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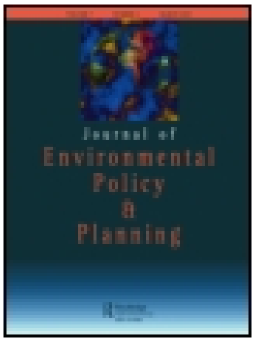


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# Knowledge for environmental governance: probing science–policy theory in the cases of eutrophication and fisheries in the Baltic Sea

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**ABSTRACT**
How science and policy interact has been a major research focus in the International Relations (IR) tradition, using the epistemic community (EC) concept, as well as in the alternative perspective of Science and Technology Studies (STS). Should science be autonomous and as apolitical as possible in order to 'speak truth to power', as suggested by EC or should the inevitable entanglement of science and politics be accepted and embraced so as to make advice more conducive to negotiating the explicit travails of political decision-making as suggested by STS? With this point of departure, we compare similarities and differences between science–policy interactions in the issue areas of eutrophication and fisheries management of the Baltic Sea. To examine how knowledge is mobilised, the concepts of 'uncertainty' and 'coherence' are developed, drawing on both EC and STS thinking. We then reflect on the explanatory value of these approaches in both cases and discuss how a separation of science and policy-making in the pursuit of achieving scientific consensus leads to ineffectual policies. Drawing on STS thinking, we urge for a re-conceptualisation of coherence in order to accommodate a more reflexive practice of science–policy interactions.

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## 1. Introduction

Interactions between science and policy are commonly described as key processes in environmental governance (Renn, Klinke, & van Asselt, 2011). Scientific advisory work is often seen as a crucial aspect for the success (or failure) of environmental governance policies. This is particularly the case in arenas of high environmental and political complexity, such as those characterising the attempts to mitigate nutrient pollution (eutrophication) and sustainable management of commercial fish stocks (fisheries management) in the Baltic Sea.

Epistemic Communities (EC) and Science and Technology Studies (STS) have for some time investigated science–policy interactions, with rather limited cross-fertilization between these approaches (Haas, 2004; Jasanoff, 2004; Lidskog & Sundqvist, 2002, 2015). Despite important differences between the two academic traditions, Lidskog and Sundqvist (2015) argue that 'there have been few attempts to systematically deal with the contribution of STS to enriching the International Relations (IR)[1] understanding of the role of science in international environmental governance' (p. 2). Both approaches agree that the interplay between science and policy is important, but vary substantially in their ways to conceptualise, analyse and explain science–policy interactions. Despite differences in assumptions and the respective analytical foci of EC and STS, it is widely accepted that scientists play a key role in informing environmental governance in general and marine environmental governance in particular. It is, however, less clear what role scientific knowledge actually has in shaping

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international governance regimes such as eutrophication management in the Baltic Sea under the Helsinki Convention and management of commercial fish stocks in the Baltic Sea under the EU's Common Fisheries Policy (CFP). Both interest areas have strong science-based knowledge networks with the long established International Council for the Exploration of the Seas (ICES) overseeing scientific advice for fisheries and the more recently established Baltic Nest Institute (BNI) conducting a similar role in the case of eutrophication.

The diversity of countries (socio-economic, culturally, national interests, politico-administrative traditions, etc.) suggests that it may be difficult to generate effective environmental governance cooperation in the Baltic Sea Region (BSR) (Joas, Jahn, & Kern, 2008). Still, the region, with the establishment of The Baltic Marine Environment Protection Commission (HELCOM), is regarded as a pioneer and forerunner of transnational environmental governance, including in the two issue areas focussed on in this paper (Joas et al., 2008). The relatively long-term science–policy dynamics that have unfolded in the region enable us to examine how knowledge contests and their relationship to policy have fluctuated and shifted over time.

The limited research that considers the relative analytical merits of STS and EC has been mostly conceptual, drawing on empirical examples for illustrative purposes. There is literature in the BSR context that has examined more in-depth the various aspects of environmental governance (Gilek & Karlsson, 2016; Hassler, Boström, & Grönholm, 2013) and science–policy interactions in particular (Gilek, Karlsson, Udovyk, & Linke, 2015; Linke, Gilek, Karlsson, & Udovyk, 2014, 2016; Pihlajamäki & Tynkkynen, 2011). However, few, if any, studies have explicitly undertaken an analytical comparison that includes the historical dynamics and developments of science–policy interactions of two important environmental governance concerns such as eutrophication and fisheries.

In this paper, we investigate our two empirical cases by addressing the question whether we as science–policy analysts can gain an improved understanding through conceptualising science and policy as separated (Haas, 2004) or intertwined in a process of 'co-production' (Jasanoff, 2004)? We analysed developments over time in our two issue areas to reach an improved understanding about: (1) how a boundary is drawn between science and policy *in practice* and (2) what role the specific structuring of this boundary may have with respect to expert community coherence and the handling of uncertainty.

To examine how knowledge is mobilised, we conceptually develop 'uncertainty' and 'coherence' and apply these understandings to examine our two policy areas. We then discuss the relative explanatory value of the EC and STS approaches in each case to examine how expert networks can influence policy and decision-making power in international environmental governance. Finally, we present similarities and differences among the cases and reflect on lessons learned in relation to EC and STS theory.

## 2. Analytical scope and focus

Haas (1992) introduced the EC approach to investigate the role of experts in regime formation and development. According to Haas (1992), an EC is an integrated, transnational network of experts through which new ideas circulate from societies to governments and that works to facilitate international environmental cooperation. The EC approach suggests a clear separation between science and policy-making as a reason for success as indicated by the following claim: 'The more autonomous and independent science is from policy the greater its potential influence' (Haas, 2004, p. 576). STS scholars, on the other hand, argue that Haas and the IR (including EC) research tradition are leaning 'on an unproblematized, almost positivistic, view of science' (Lidskog & Sundqvist, 2002, p. 83; cf. Jasanoff, 1996). Should science be autonomous and as apolitical as possible in order to 'speak truth to power', as Haas (2004) conceptualisation of science–policy suggests? Or should the messiness and political nature of science, as suggested by STS, be accepted and embraced so as to make advice more conducive to negotiating the explicit travails of political decision-making?

From these contrasting perspectives, our analytical point of departure is Davis Cross' (2013) work, urging for more empirical research on several issues that she sees underexamined in the EC literature. Responding to Davis Cross' critique of EC by drawing on STS concepts may advance our understanding of the complexity and messiness of science–policy interaction. Among other factors, Davis Cross (2013) argued that the EC approach would benefit by paying more attention to (1) the *coherence* of the science–policy networks and (2) the role that *uncertainty* plays in the interaction between scientific advice and its policy uptake.

