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Policy brief: institutions, practices and tools to address complexity, uncertainty and ambiguity in participatory fisheries management. An attempt to redefine the institutional role of science in EU fisheries policies.

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Abstract

Fisheries management in the European Union appears to face a substantial crisis in the legitimacy of the scientific underpinning of policy. Feelings of distrust exist among different groups of actors: fishers don’t believe the scientists, scientists don’t believe the fishers, policy makers don’t believe the fishers etc. Fisheries science is acknowledged to be fundamentally uncertain and findings are often open to alternative interpretations. The history of fisheries policy in Europe has shown a development that has been termed the “TAC machine” by authors: an annual cycle of stock assessment and TAC (Total Allowable Catch) decisions which create an interlocked system of mutual dependencies mainly between policy makers and fisheries scientists. Recently, there have been many attempts to redefine the role of fisheries science in fisheries management. One of these attempts can be characterised as “participatory fisheries modelling”: a process of joint model development between stakeholders and scientists with the aim to inform future management decisions.

The JAKFISH project (Judgement and Knowledge in Fisheries Management involving Stakeholders) has specifically looked at participatory modelling as a potential tool to enhance mutual understanding and increase legitimacy. A dual approach was followed: on the one hand several case studies of participatory modelling were carried out and monitored and on the other hand an analysis of institutions and social networks was conducted to inform future arrangements.

A key findings are that participatory modelling appears to be most instrumental when already a clear and agreed methodology exists and that participants (stakeholders, scientists) to some extent have aligned expectations of the possible outcomes. The inverse situation where such an agreed methodology did not exists or when expectations were diverging, did not generate really instrumental results. The participatory modelling case studies have shown that they can achieve certain results but that they require a substantial investment in time and resources. Therefore, there needs to be prioritization of which cases should or could enter a full participatory modelling process. A pre-evaluation of probability of success could screen for: network involved (legitimacy of scientists and stakeholders, previous linkages between stakeholders), availability of data and methods, purpose and timing of stakeholders involvements and inks to a decision making process.

A major finding from the social network analysis is that networks where individuals within groups are in frequent interaction, through participatory decision-making, does not necessarily lead to more agreement on facts or values. At the start of the JAKFISH project we hypothesized that 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. 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 experiments with participatory modelling have shown that that can – in some cases – be used to get agreements on facts. The detailed study on the Dogger Bank decision-making, has further shown that when science is produced to directly underpin policy (even backed up by European law), participation will be constituted very differently compared to a more exploratory role of science. An important distinction to be made is between **scientific proof-making**, which is evaluated against set of internal scientific criteria, and **scientific justification,** which is evaluated by a broader audience consisting of scientific peers,

government officials, industry stakeholders and environmental NGOs) next to the scientific peers. In the Dogger Bank case, this has added a number of quality criteria to those which count among scientific peers. These additional quality criteria depend on and vary with the particular policy issue, the stakes involved, and the particular extended audience that are to evaluate the justification.

Whether scientific uncertainty becomes an issue in a policy making context, not only depends on the amount of uncertainty, but also on the stakes involved and the burden of proof placed on the science. The claim in the European Habitats Directive that site designation is an exclusively scientific exercise, which places all the burden of proof on the science, can trigger disproportionate attention to scientific complexity and uncertainty, particularly where stakes are high, as they are in the UK case.

The JAKFISH project has shown that participatory modelling requires an effective facilitation strategy where scientists, stakeholders and policy-makers actively connect and discuss. There is a need to train the participants in these process. It needs the realization that participatory modelling both builds trust and is built on trust, that it takes time and effort and that the outcome is more than the individual parts.

1 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, 2003). However, the CFP is widely criticized for not delivering on the ecological sustainability (Daw and Gray, 2005), on the economic sustainability (REF) and on social sustainability (refs) (Symes, 2009). In addition the scientific underpinning of the actual decision-making has been under heavy debate for many years already (Sissenwine and Symes, 2007, Piet et al., 2010, Degnbol et al., 2006)[more refs].

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). Fisheries science and fisheries management in Europe have to a large extend 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 VPAs and producing short term predictions) and policy makers (deciding on TACs). Alcock argues that institutional structures affects perceptions of salience, credibility and legitimacy of science and found that "fisheries stock assessment processes that are embedded within policymaking organizations are more influential within those organizations than outside of them" (Alcock, 2004). 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).

