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Unravelling science-policy interactions in environmental risk governance of the Baltic Sea: comparing fisheries and eutrophication

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Abstract

Interactions between scientific assessments and management decision-making are key determinants for the efficiency of environmental risk governance. This applies particularly to marine ecosystems like the Baltic Sea, where fisheries and eutrophication pose serious threats connected to environmental, social and economic aspects of sustainability.

Using contemporary science-policy theory, this paper investigates structures, challenges, and prospects of science-policy interfaces connected to fisheries and eutrophication governance in the Baltic Sea. We analyse and compare the two cases with respect to two aspects: First the design and organisational structures of the institutional frameworks and second the management of uncertainties and stakeholder disagreements in the two risk cases.

The analyses reveal how conventional natural science-based policymaking is insufficient for the requirements of complex environmental governance arenas like fisheries and eutrophication. Both cases show a high, almost exclusive, dependence on science-based advice regarding the organisational and institutional structure of their science-policy interfaces. They also expose remarkable differences with respect to stakeholder disagreements about the interplay between science, other knowledge and policy decisions. In the eutrophication case consensual science-based advice shaped policy decisions in a comparatively uncomplicated manner. In fisheries by contrast, stakeholder disagreements and different interpretations of scientific uncertainties created serious confusions about the basic role of science in policy.

We identify and discuss factors contributing to the observed differences in the science-policy interplay of fisheries and eutrophication management. Our results highlight a misleading conceptual understanding of science-policy interfaces between the normative idea of objective, science-based policy-making and the political challenges of dealing with various social aspects of uncertainty and stakeholder disagreements in environmental risk governance.

1. Introduction

The relationship between science and policy is a topic of continuous debate, both in social science theory (e.g. Nowotny et al. 2001), in studies of environmental risk governance (Renn 2008), and in discussions on practical implementations and improvements of ecosystem management (e.g. Rice 2005). Scientific expertise serves as a basis for decision-making in most policy domains of industrialised societies. However, when social or political conflicts emerge, the primacy of science in politics is often put into question thus creating new demands and challenges for the science system. Crucial questions for analysing and ultimately improving the efficiency of science-policy interfaces can therefore be identified: How does science inform political decision-making for adequate “risk governance”?[1] Which factors facilitate or hinder the cooperation between science and policy? And which avenues for improving the interplay between science, policy and other stakeholders’ interests can be identified for a more effective and democratised governance of marine

[1] The term and discussions about “risk governance” are delineated in van Asselt and Renn (2011).

ecosystems?

In this paper we address these generic questions by focussing on how scientific uncertainty as well as stakeholder disagreements and conflicts influence interactions between science and policy in the governance of the Baltic Sea marine environment. We look at experiences from two empirical cases of marine environmental risk governance (fisheries and eutrophication) and analyse how they match with theories and concepts about science-policy interfaces from risk sociology and science and technology studies.[2]

The international governing system for environmental risks in the Baltic Sea region has been depicted as a policy pioneer (e.g. Joas et al. 2008; Kern 2011). However, even though Baltic regional cooperation in policy, management and science is well-developed compared to most other regional seas in Europe and worldwide (Kern and Gilek 2013), the environmental status is still severe in many areas (HELCOM 2010) and it is far from resolved whether the regionally agreed environmental objectives of reaching good environmental status by 2021 in the Baltic Sea Action Plan (BSAP) will be met (Gilek and Kern 2011). More sophisticated knowledge about science-policy interactions and their challenges for ecosystem management will therefore be of crucial relevance and may reveal important lessons not only for the governance of the Baltic Sea, but also for other marine regions as well as other cases of environmental risk governance.

Scientific uncertainties and stakeholder disagreements are particularly problematic for marine environmental governance when the so-called *Ecosystem Approach to Management* (EAM) is applied (Garcia et al. 2003; Backer et al. 2010). The EAM, incorporated in marine policies both in Europe and elsewhere, aims to make trade-offs among multiple and often conflicting management objectives linked to environmental, social and economic dimensions of sustainable development. The EAM has significant implications for science-policy interactions and requires various organisations engaged in marine governance to adapt to this new approach (Rice 2005; Wilson 2009). As Rice (2005, 269) puts it for fisheries governance, "we have to accept that uncertainty in the science inputs to management will be larger (and more realistic) in an EAF [Ecosystem approach to fisheries]". Therefore, the uncertainty challenge connected to implementing an EAM is high on the political as well as on the scientific agenda in the Baltic Sea cases studied here, where science-based advice serves as a primary source for management decision-making (e.g. EC 2008).

To unravel and compare the science-policy interactions linked to the cases of fisheries and eutrophication in the Baltic Sea, our analysis entails two successive steps: First, we look at the formal organisational structures of the respective science-policy interfaces to investigate in which way institutional arrangements impact on their functioning. In a second step, we concentrate on the 'backstage views' about uncertainties and disagreements, i.e. we take a look behind the official policy scene by studying extensive material from interviews with various kinds of stakeholders around the Baltic Sea.

The article comprises five sections: this introduction is followed by a brief presentation of the theoretical context and the empirical material analysed in the study. The subsequent two sections present the results from our analyses of *1)* organisational structures of science-policy interfaces in the two cases and *2)* how

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[2] Overfishing and eutrophication are today defined as two major environmental risks to the Baltic Sea ecosystem in key regional policy documents like the Baltic Sea Action Plan (BSAP; HELCOM 2007) and the EU Strategy for the Baltic Sea Region (EC 2009).

uncertainties and disagreements influence science-policy interactions linked to fisheries and eutrophication in the Baltic Sea. In the final discussion we link the experiences from the two cases to the theoretical context.