### 2.1. Coherence

As Davis Cross (2013) argues, the persuasiveness of actors in ECs 'rests in large part on their degree of internal cohesion and professionalism' (p. 147). Within scientific communities, knowledge is reconstituted and made 'robust' through collective exchange and debate through different media, networks and events. Knowledge is produced, evaluated and transmitted by different actors to frame environmental problems and promote various policy solutions. Through these interactions, alliances are formed around ideas that help form and maintain expert networks in practice.

When international environmental policy-making institutions, such as HELCOM[2] in the eutrophication case or bodies associated with the EU CFP, claim that their policy actions are rooted in facts by virtue of the scientific consensus on causes and solutions, it makes policy coordination and development less problematic. It creates an impression that decision-making processes are premised on and bounded by 'the truth about nature' rather than steeped in knowledge battles and controversies over the causes and consequences of environmental problems. Moreover, the EC approach adopts the view that it is possible and indeed desirable to insulate scientific knowledge production from discussion about values and interests. The EC approach supposes that due to the relative political intractability of values and interests, these issues can only be negotiated through compromises and trade-offs. In contrast, the production of (consensus-based) scientific knowledge can and should be framed as apolitically as possible, to avoid actors viewing facts through the prisms of values and interests (Haas, 2004). STS, on the other hand, declares such a distinction as obsolete and sees scientific consensus as the result of negotiations and compromises between actors that take place in a wider societal context. Instead of consensus, STS draws on the notion of closure to describe the results of such processes (Lidskog & Sundqvist, 2015). Hence, while STS takes a more micro-level epistemological approach to the study of science–policy interactions, the EC approach is more prescriptive and as such has important normative implications. EC focuses less on how science and policy actually interact in practice and more on how this interface should or could work more effectively (aiming to minimise the impact of values on knowledge production) (Lidskog & Sundqvist, 2002).

There are likely to be competing expert networks, with disciplinary-based commitments, vying for scientific and political influence in relation to a given environmental problem. Their relative coherence may be an important factor in determining their capacity to 'compete' for policy influence. Sharing professional knowledge may work to reduce uncertainty and provide focal points to coordinate expectations among EC actors. Knowledge here is understood as facilitating a relationship among professionals that they can draw on strategically in networks to address particular policy problems.

The literature discussed above suggests that understanding the internal dynamics and relative coherence of ECs can provide important insights into their possibilities to influence policy development within our two case study areas. In contrast, the STS literature argues that we must go beyond considering the role of small groups of experts in the production of scientific knowledge to include the contexts and broader networks in which these expert groups act.

### 2.2. Uncertainty

Environmental decision-makers in our two issue areas are confronted with what they see as complex environmental and technical questions that require the input of science to make the issues more legible and to provide a rational underpinning for policy action (Haas, 1997). Therefore, uncertainty provides both a challenge and an opportunity for an epistemic community (EC) to influence environmental decision-makers.

In a STS tradition, post-normal science (PNS) studies tell us that when dealing with complex environmental issues, marked by high uncertainty and high societal stakes authoritative scientific knowledge alone is insufficient to advise on policy problems (Funtowicz & Ravetz, 1993). PNS scholars advocate the enrichment of 'normal' science by local and practitioner knowledge to aid understanding and management. Therefore, an extension of the peer review community is suggested, which is 'not merely an ethical or political act; it can positively enrich the processes of scientific investigation' (Funtowicz & Ravetz, 1993, p. 753). In addition, PNS also urges for more interdisciplinarity to address both issues of technical uncertainty (epistemological and methodological questions) and uncertainties in policy design (Spruijt et al., 2014). The implications of this view for complex policy issues such as eutrophication and fisheries management is that the generation and application of scientific knowledge must be undertaken transparently and include a broad range of expertise and knowledge through integration of various scientific disciplines and practitioner/stakeholder inputs.

An analytical entry point is to consider how scientific uncertainty is interpreted and coped with in relation to ambitions for implementing a precautionary approach (PA) in environmental policy. The precautionary principle applies 'where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation' (UNCED Article 15, 1992). Key concerns regarding uncertainty in this paper thus relate to how precaution is interpreted and argued by scientists and other experts in the studied cases and how precautionary methods and strategies are adopted in expert advice.

In agreement with Davis Cross (2013), we see that the concepts of coherence and uncertainty are likely to be important when examining any given expert community's influence on environmental policy. This is particularly so if these insights are augmented by a more critical STS stance that suggests that influence is more an ongoing function of the amorphous and dynamic relationship between science and policy rather than the end result of 'truth speaking to power'.

## 3. Case study selection and methodology

### 3.1. Case study selection

We have strategically chosen two important and complex cases with large-scale environmental and societal implications: eutrophication and fisheries management in the Baltic Sea. These cases exhibit different types of characteristics in terms of complexity of sources and scientific uncertainty, as well as, how current science–policy interactions are organised.

Eutrophication governance in the Baltic Sea is a complex multi-level governance arrangement, where the international level via EU legislation and HELCOM recommendations and action plans play a dominant and steering role (Karlsson, Gilek, & Lundberg, 2016). National measures are also important for implementing the international policies and to give effect to national policy priorities. Complex structures and processes for science–policy interactions on eutrophication have developed at national and international levels. Lately, the HELCOM system has been a dominant arena for developing scientific assessments and advice, particularly the development of the eutrophication segment within the 2007 HELCOM BSAP and its subsequent renegotiation and implementation (Linke et al., 2014).

Fisheries in the Baltic Sea is primarily managed through the CFP with associated institutionalised processes for science-based advice and decision-making on total allowable catches (TACs) (Sellke, Dreyer, & Linke, 2016). Decisions on TACs for commercial fish stocks are taken by the EU Council of Ministers with input from scientific advice developed by ICES, as well as stakeholder input from so-called Advisory Councils (ACs). For the Baltic Sea's scientific assessments and advice, this input is linked to ICES' work on regional fish stocks, such as cod, herring and sprat in the Baltic Sea.

### 3.2. Methodology

The actor configurations of interest to us are communities of experts who come together because they share a common understanding of the scientific and political nature of our two environmental issue areas. The case studies are focussed on exploring coherence and uncertainty in relation to particular policy developments at a regional Baltic Sea level. For eutrophication, the case study explores science–policy interactions linked to the 2007 HELCOM Baltic Sea Action Plan (BSAP). This case exhibits complex science–policy interactions occurring at multiple levels across various countries. We therefore focus on the regional level and the BSAP, including earlier developments of potential significance, particularly in the Swedish context. In tracing the origin of the expert communities influential in shaping the 2007 BSAP, it became clear that earlier Swedish-based science projects and networks were of key importance. In the fisheries case, attention is paid to how international fisheries has been made manageable through a division of labour between science and policy in an institutional system designed for this task. We explore how the high degree of scientific uncertainty and its problematic role for decision-making has been handled in different periods and how calls for ecosystem-based and precautionary environmental governance are addressed. Analysis of expert/scientific communities linked to HELCOM, ICES and CFP activities is thus means for exploring how cognitive and normative aspects of science–policy interactions come to be adopted, exchanged and formalised in eutrophication and fisheries management. Such communities of experts rely on scientific evidence to support claims for policy reform.