So how can the science for European fisheries management be characterized. A small excursion into the philosophy of science is appropriate here. Scientific support for fisheries management is often justified by the independent and objective position that the scientists have in the policy domain (ICES, 2008). This often 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 a direct societal impacts. Concept like regulatory science and boundary work (Jasanoff, 1990, Yearley, 2006), Mode II science (Gibbons et al., 1994), epistemic communities (Haas, 1989), post-normal science (Funtowicz and Ravetz, 1994). 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 fisheries management debate. Post-normal science is thought to apply when stakes are high, scientific knowledge uncertain and decisions urgent, which often is the case for fisheries. 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.

The process of the extended peer review is already 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. Stakeholder have gained a formal advisory status in policy making. 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 projects that has experimented with forms of participation of stakeholders in fisheries management. JAKFISH has specifically looked at participatory modelling as a potential tool to enhance mutual understanding and increase legitimacy. 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, 2011), 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., 2011), and we studied the institutional aspects of participatory science for management.

In this policy brief we intend to summarize the JAKFISH results with a specific focus on the potential policy implications of these findings.

2 How participatory modelling helps (or not)

2.1 Participatory modelling in natural resource management

The review of participatory modelling in natural resource management made a conceptual and empirical contribution to the growing field of research on participatory modelling in natural resource governance. There is a recent trend in the scientific literature to discuss participatory modelling as the multifarious ways in which a modelling exercise can be linked to stakeholder involvement. It is important to design the participatory modelling exercise 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.

Key conclusions that are drawn:

- Be upfront and precise about purpose, timing, type and level of involvement
- Define what is sought to be achieved
    - Collective learning for consensus-building and / or conflict reduction

- Knowledge incorporation and quality control for better management decisions
    - Higher levels of legitimacy of and compliance with management decisions
    - Advancing scientific understanding of potential and implementation requirements of participatory modelling
- Define when to involve stakeholders and their particular contribution sought
    - Direct involvement: Providing input to model **construction**
    - Indirect involvement I: Providing input to **framing** the modelling endeavour
    - Indirect involvement II: Providing input to **evaluating** modelling steps
    - Indirect involvement III: Providing input to **using** the model

When designing a participatory modelling process, it is essential to reflect and decide on which professionals to include in the exercise. 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 segregated and fulfilled by different individuals. If special expertise in modelling was deemed indispensable for successful facilitation, the first option might be regarded as the best choice.

Fisheries management simulation game

FISH EX1 is a role play simulation which looks at how competing stakeholders develop risk perceptions in fishery management and considers how they could be encouraged to negotiate with each other. The aim of the simulation is to consider how different stakeholder mental models can be reconciled by achieving common understandings about the risks to fish stocks through the use of a role play simulation exercise.

The simulation uses a role play methodology to enable players to interact and negotiate their demands. The aim is not to re create reality itself, rather, to bring about psychological fidelity (Gredler, 1992, Borodzicz, 2005) and enable players to take on the role of stakeholders and simulate the negotiation process. The simulation experience also helps players to perceive and understand the world from a different viewpoint to their own. The exercise takes the form of a role play simulation lasting about 1- 2 hours, the exercise is designed to be used with actual stakeholders, although not playing their own roles. Players do not need to be experienced in the roles they perform.

2.2 Participatory modelling (short description of the cases and the overall results; taken from D6.1):

The four JAKFISH case studies shed light on possible ways, their pros and cons to put the concept into practice. A variety of types, forms and tools of participatory modelling were identified and tested in case studies over a one to three year time frame. Thanks to the available project funds and scientific working time, the case studies could maturate and develop within their own context. Some stakeholders had only limited time available. It is likely that lack of time and money limits any operational version of the participatory modelling methodologies.

The details of how the uncertainties were addressed varied by case study, but in all cases extensive discussions between scientists and RAC/ ICCAT stakeholders were found to be an important precursor to creating the atmosphere of goodwill required to openly address the uncertainties in a participatory, transparent, clear and understandable manner. The Western Baltic Herring and the Mediterranean case studies developed along fairly similar, pragmatic tracks, while the central Baltic herring and the Nephrops cases followed their own paths. The models used (standard as well as the non-standard approaches) were open for modifications based on stakeholder input but each model contained some core elements that had been pre-framed by scientists.