2. Theoretical context and empirical material

Science-based advice is used in decision-making in almost all areas of societal problems, whether it regards health threats, bio-medical problems, or environmental issues like the ones addressed in this paper. However, the role of science-based advice for political decision-making faces various challenges. While most policy-domains are highly, some even exclusively, based on expert inputs from scientists, the social status and perceived credibility of science-based advice and scientists is often rather low. Bijker et al. (2009, 1) call this phenomenon the paradox of scientific authority, claiming even that "cases in which science-based advice is asked most urgently are those in which the authority of science is questioned most thoroughly".

For a long time the role of science has been perceived as 'on top' of society, as an autonomous institution providing rational knowledge on which society can be built (Polanyi 1962). From this view of science as undiluted by interests and social values (Merton 1942), a linear science-policy concept is derived, in which science has the capability of 'speaking truth to power' by delivering value-free, objective input to rational political decision-making (Funtowicz and Strand 2007). This has resulted in strict demarcations between the institutions of science and those of policy in most science-dependent domains of politics. However the linear model, assuming a direct knowledge transfer from science to policy and decision-making, has been challenged by a number of observations, leading to contradictions for science-based policymaking, as e.g. Weingart (1999, 151) observes: "despite the loss of authority of scientific expertise, policy-makers do not abandon their reliance on existing advisory arrangements, nor do the scholars adapt their ideas on science and its relation to politics". In accord with Weingart's statement, a growing body of literature is calling for a rethinking of this relationship between science and policy, a re-definition of the expert and legitimate expertise, the boundaries between local/lay and global/universal knowledge and the implications of uncertainty (Bäckstrand 2004; Funtowicz and Strand 2007; Lidskog 2008; Linke and Jentoft 2013). By emphasizing the social and societal contexts in which science-policy interfaces are embedded, theories from science and technology studies and risk governance have drawn attention to re-conceptualize science-policy relations and their institutionalisation. Bijker et al. (2009, 6) express this in the simple research question: "How can scientific advice still have some authority when developments in political culture have eroded the stature of so many classic institutions, and when science and technology studies research has demonstrated the constructed nature of scientific knowledge?".

Scientific uncertainty is often seen as the central problem to the linear science-policy model and has been depicted as a "monster" or a "plague" (van der Sluijs 2005; Funtowicz and Strand 2007; Dankel et al. 2012). Uncertainty thus becomes of crucial importance for understanding the role of science in policy-making connected with environmental risk governance since the concept of risk assumes calculability, i.e. how to interpret and evaluate the probability and severity of negative outcomes (Renn 2008). Today, an overly narrow focus on expressing risks in probabilistic terms has been accompanied by more nuanced categorisations of how to address risks in policy and decision-making under different types of uncertainty, put forward for example in Stirling's (2010) 'uncertainty matrix' or in the concept of 'post-normal science' (Funtowicz and Ravetz 1993).

Uncertainty implies a more fundamental, un-quantifiable state than the risk concept and can in its simplest form be taken to mean 'absence of relevant information'. Science-policy analysts attempt to further classify uncertainty in e.g. epistemological and methodological components, as well as institutional factors (Funtowicz and Ravetz 1990; 1993; Hellström and Jacob 2001). The notion of 'institutional uncertainty', as introduced by Hellström and Jacob refers to distinct roles of institutional aspects on risk governance and points to the particular influence of such arrangements on epistemic criteria.[3]

The considerations outlined here depict challenges and shortcomings with a linear science-policy model when various meaningful and legitimate interpretations of risk and uncertainty among stakeholders are addressed. Hellström and Jacob (2001) distinguish two "meta-scientific orientations" in the way uncertainty is taken up in the study of risk and policy: objectivism and constructivism (ibid, 5-21). According to these authors, the two orientations bear different understandings about the role of science in policy and decision-making, and how science-policy interfaces should be organised to function adequately.[4] While the objectivist perspective classifies inadequate control of risk as due to insufficient data or knowledge (i.e. epistemological and methodological uncertainty), the constructivist perspective questions this assumption by stating that lack of knowledge also has important social functions (ibid, 18). Identifying and analysing such situations (of institutional uncertainty), where social interests maintain uncertainties, is crucial for an improved understanding of how socio-cultural contexts impact on the functioning of science-policy interfaces. In this (soft constructivist) perspective, the problem of uncertainty in science-policy relations transcends the question of internal research practices and scientific knowledge claims. The social context of scientific (or any other) knowledge claim, i.e. the communication, interpretation and use of it by various actors, actually becomes the most vital aspect of science-policy interactions.

Empirical material and methods:

The comparative analyses of the two case studies required a combination of document and interview analyses. Our empirical sources consist of regulatory, policy and other documents, and in particular semi-structured in-depth interviews (12 in the fisheries and 17 in the eutrophication case) with stakeholders and key persons connected with the assessment and management of the risks targeted in the case studies.[5] All interview respondents dealt with risk assessment or risk management and worked within EU member countries around the Baltic, in academia, agencies, political forums, industry, media or NGOs. The interviews were conducted in face-to-face situations following a predesigned questionnaire protocol adapted to each case study.

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[3] This means for example when a specific management aspect (e.g. a fishing quota or a nutrient reduction target) becomes of key relevance for decision-making, the epistemic criteria of how to deal with and express scientific uncertainty are not stable but influenced by the actual social stakes at hand.

[4] It has to be noted here, that we are aware of the tensions between and shortcomings with the two approaches for an application to science-policy analyses, not least due to their basically different epistemological and ontological points of departure. The objectivism/constructivism tension yet roots in the fact that the constructivist orientation to risk has been developed mainly as a critique of objectivism (Hellström and Jacob 2001, 33). We regard the distinction proposed by Hellström and Jacob as a useful tool for analysing the different aspects of science-policy interfaces in fisheries and eutrophication addressed in this paper.

