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Savitri Jetoo, Nina Tynkkynen, Marko Joas, Magnus Hellström, Conny Sjöqvist and Anna Törnroos

Faculty of Social Sciences, Business and Economics, Åbo Akademi University, Turku, Finland

ABSTRACT
This article expands the discussion of Baltic Sea environmental governance by examining the implications of climate change on governance. It scrutinizes the physical challenges posed by climate change and analyses how the existing governing system can meet these challenges. The findings indicate that the present governing system is limited and cannot capture future changes and feedback effects. Therefore, this article recommends that multiple governance approaches should be explored. Management practices should be cross-sectoral and flexible, based both on the recognition of past experiences and all types of knowledge, including scientific but also local. Further interdisciplinary research can guide this process.

KEYWORDS Baltic Sea; climate change; Baltic Sea time machine; challenges; research agenda

1. Introduction

1.1. Background

Recently a group of prominent scientists introduced the idea that the Baltic Sea can serve as a time machine to study the consequences and mitigation of future coastal perturbations, due to its unique combination of an early history of multistressor disturbance with ecosystem deterioration and a cross-border environmental governance system in place to address these problems (Reusch et al. 2018). In particular, the environmental governance system of the Baltic Sea is often praised as being one of the most advanced regional governance systems in the world (VanDeveer 2011; Haas 1993). This is a multilevel system, characterized by the strong presence of EU environmental regulation, a regional convention for marine protection (Helsinki Convention), the relatively ambitious national environmental policies of the coastal countries, as well as active local level actors, both governmental and non-governmental (Tynkkynen 2013; Kern 2011; Jetoo and Joas 2018; Ringbom and Joas 2018; Gronholm; Jetoo 2019). The system has enabled certain trend reversals in the Baltic Sea, including the return of top predators, recovering fish stocks, and the reduced input of nutrient and harmful substances during the last couple of decades (Reusch et al. 2018). Yet, while there are numerous lessons to be learned from the case

CONTACT Savitri Jetoo savitri.jetoo@abo.fi Department Faculty of Social Sciences, Business and Economics, Åbo Akademi University, Fänriksgatan 3, Turku 20500 Åbo, Finland

of the Baltic Sea in both research and practice, climate change, with its all-encompassing effects and accelerating pace, might be challenging the lessons of the time machine. In brief, we cannot afford to wait for the results of the time machine. We need to act based on other premises or reconfigure our understanding of the time machine for the purposes of combatting climate change. This article 'breaks the ice' on dialogue for this action.

This is a conceptual study with the objective to examine how climate change challenges the governance of the Baltic Sea Region and how well the existing governance system is able to surmount these obstacles. More specifically, it explores the governing environment by looking at the physical challenges posed by climate change. It aims to answer the following research question: What type of governance of the Baltic Sea environment is needed to address the challenges posed by climate change? Special attention is paid to the possible lessons learned from the past as well as the timescale of the problem at hand. It also makes recommendations for further research that will be of use to both practitioners, such as governmental policy makers, and fellow researchers in academia.

1.2. Methodology

This article examines the influences of climate change on the Baltic Sea governance system. First, we present the physical impacts of climate change on the Baltic Sea ecosystem using key documents produced by the Helsinki Commission (HELCOM), and peer-reviewed scientific literature. This highlights the complex changes and uncertain marine environment of the Baltic Sea and advances key aspects of the effect of climate change on the biological system. The article then uses both HELCOM and Baltic Sea relevant EU policy documents as well as previous research on Baltic Sea climate governance to assess how well the governing system is able to meet the requirements posed by climate change. The scientific data was collected using the keywords 'governance,' 'Baltic Sea,' and 'climate change,' as well as combinations of these. In doing so, the best practices for literature reviews were followed (Rowe 2014), for example, a keyword search of 'governance,' 'climate change,' and 'Baltic Sea' revealed 744 results in the Science Direct database. When years '>2017' was selected, this limited the results to 232 article that were read in detail and analyzed using the qualitative content analysis method. Here, we used a framework of analysis with four categories: hierarchical or network-based governance; integration across policy sectors; public engagement; and definition of the appropriate scale (see Section 4) was used as a reading guide to structure the analysis. These themes inductively emerged from reading of the theoretical climate change governance literature. They were then chosen by the authors as being central challenges to the governance of climate change in the Baltic Sea region and applied to the Baltic Sea related data (the 232 papers) in a deductive process, as a reading guide.

2. The impact of climate change on the Baltic Sea

This section examines the physical and biological challenges of climate change on the Baltic Sea. It relies on a key literature and data from the National Oceanic and Atmospheric Administration (NOAA).

