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Judgement and Knowledge in Fisheries involving Stakeholders

Final report

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Judgement and Knowledge in Fisheries involving Stakeholder

Final report

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Table of contents

Executive Summary

Stakeholder involvement is perceived as an important development in the European Common Fisheries Policy. But how can uncertain fisheries science be linked with good governance processes, thereby increasing fisheries management legitimacy and effectiveness? Reducing the uncertainties around scientific models has long been perceived as the cure of the fisheries management problem. There is however increasing recognition that uncertainty in the numbers will remain. A lack of transparency with respect to these uncertainties can damage the credibility of science.

The project Judgement and Knowledge in Fisheries Involving Stakeholders (JAKFISH) was a 3 year project with 10 partners from the EU and Norway. It provided an integrated approach to stakeholder involvement into fisheries management and examined the institutions, practices and tools that allow complexity, uncertainty and ambiguity to be dealt with. The JAKFISH project reviewed the general literature on participatory modelling in natural resource management and derived a number of key recommendations from that review. The project also developed a fisheries management simulation game that was successfully applied in a number of occasions.

In four different case studies, the JAKFISH project invited fisheries stakeholders to participate in the process of framing the management problem, and to give input and evaluate the scientific models that are used to provide fisheries management advice. JAKFISH investigated various tools to assess and communicate uncertainty around fish stock assessments and fisheries management. 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 also contribute to collective learning, increase legitimacy, and advance scientific understanding. Modelling should not be seen as the priority objective. The crucial step in a science-stakeholder collaboration is the joint problem framing.

The JAKFISH project also carried out social network analyses of the institutions and networks involved in six fisheries management systems (four in Europe, one in Australia and one in the USA). The results suggest that management systems with high participation in decision-making tended to have more disagreement about facts and values. When experts discuss matters more with colleagues from other stakeholder groups, their values, interests, opinions, and knowledge tend to differ. Consensus within a stakeholder group seems to be higher if the most important discussion partners are selected within the group.

The discussion about the role of uncertainty in natural resource management and decision-making often assumes that it is the scientists that help other stakeholder better understand uncertainties and that this happens after the uncertainties have been identified. Our research refuted both assumption. Communication about uncertainty is clearly a two-way process and it already is happening during the problem framing and research process.

An important difference has been identified between *scientific proof-making* and *scientific justification*. Scientific proof-making is evaluated against set of internal scientific criteria. Scientific justification is evaluated by a broader community consisting of scientific peers, government officials, industry stakeholders and environmental NGOs.

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 places all the burden of proof on the science which then triggers disproportionate attention to scientific complexity and uncertainty, particularly where stakes are high.

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 Summary Description of Project Context and Objectives

JAKFISH aims to learn about basic requirements – whether procedural or structural, for example – to exploit the assumed potential of active involvement of stakeholders in the modelling process. JAKFISH is enhancing understanding of these processes with the use of four case studies, examining how to deal with data-poor stocks and fisheries that generate bycatches of other species, stocks that mix and migrate over different management areas, assessing the different mental models of stakeholders and scientists on herring dynamics in a comprehensive, Bayesian framework, and developing long-term management plans for a stock that is shared over many countries with different interests.

The issues of the stakeholders are the key starting point. JAKFISH then marshals the available social, technical and ecological knowledge to help solve those issues, providing a powerful platform of collaboration. By studying these processes, the project is able to provide recommendations on best practice for collaboration while aiming to develop institutions, practices and tools for dealing with scientific support to policy under high uncertainty, with a focus on European marine governance and in particular on fish harvesting.

The project's approach to applying participatory modelling in its own research is exploratory. The case studies in which the involvement of stakeholders in the modelling process is being explored only partly follow a common approach, with the respective modelling exercise opened up to stakeholders in varied ways. This flexible approach has been chosen because relatively little is still known about what might constitute best practice in participatory modelling methods for natural resource governance.

The institutional and network analysis in JAKFISH is not restricted to the case studies on participatory modelling but extends to case studies in the US and Australia. This is expected to give insight in the properties of social network that are conducive of participatory knowledge development and input into a policy process.

The JAKFISH project reviewed the general literature on participatory modelling in natural resource management and derived a number of key recommendations from that review. The project also developed a fisheries management simulation game that have successfully applied in a number of occasions.

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The JAKFISH project also carried out social network analyses of the institutions and networks involved in six fisheries management systems (four in Europe, one in Australia and one in the USA). The discussion about the role of uncertainty in natural resource management and decision-making often assumes that it is the scientists that help other stakeholder better understand uncertainties and that this happens after the uncertainties have been identified. In JAKFISH a detailed study was carried out to investigate this assumption in the decision-making on the Dogger Bank.

2 Description of the main S&T results

2.1 Review of relevant literature on participatory modelling in natural resource management

JAKFISH has 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 from this work:

- 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
- Account for model complexity as a limiting factor for transparency and stakeholder motivation
- Provide for information and communication tools and stakeholder capacity-building (if required)
- Consider the need for independent verification
- Be aware of the challenge of integrating different forms of knowledge
- Provide sufficient room for deliberation in the participatory modelling process
- Select carefully the professionals that might be needed in the participatory modelling endeavour

Deliverable 2.1 Conceptual reflections on participation in the governance of fisheries and recent EU-level reforms for strengthened stakeholder involvement

Authors: Marion Dreyer, Ortwin Renn, Edward Borodzicz, Ben Drakeford

This deliverable presents a set of concepts which have been evolving in the literature on participation in the governance of risk and the environment in the past decade. The authors consider these concepts particularly useful for advancing discussions about integration of different forms of knowledge and inclusion of stakeholders in fisheries management. The paper identifies a functionalist view of participation in Council Regulation (EC) No 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy and argues that the challenges of integrating science with participation and including a wider diversity of stakeholders requires combining this approach with a deliberative approach to participation. This argumentation builds on the concept of 'analytic-deliberative processes' which was coined by the US National Research Council (NRC) and which is one of the promising suggestions for developing an integrative approach to governance based on the inclusion of experts, stakeholders, and the general public. The authors present a four-stage approach to the governance of risk which is inspired by the concept of analytic-deliberative processes and distinguishes stage-specific functions of stakeholder and public participation. This governance framework suggests a much earlier involvement of stakeholders than that through the Regional Advisory Councils under the reformed Common Fisheries Policy.

Deliverable 2.2: Report of the ICES 2008 Theme Session on Governmental Quality and Risk Management

Authors: Martin Pastoors, Tammo Bult, Laurence Kell, Sakari Kuikka, Bonnie McCay

The ICES Theme Session on Governmental Quality and Risk Management was held at the ICES Annual Science Conference 2008 (Halifax, Canada) and was co-convened by Tammo Bult (Wageningen IMARES), Laurence Kell (CEFAS), Bonnie McCay (Rutgers the State University), and Sakari Kuikka (University of Helsinki). The theme session took place on Friday September 26. A total of 8 posters and 16 oral presentations were given, including two invited speakers:

- Jan van Tatenhove - Environmental Policy Group, Dep. of Social Sciences, Wageningen University: presentation O:17
- Bonnie McCay – Dep. of Human Ecology, Cook College, Rutgers the State University: presentation O:16

The theme session brought together participants from a range of disciplines and discussions covered how to change the current system to make it more robust to uncertainty in model, implementation, and institutional uncertainty..

Participation, transparency, trust and accountability are factors that determine the degree to which science is used in the management decision process and policy making. ICES should develop guidelines for "good practices". A session that contrasts various approaches to organize participation and transparency, and its effect on management, could be used as a base for this. All these features can also be improved, if ICES could be even more active in publishing scientific findings in various stakeholder magazines

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

Authors: Marion Dreyer, Ortwin Renn, Ben Drakeford, Edward Borodzicz, One main objective of the JAKFISH project is to learn about the variety of possible options to involve stakeholders in activities related to modelling and about basic requirements (procedural, structural) to exploit the assumed potential of such participatory practice. This deliverable presents related insights that the authors have drawn from a review of recent studies that address stakeholder involvement in modelling activities as a promising approach for moving towards strengthened participation in fisheries governance. The paper is structured into two parts. The *first* part is a brief *overview* of the main results of the literature review. It describes the relevance of participatory modelling as an approach to stakeholder involvement in fisheries governance, sets out some forms of 'participatory modelling' (understood in a broad sense) presented in the body of literature reviewed, and highlights those issues that these studies identify as central in regard to further developing and effectively using this participatory method. The *second* part of the Deliverable focuses on *two particular projects* concerned with involving stakeholders in modelling activities in research into fisheries sustainability. There is first, the 'Invest in Fish South West' (IiFSW) project, a stakeholder-driven project which was funded by a group of organisations and institutions with a direct stake or interest in England's South West fisheries. The second project is the EC-funded research project 'Precautionary risk methodology in fisheries' (in short: PRONE). The more detailed analysis of these projects highlights the rationale of the exercises in including stakeholders in modelling activities, the way in which the involvement processes were designed, the results achieved, and insights gained from the analysis of these processes in relation to opportunities and pitfalls of using 'participatory modelling' in fisheries governance.

Deliverable 2.4: Review of literature about participatory modelling in natural resource governance: Findings from forestry management and water resources / river basin management

Authors: Ben Drakeford, Edward Borodzicz, Marion Dreyer, Ortwin Renn

The JAKFISH project also aims to take advantage of experiences gained in other areas of natural resource governance. This deliverable presents insights that the authors have drawn from a review of studies concerned with participatory modelling techniques in *water resources and river basin management* and *forestry management*. The paper describes the relevance of participatory modelling as an approach to stakeholder involvement in these fields of natural resource governance; presents an overview of those issues that the bodies of literature reviewed identify as central in regard to further developing and effectively using this participatory method; outlines some conceptual considerations provided by this research in regard to the question of how to incorporate dealing with uncertainty in participatory natural resource management; and sets out some key aspects that require careful consideration when aiming at developing and using participatory modelling in fisheries governance.

Deliverable 2.5: Summary report of the international expert workshop on "Participatory modelling in natural resource governance: promises, pitfalls, improvement opportunities"

Authors: Marion Dreyer, Ortwin Renn

Besides the literature reviews WP2 convened an international expert workshop on "Participatory modelling in natural resource governance: promises, pitfalls, improvement opportunities" in order to investigate experiences gained in other areas of natural resource governance where participatory modelling techniques have been used. The workshop was held in the Castle of Haigerloch (near Stuttgart, Germany) on 18-19 June 2009. The purpose of the one and a half days exploratory workshop was to improve the JAKFISH project's understanding of the current practice of participatory modelling in natural resource governance; exchange and reflect on experiences, viewpoints and analytical findings with regard to the promises, challenges and improvement opportunities of such participatory processes; and discuss the potential of participatory modelling in fisheries governance in the light of experiences gained in the application of participatory modelling in other areas of natural resource governance, with a focus on water management, river basin management and forestry management. The deliverable describes the workshop's structural design and sets out its main outcome resulting from the workshop presentations and discussions.

