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JAKFISH Policy Brief: coping with uncertainty, complexity and ambiguity in fisheries management through participatory knowledge development

M.A. Pastoors[1], C. Ulrich[2], D.C. Wilson[3], C. Röckmann[1], D. Goldsborough[1], D. Degnbol[3], L. Berner[3], T. Johnson[4], P. Haapasaari[5], M. Dreyer[6], E. Bell[7], E. Borodzicz[8], , K. Hiis Hauge[9], D. Howell[9], S. Mäntyniemi[5], D. Miller[1], R. Aps[10], G. Tserpes[11], S. Kuikka[5], J. Casey[7].

Corresponding author: Martin Pastoors (martin.pastoors@wur.nl)

Abstract

The legitimacy of the scientific underpinning of European fisheries management is often challenged because of perceived exclusion of fishers knowledge and the lack of transparency in generating scientific advice. One of the attempts to address this lack of legitimacy has been through participatory knowledge development. In this paper, we will present the results of the JAKFISH project (Judgement and Knowledge in Fisheries Management involving Stakeholders) that focussed on the interplay between different actors in constructing the underpinning of policy decisions for sustainable fisheries. We tested participatory modelling as a tool to enhance mutual understanding and to increase legitimacy and found that it can be instrumental in developing a broader knowledge base for fisheries management and in building up trust between scientists and stakeholders. However, the participatory approach may not always work. Through social network analyses we found that the number of connections and the frequency of interactions between individuals in different groups (science, fisheries, eNGOs, policy) provides an important clue on the potential effectiveness of participatory approaches. We used three concepts to evaluate the role of scientific knowledge in policy making: salience, legitimacy and credibility. In situations with high stakes and high uncertainties, the evaluation of scientific analyses for policy decisions needs to involve a broader peer community consisting of scientists, policy-makers, NGOs and fisheries in order to increase legitimacy of results. When stakes are low and uncertainties are modest, the credibility of scientific results are sufficiently addressed through traditional scientific peer review.

Keywords: fishery management, participatory modelling, social network analysis, legitimacy, salience, credibility, management plan

1) IMARES, Netherlands, 2) Danish Technical University, National Institute of Aquatic Resources, 3) Aalborg University, Innovative Fisheries Management, 4) University of Maine, School of Marine Sciences, 5) University of Helsinki, 6) Dialogik gemeinnuetzige Gesellschaft fuer Kommunikations – und Kooperationsforschung mbH, 7) The Secretary of State for Environment, Food and Rural Affairs, 8) University of Portsmouth, 9) Institute for Marine Research, 10) Estonian Marine Institute, University of Tartu, 11) Hellenic Centre for Marine Research

Context of scientific advice, stakeholder participation and fisheries management

The European Common Fisheries Policy (CFP) is a policy that is set out to achieve ecological, economic and social sustainability supported by sound science (EC, 2002). However, the CFP is widely criticized for not delivering on the ecological sustainability (Daw and Gray, 2005), on the economic sustainability (Österblom et al., 2011) and on the social sustainability (Symes, 2009). Many authors have pointed to the legitimacy crisis in European fisheries management (Wilson, 2009, Mikalsen and Jentoft, 2008, Van Hoof et al., 2005, EC, 2009). In addition the scientific underpinning of the actual decision-making has been under heavy debate for many years (Sissenwine and Symes, 2007, Piet et al., 2010, Degnbol et al., 2006, Rijnsdorp et al., 2007). Recently there have been several attempts to redefine the role of science in fisheries policy (Schwach et al., 2007, Degnbol et al., 2006, Mackinson et al., 2011) and to change decision-making from short term to long term (EC, 2009).

Fisheries science and fisheries management in Europe have to a large extent co-developed. In a paper produced under the Policy Knowledge and Fisheries Management project (PKFM), Holm and Nielsen have introduced the concept "TAC machine" to describe "the cyclical routine it builds around the construction and certification of annual TACs"(Nielsen and Holm, 2007, Holm and Nielsen, 2004). In the TAC machine, there is a clear division of work between scientists (carrying out scientific assessments and producing short term predictions) and policy makers (deciding on TACs). In assessing the impacts of knowledge on policy-making, the lessons from the Global Environmental Assessment project (Cash et al., 2002, Eckley, 2001, Clark et al., 2010) point to three main attributes of effective assessments: 1) credibility (scientific and technical believability of the assessment to a user of that assessment), 2) salience (the ability of an assessment to address the particular concerns of a user) and 3) legitimacy (political acceptability or perceived fairness of an assessment to a user) (See also: Wilson, 2009 p. 53-69)

Scientific support for European fisheries management is often justified by referring to the independent and objective position that the scientists have in the policy domain (ICES, 2008). *"Advice should be objective and impartial, prepared in accordance with the most recent accepted scientific methods, provided in a timely manner and be easily available and well explained. It should be formulated with respect to precautionary criteria."* (EC, 2003). Wilson (2009 p. 129) describes this role as *"the traditional view of science and policy, [in which] science is supposed to be the objective other that provides the parties involved in the policy negotiations with an agreed basis for discussion."* This position refers back to classical notions and norms about science (Merton, 1968). However, even in the domain of so-called "pure science" these norms have come to be challenged. Thomas Kuhn introduced the concept of "normal science" which described the normal activity of "puzzle solving" and which has the important property that it would stay within the currently accepted paradigm. Translated back into the European science for fisheries management, this would equate to activities in the paradigm of stock assessment and fisheries advice: the scientific components of the TAC machine.

Several authors have challenged the concept of normal science when it comes to applied sciences that have direct societal impacts. Using concepts like "regulatory science" and "boundary work" (Jasanoff, 1990, Yearley, 2006), "Mode II science" (Gibbons et al., 1994), "epistemic communities" (Haas, 1989) and "post-normal science" (Funtowicz and Ravetz, 1994) all direct attention not just to the content of the science but specifically also to the context in which the science for policy is produced. Within the JAKFISH project, we have used the concept of post-normal science as a key concept in describing the changing role of scientists and stakeholders in the European fisheries management debate because stakes are high, scientific knowledge is uncertain and decisions are urgent. A central element of post-normal science is "extended peer review", where the scientific peer community is extended to include stakeholders (Funtowicz and Ravetz, 1993) and where the review process extends beyond ensuring the scientific credibility to ensuring the relevance of the results for the policy process.

With the challenges to the normal science paradigm, there are also implications for the role of scientists in providing the knowledge base for policy making (e.g. Hanssen et al., 2009, Hoppe, 2009, Hoppe, 2005, Halffman, 2008, Pielke, 2007). Pielke, for example, describes four idealized roles of science for policy-making that derive from two basic ideas on the role of experts in democracy and on the role of science in society (Pielke, 2007 p. 14). The *honest broker of policy alternatives* is how we could see the role of a science facilitator in a participatory knowledge development process: engaging, clarifying and opening possibilities and alternatives.

Table 1.1 four idealized roles for scientists in decision-making (adapted from Pielke, 2007 p. 14)

		Role of science in society	
		Linear model: flow of knowledge from basic to applied research	Stakeholder model: users of science have a role in its production
Role of expert in democracy	Interest Group Pluralism: Experts align with favoured group	**Pure scientist** Focuses on research without consideration of use; available to everyone.	**Issue advocate** Focuses on implications of research for political agenda
	Policy alternatives come from experts.	**Science arbiter** Seeks to stay removed from policy, but has direct interactions with policy makers. E.g. advisory panels	**Honest broker** Engages in decision-making by clarifying scope of choice for decision-makers.

Extended peer review is already becoming visible in the European fisheries management process. Clearly, a more formal role of stakeholders in fisheries policy has been institutionalized through the formation of Regional Advisory Councils in the Common Fisheries Policy of 2002 (EC, 2002) (EC, 2008). Stakeholder have gained a formal advisory status in policy making (Mackinson et al., 2011). With the advisory role of stakeholders, also came a need to develop an understanding of the meaning of the scientific work underpinning the fisheries policy and a need to be actively involved in improving the scientific knowledge. At the same time the ICES advisory process experienced a change process which opened up the previous closed advisory process to involve stakeholders as observers to the advisory meeting (Stange et al., 2012). Participation became a new keyword in European fisheries policy. But how was the new role of stakeholders constituted and how could they actually participate in the process of knowledge generation and application?

The JAKFISH project (Judgement and Knowledge in Fisheries Management involving Stakeholders) is one of a few European research projects that have experimented with forms of participation of stakeholders in fisheries management. JAKFISH specifically looked at participatory modelling as a potential tool to enhance mutual understanding and increase legitimacy of knowledge underpinning management decisions. In this project, we followed a number of different strategies to investigate the role of participatory knowledge development. We looked at participatory approaches in other domains on the management of natural resources (e.g. forestry, river basins etc.) (Dreyer and Renn, 2011a), we initiated concrete participatory modelling case studies in which we assessed uncertainties and jointly developed potential management strategies (Ulrich et al., 2010, Tserpes et al., 2011, Haapasaari et al., 2011a, Röckmann et al., 2012), and we studied the institutional aspects of participatory science for management. In this policy brief we want to summarize three findings that are related to participatory modelling:

- A review for participatory knowledge development and participatory modelling in fisheries management
- Lessons from participatory modelling in JAKFISH case studies
- The changing role of science and stakeholders in underpinning the knowledge base for fisheries management

Participatory modelling in natural resource management

Policy-makers in fisheries management are seeking increased public participation in decision-making (EC, 2009, EC, 2002). This is a general trend in environmental policies that goes back to the Rio declaration (UNCED, 1992, principle 10 on public participation) and the Aarhus convention (UNECE, 1998). The EC White Paper on European Governance (EC, 2001) lists participation as one of the five principles of good governance.