2.1. The Baltic Sea environment – a history of physical change

The Baltic Sea is a sea of change, especially when it comes to major climate driven changes. The historical development of conditions in the Baltic Sea basin over past millennia is established and based on proxy data from sources such as fossils, pollen and insects, tree ring widths and density, and also written records (HELCOM 2013). After the Ice Age (between 18,000 and 11,000 years ago) when glaciers covering the region receded, the warmer Holocene period followed with a number of major changes. In this period, the Fennoscandian ice sheet melted causing a rise in sea level and the slow and still continuing isostatic uplift of the land, thus decreasing relative sea level (HELCOM 2013; BACC II Author Team 2015). After this period, around 7,500–5,500 years ago, a relatively stable period occurred with summer temperatures of 1–3.5°C higher than at present (HELCOM 2013). The next relatively stable period of climatic conditions, the 'Medieval Warm Period,' typified by warm and dry summers across Europe, prevailed in the tenth and eleventh centuries. The climate of the past 500 years is characterized by centennial-scale variability and rapid shifts. During the past 200 to 300 years, the climate of the Baltic Sea basin has been controlled by global climate as well as regional circulation patterns with a strong interlinkage between atmospheric patterns. During this period, measurements of environmental conditions have been made with increasing accuracy. The Baltic Sea, with its wide drainage area (Figure 1) has a dense observation network covering an extended time period. A continuous time series exists since the middle of the eighteenth century for a few stations; a denser network of stations was developed from the middle of the nineteenth century (HELCOM 2013; BACC II Author Team 2015).

Historical proxies and the contemporary measurements show that the Baltic Sea region is the world's fastest warming large marine ecosystem. Air temperature has increased more rapidly than the global average since the 1870s (BACC II Author Team 2015) and sea's surface temperature has increased on average by 1.35°C between 1982 and 2006 (Belkin 2009). In some local areas the sea's surface temperature has increased even more when the data is extended to recent years (Figure 2 uses data retrieved from NOAA between 1982 and 2017). This is also manifested as seasonal changes, with an increase in the duration of the growing season and a decrease in the duration of the cold season (BACC II Author Team 2015). Moreover, ice season length and ice thickness have declined (Merkouriadi and Leppäranta 2014). Data on ice cover in the Northern Hemisphere from December to January for the years 1979–2020 shows that the decrease has been on average 3.02% per decade (Figure 3). In the past 200 years, wind patterns and storminess have been dominated by multi-decadal variations, but a north-easterly shift of storm tracks as well as an increase in storm surges appears more consistent in recent times. In line with this, there is some indication of an increased duration of precipitation periods and an increased risk of extreme events (BACC II Author Team 2015).

2.2. Climate change related effects on the biology of the Baltic Sea

Climate change is likely to have large abiotic and overall effects on the Baltic Sea biological ecosystem. What these effects exactly are and how they interact with existing major stressors such as eutrophication, organic pollutants, overfishing, invasive species,

Figure 1. The study area: the Baltic Sea and its drainage area.

acidification, and other anthropogenic disturbances, such as marine traffic, and construction, are currently very difficult to project. Climate related changes are likely to affect the biology in the Baltic Sea in several ways:

(1) On an individual organism and species le

Species can either tolerate or adapt to changes shifting their tolerance limit over time, shifting behaviors linked to their lifecycle, or by migrating to more favorable areas. The adaptive potential of a species to a changing environment is dictated by its level of genetic diversity (Lynch 1996). Species with less genetic variation, for example, with narrower reaction norms, are prone to extensive range shifts compared to species with

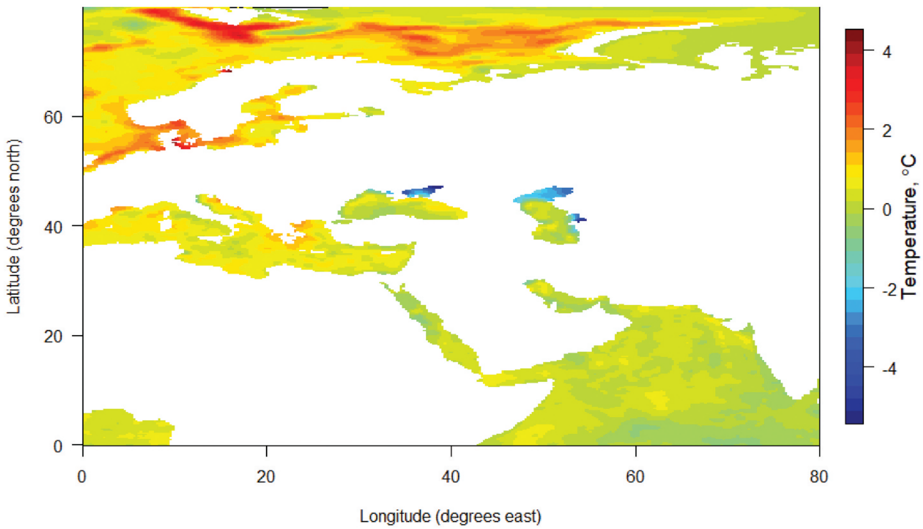

Figure 2. Change in average January temperatures between 1982–5 and 2014–17 (data retrieved from: ftp://eclipse.ncdc.noaa.gov/pub/OI-daily-v2).