Deliverable 2.6.1: Review tools, decision aids and procedures in fishery management focusing on the development of a prototype of a role play in simulating stakeholder responses to uncertainty

Authors: Edward Borodzicz, Ben Drakeford

This paper reports on the research carried out by the authors over two consecutive EU funded projects and constitutes the deliverable 2.6 for the JAKFISH project. 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, hence, players do not need to be experienced in the roles they perform.

Deliverable 2.6.2: Some guidance on how to use participatory modelling in fisheries governance: A synopsis of the literature reviews

Authors: Marion Dreyer, Ortwin Renn

- 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
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- Be aware of the challenge of integrating different forms of knowledge
- Provide sufficient room for deliberation in the participatory modelling process
- Select carefully the professionals that might be needed in the participatory modelling endeavour

Deliverable 2.7: ***Edited volume (or Special Issue) on participatory modelling in natural resource management (with special emphasis on fisheries management)***

Authors: Marion Dreyer, Ortwin Renn

Status: *published in Environmental Policy and Governance)*

This editorial describes how this special issue seeks to make a conceptual and empirical contribution to the growing field of research on participatory modelling in natural resource governance. Conceptually, the collection of papers accentuates and carries on the recent trend in the literature to discuss participatory modelling as the multifarious ways in which a modelling exercise, understood as being composed of different process stages, can be linked to stakeholder involvement. Empirically, the special issue provides insights gained from case study research into the importance of designing a 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). Furthermore, it highlights the challenge that the complexity of simulation models may present for stakeholder involvement and uptake of participatory simulation modelling by policy-makers and managers in actual policy and management decision-making. The editorial finishes with a short summary of each of the six papers which the special issue comprises.

There are six articles in this collection. The first paper by Hare starts by suggesting a distinction of four basic forms of participatory modelling. Hare's classification is informed by a comparative review of existing frameworks for categorizing participatory modelling processes and empirically related to a number of participatory modelling exercises in the water sector. Hare then discusses the potential of widespread adoption of participatory modelling by resource managers in the water sector. He argues that processes that support social learning and the development of conceptual models are most likely to be adopted.

In the second paper, Squires and Renn present the IiFSW project in which they were involved as scientific manager and group moderator, respectively. In this case, stakeholders were involved in bio-economic modelling which was used as a tool to support consensus building on policy recommendations for European marine fisheries. Squires and Renn conceptualize 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.

In the third paper, Edwards and Smith report on participatory processes using agent-based simulation models which were employed in the New Forest National Park, England. The authors point out the benefits as well as the limits of using simulation models in participatory recreational land-use management. They stress that to be really effective models cannot merely be used as tools in one-off projects, especially when stakeholder views are strongly diverging. The models would need to be embedded in decision-making institutions so that debate and shared learning were enabled over longer periods of time.

Ravera et al. then provide a comparative analysis of two cases of participatory modelling in land-use management which were carried out as part of adaptive action research. Although the case studies were carried out in very different bio-physical and socio-economic contexts (the UK and Nicaragua), the authors are able to draw some general lessons from comparing the results of the two research projects. Their analysis highlights that learning in Participatory terms of enhancement of adaptive capacity requires, in particular, stakeholder involvement throughout the modelling process, building bridges between different epistemological approaches, and flexibility and sensitivity to context-dependent socio-cultural processes.

In the fifth paper, Stefanska et al. present an interactive simulation game, the Floodplain Management Game, and what they observed in a number of game runs. The key feature of the role-playing game is that it unites technical (problem-solving) and relational issues (interaction between managers and farmers) in a single game. One main observation reported by the authors is that in most game runs participants remained consciously focused almost entirely on the technical issues and failed to address relational processes which undermined the success of their policy exercise. The game is discussed as a diagnostic tool for researchers in identifying bottlenecks in collective problem solving and as a learning tool for stakeholders to gain insight into the importance of social relationships and stakeholder interdependence in managing the problem.

The final paper by Webler et al. reports on a research project to better understand how modellers and outreach professionals anticipate how models are perceived and used by local policy-makers and how they think models ought to be used by local policy-makers in water management. Although some of the interviewed modellers and outreach professionals expressed support for the idea of local input into the design of nitrogen-loading models, the authors also found strong opposition among some interviewees towards local participation in model development. They note a general lack of communication between expert modellers and local policy-makers as potential users of such models in local decision-making and argue that outreach professionals can play a critical role in mediating constructive relationships between modellers and model users.

2.2 Accountability, Participation and Uncertainty in Fishery Management

The recently released Green Paper on the CFP further explores avenues to increase participatory decision-making. Regardless of whether this increased stakeholder involvement will take place in the knowledge production, the advisory phase or in decision making, there will be a need to present "science for policy" in a way that stakeholders understand it. Stakeholders should be able to evaluate the relevance, strengths and limitations of the scientific approach. Communication of uncertainty is a key element in such a process.

So far, discussions on uncertainty have mainly focused on technical uncertainty, i.e. uncertainty that can be quantified through some kind of statistical or mathematical model. Epistemic uncertainty, i.e. uncertainty due to partial or incomplete knowledge, and which may not be reducible, is more challenging to handle, both scientifically and in policy or decision making.

We reviewed the literature on ways of categorizing the sorts of uncertainty (as opposed to the origin of uncertainty) and presented an overview of tools that have been developed to assess and communicate different sorts of uncertainty and we discuss the relevance and applicability of these tools to fisheries management situations. Although tools that cover technical and to some extent epistemic uncertainty already exist within the domain of fisheries science for policy (like Bayesian methods and simulation techniques), we conclude that tools from other research areas that cover broader aspects of uncertainty are available and could very usefully be applied in the fisheries domain. For example, tools to reflect whether the policy problem has been addressed adequately.

We have presented conceptual approaches to uncertainty, which can contribute to a deeper understanding about uncertainty, and we have presented tools to address and assess uncertainty of a more qualitative kind. The frameworks and checklists cover as many sources of uncertainty as imaginable in the development of models, mapping assumptions and categorising the quality of data. Possible impacts of non-quantified uncertainties can be explored by using sensitivity analysis, simulation modelling and Bayesian approaches. In cases where causal links are unknown or may not have been captured, pedigree matrices can reflect the soundness of various aspects of the scientific approach, including data, parameters, the ability to verify results and the state of the art of the scientific discipline. The tools we have presented can also help to evaluate whether uncertainty has been taken into account in a satisfactory way during a decision making process, for example in extended peer reviews.

The concepts of uncertainty are challenging. Even fishery scientist repeatedly mix the concepts of Bayesian and frequentist probabilities without explicitly stating when and why they do so. This indicates a potential difficulty in communication and classification of uncertainty. It is possible that such mistakes go unnoticed in a peer review process and also in an extended peer review process.

2.3 Four examples of Participatory Modelling in Fishery Management

Participatory modelling is a relatively new approach in European natural resource governance. It is foremost an object of research, not an approved method. 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.

The Participatory Modelling (WP4) attempted to achieve the following objectives:

1. To explore the articulations of the RACs on the alternative management approaches that they are considering with respect to the practical problems they are facing.
2. To apply, test and modify existing simulation tools for use in interactive and participatory policy development.
3. To steer the future development of the FLR bio-economic simulation framework towards being the basis of tools that facilitate and clarify discussions within real-world negotiation contexts.
4. Bridge the gap between the requirements by the stakeholders and the available modelling tools.

2.3.1 Western Baltic Spring Spawning herring

Despite its relatively small stock size and economic value, Western Baltic spring spawning herring (WBSS) is managed in a highly complex governance scheme, with demanding scientific challenges and an elaborate political process of resource allocation among fishing fleets. WBSS herring spawns in the western Baltic Sea, where it is exploited by several EU fishing fleets. It migrates into the Kattegat, Skagerrak and eastern North Sea areas, where it mixes with North Sea autumn spawning herring (NSAS), in an age and season- dependent pattern with high variability, and where it is exploited by both EU and non-EU fleets. For the two separate management areas, TACs are set at different times in the yearly TAC-setting process, and this can result in conflicts over quota allocations to individual fleets.

Industry stakeholders of two Regional Advisory Councils – the Pelagic and Baltic Sea RACs – and scientists involved in the FP7 JAKFISH project engaged in collaboration, aiming to improve stock management through joint development of a robust Long-Term Management Plan. A common understanding of relevant scientific and political issues was developed and used to conduct Management Strategies Evaluations in an interactive process.

In this process engaging stakeholders and scientists around complex policy and governance issues, we placed uncertainty at the heart of the discussions. We found ourselves exactly in the situation referred to as “Post-Normal Science” by Funtowicz and Ravetz (1993), i.e. that the science needed for policy when uncertainty is large and stakes are high is no longer purely academic “normal” science, but applied, problem-solving science. While this has long been recognized in other fields of natural resource management, the uptake of this concept has emerged only recently in fisheries science, together with the increased development of long-term management plans. And this shift in the role of science has raised major questions in the scientific community (see e.g. Rochet and Rice 2009, Butterworth et al. 2009, Kraak et al., 2010, Wilson, 2009).

Involving stakeholders in an “extended peer review” process has acted as a natural and positive driving force for changing the whole perspective in fisheries management, from top-down short-term advice to bottom-up long-term commitment. The need to justify and explain the reasoning behind the scientific models, the outcomes of which will directly impact the livelihood of the stakeholders involved, leads to an auto-evaluation of the quality and soundness of the scientific knowledge (illustrated by the pedigree matrices), which in turns focuses the attention towards the most uncertain but important factors. This drives a natural and shared understanding that these factors should then be accounted for in the models, but with large confidence intervals around parameter values and related natural processes, and that the policy decisions should account for the potential risks linked to them. And if scientific uncertainty cannot be resolved, then the management must adapt to it and be precautionary. In some simulations being run with the same underlying dynamic of the herring stock, but with assumed perfect levels of knowledge, the uncertainty in management outcomes was considerably reduced, and higher yields were allowed. The participatory modelling process makes it easier to understand this fact, and for it to then be accepted.

A direct consequence of this is that it is in the interest of the stakeholders to actively participate in the reduction of scientific uncertainty, as this would lead to improved management and thereby greater fishing rights. This approach is the key idea behind the results-based management and the reversal of the burden of proof, and we have experienced directly in our case study that such participatory modelling was an integrated part in shifting to this paradigm.

During the winter 2008-2009, contact was taken and first ideas were developed together with some representants of Danish PO and Danish Fishermen Association. In the next step, positive contacts were taken with both the Pelagic RAC and the Baltic RAC. Two scientists from DTU Aqua attended the Pelagic RAC WG I and II meeting on January 29th, on behalf of both JAKFISH and GAP1 FP7 projects. In the same meeting participated as well a representative from, as well as with Pelagic RAC. The participatory process received a strong and positive support from the pelagic RAC, which included it in their recommendations to the European Commission dated 27 February 2009, stating that "*The Pelagic RAC would like to inform the Commission that it is committed to the JAKFISH/GAP1 projects (in collaboration with the Baltic Sea RAC), which seek to develop a long-term management plan for Western Baltic herring. The Pelagic RAC recommends that no management plan is introduced by the Commission for this stock until the results of these projects are known.*"

In the early phases of the modelling planning, it was intended to mostly build over the approach developed for Herring in the Western British Isles (ICES SGHERWAY, 2009 and Kell et al., 2009). The objective was to develop an operating model which accounts for stock mixing and mismatch between management areas and stock areas (figure 1).