[5] This was done as part of the research project Environmental Risk Governance of the Baltic Sea (RISKGOV; www.sh.se/riskgov). The interviews were conducted between February and November 2010.

The interview respondents were based in Sweden, Denmark, Germany, Poland and Finland or worked for supranational organisations such as HELCOM, ICES or the EU Commission. The interviewee sample of both case studies consisted in total of seven scientists, ten 'stakeholders' (including NGOs), seven employees of national authorities (ministries and agencies) and five of supranational organisations.

The interviews centred on obstacles and opportunities for risk governance of the Baltic Sea, with emphasis on the role of institutions, uncertainty and disagreement, and the challenges for implementing the EAM. The interviews were transcribed and analysed using qualitative analysis implying "a careful, detailed, systematic examination and interpretation of a particular body of material in an effort to identify patterns, themes, biases, and meanings" (Berg 2001). This qualitative method was employed because e.g. the terms "science-policy" and "uncertainty" were often not used specifically in the interviews, but expressed by using various terms, examples and lines of reasoning. The initial scanning was followed by an examination of particular actors, attitudes and judgments regarding the existing science-policy interactions, uncertainty interpretations and the treatment of stakeholder disagreements. In addition to this we officially attended twelve Baltic Sea *Regional Advisory Council* meetings between 2008 and 2012, had numerous informal communications with various stakeholders and participated frequently in workshops where the science-policy relation in fisheries or eutrophication were central topics of discussion.

3. Organisational structures of science-policy interfaces

3.1 Fisheries

Fisheries management in the Baltic Sea is today primarily realised via the EU's *Common Fisheries Policy* (CFP), which goes back to 1970.[6] The central scientific body that pools scientific assessments and gives advice to governmental authorities like the EU Commission is the *International Council for the Exploration of the Sea* (ICES). Since it draws on data, information and human resources provided by *National Fisheries Institutes* (NFIs), ICES' independence is partially constrained by different national-level preferences and objectives impacting on the international integration of assessments (Sellke et al. 2010, 15). NFIs differ in their institutional setup, historical and cultural backgrounds. Some NFIs are part of universities, whereas others are governmental organisations and therefore put different emphasis on their ICES-related work (Wilson 2009, 101). Furthermore, regional cooperation at the Baltic Sea level between ICES and the Helsinki Commission (HELCOM) is regarded as weak:

> "This is what I criticise, the lacking cooperation between ICES and HELCOM. It's rather a competitive than a cooperative relationship. This roots in HELCOMs historical connection to the environmental movement, a perspective that has always been in tension with fisheries." (ICES scientist)

Fisheries management in the Baltic Sea therefore represents a tight and EU-centralised interplay between scientific progress (via ICES) and practical politics (EU

[6] Russia, as the only riparian Baltic state not part of the CFP, has bilateral agreements with the EU to regulate fisheries jointly.

Commission) that was developed and established during the 1960s and 1970s (Gezelius 2008). A path-dependent process configured this development of scientific assessments and subsequent management measures resulting in annual fishing quotas (*Total Allowable Catches*, TACs) as a dominant management tool of the CFP (Hegland and Raakjaer 2008). This formalised interdependency between science and political decision-making has been described as the 'TAC-Machine' (Holm and Nielsen 2004), which, by following an annual single fish stock approach, has resulted in 'institutional inertia' for fisheries management in the EU (Wilson 2009, 93), implying that it is highly difficult to change the system towards addressing more complex environmental governance issues like multi-species interactions or ecosystem-based management.

Recently, the CFP has undergone institutional change including enhanced stakeholder involvement, as well as a more regionalised fisheries management. The most important outcome of a reform in 2002 is a new type of stakeholder organisation called *Regional Advisory Councils* (RAC) aiming to include "all the interests affected by the CFP" for the particular regional sea (EC 2004, 17).[7] RACs, such as the Baltic Sea RAC, consist of stakeholders from the fisheries sector, NGOs and other interest groups and are a forum for stakeholder interaction, knowledge inclusion and policy advice from regional levels – thus contributing to the introduction of new, more inclusive modes of governance. However, the regionalisation of the CFP goes far beyond the RACs and constitutes a major pillar in the on-going reform in 2012/2013 to address various shortcomings identified in EU fisheries management (EC 2011; Raakjær and Hegland 2012). Linked to this development, ICES is also going through organisational change in an attempt to improve its efficiency as well as its capacity to extend beyond fisheries and also give ecosystem-based advice (Stange et al. 2012). Examples of this transition include the establishment of various expert working groups to strengthen ecosystem-based fisheries assessment and advice in the Baltic Sea and North Sea[8], as well as several workshops, conferences and meetings aimed at improving stakeholder involvement and interdisciplinary perspectives in the generation of fisheries advice. However, even though ambitions are currently high within ICES to implement an ecosystem-based approach in fisheries advice (ICES 2010), many of the scientists and experts linked to ICES are sceptical to the feasibility of EAM: "If you really want to consider the entire ecosystem for fisheries or other impacts and pollution, that's an impossible task. Even a simple ecosystem like the Baltic is too complicated to model in a quantitative way" (ICES-associated scientist).