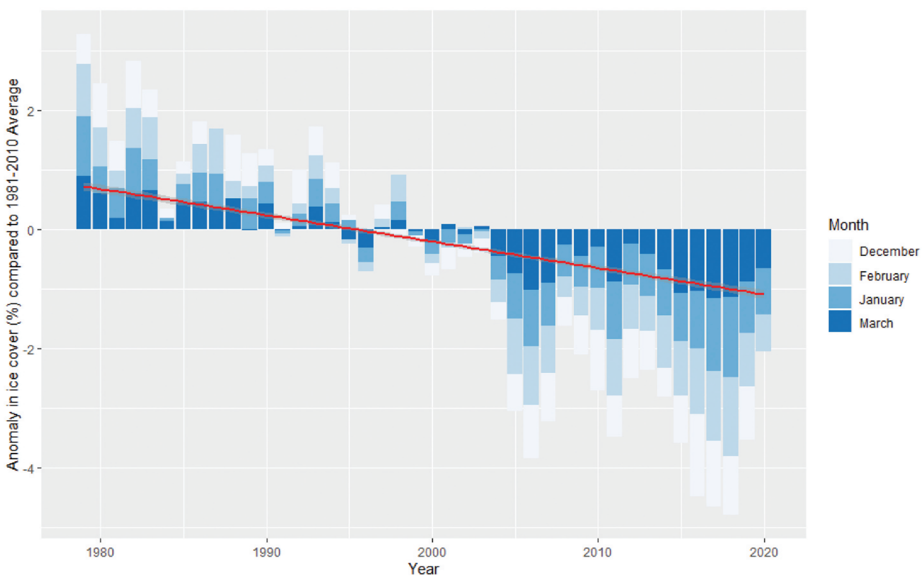

Figure 3. Anomaly in ice cover on the Northern Hemisphere from 1979 to 2020. Trendline in red. Average decrease in sea ice cover amounts to 3.02% per decade. Data source NOAA, 2020: https://www.ncdc.noaa.gov/snow-and-ice/extent/sea-ice/N/3.

a higher level of genetic variation as the environment changes (Hughes et al. 2008). The Baltic Sea hosts a mix of marine and freshwater species, making it a marginal habitat for many of its inhabitants. Most species in the Baltic Sea now live at the edge of their distribution range. Johannesson and André (2006), for example, showed that populations of marine species in the Baltic Sea are genetically less diverse compared to sister populations in the North Atlantic. This constitutes an evolutionary risk to multiple species in the region as climate change progresses (Johannesson et al. 2011).

(1) On the population and community level:

Depending on how a species copes with physical changes along the Baltic Sea gradient, the entire population and its distribution can increase (in some areas or throughout the region) or decrease (Bell and Gonzales 2009; HELCOM 2018). If this is the case for commercial species, it may have serious economic consequences, for fisheries, as well as for regional management and governance. Community-level changes entail alterations in the community composition, either a turnover, loss, or gain of species.

Abiotic changes potentially affect key habitat forming species in the Baltic Sea, such as the brown algae *Fucus vesiculosus* or eelgrass *Zostera marina*; species relying on these habitats might in turn be indirectly affected (Kersen et al. 2011; Wahl et al. 2015). Moreover, the changes to individual species and/or changes on the population and community level might have consequences for both the functioning of the ecosystem, for example, for production, filtration rate of water, sediment, and particle fluxes in and out of the sediment, and for the resilience of the system (HELCOM 2018). These changes on an ecosystem level through the functioning of the system are linked to the characteristics, or traits of an organism, and these are spatially and temporally variable for many taxonomic groups in the Baltic Sea (Pecuchet et al. 2020; Törnroos et al. 2015, 2019; Klais et al. 2017; Pecuchet, Törnroos, and Lindegren 2016), for example, changes to individual species distributions or phenology, or community composition may cause changes in the food web with potential shifts for the entire ecosystem (Yletyinen et al. 2016; Doney et al. 2012).

These three levels – individual organisms, communities, and habitats – are in many ways important for societies in the Baltic Sea region and beyond. They, for example, provide food for consumption (fish, bivalves, crustaceans), or regulate processes, such as mitigate erosion or aid nutrient cycling. They also have cultural importance, such as diverse underwater coastal landscapes (Ahtiainen et al. 2019; Ahtiainen and Öhman 2014). Thus, depending on the effect of climate change on the levels of ecological organization, consequences for ecosystem services could be extensive and variable.

2.3. Key knowledge gaps

Basic information on species or taxon/group specific tolerances to temperature, oxygen, and salinity is critically needed to better predict the impact of climate change on the marine ecosystem. Preferably such information would span across organism groups and cover the whole region. Such knowledge is primarily gathered through laboratory and field experiments and is labor intensive. Moreover, it is not only the maximum tolerance limits that are of interest but particularly species-specific responses to the variability in climate-related variables, for example, prolonged variability of temperatures or an increased number of heat waves, that should be prioritized. Direct measurements can be supplemented by climate projections and biophysical models of dispersal and connectivity to simulate future species distributions based on the best knowledge of species tolerances, or other characteristics linked to key aspects of fitness such as adult maximum tolerances or reproductive volume (Jonsson et al. 2018).

More information about the genetically based adaptive potential in key species in the Baltic Sea is needed. Wennerström et al. (2013) showed that patterns of genetic diversity are not always correlated with salinity alone but species-specific patterns in intra-specific variations exist among several of the studied species of fish and macro-algae, complicating effective management efforts. Not only salinity, but also oceanographic connectivity across the North Sea–Baltic Sea transect dictates the genetic patterns of species (Teacher et al. 2013; Sjöqvist et al. 2015). A potential effect of climate change is an alteration of existing oceanographic currents, with secondary effects on oceanographic connectivity, such as gene flow, between subpopulations in the region. This may have unexpected consequences for the distribution of key species in the region in the future. Studies also show that rapid evolution, even in macro organisms is happening on an ecologically relevant timescale. The brown algae *Fucus vesiculosus* and *Fucus radicans*, for example, are thought to have diverged into separate species inside the Baltic Sea only a few hundred years ago (Bergström et al. 2005). The European flounder *Platichthys flesus* has also been shown to have diverged into two separate species inside the Baltic Sea within less than 3,000 generations (Momigliano et al. 2017). These examples demonstrate that projecting species-specific distribution ranges in the face of climate change is extremely challenging.