We apply a combination of methods in the case studies including a backbone consisting of document analysis of a wide range of literature, policy documents and meeting minutes linked primarily to HELCOM and ICES. Understandings through these sources were expanded and verified through participatory observation at relevant meetings, as well as by formal and informal interviews with actors of the respective expert communities. Linked to the eutrophication case, we performed participatory observations and informal interviews with 15 key scientists and HELCOM representatives during the years 2011–2016 at a set of scientific conferences and policy events. These included the annual ICES science conferences (2011–2016), the biannual Baltic Sea Science Congress (2011 and 2015), the HELCOM Baltic Sea Science Day and back-to-back science–policy meetings arranged by the Academy of Finland (2013), the Annual Forum for the EU Strategy for the BSR (2015) and the Swedish EPA's conference on environmental quality objectives (2014). In addition, we arranged a roundtable with invited experts and decision-makers in November 2013 on Swedish Environmental Quality Objectives (where eutrophication was one topic covered), as well as two panel discussions with invited experts at the annual Swedish politician and expert gathering in Almedalen (2015 and 2016). Finally, we performed an in-depth semi-structured interview (2015) with a Swedish university scientist with extensive experience in eutrophication science and policy in Sweden and the BSR. The fisheries data presented were derived from long-term ethnographic field study, including document studies of policy papers, meeting minutes, reports and correspondence, 27 semi-structured formal interviews and numerous informal interviews and communications with Advisory Council (AC) stakeholders, involved scientists and policy-makers, as well as, participatory observations of 29 AC meetings held between 2008 and 2015.

The data are presented as chronological narratives organised in the following way in both issue areas: (1) outline of the expert communities (development, 'membership', coherence/ consensus building); (2) role of uncertainty and connectivity with decision-makers relating to particular decisions and (3) community coherence and policy influence. To allow sufficient focus on the paper's key analytical concepts of uncertainty and coherence, our accounts relating to expert community membership are outlined with a relatively high level of aggregation. Using an approach built on both document analysis and observations/interviews provided a means to track change over time and therefore illustrate how the positions of the expert communities changed in response to both coherence and uncertainty as well as contextual factors, such as emerging resource management knowledge, the role of the EU, policy cycles, etc.

## 4. Case study results

### *4.1. Eutrophication*

Science–policy interplay linked to eutrophication of the Baltic Sea has changed substantially over the past 50 years.

*First*, in a stage of *recognition and agenda setting* (1960s to early 1970s), the scientific community started to generate results indicating that eutrophication might be occurring and that anthropogenic nutrient inputs could be the cause (Fonselius, 1969). At this stage, expert communities mainly followed the boundaries of traditional scientific disciplines and were quite national in character, as explained by an interviewed scientist. Up until then eutrophication was primarily seen as a problem in lakes and near to cities and industries. However, scientific observations of reduced oxygen levels in deeper waters of the Baltic Sea spurred further scientific investigations and discussions, not the least in the Nordic countries. Epistemic uncertainty was substantial as was disagreement among competing scientific expert communities (e.g. limnology and marine biology/ecology) on whether or not oxygen depletion and other environmental changes in offshore areas were indications of anthropogenic nutrient enrichments. As a scientist explained when referring to the Swedish context, this had practical implications since environmental authorities mainly employed limnologist with the consequence that arguments presented by marine ecologists did not always become accepted.

Science–policy interactions were infrequent and characterised by a clear separation of scientific knowledge production from policy and decision-making. Still, by the early 1970s, the scientific evidence base assembled had resulted in a common recognition of the Baltic Sea as one of the most polluted seas in the world (Joas et al., 2008). Eutrophication was, however, compared to hazardous chemicals relatively low down on the political priority list. Nevertheless, at the end of this stage, eutrophication was acknowledged as a significant environmental risk and the 1974 Helsinki Convention contained specific objectives and measures for preventing land-based nutrient pollution (Helsinki Convention, 1974: Annex3). Important to this development was the 1968 formation of an ICES working group on the Baltic Sea environment and the increased scientific efforts to assess eutrophication risks that came in the wake of the group's report (ICES, 1970). One example of a large research project that became very important for the development of the marine ecology dominated expert community was the Swedish project based at the Askö Laboratory on 'Dynamics and Energy Flow in the Baltic Sea' (1971–1980). Interestingly, an interviewed scientist argued that detergent manufacturers[3] made an attempt to delay the acceptance of eutrophication as an environmental problem by commissioning their own, often poorly designed, research showing that phosphorus does not promote algal growth (cf. Eberly, 1974). Even if this attempt to delay consensus on eutrophication as an environmental problem seems to have been unsuccessful, it serves as an example that the eutrophication issue was associated with various stakes.

*Second*, from the mid-1970s to 2000, we observe a growing importance of expert communities in *scientific assessment and internationalisation of environmental policy*. For example, several regionally important policies came into force such as the 1988 HELCOM Ministerial Declaration (HELCOM, 1988), and EU Directives (e.g. the Nitrates Directive and the Water Framework Directive).

Uncertainty was still substantial concerning the sources and magnitudes of nutrient inputs, as well as internal nutrient dynamics. Above all, there was a scientific debate about which nutrient (i.e. nitrogen or phosphorus) was limiting plant and algae growth and, hence, would be most efficient to target in management. This question had real practical implications and costs when coastal sewage treatment plants began to develop capacities for nutrient removal, since biological nitrogen removal is far more expensive than chemical phosphorus removal. Authorities such as the Swedish EPA were initially, reluctant to recommend nitrogen removal. One of our interviewees observed that this could be partly linked to the aforementioned domination of limnologist at the authority. To reduce uncertainty, several large marine research projects were started in Sweden and elsewhere. Publications from these projects gave quite compelling evidence that nitrogen usually limits the spring algal bloom, which is a vital determinant of oxygen depletion (e.g. Larsson, Elmgren, & Wulff, 1985). Phosphorus, on the other hand, was found to limit summer blooms of cyanobacteria. As a result, countries such as Sweden started from the mid-1980s to put requirements also on tertiary treatment for nitrogen removal in sewage treatment plants along the Baltic Sea coast.