What lessons can be drawn from the application of participatory modelling techniques in natural resource management? And how can we define participatory modelling in the first place? Recently there have been a number of special issues devoted to participatory modelling in scientific journals (Bousquet and Voinov, 2010, Dreyer and Renn, 2011a). "Participatory modelling" is not a "clear-cut concept" but rather "an emerging umbrella term covering a variety of possible ways of linking modelling with participation" (Dreyer and Renn, 2011a) including situations where the participation only deals with the *use* of models. That is where participatory modelling is different from other concepts like 'group model building' and 'mediated modelling' (See Voinov and Bousquet, 2010 for a review of concepts). The broad notion of participatory modelling embraces the involvement of stakeholders in one or more stages of the modelling process: data collection, model definition, model construction, model validation and model use (Dreyer and Renn, 2011a, Hare, 2011).

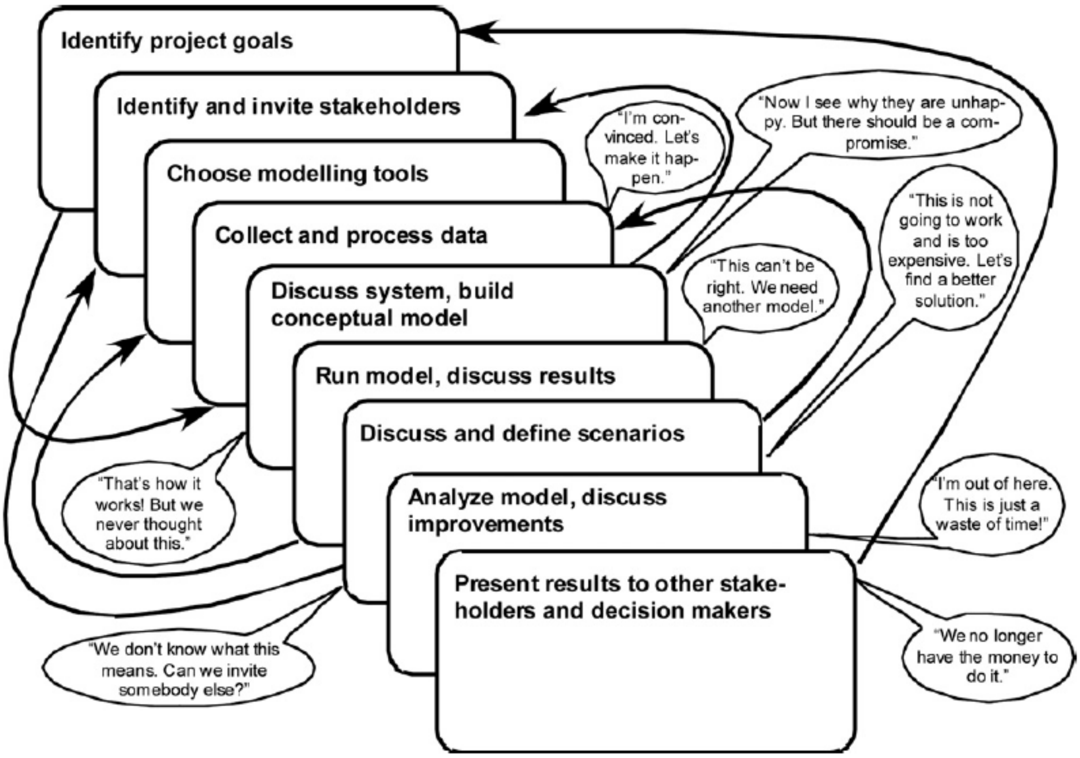

Figure 1.1 Different stage of a participatory modelling process (Voinov and Bousquet, 2010)

There are three main reasons why public participation could be beneficial for policy-making: 1) public engagement, 2) conflict resolution and 3) improving decision quality (Coffey, 2005). While these three categories may be applicable to public participations in general, for participatory modelling we have so far mainly seen examples of the first category (public engagement and social learning) and the third category (decision quality and improving the knowledge base) (Voinov and Bousquet, 2010). Conflict resolution could be approached using 'mediated modelling' approaches (Van den Belt, 2004). Finally, another motivation for participatory modelling could be to advance scientific understanding of the potential applications and conditions for participatory modelling (Dreyer and Renn, 2011b).

Public engagement through participatory modelling can be expected to result in social learning about the system complexities and feedback loops. This can be achieved by actively involving stakeholders in the framing and validating of a modelling process (Ravera et al., 2011, Edwards and Smith, 2011), by mental modelling (Haapasaari et al., 2011a) or by gaming approaches (Stefanska et al., 2011, Borodzicz and Drakeford, 2011) to involve stakeholder groups in simplified but still marginally realistic explorations of system properties.

The problem framing involves all relevant stakeholders and turns attention to the socially constructed character of management problems. It is not just about values and interests, and also incorporates stakeholders' perceptions and lines of reasoning (Jones et al., 2011, Clark and Stankey, 2006). It shows that people have different mental models about how systems work (Verweij et al., 2010, Verweij and van Densen, 2010). Making explicit how different stakeholders or groups piece together a problem through mental modelling (Jones et al., 2011) or influence diagrams (Kuikka, 1999) can facilitate social learning and lead to better communication.

The FISHEX1 role play simulation that was developed in the JAKFISH project addresses risk perceptions in fishery management by competing stakeholders and considers how they could be encouraged to negotiate with each other. The aim of the simulation is to reconcile different mental models of stakeholders by achieving common understandings about the risks in the fisheries system. The role play methodology enable players to interact and negotiate their demands which brings about psychological fidelity (Borodzicz, 2005) and enables players to take on the role of different stakeholders. The key element appears to that that players can perceive and understand the world from a different viewpoint than their own ('role reversal').

Improving the decision quality and the knowledge base has been a key focus for much of the participatory modelling case studies that have been described recently (Hegland and Wilson, 2009, Ulrich et al., 2010, Squires and Renn, 2011). A key example is the work carried out on Western Horse Mackerel by an ad-hoc consortium of the Pelagic RAC and individual scientists (Hegland and Wilson, 2009). This process led to the first step of the implementation of a management plan for this stock in 2008 and was based on participatory modelling where the main challenge was to develop a harvest strategy for a species for which a regular stock assessment could not be carried out. At the time is was considered as a considerable success by the participants even though the implementation of the management plan turned out to be rather different from the evaluation that took place in the participatory modelling process.

The Invest in Fish South West project (Squires and Renn, 2011) involved stakeholders in bio-economic modelling as a tool to support consensus building on policy recommendations for European marine fisheries. Squires and Renn describe the project as an attempt to implement an analytical–deliberative process and emphasize that this concept can act as a catalyst to improve the performance of participatory modelling, including support of social learning.

The implied (but not explicit) consequence of improving decision quality is that the acceptance of measures derived from the participatory knowledge base will be higher and therefore more effective. However, Jacobsen et al argue that these expected benefits are largely dependent on the overall framing of fisheries management (Jacobsen et al., 2011). The framing can either be approached from solving a commons dilemma or from making effective bureaucratic regulations for the fishing industry. Fisheries managers and many natural scientists start from the latter approach while the fishing industries and many social scientists start from the former. If participatory science is merely intended for "increasing knowledge and …. as a tool to incorporate fishers into the dominant system to make them share the rationalities", it is unlikely that the acceptance of measures by the fishers will be nominally higher (Jacobsen et al., 2011).

It is important to design the participatory modelling process with a clear purpose in mind (emphasizing collective decision-making on policy or management options and social learning as two distinct purposes). A challenge in this process is dealing with the complexity of simulation models for stakeholder involvement and uptake of participatory simulation modelling by policy-makers and managers in actual policy and management decision-making.

Best practices in participatory modelling (Voinov and Bousquet, 2010):

1. Keep it flexible and focus on the process rather than the product.

2. Environmental systems are open in time and space: make the process that deals with them also open and evolving. Promote adaptive management, adaptive modelling and adaptive decision-making
3. Maintain societal and scientific openness, and transparency of methods and models. Rely on collaborative research, and open source models
4. Mind the people. Always be aware of social and group dynamics, special interests, power and hierarchies
5. Facilitate and encourage learning - learn from each other and the process
6. Go in circles and branch out - go back, reiterate, refine
7. Accept a different kind of uncertainty - be certain about uncertainty
8. Accept untraditional metrics of success - group validation and verification

When designing a participatory modelling process, it is essential to reflect and decide on which professionals to include in which part of the process. There is general agreement that there is a need for both modelling expertise and facilitation expertise. Careful choice is required between the option to have these two types of expertise provided by a single person, and the alternative option to have the facilitator and modeller roles fulfilled by different individuals.