3. The governance of climate change and the Baltic Sea time machine

This section presents the governing system of the Baltic Sea environment and examines the characteristics of climate change in this governing system, using key literature.

3.1. The governing system of the Baltic Sea environment

It is evident by now that the stumbling block to combat climate change or marine pollution is not an absence of technical solutions but rather political and institutional factors. It is, therefore, critical how successful different forms of governance are in combatting these problems (Weibust 2014). From this viewpoint, the idea of the Baltic Sea as a time machine implies that because of a well-institutionalized governing system, environmental governance of the Baltic Sea can form a model for other coastal and marine systems (Reusch et al. 2018). Indeed, compared with many other marine areas, environmental issues are relatively high on political agendas in the countries surrounding the sea, and the Baltic Sea region is a forerunner with a long record of international cooperation, extensive scientific research, and a well-developed governance structure. Baltic regional environmental cooperation has existed for over 35 years, which makes it one of the oldest and most active cases of international environmental cooperation and an eventual lesson-to-learn for both scholars and practitioners of environmental politics (VanDeveer 2011).

There is also clear evidence that international and national environmental governance institutions can not only handle local or regional level problems but also find solutions to global problems. This was evident in the case of ozone layer protection as the international environmental regime created by the Montreal Protocol, signed in 1987, achieved universal ratification in 2010 as well as a very high national implementation rate (Godin-Beekmann, Newman, and Petropavlovskikh 2018). Severe global environmental problems can thus be solved through multi-level environmental governance. In the Baltic Sea region, regional (environmental) governance structures are relatively solid. Why then, do we still see climate change as the greatest challenge for the Baltic Sea and its governance structures?

Despite the well-established governing system in the Baltic Sea region, climate change will fundamentally challenge the provisions of HELCOM (Helsinki Commission, see below), the international protection regime, as well as the policies of national governments regarding marine environmental protection. It has not yet properly been taken into account in the governance of the Baltic Sea environment (Hasler et al. 2019). The Helsinki Commission has only recently started working on climate change in a comprehensive way (HELCOM 2013). Illustratively, in the Baltic Sea Action Plan (2007), which is the basic instrument guiding HELCOM's policies, climate change is not addressed as one of the strategic goals. Yet, as discussed in sections above, climate change is a problem that will most evidently have a vast impact on the biology of the ecosystem and various environmental problems of the Baltic Sea (including eutrophication) and their abatement (Keessen 2018; Jetoo 2019). In addition, it will eventually create economic and societal problems especially where homes, industries, harbors, and other developed areas are located (Bartosova et al. 2019). Therefore, climate change and its impacts cannot be omitted when planning and implementing governance of the Baltic Sea environment. The task is tricky; climate change is a global problem whereas many other environmental problems of the Baltic Sea are local or regional. Yet, as these local problems are exacerbated by the impacts of climate change, their governance requires concerted cooperation. Climate change governance, in particular when linked to marine governance, necessitates cross-generational thinking and the attempted anticipation of the unpredictable future impact of climate change. Whatever the governance approach is, it inevitably needs to deal with the complexities, uncertainties, and ambiguities that are central characteristics to this research problem (Renn 2008).

3.2. Characteristics of climate change and the Baltic Sea governing system

There are a number of accepted characteristics of climate change that are known or unknown that challenge the existing governing system of the Baltic Sea. This is assessed from the literature as follows:

(1) Scientific uncertainty: Although it is known that the Baltic Sea is warming and that this warming will continue, many uncertainties remain (Hassler et al. 2019). Some of these uncertainties include changes in the hydrological cycle, the effect of changing atmospheric aerosol loads, the changes in salinity, the specification of future emissions, the impact of climate change on urban complexes, and the quantification of the effect of climate change on a basin-wide scale in the Baltic Sea Region (BACC II Author Team 2015). There is also need for a better understanding of the role of the Baltic Sea in the global carbon cycle (Kuliński, Pempkowiak, and Herndl 2011).

(2) Different timescales: Baltic Sea governance needs to take into account space and time, as its natural marine environment is characterized by high spatial and temporal variability and complex regulatory structures (Langlet 2018). As such, the response of the Baltic Sea to climate change encompasses a range of timescales. Water temperature and ice cover, for example, reacts much quicker to atmospheric temperature change as compared to the response of salinity to changes in freshwater input (Omstedt and Hansson 2006). As pointed out above, the timescales on which different levels of biological organization are affected by and react to climate change varies. This challenges a stable and authoritative multilevel governing system where changes have to be passed through several tiers before they are approved and can be implemented.