A final reflection about successes and failures based on our participatory modelling experiences: we consider transparent two-way communication a key factor for an effective extended peer review process where scientists and stakeholders acknowledge uncertainties, mutually reflect on knowledge gaps that may really matter, and take into account a realistic time frame. We conclude that participatory modelling has the potential to facilitate and structure discussions between scientists and stakeholders about uncertainties and the quality of the knowledge base; it can contribute to collective 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 an open, transparent way, 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 (often called Long Term Management Plans). In these cases we simulated and helped develop realistic 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 contract, 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 completely different agendas in mind and could not find a way to bridge the gap between science and stakeholders. 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 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.

Timing

The JAKFISH case studies pointed out the challenges of time and timing and the issue of financial resources to sustain the participatory modelling which implies working with a group of people with different background and knowledge. The 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.

Model complexity

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 would be 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.

Integrating different forms of knowledge

Participatory modelling is sometimes expected to "integrate all types of knowledge (empirical, technical and scientific) from a variety of disciplines and sources" (Voinov and Bousquet 2010). However, practical implementation is difficult. The Investinfish South West (IiFSW) project faced methodological difficulties when trying to integrate stakeholders' non-scientific knowledge into a bio-economic model at the model development stage (Squires 2009). The Baltic case study pushed forward this exercise of knowledge integration successfully by developing formalized approaches (mental modelling and conditioning of stakeholder-models on various sources of available data (Mäntyniemi et al. 2009)), but the stakeholder appreciation of the final outcome was relatively low and the costs in terms of scientific time and skills were high.

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.

Communication tools and user-friendliness

Van der Sluijs (2001, 2002) found that the usefulness of complex computer-based models was rated higher by non-scientific stakeholders if the following information and communication tools were used: (i) a comprehensible and detailed user manual; (ii) an understandable model presentation; (iii) an interactive and attractive user interface; (iv) a comprehensible account of uncertainties; and (v) an adequate model moderation. This checklist seems appropriate if the stakeholders are expected to be directly involved in the model development and use. However, none of our four cases provided all of these five requirements. All communication processes in the case studies were articulated around points (ii), (iv) and (v).

Good examples of the development of user-friendly interfaces for non-technical (expert) users are models such as Investinfish South West (IiFSW 2007), TEMAS (Sparre 2003, Ulrich et al. 2007, Andersen et al. 2010) or ISIS-Fish (Mahévas and Pelletier 2004). However, stakeholders did never use these models on their own, often due to lack of time and capacity. In reality, stakeholders mostly asked the scientists to provide the answers to their requests. The usefulness of an interactive and attractive user interface (iii) will increase, if it is tailored to the potential user group and their needs.

If many scenarios and hypotheses are to be explored, it seems more adequate to have a model interface friendly for the scientists rather than for the stakeholders, i.e., it should be flexible, generic, compute fast, and generate synthetic and clear output. A model interface with buttons, menus, etc. obliges the modelling to follow some fixed and pre-defined lines set up by the original model developer, and this may come at costs in terms of flexibility to address new thoughts and ideas, and may create parameterization issues if data is lacking to fit the model frame (Andersen et al. 2010).

2.3 Who participated in the participation?

The participatory modelling case studies in JAKFISH were approached from a rather pragmatic point of view: how can JAKFISH help to address an issue that is raised by stakeholders and that could be amenable to participatory modelling. The results of the case studies have been described above.

In this section we will provide a reflection on the participatory nature of the participation. Unfortunately a formal social network analysis has not been carried out for the participatory modelling case studies (except for the Mediterranean swordfish case study), and therefore we merely attempt to reflect on the case studies taking into account the lessons we have drawn from the institutional analyses

The social networks in the four participatory modelling case studies have very different properties.

- The pelagic case study involved a network with a relatively limited number of people who were reasonably familiar with each other and with the scientific methodologies applied in fisheries modelling. One main research institute, one dominating industry organization with long experience, and historical good collaboration between the two of them. There were a small number of key-informants that were able to cross the science-stakeholder domains effectively.
- The Baltic case represented a small but broad network of people originating from different backgrounds and professional roles. There was no real key-informants in the system and this is reflected by the rather widely different perspectives that resulted from the mental modelling process.
- The Nephrops case was a very broad and diffuse network of which some of the network members has substantial experience in science-stakeholder collaboration but where also a substantial number of members had no prior engagement or were even sceptical of the ambition for participatory modelling. In this case there were no leading key-informants that were driving the process.
- The swordfish case was a rather hierarchical social network with a lot of focus on science and management. In this case there was a key person in the network who easily crossed the border between science and policy and who, from the social network analysis was shown to attract most of the relationships with other members of the network.