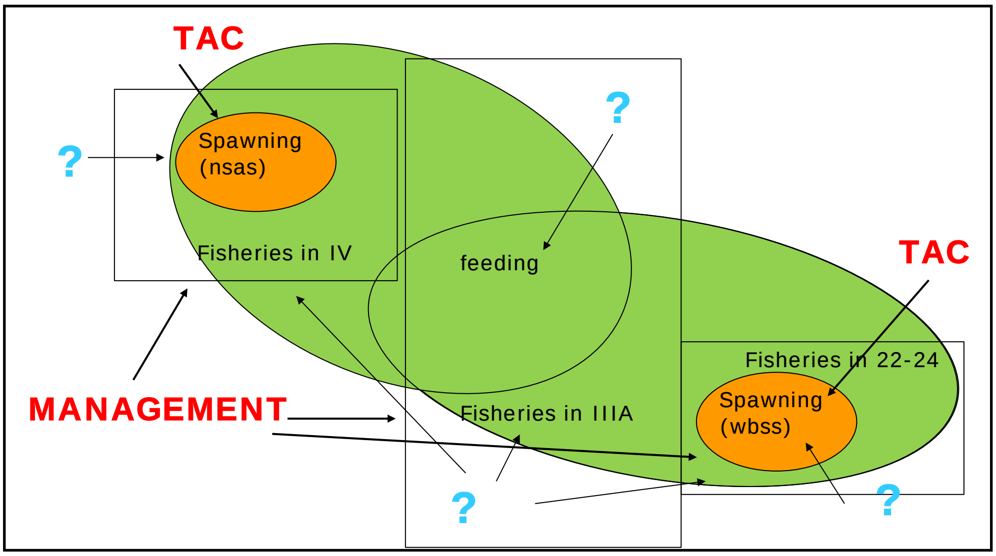


Figure 1 – conceptual operating model for WBSS herring (adapted from Kell et al., 2009).

However, the EC agenda and the need to address WBSS herring LTMP in an approach consistent with EC request steered the modelling work more towards robust single-stock Management Plan. It turned out to be necessary to start from the results obtained by ICES (2009) instead of developing new approaches, both because the RACs needed to get full understanding of ICES' results in order to be able to comment on these, and because it was necessary to get consistency within the scientific body about long-term development of WBSS herring.

The EC had initiated a process aiming at establishing long-term management plans for all pelagic stocks in the Baltic Sea, including WBSS herring. The process involved first a request to ICES for proposing robust values of long-term management objectives in terms of fishing mortality (A), with a maximum interannual variation of the TAC (B) and a trigger spawning stock biomass (C). ICES met in February 2009 (ICES WKMAMPEL) and proposed the following values:

	Western Baltic herring (*)	**Central Baltic herring**	**Gulf of Riga herring**		**Sprat**
Fishing mortality **[A]** (year^{-1})	< 0.25	0.22	0.26	0.35	0.40
Annual TAC variation **[B]** (± percentage)	15	15	15	20	20
Spawning-stock biomass **trigger** **[C]** ('000 t)	None	800	60		400
Probability of SSB_{2015}<**[C]**	< 5% (**)	< 5%	< 5%		< 5%
B_{lim} ('000 t)	110 (***)	385	40		200
When $SSB<B_{lim}$	F = 0	F = 0	F = 0		F = 0
F when $B_{lim}<SSB_y<[C]$	Not Applicable	$0.22*[(SSB_y-385)/(800–385)]$	$0.26*[(SSB_y-40)/(60–40)]$	$0.35*[(SSB_y-40)/(60–40)]$	$0.40*[(SSB_y-200)/(400–200)]$
Spawning-stock biomass in 2015 SSB_{2015} ('000 t)	(*)	1 056	117	101	962
Yield in 2015 Y_{2015} ('000 t)	(*)	190	24	29	256

Based on these results, EC requested the institutes MRAG and IFM to provide with a socio-economic impact assessment of such management plans. The work took place over March to July 2009, and builds on analyses of profitability by fleet for the whole Baltic Sea (EC, 2009). The EC is expected to give its conclusions about the LTMP in a non-paper to be produced in February 2010.

After the publication of ICES response to EC request, the EU requested the Pelagic RAC (PelRAC) and the Baltic Sea RAC (BSRAC), who share the advisory responsibility for the Western Baltic Herring stock, to set up a common focus group and provide common recommendations about the management of this stock. This focus group with a limited number of participants met for the first time on May 18th 2009. Clara Ulrich (DTU Aqua) participated to this focus group on behalf of the JAKFISH project, and was the only scientist invited. The meeting was very successful in terms of contacts between the various stakeholders, and between stakeholders and the scientist from DTU Aqua. It appeared though clearly that both RACs have different levels of basic understanding about the general topic of management plans and modelling approaches. The presence of the scientist was obviously much appreciated. This was confirmed when the whole Pelagic WG of the BSRAC met on June 15th and was presented the preliminary findings of the socio-economic impact assessment for the whole Baltic Management Plans. This pointed out a need for additional scientific support in order to understand the models outcomes and underlying assumptions before any agreement and commitment from the industry can be reached.

Finally, informal contacts were established between the scientists of DTU Aqua, the contact persons in the EC in charge of this issue, and the secretariats of both RACs, in order to inform about the state of the art in the various places and insure highest consistency and synergy. People got additional chance to talk with each other when they met in various places, such as ICES workshops and Annual Science Conference in September 2009.

All this helped developing a positive climate of openness, trust and support between the various persons involved, which is considered as a key achievement in the process of improved governance.

The culmination of this process of contact with stakeholders took place during the second JAKFISH workshop on WBSS herring LTMP, in London, October 21th 2009. It was attended by 2 representatives from BSRAC, 4 representatives from PelRAC and 4 scientists from DTU Aqua and IMR. The focus of the meeting was first to (1) provide scientific support to stakeholders to fully understand the LTMP proposal from ICES (2009), with particular focus on the hypotheses in the model and the sources of uncertainty included, and start suggesting alternative propositions to be investigated, and (2) review the sources of uncertainty in the biological knowledge, and the main differences in the perception of issues and stock development between scientists and stakeholders.

Two additional JAKFISH workshops were held with BSRAC and PelRAC in 2009. The third meeting (January 2010), although attended by a very large number of more diverse stakeholders, was mainly driven by the scientists, in an attempt to explain in further detail the issues discussed during the second meeting. The scientific process leading to the current perception in stock assessment was reviewed, and its intrinsic variability was underlined. This was meant in the aims of both i) reaching understanding from the stakeholders about the precarious state of the stock and commitment around the urgent need to establish a rebuilding strategy, and ii) justifying why a LTMP for WBSS herring should be particularly cautious and robust to the main sources of uncertainty. After having addressed the theoretical and scientific background, a first set of simulation results for different HCRs was presented, and this gave a general overview of the effects of and trade-offs between different objectives, i.e. ecological versus more economically oriented ones. The second and third meetings were recorded on tape for further analysis.

The fourth meeting (March 2010) was driven by the stakeholders. More simulation results were presented by the scientists, after which a discussion was held mostly among the stakeholders from both RACs on the simulation results as well as on political arrangements to be included in the LTMP. The process ended in May 2010, when both RACs and the scientists independently formulated their contributions and recommendations in response to the Commission's non-paper on the establishment of a multi-annual plan for the pelagic stocks in the Baltic.

Beside these meetings, the work progress was framed by regular email correspondence between stakeholders (mostly PelRAC) and scientists regarding requirements about the types of scenarios to be analysed and the evaluation criteria of interest, as well as timely feedback on the ongoing results. As such, the process has co-evolved until reaching the final set-up and results which formed the basis for the final recommendations.

Finally, the main JAKFISH participants for this case study attended all the ICES Workshop on procedures to establish the appropriate level of the mixed herring TAC (Spring Western Baltic (WBSS) and Autumn Spawning North Sea (NSAS) stocks) in Skagerrak and Kattegat (Division IIIa) (ICES WKWATSUP (chaired by Lotte Worsøe Clausen, DTU Aqua).

2.3.2 North Sea Nephrops

The Nephrops sub-group of the North Sea RAC were in the process of drafting a long term management plan (LTMP) for the fishery, which could subsequently assist in efforts to gain accreditation from the Marine Stewardship Council (MSC), whose "pre-assessment" process had highlighted the need for a formal management plan). However, the different fishery stakeholders have been struggling with agreeing on objectives for the fishery. Discussion about potential future structures of the fleet resulted in a consensus that the plan should not seek to determine a particular structure, but rather that the current fleet structure was satisfactory and should be allowed to evolve naturally.

The different stakeholders had different views and objectives:

- Small coastal fishers: Prevent competition with bigger boats in "their" coastal Nephrops fishing grounds. Keep current employment level.
- Larger more offshore fishers: Ensure high profits by keeping the spatial fishing flexibility, i.e. keep whole area Total allowable catch (TAC) instead of introducing TACs per functional unit.
- Policy makers, managers: Quickly implement a LTMP and ensure sustainable fisheries.
- Scientists: Improve the modelling structure by including spatial dynamics, fleet dynamics and size-based population dynamics.

There are large uncertainties in the science and management. Management advice by ICES is provided at the level of eight functional units (FUs; areas with suitable grounds for Nephrops in the North Sea) though management is applied through a single area TAC. Also, there are diverse fleet segments (eight nationalities, different gears) that can move freely between the FUs. This flexibility in fishing pattern was considered essential for operational reasons by the fishing industry but it concerned scientists as the system did not offer protection from overfishing to the separate stock units.

The ambition of JAKFISH was to help the stakeholders finding common objectives and move forward with improving the LTMP draft. So the original purposes of the participatory modelling approach were:

- Collective learning for consensus-building and conflict reduction.
- Improve the knowledge base and quality control for better management decisions

However, the scientists involved perceived the biggest challenge in the FLR programming, namely to simultaneously use several dimensions (time, length, sex, area), to solve the "age and length" modelling dilemma, to produce alternative growth models for crustaceans, and to establish a link between fishing mortality and effort for gear types.

The JAKFISH scientists prepared pedigree matrices for North Sea Nephrops to reflect on three areas of concern: the status of knowledge concerning (1) biological parameters, (2) the data, and (3) fisheries related aspects. In the end, the pedigree matrices were not used in discussions with stakeholders; timing was considered to be too early in the process because of the internal disagreements among the stakeholder groups. Nonetheless, filling the matrices had helped the scientists with mapping uncertainties in a structured way and facilitated the communication among the scientists.

