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The Challenge of Bridging Science and Policy in the Baltic Sea Eutrophication Governance in Finland: The perspective of Science

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Abstract This article examines the views of scientists on intricacies of scientific knowledge that affect science–policy interface in the Baltic Sea eutrophication governance in Finland. The analysis demonstrates that these intricacies can be divided into five categories: (1) uncertainty of knowledge concerning ecological processes, (2) heterogeneity of knowledge, (3) societal and political call for (certain) knowledge, (4) contingency of the knowledge that ends up taken as a baseline for decision making and further research, and (5) linkages of knowledge production, processing, and communication to particular characteristics of individual researchers and research societies. By explicating these aspects, this article illustrates the ways in which scientific knowledge concerning eutrophication is human-bound and susceptible to interpretation, thus adding on to the uncertainty of the Baltic Sea environmental governance. The aim is, then, to open up perspectives on how ambiguities related to science–policy interface could be coped with.

Keywords Baltic Sea · Environmental governance · Eutrophication · Finland · Knowledge production · Science–policy interface

INTRODUCTION

Extended eutrophication is regarded as one of the most serious environmental risks for the Baltic Sea. A multitude of protective policies and measures have taken place since the early 1970s, but the problem of eutrophication of the Baltic Sea has not yet been solved. We argue that complexity of risk governance concerning eutrophication is not confined to the inadequacy of scientific research, or to problems in adjusting national governance structures to the implementation of scientific recommendations. Rather, it is rooted in the challenges of multi-level governance, regionality, and, as this article addresses, knowledge–policy interface.

A number of scholarly works discuss knowledge–policy interface in fisheries management in the Baltic Sea (e.g., Peuhkuri 2004; Wilson 2009), or the work of the Baltic Marine Environment Protection Commission HELCOM in general (Aps et al. 2009). For a number of reasons, also eutrophication is an interesting case to scrutinize from the point of view of knowledge–policy interface. Eutrophication was recognized as a large-scale environmental risk for the Baltic Sea in the late 1970s (Elmgren 2001), and can be positioned in between "old", bound, and post-modern, diffuse environmental problems (Peuhkuri 2004). On the one hand, symptoms of eutrophication are clear and easily perceived by water users, as the water gets algaeic and slimy as a result of eutrophication. On the other hand, there are uncertainties concerning the determination of causal relations of the problem; in addition, many aspects of the problem are provable by scientific examination only.

As regards the Baltic Sea eutrophication governance, challenges of knowledge–policy interface are rooted in certain qualities of (scientific) knowledge. Leaning on the understanding of knowledge as a socially constructed human product formulated in interaction with the physical world (e.g., Bloor 2004), we argue that scientific knowledge is limited, controversial, bound, uncertain, socially conditioned, and constantly under change. This gives room for different interpretations of what "the facts" are, and, further, for the politicization of knowledge. In addition, material conditions, structures, forms and practices determine processes of knowledge production, processing, and communication. The aim of this article is to illustrate the ways in which human endeavor engages with the ideas of

scientific knowledge concerning eutrophication, thus posing challenges to the Baltic Sea risk governance. We do this illustration by scrutinizing the views of Finnish scientists on knowledge–policy interface related to the Baltic Sea eutrophication governance in Finland.[1] By tying our examination to certain recent policy debates, we address the main research question: What kinds of intricacies of (scientific) knowledge that affect science–policy interface in the eutrophication case do the scientists identify? By this explication, we aim also to open up perspectives of how ambiguities related to knowledge–policy interface could be coped with. These perspectives are discussed in the concluding part of the article.

METHODOLOGICAL UNDERPINNINGS AND MATERIALS

Our research draws on the argument that scientific knowledge is not a transcendent mirror of reality, but both embeds and is embedded in social practices, identities, norms, conventions, discourses, instruments and institutions—in all what we refer to as social (Jasanoff 2004). As a loose background for our understanding of the nature of knowledge as socially constructed one might thus refer to the academic field of science studies. As Demeritt (2006, pp. 454–455), who has published on the articulation of scientific knowledge with power and climate policy, puts it, "this otherwise heterogeneous body of academic scholarship is united by its agnostic stance toward scientific truth and its emphasis on the socially contingent manner in which the objects of science are constructed and knowledge about them is socially validated".