Expert community coherence was still mainly limited to scientific settings, with the occasional participation at hearings with decision-makers (e.g. a hearing at the Swedish EPA in 1986). Still, expert communities had extended both internationally (e.g. the Baltic Marine Biologists) and had established more formalised multidisciplinary collaborations. All in all, this meant that the outlined marine ecology/science-based expert community gained in regional coherence and influence, strongly building on membership from the mentioned Askö Laboratory projects.

*Finally*, starting around the year 2000, we observe a stage of more direct *science-based policy development*. There was at this time a perception that the environmental status of the Baltic Sea was not improving as fast as expected given the substantial nutrient reduction measures already taken. For example, cyanobacteria blooms were frequent and large areas exhibited oxygen depletion of deep water layers (HELCOM, 2009).

This led to a state of uncertainty in eutrophication policy about what the appropriate management approach should be. In response, the Swedish EPA asked an international panel to review the knowledge base (Boesch, Hecky, O'Melia, Shindler, & Seitzinger, 2006). Interestingly, the panel could not agree on joint recommendations. While some limnologists argued that there was a lack of field studies to verify the importance of nitrogen, the marine ecologists argued that the evidence was sufficient to conclude that both nitrogen and phosphorus are important. Still, the disagreement seems mainly to have been caused by different interpretations of the weight of evidence and only a few years later the view that both nutrients should be managed had become rather consensual in science and policy alike (Conley et al., 2009). Consequently, despite a short period of renewed disagreement between various expert communities, the marine science-based community soon again emerged as the most coherent and influential.

In parallel, HELCOM revised its environmental management approach in light of the perceived management failure. This resulted in the adoption of the so-called Ecosystem Approach to Management (EAM), which states that the management of the Baltic Sea environment should rest on '[… ] the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics [… ]' (HELCOM & OSPAR, 2003). A definition that has a very strong resemblance to the definition of the holistic systems ecology developed and practiced at the Askö Laboratory (as mentioned at an expert roundtable we arranged). Although we do not claim to have revealed a direct causal link, it seems clear that HELCOM's adoption of EAM further strengthened the influence of the outlined marine science dominated expert community.

Following this policy change, substantial effort within the HELCOM expert system was put to work implementing the EAM. Here, the 2007 HELCOM BSAP is an illustrative example (HELCOM, 2007). In contrast to the previous HELCOM eutrophication policy, nutrient reduction targets in the BSAP were based on scientific assessments of ecological indicators linked to a policy objective of reaching a 'good ecological status' by 2021 (HELCOM, 2007). A science–policy arrangement of particular importance in this process was the input of knowledge and advice from the so-called Baltic Nest decision support system developed as part of a Swedish research programme (MARE, 1999–2006[4]), and run by the BNI. The 'Nest system' integrated environmental data and modelling with economic parameters to build scenarios and advice that had direct influence on how nutrient reduction targets were set and allocated among countries (Karlsson et al., 2016). A core group of scientist and practitioners linked to the BNI belong to the same group of marine scientists who had generated evidence on the importance of both nitrogen and phosphorus, hence indicating a further strengthening of this expert community through a formalised connection with policy-makers. A key mechanism strengthening the coherence of this expert community was the strategy to build the science support system on databases of available empirical information combined with explorative modelling and scenario approaches. As mentioned by several of our respondents, this contributed to consensus building within the expert community, while at the same time allowing the scientists to remain in a traditional knowledge-provider role.

The tight collaboration between Baltic Nest and HELCOM has by some commentators been described as an example of how legitimate and effective eutrophication management can be co-produced among scientists and decision-makers (e.g. Johansson, Wulff, & Bonsdorff, 2007). Some critique on the sole dependence on one support system was however voiced by farmers' organisations (The Federation of Swedish Farmers (LRF), 2010). More recently, as stakes and impacts become visible during national implementation of reduction targets, the farmer critique has become more detailed in terms of which measures to take, not least in relation to interpretations of cost–benefit analyses (Baltic Farmers' Forum on the Environment (BFFE), 2013; LRF, 2013). The Baltic Nest system can be observed to be responding by integrating more expert groups around the Baltic Sea, as well as by widening information sources and methodologies (e.g. socio-economics). Still, these adjustments seem mainly to be focussed on increasing the credibility of the management advice and it remains to be shown that stakeholders will perceive Nest advice as a more legitimate in the future.

### 4.2. Fisheries

Science–policy interactions in Baltic Sea fisheries management are in many ways distinct from those observed in eutrophication. Scientific developments in fisheries management have from the start co-evolved in an international political context. Fisheries management also has a much longer history than eutrophication since concerns about 'the overfishing problem' were already raised at the end of the nineteenth century, for example, with the North Sea Fishery Conference in 1881 (Gezelius, 2008). This early awareness of overfishing risks created a need for scientific knowledge about fish populations and marine environments to enable advice to policy, a purpose for which ICES was established in 1902.

A first period of *establishing science–policy interactions in modern international fisheries management* took place from the 1950s until early 1980s, where conceptual and institutional issues were discussed and resolved concurrently in scientific (i.e. in ICES) and relevant policy communities (two North Atlantic Fishery Commissions) resulting in a 'standard approach' to fisheries science and management (Gezelius, 2008). This standard approach entailed annual scientific fish stock assessments and subsequent political quota management. Slightly later, the standard approach was also applied in the Baltic Sea with the *International Baltic Sea Fishery Commission* (IBSFC) and in the EU's CFP, established in 1983. The standard approach deploys fishing quota regulations via the so-called TACs, for which ICES provides scientific knowledge and advice on fish stocks and sustainable TAC levels. This management chain of scientific stock assessments, annual catch forecasts and subsequent political decisions on fishing quotas (TACs) forms a tightly interwoven institutional arrangement of science–policy co-production, labelled and described as the 'TAC machine' (Holm & Nielsen, 2004). However, while presenting a remarkable institutional success of international policy-making, the CFP has been criticised for sustainability failure due to insufficient consideration of scientific advice in political decision-making (Villasante, Do Carme Garcia-Negro, Gonzalez-Laxe, & Rodriguez, 2011).

The introduction of quota management and its institutionalisation via the 'TAC machine' builds on the assumption of making accurate scientific estimations of fish stock sizes and catch predictions for the following year, to which the fishing quotas (TACs) apply. The institutional arrangements under this standard approach enable a clear division of labour between the domains of science and policy/management and have resulted in a path-dependent development process of mutually supporting interactions between the two institutions (Hegland & Raakjær, 2008). From a theoretical angle, the 'TAC machine' can hence be described and analysed as an example of a 'co-production of science and policy' (Jasanoff, 2004). While political ideas, constraints and preferences to install TAC-based management fuelled and supported the developments of scientific procedures, the latter equally shaped the progress of this particular management path. Despite problems in handling the enormous uncertainties in data inputs and to integrate EAM perspectives, the institutional system described here still remains a fundament for fisheries science and management in today's CFP and ICES context, hence also for the Baltic Sea.