Despite these recent changes, the original set-up still shapes today's science-policy interface of fisheries management in the Baltic Sea under the current CFP: ICES provides quota-advice for single fish stocks (TACs) as the foundation for the EU Commission's proposal to the Council of Ministers and the European Parliament, where the political "co-decisions" are finally taken (Hegland 2012; Figure 1).[9]

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[7] Five RACs cover specific geographical regions of EU waters and two RACs address specific fisheries types (pelagic and high seas/long distance fleet) see http://ec.europa.eu/fisheries/partners/regional_advisory_councils/index_en.htm.

[8] For example via ICES/HELCOM's Working Group on Integrated Assessments of the Baltic Sea and ICES' Working Group on Integrated Assessments in the North Sea.

[9] The decision-making on quota management today (2012) still lies exclusively with the Council of Ministers.

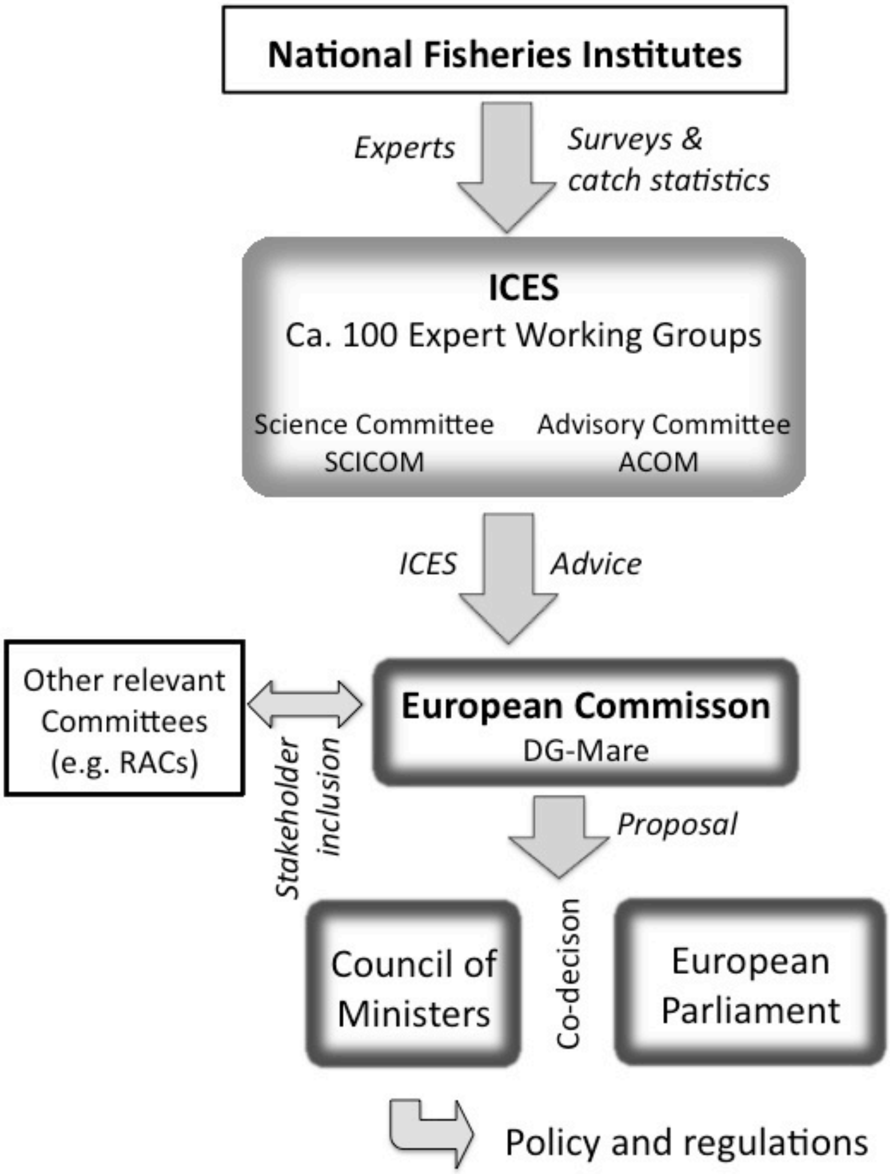

Figure 1: Organisational structure and implementation of scientific advice in the EU fisheries policy framework.

3.2. Eutrophication

Risk assessment and science-based advice connected with eutrophication in the Baltic Sea are also tightly linked to management, although via a less sophisticated and more informal institutional arrangement than in fisheries (Figure 2): The science-policy interface is situated on a regional level in this case and realised through a close relation between a specific decision-support-system called 'NEST' and HELCOM. In close cooperation with HELCOM, one large research project (MARE) set out to develop a single model (NEST) that provided scientific recommendations for a transnational eutrophication management plan for the Baltic Sea (Wulff et al. 2007).[10] This close entanglement of science and management – we call this the NEST-HELCOM nexus – is inscribed in the eutrophication segment of the BSAP (HELCOM 2007) and has been described as a great success through developing scientific decision-support by increasing knowledge on how to reverse the harmful effects of eutrophication in the Baltic Sea ecosystem (Johansson et al. 2007). With respect to eutrophication, the BSAP has therefore been depicted by scientists as "…a unique example of how research and politics can communicate in defining reduction targets for a marine environment" (Österblom and Wulff 2008, 13), a view that has been expressed by our interview respondents from all sectors.

Compared to the EU-centralised decision-process for fisheries, the choices and implementation of policies for mitigating eutrophication rest more or less completely with nation states and their cooperation under the BSAP. The BSAP is however still far from being implemented, implying that the progress of science-policy interactions is still not met at the level where the most concrete measures are taken.