We do not touch here the philosophical or methodological debates internal to that field (to get an overview, see Sismondo 2004), but let the data advocate for us. As a loose interpretive framework, science studies beg for illustration rather than proof (cf. Jasanoff 2004).

As a result of our analysis, we introduce categorizations of aspects of knowledge that scientists find out problematic for knowledge–policy interface in the case. The categories are derived inductively from the empirical data by applying qualitative content analysis. As this method indicates, we have first developed a deep understanding of the data, then classified, and finally conceptualized it into new kinds of categorizations.

Our data consists of 18 in-depth interviews of eutrophication experts (scientists hereafter) working for universities and sectoral research institutes in Finland (see next section). The interviews were conducted during the fall 2009. For the purposes of our study, it was crucial to find those scientists that have actively participated in policy debates concerning eutrophication. First, interviewees were chosen on the basis of our own experience on the issue. After that we followed the so-called "snowball method" which implied that interviewees named all possible experts and specialists on the issue of our interest that he/she thought we should take an interview with. After some 15 interviews, no new names to be interviewed popped up. The majority (13 of 18) of our interviewees were from sectoral research institutes, only five from universities, which more or less corresponds with the share of eutrophication experts between these institutions. Most of the interviewees had their background in marine (or other natural) science; no social scientists were included in the group of interviewees except for a couple of economists. This is because there basically are no social scientists studying the Baltic Sea eutrophication in Finland. As some of the interviewees asked for anonymity, we refer to the interviews in this article only by giving the date of the interview, and the information whether the interviewee represents a university or a sectoral research institute. When referring to the interviews in the text, the abbreviation RU indicates the representative of a university, while the abbreviation RS refers to the representative of a sectoral research institute.

The interviews followed thematic guidelines, but only very loosely. The main themes of our discussions with the interviewees were agriculture, wastewaters of urban and dispersed settlements, and internal nutrient load, because these issues are usually mentioned as the most important nutrient sources contributing to eutrophication, and, moreover, because these topics have recently been under public debate in Finland.

EUTROPHICATION GOVERNANCE IN FINLAND

Main Policies and Actors

EU directives, national laws and national, regional and local policies regulate the use of Finnish coastal and inland waters in order to combat eutrophication. By and large, these regulations set nutrient (phosphorous and nitrogen) reduction targets. National policies and measures are guided by Finland's Programme for the Protection of the Baltic Sea (2002), which presents the actions needed to meet the Water Protection Targets to 2005 (1998), and the Water Protection Policy Outlines to 2015 (2006). The latest addition to the

[1] This article is part of the PROBALT project, funded by the BONUS Baltic Organisations Network for Funding Science EEIG. At this stage of our project, we concentrate on understanding scientists' perspective. In latter stages of the project, the scope of study will be broadened to perceptions of other actors of eutrophication governance in Finland. For practical reasons, our focus is on Finland.

national policies is a Government Report on Challenges of the Baltic Sea and Baltic Sea Policy published in 2009. Since 2007, HELCOM's Baltic Sea Action Plan (BSAP) works as an umbrella for national policies that in Finland are generally more stringent than HELCOM requirements. Although national eutrophication policies are relatively ambitious, the targets are not easily met. Looked from the political perspective, failure to meet nutrient reduction targets is largely due to conflicting interests of different sectors, the environmental and agricultural in particular, and, consequently, to insufficient (implementation) instruments, in some cases even the complete lack of them.

The main actors of eutrophication governance in Finland are researchers, officials in the Ministries of the Environment and of Agriculture and Forestry and at the Finnish Environment Institute, members of parliament responsible for relevant legislation, and members of local governments and administration (especially) in coastal regions.