A *second* period of science–policy interactions in EU and Baltic fisheries pertains to the adherence to the *precautionary principle*. The precautionary principle (UNCED, 1992) became installed in the assessment–management interactions of ICES and political decision-making (e.g. CFP) via the PA (Udovyk & Gilek, 2013). It was introduced to fisheries science and management during the 1990s in response to the problem of high uncertainty in fish stock assessments, which undermined the credibility of science and hence the legitimacy of political decisions based on it (Dankel et al., 2012). ICES' adoption of the PA can be seen as a reaction to an insufficiently clarified separation of roles between science and policy-making in the co-produced TAC system. As our empirical material reveals, this lack of clarity becomes most obvious when key actors, mainly ICES scientists and policy-makers from the EU Commission, need to resolve questions on how to deal with and react to assessment uncertainties and what level of risk should be taken to reach a specified objective such as MSY (*Maximum Sustainable Yield*). The PA is an attempt to rebuild coherence in the science–policy interface by dividing the responsibility of addressing and handling uncertainty between science and management via a clarification of the science–policy boundary (Nielsen, 2008). In summary, our detailed ethnographic investigations expose, that while the PA enabled a clearer relationship between science and policy, its introduction in fisheries science (ICES) and management (CFP) did not shift the 'burden of proof' as required by the Rio Declaration on the precautionary principle.

A *third*, still ongoing, period of *re-arranging science–policy interactions* in ICES and EU fisheries management can be detected since the early 2000s. This reorientation is connected to a broader 'democratic turn' in EU policy-making, implying not only that the scientific community should be held more accountable for the use and utility of its knowledge but also a shift from 'a legitimation through knowledge to a legitimation through participation' (Maasen & Weingart, 2005, p. 2). This new participatory framing of science–policy relations has been described as a typical example of 'PNS' in EU fisheries (Dankel et al., 2012) and as 'interactive' or 'participatory' governance (Linke & Jentoft, 2016). Our analysis reveals that this new framing is characterised by new attempts to maintain coherence of science–policy interactions and handling uncertainty under the inclusion of an EAM to fisheries management and the adherence to democratic requirements such as increased transparency, stakeholder participation and knowledge inclusion from outside science.

From our ethnographic study, we detect three major adaptations of science–policy interactions to deal with these new challenges, aiming to support ICES' expert community coherence and legitimacy as well as the salience of scientific advice for policy-making: (1) the inclusion of wider stakeholder involvement in EU fisheries management; (2) more holistic ecosystem and sustainability perspectives and (3) implementation of the EU's *Marine Strategy Framework Directive* (MSFD). This multifaceted broadening of fisheries management puts further demands on the traditional science–policy interface. Fisheries scientists working in ICES are trained first and foremost to respond to the TAC system's imperative of setting sustainable catch limits. Our research reveals that they are extremely challenged by the broadened science–policy perspectives and would for instance rather opt for a multi-species approach instead of fully-fledged EAM, because in many scientists' view it is impossible to connect all the different variables required for the latter approach. EAM-based concepts also do not allow for a pure scientific definition of management objectives and the installation of a clear boundary between the realms of science and policy as applied under the first two periods (Dickey-Collas, 2014). Reference points like the MSY are highly normative in nature and hence require an opening up of scientific procedures for generating knowledge and advice that is attentive to stakeholders' concerns and perspectives. Consequently, a new and more flexible approach is required to clarify the roles of scientific advice from policy and political decision-making. The installation of ACs[5] in the CFP after 2002 (European Commission, 2002, 2004) attempts to adapt EU fisheries management to this new governance context by reforming the top-down science-based approach towards increased stakeholder involvement and knowledge inclusion. ACs are obliged to provide recommendations to the EU Commission on behalf of the fisheries sector and other interest groups. Although the ACs are generally seen as contributing successfully to the shift in EU fisheries governance, they are, as our research shows, also a learning process of new types of science–policy–stakeholder interactions with various unforeseen consequences (Linke & Jentoft, 2016). Our analyses clearly highlight that such interactive learning processes require more time, resources and modes of interaction among the various actors than under the first two periods described above.

A key question in this new governance context of EU and Baltic fisheries is how to implement an EAM by combining scientific developments with stakeholder input and other societal concerns. This is pursued through recent developments in ICES to explore and establish so-called *Integrated Ecosystem Assessments* (IEAs), which should serve as 'a formal synthesis tool to quantitatively analyse information on relevant natural and socio-economic factors, in relation to specified management objectives' (Möllmann et al., 2014, p. 1188). Our observations clearly demonstrate that the inherent challenge of IEA's to include social and economic management perspectives severely contests the classic demarcation between science and policy.

To round off, the developments under the third period of science–policy interactions investigated here, spark entirely new questions and challenges of how ICES maintains its expert community coherence while opening its portfolio from being an exclusive knowledge provider for policy and decision-making (on single fish stocks) towards EAM perspectives under stakeholder participation and knowledge inclusion from other (social) scientific disciplines, as well as from non-scientific sources (stakeholders).

## 5. Discussion and conclusion

HELCOM and ICES are both important institutions in the respective fields of eutrophication and fisheries. They act as key providers of knowledge, monitoring and expert advice to political authorities and thereby exert substantial influence over eutrophication and fishery policies and management (Hassler et al., 2013). There are similarities in science–policy interaction between the fisheries case (ICES-EU) and the eutrophication case (NEST-HELCOM nexus) as seen in the traditionally strong focus on natural science generated knowledge and on evidence rather than precaution in advice and decision-making. There are also important divergences in their mandates and in the way they work. HELCOM, as the governing body of the Helsinki Convention, is a more formal player in the policy sphere than ICES, which acts primarily as an advisory organisation. However, in practice, these differences are not as evident since ICES advice is an integral part of European fisheries management under the CFP. This final section of the paper highlights key insights derived from our empirical work, using both EC and STS perspectives. We reflect on what can be gleaned by comparing aspects of EC and STS theory in these two different cases.

