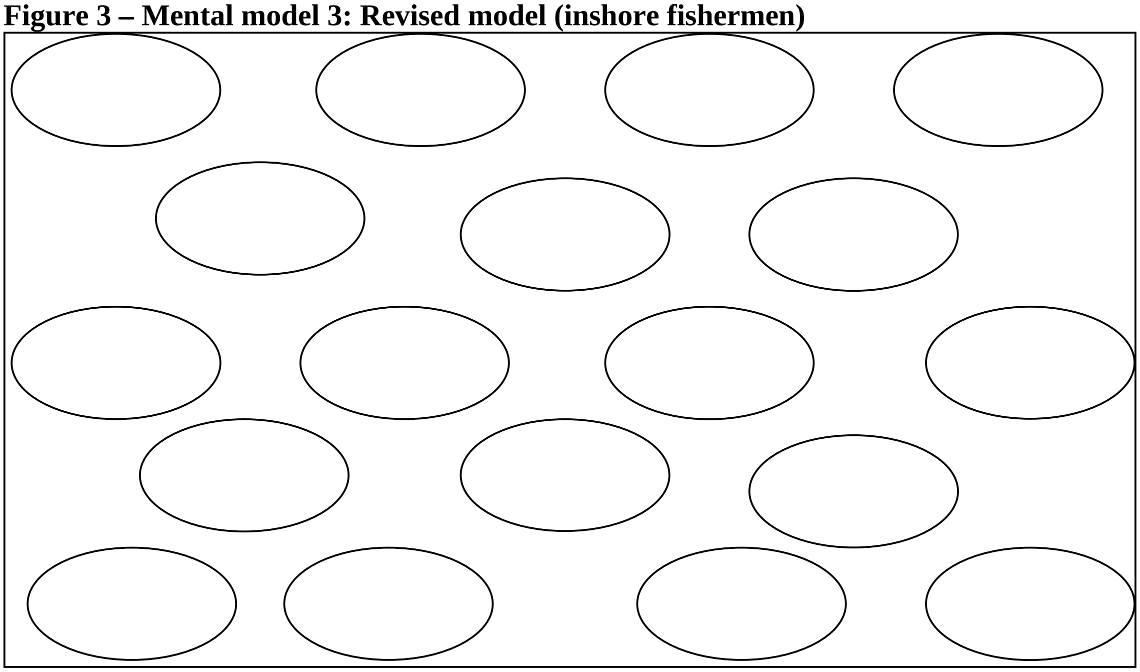
To facilitate the 2nd step of the mental modelling procedure, the results of a pilot survey (carried out some months before the main survey) were used to create the "comprehensive model". A comprehensive model was generated for each of the 8 stakeholder groups and was the second model that was presented to the interviewee. An example is given below for the inshore fishermen group.

Figure 2- Mental model 2: Comprehensive model (inshore fishermen)



The comprehensive model was presented to the respondents as a summary of risks identified by peers in their category. The respondents were then asked if they would like to revise their mental model as a result of seeing what others in their profession/area of expertise thought represented risks in the fishing industry. Some respondents chose to do so, while others declined. For some, this was because of time constraints and perhaps a flaw in the mental modelling process is one of time. The adapted version of the mental modelling procedure used in the PRONE project required around 1 hour to complete. It may be for this reason that some interviewees declined to go past the first step. For those that did, it facilitated the use of a third mental model, which was the final stage of the 3-step mental modelling procedure.

Figure 3 – Mental model 3: Revised model (inshore fishermen)



The third mental model produced enabled the respondent to revise their original mental model (mental model 1) having seen mental model 2 (comprehensive model). Specifically, respondents were asked to discuss the reasons why they added new risks in mental model 3. Respondents were also asked to discuss the impact this had on their ranking of risks and ideas/thoughts concerning relationships and linkages between the risks identified. In addition, respondents were asked to record reasons why, if any, they had not included risks from the comprehensive model.

Ultimately the use of the mental modelling procedure provided two distinct data sets. Quantitative data were collected in terms of risk ranking in mental model 1 and mental model 3. Qualitative data were collected via the protocols recorded throughout the process.

2.6 What was the outcome of stakeholder participation - the UK case study?

Of the eight stakeholder groups engaged in the PRONE project, three distinct groups of stakeholders were found to have similar views on risk in the fishing industry. This is an interesting finding in itself, as it is usually assumed that stakeholders have different aspirations for the resource based on their use of it. It is, therefore, expected that they would have identified different risks. However, it was found that there are some similarities between stakeholder groups. Of the three stakeholder groups that were found to have similar perceptions of risk in the fishing industry, the first group combines the catching sector and representation of the catching sector – namely inshore and offshore fishermen and fishing organisations.

The responses given by each of the stakeholder groups generally related to current fisheries management in terms of quota and other effort restrictions. These risks were mainly highlighted by offshore fishermen, as inshore fishermen are not governed by all of the effort restrictions imposed on offshore fishermen (e.g. days at sea). Overall, there is a clear categorisation of risks from the catching sector related to management or rather mis-management issues. Protocol analysis clearly indicates a difference in perception of stocks between fishermen, scientists and ultimately policy makers.

It was also found that scientists and NGOs had similar perceptions of risk in the fishing industry. The main risks perceived related to mismanagement in terms of overfishing and habitat destruction, ultimately leading to stock reduction. There was also some agreement between scientists and NGOs concerning the scientific advice that feeds into policy formulation. NGOs perceived the science to represent a risk as too many fish are allowed to be caught. Scientists on the other hand, highlighted science to represent a risk in that scientific advice takes too long to feed into policy and TACs are not set purely on biological advice.

With the exception of both consumer groups and government regulators, there were a number of risks identified by the other five groups of stakeholders. Consumers, with the exception of overfishing, suggested a number of risks that were not considered by the other groups. Responses generally focussed on climate change and pollution, which tend to be areas that are subject to media interest. In the UK, there was little difference in risk identification between the fishing aware and fishing unaware consumers.