(3) Long (cross electoral and generational) timeframes: Anthropogenic pressures such as increased greenhouse gases from the burning of fossil fuels have been increasing since the Industrial Revolution. This long-term timescale transcends the short-term timeframe and decision-making cycles of politics, for example, the four-year national presidential term of leaders in some countries in the Baltic Sea Region or even the two-year rotating chairmanship of HELCOM. This poses a challenge to the governing system, which must endure beyond short-term political timeframes, find ways to adapt to the uncertainty of short-term effects, and at the same time be stable enough to make decisions safeguarding future generations.

(4) Cross-cutting (interlinking and overarching) issue: Climate change is an all-encompassing stressor that impacts every other stressor to the Baltic Sea ecosystem. The interactions between aquatic invasive species, eutrophication, hazardous substances, maritime activities, and climate change are still unknown (HELCOM 2018). This challenges the fragmented, multilevel governing system as governance needs to be inclusive, prioritizing cooperation at the local, regional, national, and international levels to pool all sources of knowledge.

(5) Disruption of business as usual (or life as we know it): Although the figures vary by country, the Baltic Sea region is still heavily dependent on fossil fuels for energy (Siksnelyte et al. 2019). As such, the main activities associated with the way of life of Baltic Sea societies produces greenhouse gases. Normal life activities such as transportation, agriculture, industrial production, shipping, etc. would need to be changed to reduce greenhouse gases (GHG) emissions (mitigation measures), which will impact living standards and ways of life. Adaptation measures would particularly impact urban development, with overheating becoming more prevalent in households during the summer. These disruptions to life as we know it are unknown and unprecedented and will need to be governed carefully through coordinated approaches to balance the needs and perspectives of different stakeholders. Different forms of instruments would need to be used for adaptation and mitigation actions, including a mix of regulation, incentives, voluntary measures, and soft law (Ollikainen et al. 2019).

(6) Benefits of climate change: There are actors who benefit, at least in the short-term, from a warming climate. This is particularly evident in the Arctic (Romppanen 2018) but also in the Baltic Sea region. Ice melting may enable shorter shipping routes and lighter hulls, which in turn will help reduce fuel

consumption and shipping emissions. The effects are complex, however, and need governance on different levels to realize; for example, in terms of new Ice Class requirements and insurance policies.

4. The challenge of climate change and the Baltic Sea governance system

The characteristics of climate change and the Baltic Sea region discussed in the previous section has implications for the governance system. This section scrutinizes how, according to the literature, climate change is challenging governance at large and analyses how well the existing governance system of the Baltic Sea environment is able to meet these challenges.

4.1. From hierarchy to networks – or balancing between the two?

Environmental policy literature notes that 'no single actor, public or private, has all [the] knowledge and information required to solve complex, dynamic and diversified problems; no actor has sufficient overview to make the application of particular instruments effective; no single actor has sufficient action potential to dominate unilaterally in a particular governing model' (Kooiman 1993, 4). Climate change makes cross-boundary demands on governance (Fröhlich and Knieling 2013). This implies that instruments, processes, mechanisms, and organizations in conjunction with public, private, and civil society stakeholders should be used to arrange environmental governance (Lemos and Agrawal 2006) and that different forms and levels of political and administrative processes are at stake. Accordingly, a wide range of scholars agree that some type of a multilevel governance system where policy networks form the basis for negotiation is key (Hooghe and Marks 2003; Jänicke and Jörgens 2009; Rabe 2007).

This kind of a multilevel governance system has been in place in Baltic Sea environmental governance since the 1990s and has also been extensively addressed in research (Joas, Jahn, and Kern 2008; Tynkkynen et al. 2014; Gilek et al. 2016; Gänzle 2017). This governing system evolved from strong diplomatic cooperation on environmental policy across the Baltic Sea during the Cold War Period (Joas, Jahn, and Kern 2008). It culminated in the signing of the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea (the Helsinki Convention) in 1974 by all Baltic Sea Coastal countries. Today, the contracting parties to the convention are the Baltic Sea coastal member states (Finland, Sweden, Denmark, Germany, Poland, Lithuania, Latvia, Estonia, and Russia) and the European Union. The Helsinki convention established the Baltic Marine Environment Protection Commission (Helsinki Commission-HELCOM) as its governing body to advance intergovernmental cooperation for the protection of the marine environment of the Baltic Sea from pollution (Jetoo 2018). Whilst HELCOM envisions a healthy Baltic Sea environment, there is no mention of climate change in its vision statement for the future. This lack of focus on climate change is carried forward into the main instrument of HELCOM, the Baltic Sea Action Plan (BSAP).

The BSAP was signed in 2007 and represents a renewed call to action by coastal states and the EU for the restoration to a good ecological status of the Baltic Marine environment by 2021 (HELCOM 2007). This plan incorporates the latest scientific knowledge, using the results of monitoring and assessment programs to identify major environmental problems, leading to four thematic focus areas: eutrophication, hazardous substances, maritime activities, and biodiversity. The BSAP also includes sections on the development of assessment tools and methodologies, awareness raising and capacity building, financing and implementation, and review (HELCOM 2007). The BSAP represents the culmination of HELCOM's activities to implement the ecosystem approach, which started in 2003 (Jetoo 2019). This plan, however, is not comprehensive as it does not include an emphasis on climate change. Rather, there are only two mentions of the word climate change in the entire BSAP, in the preamble. It recognizes the significant impact of climate change on the Baltic Sea ecosystem and that it will 'require even more stringent actions in the future and of the efforts made by the Conference of the Parties to the 1992 United Nations Framework Convention on Climate Change' (HELCOM 2007, 3). It does not, however, go into any further details as to what these actions are or the work that is necessary to determine these stringent actions.