The science-policy interactions in the eutrophication case differ from fisheries also in the spatial as well as the historical perspective, not least since the CFP is about two decades older than the measures on eutrophication introduced by HELCOMs BSAP. By providing a regional basis for eutrophication management, the BSAP-related scientific assessments and advice connect the plan to various EU directives[11] for a synergistic convergence of aims and objectives (Andersen et al. 2011), arranging the case for improved multi-level governance. However, so far there are no signs that this regional cooperation between science and management extends to the design of the EU's *Common Agricultural Policy*.[12]

Ultimately, the success of eutrophication governance in the Baltic Sea will be determined by national implementation plans connected to the BSAP, which have been prepared with varying contents and structures during 2010 and 2011 (Pihlajamäki and Tynkkynen 2011).[13]

The inclusion of stakeholders in eutrophication assessment and management is largely underdeveloped. HELCOM recently started to move from an observer strategy[14] to more stakeholder dialogue through conferences and forums aiming at assembling suggestions from stakeholder groups for a successful implementation of the BSAP.[15] However, it is still early days of this development and our interviewed stakeholders expressed several difficulties with getting involved at the regional level, such as lack of resources, time, and will. A representative from a farmer's organisation expressed this: "So we are now actually in a process where we try to get into that process, but it's difficult and it's not, I would say, sort of, strong unwillingness, it's simply time constraints".

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[10] MARE stands for *Marine Research on Eutrophication, a Scientific Base for Cost-Effective Measures for the Baltic Sea*. The project lasted from 1999-2006; for a description of NEST see: http://nest.su.se/nest.

[11] Examples of such EU Directives are: the Water Framework Directive (WFD), the Marine Strategy Framework Directive (MSFD), the Nitrates Directive and the Urban Wastewater Directive.

[12] Despite successful regional cooperation through HELCOM and BSAP serving as pilots for a number of EU policies and directives (Backer et al. 2010), this policy obviously develops according to other logics.

[13] The effectiveness of the national plans will be evaluated at a HELCOM Ministerial meeting in 2013.

[14] The observer list is published at: http://www.helcom.fi/helcom/observers/en_GB/observers/.

[15] Examples of recently established stakeholder forums are: the HELCOM Fisheries and Environmental Authorities Forum and the HELCOM Agriculture and Environmental Authorities Forum.

Consequently, the current Baltic Sea eutrophication policy connects a complex environmental phenomenon with regard to pollution sources and ecosystem responses with a straightforwardly applied science-based management system.

Figure 2: Organisational structure and schematic description of the role of science in the eutrophication management regime of the Baltic Sea: the two boxes on the left side account for scientific research and advice while the other three refer to the management system.

4. Uncertainties and disagreements at science-policy interfaces

4.1. Fisheries

In EU fisheries governance under the CFP, major conflicts exist between the key stakeholder groups, such as fishermen, NGOs, scientists and managers. The disagreements concern which knowledge about fish stocks is most accurate, objective and reliable – and hence most applicable for decision-making on various management issues (e.g. fishing quotas, gear use and areas or seasons closed for fishing). Many of these conflicts emanate from the science-based policy structure of the CFP itself (Figure 1). While being 'probably the most science-dependent sector in the EU' (Griffin 2009, 563) neither scientists nor other actors in this governance system are satisfied with the outcomes of the CFP (Gray and Hatchard 2003; Daw and Gray 2005; Raakjær 2009). Stakeholder groups are dissatisfied for different reasons and consider separate aspects of CFP's management system as the causes for its failure. In the following we describe three major sources of disagreements in fisheries governance. They refer to different sites in the governance system where uncertainty comes to the foreground.

First, fisheries management under the CFP faces a high degree of uncertainty in the scientific assessments due to inherent natural variability and ecosystem complexity, combined with difficulties in obtaining and assembling data from different sources, institutions and countries. This type of uncertainty relates to the science base in the assessment phase, such as lack of data or model inaccuracy when attempting to estimate the overall status or reproductive capacity of individual fish stocks. Other sources of uncertainty in the scientific assessments regard the treatment and reliance on fisheries dependent-data (e.g. catch and by-catch information; landing data or estimations of so-called 'illegal, unregulated and unreported fishing'). These complex types of uncertainty create tensions in the scientific community, e.g. within ICES, about the adequacy of different data sources and how to treat and use them, factors which finally impact on disagreements about how to present uncertainty in science-based advice for management (Wilson 2009, 123ff). One interviewee in our study admitted this uncertainty problem for science as follows: "Yes … we have uncertainty also in the observations … dealing with uncertainty in fish stock assessment is much like you do it in economics or sociology, it's partly a judgment call" (ICES-associated scientist).

A second site where the notion of uncertainty unfolds is at the heart of the science-policy interface – between science-based advice and management decision-making. It has its origin in the interactions between ICES as major knowledge provider and the EU Commission (represented by DG Mare) as the major user of the science-based advice: While managers at DG Mare prefer precise numbers that they can justify (e.g. on stock size and fishing quotas), ICES favours to give more qualitative expressions in order to account for various sources of uncertainty, such as "'stock dynamics at low levels are not understood', 'data problems from discards', or 'changing fishing patterns'" (Wilson 2009, 125). In short, the disagreements are that managers want concrete numbers while scientists like to give more nuanced, qualitative expressions resulting in tensions between science and management about how to deal with scientific uncertainty in the policy system. This again gives rise to disagreements about the basic role of science in management, leading to constant negotiations about where to draw the science-policy boundary, both within ICES as well as in discussions about the science-advice in the wider governance system, involving policy-makers and other stakeholders.