Risks identified by government regulators tended to focus on capacity and technological issues. Reponses were generally focussed on excess fleet capacity in line with resource capacity. Government regulators did though seem to recognise the concerns of the fishing industry in terms of science and quota. While they perceive quota to be the correct method to regulate fishing in the North Sea, they perceive the science that feeds into policy to represent a risk.

2.6.1 How were the results presented to other stakeholder groups: an example of inshore fishermen

An example of the results produced during the interview process (see table 2) is presented for the inshore fishermen stakeholder group.

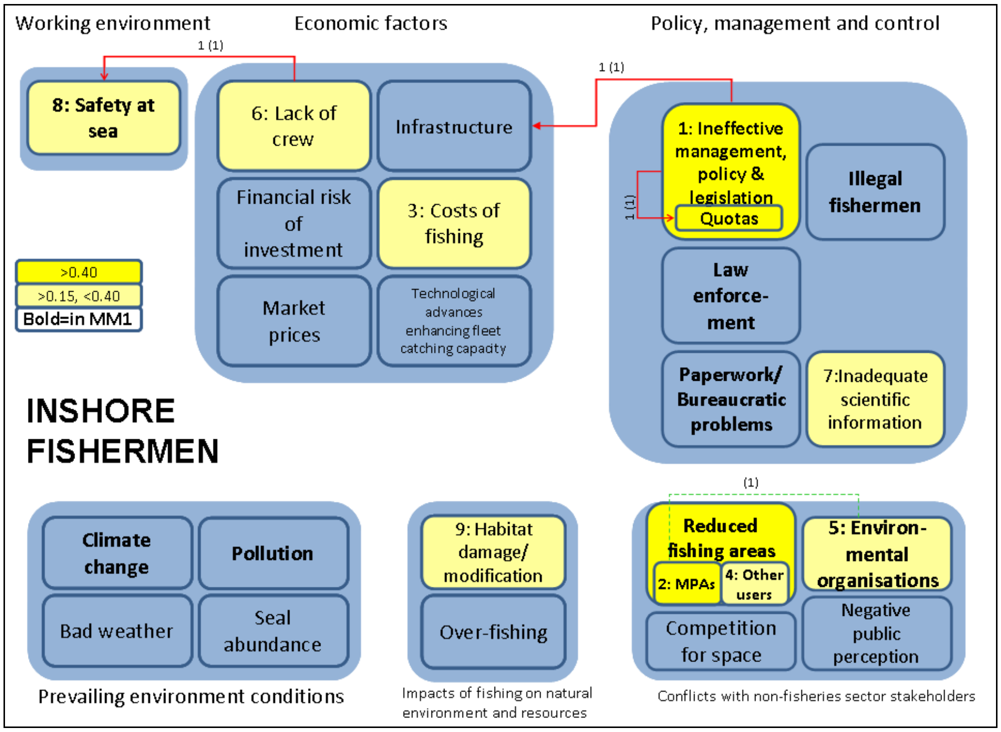
Table 2: Risk perception register: inshore fishermen

Rank[1]	Risk	Number giving scalar	Risk significance scalar[2]			
			Mean	Min	Max	Stdev
1	INEFFECTIVE FISHERIES MANAGEMENT, POLICY & LEGISLATION[3]:	7(8)[4]	**0.60**	-	1.00	0.33
	(QUOTAS)	*5(6)*	***0.43***	-	*1.00*	*0.40*
	(OTHER ASPECTS)	*4(5)*	***0.35***	-	*1.00*	*0.41*
2	REDUCED FISHING AREAS: MPAs	5	**0.45**	-	1.00	0.40
3(4)[5]	COSTS OF FISHING	6	***0.36***	-	0.70	0.27
4(3)	REDUCED FISHING AREAS: OTHER USERS (E.G. WIND FARMS, DREDGING, ETC.)	6	***0.35***	-	0.80	0.32
5	ENVIRONMENTAL ORGANISATIONS	3	***0.28***	-	1.00	0.41
6	Obtaining appropriate crew	3	***0.26***	-	1.00	0.40
7	inadequate scientific information/process	2	***0.23***	-	1.00	0.42
8	SAFETY AT SEA	2(3)	***0.18***	-	1.00	0.36
9	habitat damage/modification	2	***0.16***	-	0.80	0.31
10	PAPERWORK/BUREAUCRATIC PROBLEMS	3	0.13	-	0.50	0.19
11	technological advances enhancing fleet catching capacity	1	0.10	-	0.80	0.28
12	investment uncertainty	1	0.10	-	0.80	0.28
13	POLLUTION	1	0.09	-	0.70	0.25
14	LAW ENFORCEMENT	2(4)	0.06	-	0.30	0.12
15	infrastructure	1	0.06	-	0.50	0.18
16	competition for space	1(2)	0.05	-	0.40	0.14
17	bad weather	1	0.05	-	0.40	0.14
18	seal abundance	1	0.04	-	0.30	0.11
19	negative public perception	1	0.03	-	0.20	0.07
20	CLIMATE CHANGE	1(4)	0.01	-	0.10	0.04
21	market price changes	1	0.01	-	0.10	0.04
22	overfishing	1	0.01	-	0.10	0.04
23	ILLEGAL FISHING	0(4)	-	-	-	-

Notes:
Ranking is derived from order of mean scalar values at the stakeholder group level. It is not an average of individual stakeholders' ranking. 2. Significance range (0-1), where 0 represents 'no significance', 1 represents 'strongest possible significance'. Mean includes 0 values. 3. Where risk text is shown in CAPITALS – risk was included in 'Comprehensive MM2'. Where risk text is shown in Normal text – risk was newly identified by respondent at MM3stage. 4. Where the number of interviewees is shown as 7(8), for example, this signifies that whilst 7 interviewees actually assigned a scalar value to the risk, 8 in total mentioned the risk at some point in the interview. 5. Where the rank of a risk is shown as

3(4), for example, this signifies that whilst this risk is ranked 3rd in terms of its scalar value, its rank changes to 4th under the alternate methodology which assumes that a risk has no value (i.e. not zero) if it was actually mentioned by an interviewee but for some reason they did not assign a scalar value to it.