The critical issues is of course: is more participation always better (Wesselink et al., 2011, Stange, 2012, Eckley, 2001)? The real issue to be addressed is: what are we trying to achieve? And: is participation the best way to realise these goals? In looking for participatory research and modelling we should "not to lose sight of the ironies of real power politics, and thereby safeguard realism and reflexivity in our strivings for more participatory and deliberative democracy'' (Hoppe, 2011 p. 19). Similarly, in a workshop co-organized by the European Environmental Agency in 2001, the experiences of participants challenged the assumption that "more participation is always better" (Eckley, 2001). They argued for a critical reflection on how participation affects the outcome of a policy process by assessing the links between participation and credibility, salience and legitimacy. For example, involving stakeholders in the first phase of a participatory knowledge process has the potential to increase both legitimacy and salience. Below we will use these attributes to evaluate the outcome of the participatory modelling case studies in the JAKFISH project.

Lessons from participatory modelling in JAKFISH case studies

In the JAKFISH project, a variety of types, forms and tools of participatory modelling were identified and tested in four case studies (Table 1.2) over a three year period (Röckmann et al., 2012). Unfortunately there was no formal evaluation process associated with the participatory modelling case studies (Jones et al., 2009, Maru et al., 2009, Eckley, 2001), so the reconstruction below is based on an ad-hoc and post-hoc methodology (Röckmann et al., 2012, Dreyer and Renn, 2011b).

Table 1.2 Overview of JAKFISH participatory modelling case studies, adapted from (Röckmann et al., 2012)

Case study	Western Baltic Spring Spawning Herring	Central Baltic herring	Mediterranean swordfish	North Sea Nephrops

Case study	Western Baltic Spring Spawning Herring	Central Baltic herring	Mediterranean swordfish	North Sea Nephrops
Topic	Harvest Control Rule	Improving stock assessment	Management Strategy Evaluation	Long Term Management Plan
Purpose	Social learning and improving decision quality	Social learning and understanding participatory modelling	Improving decision quality	Improving decision quality
Methods	Informal roundtables FLR model	Influence diagrams Bayesian meta-model	FLR model	Port meetings outline for FLR model
Participants	Scientists PRAC, BSRAC (EC policy makers)	Scientists 6 stakeholders	Scientists ICCAT experts (Greek) fishers	Scientists NSRAC
Participation	High level of participation in workshops	In interview sessions and during final workshop	During ICCAT sessions and targeted meetings with fishers	Scientists participated in NSRAC meetings.
Output	Conclusion document by focus group (JAKFISH, 2010) and policy recommendations by stakeholder organizations (PRAC, 2010, BSRAC, 2010)	Stakeholder workshop and questionnaires Potentially new assessment methodology	ICCAT scientific paper	Presentation at JAKFISH symposium, March 2011
Outcome	No LTMP implemented (yet) because Norway was not involved in evaluation process.	No impact on ICES stock assessment methodology (yet)	Recommendation by ICCAT (2011-03)	LTMP development continues despite low input from JAKFISH process.
Credibility	Scientists participated in individual capacities. Results have not been through scientific peer-review.	Results will be published in peer-reviewed papers. Credibility not rated highly in evaluation.	Results have been through ICCAT peer-review system.	Was low because the scientific methods were not appropriately explained or substantiated.
Salience	Salience was high because stakeholders and policy-makers contributed	Not considered to improve salience of stock assessment	Salience was high because the results could be taken up in specific regulations	Salience was lacking because the participatory process did not address the key management issues
Legitimacy	Legitimacy was compromised because Norway was not part of the process.	Legitimacy high because different perspectives were combined.	Legitimacy was suboptimal because only Greek fishers were included in the process.	Legitimacy increased because different stakeholders felt their perspectives were being included.
Reference	(Ulrich et al., 2010)	(Haapasaari et al., 2011a, Mäntyniemi et al., 2011)	(Tserpes et al., 2011)	---

Western Baltic Spring Spawning herring Harvest Control Rule

Western Baltic Spring Spawning (WBSS) herring is managed in a complex governance scheme in which the EU and Norway are involved and where various stocks and sub-stocks of herring co-exist, originating from both the Western Baltic Sea and the North Sea (ICES, 2010). A single Total Allowable Catch (TAC) is agreed and applied for the whole area of this stock. On the EU side, two Regional Advisory Councils (Pelagic RAC and Baltic Sea RAC) provide recommendations on the management of the stock.

The European Commission (EC) requested ICES to provide parameters for Harvest Control Rules for pelagic stocks in the Baltic Sea (ICES, 2009) including the Western Baltic Spring Spawning (WBSS) herring. This request accelerated and framed the participatory modelling process initiated in JAKFISH (Ulrich et al., 2010) because a joint action was required from scientists (i.a. ICES) and stakeholders (i.a. RACs). The participatory modelling purposes were to improve social learning (about assessment and evaluation techniques) and to improve decision quality (by joint scenario selection).

The participatory modelling process consisted of three steps:

1. creating a common understanding of the process and the implications of simulation-based Management Strategy Evaluation using the FLR framework (Kell et al., 2007)
2. evaluating a number of alternative management scenarios
3. reaching agreement and commitment on a preferred Harvest Control Rule (PRAC, 2010, BSRAC, 2010, JAKFISH, 2010).

Scientists and stakeholders jointly selected scenarios and evaluation criteria, which ensured a broad scope and high relevance (salience) of the evaluation process. Because the initial request has been formulated by the EC, the stakeholder participation became to be restricted to members of the joint Pelagic RAC and Baltic Sea RAC focus group. This meant that Norway was not involved in the participatory process.

The participatory process lasted about one year. A relatively large amount of time was spent on getting acquainted with each other and on problem framing. A consensus was reached on the preferred Harvest Control Rule, which was submitted to the European Commission by the separate RACs (PRAC, 2010, BSRAC, 2010). Afterwards, it became clear that there were still unresolved political issues around the sharing of the TAC across areas, fleets and Coastal States. An important lesson learned from the WBSS case study is the need to discuss all potentially conflicting issues and especially the politically sensitive ones, early in the process. Mutual understanding of motivations, concerns, wishes and expectations are essential to a successful participatory modelling process.

Despite the efforts in the participatory process, an actual management decisions has not yet been agreed because of unresolved differences of opinion between Coastal States.

Stakeholders' views and reflections on the relevance and quality of the JAKFISH approach were attempted through a questionnaire, but the return was low and could not be used for analysis. However, stakeholders were eager to participate in a joint publication that was presented at the ICES Annual Science Conference (Ulrich et al., 2010). Stakeholders expressed appreciation of the collaboration that had developed during the JAKFISH project but they also emphasized that stakeholders' objectives differ from scientists' objectives: developing the HCR came first in their priorities and learning about participatory modelling was only second.

An overall assessment on the performance of the WBSS herring participatory process on the three main attributes:

- Credibility: the scientists participated in individual capacities. Results of the participatory process have not been through a scientific peer-review.
- Salience was high because stakeholders and policy-makers contributed jointly.
- Legitimacy was compromised because Norway was not part of the process.

Improving stock assessment of Central Baltic herring

According to the ICES scientific advice, Central Baltic herring is "harvested unsustainably" and the biomass is "stable but low" (ICES, 2012). There appears to be a reduced growth-rate for this stock for which different well-justified hypotheses exist. The competing hypotheses could lead to potentially opposite management advice. The JAKFISH Central Baltic herring case study set out to test alternative probabilistic models around different model hypothesis in discussions with stakeholders. The main purpose of the participatory modelling was to improve social learning (about alternative hypothesis) and to improve the understanding how participatory modelling could be used as an integrated assessment tool.

The participatory modelling steps were to:

1. integrate stakeholders' knowledge into the modelling of Baltic herring population dynamics
2. formalise this integration
3. explore the consequences of alternative management options based on the integrated knowledge
4. examine structural uncertainty related to management of the herring stocks.

Six stakeholders (fisheries managers, scientists, fishers and conservationists) from four Baltic Sea countries were asked to convert their knowledge about stock assessment and management of the Central Baltic herring into model hypothesis using one-to-one facilitated modelling sessions. Graphical causal systems models were used to develop separate biological models and fishery management models for each of the stakeholders. The conceptual models were based on assumptions about causalities and factors influencing the biological and management processes affecting the Central Baltic herring. The strengths of the assumed causalities were expressed as probabilities (Jensen, 2001). The participatory modelling exercise revealed very diverging views between stakeholders about factors influencing the population dynamics of herring. Despite the diverging views there was – to some extend - agreement about beneficial management actions.

The six individual stakeholder models were afterwards pooled and combined with scientific data by the JAKFISH main case study researcher into a single meta-model using Bayesian model averaging (Mäntyniemi et al., 2011). Formulating the stakeholder views as a mixture of multivariate normal distributions simplified the meta-modelling task and increased the possibility to take the stakeholder views into account. However, such a simplification could not account for relationships that are hard to linearize by simple transformations. The approach results in a mixture of stakeholder views and the views of the case study researcher.

Each of the stakeholders participated in two workshops. The first was arranged for each stakeholder separately in which the model development was carried out independently of the others. The second combined workshop took place at the end of the project where the individual and analysed models of all stakeholders were presented, discussed and open for feedback.

Two questionnaires were distributed to the six stakeholders: first after the completion of the modelling work, and second after the final workshop. All stakeholders participated in the second workshop and all stakeholders returned carefully filled in questionnaires. The stakeholders identified several benefits in the participatory modelling approach to improve stock assessments and management and help people understand and commit to management. The process also facilitated communication, cooperation and understanding between stakeholders. However, the stakeholder also had reservations against the "subjective approach" of the Bayesian method, the small sample size and the “calibration” of the models against the historical catch data, which was thought to be flawed to an unknown extent (Haapasaari et al., 2011a, Haapasaari et al., 2011b).