It appears that the success of a participatory process can be related to a certain extent to individual personal skills: is there a key “informant”, a person that is willing and able to communicate with stakeholders and scientists and who understands both the basic scientific background and main drivers and interests for different stakeholders?

Another important explanatory factor for the performance of the social networks in the participatory modelling cases is the role that stakeholders perceive to have and their assessment on the potential to influence actual policy decision. If there is a real scope for action (pelagic case, swordfish case) there is commitment and determinacy to „solve the issue“ whereas in situations where the role of the end product is less clearly defined (nephrops case, Baltic case) the impact of participatory modelling is lower.

2.4 Paradigms and the distinction between normal science and post-normal science.

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 (pelagic case, 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 were post-normal science should apply and deliver new mechanisms for bridging the science-policy divide. Yet, what we observe is that in this situation the JAKFISH approach to participatory modelling as 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.

2.5 Can participatory modelling make a difference?

So after carrying out the four participatory modelling case studies, 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.

In terms of direct impacts on fisheries management decisions, it is still too early to judge. The pelagic case has contributed to the development of a management plan that was proposed to the European Commission. However, to date, the European Commission has not drawn up the management plan that they intend to submit to the European Council of Ministers for approval.

The task division in the pelagic and swordfish cases has been that the scientists in the process presented windows for decision making (range of acceptable scenarios based on overall policy objectives) and trade-offs between the various options. Stakeholders would then interact with scientists to determine optimal scenarios and required outputs.

The added value of involving an “extended peer community” in the process of participatory modelling has lead to a mutual learning on the framing of issues (both in the scientific domain and the stakeholder domain) and thereby we can infer that the results obtained in those cases have greater legitimacy compared to a closed scientific process.

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.

3 How institutions help (or not)

3.1 Social networks and institutions

What impact does the organization and interactions of the science policy network have on patterns of agreement about biological and economic facts? This is the research question that was at the heart of the JAKFISH deliverable 5.1 "A social network analysis of a marine management science policy community for six case studies". Using social network analysis techniques we assessed 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 and two case studies outside the EU. Each case study was carried using a uniform sequential procedure: discourse analysis, survey design, online survey, social network analysis, interpretation of the results in the context of the discourse analysis.

The case studies with high participation (in decision-making) tended to have negative network autocorrelation (hence more disagreement). This result suggests that in a more participatory management system, there is higher disagreement among experts possibly because they result from discussion relations among experts with different values, interests, and knowledge.

Two important network characteristics used in the analysis were Network Heterogeneity[1] and Input Degree Centralization[2] were found to not fully describe participation. The two measures show some correlation. Input degree centralization appears to be positively related to heterogeneity. 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.

[1] Indicator (between 0 and 1) that describes the proportion of links between actors with different personal characteristics. A low heterogeneity (e.g. .45) indicates that the actors tend to discuss with partners with the same characteristics as their most frequent discussion partners. For example fishermen that have many links with other fishermen. A high network heterogeneity (e.g. .75) indicates that the actors tend to discuss with partners with different characteristics as/from their most frequent discussion partners.

[2] Indicator (between 0 and 1) for the distribution of nominations by respondents. A low input degree centralization (.e.g. .35) indicates that a few experts are mentioned by many as their most frequent communication partners while many are not mentioned at all.

When experts discuss matters more with colleagues from other stakeholder groups, their values, interests, opinions, and knowledge are less similar. Consensus within a stakeholder group seems to be higher if the most important discussion partners are selected within the group. So more participation (in science, in policy-making) does not (necessarily) mean more agreement on facts or values. Management systems with low participation might show more agreement because stakeholders lack opportunities to discuss controversial ideas. Higher participatory systems may, however, succeed in establishing discussion relations among experts with different values, interests, and knowledge.

The original design of D5.1 was driven by the underlying hypothesis: *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 the question of how formal institutions are expressed in actual interactions. It is clearly 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.

The edge question that JAKFISH was meant to address follows from this: *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?* We addressed this question both by experimenting with participatory modelling as a method for getting people to focus the conversation on facts and what a "fact" is and by analysing the same question from the broader institutional perspective, i.e. how scientists were dealing with uncertainties in the midst of controversy and the different ways that participation is organized as expressed in the actual interactions of the people involved.

3.2 Scientific proof-making vs. scientific justification

A dedicated study was carried out within the JAKFISH project to analyse how scientists interact with decision makers and stakeholders in dealing with complexity and uncertainty. The basic assumption was that scientists "help other stakeholders to … understand complexity and uncertainty ". We carried out an in-depth study of the scientific justification of boundaries for marine protected areas on the Dogger Bank. 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.