Thirdly, a general confusion about how to deal with and communicate scientific uncertainty is used by different stakeholders to interpret the scientific assessments according to their own interests, often blaming opposing stakeholder groups of misunderstanding and misinterpreting science. Representatives from the fishing industry are generally supporting (for example through lobbying) the historical practice of the Council of Ministers to set higher fishing quotas than those proposed by ICES. Instead of discussing different views about uncertainty, for example in the RAC, they might use other channels to influence CFP decisions, as a fisheries representative explained to us:

> "[We] keep the politicians aware by meeting them, talking about where we are standing right now and what's the problem and what should be done so that at least our ministry should be very aware of these things really. She goes to Brussels to decide about it." (Fisheries representative)

Environmental NGOs on the other hand try to emphasize the precautionary approach of the CFP, aimed to deal with uncertainties, a perspective that often clashes with the fishermen's perspective:

> "Then we have quite a lot of discussion. Should we use this precautionary approach or not? It's too precautionary very often from the fishermen's point of view. [...] I think, that they [NGOs] see it strictly from their point of view. If ICES has even some advice, they read it literally. They [the NGOs] have a very narrow focus." (Fisheries representative)

This disagreement, induced by different interpretations of uncertainty in science-based advice becomes most obvious in negotiations between the different stakeholder in the RAC: Environmental organisations usually emphasize ICES's advice and use the assessment uncertainties to underscore a need to reduce fishing activity through precautionary approaches to fisheries management. Industry representatives on the other hand express their concerns that scientific uncertainty and lack of data cannot be used to diminish the economic viability of the fishing sector by reducing allowable catches (Linke et al. 2011). A stakeholder from the fisheries sector put it like this: "If ICES does not have proper data for good advice, then I think it would be better for them to give no exact advice at all". Here social and economic values and worldviews inflict on the science-policy interface of fisheries management. Since the policy system is built up as almost exclusively science-based, this does not only create conflicts in the governance processes. The neglected role of deliberation and stakeholder advice often results in abrupt failures like non-compliance of the fishing sector, distrust among actors and contradicting management objectives within the CFP (e.g. concurrent funds to modernise and scrap fishing boats). Despite the establishment of RACs, the actual advice is mainly based on (natural) science and real stakeholder involvement or knowledge inclusion from the non-science sector is still underdeveloped.[16] If the other two pillars of the EAM apart from good environmental status (i.e. economic and social sustainability) will be allowed to enter the governance arena, the policy system needs to be reformed and adjusted with regard to these two aspects. The role of science and scientific uncertainty may then shift, from being used as an object open to interpretation towards one input among several others influencing the interaction between expert advice and other societal concerns in political decision-making (Linke and Jentoft 2013).

4.2. Eutrophication

Besides the complexities in ecosystem functioning, we also face a diverse political arena to manage and control nutrient pollution and connected eutrophication problems and risks in the densely populated region of the Baltic Sea drainage system. Moreover, there are indications that possible large-scale environmental effects at the ecosystem level such as ‘regime shifts’ and ‘trophic cascading effects’ can be amplified by other human perturbation such as overfishing of cod (Casini et al. 2009).

In spite of this complexity, the science-policy interface of the regional eutrophication policy in the Baltic Sea exhibits a comparatively smooth and straightforward process tightly coordinated between the actors of the scientific advisory system (via the NEST model) and the management regime under HELCOM. While scientific disagreements existed earlier on whether nutrient management should focus only on nitrogen, phosphorus or both, this is now seen as largely settled with recent agreements that both nutrients need to be controlled (Conley et al. 2009a). As one scientist in our interview study stated, this debate “has faded away, now it is a consensus that both nutrients should be reduced”. This mirrors an overall agreement about the complex phenomenon of eutrophication as such, as well as about how to control it, which exists within both the scientific community as well as among managers at HELCOM, national authorities and at the EU-level, jointly stating that nutrient reduction is the only effective long-term strategy, at least for the Baltic marine ecosystem:

> “Well I think it is quite simple and very well understood scientifically [...] too high inputs of nutrients, phosphorus and nitrogen, stemming mainly from agricultural activities [...] everybody has a quite good understanding, of those processes and what we need to do in order to reverse this process.” (HELCOM expert)

However, a debate is still apparent, in particular on the national implementation level, concerning which specific reduction measures are most cost-effective, e.g. when comparing emission reduction measures with land-use changes designed to increase

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[16] For example Gray and Hatchard (2003) criticise that RACs might be “more rhetorical than real” and just another “lip-service” paid by the EU Commission to take up new concepts of ‘good governance’.

nutrient retention (e.g. Gren 2008; Elofsson 2010).[17] In response, a mechanism for a regional nutrient trading system, similar to that of the Kyoto protocol for carbon dioxide, has been proposed for achieving a cost-effective and fair implementation, as Gren (2008, 281) notes: "An extension of the HELCOM BSAP to allow for nutrient trading may increase the probability of successful implementation of the agreement". The practical challenges with setting up such a system are huge and at present HELCOM's contracting parties are committed to find individual management strategies for nutrient reductions via the national implementation plans (HELCOM 2007). In doing so, possible uncertainties in the scientific assessments are generally not sparking major disagreements or serious conflicts, neither among countries nor among stakeholder groups. Despite some objections voiced e.g. by the Swedish farmers that 'a completely new and previously untested model is used as the basis for a multi-million decision' (LRF 2010), stakeholders have so far not contested the overall regional eutrophication policy as such, as seen in the fisheries case.

A number of studies have also investigated possible technical solutions like nutrient extraction through mussel farming, chemical sequestration of phosphorous, artificial oxygenation or a change of saltwater inflow (Conley et al. 2009b; Conley 2010). Although these 'engineering approaches' are judged by some actors to be appropriate complementary measures in coastal recipients, their potential for addressing large-scale offshore eutrophication in the Baltic Sea is seen as marginal or with great scepticism. As one scientist expressed this issue to us: "…in some cases local measures are meaningless because you have local measures in an open coast and what is actually affecting the situation is the large-scale eutrophication."