The provisions of the BSAP are flexible and implementation measures are left to the discretion of member states. This is strategic and important, as the environmental impact, conditions, and policies vary in each nation state and at the local level, necessitating different cooperative policy approaches. As such, successful governance can only be achieved in a combination of governance models that include but reach beyond the nation state. In the multilevel environmental governance setting, responsibilities are shared with international, supranational, transnational actors, subnational, and non-governmental actors. National governance dominated until the end of the 1980s but after the end of the Cold War, intergovernmental cooperation increased. Numerous transnational networks also developed in the region after the cold war (Joas, Jahn, and Kern 2008): civil society organizations (for example, the Coalition Clean Baltic or Social Hansa), economic organizations (for example, the Baltic Sea Chamber of Commerce Organization) and sub-national organizations (for example, the Baltic Ports Organization).

The emergence of multilevel governance in the Baltic Sea region is tied to the Europeanization of the region. With EU enlargement, all the nation states that are signatories to the Helsinki convention are EU members, except Russia. As such, the governance of the Baltic Sea is embedded within the EU multilevel governance architecture and regulative structure, with governing extending beyond the nation state (Ringbom and Joas 2018). EU directives and funding mechanisms such as project funding through Interreg, shape the policy development of the whole region. The EU has also developed its own macro-regional policy for the region unveiled in 2009, the EU Strategy for the Baltic Sea Region (EUSBSR). The EUSBSR operationalizes the promise of network governance by acting as an overarching platform that fosters cooperation between key Baltic Sea region governance networks and their members across the region (Grönholm and Jetoo 2019).

Despite the ideal of network governance, highly institutionalized intergovernmental cooperation within the HELCOM regime, as well as Russia's non-EU membership adds a greater element of hierarchy for environmental governance in the region (Tynkkynen 2013). EU members retain national authority, albeit with a strong overlay of supranational governance. This hierarchy can reduce flexibility and be an obstacle for negotiation but it may also provide some benefits that negotiation-based network governance does not provide, in particular through regulatory power (Jordan et al. 2005).

4.2. Integration across policy sectors

A wide variety of sectoral policies may turn out to have unexpected and unwanted environmental consequences (or externalities) especially for climate change. Calls have been made to avoid such fragmented decision-making by integrating different policies

(Tynkkynen et al. 2014). Climate change is relevant for different policy sectors and sectoral planning, even more so when its linkages with the marine environment and problems such as eutrophication or biodiversity decline are considered. Consequently, the integration of climate policy issues in different sectors and the accordant policies are a central mechanism. Demand for the integration of environmental issues into other policy sectors was generally recognized in the 1970s (Fröhlich and Knieling 2013). Institutional research suggests that systems with a greater capacity to integrate across policy sectors and interests are more successful in achieving high levels of environmental performance (Fiorino 2014).

Policy integration means that environmental factors are taken into account in the formulation and implementation of all sectoral policies. Integration also involves a cross-sectoral dimension since environmental problems such as climate change necessitate tackling the multiple causes and sources of pollutant emissions and natural resource mismanagement across sectors (Liberatore 1997). The ecosystem approach is one attempt to facilitate integration across policy sectors. As defined in HELCOM BSAP (2007, 4),

> the ecosystem approach is based on an integrated management of all human activities impacting on the marine environment and, based on best available scientific knowledge about the ecosystem and its dynamics, identifies and leads to actions improving the health of the marine ecosystem thus supporting sustainable use of ecosystem goods and services.

What separates the ecosystem approach from traditional management is the strong focus on human inclusion in the ecosystem where human use of ecosystem services and utilization of natural resources are managed in a sustainable way, encompassing a multi-stakeholder approach in decision-making processes within the management (Söderström 2017; Jetoo and Joas 2018).

The EU Maritime Spatial Planning Directive 2014/89/EU (MSPD 2014) also aims at policy integration by establishing a framework for maritime spatial planning. In Article 5, Clause 2, it advances maritime spatial plans as a means to further sustainable development and for building resilience to climate change (MSPD 2014, 141). The MSPD highlights the use of the ecosystem approach in maritime spatial planning. In the preamble, Clause 3 identifies

> maritime spatial planning as a cross-cutting policy tool enabling public authorities and stakeholders to apply a coordinated, integrated and trans-boundary approach. The application of an ecosystem-based approach will contribute to promoting the sustainable development and growth of the maritime and coastal economies and the sustainable use of marine and coastal resources (MSPD 2014, 135).

Integration is emphasized in this directive with its focus on the ecosystem approach and its elements, including cross border cooperation and land-sea interactions. It also stresses the need for adaptive management that allows for refinement as more data and information becomes available and best available knowledge is used.

In practice, however, policy integration is difficult. The main constraints of integration include prevailing short-term perspectives and the lack of capacity and difficulties in handling distributive issues. Short-term perspectives lead to discounting the future in economic, political, and even psychological terms. Regarding the integration of environmental objectives into policies such as agriculture, energy, or tourism, the risk of diluting integration over time is high due to the strong tendency to focus on short-term perspectives in all fields of economic production and in consumption behavior (Liberatore 1997, 121).