An overall assessment on the performance of the Central Baltic herring participatory process on the three main attributes:

- Credibility: results will be published in peer-reviewed papers. Credibility not rated highly in the project evaluation.
- Results are not considered to improve the salience of stock assessment
- Legitimacy is relatively high because different perspectives have been combined. However, the low number of participants negatively affects legitimacy.

Mediterranean swordfish Management Strategy Evaluation

The International Commission for the Conservation of Atlantic Tunas (ICCAT) is the relevant management authority for Swordfish in the Mediterranean. ICCAT combines the management authority with scientific capacity to assess stocks (through the Standing Committee on Research and Statistics SCRS). Mediterranean swordfish is considered over-exploited with current spawning stock biomass is more than 40% lower than the biomass that would support maximum sustainable yield (ICCAT, 2010). The biological and management situation is complex: Mediterranean swordfish is assessed as a single stock but there are indications that it consists of several independent sub-stocks with unknown rates of mixing. There is a large amount (50 – 70%) of juveniles in the catches and catch misreporting of undersized fish is occurring (ICCAT, 2009).

The ICCAT Commission requested for an evaluation of the impact of different recovery measures, such as temporary closures, capacity reduction and quota management schemes. This request was picked up by JAKFISH to set up a participatory modelling process involving ICCAT scientists and Greek stakeholders (fishers, local fisheries managers) with the aim to develop and evaluate management scenarios for the Mediterranean swordfish. The overall purpose was to improve decision quality by involving different groups of stakeholders in the modelling process.

Different management scenarios were developed and evaluated using FLR-based simulation tools (Kell et al., 2007, Tserpes et al., 2011, Tserpes et al., 2009). Results of management strategy evaluations were presented and discussed iteratively in four ICCAT Scientific Commission meetings and simplified presentations were given in three meetings with Greek fishers. The feedback from both types of meetings facilitated the final development of scenarios, the incorporation of uncertainties and the definition of acceptable risks.

The timing of the participatory process fitted well with the formal ICCAT process. The ICCAT Scientific Committee provided a general outline of the management scenarios that should be evaluated in the JAKFISH process. This facilitated a quick, focused and pragmatic start of the case study in terms of model selection and development. Uncertainties and acceptable risks were defined at a later stage during the process.

Greek fishers raised questions about certain types of uncertainties that were not considered in the management strategy evaluations (e.g. the effects of climate change). But because of a lack of relevant scientific knowledge, these issues were not taken up in the modelling process. One could argue that a truly participatory process would have allowed for a different problem framing because of the inputs from the fishers. Instead, the case study continued as originally foreseen. The ICCAT stakeholders had a stronger influence on the framing of the case study than the Greek fishers.

The results of the participatory modelling has resulted in a ICCAT recommendation on swordfish (ICCAT, 2011). ICCAT member states subsequently reached consensus on one specific technical measure that was recommended (seasonal closure). This measure emerged because of the apparent link with the biology of the stock.

An overall assessment on the performance of the Mediterranean swordfish participatory process on the three main attributes:

- Credibility: results have been through ICCAT peer-review system.
- Salience was high because the results could be taken up in specific regulations
- Legitimacy was suboptimal because only Greek fishers were included in the process and not all their concerns were included in the process.

North Sea Nephrops Long Term Management Plan

North Sea Nephrops is managed as an EU resource under a single TAC for the whole area. Nephrops are known to aggregate in relatively fixed aggregations ("functional units") with little exchange between them. The Nephrops case study was selected in JAKFISH because the North Sea RAC was already well underway with the development of a Long Term Management Plan for Nephrops fisheries (NSRAC, 2009). In addition, there were different objectives between stakeholder groups (e.g. small coastal fisheries vs. large offshore fisheries) and there are high uncertainties in the scientific advice. The main purpose of the case study was improving decision quality and the knowledge base but social learning and consensus building were also envisioned.

When the case study started, specific scientific goals had been listed relating to a spatial framework for TAC setting, rules for effort distribution and fleet structure. The scientists perceived the biggest challenge in the FLR programming (Kell et al., 2007) to simultaneously use several dimensions (time, length, sex, area) and to solve the “age and length” modelling dilemma, to produce alternative growth models for nephrops and to establish a link between fishing mortality and effort for different gear types.

The Nephrops case study had a slow and difficult start. Neither stakeholders nor scientists knew what was expected from each other and the objectives and process were not clearly formulated. Scientists felt stuck not knowing what the stakeholders wanted to have evaluated using their framework for evaluation. And stakeholders in the NSRAC were unaware of the potential contributions to be expected from the scientists. A joint problem framing was not achieved. As a result, stakeholders and scientists have not managed to fully engage around a participatory model development.

The case study started to pick up again towards the end of the JAKFISH project when there was a revival to engage scientists and stakeholders in a set of joint problem framing workshops. These workshops were attended by NSRAC representatives and regional smallscale fisheries. The workshop enhanced the understanding of the main issues and requirements to account for in a future management plan.

The Nephrops case study is an example of lack of communication and mutual understanding between scientists and stakeholders. There were very different perceptions about the achievements of the case study. The JAKFISH scientists experienced a case study with significant delays and problems which negatively affected outcomes. From the stakeholders' perspective "almost all the fishers believed that it was right to protect the stocks via long term management plans", and "Importantly – Fishers felt they had been listened to" (Park, 2011).

Mutual problem framing in an open, transparent and flexible way is an essential first step in a participatory modelling process. This allows the identification of stakes, problems, possibilities and needs. The actual modelling should only start after the need for modelling has been jointly stated and the goal of modelling has been identified. In the Nephrops case study, it appears that the JAKFISH scientists had perceived the modelling as too much centre-stage and that participation was secondary.

Mutual trust benefits from open and transparent communication. The historical relationship between fisheries and science has left some legacies of mistrust amongst parties. The ability to overcome these is crucial to the success of mutual problem framing.

Mutual learning is often necessary to create a common knowledge basis and understanding of what is required and possible. One-way education of scientists "teaching" the stakeholders should be avoided. In the Nephrops case study, the initial scientific modelling goals had been too ambitious and not realistic and the toolbox, proposed by the scientists, was not suitable.

An overall assessment on the performance of the North Sea nephrops participatory process on the three main attributes:

- Credibility was low because the scientific methods were not appropriately explained or substantiated.
- Salience was lacking because the participatory process did not address the key management issues
- Legitimacy increased because different stakeholders felt their perspectives were being included.

Reflection on the participatory modelling case studies

We consider transparent two-way communication a key factor for an effective extended peer review process where scientists and stakeholders acknowledge uncertainties, reflect on knowledge gaps and take into account a realistic time frame. Participatory modelling has the potential to facilitate and structure discussions between scientists and stakeholders, contribute to social learning, increase legitimacy and advance scientific understanding. However, when approaching real life problems, modelling should not be seen as the priority objective. Rather, the crucial step in a science-stakeholder collaboration is the joint problem framing in order to ensure that the relevant problems are tackled.

Based on our experiences and the stakeholders' feedback received through the extended peer review, we note that the stakeholders' purposes of participating in modelling are likely to diverge from scientist' objectives (Jacobsen et al., 2011). This needs to be realized and acknowledged when entering a participatory modelling process. Scientists need to be aware of the broader political and societal processes in which the modelling takes place and stakeholder need to be aware of the limitations and possibilities of the modelling process.

The Western Baltic Herring and Mediterranean swordfish case studies were examples where the modelling efforts were closely linked with actual developments of harvest control rules (as part of Long Term Management Plans). In these cases we simulated and helped develop management scenarios that addressed the issues important for stakeholders and policy makers. The case studies objectives were discussed in meetings with the key stakeholders at the start of the project.

In contrast, the central Baltic herring case study had mostly an academic motivation: studying and modelling different stakeholder views on herring population dynamics and fisheries management. Here there was no pressing management issue that was being addressed. Nevertheless, the timing and level of stakeholder involvement was carefully planned at the beginning of the study. Stakeholders were well informed from the start but already during the process they raised their concerns over the practicalities of incorporating such an approach into a possible management framework. So even though the case study did not aim to have a direct impact on a fisheries management framework, to many of the stakeholders this was an important (implicit) motivation to participate.

The North Sea Nephrops case study stood out as a very different process compared to the other three case studies. Here, scientists and stakeholders had different agendas in mind and could not find a way to bridge the gap. What was supposed to develop as a participatory modelling exercise, ended up being mainly used for improving communication to clarify this situation and establishing long-term goals. Taking on a “facilitation” strategy, as proposed by Hanssen et al. (2009), could have been much more rewarding, as scientists would have focused on reducing societal dissent from the beginning of the case study instead of initially focussing on modelling and uncertainties only.

The review of the literature on participatory modelling has pointed out the importance of early stakeholder involvement (Eckley, 2001, Voinov and Bousquet, 2010, Dreyer and Renn, 2011b) in order to achieve the purpose of increasing legitimacy of and compliance with resulting management measures. This can now be confirmed through the four JAKFISH case study experiences.