Two important findings from the study discount the traditional image that scientists help others to understand complexity and uncertainty.

1) Communicating complexity and uncertainty is not a one-way process. Instead, the dynamics can go both ways. In the UK case some of the main stakeholders also informed the scientists about the concerns they wanted to have addressed, which kind of justification they would find appropriate and which kinds of uncertainties they would find acceptable. In that way some of the stakeholders have taken part in formulating the quality criteria for science and these criteria have actually directed some of the scientists' choices.

2) Communicating complexity and uncertainty is something that does not only happen after the research process but is essentially something that is produced during the research process. In both of the cases studied, 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. Public communication of scientific complexity and uncertainty was not something that came after the research process but was an integrated part of the scientific process.

In the German and UK designation processes on the Dogger Bank, scientists have considered the stakeholders in their scientific decision making during the research process. In the UK case they have interacted more directly with the government stakeholders and to a lesser degree with other stakeholders. In the German case, scientists' considerations 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 two cases has illustrated an important difference between **scientific proof-making**, which is evaluated against set of internal scientific criteria, and **scientific justification**, which is evaluated by a broad audience (government officials, industry stakeholders, environmental NGOs and the European Commission) next to the scientific peers. In the Dogger Bank case, this has added a number of quality criteria to those which count among scientific peers. These additional quality criteria depend on and vary with the particular policy issue, the stakes involved, and the particular extended audience that are to evaluate the justification.

Whether scientific uncertainty becomes an issue in a policy making context, not only depends 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, which places all the burden of proof on the science, can trigger disproportionate attention to scientific complexity and uncertainty, particularly where stakes are high. The study shows that what counts as scientific justification for the boundaries of the areas depends on the particular publics, stakeholders, governmental departments and other institutions for whom the sites should be justified.

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. The Dogger Bank case showed that the stakeholder interest in the science and uncertainties depended on the kind and amount of stakes the particular stakeholders had in the policy issue: the more stakes, the more concerns for the science and for the uncertainty. In the Dogger Bank case stakeholders were concerned about the kind of data used, the way it was analysed, the way the analysis then led to the definition of boundaries on the Dogger Bank.

4 Way forward

4.1 When and how to participate?

The need for participatory research and participatory modelling has been observed in situations where science has had an important role to play in policymaking, like in fisheries management. But this is seldom where participatory research is carried out. It tends to be carried out in situations where science plays a more explorative and less politically important role (like in the Central Baltic herring case). This is where stakeholder's interests in the details of the scientific methodology are perhaps least outspoken.

In the Dogger Bank study the stakeholders were very interested in the details of the scientific decision-making for the boundaries of the Natura 2000 areas. In the participatory modelling processes in JAKFISH, the stakeholders seem to be less concerned with the scientific decision-making and more interested in the outcome of the modelling process. This can probably be explained by the differences in the role that science plays in the two situations. In the Dogger Bank case, science is produced 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 the stakeholders would like to know the effect of. In the former case stakeholders would often like particular conclusions to come out of it. In the latter case they just want to explore some issues in order for them to reflect on the kind of management they want.

The participatory modelling case studies have shown that they can achieve certain results but that they require a substantial investment in time and resources. Therefore, there needs to be prioritization of which cases should or could enter a full participatory modelling process. A pre-evaluation of probability of success could screen the following items:

- network involved (previous linkages between scientists, stakeholders and policy makers)
- Availability of "science facilitators" to guide the process
- availability of data and methods
- purpose and timing of stakeholders involvements,
- links to a decision making process.

4.2 Role of science: facilitator of pacificator?

Hansen et al (2009) have distinguished between two main roles for scientists in decision-making process: facilitator or pacificator. Translating this to participatory modelling, one first needs to establish whether the participatory modelling would be aspiring for positive changes or not. Is the management issue dealing with an unsatisfactory management that could be improved (e.g. Western Baltic Herring) or is it dealing with unpopular changes that will undermine the current situation or create more constraints (e.g. Dogger Bank, North Sea Nephrops). If positive changes could be achieved, the legitimacy of the final political decision could be less disputed and therefore there will be less pressure on the scientists. If negative changes are likely, then the science will be disputed unless the political decision making is also democratic and transparent.

In any case, 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., 2011). And it needs a realization that participatory modelling is build on trust, and that takes time.

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