4.3. Public engagement

A governance approach is not an automatic record of democracy and empowerment (Griffin 2010), so the ecosystem approach is not the tool to achieve the feasibility, cost-effectiveness, and public acceptability of policy instruments and governance measures, as demonstrated in the case of Baltic Sea environmental governance (Linke et al. 2014). The debate around the environmental governance concept anticipates that environmental problems are identified by social perception and definition. Research on environmental regimes increasingly acknowledges that experience-based knowledge of those affected by environmental changes may serve as a useful instrument to facilitate effective environmental management (Martello and Jasanoff 2004). Scientific knowledge is important to define the problem and its possible solutions; yet, formal science usually produces highly generalizable understandings that in a policy process need to be made smaller to apply to specific cases (Cash et al. 2006, 2).

Stakeholder knowledge, in turn, is more local in character and bound to specific contexts. To bridge the gap, integrative and participatory approaches that combine different types of knowledge and experience are needed (Pellizzoni 2010). This involves various approaches to support integration of such knowledge into environmental policy-making, including working groups, public hearings, and other participatory mechanisms to encourage public engagement (Steyaert and Ollivier 2007). Further benefits associated with participatory forms of governance are transparency, grass-root connections, legitimacy, and appropriateness for the problem (Fröhlich and Knieling 2013). Research on Baltic Sea environmental governance demonstrates that the regional HELCOM regime is an example of a close, even exclusive science–policy interface (Tynkkynen 2015; Linke et al. 2014; VanDeveer 2004). The scientific community has been an important advocate for environmental protection, and HELCOM has put heavy emphasis on the role of natural science in its agenda-setting (Linke et al. 2014). Less emphasis has been put on stakeholder involvement. In addition, stakeholder involvement often happens only in the implementation phase, i.e. stakeholders do not participate in the definition of the problem and its possible solutions from the beginning (Tynkkynen 2015). Morf et al. (2019) also note that, with the exception of statutory authorities, stakeholder engagement is often limited to self-motivated stakeholders and consultation rather than more inclusive forms of participation. Whilst the HELCOM BSAP includes a section on awareness raising and capacity building, this was not implemented evenly in all countries, and it followed the dominant governance model of each country. Stakeholder engagement, for example, was not mentioned in the Finnish National Implementation Plan (NIP), whilst for the Baltic States and Russia it mainly referred to expert training of locals or awareness raising (Jetoo 2019). This is in keeping with the top down governance model of these countries.

4.4. Definition of the appropriate scale

The rationale for scaling up tasks from one level to a higher level of governance stems from the innate multiscale and transboundary character of many environmental problems, including climate change and its impact on other environmental changes. The EU has followed this rationale: The EU environmental *acquis communautaire* (accumulated legislation) constitutes an impressive body of legal mechanisms for environmental protection; by the late 2000s it numbered over 200 significant items and several hundred supporting actions (IEEP 2010). Without scaling up, many member states would probably not have achieved their current levels of environmental protection (Jordan and Liefferink 2004). For Baltic Sea environmental governance, *acquis* plays a significant role through a number of directives as well as the EUSBSR, and it has also forced the countries on the eastern shores of the Baltic Sea to improve their policies and regulation regarding the marine environment as well as that related to climate change at large (Jokela 2011).

Scaling up is not the only alternative, though. In many cases, scaling down to the local level is key, especially in terms of the facilitation of public engagement and public acceptability of governance measures but possibly also in economic terms (Roggero, Kähler, and Hagen 2019). In the EU, the principle of subsidiarity in favor of lower governance level autonomy also acts as the primary *de jure* mechanism for allocating tasks in areas of shared powers, including environmental protection (Jordan and Jeppesen 2000). In the Baltic Sea region, cities are important and active players in governing climate change in particular and have set their emissions targets and developed adaptation plans (Kern 2011; Joas 2012; Carbon Disclosure Project 2012). A high proportion of greenhouse gas emissions are produced in cities, and the impact of climate change become noticeable and tangible at the local level. This work is, however, quite distant from what, for example, the HELCOM does, and is mostly not linked to marine policy objectives. This work falls under the remit of the Union of Baltic Cities (UBC), which is a transnational network of 100 cities in the Baltic Sea region funded by member fees and various EU funding instruments (Jetoo 2017). The UBC conducts its work through seven commissions, including the sustainable cities commission located in Turku, Finland. Through this commission, the UBC is working with key partners in the EU funded (DG ECHO funding 2019–2020) Cascade project (Community safety action for supporting climate adaptation and development), which aims to build local capacity to climate change related risks (UBC 2019).

Ultimately, subsidiarity can be used as a 'scaling device' to define the relevant temporal and spatial scales as well as the appropriate management measures. This requires 'reframing the problem in different ways and from different perspectives so that adequate problem-specific constituencies will take shape' (Haila 2008, 207), and so that the most appropriate scale of activity is found. For HELCOM work, this has not been the case. In most of its work, the scale of activities is the entire Baltic Sea (Tynkkynen 2015) and the scale definitions of the regime and stakeholders differ from each other quite significantly. This has also hampered the effectiveness of the regime, as in its provisions the socio-economic variety of different regions is omitted (Tynkkynen 2015).