Clearly, there has been strong expert community coherence and long-term policy influence of science via ICES on all developments of international, that is, EU and Baltic Sea, fisheries management. However, the short-term impact of the scientific advice on political decisions has been criticised as rather weak. TACs have for a long time been decided far in excess of those considered sustainable by scientific advice, both by the IBSFC (Aps, Kell, Lassen, & Liiv, 2007) and by EU authorities (Villasante et al., 2011). The practice of inflating TACs has been described as 'decision overfishing', triggered by political pressures of continuous overcapacity of the contracting countries' fishing fleets, and has been interpreted as a main cause for the depletion of many Baltic fish stocks (Aps & Lassen, 2010). We conclude that, while key characteristics proposed by Haas (1992) for the existence of a strong EC were all in place with the ICES expert community system, science's direct influence on fisheries policy and management remained limited by the fractious fishing politics. An interesting contrast can be observed with the influence of ICES' policy advice over the last decade. When the exclusive science–policy interplay in EU fisheries has been opened for stakeholder involvement, knowledge inclusion and increased dialogue, the political TAC decisions have converged more with the scientific advice. This observation points to a contrary conclusion than expected from Haas (2004) conceptualisation of how ECs exert policy influence, that is, that '[c]onsensus in isolation builds value and integrity, and then its consequences should be discussed publicly' (p. 576): when ICES was working according to a linear science–policy mode of building internal expert consensus, as proposed by Haas' quote, it did not have the predicted or desired, EC-influence on political decision-making (until the early 2000s). Subsequently though, when ICES' scientific knowledge production and advisory procedures became more transparent, incorporating methods of dialogue with stakeholders and society, a more direct and positive influence of scientific advice on policy-decisions seems to appear.

Arguably, eutrophication is a dissimilar environmental policy problem to overfishing in several ways. The implications of increased or tighter regulation in relation to eutrophication rely more on voluntary compliance and potentially affect a wide range of stakeholders at different spatial and temporal scales (i.e. there is no annual TAC equivalent that directly affects actors' livelihoods). During the emergence of eutrophication, the main source of contention related to contests among natural science experts over the effects of divergent nutrient causal pathways on eutrophication. Until the 1990s, eutrophication was not primarily a political concern, although, as we report, there were science-based interventions backstage by stakeholder interests attempting to sway scientific opinion concerning causal agents – endeavouring to engender scientific uncertainty and/or to delay and mislead policy action. Disciplinary incoherence and related uncertainty over understanding of eutrophication processes and implications continued into the 2000s. This occurred mainly through academic institutional processes, but it also resulted in policy frustration about how to configure effective policy settings in relation to contested scientific understandings of the problem. In our account, this disciplinary-based uncertainty combined with an evolving recognition of the potential for large-scale environmental impacts spurred broad political pressure to improve the evidence base so that policy could be developed with more confidence. Through this time, the governments in Sweden and other Nordic countries in particular played a strong role in supporting increased large-scale and multidisciplinary research to try to bridge competing scientific viewpoints. Hence, while all of the other formal requirements for an EC appeared to be met, the lack of consensus around causal beliefs between different disciplines tended to thwart the possibility of an agreed understanding among scientists of the problem to be addressed (large-scale eutrophication in the Baltic Sea). The main bone of contention in eutrophication policy formation historically appears to have been less about stakeholders' concerns and more about disagreements between scientific disciplines over causal beliefs (the N vs. P wrangling) – which when converted into policy has implications for sectoral interests. These tensions between different disciplines over eutrophication's causal agents and processes were seen to be largely resolved with the establishment of the Baltic Nest science support system. According to EC-based arguments, expert knowledge processes should be kept insulated from policy and political processes, as this would allow for a higher degree of policy influence. It can be argued that this occurred when the Nest system quite directly influenced the nutrient reduction targets formalised in the BSAP (cf. Karlsson et al., 2016). Still, despite close interaction between HELCOM and Baltic Nest during the development of the 2007 BSAP, the experts linked to Baltic Nest stayed in a traditional knowledge-provider mode by presenting modelling results and scenarios to policy-makers. This means that, in EC terms, there appeared to be scientific consensus on eutrophication. However, cracks in the relationship between science and policy started to appear during the implementation of BSAP. Arguably, this is because the national targets for nutrient reduction embedded in the BSAP have not been politically grounded with broader array of publics across Baltic countries – this is a lack of 'closure' in STS terms. During the process of transposing expert knowledge, almost exclusively from natural science into eutrophication policy, there was a lack of clarity around how national and sectorial interests would be affected, even though Baltic Nest had incorporated some economic modelling. Davis Cross (2013, p. 143) writes that this is not unusual in cases where the costs of change are not known with clarity. While Baltic Nest-derived scientific knowledge through its research and modelling largely shaped the national nutrient reduction targets decided in the BSAP, effective implementation is still severely challenged since the actual costs are not imposed on emitters. Consequently, in this case the relatively autonomous and apolitical relationship between science and policy, as advocated by Haas (2004), is later on infused in the difficulties of effective policy implementation. The resulting national-scale commitments are voluntary and not fully binding, which is completely different from the institutional arrangement of European fisheries management.

Looking more specifically at *uncertainty*, it is clear that various types of uncertainty have presented both opportunities and challenges to science–policy interplay in the two studied cases. There are, however, substantial differences in how uncertainty seems to have influenced these interactions, as well as how it has been emphasised and coped with. In the eutrophication case, uncertainty on the nitrogen vs. phosphorus question and on ecosystem dynamics and delays have in general led to calls for more or better science and, hence, contributed to strengthen and develop the coherence of expert communities. Similarly, recent policy developments to promote a holistic EAM have also strengthened providers of ecosystem knowledge and advice such as Baltic Nest. Interestingly, despite the fundamentally uncertain nature of ecosystems and their responses to nutrient input, uncertainty and precaution have been quite invisible (or even downplayed) in science–policy interactions in the eutrophication case. Instead, the general focus has been to develop scientific consensus in line with an EC type of conceptualisation of the role of uncertainty.

In fisheries, uncertainties linked to fish stocks and ecosystem dynamics have on the contrary always been a fundamental problem to the generation of ICES advice and continuously challenged the credibility of science. The ICES system has responded differently by developing new methodologies and approaches to adopt a PA and lately also on enabling multi-species assessments and IEAs including stakeholder involvement. Still, despite this engagement on how to assess and cope with uncertainty in the development of advice, communicating and coping with uncertainty over science–policy interfaces is still problematic and contentious because policy-makers still mainly ask for concrete estimates rather than probabilities or scenarios. Recently, however, it seems that the ongoing 'democratic turn' of European fisheries management, including the development of ACs and more 'integrative' procedures adopted by ICES to develop advice, provide an opening for a shift in addressing uncertainty in fisheries management.

In line with recent development in fisheries management, STS-inspired research argues that science–policy interactions would be better served by opening up for greater stakeholder participation in deciding on how to cope with uncertainty. The EC argument of achieving scientific consensus before opening up for stakeholder engagement appears to problematically exclude the implementation phase of the policy cycle – it is more concerned with policy outcomes in terms of policy aims and plans for action than in the creation of effective and legitimised policy implementation milieus.