The JAKFISH case studies pointed out the challenges of time and timing and the issue of financial resources to sustain the participatory modelling. The participatory modelling process confronts the participants with the steps of forming (get to know each other), storming (frame the problem, express ideas, map conflicts and misunderstandings etc.) and norming (develop common understanding and agree on main objectives) before it can reach the performing step of the modelling phase itself (Tuckman 1965, Mackinson et al. 2009). Depending on the context, the initial phases of getting acquainted can be very time-demanding. In most cases, this time can hardly be reduced because it also covers the time for deliberation and maturation of the issues being discussed. The inclusion of the participatory modelling process within a broader political and scientific agenda, such as in the pelagic and Mediterranean cases, helps to manage the overall time requirements. Regular milestones and political requests for advice by external parties, forced the scientists and stakeholders to keep on track and deliver operational outcomes and maintain motivation and commitment to the participatory modelling project at a high level.

Participatory modelling techniques in fisheries management are considered as a way forward in developing transparent procedures for generating and using knowledge. However, computer-based models are becoming increasingly large and complex. The quest for more holistic, integrated approaches that take into account different uncertainties conflicts with the ambition for greater transparency. The four JAKFISH case studies illustrate different ways of handling this conflict. The pelagic and Mediterranean case studies used a fairly standard management strategy evaluation approach based on single-stock projections with available stock assessment data. In these cases the assumptions and issues in the models could be explained in relatively simple terms. In contrast, the Nephrops and Baltic case studies represent situations where the standard modelling approaches were not suited and where new, non-standard approaches were needed. In the Baltic case, the integrative model development had been the explicit objective but the usefulness was questioned by the stakeholders involved. In the Nephrops case, the scientists focused on developing an innovative model that would fit the specific Nephrops biology and fisheries but only to find that the stakeholders were already questioning the standard model, let alone the potentially new and more complex model. Discussing the trade-off between model complexity and transparency at the start of the participatory modelling process seems a prerequisite to develop an effective participatory process.

In the Western Baltic herring and the Mediterranean swordfish case studies, the main differences in perception among stakeholders and scientists were not accounted for as structural uncertainty but rather as irreducible sources of uncertainties. These were translated into larger confidence intervals around the corresponding biological parameters in the simulation models. This resulted in lower target fishing mortalities to maintain pre-agreed stock levels with a certain probability (Ulrich et al. 2010, Tserpes et al. 2009, 2011). These approaches brought probabilities about biological issues at the heart of the modelling and management discussions but could not address the uncertainties associated with decision-making, implementation of measures or adaptation strategies by fishermen. The net effect is that the modelling reinforced the traditional view of science for fisheries management through stock assessment and biological processes.

So will participatory modelling only work when there is an agreed method? Of the four participatory modelling case studies that were carried out in JAKFISH, two were relatively successful in the sense that they generated actual participatory modelling work and conclusions from them (WBSS herring case, Mediterranean swordfish case). In those two cases the basic scientific method was not disputed (age-based approach in Management Strategy Evaluation framework) and was based on state of the art in the field. It did not require new developments or techniques, but mainly focussed on scenarios and outcomes. This is almost a description of the puzzle solving properties of „normal science“ within the dominant „paradigm“ as described in the classic work by Thomas Kuhn (Kuhn, 1962).

The two case studies that did not result in clear recommendations (nephrops case, Baltic case) proved to be examples where the normal science paradigm had not been established. Nephrops is a species that is currently not assessed using age-based techniques that are underlying the dominant Management Strategy Evaluation frameworks. Therefore this could not be an issue of puzzle solving and instead the focus had to be on devising an acceptable paradigm. So this could be an example of post-normal science. Stakes are high (nephrops presents an important economic component for several north sea fisheries), scientific knowledge is uncertain (many unknowns on these short-lived, bottom inhabiting animals and about the dynamics in fisheries) and decisions urgent (in order to develop a management plan and obtain MSC accreditation). So this is where post-normal science should apply and deliver new mechanisms for bridging the science-policy divide. Yet, what we observed is that in this situation the JAKFISH approach to participatory modelling has not been able to bridge the gap. Whether this is dependent on the particular arrangement in the nephrops case study or that is a more systematic feature of participatory modelling is not known at this stage but it does provide a challenging idea to the notions of normal science and post-normal science.

The changing role of science and stakeholders in underpinning the knowledge base for fisheries management

If participatory modelling or participatory knowledge arrangement is going to have an impact in the fisheries management communities, we need to understand how these communities are structured and developed. What impact does the structure organization of the science-policy network have on patterns of agreement about biological and economic facts? This is the research question that is at the heart of the JAKFISH social network analysis of the marine management science-policy communities in six case studies[1] (Goldsborough et al., 2012). Interactions among stakeholders and exchange of knowledge are important for successful management and policy planning because they help stakeholders to communicate their positions, understand their peers' point of views, and negotiate deals and compromises (Crona and Hubacek, 2010, Bodin and Prell, 2011). Social network analysis is a quantitative methodology designed to analyse patterns of interactions and exchange between social actors. We used social network analysis to assess the implications of different ways that scientists, managers and other stakeholders organise their common work within an overall fisheries management framework in four EU case studies, one in Australia and one in the USA. Each case study was carried using a uniform sequential procedure: discourse analysis, survey design, online survey, social network analysis and interpretation of the results in the context of the discourse analysis. Network visualization (sociograms) was carried out using Pajek (De Nooy et al., 2011) and provides an indication of the differences between the networks in the case studies (Figure 1.2). Two important metrics that describe the properties of the networks are the *indegree centralization* that measures whether there are just a few key experts or that there is a more distributed network[2] and *network heterogeneity* that measures the proportion of links between individuals of different groups[3].

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[1] The case studies in the social network analysis do not overlap with the participatory modelling case studies except for the Mediterranean swordfish case studies.

[2] *Indegree centralization* is an indicator (between 0 and 1) for the distribution of nominations by respondents. A high indegree centralization indicated that there is a concentration of interactions on a small number of experts. A low indegree centralization indicates that it is a more distributed network where respondents tend to nominate different experts.

[3] *Network heterogeneity* is an indicator (between 0 and 1) that describes the proportion of links between actors of different groups. A low heterogeneity (e.g. 0.3) indicates that the actors tend to discuss with partners in their own group as their most frequent discussion partners. A high network heterogeneity (e.g. 0.7) indicates that the actors discuss often with partners from other groups.

Gulf of Riga herring (Figure 1.2-A)

The Gulf of Riga herring case study examined fisheries management practices within Estonia. The top-down nature of this management system and the absence of specific institutions for stakeholder participation is reflected in a high indegree centralization (50%, only a few actors play an important role in the network) and a high network heterogeneity (75%, because few formal institutions exist)

Baltic Salmon Finland (Figure 1.2-B)

The Baltic Salmon management in Finland is a highly contentious issue that regularly features in the Finnish media and in meetings where people with different interests get together. Most stakeholder types mingle in the discussion network although the commercial fishers and landowners remained relatively separate and mainly linked to the rest of the network through national and district level government officials. The regional organisation of salmon management in Finland shows up in the sociogram with several clusters of experts (indegree centralization of 37% indicates modest concentration on key experts) from different stakeholder types interacting (network heterogeneity of 66% shows substantial mixing). There is one strong central governmental actor, most likely linked to the national (decision) level.

Baltic Salmon International (Figure 1.2-C)

The Baltic Salmon international management network within the EU deals with the wild salmon stocks in the Baltic Sea that have mostly been depleted during the 20th century. This network shows a high number of interactions within the scientists community and within the stakeholder community with links provided by the management authorities. The network heterogeneity of 31% is the lowest of the case studies, indicating that the experts largely interact within their own group. The indegree centralization of 29% indicates that it is a rather distributed network where many are perceived as experts. The Baltic Sea RAC and the ICES assessment working group meetings play an important organizing role in this network.

Mediterranean swordfish (Figure 1.2-D)

The Mediterranean swordfish fishery is an international fishery with at least 11 countries targeting the stock. Fisheries management is carried out through ICCAT. The response rate to the survey was low in the Mediterranean swordfish case study (only 31%). This is reflected in this network because there are many experts not actually connected to the network. The network shows a cluster in the top right corner representing interactions between actors in the Greek national setting. Although one actor (a scientist) appears to be central in the network, the indegree centralisation is only 22% indicating that it is a rather distributed network. The network heterogeneity of 56% indicates substantial discussions between experts from different stakeholder types, but communication across stakeholder types happen mainly in local or national contexts and less at the international level of ICCAT where scientific advice and political decisions are made. Scientists appear to see each other as the important discussion partners in this network.

New England groundfish USA (Figure 1.2-E)

The New England groundfish fishery management in the United States deals with a complex of 19 stocks (12 species) of demersal finfish. The fishers pursue these stocks in the Gulf of Maine, Georges Bank and southern New England waters using a variety of gear types. Management is institutionalized through the New England Fisheries Management Council (NEFMC) that brings together a diverse group of participants (government officials, fishers, NGOs and scientists).

Most actors take part in the discussions in this distributed network[4] (indegree centralization is only 24%) and with a relatively high level of discussions between actors of stakeholder groups (network heterogeneity of 54%).

Northern prawn Australia (Figure 1.2-F)

The Australian Northern prawn fishery consists of 52 trawlers from fishing ports between Brisbane and Perth. The fishery is managed by a multi-purpose co-management arrangement, developed after years of facilitated multi-stakeholder workshops. The management system and legislation places a strong emphasis on a partnership approach among fisheries managers, scientists, and relevant stakeholders.