The Nephrops case study had a slow and difficult start. Neither stakeholders nor scientists knew what could be expected from each other, and in particular the scientists felt stuck not knowing what the stakeholders wanted to be evaluated and modelled. In addition, major staff changes at one scientific institute and inadequate internal communication led to delays and misunderstanding. As a result, stakeholders and scientists have not managed to fully engage around model development, and the case study failed to establish a structured work plan early in the project. Only at a late stage in the project did the case study start to actively engage in problem framing with the stakeholders. These were RAC representatives as well as grass rooted fishers. Triggered by the Nephrops sub-group of the North Sea RAC and co-funded by the JAKFISH project, stakeholders organised meetings in various ports to set out clear objectives and a range of management options, and aiming at a management plan that would have industry "buy in". Those meetings enhanced the understanding of the main issues and requirements to account for in the future management plan. The JAKFISH scientific input to these discussions focused on technical modelling challenges and mapping out uncertainties.

The Nephrops case study is an example of lack of communication and mutual understanding between scientists and stakeholders. Comparing the extended peer review with reflections of JAKFISH Nephrops scientists, there had been different perceptions about the work progress. From the scientists' perspective, the case study experienced significant delays and problems, which affected negatively the project outcomes. The case study did not progress in terms of the scientific goals and the expected FLR development. From the stakeholders' perspective, the evaluation proved much more positive: "almost all the fishers believed that it was right to protect the stocks via long term management plans" and "fishers felt they had been listened to" (Mike Park, pers. comm).

Mutual problem framing in an open, transparent, truthful and flexible way is crucial in a participatory modelling process to identify the real stakes, problems, and needs. Internal conflicts, e.g. between different stakeholder groups (here: small coastal versus larger offshore fleets) can block a collaborative process. Science could focus on reducing societal dissent in complex unstructured situations where scientific uncertainties are large and different interests play a role (Hansen et al, 2009). In the Nephrops case study, focussing on the "facilitation" strategy from the beginning could have been more rewarding. Instead of continuing with a poorly defined participatory modelling goal, scientists should have focussed on resolving the societal conflict, keeping in mind that consensus is not always possible in international settings with several stakeholder groups in different countries. We conclude that one should only start modelling, once the need to model has been stated and a goal for modelling has been identified. In the Nephrops case study, it appears that initially, the JAKFISH scientists had perceived the modelling as too much centre-stage, and participation was secondary.

2.3.3 Central Baltic Herring

The Central Baltic herring case study focussed on two main fields of work: 1) participatory modelling of the Baltic herring fishery and 2) reflections on the role of knowledge and fishery management institutions in the Baltic Sea.

Participatory modelling

In participatory modelling, the Central Baltic herring case study concentrated in factors behind the negative biomass trend and poor growth rates of the Baltic Main Basin herring stock(s). There exist different kinds of hypotheses on these, and the different assumptions lead to different kinds of management conclusions. Our aim was to study how a participatory modelling approach and the Bayesian method would change the understanding of the herring fishery, and to develop participatory modelling methodology.

We selected six stakeholders for the participatory modelling. Criteria for the selection were that the persons had to represent different stakeholder groups and different Baltic Sea countries, and be acquainted with Baltic herring. We approached the selected persons directly through email and sent requests for collaboration, titled "Expert help in herring stock assessment". The selected stakeholders were: 2 researchers from Sweden, a fisheries manager from Estonia, a representative of a fisherman organisation from Finland, a commercial fisherman from Poland (who also is the chairman of a regional stakeholder organisation), and a representative of an environmental NGO/parliament member from Estonia. Each stakeholder built his own model, independently of the others. Thus, six modelling interviews were carried out between February and June 2009.

The modelling consisted of two parts. Firstly we asked the stakeholders to build a biological stock assessment model focusing on factors that they believe influence the survival of herring eggs, and the growth and mortality of Baltic herring. Secondly we asked them to frame the problem of herring fishery management, i.e. to name factors that should be taken into account in management, to define objectives for it, and measures to reach these objectives. We used Bayesian networks as our modelling tool.

The interviews took from four to six hours each. The modelling sessions were documented by building the models and recording all the parts and parameters, and by tape-recording all the discussions. Six different models resulted from the modelling sessions. Each participant was asked to fill in a feedback questionnaire regarding the modelling.

During 2010, the separate biological system models were analysed and compared and a meta-model synthesising the stakeholder models with scientific data on Central Baltic herring was built using the Bayesian model averaging methodology. In a final stakeholder meeting in Helsinki (Nov 2010), the biological meta-model and the different management models were presented and discussed. Differences between views were analysed, and management actions resulting from the meta-model were considered. All the six stakeholders participated in the meeting. Feedback about the models and the results was collected using a questionnaire. The meeting was recorded with a video. The whole process will be analysed and summarized, and a peer-reviewed article will be written. The meta-model will be further developed in the IBAM (BONUS programme) and the ECOKNOWS (EU 7th framework programme) projects.

The participatory modelling was carried out using Bayesian modelling techniques that facilitated discussion and structured the complex issues around Central Baltic herring. It also enabled an explicit treatment of uncertainty. The participatory exercise revealed diverging views of different stakeholders about factors influencing the population dynamics of the herring. Despite this disagreement on influencing factors, there can be agreement about management actions. The approach is valuable to analyse and illustrate consequences for management advice of different management objectives and different assumptions about system dynamics.

Formulating the stakeholder views as a mixture of multivariate normal distributions simplified the modelling task and increased the possibility to take the stakeholder views into account in practice. However, such a simplification naturally reduced the chance to account for relationships that are difficult to linearize by using simple transformations.

The six stakeholders saw several benefits in the participatory modelling approach, highlighting the potential of the approach to

- improve stock assessments and management by enabling to account for factors that have not necessarily been taken into accounted in other assessment methodologies
- help people understand and commit to management
- integrate different objectives and analyse trade-offs among them
- demonstrate and raise awareness of the complexity of fisheries systems
- make explicit and enable combination of different views, expertise and priorities
- facilitate communication, cooperation, understanding and consensus between stakeholders.

Challenges or pitfalls that the stakeholders saw in the approach relate to

- the subjective approach of the Bayesian method
- the small sample size and definition of “minimum” necessary input
- “calibration” of the models against the historical catch data, which can be flawed to an unknown extent
- complexity and slowness of the method for practical use
- avoidance of “noise” coming from the involvement of too many factors
- lack of knowledge of individual stakeholders and a need to prepare for the modelling.

Some of the pitfalls identified by the stakeholders indicate that properties of the Bayesian reasoning and purpose of the modelling have not have been really understood. Future impact of the work achieved depends on whether the ICES working group dealing with Baltic herring stock assessment is willing to take the ideas and results into account.

Reflections on the role of knowledge and fishery management institutions in the Baltic Sea.

The reflections on the role of BSRAC as a boundary institution in the Baltic Sea has been a relatively self-contained deskstudy that has been published in three separate publications which are summarized below.

Baltic study on the use of scientific information in the past

Author: Robert Aps

This paper explores the performance of the Baltic Sea Regional Advisory Council (BS RAC) as a boundary organization producing recommendations to the EU Commission on fisheries issues under the Common Fisheries Policy (CFP). The boundary work of the BS

RAC in balancing of stakeholder's interests in transformation of science-based advice into agreed management recommendations is considered to be an important element in setting the Baltic Sea TACs. Intended role of the BS RAC is to serve as negotiator between international scientific communities (ICES) and users of scientific and technical advice (fishing industry, decision makers). BS RAC acts also as facilitator of dialogue between fishing industry, scientists and decision makers to encourage research agendas that reflect the interests and needs of fishing industry. BS RAC acts as translator of scientific information produced by ICES, putting general findings into fishery-specific practical language. Today, the BS RAC is entering a period of difficult change during which it has to focus on the questions: is the failure of EU CFP rooted in MSY as inappropriate management objective, and is it necessary to change for MEY as a principle for stock management in the future CFP? It is necessary also to define the Baltic fisheries as a spatial resource with aim to secure the fishing industry's interests in the context of the coming age of Marine Spatial Planning.

Recovery of depleted Baltic Sea fish stocks: a review

Authors: Robert Aps, Hans Lassen

Attempts to recover some depleted Baltic fish stocks between 1995 and 2008 are reviewed. Management measures aimed at recovery were adopted by competent authorities (until 2005 the International Baltic Fisheries Commission, IBSFC), including the Baltic Salmon Action Plan (1997), Long-Term Management Strategy for Cod Stocks in the Baltic Sea (1999), Long-Term Management Strategy for the Sprat Stock in the Baltic Sea (2000), Recovery Plan for Baltic Cod (2001), and the Long-Term Objectives and Strategies for the Management of Baltic Sea Herring (2000–2002). For all stocks, TACs have been set systematically more than the scientific advice based on sustainable exploitation. We interpret this as "decision overfishing". There is also evidence of extensive underreporting of catches, which is interpreted as "implementation overfishing". This means that a management body is knowingly maintaining a situation of overfishing. Nevertheless, measures have also been taken to combat the situation. Our analysis suggests that decision overfishing is related strongly to overcapacity of the fleets. The combination of decision overfishing and implementation overfishing, and not the management measures per se, could be the reason for the failure of depleted stocks to recover.

The Baltic Sea Regional Advisory Council as a hybrid management framework for sustainable fisheries

Authors: Robert Aps

The conceptual model of the BSRAC consultation process is developed using the Bayesian Belief Network (BBN) methodology and the HUGIN RESEARCHER software. The simple BBN model is used to conceptualize the BSRAC consultation process. Hypotheses generation representing the BSRAC advice options on setting the Total Allowable Catches (TACs) as well as setting the conditional probabilities have been done externally based on the BSRAC Statements and Recommendations for 2007-2008, and International Council for the Exploration of the Sea (ICES) Advice on the Baltic fish stocks.

The BSRAC advice was analysed as the result of hybridization of three different settings: 1) ICES science based advice, 2) non-industry stakeholders' argumentation, and 3) industry stakeholders' argumentation. Four main conclusions emerged:

1. The number of alternatives presented in ICES scientific advice should be limited to a number where in-depth analysis and choice between alternatives is reasonable and feasible to consider in a limited amount of time. Presentation of ICES scientific advice should be considerably improved by grouping the similar alternatives or by decreasing the number of alternatives. Important factor to be considered for ICES scientific advice alternatives is a clear and communicated difference between them - choices should be set up in a way that argumentation and comparisons even between the most similar alternatives would make sense.
2. Current advisory systems in fisheries focus on the biological sciences and little quantitative advice is available about the social and economic impact of alternative management strategies. Consequently, the socio-economic arguments used by the BSRAC industry stakeholders sometimes cannot be clearly formulated and sufficiently justified.
3. Argumentation of the BSRAC non-industry stakeholders (Fisheries Secretariat, WWF and Coalition Clean Baltic) is usually based on the scientific advice provided by ICES. At the same time the argumentation of the non-industry stakeholders is usually not strong enough because of insufficient knowledge on the fishing industry itself and the argumentation is mainly focused on the dynamics of the fishery resources.
4. BBN simulations showed that the most informative variable to observe (Industry Argumentation) is the variable with the highest mutual information with the hypothesis variable (TAC Recommendation). As a result we can expect that if the industry argumentation is weak then the BSRAC would usually recommend the exploitation of fish stock concerned on a level of exploitation believed to be sustainable. However, if the industry reasoning is expected to be strong no matter what is the status of the rest of variables then there is a quite high probability that the BSRAC would recommend, referring to the industry's high demand for the fishery resource (socio-economic reasons), to set the TAC for fish stocks concerned at a level higher that is believed to be sustainable.