Although it is difficult, if not impossible, to estimate the number of scientists focusing on the Baltic Sea studies in Finland, it can be noted that the size of this group is rather small, and natural science is heavily emphasized. Eutrophication research is polarized into two main groups. One group of researchers works at universities, mainly at the Universities of Helsinki and Turku. The other group works for sectoral research institutes Finnish Environment Institute SYKE, operating under the Ministry of the Environment, and MTT Agrifood Research Finland (subordinate to the Ministry of Agriculture and Forestry), the main Finnish research institute in the field of agricultural and food research and agricultural environment research. A number of eutrophication researchers of the first group work for Centres for Economic Development, Transport and the Environment (*Elinkeino-, liikenne-ja ympäristökeskus*, *ELY*, before 2010 regional environment centres, *alueelliset ympäristökeskukset*). The Finnish Institute for Marine Research subordinate to the Ministry of Transport and Communications was closed down in 2008 when its functions were transferred to Finnish the Environment Institute and Finnish Meteorological Institute.[2]

Although sectoral research institutes have a direct link to policy making because of their subordination to the Ministries of the Environment (SYKE and regional environmental centres) and of Agriculture and Forestry (MTT), also certain university researchers are regularly heard by politicians and officials. In their work of preparing policies, drafting new legislation and the like, the Ministries officials hold workshops and hearings where certain experts and stakeholders are invited to participate. For example, in the preparation of the Government Report on Challenges of the Baltic Sea and Baltic Sea Policy, the Environment Committee (in charge of the preparation) heard a variety of actors including politicians, officials, actors from the private sector, NGOs, and researchers (see Environment Committee 2010). Later in this paper, in section "Linkages of knowledge production, processing and communication…", we scrutinize practices of interaction between researchers and policy makers in more detail.

Recent Debates Related to Eutrophication Governance

To understand related policy debates, we need to have a look at the basic dynamics of the Baltic Sea eutrophication and Finland. The annual nutrient load from Finland to the Baltic Sea in 2000–2006 was on average 2 600 tons of phosphorus and 50 000 tons of nitrogen (Ministry of the Environment 2009). Agriculture is the most significant single source of both nutrients: 62% of total phosphorus and 57% of the total nitrogen input. Other sources of diffuse load are dispersed settlement (12% of P, 3% of N) and forestry (6% of P, 4% of N). The largest loads from point sources, 7% of total phosphorus and 18% of total nitrogen input, originate from municipalities, while other sources (industry, fisheries etc.) cover less than 5% of total loads (Ministry of Environment 2009). In addition to diffuse and point sources, the catchment area receives atmospheric deposition of nitrogen equivalent of 18% of the total nitrogen, and 6% of the phosphorus (Finnish Environment Institute 2010). One (increasingly) significant source of phosphorus is internal load, i.e., the release of phosphorus from sea bottom sediments in anoxic conditions.[3]

Although it appears generally accepted that both external nitrogen and phosphorus emissions should be reduced in order to effectively combat eutrophication, the debate concerning eutrophication governance is shaped by the main question about the dynamics of nutrient enrichment in the sea, and the role of different nutrients as causes of eutrophication. Some scientists have suggested that in order to cut down summertime toxic algae blooms, nitrogen loads should not be limited (e.g., Håkanson and Bryhn 2008).[4] If

[2] A couple of our interviewees currently working for SYKE used to work at the FMI. Despite critical voices that before the reform doubted that the reform would radically worsen the state of the marine research in Finland, our interviewees seemed to have adjusted by now.

[3] Any given year, the magnitude of phosphorus release can be several times larger than the external load, but in the long-term the net release is smaller (HELCOM 2009).

[4] Håkanson and Bryhn (2008) argue that nutrient reductions should concentrate on phosphorus, because (i) of the implications of uncertainties related to nitrogen cycle to the outcome and cost-effectiveness of nitrogen abatement, (ii) the possibility that lower nitrogen concentrations may increase the risk of cyanobacterial blooms, (iii) laboratory experiments provide scant information for management decisions for real aquatic systems, and (iv) in long-term, phosphorus is limiting primary production.

this was the reality, all efforts should be concentrated on restricting the phosphorus input, and forget about the nitrogen. Other experts (incl. most of our interviewees) emphasize that both nitrogen and phosphorus reductions are essential in order to combat eutrophication due to interconnected cycles of oxygen, phosphorus, and nitrogen (see Vahtera et al. 2007).