Figure 4: Mental model of clustered risks and linkages: inshore fishermen



Notes: Text in bold indicates risks identified spontaneously in MM1 additional to those in MM2. Risk numbering shows overall rank as defined by mean scalar value. Linkages show arrow heads where the direction of the link was identified. Where the value “0.7(2/3)” is shown, for example, this means that the average value assigned to that link was 0.7, based on values assigned by 2 respondents out of a total of 3 respondents who identified that linkage (where only 2 actually assigned values to it). Where the value “1(1)” is shown, for example, this means that the average value assigned to that link was 1, based on 1 respondent who identified that linkage and assigned a value to it. Solid, red lines with arrow heads show the direction of a link where specifically identified by respondents. A broken, green line indicates that two risks were linked by respondents but the direction of that cause-effect linkage was not specifically articulated. The thickness of a solid or broken line indicates the number of interviewees mentioning that link, not the strength of the scalar value assigned to that linkage.

The results of the risk identification survey were presented to the various stakeholder groups in the format of table 2 and figure 4. Figure 4 was thought to be particularly useful as it grouped the many risks identified by the various stakeholders interviewed. For example, lack of crew, infrastructure, financial investment, cost of fishing, market prices, and technological advances were all considered economic factors (see figure 4). For inshore fishermen, all of the risks identified were grouped into six categories. It was thought that presenting the grouped mental model would enhance communication to other groups, rather than present individuals with a list of lets say 100 risks ranked numerically (e.g. table 2).

When provided with the additional notes (found directly below figure 4) individuals seemed able to quickly grasp the perception of risk by others in their stakeholder category. When presented with models for other stakeholder groups individuals began to compare across stakeholder groups. In this way, individuals began to understand the wide ranging perception of risk among the variety of people that utilise the resource. This is, however, the very first steps of stakeholder communication. The real challenge is for stakeholders to take ownership of the resource and move forward together in terms of policy formulation.

2.7 Summary of stakeholder engagement in the risk perception and identification survey

Mental modelling is a well established technique in the social sciences, but the PRONE project represents one of the first attempts to apply the methodology to the field of fisheries addressing risk and uncertainty in fisheries beyond the precautionary principle. The mental modelling approach adopted in this paper highlights the divergent perception of risks in the fishing industry among the multiple stakeholders with an interest in the marine environment in the four countries.

The Mental modelling methodology used appears to lend itself well in reviewing the perception of risk in the fishing industry. This research represents a starting point to facilitate dialogue between stakeholders on the one hand, and policy makers and fisheries managers on the other. The real challenge appears to be in the communication of risk between stakeholder groups, particularly between scientists and fishermen.

3. Risk communication and Trust[18]

Once the PRONE project had dealt with risk identification in the fishing industry, it moved on to review the way that risk are communicated among stakeholders. During the risk identification phase of the PRONE project, it became apparent that communication between the main stakeholder groups could be improved. Understanding the perception of risk from each stakeholder group is, of course, important. However, if these perceptions of risk are not communicated and understood by other groups then progress in the fisheries management process becomes distorted. Furthermore, if any piece of management legislation is to be complied with, it must be understood by the stakeholders that it affects. The fisheries science process provides the main input into the fisheries management process via stock assessment. One of the main areas of contention in the fisheries industry currently focuses on the science behind policy formulation. There is growing contention between fishermen and scientists in terms of the perception of stocks. There is also a growing interest from other stakeholders, such as conservationists regarding the science that has a large influence on policy. In line with this, the second survey focussed on communication and trust in the fisheries science process.

The second survey undertaken was targeted at the main stakeholder groups and addressed five main roles with respect to risk communication:

- The validation of the key findings and concepts of the prior mental models from the previous PRONE survey establishing the extent of common appreciation of the risks within the fisheries science process (between stakeholders within countries and across countries).

[18] This section is largely taken from Glenn et al (2009).

- The identification of stakeholder perceptions of current communication strategies within fisheries science and their strengths and weaknesses.
- The identification of the extent of consensus and diversity over the corollary of risk communication trust.
- The identification of areas in detail where risk communication could be targeted to readily improve the common appreciation of risks (i.e. where there are major deviations from the generally held opinion) and to build essential trust.

3.1 Risk communication literature

Risk communication has developed out of concern over the general public's understanding of the information communicated by expert analysts about risks and whether the intended messages are being appropriately received and interpreted. This is quite clearly seen in the fishing industry and it was in fact one of the risks identified by fishermen in the risk identification survey. In fisheries, this is often thought to arise resulting from people's ability to understand the data produced by scientists that subsequently forms a large part of the management process. This often results in scepticism of scientific data and subsequent recommendations (Peterman, 2004; Cattermoul and Borodzicz 2007). While risk communication appears to be growing in the literature, there appears to be rather few examples within the scope of fisheries. It is, therefore, not considered that technical risk information serves well the purpose of risk communication (see e.g. Slovic, 1987;1993 and 2000). In the fishing industry, access of stakeholders to data generated by scientific stock assessments does not serve the purpose of risk communication. Further, the information in the literature concerning fisheries is mainly limited to the evaluation of risk in terms of seafood consumption (see e.g. Peixoto Boischio and Henshel 2000, Burger and Waishwell 2001, Anderson et al 2004, Burger 2008, Burger and Gochfeld 2008), with only a few papers exploring other perspectives (e.g. Knuth 1990).