2.3.4 Mediterranean Swordfish

The objective of the Mediterranean case study was to develop and evaluate management scenarios (including bio-economic modelling) for the Mediterranean swordfish, based on the recommendations of ICCAT and interactions with Greek stakeholders. The case study investigated options of an operational management system for this particular situation where scientific knowledge is relatively poor, various stake conflicts exist, and harmonised management practices are generally lacking. Different management scenarios were developed and evaluated using simulations. ICCAT was considered the main stakeholder, particularly the ICCAT Scientific Commission. Apart from ICCAT, fishers and local managers in Greece were involved in a series of interactive meetings to discuss scenario objectives, uncertainties and discuss results.

The Mediterranean swordfish stock is considered to be over-exploited; current spawning stock biomass levels are >40% lower than those that would support maximum sustainable yield [69]. 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 rate of mixing. The stock-recruitment relationship is not well defined; catch misreporting of undersized fish is considered to be a problem; and there is a large amount (50 – 70%) of juveniles in the catches [70]. The exploitation pattern of swordfish fisheries is complex and difficult to manage, with several small- and medium scale fisheries from various EU and Non-EU Mediterranean countries.

The International Commission for the Conservation of Atlantic Tunas (ICCAT, the relevant management authority) asked for an evaluation of the impact of different recovery measures, such as temporary closures, effort control (e.g. capacity reduction) and quota management schemes. ICCAT and various EU groups have discussed the potential application of various management measures. Several Mediterranean countries have imposed specific technical measures aiming to improve the stock exploitation pattern and ICCAT has established seasonal fishery closures. Nonetheless, there is a lack of a harmonised management plan that would support stock recovery, resulting in various conflicts among the different fishing fleets.

Preliminary results of management strategy evaluations were presented and discussed in four ICCAT Scientific Commission meetings. Additionally, popularized presentations were given in three meetings with fishers. The feedback from both types of meetings facilitated the final development of scenarios, the incorporation of uncertainties and the definition of risks.

Management scenarios addressed uncertainties of biological parameters (assessment estimates and stock/recruitment models), fishery data (catch misreporting), and implementation of management measures. Through a risk analysis the danger of stock collapse within 4-5 generations (about 15-20 years) was assessed. Scientists filled three pedigree matrices to schematically reflect the state of knowledge and uncertainties about the stock and the fisheries. One matrix focused on the status of knowledge concerning biological parameters, the second one on data, the third one on fisheries related aspects (e.g. regulations, compliance, bycatch). The matrices were presented to stakeholders (ICCAT, fisher groups and local managers) at intermediate meetings, i.e., they served as a tool to discuss uncertainties. Stakeholders suggested minor changes that were incorporated in the final versions of the matrices. Scenario projections and risk analysis estimates were included in the latest report of the ICCAT Scientific Commission and utilized for drawing management recommendations [69].

A few questions concerning uncertainties were raised by fishers that were not incorporated in the evaluation models, such as effects of climate change on fish migration routes. The lack of relevant scientific knowledge did not allow the identification of meaningful assumptions or even speculations about those uncertainties.

The ICCAT stakeholders reviewed the participatory approach and the contribution of the project to scenario evaluations by filling in questionnaires. Fishers and local managers received a slightly modified version of the original questionnaire: questions dealing with technical specifications of the models were omitted. Also, one questionnaire was prepared and distributed to the stakeholders after the completion of the modelling work (management scenario evaluations) asking them to review and evaluate the accomplished work.

The timing of the JAKFISH process fitted well in the formal ICCAT process: when the time the JAKFISH project started, the ICCAT Scientific Committee had pointed out the necessity for the establishment of a long-term management plan for the Mediterranean swordfish stock. When collaboration was agreed, the 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 tools and model building. Uncertainties and risks were defined at a later stage during the process. The regular time frame of ICCAT specific species-group meetings facilitated the presentation and discussion of intermediate results and consequently the overall planning of the JAKFISH work.

Fishers raised questions about certain epistemic uncertainties that were not considered in the existing evaluation models due to lack of relevant scientific knowledge. Hence, the case study did not zoom in on those uncertainties raised by the stakeholders, and one could argue that in this respect the science did not entirely follow a “post-normal” approach, which would have meant to focus on a different problem framing. Instead, the case study stuck to its foreseen modelling approach, producing various management strategy simulations. This suggests that there is always the possibility that stakeholders can raise questions that cannot be addressed – independently of the modelling tools used.

Through the participatory modelling process, ICCAT member states reached consensus on one specific technical measure (seasonal closure). This method emerged as having an evident link with the biology of the stock, and it was felt that it could be agreed on between the different countries and enforced over all fishing sectors. The model simulations indicate that it can lead to stock recovery.

2.4 Comparative Research of Scientific Institutions and Practices

Work Package five in JAKFISH was responsible for the comparative research on existing approaches to handling complexity and uncertainty in fisheries management decision-making both within and beyond Europe. The objective was to identify the most effective institutional forms, practices and techniques for developing science-based policies and marine management measures through a participatory approach. The WP has two main subtasks:

1) Social network analyses of Fishery Management systems
2) Deciding on the boundaries of the Dogger Bank: a qualitative study of science practices

2.4.1 Social Network Analyses of Fishery Management systems

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.

1) Gulf of Riga herring management (Estonia).
2) Baltic salmon management (Finland)
3) Baltic salmon management (international)
4) Mediterranean swordfish (ICCAT, international)
5) Northern prawn fisheries (Australia)
6) New England groundfish fisheries (USA)

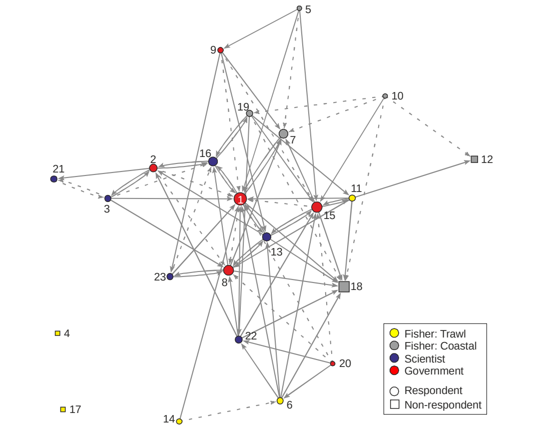
Gulf of Riga herring management (Estonia).

The case study examines fisheries management practices within Estonia, focusing on Gulf of Riga herring. Gulf of Riga herring is a separate population of Baltic herring (Clupea harengus membras) that occurs mainly in the Gulf of Riga, the eastern part of ICES Sub-division 28.

The social network diagram depicts a top-down management system centralized around a few government representatives. The study suggests that the management system in Estonia is in a developing phase from top-down procedures towards enhancing stakeholder involvement; the heterogeneity of the discussion network may reflect the effort of the Fisheries Local Action Groups (FLAGs) and the Estonian Fisheries Network in increasing stakeholder participation. Today, discussion between groups takes place, but a systematic mode of accounting for stakeholder views in decision making seems to be missing. A common will towards participatory practices seems to have emerged, however.

There seems to be a consensus on how to manage the Gulf of Riga herring stocks: e.g. closing the trawling season in the spring is a conventional procedure practically agreed by all. On the other hand, there is some disagreement especially on facts, which can lead to clashing views if uncertainty increases, or if stakes become more critical.

The qualitative study indicated that the procedure of organizing scientific research for management is not adequate, and neither is the transparency of scientific research sufficient to enable an extended peer review. A more stable and long term oriented basis for organizing science for management might be a way to increase both the reliability and the understandability of the scientific processes. This is also a requirement for further involving stakeholders in the policy processes.

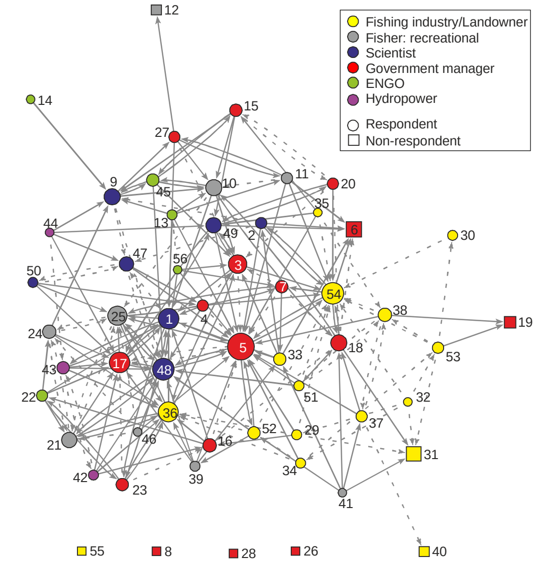


Baltic salmon management (Finland)

The case study examines Baltic salmon fisheries management practices in Finland which is a highly conflicted issue that from time to time heats up in Finnish media and in meetings where people with different interests get together.

The actor groups mingle in the discussion network but the industrial fishermen/ landowners are a bit on their own, mainly linked to the rest of the network through national and district level government officials.

The opinions and beliefs of the fishing industry and the hydropower representatives most often differ from those of the other groups. The study suggests that persons thinking the same way tend to discuss mostly with each other and that discussion may increase agreement between people. This is also indicated by the positive network effects even though they are sparse. Based on these results it could be assumed that enhancing interaction might bring about increasing agreement among the actor groups.



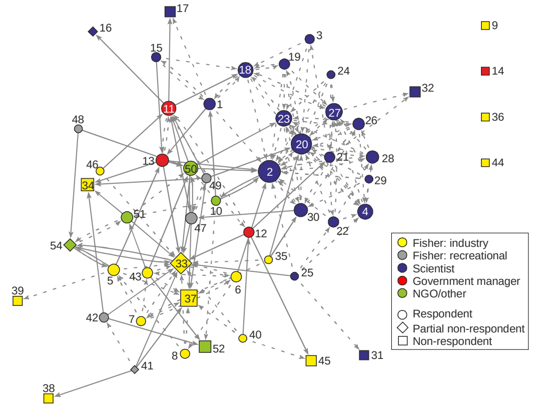
Baltic salmon management (international)

The case study examines Baltic salmon fisheries management practices within the EU. Most of the wild salmon stocks in the Baltic Sea have been depleted during the 20th century, and the remaining ones vary in their status.