While the unfolding of eutrophication policy in the Baltic goes some way in supporting Davis Cross' (2013) hypothesis 'that if an epistemic community is not internally cohesive, then it is less likely to be as persuasive as one that is' (p. 147), the problem today is that epistemic persuasiveness may not culminate in effective policy if it largely excludes active consideration of implementation (i.e. stakeholders') contexts. As Haas (2004) argues, the efforts of scientists working within their institutional settings early on in science–policy process may well provide important foundational knowledge valuable to setting policy parameters, including reflection and the possibility of shifting thinking by states on their national interests. However, as insights from STS suggest, this science–policy interaction is likely to be more effective if undertaken through collaboration with interested and affected publics, which also requires more interdisciplinarity and social science research to support such argumentations vis-à-vis policy. How to do this in an efficient and effective way that combines science and its interaction with political preferences across the entire policy cycle remains a challenging question. Ongoing examination of the views of fisheries actors and ecological monitoring of outcomes emanating from the reformed CFP regulations relating to science–policy interactions provide important and relevant insights here.

The historical specificity and the institutional characteristics (e.g. path dependencies) of the two cases considered here suggest that the applicability of the findings is highly contingent to these contexts. That said, this article shows that applying a combination of conceptual thinking from STS and EC to examine environmental governance issues can provide an enriched understanding of science–policy relationships. EC's focus on the macro-structural levels as units of analysis appears useful in providing broad explanatory factors that affect the formation of science–policy relations. However, EC theory is unable to fully account for the detailed dynamics of actor interactions that either reproduce or negate opportunities for change. STS contrastingly emphasises an ethnographic, more micro-level approach to illuminate the nuances of, sometimes messy, science–policy interactions by detailing the way that knowledge becomes usable for policy.

As the fisheries case illustrates, there are ways to include stakeholders into established science–policy interactions that are credible and may lead to effective, more widely supported policy settings and goals. This supports the view of an inherent entanglement of science–policy relationships urging a re-conceptualisation of coherence to accommodate a reflexive practice of science–policy as it develops in practice. This finding goes beyond the EC focus on disciplinary coherence and scientific consensus to capture the knowledge politics of stakeholders, and thereby contributes to understanding the gaps between knowledge and action. A shift towards closing these gaps would entail deeper consideration and contextualisation of the credibility, usability and acceptability of knowledge in the particular regional, national and local domains in which it is to be applied.

## Notes

1. International Relations, including the theory of Epistemic Communities.
2. Monitoring and reduction of nutrient inputs from agriculture, transports and various land-based sources are core areas of HELCOM operations.
3. Detergents contained high levels of phosphates at this time.
4. In terms of both methodological approach and key marine scientists, Baltic Nest can via the MARE project be traced back as far as to a large Swedish research project on Dynamics and Energy Flow in the Baltic Sea (1971–1980).
5. With a CFP reform in 2013, the name changed from *Regional Advisory Councils* (RACs) to *Advisory Councils* (ACs).

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## References

Aps, R., Kell, L. T., Lassen, H., & Liiv, I. (2007). Negotiation framework for Baltic fisheries management: Striking the balance of interest. *ICES Journal of Marine Science*, *64*, 858–861.

Aps, R., & Lassen, H. (2010). Recovery of depleted Baltic Sea fish stock: A review. *ICES Journal of Marine Science*, *67*, 1856–1860.

BFFE. (2013). *Viewpoints from the farmer organisations around the Baltic Sea to the proposal for the ministerial declaration concerning revised HELCOM Baltic Sea Action Plan*. Retrieved from http://www.lrf.se

Boesch, D., Hecky, R., O'Melia, C., Shindler, D., & Seitzinger, S. (2006). Eutrophication of Swedish Seas. *Rapport 5509, Naturvårdsverket* (Swedish EPA).

Conley, D. J., Paerl, H. W., Howarth, R. W., Boesch, D. F., Seitzinger, S. P., Havens, K. E., … Likens, G. E. (2009). Controlling eutrophication: Nitrogen and phosphorus. *Science*, *323*, 1014–1015.

Dankel, D. J., Aps, R., Padda, G., Röckmann, C., van der Sluijs, J. P., Wilson, D. C., & Degnbol, P. (2012). Advice under uncertainty in the marine system. *ICES Journal of Marine Science*, *69*(1), 3–7.

Davis Cross, M. (2013). Rethinking epistemic communities twenty years later. *Review of International Studies*, *39*, 137–160.

Dickey-Collas, M. (2014). Why the complex nature of integrated ecosystem assessments requires a flexible and adaptive approach. *ICES Journal of Marine Science*, *71*, 1174–1182.

Eberly, W. R. (1974). History of the phosphate detergent Ban in Indiana. *Proceedings of the Indiana Academy of Science*, *84*, 405–414.

EC (2002). Council regulation 2371/2002 on the conservation and sustainable exploitation of fisheries resources under the common fisheries policy. *Official Journal of the European Communities Legislation*, *358*, 59–79.

EC (2004). Council decision of 19 July 2004 (585) establishing regional advisory councils under the common fisheries policy. *Off. J. Eur. Union* L256/17-20.

Fonselius, S. H. (1969). Hydrology of the Baltic deep basins. III. *Fishery Board of Sweden, Series Hydrography*, *23*, 1–97

Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the post-normal age. *Futures*, *25*, 739–755.

Gezelius, S. (2008). The arrival of modern fisheries management in the North Atlantic: A historical overview. In S. Gezelius & J. Raakjaer (Eds.), *Making fisheries management work* (pp. 27–40). London: Springer.

Gilek, M., & Karlsson, M. (2016). Seeking pathways towards improved environmental governance of the Baltic Sea. In M. Gilek, M. Karlsson, S. Linke, & K. Smolarz (Eds.), *Environmental Governance of the Baltic Sea* (pp. 299–246). London: Springer.

Gilek, M., Karlsson, M., Udovyk, O., & Linke, S. (2015). Science and policy in the governance of Europe's marine environment – the impact of Europeanization, regionalization and the ecosystem approach to management. In M. Gilek & K. Kern (Eds.), *Governing Europe's marine environment. Europeanization of regional seas or regionalization of EU Policies* (pp. 141–160). Farnham: Ashgate.

Haas, P. M. (1992). Introduction: Epistemic communities and international policy coordination. *International Organization*, *46*(1), 1–35.

Haas, P. M. (1997). Scientific communities and multiple paths to environmental management. In L. Brooks & S. VanDeveer (Eds.), *Saving the Seas: Values, Scientists, and International Governance* (pp.193–228). College Park: Maryland Sea Grant College.

Haas, P. M. (2004). When does power listen to truth? A constructivist approach to the policy process. *Journal of European Public Policy*, *11*, 569–592.