The main topics of discussion concerning the Finnish eutrophication governance are related to agriculture, nitrogen removal in urban wastewater treatment, and the treatment of wastewater in dispersed settlements. The document Water Protection Policy Outlines to 2015 states that "the most important objective is to reduce nutrient pollution, particularly from agricultural sources. A target has been set to reduce agricultural nutrient loads by at least a third of their average level over the years 2001–2005 by 2015." (Ministry of the Environment 2007) In a report on nutrient reductions from agriculture National Audit Office of Finland (2008) estimated that the current actions are insufficient to meet the 30% reduction requirement by 2015. The report as well as the Government Report from 2009 both pinpoint that the reason behind the failure to take sufficient actions lies in the way agri-environmental aid is currently implemented. The goals and targets of protection and agricultural policies (especially the EU Common Agricultural Policy CAP) are conflicting, and thereby resulting in lower reduction than set by the target. The reduction potential from agriculture lies within two policy instruments; the agri-environmental aid and the Government Decree on the restriction of discharges of nitrates from agriculture into waters (931/2000). In order to reach the 30% reduction target, the implementation of the former needs to be revised. Partly because of the emphasized role of agriculture for the socio-economic development of the rural areas in Finland, linked to the strong position of the Centre Party (former Agrarian Party or *Maalaisliitto*) in the Finnish government, farmers have traditionally been somewhat treated with kid gloves in Finnish politics. Therefore, it has been relatively difficult to establish more stringent environmental policies to control agricultural activities, no matter the various research reports (and the public) that have constantly called for them (e.g., Jokinen 2000). However, while many researchers and policy actors stress the importance of the reduction of nutrient input from agriculture, others feel it to be too difficult (albeit important), and therefore suggest that, above all, efforts should be concentrated elsewhere, such as improved wastewater treatment as it provides "an easy way to get results" (RU 5.11.2009).

In addition, Finnish nitrogen politics has been under debate. It has been criticized as well by a group of scientist, the Finnish media (e.g., *Helsingin Sanomat* November 18 2009) as by the European Commission. The EU's Urban Waste Water Directive (91/271/EEC) was adopted in 1991. It requires the minimum of 70% reduction of nitrogen of wastewater collected in agglomerations of more than 10,000 population equivalent. In Finland, on average only 56% of the nitrogen is removed at wastewater treatment plants (Santala and Etelämäki 2009). In 2005, 18 wastewater treatment plants out of the total 89 (with agglomeration of more than 10,000) were removing over 70% of the nitrogen, and 15 were waiting to be improved (Pietiläinen 2008). In 2007, the Commission sued Finland over failure to require more stringent treatment of nitrogen, but the case was dismissed by the Court of Justice in 2009. Finland's argument was that nitrogen originating from inland wastewater treatment plants does not contribute to the Baltic Sea eutrophication. Still, some actors call for more resolute urban wastewater treatment and nitrogen removal when it comes to the Baltic Sea eutrophication policies in Finland. A crucial question characterizing this debate is: Is nitrogen retained in rivers and lakes, or is it flushed through to the sea?

Recently, the treatment of wastewater in dispersed settlements has formed perhaps the most heated topic of public debate related to eutrophication in Finland. Since 2004, the treatment of this wastewater has been regulated by the Onsite Wastewater System Decree (542/2003). The Decree sets minimum standards for wastewater treatment and planning, construction, use, and maintenance of treatment systems. According to Finland's Environmental Protection Act (86/2000), wastewater in areas not connected to any centralized sewerage system must be treated so that there is no risk of polluting the environment. The Decree has been criticized by a number of scientists and the general public as well because it introduces compulsory actions to all areas not connected to urban wastewater treatment system, regardless of the location of the area with respect to the Baltic Sea or surface waters in general.

Finally, the role of internal load—crystallized mainly in the question whether the nutrient reductions should be made inland or at the sea—has been debated over in Finland, in the media in particular (e.g., *YLE* May 7, 2009; *Helsingin Sanomat* February 24 and 28, 2010). A rising topic of discussion, although not yet highly popularized, is the impacts of climate change on eutrophication.