One of the key aspects of successful risk communication is to know something about the audience (people) that the risk information is being communicated to. For example, it is of little use to communicate risk information to fishermen in a way that they do not understand. For many years, fishermen have been presented with the data that is produced via stock assessments. However, if it is not presented in a way they understand, fishermen are unlikely to comply with the management measures arising from stock assessments. This is one of the main concerns in the fisheries science process. As Hampel (2006) notes scientists differ in their understanding of risk, with even greater differences between scientists and the public. Covello *et al* (1987) note that the assessment of recipients (both individuals and groups) needs to take onboard their "interests, concerns, fears, values, priorities, and preferences" (p.111). It should also consider the barriers to comprehension: the lack of familiarity with an issue or concept, the lack of a mental model relevant to the topic and the presence of misconceptions, which may need particular approaches and emphasis to address (Rowan 1991). All of these characteristics vary between groups and change over time, such that an approach used in one context or for one group may not be appropriate for another or even the same group at another point in time (Bier 2001). Bier (2001) summarises some of the key characteristics of the 'audience' as: "

- The audience's level of knowledge and education;
- The audience's mental models, attitudes and beliefs about the issues at hand;

- The audience’s level of receptivity and openness to the ideas being communicated;
- The audience’s concerns about the issue.”(p.147)

One risk communication issue in fisheries that featured prominently in the original risk identification survey was the perception of cod stocks in the North Sea. Fishermen find it difficult to accept scientific advice (e.g. policy) based on a declining cod stock when their perception is that stocks are increasing. The issue of conceptualisation is thus important and deserve some attention. For example, overexploitation of fish stocks may be conceptualised in different ways by different groups of people. Some people e.g. conservationists may want a pristine environment where as others e.g. fishermen see the resource as a working environment and thus conceptualise exploitation in a different way (e.g. a by-product of fishing).

The way that information is communicated to and between stakeholders is important. The main tension in terms of communication is that stakeholder’s feel for the most part they are not part of the management process and are only involved when decisions have already been made. Further, when the information is communicated it is difficult to interpret and thus understand. Perhaps the first issue to address is understanding the information that is communicated. In particular, there are tensions between communicating and translating scientific models and their uncertainties for a lay audience (Faulkner and Ball 2007). While the need for further discourse and exploration of the issues is noted, emerging thinking is that the simplification of messages for ease of management and comprehension may not be the way forward (Durodie 2003). Studies of the effectiveness of communication tools with detailed information have shown that complex messages can be effectively conveyed (Usher et al 1995, Burger and Waishwell 2001), although other studies have revealed improvements to be notably slow to take effect (White et al 2001). As Faulkner and Ball (2007) highlight, the translation of complex science is a key challenge of risk communication - how to communicate effectively and yet avoid information overload and loss? With the assessment of risk often the preserve of scientists, independent of decision-makers who consequently do not fully appreciate the nature of the science undertaken, even here attention to risk communication is required (Faulkner and Ball 2007).

In terms of the practical delivery of risk communication evaluation it is evident that there are two main approaches, either the direct evaluation of a specific message with a target audience (Burger and Waishwell 2001, Burger et al 2003a,b, Knuth et al 2003) or by examining the knowledge base of the general public or a specific audience (Velicer and Knuth 1994, Knuth 1995, Burger and Gochfeld 2008).

How stakeholder participation should take place, however, remains largely open to question, with little empirical evidence as to what processes are appropriate in any particular situation (Bier 2001), although Renn (1995) explores the strengths and weaknesses of different approaches. In noting this though there are a number of general principles accepted:

- Stakeholder participation requires true commitment to the process, without which there is a serious risk of a loss of trust and credibility.
- The roles of different stakeholders need to be clearly established early on in the process, with stakeholders preferably enfranchised.
- A needs assessment is required to scope participation.
- Stakeholders need to be informed about the issues on which they are to comment if their input is to be meaningful, possibly needing information to be conveyed before input is sought (Bier 2001).

Following a review of the literature concerning risk communication and trust, a further survey was designed to establish the extent of consensus and disagreement over:

1. The severity and nature of risks within the fisheries science process between countries and stakeholder groups.

2. Its corollary trust in the scientific community operating as part of the process.

These sections in turn would contribute to establishing the extent of common appreciation of risks, identify stakeholder perceptions of the current communication strategies and identify potential areas for improved risk communication within the ICES fisheries science system.

3.2 Methodology

To elicit the perception of risk in relation to the fisheries science process, respondents in each stakeholder group were presented with a show card (see figure 5) - a diagram of the fisheries science process. This was aided with several definitions (see figure 6). The interviewer then asked two primary questions based on the diagram and recorded the answers given on a 6 point scale: (1) the likelihood of risk occurring in each part of the diagram A to F and (2) the impact of the risk occurring. Show cards contained both the questions and the 6 point scale for responses. If the interviewee required examples to assist in their decision process, they could be provided by the interviewer from a list provided of both possible risks and end impacts (see table 5).

Before the interview commenced, each respondent was given an introduction to fisheries science so they were aware of the fisheries science process in the context of the PRONE project.

'Fisheries science forms one of the major information bases upon which fisheries management decisions are made. For example, under the Common Fisheries Policy (CFP), annual scientific advice prepared by ICES is used to set Total Allowable Catches (TACs) which are negotiated annually by the EU Council of Ministers. Other types of management decisions which made using scientific information are technical measures, effort restrictions and Recovery Plans for stocks in serious trouble.'