Although substantial scientific uncertainties exist regarding eutrophication assessments and advice, particularly in relation to an EAM, in contrast to fisheries, lack of data and knowledge do not seem to be decisive in the discussions about appropriate policies for eutrophication in the Baltic Sea. This largely missing role of scientific uncertainty in the policy debate can be detected both in the official regulatory framework as well as in the informal discussions and opinions of the actors interviewed in our study. One scientist reflected on the ignorance of uncertainty in eutrophication policy-making by comparing it with the climate change regime:[18]

> "Climate researchers are much more used to work with uncertainties. They also stress that they work with scenarios, not predictions. I think it is very important to make this distinction, that you can set scenarios. You can use the uncertainties in these ensembles and there are many more people involved and it is also very important that there are a number of independent institutions that do these studies."

In summary, the close interplay between scientific assessments and management decisions has so far been realised by a handful of people through the tight NEST-HELCOM nexus, which made it possible to translate science more or less directly into political action and management proposals, even though the EU's *Common*

[17] The policy objectives changed from general 50% nutrient reductions everywhere towards a system of most cost-effective measures to be undertaken in the different sub-regions of the Baltic Sea (Wulff et al. 2007).

[18] Also recent research on eutrophication tries to take account of these uncertainty challenges, e.g. through a quantification of model uncertainties, simulations and scenario building (cf. Meier and Andersson 2012).

Agricultural Policy is still hardly influenced by these processes.[19] Affected stakeholder groups like farmers are organising themselves with regard to nutrient reduction strategies, both on the national as well as on the international level. This means that the role of uncertainty can still cause major obstacles for future attempts to implement the BSAP, i.e. that eutrophication may run into similar conflicts like fisheries due to the strong reliance on science-based advice largely excluding other stakeholders' perspectives.

Future developments in the science-policy interplay of eutrophication will show how the so far neglected role of scientific uncertainty, and possible disagreements and conflicts connected with it, may play out in the overall governance arena.

5. Discussion

This paper investigated factors interfering with the interplay between science and policy in two cases of governing marine transnational environmental risks. As we have seen in the theory section, different views exist about how to conceptualise science-policy interfaces for effective cooperation in environmental management. Following an objectivist perspective, the specific role and function of social and cultural aspects are usually omitted from the interplay between science and policy. A more constructivist perspective on the other hand highlights the social context by emphasising the impact of interests, values and worldviews on the functioning of science-policy interactions. In this study we analysed how organisational structures, uncertainty and stakeholder disagreements influence the science-policy interfaces for governing fisheries and eutrophication in the Baltic Sea.

5.1 Fisheries

The fisheries case exposes a simultaneous politicization of science and scientification of politics. EU fisheries management under the CFP shall be guided by "a decision-making process based on sound scientific advice, which delivers timely results" (EC 2002 Art. 2,2). While this exclusive reliance on science is manifested in the centralised quota management system of the 'TAC machine' (Holm and Nielsen 2004), stakeholders have divergent views about which objectives should be prioritized and on how and where to draw the science-policy boundary, a demarcation decisive for the overall structure of the policy system (Nielsen 2005). A problem we have seen is that both science and scientific uncertainty are often conceptualised in an objectivist perspective by key actors and in the main documents of the CFP: Lack of knowledge, data and information for sustainable fish stock management are often addressed as solely in need of more and better research. While this is clearly relevant, the linear-scientific framing of this politically heated and basically value-laden controversy will (if kept throughout the reform process) risk a continued neglect of the socio-economic aspects that are fundamental for establishing a functioning governance process in the long term (cf. Aps et al. 2011). In this 'grey-zone' of a scientised policy regime, the confusion around uncertainty severely hampers efforts to move towards more sustainable fisheries governance, not least since various stakeholders e.g. from NGOs and fisheries use it to defend their particular interests, blaming other groups of misunderstanding the role of science. As Sarewitz (2004, 396) argues, uncertainty "is

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[19] An important aim for this policy's reform in 2013 is to bring it better in line with the WFD and MSFD (Lundberg forthcoming).

the location where conflicts between competing sets of facts and disciplinary perspectives reside". Hence the idea of reducing uncertainty through more research builds on an insufficient science-policy understanding. Following Sarewitz, this may result in that an unavoidably politicised science can "make environmental controversies worse" (ibid). Besides relying on scientific research and advice for managing a value-laden environmental controversy like fisheries, the value disputes also need to be addressed as political challenges and their societal implications to be explored and attended to. Since accountability for environmental governance ultimately rests within the political and not the scientific domain, foremost political reform is needed.

For fisheries, new modes of governance have therefore been included in the CFP since 2002, with the RACs as a major reform output aiming to address major disagreements. In the on-going CFP reform process (CEC 2011), attempts are made to adapt science-policy interaction to uncertainty challenges, e.g. in discussions about reversing the burden of proof in fisheries governance (Linke and Jentoft 2013). In this line of reasoning Bundy et al. (2008, 152) have concluded that "[t]he current crisis in fisheries is not caused by lack of scientific information, but by lack of a holistic view of ecosystems" and proposed a new governance model that gives the social aspects a more prominent place. This "inverted pyramid model" requires, as these authors state, both business incentives, awareness of social justice and broader ethical issues, as well as a balance of power to prevent a continuing governance crisis.