MULTIPLE FACES OF THE BALTIC SEA EUTROPHICATION SCIENCE

In the analysis, we extrapolated the intricacies of (scientific) knowledge and science–policy interface in the Baltic Sea eutrophication case into five categories. Some of these categories refer to ontological qualities of knowledge, while some are exterior and material. Some of the

categories refer to the internal workings of science, whereas others to science's relations with the outside world. Therefore, the categories are overlapping and by no means commensurate. Also the strength of the linkages between the different categories varies. Still, we think that this kind of classification can be made for analytical purposes.

The categories are here referred to as aspects of scientific knowledge that affect knowledge–policy interface in the Baltic Sea eutrophication governance in Finland. These aspects are the following: (1) uncertainty of knowledge concerning ecological processes, (2) heterogeneity of knowledge, (3) societal and political call for (certain) knowledge, (4) contingency of the knowledge that ends up taken as a baseline for decision making and further research, and (5) linkages of knowledge production, processing and communication to particular characteristics of individual researchers and research societies. In the following, we discuss each aspect and some of their possible implications to the science–policy interface.

Uncertainty of Knowledge Concerning Ecological Processes

The uncertainty of scientific knowledge concerning ecological processes related to eutrophication stems first and foremost from the nature of these processes. Processes involve interdependencies, randomness, and variable and cross-cutting temporal and spatial scales that are difficult, in some cases even impossible, to predict and to systematize by science. In the Baltic Sea eutrophication case, the effects of climate change on the problem of eutrophication were mentioned as a general example of such uncertainty. In many cases, the uncertainties seem to be due to the margin of error embedded in scientific research. In addition, despite the fact that the Baltic Sea is often referred as one of the most extensively studied seas in the world, there still exists a constant need to know more about diverse dynamic processes and emergent phenomena. One such issue is internal nutrient cycle as explained by one of the interviewees:

> …if you search for journal articles on nutrient release from the bottom sediments, you don't find many articles, although (internal nutrient cycle) is one of the key issues. (…) It is one of those issues that requires further research (RS 20.10.2009)

Many interviewees expressed their concerns over the implications of various uncertainties for risk governance.

> We know exactly that nutrients cause eutrophication. Therefore, in order to combat eutrophication we need to reduce nutrient input. After this it gets more complicated. (…) We simply don't know how the Baltic Sea reacts to decreased nutrient loads, for example how long it takes for the sea to return to any given reference point, or to what kind of reference point we can realistically aspire to. (RS 12.11.2009)

Uncertainty was seen to have further influence on the linkage between science and policy, since uncertainty related to the scientific knowledge opens up an opportunity for possible opposition. It enables directing the focus of public discussion toward uncertainties, thereby undermining the main message conveyed by a certain research result. The unknown and uncertain points can easily be raised into the discussion without any scientific back-up, whereas their neutralisation requires scientific evidence and argumentation. This has happened also in Finland, where one politician has argued that instead activities onshore, eutrophication prevention efforts should be concentrated to the sea (offshore) to diminish the internal load.

> No matter what the scientific community says (…) there is always some opposition, and people easily believe the opposition. Scientific knowledge is often questioned by asking whether other possibilities could exist. This makes the scientific community look less convincing. You can see it in that some politicians randomly take up arguments discussed 10 or 15 years ago, and use them, although the scientific community is no longer considering the argument relevant and right. (RU 26.10.2009).

Heterogeneity of Knowledge

This second aspect of our categorization implies that there are different definitions and interpretations concerning the problem of eutrophication and its solutions also within the scientific community. Scientific knowledge, by nature, tends to leave room for interpretation, which means that same results can be interpreted very differently depending on the perspective. Differing definitions of the problem can also be explained by different indicators used to measure (certain elements of) the problem. One interviewee explained:

> When you choose the right time and spatial scale, you can in principle find the most suitable results for you within the very same data. This means that based on the same data, you can either say that nitrogen should or should not be reduced. (RS 6.11.2009)

As commonly acknowledged by Finnish scientists and experts, there are a number of questions related to the Baltic Sea eutrophication that the scientific community does not agree upon. In some, but nearly not all, cases the

disagreements stem from uncertainty. Among disagreed questions are, as the policy debates well reflect, the scope and influence of internal nutrient load, the role of phosphorous versus nitrogen for the problem of eutrophication, and the magnitude of nutrient load from inland waters to the Baltic Sea eutrophication. Regarding the debate on the role of phosphorous versus nitrogen for the problem of eutrophication, one interviewee representing the academia commented that:

> Everyone agrees that we need to reduce phosphorus input, but regarding the need for nitrogen reductions there have been some bloody battles. (RS 26.11.2009)

In regard to the nitrogen removal in waste water treatment plants, experts had differing views on whether nitrogen is actually retained in rivers and lakes, or whether significant amounts of it are flushed through to the sea. This problem is linked with uncertainty and the need for further research, as often is the case when interpretations conflict.