Figure 5: Show card presented to interviewer

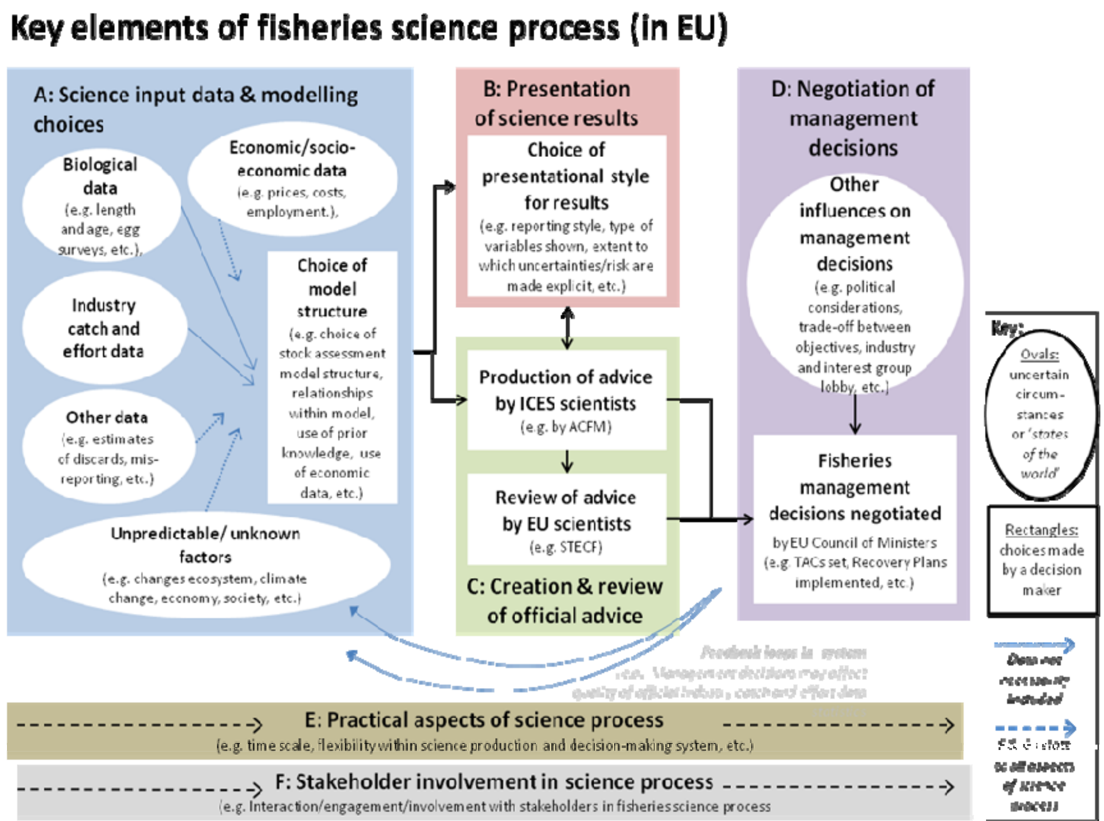


Figure 6: Show card presented to interviewee

SHOW CARD 1 (Text)

The first section of this interview is about **your perceptions of risk in relation to the fisheries science process**.

- We assume the overarching purpose of creating fisheries science is to provide advice for the sustainable use of fish stocks and protection of the marine environment.

- By fisheries science we mean stock assessment, fisheries modelling, etc. that is carried out by fisheries scientists.

- By fisheries scientists we mean national government-funded scientists and/or those whose work is directly used to create advice for management – in the EU we mean ICES scientists – most of the UK's ICES scientists work at CEFAS and FRS.

- By the fisheries science process we mean all the stages from gathering data, creating models and results, presenting results, creating advice from the results and making-management decisions based on the results.

- By risks we mean factors/issues/hazards which could affect an aspect of the fisheries science process.

In terms of the **Likelihood of Risk** occurring, each respondent was specifically asked:
'For each part of the fisheries science process, HOW LIKELY is it that one or more risks could occur which would affect the quality or usefulness of fisheries science within the fisheries science process?'

They were also asked what type of risk they were thinking of, both to assist in the mental construction of their answer and to assist in the qualitative interpretation of the data. In answering the question, their attention was drawn to the fact that Likelihood is not the same as Impact, with the following illustration given:

> *'For example, you are highly likely to catch a cold, but the impact on your health of catching it would be low. However, you are highly unlikely to catch smallpox, but the impact of catching it on your health would be high.'*

Their responses were recorded using the following scale by the interviewer:

Table 3

LIKELIHOOD OF RISK(S) OCCURING		SCALE
Highly unlikely	< 10% probability	1
Unlikely	< 33% probability	2
More unlikely than not	<50% probability	3
More likely than not	>50% probability	4
Likely	> 66% probability	5
Highly likely	> 90% probability	6

In terms of the **Impact of risk** occurring, each respondent was then asked:

'In your opinion, what would be the POTENTIAL IMPACT of this risk (/these risks), if it (/they) occurred, on the quality or usefulness of fisheries science results?'

Supplementary to which they were also asked what type of impact(s) they were thinking of and as with the preceding Likelihood of Risk question a 6-point scale was utilised to elicit and record their answers:

Table 4

POTENTIAL IMPACT IF RISK(S) DID OCCUR	SCALE
Negligible / no effect	1
Minor effect	2
Moderate effect	3
Severe effect	4
Major effect	5
Catastrophic effect	6

Table 5: List of Possible Risks and Impacts

Part:	**Possible risks could relate to:**
A: Science input data and modelling choices.	• Concerns about way in which biological data is collected or sampled • Concerns about reliability of industry catch and effort data from official stats or samples • Other important data may not routinely be included, e.g. discards, mis-reporting estimates, economic & socio-economic data • Concerns about un-predictable or unknown factors (e.g. changes in ecosystem, climate change, economy, society, etc.) are not / cannot be included • Concerns about choice of model structure, relationships within model, use of prior knowledge, use of ‘new’ data (e.g. economic) etc.
B: Presentation choices of science results	• Uncertainties within the data or in the choice of model structure not being made clear at reporting of results stage so results appear overconfident • Results being reported as confident single-point estimates rather than ranges • Reporting style or use of graphics is very technical so results are only accessible to limited audience and is therefore less accepted / understood
C: Creation and review of official advice	• Perceptions that ICES scientists do not act independently of politics • Perceptions that ICES advice is biased towards biological information, for example. • Perceptions that ICES scientists are overcautious / err towards precautionary principle • Similar risks in relation to STEFC scientists and process
D: Negotiation of fisheries management decisions	• ICES science results being interpreted selectively in negotiations by EU Council of Ministers • ICES science results being used as single-point high confidence estimates, as compared to ranges with more cautious confidence estimates. • Concerns about trade-off between fisheries management objectives (e.g. employment ‘v’ conservation ‘v’ profits) given precedence to biological advice • Concerns about national political considerations and concessions which influence decisions • Concerns about strength of lobbying by interest groups (environmental, fishing industry, etc.)
E: Practical aspects of science process	Misperception or mistrust of science results as a result of: • Length time-scale of whole process

	• Lack of flexibility within process in terms of choice of model structure, etc.
F: Stakeholder involvement in science process	Misperception or mistrust of science results as a result of: • Exclusion or only partial (e.g. one-way) involvement of stakeholders in science process • Lack of use of fishing industry knowledge or data-sets, etc. creating

3.3 Key findings of the communication survey

The data collected from the survey were analysed in several ways utilising both qualitative and quantitative methods. The most useful results, in terms of evaluating the risk communication process were those derived from the risk registers, correlation analysis and the qualitative summaries of verbal comments.