The sociogram shows how the scientists constitute a very dense net of ties between them. Stakeholder groups have fewer ties between them. In the middle there are three managers.

The low network density rate indicates a very low rate of discussion in the whole network. The q-sort analysis shows that individual actors agree more on management goals and salience of facts, than the facts themselves and this applies to groups as well. The fishing industry has most frequently positions that markedly differ from the others, both in relation to facts and to values. Agreement between fishing industry and recreational fishers is more usual than agreement between the other groups, and this concerns especially management statements. The fishing industry and the scientists disagree most frequently on facts.

Baltic salmon management lacks a consensus especially on relevant facts, and that finding common understanding is not advanced by the scarce interaction between the actor groups; the study gives an impression that especially the scientists are very much on their own.



Mediterranean swordfish (ICCAT, international)

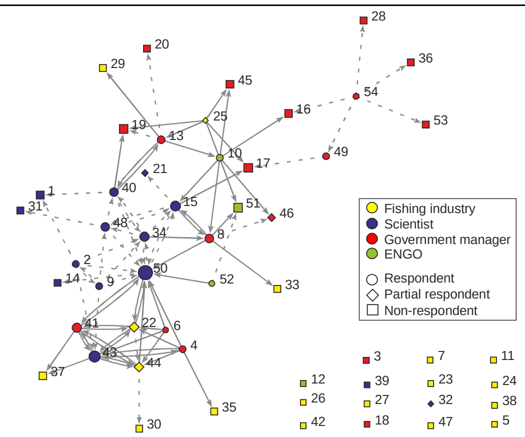
The Mediterranean swordfish fishery is a highly international fishery, with at least 11 countries targeting the stock. Stock assessment results indicate that the Mediterranean swordfish stock is over-exploited

In the Mediterranean swordfish case, communication across stakeholder types happen mainly in local or national contexts, rather than at the international level of ICCAT where scientific advice and political decisions are made.

In the network as a whole there was more agreement on the salience of different statements than on the content of the factual and value statements, while the comparison between groups showed that there was higher disagreement on the salience of the statements. In the network there was higher agreement on values than on facts.

Overall there seems to be a fair amount of agreement between the stakeholder groups in this network on several of the statements. Looking at country affiliation, more disagreement was observed. The Greek stood out as a group, which can be partly attributed to methodological differences in how they were identified as relevant to the network. However, it could also be related to national differences in regulation or fishing practices.

In terms of the relation between communication networks and levels of agreement, we found only negative network effects. Thus we conclude that respondents in this case tend to have frequent discussion ties with peers that have different values or opinions on management goals, and that previous discussions have not brought about consensual opinions among discussion partners.



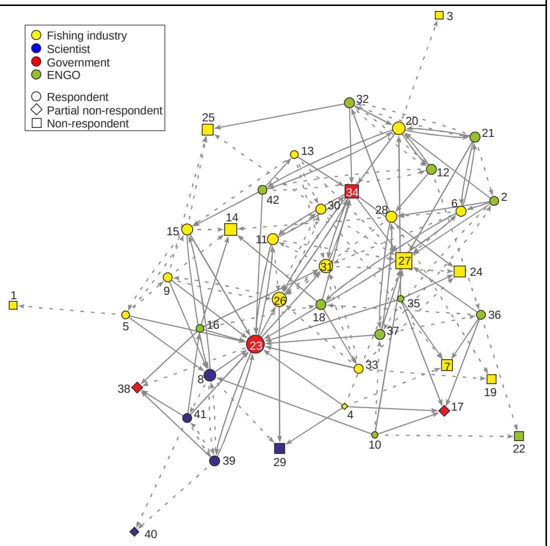
New England groundfish fisheries (USA)

The case study examines New England groundfish fishery management practices within the United States. The groundfish fishery is a complex of 19 stocks (12 species) of demersal finfish. U.S. fishermen pursue these stocks in the Gulf of Maine, Georges Bank, and southern New England waters using a variety of gear types.

The discourse selected for this analysis generated a substantial amount of disagreement among different respondents and stakeholder groups.

The NEFMC brings together a diverse group of participants, although the scientists do tend to function more autonomously compared to the other groups. Differences of opinion exist on the management issues (values) which corresponds to the NEFMC being designed to represent the heterogeneous views within the management system. Science advisors frequently hold positions on knowledge that markedly differ from the other groups because they are a more homogeneous group.

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". This also has an effect on the network autocorrelation analyses.



Northern prawn fisheries (Australia)

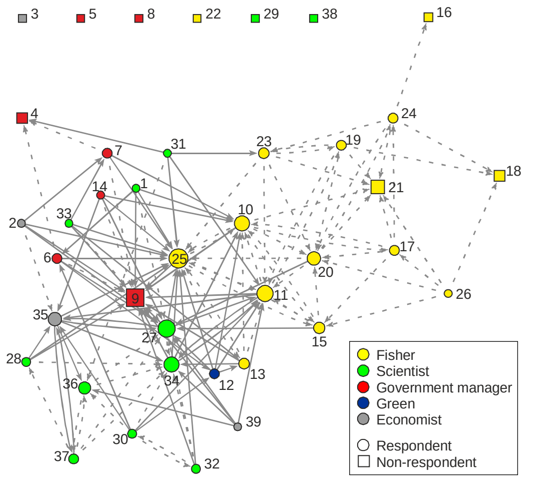
Note: the results in the Australian Northern Prawn Fisheries case study are preliminary because the analysis could not be completed due to illness of the main analyst.

The Australian Northern prawn fishery consists of 52 trawlers from fishing ports between Brisbane and Perth. The Northern prawn fishery has been through a long struggle to reduce overcapacity. 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 underlying rationale is that the achievement of sustainable fisheries is very much linked to the level of trust and confidence that exists between industry, managers, scientists, and stakeholders generally.

The discourse selected for this analysis generated a substantial amount of disagreement among different respondents and stakeholder groups. The distribution of nominations within the network is quite unequal (Input degree centralization 0.39). Some experts are mentioned by many as their most frequent communication partners while many are not mentioned at all.

NORMAC members who are not also RAG members have significantly more positive opinions on values and interests than respondents who are not affiliated to a management institution. On the knowledge claims, Fishermen and NORMAC members take significantly different positions most often. On the salience of knowledge, experts may have convinced their discussion partners of the importance of knowing the facts correctly.

A separate paper is foreseen to be released in 2012 on this Australian case study. That forthcoming analysis suggests that the Australian network analysis showed that agreement about scientific facts among people who disagreed about values and interests increased when they worked together on management committees. This finding would contradicts the conclusions reached in the analysis above. Therefore, it is important to closely examine the implications of both analyses before final conclusions are drawn



Comparison over case studies

In order to test for interactions between network properties, context and network autocorrelation effect, a multivariate statistical analysis was carried out using a multilevel regression model. All predictors have negative effects, indicating that a higher score on the predictor is associated with more negative autocorrelation and, vice versa. Some key findings:

More heterogeneous networks have more negative autocorrelation (factor: -0.45). 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 is higher when the discussion partners are selected within the group. Example of a heterogeneous network is Gulf of Riga herring. Example of a network that is low on heterogeneity is Baltic Salmon International.

Centralized networks have more negative autocorrelation (factor: -0.22). Centralization is associated with discussion links between experts that disagree. This suggests that the central experts in these network are not effectively influencing their peers. Example of a centralized network is the Gulf of Riga herring. Example of a low centralized network is Mediterranean Swordfish and New England Groundfish.

International systems are associated with negative autocorrelation (factor: -0.24). But we should note that the difference is probably mainly driven by the Mediterranean swordfish case. Consensus is probably higher in a national system because experts and issues have a larger shared history.

Management systems with high participation (in decision-making) have negative network autocorrelation (hence more disagreement, factor: -0.17). This difference did not show up in the average scores per case study because those averages were not corrected for other factors. If we would compare management systems with comparable communication networks (same heterogeneity and centralization) and the same national or international scope, the management systems with high participation will have more negative network autocorrelation, so more disagreement among frequent discussion partners. 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.

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. It is important that we control for this effect if we want to determine the effects of participation level.

More participation (in science, in policy-making) does not (necessarily) mean more agreement on facts or values. Management systems among the selected case studies with low participation have more agreement. 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 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.* 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?* The main part of the project addressed this question by experimenting with participatory modelling as a method for getting people to focus the conversation on facts and what a "fact" is. WP 5 examined 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.

Network Heterogeneity and Input Degree Centralization do 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 which is an interesting result.

2.4.2 Deciding on the boundaries of the Dogger Bank: a qualitative study of science practices

Task 5.2 in work package 5 which is aimed at a qualitatively analysis of how scientists in their daily practice help decision makers and stakeholders deal with complexity and uncertainty. Two subsets of objectives were identified:

- To explore how scientists have handled scientific uncertainty in delivering advice for management in different national and institutional settings with different degrees of decision stakes. To explore how stakes influence the way scientific uncertainty and proof is produced and defined.
- To identify and discuss some main issues and best practices for stakeholder participation in science for management.

According to the project description task 5.2 would be based on interviews from the case studies in task 5.1 (quantitative social network analysis) to " help other stakeholders to … understand complexity and uncertainty ". When starting the research task, we found that the study of scientists’ individual practices in handling science and complexity could best be dealt with in a detailed in-depth study of scientific decision-making. In order to achieve this level of detail, the focus has been on one single case (Dogger Bank advice and decision-making) and to report the other case studies in deliverable 5.1.

Scientific justification of boundaries for the protected areas on the Dogger Bank is the detailed in-depth study of what motivates scientific decisions in the processes of designating Special Areas of Conservation for the protection of the sandbank habitat type under the EU Habitats Directive. In the study we looked at the parallel processes in the UK and Germany for defining where the sandbank habitat type is within in their respective Exclusive Economic Zones. 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.

The formulation that scientists 'help other stakeholders to … understand complexity and uncertainty' suggests that it is a one-way process: scientists mediate knowledge and the accompanying uncertainties to stakeholders in order for them to better understand. The research has shown that 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.

The formulation 'help other stakeholders … understand complexity and uncertainty' also suggests that communicating complexity and uncertainty is something that happens after the research process. The study has shown that scientific complexity and uncertainty is 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.

Instead of focussing on the "helping" role of scientists towards other stakeholders, we focussed on the way scientists have interacted with and related to stakeholders in their production and communication of scientific complexity and uncertainty and how their approaches have helped develop policies in highly uncertain contexts?

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 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.

2.5 Synthesis of JAKFISH results

Stakeholder involvement is perceived as an important development in the European Common Fisheries Policy. But how can uncertain fisheries science be linked with good governance processes, thereby increasing fisheries management legitimacy and effectiveness? Reducing the uncertainties around scientific models has long been perceived as the cure of the fisheries management problem. There is however increasing recognition that uncertainty in the numbers will remain. A lack of transparency with respect to these uncertainties can damage the credibility of science. The EU Commission's proposal for a reformed Common Fisheries Policy calls for more self-management for the fishing industry by increasing fishers' involvement in the planning and execution of policies and boosting the role of fishers' organisations. One way of higher transparency and improved participation is to include stakeholders in the modelling process itself.