Hassler, B., Boström, M., & Grönholm, S. (2013). Towards an ecosystem approach to management in regional marine governance? The Baltic Sea context. *Journal of Environmental Policy and Planning*, *15*, 225–245.

Hegland, T., & Raakjær, J. (2008). Recovery plans and the balancing of fishing capacity and fishing possibilities: Path dependence in the common fisheries policy. In S. Gezelius & J. Raakjær (Eds.), *Making fisheries management work* (pp. 131–159). Dordrecht: Springer.

HELCOM (1988, February 15). *Declaration on the protection of the environment of the Baltic Sea*. Helsinki.
HELCOM. (2007). *HELCOM Baltic Sea action plan*.
HELCOM (2009). Eutrophication in the Baltic Sea – an integrated thematic assessment of the effects of nutrient enrichment in the Baltic Sea region. *Baltic Sea Environmental Proceedings* No. 115B.
HELCOM & OSPAR. (2003). *Statement on the ecosystem approach to the management of human activities*. First Joint Ministerial Meeting of the Helsinki and OSPAR Commissions, Bremen, 25-26/6/03.
Helsinki Convention. (1974). *Convention on the protection of the marine environment of the Baltic Sea area*.
Holm, P., & Nielsen, K. N. (2004). The TAC machine. In *Report of the Working Group on Fishery Systems* (pp. 40–51). WGFS Annual Report. Copenhagen: ICES.
ICES. (1970). Report of the working group on pollution of the Baltic Sea. *ICES Coop. Res. Rep. Ser. A.*, *15*.
Jasanoff, S. (1996). Is science socially constructed—and can it still inform public policy? *Science and Engineering Ethics*, *2*(3), 263–276.
Jasanoff, S. (Ed.). (2004). *States of knowledge: The co-production of science and social order*. London: Routledge.
Joas, M., Jahn, D., & Kern, K. (Eds.). (2008). *Governing a common Sea. Environmental policies in the Baltic Sea region*. London and Sterling: Earthscan. p. 238.
Johansson, S., Wulff, F., & Bonsdorff, E. (2007). The MARE Research Program 1999–2006: Reflections on program management. *AMBIO: A Journal of the Human Environment*, *36*, 1–4.
Karlsson, M., Gilek, M., & Lundberg, C. (2016). Eutrophication and the ecosystem approach to management: A case study of Baltic Sea environmental governance. In M. Gilek, M. Karlsson, S. Linke, & K. Smolarz (Eds.), *Environmental Governance of the Baltic Sea* (pp. 21–44). London: Springer.
Larsson, U., Elmgren, R., & Wulff, F. (1985). Eutrophication and the Baltic Sea: Causes and consequences. *AMBIO: A Journal of the Human Environment*, *14*, 9–14.
Lidskog, R., & Sundqvist, G. (2002). The role of science in environmental regimes: The case of LRTAP. *European Journal of International Relations*, *8*(1), 77–101.
Lidskog, R., & Sundqvist, G. (2015). When does science matter? International relations meets science and technology studies. *Global Environmental Politics*, *15*(1), 1–20.
Linke, S., Gilek, M., & Karlsson, M. (2016). Science-policy interfaces in Baltic Sea environmental governance: Towards regional cooperation and management of uncertainty? In M. Gilek, M. Karlsson, S. Linke, & K. Smolarz (Eds.), *Environmental Governance of the Baltic Sea* (pp. 173–203). London: Springer.
Linke, S., Gilek, M., Karlsson, M., & Udovyk, O. (2014). Unravelling science-policy interactions in environmental risk governance of the Baltic Sea: Comparing fisheries and eutrophication. *Journal of Risk Research*, *17*, 505–523.
Linke, S., & Jentoft, S. (2016). Ideals, realities and paradoxes of stakeholder participation in EU fisheries governance. *Environmental Sociology*, *2*(2), 144–154.
LRF. (2010). *Synpunkter från LRF på Slutrapport av Naturvårdsverkets regeringsuppdrag 17 i regleringsbrev för 2008: Förslag till nationella åtgärder enligt Baltic Sea Action Plan*. [Opinions from LRF on the final report of the Swedish Environmental Protection Agency's government report 17/2008: Recommendations for national measures according to Baltic Sea Action Plan] Remissyttrande 2010-01-15.
LRF. (2013). *Hur återställer vi Östersjön? Effektivare strategier mot ett mindre övergött hav*. Stockholm: Lantbrukarnas Riksförbund.
Maasen, S., & Weingart, P. (Eds.). (2005). *Democratization of expertise? Exploring novel forms of scientific advice in political decision-making*. Dordrecht: Springer.
Möllmann, C., Lindegren, M., Blenckner, T., Bergström, L., Casini, M., Diekmann, R., … Gårdmark, A. (2014). Implementing ecosystem-based fisheries management: From single-species to integrated ecosystem assessment and advice for Baltic Sea fish stocks. *ICES Journal of Marine Science*, *71*, 1187–1197.
Nielsen, K. N. (2008). *Boundary construction in mandated science. The case of ICES' advice on fisheries management* (PhD Thesis). University of Tromsø, Tromsø.
Pihlajamäki, M., & Tynkkynen, N. 2011. The challenge of bridging science and policy in the Baltic Sea Eutrophication Governance in Finland: The perspective of science. *AMBIO: A Journal of the Human Environment*, *40*, 191–199.
Renn, O., Klinke, A., & van Asselt, M. (2011). Coping with complexity, uncertainty and ambiguity in risk governance: A synthesis. *AMBIO: A Journal of the Human Environment*, *40*, 231–246.
Sellke, P., Dreyer, M., & Linke, S. (2016). Fisheries: A case study of Baltic Sea environmental governance. In M. Gilek, M. Karlsson, S. Linke, & K. Smolarz (Eds.), *Environmental Governance of the Baltic Sea* (pp. 45–71). London: Springer.
Spruijt, P., Knolb, A., Vasileiadouc, E., Devileeb, J., Lebreta, E., & Petersenc, A. (2014) Roles of scientists as policy advisers on complex issues: a literature review. *Environmental Science & Policy*, *40*, 16–25.
Udovyk, O., & Gilek, M. (2013). Coping with uncertainties in science-based advice informing environmental management of the Baltic Sea. *Environmental Science & Policy*, *29*, 12–23.
UNCED. (1992). Report of the Conference (Rio de Janeiro, June 3–14, 1992). A/CONF.151/26/Rev.1, 1. New York, United Nations.
Villasante, S., Do Carme Garcia-Negro, M., Gonzalez-Laxe, F., & Rodriguez, G. R. (2011). Overfishing and the Common Fisheries Policy: (Un)successful results from TAC regulation? *Fish and Fisheries*, *12*, 34–50.