The results suggest that there is consensus between some stakeholder groups within and between countries. In line with *a priori* expectations, fishermen perceived the fisheries science process to be a higher risk than scientists, who considered the risk to be much lower. The other stakeholder groups appeared to be somewhere in between fishermen and scientists regarding their perception of risk in the fisheries science process. Therefore, the results suggest that there is not consensus across stakeholder groups and a common appreciation of risk is lacking. However, some similarities between the countries were evident.

Referring back to figure 5, risk was generally perceived to be highest for part D of the process. Part D refers to the negotiation of management decisions and considers influences on management decisions. For example, political agenda, trade off between objectives. Part D refers to negotiation at EU level by the European Council of Ministers in determining how the overall TAC will be split between member countries. Scottish fishermen, in particular, are often unhappy with the result of EU level negotiations as they feel they are not adequately represented.

Risk was also perceived to be high for part A of the process which refers to scientific input into policy formulation. A number of different risks were recorded during the interviews, many of which were in line with those recorded in the risk identification and perception survey. There are several concerns regarding the fisheries science process, many of these concerns are voiced by fishermen and are centred on the method of data collection and analysis. For example, fishermen often suggest that stocks are much higher than the results of stock assessments produced by scientists and that this may be because of the out dated techniques used by scientists. The main risks identified for part A of the science process were insufficient, poor quality unreliable data. Fishermen, in particular, also thought that socio economic indicators were not adequately represented in the process.

Risk was also perceived to be high for part F which is concerned with stakeholder involvement in the science process. Stakeholders often feel that they are not part of the process and when they are their views are not heard. Even when their views are heard they are only taken into account after management decisions have been made. Part B of the process – the presentation of science results to stakeholders was associated with a low level of risk. The risks raised were mainly centred on the use of overly complicated scientific language and presentation styles.

For part E, (practical aspects of science process) a number of risks were cited, although there was little agreement between stakeholder groups. The main concern was reported to be a lack of flexibility in the process. Fishermen have particularly strong feelings regarding this issue, as they feel the science is lagging behind and it takes too long for scientific data to reflect change in policy. For example, cod fishermen in the North Sea suggest that stocks are increasing. However, by the time this is reflected in management policy (resulting from the lengthy scientific process) the situation could be different (e.g. lower stock levels) and higher quotas in the future (as a result of science taking time to feed into policy formulation) could be detrimental to the stock. Finally, the results produced for part F of the process suggest consensus between many of the stakeholder groups, noting that the lack of stakeholder involvement was a risk.

In terms of the consequences of these risks, amongst the large number cited for each part of the fisheries science process, four stood out as receiving widespread recognition, being mentioned repeatedly for the different parts of the process: Distorted and poor decision-making; incorrect conclusions, results, advice and management actions; misinterpretation of the science and advice; and mistrust.

3.4 Trust element of the survey

The second part of the survey focussed on trust within the fisheries science community. Given that stock assessment and fisheries modelling is largely undertaken by ICES, the survey instruments targeted trust through ICES stated aims of fisheries science (ICES, 2002). The main object of this exercise was to understand the view of different stakeholder groups of the fisheries science community and their trust in the fisheries science process.

Based on the literature, Section 2 of the survey instrument targeted ‘Trust’ through ICES’ stated aims of fisheries science (ICES 2002) translated into a series of 18 statements (see table 6) in accordance with the theoretical disaggregation of the components of trust as drawn from Dietz and Den Hartog (2006), Levin et al (2002) and Usoro et al (2007) and presented in Figure 7 (and discussed in the literature review). These statements, while inspired by ICES, equally apply to the other fisheries science communities.

Figure 7: Components of Trust

General	general (ICES stated) aims of fisheries science (1,2,3)			
Component parts of trust	competence (4,5)	benevolence (9,10)	integrity (14,15)	predictability (16)
Explanatory factors of component parts	common language (6,7) common vision (8) discretion - linked to credibility		credibility (17,18)	
			consistency - linked to predictability	
		receptivity (11) strong ties (12,13)		

(Dietz and Den Hartog, 2006; Levin et al., 2002; Usoro et al., 2007)

To elicit these views, respondents were asked to indicate whether they agreed or disagreed with 18 statements (based on ICES stated aims of fisheries science 2002) using a 7 point scale from 1 ‘strongly agrees’ to 7 ‘strongly disagree’. The respondents were also asked to state why they provided the answer that they did to enable the collection of qualitative data. The statements are presented in table 6

Table 6: Trust statements

Theoretical structure of trust		
general (1-3)	1	Fisheries science produced by the ICES scientific community is relevant, responsive, sound and credible and concerns marine ecosystems and their relation to humanity.
	2	ICES can be relied upon to produce the scientific information and advice that decision-makers need.
	3	I would accept and abide by management decisions (and associated regulations) based purely upon fisheries science produced by the ICES scientific community, even if I felt they were not entirely supportive of my own interests.
competence (4-5)	4	The ICES scientific community is a competent and effective source of scientific information and advice.
	5	The ICES scientific community performs its role of providing information and advice that is relevant, responsive, sound and credible and concerns marine ecosystems and their relation to humanity very well.
common language (6-7)	6	Stakeholders, fisheries managers and the ICES scientific community share a common understanding of key terms and words.
	7	The ICES scientific community communicates key results in an easily understood manner.
common vision (8)	8	Stakeholders (e.g. fishing industry, environmental groups, etc.), fisheries managers and the ICES scientific community share a common understanding of the type of information and advice required to make fisheries management decisions.
benevolence (9-10)	9	The ICES scientific community acts in the best interests of all fisheries stakeholders, including the fishing industry.
	10	The ICES scientific community is interested in the sustainability of the fishing industry as well as the sustainability of living marine resources and protecting the marine environment.
receptivity (11)	11	The ICES scientific community is willing to consider alternative ideas about and sources of fisheries 'knowledge' (e.g. those from the fishing industry or environmental groups).
strong ties (12-13)	12	Non-governmental organisations (e.g. the fishing industry, environmental groups, etc.) are able to access and interact with ICES scientists.
	13	Inclusion of non-governmental organisations (e.g. the fishing industry, environmental groups, etc.) in the ICES science process improves transparency.
integrity (14-15)	14	The scientific information and advice produced by the ICES scientific community is objective and has integrity.
	15	In general, members of the ICES scientific community would use any information provided to them in confidence in the manner for which it was intended.
predictability (16)	16	The ICES scientific community carries out its work in a consistent, reliable and predictable manner.
credibility (17-18)	17	The scientific information and advice produced by the ICES scientific community is fully independent and impartial.