In certain international meetings, researchers have claimed for a "common voice" of the Baltic Sea researchers in order to "better get the message through" to policy makers at various levels. The idea is that, resembling the International Panel for Climate Change (IPCC), the Baltic Sea researchers should unite themselves and establish a united view on the various environmental problems of the Baltic Sea. True, there is the International Council for the Exploration of the Sea (ICES) that provides the Helsinki Commission (HELCOM) with scientific information and advice (e.g., Aps et al. 2009). However, only a very limited number of Baltic Sea environmental researchers participate in the work of that Council. Otherwise, no such common view or voice for the Baltic Sea scientists exists. As regards to eutrophication, some interviewees supported the idea of forming a "common voice", to exist at least among the Finnish researchers, while some of them did not actually like it. Instead, they considered that differing views are only for good:

> …some people think that the nature of the research process is such that once a certain issue has been studied for a while, all researchers agree on it. In my opinion this kind of an agreement would put a stop to the dynamics of research: Initially, every motivated researcher aims to prove prevailing understandings wrong. (RS 12.11.2009)

In any case, differing interpretations of the essence of the problem lead to varying nominations for the possible solutions of the problem. For example, the phosphorous versus nitrogen question leads to definitional struggles over whether protective efforts should be concentrated on the reduction of phosphorus, or whether the reduction of nitrogen is needed as well.

Consequently, scientists hold differing views on the effectiveness of current protection policies and policy instruments, too. In most cases, the existence of varying and sometimes contradictory scientific knowledge implies that societal actors (media, politicians, officials, the public…) can choose which interpretation to take up:

> …if the proposed solution is inconvenient, politicians don't believe it and they go and find another opinion about it. (RU 26.10.2009)

Societal and Political Call for (Certain) Knowledge

As probably everywhere else, the societal and political call for knowledge directs the research carried out in national research institutes and universities also in Finland. This is due to the evident dependence on national and international project funding. Moreover, sectoral research institutes, such as the Finnish Environment Institute and the MTT Agrifood Research Finland that are funded by the Finnish Ministry of the Environment and the Ministry of Agriculture and Forestry need to concentrate on issues that political and administrative bodies regard as relevant.

> Some questions come from ministries, so they do direct research. Good example is the Baltic Stern – project,[5] which did not come from the Finnish ministries per se, but still the initiative stemmed from the political side. I don't believe that researchers could have figured out that it is the thing to do right now. (RS 13.11.2009)

The societal and political call for knowledge is partly defined through the priorities of wider society, but particularly by the media, policy makers, administrative bodies and institutional structures themselves. The role of the public and media in defining what is and what is not interesting was pointed out by many of the interviewees:

> The role of phosphorus and nitrogen is important, because the spring bloom is caused by nitrogen input, and spring happens to be the most productive period out of the year. Significant proportion of the spring bloom sinks to the bottom thereby initiating oxygen depletion. But the spring bloom is not interesting for the media, because people don't go to their summerhouses in the spring and the water is cold. (Thus, the public does not perceive the problem of eutrophication in spring.) (RS 12.11.2009)

[5] Inspired by the "The Economics of Climate Change - The Stern Review" (2007), the Swedish and Finnish Ministers of Environment jointly called for a Stern-like review of the Baltic Sea. Following this call, a couple of Stern-related studies on the Baltic Sea were initiated in both countries.

The implications of the call for certain knowledge were considered, in the worst case, to weaken the possibilities for doing basic research and, potentially, to divert the focus of research from what is not yet known to what already is known.