5.2 Eutrophication

We have shown that the eutrophication case exposes a linear conceptualisation of science-policy interactions, in which a large research project resulted in a single model of science-based policy advice that was taken to a great extent as the sole basis for policy decisions in the BSAP. The scientific knowledge was used in a remarkably direct manner and the social context of various stakeholders did not interfere on this interplay to any substantial degree. This close connection between science and policy (NEST-HELCOM nexus) has been interpreted as a "real success-example" by the actors involved, a view in line with the objectivist tradition of science-policy concepts. In this case, science has been able to "speak truth to power", probably due to the fact that only a limited number of stakeholders have been involved so far. Serious disagreements between different actor groups, such as farmers, scientists and managers, or practical conflicts of interest as we have seen in the fisheries case, cannot be detected yet and the regional eutrophication policy thus exhibits a rather harmonious interplay between science and policy-making. The uncertainty challenge for science-policy interactions has so far not played out to be a major obstacle or source of conflict in the eutrophication case. As our study suggests, this is partly due to a narrowly constructed science-policy system, where the social context of additional stakeholders' interests and views, e.g. on how to implement cost-effective nutrient reduction in the agricultural sector, have not yet come to play. Here, the so far unarticulated role of scientific uncertainty may potentially come into the foreground, in particular if and when the BSAP will be implemented in national policies and thus more directly affect stakeholders' interests. Such practical problems of eutrophication management will certainly bring about challenges for science-policy interaction, i.e. how to draw the boundary between the two domains while dealing with the entanglement of facts and values. This may then also lead to repercussions for scientific discussions on how to assess, express and communicate various aspects of scientific uncertainty to different stakeholders. The national implementation plans will have to show in the coming years, how the agreed science-based targets of the BSAP can be reached and if similar governance failures as in fisheries will occur.

5.3 Comparing cases: lessons learned

Our study shows interesting similarities as well as peculiar variations between the science-policy interfaces of fisheries and eutrophication. While both cases exhibit highly science-based organisational structures, they expose different ways in which stakeholder disagreements spark conflicts, especially about how to deal with uncertainty. In eutrophication a consensual science-based advice has shaped policy and management decisions in a comparatively uncomplicated and harmonious manner. In fisheries, uncertainty within the institutional system has created confusion about the basic role of science in policy. The interactions in the eutrophication case follow an objectivist conceptualisation, i.e. the idea that scientific assessments, sufficient knowledge and appropriate advice can suitably be used to manage the risk of unwanted algal blooms in the Baltic Sea. Fisheries science-policy interactions in contrast need to be explained much more thoroughly using also a constructivist perspective. Disagreements between the stakeholders involved in this governance domain tend to conserve and even exacerbate the "institutional uncertainty" in the policy system.

Besides relating to the divergence in science-policy interfaces of the two cases, we can identify four other factors behind these differences. First, the dominating CFP goes back to the 1970s (around two decades before the initial measures on eutrophication by HELCOM arrived), and hence the time for stakeholder mobilisation has been much longer in the case of fisheries. Second, the CFP is a EU harmonised area of decision-making, with a direct impact on stakeholders' work e.g. via quota-settings, which creates strong potential for the mobilisation of for example fishermen, whereas eutrophication policy under HELCOM still needs to be implemented on the national level before it influences stakeholders like farmers. Third, the degree of organisation on the international level among like-minded Member States and stakeholder groups is comparatively high in the fisheries sector. Fourth, the national and international public debates on overfishing have led to a strong politicisation of the whole field, feeding into controversies, which cannot yet be seen to a similar extent in the eutrophication case.

These factors contribute to explain the observed differences between the science-policy interplay in our two cases, even though additional studies are needed to describe their relative impact, not least with respect to the effect of scientific uncertainty. Furthermore, we have not found any processes yet in place for preventing the eutrophication case evolving into a similar dilemma as fisheries, implying that reactive measures to cope with stakeholders' disagreements of various kinds may be needed.

In general, our results expose a misleading conceptual understanding of science-policy interfaces in both cases, namely the confusion between the normative idea of natural science-based policy-making, and the practice of political decision-making dealing with uncertainty and stakeholder disagreements. This is evident for fisheries but can also be seen behind the curtains in the eutrophication case resulting in misunderstandings about actor roles when aiming for governing complex risks like those of the marine environment: Scientists wonder, and often become frustrated, that their "best available advice" often gets ignored while politicians face multiple, often opposing constraints, struggling to lean on 'rational' claims provided by science while needing to take other stakeholder's interests into account. This is particularly true when aiming for implementing the EAM, implying a balance of environmental and social dimensions. In the eutrophication case, the EAM is supported by the scientific community and seems to have a potential role as 'communication facilitator' between science, policy and other stakeholders, whereas the EAM in fisheries has been questioned due to practical interpretation and implementation challenges.

When analysing our findings in relation to the theoretical outset, it becomes clear that present science-policy interfaces of both eutrophication and fisheries are not yet capable of fully addressing the problems of scientific uncertainty in conjunction with the social aspects of governance. In both cases increased knowledge inclusion and stakeholder participation is seriously needed to pave the way for improved environmental governance. There are, however, indications of a growing awareness among all stakeholders that the definition and interpretation of "how good is good" cannot be answered by science but needs to be addressed as subject to human values and worldviews. As one scientist in our eutrophication case study expressed it: 'But there is one issue that has been discussed very little: what is a good Baltic Sea, what is a good environment? That is a societal question not a scientific one'. Concluding this paper we slightly convert this statement by arguing for a need to expand the definition of what constitutes science and its advice to also include the so far neglected domains of the social sciences. This would transgress the idea of science-policy interfaces as a mere intersection between facts (science) and values (policy), opening up for including perspectives, values and worldviews from all stakeholders involved in a specific governance arena.

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