The project Judgement And Knowledge in Fisheries Involving Stakeholders (JAKFISH) was a three-year project consisting of 10 partners from the EU and Norway. It is a distinctive project in that it provides an integrated approach to stakeholder involvement into fisheries management. It aimed to examine and develop the institutions, practices and tools that allow complexity, uncertainty and ambiguity to be dealt with effectively within participatory decision-making processes; to examine how scientific information is used and what types of roles scientists play in the formulation of policies; to study how the current scientific processes take into account the multiobjective nature of fisheries management; and to synthesise the obtained views, redefining the institutional role of science to improve overall governance in the Common Fisheries Policy (CFP).

The synthesis of the project is captured in two main synthesis documents:

1. Analyses of the lessons from participatory modelling studies
2. Policy brief on institutions, practices and tools to address complexity, uncertainty and ambiguity in participatory fisheries management.

2.5.1 Evaluations of the technical changes and social interactions that occurred during the participatory process, and summarizing on improved scientific skills.

Authors: Christine Röckmann, Clara Ulrich, Marion Dreyer, Ewen Bell, Edward Borodzicz, Päivi Haapasaari, Kjellrun Hiis Hauge, Daniel Howell, Samu Mäntyniemi, David Miller, George Tserpes, Martin Pastoors

How can uncertain fisheries science be linked with good governance processes, thereby increasing fisheries management legitimacy and effectiveness? Reducing the uncertainties around scientific models has long been perceived as the cure of the fisheries management problem. There is however increasing recognition that uncertainty in the numbers will remain. A lack of transparency with respect to these uncertainties can damage the credibility of science. The EU Commission's proposal for a reformed Common Fisheries Policy calls for more self-management for the fishing industry by increasing fishers' involvement in the planning and execution of policies and boosting the role of fishers' organisations. One way of higher transparency and improved participation is to include stakeholders in the modelling process itself. The JAKFISH project (Judgment And Knowledge in Fisheries Involving StakeHolders) invited fisheries stakeholders to participate in the process of framing the management problem, and to give input and evaluate the scientific models that are used to provide fisheries management advice. JAKFISH investigated various tools to assess and communicate uncertainty around fish stock assessments and fisheries management. Here, a synthesis is presented of the participatory work carried out in four European fishery case studies (Western Baltic herring, North Sea Nephrops, Central Baltic Herring and Mediterranean swordfish), focussing on the uncertainty tools used, the stakeholders' responses to these, and the lessons learnt. 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 also contribute to collective learning, increase legitimacy, and advance scientific understanding. However, when approaching real-life situations, 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.

This paper has been accepted for publication by Marine Policy (27/2/2012)

2.5.2 Policy brief on 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.

Authors: M.A. Pastoors, C.M. Ulrich, D.C. Wilson, C. Röckmann, D. Goldsborough, D. Degnbol, Liv Berner, Teresa Johnson, Marion Dreyer, Ewen Bell, Edward Borodzicz, Päivi Haapasaari, Kjellrun Hiis Hauge, Daniel Howell, Samu Mäntyniemi, David Miller, George Tserpes

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 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 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 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. And it needs a realization that participatory modelling is build on trust, and that takes time.

3 Potential impact (including the socio-economic impact of the project)

The potential impact of the project results cannot be foreseen at this stage because it is dependent on the uptake of the results obtained. The project has evaluated the role of science, stakeholder and policy-makers in process of fisheries management and has specifically looked at different roles for knowledge and knowledge-workers in that process. Participatory modelling has shown to be a feasible option in a number of the case studies in JAKFISH and this could generate more trust and compliance to the measures agreed. The involvement of a number of Regional Advisory Councils (NSRAC, BSRAC, PRAC) provides an important forum for disseminating the results of the JAKFISH project.

4 Main dissemination activities and exploitation of results/foregrounds

Results of the JAKFISH project have been disseminated to the stakeholder community, the policy community, the research community and the wider public (WP7)

- Completion and submission of a number of scientific manuscripts on the results of the WP case study work
- Organizing a final JAKFISH symposium, 8-9 March 2011, Brussels
- Presenting JAKFISH results to stakeholders, policy makers, researchers and the general public.
- Developing and maintaining a public website (and an intranet website)

Dissemination activities have been enhanced by the development of a JAKFISH logo

JAKFISH
Judgement and Knowledge in Fisheries Involving Stakeholders

and a JAKFISH information poster. The poster has been presented at the MARE "People and the Sea" Conference (8-10 July 2009, Amsterdam), the ICES Science Conference in Berlin (September 2009) and the fisheries policy reform session in Montpellier (17 July 2010).

The internal dissemination of project results has been organized through a SharePoint system https://www.surfgroepen.nl/sites/jakfish/int/default.aspx. This, in combination with Skype and video-conferencing has enabled effective communication within the consortium.

The external dissemination site had originally been organized through a wiki[1] but was moved to the public part of the Sharepoint system in 2009 and now has it's own domain name www.jakfish.eu.

Special dissemination actions were organized through the Research Media publications "Innovation International" where JAKFISH was one of the feature items in 2010 and again in the forthcoming issue in 2012.

Specific dissemination deliverables are summarized below.

D7.1 Journal MS. Methodological approach to including stakeholder views and existing scientific knowledge in an integrative and participative model (based on Baltic case study).

Authors: Mäntyniemi, Samu, Haapasaari, Päivi and Kuikka, Sakari

Involving stakeholders in the process of environmental management has been suggested to improve the trust between the stakeholders and managers and to improve the commitment to management actions. In this paper we show how Bayesian model

[1] http://jakfish.eu/wiki/doku.php

averaging (BMA) can be used to quantify and pool the knowledge of a group of stakeholders and demonstrate how to take this combined knowledge explicitly into account when considering management decisions. Applying BMA each time when a new piece of empirical evidence is obtained leads to consistent reweighting of the knowledge of different stakeholders, thus providing a mechanism for learning about the expertise of stakeholders from data. This property of the approach is expected to create an incentive to provide as honest information as possible because highly exaggerated views are likely to have a small posterior weight when confronted with data. We demonstrate how the BMA principle works in the context of a simplified example of fisheries management and then use this example to study the potential ways to misuse the approach.

D7.2 Journal MS on the application of the participative methodology to the Baltic Sea herring fishery.

D7.2. consists of three separate manuscripts related to the Central Baltic herring case study of JAKFISH WP4. The first manuscript (Manuscript 1: Involving stakeholders to build integrated fishery models) is about the application of the participative methodology to the Baltic Sea herring fishery, as listed in the DoW of the Jakfish project. In order to enable a thorough analysis of the two approaches used in the participatory modelling, two additional manuscripts have been included. One of them is the analysis of the application of the Bayesian model averaging method in incorporating stakeholders' knowledge in herring stock assessment (Manuscript 2: Incorporating stakeholders' knowledge to stock assessment: Central Baltic Herring) The other of the additional manuscripts presents the participatory approach to framing the management problem of the Baltic herring fishery (Manuscript 3: Framing the problem with stakeholders: five views to herring fishery management).

Manuscript 1: involving stakeholders to build integrated fishery models.

A participatory Bayesian approach was applied to investigate how the views of stakeholders could enrich models and understanding related to the stock assessment and management of the Central Baltic herring fishery. Six stakeholders that represented fishers, environmental organizations, decision makers, managers, and scientists participated in framing the management problem of the herring fishery, in constructing biological stock assessment models, and in evaluating the process and its output. The specific goal of the participatory modelling was to examine interpersonal variation in the understanding of the fishery system. Therefore each stakeholder built models of his own separately of the others. First, they built a probabilistic model related to factors influencing growth, egg survival, and natural mortality of herring. The six competing stakeholder models were pooled into a meta-model using the Bayesian model averaging methodology, and weighted by confronting it with the current scientific data. Secondly, the stakeholders extended considerations from the biological core to objectives for management, to variables that affect the achieving of these objectives, and to management measures that could be used to reach the objectives. This part of the modelling was built into graphical representations of variables and their causal relationships by using influence diagrams. The approach enabled the integrating of scientific evidence with stakeholder experience, stakeholders' beliefs on facts with their values, and biological variables with social and economic factors. The resulting holistic models reflect the fishery to a larger extent than any theoretical model can do, and can be adjusted to changing conditions.

Manuscript 2: Incorporating stakeholders' knowledge to stock assessment: central Baltic herring

In this paper we present a method by which the knowledge of stakeholders can be taken into account in stock assessment. The approach consists of a structured interview process followed by quantitative modelling of the answers. The outcome is a set of probability models, each describing the views of different stakeholder. Graphical representations of the models can be used to explore and communicate the differences and similarities between the views of stakeholders. Individual models are then merged to a large model by using the techniques of Bayesian model averaging, and this model is conditioned on stock assessment data. As result, the model can be used to give management advice where the views of interviewed stakeholders have been taken into account with a weight determined based on how well the views are supported by the observed data. The individual stakeholder models can also be analysed separately to see whether the different views imply different advice or not. We applied this method to Baltic Sea herring stock assessment by interviewing six stakeholders and conditioning the resulting models on stock assessment data provided by ICES.

Manuscript 3: Framing the problem with stakeholders: Five views to herring fishery management.

Our understanding of complex fisheries systems is limited, and the inadequacy of biological models as tools for fishery management has been acknowledged. Approaches that allow the crossing of disciplinary lines, perspectives, forms of knowledge, and scales are needed. We argue that a comprehensive problem framing including different perspectives is needed as the first step in developing more holistic understanding and models. We involved five stakeholders to frame the problem of the Baltic Main Basin herring fishery management. We asked them which variables should be taken into account in herring management, what objectives should be set, and what management measures could be used to reach the objectives. The views of the stakeholders were built into graphical influence diagrams representing variables and their dependencies. We find the approach an illustrative tool to systematically structure complex issues. Such a tool can be used as a social forum for discussion to understand the different views, collective learning and increasing understanding, as well a basis for development, and as a decision support which explicitly includes the views of different stakeholder groups. It enables the examination of social and biological factors in one framework, and facilitates bridging the gap between social and natural sciences.

D7.3 Journal MS on the application of the participative methodology to the North Sea demersal fisheries

Authors: Clara Ulrich, Aukje Coers, Kjellrun Hiis Hauge, Lotte W. Clausen, Christian Olesen, Lothar Fisher, Reine Johansson, Mark R. Payne.