The network shows frequent discussions between experts from different stakeholder types (network heterogeneity of 48%) and a relatively distributed network although with a number of experts that appear to be central (indegree centralisation of 39%). These central respondents represent each of the stakeholder groups in the management council. Only a few of the fisheries respondents appear to play an important role in the network.

Reflection on the social network analyses

The two important network characteristics that were used in this analysis (*network heterogeneity* and *indegree centralization)* showed some positive correlation. This suggests that active stakeholder interaction requires the organizing efforts of a few central actors. If this is so, then the idea of “participation” would need "unpacking" from a network perspective because it shows how different participatory roles are played out in real-life situations where decisions are being made and how leadership and participation are connected. It is not so much about participation per se, but more about who organizes and frames the participation that really matters.

When experts discuss matters more with experts from other stakeholder groups, their values, interests, opinions and knowledge are generally less similar because consensus within a stakeholder group is generally higher than consensus between groups. This would mean that more participation in knowledge production or policy-making, does not necessarily lead to more agreement on facts or values but they could succeed in establishing discussion relationships among experts. On the other hand, management systems with low participation like the Gulf of Riga herring case study, could show more consensus on facts

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[4] Unfortunately, there are a number of errors in the sociogram in the allocations of individuals to different stakeholder types. This is particularly the case for four of the key respondents who should have been labelled "Scientist".

and values just because stakeholders lack opportunities to take up and discuss controversial ideas.

The original hypothesis driving this work has been "*who people actually talk to, how frequently they talk to them, and the qualities of those discussions can have an impact on how much they agree on facts when they disagree on values and interests".* This is directly linked to how formal institutions are expressed in actual interactions. It is evident and important that proper forms of communication express controversies over both facts and values and that these two kinds of assertions are tightly related because people interpret facts to defend values. Given that such controversy is the norm in participatory approaches to management what are the potential tools that can lead to increased agreement on facts by those who disagree on values and interests? The case studies on participatory modelling showed that these methods could be an important tool for improving agreement on facts.

Another important tool could be derived from a deeper understanding how scientists deal with uncertainties in the underpinning and justification of management decisions. We looked at the scientific justification for the boundaries for marine protected areas on the Dogger Bank (Degnbol, 2012). This may seem like a very different topic than participatory modelling but there are clear relationships between the two in terms of understanding the role of scientists, knowledge and uncertainty in decision-making processes. The study focussed on the parallel processes in the UK and Germany for defining where the boundaries are of the sandbank habitat type on the Dogger Bank.

We found that communicating complexity and uncertainty is not a one-way process where scientists help other stakeholder to understand complexity and uncertainty. Instead, the dynamics can go both ways. In the UK case, some of the main (governmental) stakeholders also informed the scientists about the concerns they wanted to have addressed and which kind of justification they would find appropriate and which level of uncertainties they would find acceptable. Here the stakeholders took part in formulating the quality criteria for science and these criteria have actually directed some of the scientists' choices (Degnbol, 2012). Communicating complexity and uncertainty does not only happen *after* the research process but is essentially something that is produced *during* the research process. In both the UK and Germany, an integrated part of the researchers' scientific decision-making has been to consider which uncertainties and complexities they wanted to produce, reduce or accept and how these would be understood and perceived by stakeholders. In the UK case, the scientists have interacted directly with the government stakeholders and to a lesser extent with other stakeholders. In the German case, the considerations of the scientists were mainly based on their assumptions about what stakeholders might perceive as proper justification.

The type of considerations scientists and stakeholders have had about the science in the UK and Germany illustrates an important difference between *scientific proof-making* (which is evaluated against set of internal scientific criteria and therefore links to *credibility*) and *scientific justification* (which is evaluated by a broader audience consisting of government officials, industry stakeholders, environmental NGOs, the European Commission and scientific peers and links to *legitimacy*). In the UK, the need for scientific justification added a number of quality criteria to those which count among scientific peers. These additional quality criteria depend on the particular policy issue, the stakes involved and the broader audience that are to evaluate the justification.

Whether scientific uncertainty becomes an issue in a policy making context does not just depend on the amount of uncertainty but also on the stakes involved and the burden of proof placed on the science. The claim in the EU Habitats Directive that site designation is an exclusively scientific exercise places all the burden of proof on the science and this can trigger a disproportionate attention to scientific complexity and uncertainty.

Translating these results to the topic of participatory modelling we could hypothesize that participatory modelling reflects a case of scientific justification where it is not just the scientific review process that should be evoked, but also an extended peer review community to make sense of the results and their applicability to solve real world problems.

Conclusion: when and how to participate and to model?

So after carrying out the four participatory modelling case studies and assessing the content of six social networks, we ask the question: has it made a difference? What changes can be observed in the social networks that are underlying the case studies or in the fisheries management processes that aim to regulate the fisheries?

It is still too early to fully assess the direct impacts of the participatory modelling work on fisheries management decisions. What we can observe is that an agreed Long Term Management Plan for WBSS herring has not been agreed (yet) despite the participatory modelling efforts and the more or less joint stakeholder recommendations to the policy-makers. In retrospect, we can also observe that the socio-political context within which the case study developed has been underestimated, especially where the links between the EU and Norway are concerned.

However, the involvement of an "extended peer community" in the process of participatory modelling has lead to a mutual learning on the framing of the key issues to be addressed. We can infer that the results obtained in those cases have greater legitimacy compared to a closed scientific process which produces results from a black box. However, in the nephrops case the participatory modelling never really materialized and the mutual learning experience was less developed. This clearly shows that for participatory modelling to develop, there is a need for a shared understanding of what the key challenges are and an understanding of the ambitions and motivation of the scientists and the stakeholders. A check list of relevant questions to aks before the start of a participatory modelling process could contain the following questions:

- Will the participatory modelling contribute to decision-making or will it be limited to knowledge development?
- What are the main stakes and uncertainties?
- What is the structure of the network (heterogeneous? Centralized?)
- Are there strong disagreements expected on facts or on values?
- Do potential participants already familiar with each other?
- Will actors be available for the lifespan of the project?
- Are key actors missing?
- Will the available tools be sufficient to service the modelling process? Are they open enough for new ways of thinking and framing?

In the study on the boundaries of the Dogger Bank, stakeholders were very interested in the details of the scientific justifications because of the implications provided by the Natura

2000 regulations. In contrast, the stakeholders in the participatory modelling processes of JAKFISH seemed to be less concerned with the scientific justification and more interested in the outcome of the modelling process. This can be explained by the differences in the role that science plays in the two situations. On the Dogger Bank case, science was used to directly underpin policy (even backed up by European law). In the participatory modelling processes the science is used to explore different management scenarios which could be used to underpin the advice from the stakeholders to the policy-makers.

Is more participation always better? The real issue to be addressed is: what are we trying to achieve? And: is participation the best way to realise these goals (Wesselink et al., 2011, Stange, 2012, Eckley, 2001)? In looking for participatory research and modelling we should "not to lose sight of the ironies of real power politics, and thereby safeguard realism and reflexivity in our strivings for more participatory and deliberative democracy'' (Hoppe, 2011 p. 19). Looking back on the JAKFISH participatory modelling case studies, these are exactly the issues that came up but that were overlooked in the design of the cases. Assessing the socio-political context in which the participatory modelling will take place is an essential element of starting up such projects. In order to understand how participation affects the outcome of a policy process, it is important to assess the links between participation and credibility, salience and legitimacy and develop a strategy on how to handle these. So how will we make sure that the results of the participatory modelling will be credible? Will we formalize a review process (and if so, who will we involve)? How will we make sure it is salient and legitimate? These are important and necessary elements of a design document.

A very important element in participatory modelling projects in natural resource management (and probably in other areas as well) is a clear strategy on the evaluation of the outcome of the projects. Monitoring and evaluation of the whole process from inception to reporting is essential to assess the impacts of the work on the system we are trying to change. Jones et al (2009) provide a protocol for evaluating participatory modelling project through the "protocol of Canberra" which consists of two main components: the Designers Questionnaire (capture the project team' experience and the logic of the design) and the Participants Evaluation Guide (capture experiences of all participants in the project). This type of evaluation could provide the basis for making stronger claims on whether social learning, increasing legitimacy and an improved knowledge base have been established in the project.

Finally, the JAKFISH work has shown that for participatory modelling to work well, there is a need to train scientists in making connections between scientific and stakeholder communities (Dankel et al., 2012). And it needs a realization that participatory modelling is essentially built on trust, and that takes time.

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References

Bodin, O., and Prell, C. 2011. Social Networks and Natural Resource Management: Uncovering the Social Fabric of Environmental Governance. Cambridge University Press.

Borodzicz, E. P. 2005. Risk, Crisis and Security Management, Wileys, Chichester.

Borodzicz, E. P., and Drakeford, B. 2011. FISHEX 1: A Prototype Simulation for Stakeholder Management in Fisheries JAKFISH Deliverable D2.6.1.

Bousquet, F., and Voinov, A. 2010. Preface to this thematic issue. Environmental Modelling and Software, 25: 1267.

BSRAC. 2010. BS RAC recommendations for a multi-annual plan for pelagic stocks in the Baltic Sea.

Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., and Jäger, J. 2002. Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making. RWP02-046.