	18	The ICES scientific community acts in an independent and impartial manner.

3.5 Key findings from the communication and trust survey

This part of the survey revealed a lack of trust between certain stakeholder groups. This lack of trust was strongest between fishermen (particularly those from the UK and Faroe Islands) and scientists. Notable from the results was the lack of consensus on the existence of a common language and vision, and in respect of the second competence trust statement pertaining to whether the scientific community performs its stated role well. There was also some disagreement relating to the role of the scientific community and whether it acts in the best interests of all stakeholders. It is important to consider the role of the science community in relation to stakeholders. On the one hand, some respondents felt that the scientific community should be completely independent and not act in the interest of stakeholders (e.g. quotas etc should be set in relation only to biological sustainability). Fishermen, on the one hand, felt that the question asked of scientists is important and should consider other objectives along with biological sustainability (e.g. socioeconomic indicators). There seemed to be consensus between fishermen that they are not part of the science or the decision-making process.

Some other key results suggested that there was consensus over a number of the other statements with only one or two groups disagreeing with each, notably:

- ICES2 - 'ICES can be relied upon to produce the scientific information and advice that decision-makers need' (General)
- ICES10 - 'The ICES scientific community is interested in the sustainability of the fishery as well as the sustainability of living marine resources and protecting the marine environment' (Benevolence)
- ICES15 - 'In general, members of the ICES scientific community would use any information provided to them in confidence sensitively and only in the manner for which it was intended' (Integrity)
- ICES16 - 'The ICES scientific community carries out its work in a consistent, reliable and predictable manner' (Predictability)

A wide range of responses were received in terms of undermining trust. However, there was little agreement across the stakeholders and countries. The areas of agreement were lack of soundness and credibility, unresponsive and inflexible, flawed data and weak science, poor communications, political and lobby group interference and lack of stakeholder involvement.

Many of these issues were cited in response to more than one of the trust statements, reinforcing their significance. Where there was disagreement particular issues were often raised. The broadest disagreement was found to relate to common language and common vision. The issue raised here focussed on the inclusion of stakeholders (which stakeholders should be involved and at what time, the agenda (or the hidden agenda of some stakeholder groups) that stakeholders bring to the table and a lack of understanding relating to the way information is delivered (e.g. inappropriate presentation styles).

While there is consensus regarding some risks, there was a diverse range of risks highlighted where there was little agreement between stakeholder groups, especially between countries.

This highlights weaknesses in the current risk communication strategies and presents opportunities for further risk communication.

4. Experiences from the PRONE Project

The general objective of the PRONE project was to investigate how risk theories can be adapted to European fisheries management, embracing the full process from stock assessment, projection and advice, via management decisions, to the practical implementation of the management measures, including control. The rationale behind the project ultimately lies with the need for improved qualitative and quantitative information on the biological, economic and social consequences of current and alternative actions and tools available to fisheries managers to better manage the risks inherent in EU fisheries[19].

The objective of this report was to discuss the role of stakeholders in the above processes, with particular emphasis on stakeholder engagement in the two surveys that were carried out during the project. Risk identification and risk perception research is an important first step towards developing risk management and risk communication strategies. The results of the risk identification survey support traditional social science theory that states risk is subjective. While a number of risks were identified by some of the stakeholders, there was generally a divergent perception of risk among stakeholder groups. The different perceptions of risk appear to be influenced by a wide range of factors. Similarly, there appears to be some consensus on risks in the fisheries science process among some stakeholder groups, but generally there was a lack of agreement between stakeholders and countries.

Stakeholder engagement is considered essential in future fisheries management planning. The process undertaken in the PRONE project, while encountering difficulties, actively engaged the main stakeholder groups in fisheries management. For the most part, stakeholders that were contacted actively engaged and were keen to participate in the survey process. Stakeholders appear to recognise the role they play in managing the marine environment and the advantages of engaging where possible. The real challenge now, is to further facilitate communication by effectively communicating these risks between stakeholder groups in each of the case study countries.

[19] As stated in the Prone Proposal (2005).

5. References

Anderson, H.A, Hanrahan L.P., Smith, A., Draheim, L., Kanarek, M & Olsen, J. (2004) .The role of sport-fish consumption advisories in mercury risk communication: a 1998–1999 12-state survey of women age 18–45. Environmental Research, 95(3): 315-324.

Bier, V. M. (2001). On the state of the art: risk communication to the public. Reliability Engineering & System Safety, 71(2): 139-150.

Bostrom, A., Atman, C., Fischoff, B. & Morgan, M. (1991). *Assessing Risk Communication Documents: Completing and Correcting Mental Models of Hazardous Processes* Draft Paper, Department of Engineering and Public Policy, Carnegie Mellon University.

Bostrum, A., Fischoff, B. & Morgan, M. (1992). 'Characterizing Mental Models of Hazardous Processes: A Methodology and Application to Radion' *Journal of Social Issues*, 48(4):85-100.

Burger, J. (2008). Fishing, fish consumption, and awareness about warnings in a university community in central New Jersey in 2007, and comparisons with 2004. *Environmental Research*,108(1):107-116
Burger, J & Gochfeld, M. (2008). Knowledge about fish consumption advisories: a risk communication failure within a university population. *Science of the Total Environment*, 390: 346-354.