Contingency of the Knowledge that Ends up Taken as a Baseline for Decision Making and Further Research

By this aspect of scientific knowledge, we refer to the fact that not all knowledge ends up to the decision making system, and thus "returns" to the focus of further research (see the previous point) in a logical way. Quite the contrary, when scrutinized from close range, many issues and definitions seem virtually randomly chosen. To a certain extent, the first two aspects—the uncertainty and heterogeneity of knowledge and the room for maneuver that they leave—explain this. In addition, simplified definitions of the problem and its possible solutions are needed to communicate the issue effectively to wider audiences. Media contributes to this aspect of knowledge by playing an important role in communicating science news to the public and raising environmental issues to the public and political debate. Sometimes the problems raised up by media also seem quite randomly chosen.

> You represent certain opinion in the media, and journalists want to find someone who represents the opposite opinion. This gives the reader the impression that the opinions go fifty-fifty to both sides. Kind of the same as in climate change discussions, although in reality about 99 percent believe in climate change and 1 percent doesn't. (RS 20.10.2009)

> …it can be a complete randomness what the media picks up. The media channels that problem through to wider audiences, which all of a sudden makes the problem interesting from the political point of view. (RS 5.11.2009)

In politics and administration, some sort of generalizations and simplification are always needed, while they may lead to different kind of distortions. In many cases the generalizability of research results can be questioned. One interviewee gave an example of this problem:

> We don't know enough about nutrient input from agriculture. We've studied drainage areas in Southern Finland, but we haven't studied Northern or central Finland. Our studies are carried out in certain areas, but how do we know whether they work in other areas as well? (RS 20.10.2009)

> I simplify, although I wouldn't believe the simplification, just because that is what (the politicians and the media) expect from us. (RS 12.11.2009)

There are examples in the Baltic Sea eutrophication case where simplifications and generalizations may be perceived as generally accepted facts and end up as a baseline for certain policies. Examples from our data include the reference point to good ecological status of the Baltic Sea, which is quite arbitrarily defined but anyway taken as a main goal for nutrient reduction and other protective measures (RU 23.10.2009). Another example of this kind of a simplification is the idea that 20% of the farms are responsible for 80% of the nutrient load from agriculture in Finland, particularly favored among those politicians who call for more stringent nutrient reduction requirements for agriculture.

> I've used this particular (80/20) simplification myself (…) I only meant to make the point that not all fields and farms are equally polluting. But the ratio is not based on anything, it's an urban legend. (RS 20.10.2009)

Linkages of Knowledge Production, Processing and Communication to Particular Characteristics of Individual Researchers and Research Societies

As the preceding two sections demonstrate, it is first and foremost the linkages of knowledge production, processing, and communication to particular characteristics of individual researchers and research societies that define what kind of research the particular researcher is able to conduct. In our study it appeared that, for instance, not all scientists are able to access all national databases. This sets restrictions to the kind of knowledge individual researcher can possess.

> …we have to believe what is told to us because we don't have the rights to access the *Vahti*-database.[6] In one joint project I was able to take a look at the database and found out new things. If this was public knowledge the situation would be very different… (RU 5.11.2009)

Moreover, these linkages seem to depend predominantly on personal contacts and networks between researchers and policy-makers. It appears that only certain scientists and experts are in fact consulted and heard in policy making. This holds particularly true if we compare researchers representing universities to those representing sectoral research institutes.

> Researchers at sectoral research institutes are better informed than us in the academia and they are

[6] Database for control and nutrient load (Valvonta ja kuormitustietojärjestelmä VAHTI) is part of the environmental protection database of the Finnish environmental administration.

> actually consulted. Ministries do not listen to us. We are heard only if we shout loud enough…. but another difference is that we have the freedom to shout whereas researchers at the sectoral research institutes cannot say what they think. (RU 5.11.2009)

But the personality of the researcher also matter, even at the sectoral institutes, as the following excerpt illustrates:

> For some reason, I rarely deal with ministries, whereas some of my colleagues meet them weekly. (…) The history of the person, as well as his or her ability to present clear opinions matters. They (ministries) want someone who highlights what is known, rather than someone like me who highlights uncertainties. (RS 20.10.2009)

Obviously, the attitude of researchers toward their role in communicating research results to wider audiences is also crucial. One interviewee noted that when researchers popularize their work to the wider public, colleagues might think that they promote themselves rather than their work and consider them as less credible researchers. (RU 23.10.2009)

As a result of these intricate linkages, only certain interpretations of certain researchers are heard in policy-making. Listening to only certain scientist can potentially be misleading, since scientists are not experts on everything.