Clark, R. N., and Stankey, G. H. 2006. Integrated research in natural resources: the key role of problem framing..   . Gen. Tech. Rep. PNW-GTR-678. Portland, OR. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 63 p.

Clark, W. C., Tomich, T. P., Van Noordwijk, M., Dickson, N. M., Catacutan, D., Guston, D., and McNie, E. 2010. Toward a General Theory of Boundary Work: Insights from the CGIAR’s Natural Resource Management Programs. RWP10-035.

Coffey, C. 2005. What role for public participation in fisheries governance? *In* Participation in Fisheries Governance, pp. 27-44. Ed. by T. S. GRAY. Springer, Dordrecht.

Crona, B., and Hubacek, K. 2010. The right connections: how do social networks lubricate the machinery of natural resource governance? . Ecology and Society, 15: 18.

Dankel, D. J., Aps, R., Padda, G., Rockmann, C., van der Sluijs, J. P., Wilson, D. C., and Degnbol, P. 2012. Advice under uncertainty in the marine system. ICES Journal of Marine Science, 69: 3-7.

Daw, T., and Gray, T. 2005. Fisheries science and sustainability in international policy: a study of failure in the European Union's Common Fisheries Policy. Marine Policy, 29: 189-197.

De Nooy, W., Mrvar, A., and Batagelj, V. 2011. Exploratory Social Network Analysis with Pajek. Revised and Expanded Second Edition. , Cambridge University Press.

Degnbol, D. 2012. Qualitative analysis of scientists-stakeholders interactions that address uncertainty and complexity in developing effective policies: scientific justification on the Dogger Bank JAKFISH Deliverable D5.2.

Degnbol, P., Gislason, H., Hanna, S., Jentoft, S., Raakjaer Nielsen, J., Sverdrup-Jensen, S., and Clyde Wilson, D. 2006. Painting the floor with a hammer: Technical fixes in fisheries management. Marine Policy, 30: 534.

Dreyer, M., and Renn, O. 2011a. Participatory Approaches to Modelling for Improved Learning and Decision-making in Natural Resource Governance: an Editorial. Environmental Policy and Governance, 21: 379-385.

Dreyer, M., and Renn, O. 2011b. Some guidance on how to use participatory modelling in fisheries governance: A synopsis of the literature reviews. JAKFISH Deliverable D2.6.2.

EC. 2001. Communication from the Commission: European governance, a white paper. COM(2001) 428.

EC 2002. Council Regulation (EC) No 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy.

EC. 2003. Communication from the Commission. Improving Scientific and Technical Advice for Community fishery management. COM (2003) 625.

EC. 2008. Communication from the Commission to the Council and the European Parliament: Review of the functioning of the Regional Advisory Councils. COM(2008) 364.
EC. 2009. Green paper: reform of the common fisheries policy. COM(2009) 163.
Eckley, N. 2001. Designing effective assessments: The role of participation, science and governance, and focus. No. 26.
Edwards, V. M., and Smith, S. 2011. Lessons from the Application of Decision-support Tools in Participatory Management of the New Forest National Park, UK. Environmental Policy and Governance, 21: 417-432.
Funtowicz, S. O., and Ravetz, J. R. 1993. Science for the Postnormal age. Futures, 25: 739-755.
Funtowicz, S. O., and Ravetz, J. R. 1994. UNCERTAINTY, COMPLEXITY AND POST-NORMAL SCIENCE. 1881-1885.
Gibbons, M., Limoges, C., Nowotny, H., Schwartzmann, S., Scott, P., and Trow, M. 1994. The new production of knowledge, Sage, London.
Goldsborough, D., Berner, L., Haapasaari, P., Johnson, T., Wilson, D. C., and Pastoors, M. A. 2012. A social network analysis of six marine management science policy communities. JAKFISH Deliverable D5.1.
Haapasaari, P., Mäntyniemi, S., and Kuikka, S. 2011a. Baltic herring fisheries management: stakeholder views to frame the problem. subm.
Haapasaari, P., Mäntyniemi, S., and Kuikka, S. 2011b. Involving stakeholders to build integrated fishery models. subm.
Haas, P. M. 1989. Do regimes matter - Epistemic communities and mediterranean pollution-control. International organization, 43: 377-403.
Halffman, W. 2008. States of Nature: Nature and Fish stock reports for policy. V13.
Hanssen, L., Rouwette, E., and Van Katwijk, M. 2009. The Role of Ecological Science in Environmental Policy Making: from a Pacification toward a Facilitation Strategy. Ecology and Society, 2009.
Hare, M. 2011. Forms of Participatory Modelling and its Potential for Widespread Adoption in the Water Sector. Environmental Policy and Governance, 21: 386-402.
Hegland, T. J., and Wilson, D. C. 2009. Participatory modelling in eu fisheries management: Western Horse Mackerel and the Pelagic RAC. MAST, 8: 75-96.
Holm, P., and Nielsen, K. N. 2004. The TAC Machine. *In* WGFS 2004.
Hoppe, R. 2005. Rethinking the science-policy nexus: from knowledge utilization and science technology studies to types of boundary arrangements. Poiesis & Praxis: International Journal of Technology Assessment and Ethics of Science, 3: 199-215.
Hoppe, R. 2009. Scientific advice and public policy: expert advisers' and policymakers' discourses on boundary work. Poiesis & Praxis: International Journal of Technology Assessment and Ethics of Science, 6: 235-263.
Hoppe, R. 2011. Institutional constraints and practical problems in deliberative and participatory policy making. Policy & Politics, 39: 163-186.
ICCAT. 2009. Analysis of Mediterranean Swordfish Management Measures. ICCAT Col. Vol. Sci. Pap. 64: 1959-2068.
ICCAT. 2010. Report of the 2010 Mediterranean swordfish stock assessment meeting. http://www.iccat.int/Documents/Meetings/Docs/2010_MED_SWO_ASSESS.pdf.
ICCAT. 2011. Recommendation for management measures for Mediterranean swordfish in the framework of ICCAT. Rec 11-03.
ICES. 2008. Strategic Plan: A vision worth sharing.
ICES. 2009. Report of the Workshop on Multi-annual management of Pelagic Fish Stocks in the Baltic (WKMAMPEL), 23 - 27 February 2009 ICES Headquarters, Copenhagen, ICES CM 2009/ACOM:38.

ICES. 2010. Report of the Herring Assessment Working Group for the Area South of 62°N (HAWG). 15-23 march 2010, Copenhagen, Denmark. ICES CM 2010: ACOM 06.
ICES. 2012. Report of the ICES Advisory Committee, 2012. http://www.ices.dk/committe/acom/comwork/report/2012/2012/Her-2532-Ex-Go.pdf.
Jacobsen, R. B., Wilson, D. C., and Ramirez-Monsalve, P. 2011. Empowerment and regulation – dilemmas in participatory fisheries science. Fish and Fisheries, 13: 291-303.
JAKFISH. 2010. Conclusions from Focus Group meeting on Western Baltic Spring Spawning herring, 9th March 2010.
Jasanoff, S. 1990. The fifth branch; science advisers as policymakers.
Jensen, F. V. 2001. Bayesian Networks and Decision Graphs, Springer Verlag, New York.
Jones, N., Perez, P., Measham, T. G., Kelly, G. J., d'Aquino, P., Daniell, K., Dray, A., et al. 2009. Evaluating Participatory Modeling: Developing a Framework for Cross-Case Analysis. Environmental Management, 44: 1180-1195.
Jones, N. A., Ross, H., Lynam, T., Perez, P., and Leitch, A. 2011. Mental models: an interdisciplinary synthesis of theory and methods. Ecology and Society, 16: 46.
Kell, L. T., Mosqueira, I., Grosjean, P., Fromentin, J. M., Garcia, D., Hillary, R., Jardim, E., et al. 2007. FLR: an open-source framework for the evaluation and development of management strategies. ICES Journal of Marine Science, 64: 640-646.
Kuhn, T. S. 1962. The structure of scientific revolutions.
Kuikka, S. 1999. Parameter and structural uncertainties in Bayesian decision analysis. ICES C.M. 1999 / T:04.
Mackinson, S., Wilson, D. C., Galiay, P., and Deas, B. 2011. Engaging stakeholders in fisheries and marine research. Marine Policy, 35: 18-24.
Mäntyniemi, S., Haapasaari, P., and Kuikka, S. 2011. Incorporating stakeholders' knowledge to stock assessment: central Baltic herring. subm.
Maru, Y., Alexandridis, T. K., and Perez, P. 2009. Taking 'participatory' in participatory modelling seriously. 18th World IMACS / MODSIM Congress, Cairns, Australia 13-17 July 2009.
Merton, R. K. 1968. Social theory and social structure. , New York Free Press, New York.
Mikalsen, K. H., and Jentoft, S. 2008. Participatory practices in fisheries across Europe: Making stakeholders more responsible. Marine Policy, 32: 169-177.
Nielsen, K. N., and Holm, P. 2007. A brief catalogue of failures: Framing evaluation and learning in fisheries resource management. Marine Policy, 31: 669-680.
NSRAC. 2009. Meeting of the Nephrops Long Term Management Plan Development Group. Tuesday 14th April 2009. Pentland House, Edinburgh.
Österblom, H., Sissenwine, M., Symes, D., Kadin, M., Daw, T., and Folke, C. 2011. Incentives, social–ecological feedbacks and European fisheries. Marine Policy, 35: 568-574.
Park, M. 2011. Long Term Management Plan for North Sea Nephrops - Incorporating Stakeholders into the decision making process Presentation at the JAKFISH final symposium, Brussels,9 March 2011.
Pielke, R. A. 2007. The Honest Broker: making sense of science in policy and politics, Cambridge University Press.
Piet, G. J., van Overzee, H. M. J., and Pastoors, M. A. 2010. The necessity for response indicators in fisheries management. ICES Journal of Marine Science, 67: 559-566.
PRAC. 2010. A LTM plan for WBSS herring.
Ravera, F., Hubacek, K., Reed, M., and Tarrasón, D. 2011. Learning from Experiences in Adaptive Action Research: a Critical Comparison of two Case Studies Applying Participatory Scenario Development and Modelling Approaches. Environmental Policy and Governance, 21: 433-453.