Burger, J., Johnson, B.B., Shukla, S & Gochfeld, M. (2003a). Perceptions of recreational boat captains: knowledge and effects of fish consumption advisories. *Risk Analysis*, 23: 369–378.

Burger, J., McDermott, M. H., Chess, C., Bochenek, E., Perez-Lugo, M & Pflugh, K.K. (2003b). Evaluating risk communication about fish consumption advisories: efficacy of a brochure versus a classroom lesson in Spanish and English. *Risk Analysis*, 23: 781–803.

Burger, J & Waishwell, L. (2001). Are we reaching the target audience: evaluation of a fish fact sheet. *The Science of the Total Environment*, 277: 77–86.

Cattermoul N. & Borodzicz, E. (2007). Review of Psychological, Sociological and Cultural Risk Theories and Assessment Methodologies. Work Package 2 – Deliverable 10. PRONE Research Project: Precautionary risk methodology in fisheries.

Covello, V. T., von Winterfeldt, D & Slovic, P. (1987) Communicating scientific information about health and environmental risks: problems and opportunities from a social and behavioral perspective. In: J. C. Davies, Covello V. T., Allen, F. W (Eds). Risk Communication. Washington, DC: Conservation Foundation.

Davidson, M.J., Dove, L & Weltz, J. (1999). Mental Models and Useability. Technical report, Depaul University, Chicago

Dietz, G. & Den Hartog, D. (2006) Measuring trust inside organisations. *Personnel Review*. 35(5): 557-588.

Durodie, B. (2003). Limitations of public dialogue in science and the rise of the new ‘experts’. *Critical Review of International Social and Political Philosophy*, 6 (4): 86.

FAO. (1995a). Code of conduct for responsible fisheries. FAO, Rome.

FAO. (1995b). Guidelines for the precautionary approach to fisheries. 1: Guidelines for the precautionary approach to capture fisheries and species introductions. FAO Fish. Technical Paper.350.1. FAO, Rome.

Faulkner H & Ball D. (2007) Environmental hazards and risk communication. Environmental Hazards, 7(2): 71-78.

Glenn, H., Bezabih, M., Tingley, D., Wattage,P., Marono, S.S., Holm, D., Kell, L & Padda, G. (2009). Risk communication and trust: Survey report. Report (D22) produced for EU 6th Framework project No. 022589, PRONE: Precautionary risk methodology in fisheries.

Hampel, J. (2006). Different concepts of risk – A challenge for risk communication. *International Journal of Medical Microbiology*, 296 S1: 5-10.

International Council for the Exploration of the Sea (2002). The ICES Strategic Plan. DK-1261 Copenhagen, Denmark. 11 November 2008. www.ices.dk/iceswork/strategic%20plan-final.pdf

Kell, L.T., Pilling, G.M., Kirkwood, G.P., Pastoors, M.A., Mesnil, B., Korsbrekke,P., Abaunza, P., Aps,R., Biseau,A., Kunzlik, P., Needle, C.L., Roel, A & Ulrich, C. (2006). An Evaluation of multi-annual management strategies for ICES roundfish stocks. *ICES Journal of Marine Science*, 63:12-24.

Knuth, B. (1995). Fish consumption health advisories: who heeds the advice? *Great Lakes Research Review*, 1: 36–40.

Knuth, B. A. (1990). Risk communication: A new dimension in sport-fisheries management. *North American Journal of Fisheries Management*, 10(4): 374-381.

Knuth, B., Connelly, N.A., Sheeshka, J & Patterson, J. (2003). Weighing health benefits and health risk information when consuming sport-caught fish. *Risk Analysis*, 23: 1185–1197.

Levin, D., Cross, R, Abrams, L & Lesser, E. (2002). Trust and Knowledge Sharing: A critical combination. IBM Institute for Knowledge-based Organsiations.

Peixoto Boischio. A.A & Henshel, D. (2000) Fish consumption, fish lore, and mercury pollution—Risk communication for the Madeira River people. *Environmental Research*, 84(2): 108-126.

Peterman, R. M. (2004). Possible solutions to some challenges facing fisheries scientists and managers. *ICES Journal of Marine Science*, 61:1331-1343.

PRONE proposal (2005). Precautionary Risk Methodology in Fisheries.

Renn, O., Webler, T & Wiedemann, P. (1995). Fairness and Competence in Citizen Participation: evaluating models for environmental discourse. Dordrecht: Kluwer.

Rowan K. E. (1991) Goals, obstacles, and strategies in risk communication: a problem-solving approach to improving communication about risks. *Journal of Applied Communication Research*, 19: 300-329.

Slovic, P. (1987). Perception of risk. *Science*, 236: 280-285.

Slovik P. (1993). Perceived risk, trust and democracy. *Risk Analysis*, 13: 182-675

Slovik, P. (2000). The Perception of Risk. London: Earthscan.

Tingley D., Drakeford B & Palmieri, M.G. (2008). Risk identification and perception. Report on the 2007 interviews results in the UK. Report (D11) produced for EU 6th Framework project No. 022589, PRONE: Precautionary risk methodology in fisheries.

Usher, P.J., Baikie, M., Demmer, M., Nakashima, D., Stevenson, M.G & Stiles, M. (1995). Communicating about Contaminants in Country Food: The experience of aboriginal communities. Ottawa, Canada: Inuit Tapirisat of Canada.

Usoro, A., Sharratt, M., Tsui, E. & Shekhar, S. (2007). Trust as an antecedent to knowledge sharing in virtual communities of practice. *Knowledge Management, Research & Practice*, (5): 199-212.

Velicer, C.M & Knuth, B.A. (1994). Communicating contaminant risks from sport-caught fish: the importance of target audience assessment. *Risk Analysis*, 14: 833–841.

White, G. F., Kates, R. W & Burton, I., (2001). Knowing better and losing even more: the use of knowledge in hazards management. Global Environmental Change Part B: *Environmental Hazards 3* (3–4): 81–92.