Despite its relatively small stock size and economic value, Western Baltic spring spawning herring (WBSS) is managed in a highly complex governance scheme, with demanding scientific challenges and an elaborate political process of resource allocation among fishing fleets. WBSS herring spawns in the western Baltic Sea, where it is exploited by several EU fishing fleets. It migrates into the Kattegat, Skagerrak and eastern North Sea areas, where it mixes with North Sea autumn spawning herring (NSAS), in an age and season- dependent pattern with high variability, and where it is exploited by both EU and non-EU fleets. For the two separate management areas, TACs are set at different times in the yearly TAC-setting process, and this can result in conflicts over quota allocations to individual fleets.

Industry stakeholders of two Regional Advisory Councils – the Pelagic and Baltic Sea RACs – and scientists involved in the FP7 JAKFISH project engaged in collaboration, aiming to improve stock management through joint development of a robust Long-Term Management Plan. A common understanding of relevant scientific and political issues was developed and used to conduct Management Strategies Evaluations in an interactive process.

In this paper we review the project's achievements, and analyse the effectiveness of the collaborative process itself, and how it affected individual endeavours of the scientific and the stakeholder groups. Finally, we reflect upon the concept of Results-Based Management and how such science-stakeholder collaborations could play a role in a RBM system.

D7.4 Journal MS on the application of the participative methodology to the Mediterranean fisheries.

Authors: George Tserpes, Evangelos Tzanatos, Panagiota Peristeraki

The biological implications of different management measures concerning the Mediterranean swordfish stock were evaluated by means of simulations performed under the FLR framework. Six different scenarios were examined including seasonal closures and quota management. Recruitment was assumed to vary in levels either predicted by a Beverton-Holt stock- recruitment relationship or around a constant value (1990-1999 average). Catch misreporting was also included in the analysis. Simulations projected the levels of landings and spawning stock biomass for a period of 20 years. Results suggested that at least 4-month closures or quotas equal or less to the 80% of the mean 1995-2005 yield are needed to achieve significant (over 40%) SSB increases. The risk of stock collapse is relatively high in case of "no measures" or with quotas that are up to the mean yield of the last decade, but it is severely reduced being less than 10% even with a short two-month closure that does lead to stock rebuilding.

D7.5 Presentations sessions to stakeholder and fisheries management organizations on the results of participatory modelling and role of scientific skills.

There have been numerous presentations of the JAKFISH results to the stakeholder and fisheries management organizations. The central dissemination event has been the final JAKFISH symposium on 8-9 March 2011 in Brussels where representatives from research, policy and stakeholders participated.

The dissemination-activities to the stakeholders and wider audiences took place within the individual case studies according to the tables under D7.7

D7.6 Organizing a conference or ICES theme session on participatory modelling in decision making processes.

The final JAKFISH symposium was held in Brussels on 8-9 March 2011 and attended by researchers, stakeholders and policy makers.

The key objective of the JAKFISH symposium was to jointly discuss and assess with stakeholders the usefulness of participatory modelling approaches and new institutional arrangements in fisheries management. Symposium participants comprised some of the industry representatives (all RAC members), who had participated in the participatory modelling case studies, as well as interested environmental organizations and scientists.

The four participatory modelling cases were presented, followed by reflections on the processes by the involved parties, both from scientific and industry perspective. One general and positive feed-back to the collaborative participatory modelling JAKFISH work from the stakeholders was that they had appreciated participating in JAKFISH. They hope and expect to collaborate more with scientists and in similar research projects in the future. In contrast to the scientific ambition of learning about participatory modelling processes, the stakeholders highlighted that from an industry perspective, the driver for participation is to achieve a useful output through a participatory process, and not the participatory process per se. In short, the final result is more important to the industry than the quality of the process. The RAC stakeholders reinforced that they will keep following the further process of how and whether the JAKFISH case study results will be integrated in future management discussions.

These concrete examples of participatory processes offered good starting points for three more general discussion sessions that focused on questions around (1) the role of science in fisheries management; (2) legitimacy of stakeholder involvement in science; and (3) dealing with uncertainty in participatory modelling. Apart from concrete participatory modelling case studies, the JAKFISH project also investigates social networks and the question whether more participatory processes lead to more trust and agreement about science. This work is still on-going. A JAKFISH scientist described tools to explore how network organization in a particular case can influence agreement. Two case studies for social network analysis and the preliminary results were presented.

Most symposium participants took part in a role play on fisheries management. The different roles involved were "fishermen", "scientists, "environmental NGOs", "managers", "media", and "observers". The aim of such a simulation exercise is to confront stakeholders with each other's realities. Potentially, it can aid in conflict prevention or in problem framing that involves interdisciplinary and multi- stakeholder perspectives.

The symposium finished with a plenary discussion about what we have learned from the JAKFISH project and thinking about what we will do next. Below is a selection of comments and conclusions that were highlighted repeatedly in discussions during the two days.

5 A plan for the use and dissemination of foreground

The JAKFISH deliverable D6.1 (Evaluations of the technical changes and social interactions that occurred during the participatory process, and summarizing on improved scientific skills) has been submitted and accepted for publication by Marine Policy and is expected to appear in 2012.

The JAKFISH deliverable D6.2 (Policy brief on 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) has been prepared in draft form and will be finalized for publication during 2012. This will also be presented at the ICES Annual Science Conference 2012 in Bergen, Norway.

The JAKFISH website will be enhanced with specific results of the participatory modelling case studies.

Attention to the JAKFISH results will be generated though references on LinkedIn, Twitter and websites of the partner institutes.

6 Future research needs

The JAKFISH projected has addressed a number of key issues on participatory modelling and institutional arrangements in fisheries management. However, a number of research questions and collaboration projects still remain open for further work:

- Potential role of action research in participatory knowledge development: how to apply techniques of action research into the domain of fisheries knowledge and management. This requires that there is no disciplinary split in the definition of workpackages, but instead that they are integrated.
- Techniques for joint problem framing between stakeholders, scientists and policy-makers. Case studies should not be predefined but part of the problem framing.
- In Social Network Analysis we are interested in predicting how communication networks evolve i.e. who communicates with who, about what and when and how that affects changes in opinion based on the observed communication network. The main idea would be to test if communication helps to bridge conflicts of interest and reach joint agreement.
- Exploration of the use of serious gaming in fisheries management. The first attempt at developing a fisheries gaming example in JAKFISH suggests that this could be a very instrumental way to involve all relevant actors in a joint learning process.
- A major challenge remains to find effective mechanisms for integrating qualitative and quantitative research.
- When consensus is an important goal in fisheries management: what does consensus mean? How will it fit with interests and power. What happens when you strive for consensus with agreement on facts and values?

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JAKFISH
Judgement and Knowledge in Fisheries Involving Stakeholders

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References

Dankel, D. J., Aps, R., Padda, G., Röckmann, C., van der Sluijs, J. P., Wilson, D. C., and Degnbol, P. 2011. Advice under uncertainty in the marine system. ICES Journal of Marine Science: Journal du Conseil.

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.

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

EC 2003. 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. 2009. Green paper: reform of the common fisheries policy. COM(2009) 163.

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. pp. 1881-1885. Setac Press.

Haapasaari, P., Mäntyniemi, S., and Kuikka, S. 2011. Involving stakeholders to build integrated fishery models.

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.

Holm, P., and Nielsen, K. N. 2004. The TAC Machine. In WGFS 2004.

Jacobsen, R. B., Wilson, D. C., and Ramirez-Monsalve, P. 2011. Empowerment and regulation – dilemmas in participatory fisheries science. Fish and Fisheries: no-no.

Jasanoff, S. 1990. The fifth branch; science advisers as policymakers.

Kuhn, T. S. 1962. The structure of scientific revolutions.

Mackinson, S., Wilson, D. C., Galiay, P., and Deas, B. 2011. Engaging stakeholders in fisheries and marine research. Marine Policy, 35: 18-24.

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.

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.

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.

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. In SCRS/2010/086.

Ulrich, C., Coers, A., Hiis Hauge, K., 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. In ICES C.M. 2010 / P:07.

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.

Wilson, D. C. 2009. The paradoxes of transparency: science and the ecosystem approach to fisheries management in Europe, Amsterdam University Press.

Annex I: List of public deliverables of JAKFISH

Code	Deliverable	Responsible	Date
1,6	Opening of project web page	Laurence Kell	31-7-2008
2,1	Overview of participatory concepts	Marion Dreyer	31-8-2008
2,2	Organize ICES Theme session on governmental quality and risk management	Laurence Kell	28-2-2011
2,3	Review of projects dealing with participatory methods	Marion Dreyer	31-5-2009
2,4	Review findings from basin management and forestry management	Marion Dreyer	31-5-2009
2,5	Proceedings of workshop on common pool resource management	Marion Dreyer	31-8-2009
2,6	Review tools, decision aids and procedures in fishery management focussing on development of a dynamic role in simulating stakeholder responses to uncertainty.	Marion Dreyer	30-11-2009
2,7	Edited volume on common pool resource management based on participatory methods	Marion Dreyer	31-5-2010
3,1	Report on treatment of uncertainty in WP4 case studies.	Kjellrun Hiis Hauge	31-1-2011
3,2	Assessment of handling of uncertainty from a quantitative and qualitative perspective	Kjellrun Hiis Hauge	31-1-2011
4,1	Workplans for management strategy evaluation of case studies	Martin Pastoors	31-1-2009
4,2	Workshop reports and evaluation of case studies management strategy evaluation.	Christine Röckmann	31-1-2011
4,3	Report on Baltic study on the use of scientific information in the past	Robert Aps	30-11-2009
4,3b	Published article on Baltic study on the use of scientific information in the past	Robert Aps	
4,4	CD with simulation software used (including manuals)	Christine Röckmann	31-5-2011
5,1	A social network analysis of a marine management science policy community in each of six case studies.	David Goldsborough	31-5-2011
5,2	Qualitative analysis of scientists-stakeholders interactions that address uncertainty and complexity in developing effective policies	Ditte Degnbol	31-5-2011
6,1	Journal MS(s) or report(s) summarizing the evaluations of the technical changes and social interactions that occurred during the participatory process, and summarizing on improved scientific skills. (Month 36)	Clara Ulrich	31-5-2011
6,2	Journal MS(s) or report(s) on best practices and other lessons about fisheries science institutions and practices from the modelling exercises and comparative research (Month 36)	Clara Ulrich	31-5-2011
7,1	Journal MS. Methodological approach to including stakeholder views and existing scientific knowledge in an integrative and participative model (based on Baltic case study).	Samu Mäntyniemi	31-5-2011
7,2	Journal MS on the application of the participative methodology to the Baltic Sea herring fishery.	Päivi Haapasaari	31-5-2011
7,3	Journal MS on the application of the participative methodology to the North Sea demersal fisheries	Clara Ulrich	31-5-2011
7,4	Journal MS on the application of the participative methodology to the Mediterranean fisheries.	George Tserpes	31-5-2011
7,5	Presentations sessions to stakeholder and fisheries management organizations on the results of participatory modelling and role of scientific skills.	Martin Pastoors	31-3-2011
7,6	Organizing a conference or ICES theme session on participatory modelling in decision making processes	Martin Pastoors	28-2-2011