Rijnsdorp, A. D., Daan, N., Dekker, W., Poos, J. J., and Van Densen, W. L. T. 2007. Sustainable use of flatfish resources: Addressing the credibility crisis in mixed fisheries management. Journal of Sea Research, 57: 114-125.
Röckmann, C., Ulrich, C., Dreyer, M., Bell, E., Borodzicz, E. P., Haapasaari, P., Hauge, K. H., et al. 2012. The added value of participatory modelling in fisheries management – what has been learnt? Marine Policy, 36: 1072-1085.
Schwach, V., Bailly, D., Christensen, A.-S., Delaney, A. E., Degnbol, P., van Densen, W. L. T., Holm, P., et al. 2007. Policy and knowledge in fisheries management: a policy brief. ICES Journal of Marine Science, 64: 798-803.
Sissenwine, M., and Symes, D. 2007. Reflections on the Common Fisheries Policy.
Squires, H., and Renn, O. 2011. Can Participatory Modelling Support Social Learning in Marine Fisheries? Reflections from the Invest in Fish South West Project. Environmental Policy and Governance, 21: 403-416.
Stange, K. 2012. What we talk about when we talk about participation. Wageningen University.
Stange, K., Olsson, P., and Österblom, H. 2012. Managing organizational change in an international scientific network: A study of ICES reform processes. Marine Policy, 36: 681-688.
Stefanska, J., Magnuszewski, P., Sendzimir, J., Romaniuk, P., Taillieu, T., Dubel, A., Flachner, Z., et al. 2011. A Gaming Exercise to Explore Problem-Solving versus Relational Activities for River Floodplain Management. Environmental Policy and Governance, 21: 454-471.
Symes, D. 2009. Reform of the European Union's Common Fisheries Policy: Making Fisheries Management Work. Fisheries Research, 100: 99-102.
Tserpes, G., Tzanatos, E., and Peristeraki, P. 2011. Use of risk analysis for the evaluation of different management strategies for the mediterranean swordfish stock. SCRS/2010/086.
Tserpes, G., tzanatos, E., Peristeraki, P., Placenti, V., and Kell, L. T. 2009. A bio-economic evaluation of different management measures for the Mediterranean swordfish. Fisheries Research, 96: 160-166.
Ulrich, C., Coers, A., Hauge, K. H., Clausen, L. W., Olesen, C., Fisher, L., Johansson, R., et al. 2010. Improving complex governance schemes around Western Baltic Herring, through the development of a Long-Term Management Plan in an iterative process between stakeholders and scientists. ICES C.M. 2010 / P:07.
UNCED. 1992. Declaration of the UN Conference on Environment and Development.
UNECE 1998. Convention On Access To Information, Public Participation In Decision-Making And Access To Justice In Environmental Matters (UNECE).
Van den Belt, M. 2004. Mediated Modeling. A System Dynamics Approach to Environmental Consensus Building Island Press.
Van Hoof, L. J. W., Hoefnagel, E., van der Schans, J. W., Nielsen, J. R., Christensen, A.-S., Sverdrup-Jensen, S., Delaney, A., et al. 2005. Sharing responsibilities in fisheries management; final report. Report 7.05.05.
Verweij, M. C., and van Densen, W. L. T. 2010. Differences in causal reasoning about resource dynamics and consequences for the participatory debate on North Sea fisheries. Marine Policy, 34: 1144-1155.
Verweij, M. C., van Densen, W. L. T., and Mol, A. J. P. 2010. The tower of Babel: Different perceptions and controversies on change and status of North Sea fish stocks in multi-stakeholder settings. Marine Policy, 34: 522-533.
Voinov, A., and Bousquet, F. 2010. Modelling with stakeholders. Environmental Modelling and Software, 25: 1268-1281.

Wesselink, A., Paavola, J., Fritsch, O., and Renn, O. 2011. Rationales for public participation in environmental policy and governance: practitioners' perspectives. Environment and Planning A, 43: 2688-2704.
Wilson, D. C. 2009. The paradoxes of transparency: science and the ecosystem approach to fisheries management in Europe, Amsterdam University Press.
Yearley, S. 2006. Bridging the science - policy divide in urban air-quality management: evaluating ways to make models more robust through public engagement. Environment and Planning C: Government and Policy, 24: 701-714.

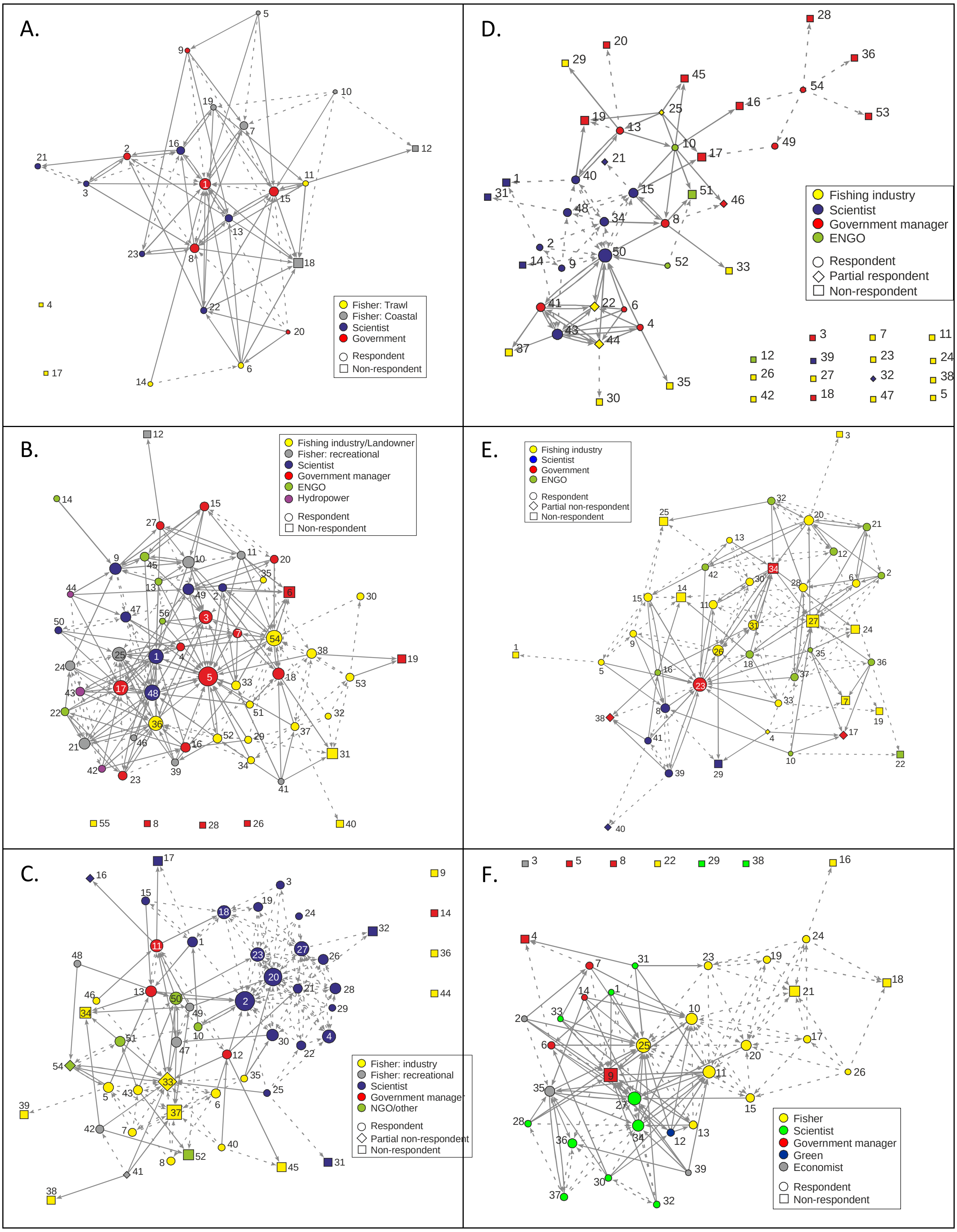

Figure 1.2 Sociograms of the discussion network in the Social Network Analyses: a) Gulf of Riga herring, b) Baltic Salmon Finland, c) Baltic Salmon International, d) Mediterranean swordfish, e) New England groundfish USA and f) Northern prawn Australia. The colours represent different stakeholder groupings. The vertex size represents the number of ties directed to the node. Dashed lines represent within-group ties and solid lines represent between-group ties. Note: the sociogram for New England groundfish USA contains a number of errors in the allocations of individuals to different stakeholder types.