> During an interview they don't ask whether you really know something about the subject or whether you simply are presenting your thoughts based on your research background and general knowledge. (RS 26.11.2009)

PERSPECTIVES OF COPING WITH SCIENCE–POLICY INTERFACE

In this article, we have identified various aspects of knowledge that intricate science–policy interface and described the ways in which the aspects manifest in eutrophication governance in Finland. Our illustration demonstrates that in this case, and by extrapolation also in any other case of environmental risk governance, ideas of science are constructed by human endeavor and thus fundamentally human achievements (cf. Jasanoff 2004). Moreover, our study indicates that while scientific knowledge is in many ways susceptible to uncertainty and human interpretation, it is also politics-bound even without direct involvement to politics and policy-making.

Accordingly, we believe that many uncertainties and complexities related to the Baltic Sea risk governance are rooted in the aspects of knowledge that we have explicated. On the basis of our analysis we want to, therefore, open up perspectives related to (1) the integration of science and policy, (2) wider understanding of the concept of knowledge, and (3) the development of research agendas concerning Baltic Sea risk governance.

First, in terms of integrating science and policy to abate uncertainty and complexity in Baltic Sea risk governance, the recognition of multiple faces of scientific knowledge production and communication challenges assumptions of universal science and expert rationality. The linkages between science and policy are far more intricate than research programmes and noble declarations of the policy relevance of science often tend to presume. This idea offers a rationale for serious deliberation concerning the objectivity and neutrality of science, and making various linkages between science and politics/society consciously more transparent. This involves the revelation of all sorts of liabilities and, more importantly, opening up diverse practices of knowledge–policy interaction to enable extensive and equal participation of researchers, regardless of institutional position, in governance efforts to manage uncertainty.

Second, if taken as a starting point the fact that (even) scientific knowledge is multidimensional and society bound, thus unable to offer absolute truths and solutions, the position of so called "laypersons" and their expertise—the experience and knowledge of those stakeholders that are involved, for example farmers or those who suffer from eutrophicated waters most—becomes more significant for Baltic Sea risk governance. Research concerning environmental governance has already for long acknowledged the role and potential of local knowledge for policy making (see, e.g., Davis 1996), whether the knowledge is scientific or any other kind. The good ideal of integrating local knowledge has, however, proven difficult to be put to use. We suggest that making of various linkages between science and society consciously more transparent and clear would facilitate public participation in Baltic Sea risk governance by helping to break up the culturally powerful position of scientific knowledge that often obscures what would be valuable in lay knowledge and expertise (cf. Pellizzoni 1999).

Finally, consciousness about the multiple faces of knowledge opens up scope for further research in the framework of the Baltic Sea studies. It challenges the biased research programmes that focus largely on the role of natural science for governing environmental risks. Namely, taking the ideas about social embeddedness of science presupposes social scientific research to be permeably integrated in research settings, instead of adding a small separate social dimension. For instance, to deeply understand the logic of science–policy interface, it would be of crucial importance to scrutinize practices, forms and

settings through which science and policy intersect in various contexts. Also the role and knowledge of "lay persons" more carefully into account in Baltic Sea governance entails social scientific research. Our analysis also shows, however, that the often repeated sentence about the profusion of scientific knowledge on the Baltic Sea environment is not the whole truth: to come to grips with uncertainty, more research on ecological processes and causal relationships is also needed in the Baltic Sea case.

To conclude with, the value and interest laden character of environmental issues, such as the eutrophication of the Baltic Sea, implies that these issues cannot be captured by any unambiguous scientific set of facts. Even in issues of unanimous scientific understanding, scientific interpretations are usually challenged by other, competing views on the issue. Therefore, scientific knowledge is inevitably only one component in policy making and risk governance. More importantly, and what we have tried to illustrate in this paper, these forces also affect the construction of scientific knowledge itself, whether the scientific community wants it or not.

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