5. Conclusions

This article expands the much-needed dialogue on climate change and governance in the Baltic Sea Region. The natural science overview, found in this article, highlights the physical and biological challenges of climate change on the Baltic Sea and the need for a research agenda focused on gathering information to narrow the scientific uncertainty gap. One key focus area for this research is species adaptability to changing temperatures, salinity and the overall changing environmental conditions associated with climate change. The governance research agenda is also partly tied to this knowledge gap as it takes a leap from knowing what is known to highlighting what is uncertain.

Thus, if one summarizes the above challenges that climate change imposes on the biological system and thereby society, it becomes evident that there is limited ability to predict future changes and chain reactions. As such, future governance of the Baltic Sea environment needs to be adaptive so as to meet the challenges that climate change is posing, especially with respect to scientific uncertainties, timescales, and disruptions to business as usual. Governance arrangements and management practices should be flexible and adaptable, based both on the recognition of past experiences and learning and all types of knowledge, including scientific as well as local. The integration of climate adaptation and mitigation in different sectors can occur through dialogue, financial incentives, or coercion.

An intergenerational perspective is, however, an essential feature of the climate governance challenge that is missing in the literature. Therefore, governance structures and planning horizons need to be relatively stable, independent of adaptability and flexibility of instruments (Fröhlich and Knieling 2013). There is evidence of successful cases where international environmental governance structures can bring feasible solutions to global problems, even threats, as the case of ozone layer can show. Climate change, however, requires action from a multitude of actors.

The Baltic Sea region has an existing governance system that is rather feasible in terms of its multilevel and multi-agency character to combat climate change as a global environmental threat. The robustness of the governance institutions in the region is evident. The governance institutions are clearly multilevel and multi-actor in character, with some evidence however, of lacking high enough participatory governance and public engagement features. As such, the unknowns of stakeholder engagement in climate governance, such as who to engage, mode of engagement, and types of knowledge to gather forms the point of departure of the governance research agenda. When it comes to GHG emission abatement, various industrial actors ought to be involved in co-creating the necessary systemic innovations, especially given that so many Baltic states are dependent on seaborne logistics.

There are many questions to guide this research agenda. How can the intergenerational perspective be included in the governance of climate change? Can the intergenerational aspect of sustainability agendas provide a way to link climate change governance to sustainability indictors? A lot more research is needed in this area. Questions on inclusion encompass, for example, what constitutes effective stakeholder engagement and how can stakeholders be engaged as partners in Baltic Sea coastal countries where the environmental governance modes vary from autocratic to participatory? Are some modes of adaptive governance better for engaging stakeholders in governing the climate adaptively? Are some modes of adaptive governance better at the local level and others at the national level? Or are there instances of command and control governance leading to better outcomes for climate governance?

Steering the Baltic Sea region in the complex area of climate governance is unlikely to be effective when only one mode of governance is used, especially given the different social and economic realities of the Baltic Sea coastal countries and societies that to a large extent are dependent on the state of the marine ecosystem. It is further compounded by differing scales and a timeframe that extends through multiple generations. Due to all the challenges posed by climate change, a range of disciplines and governance approaches (multiplicity) should be explored. As such, further research is needed to examine each case from a different theoretical perspective, both empirically and normatively. Further research should also focus on the usefulness of incremental versus abrupt policy changes that sometimes accompany extreme weather events. As this article highlights, both for the natural and social science literature, climate change is a serious problem characterized by incomplete and imperfect knowledge. Whilst monitoring, modeling, and other future research methodology can reduce the knowledge gaps, knowledge of climate change will remain incomplete and to some degree uncertain. As such, the future research agenda should focus on governance models that encompass uncertainties and knowledge gaps at all levels in the multilevel governance system. Whilst some of these uncertainties are stressed in this conceptual study, further research is needed to characterize the significance of these uncertainties and how these can be designed for climate change policies such as nutrient trading and other incentive-based carbon reduction schemes.

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Notes on contributors

Dr. Savitri Jetoo is Adjunct Professor at the Faculty of Social Sciences, Åbo Akademi University Finland. Her research interests include sustainable cities, multilevel environmental governance, transboundary water governance, water resources optimisation, sustainable development and stakeholder engagement.

Dr. Nina Tynkkynen is Associate Professor (tenure track) in public administration and the Chair of the steering group of the Sea Profiling Area at Åbo Akademi University, Finland. Her research interests include environmental governance, environmental policy and sustainability transformations.

Dr. Marko Joas is Professor in public administration at Åbo Akademi University and Dean for the Faculty of Social Sciences, Business and Economics at Åbo Akademi University. His research interests include (local) sustainable development and comparative environmental governance as well as democratic participation especially within these policy areas in the Baltic Sea Region and in Europe.

Dr. Magnus Hellström is Associate Professor (tenure track) in industrial management at the Faculty of Science and Engineering at Åbo Akademi University. His research interests revolve around circular and sustainable business models in the marine industry.

Dr. Conny Sjöqvist is a Postdoctoral researcher at Environmental and Marine Biology at Åbo Akademi University. His research revolves around molecular ecology and genetic diversity of marine species, with a special focus on the adaptation of microorganisms to environmental change.

Dr. Anna Törnroos is Associate Professor (tenure-track) in functional marine biology and interdisciplinary environmental science at Åbo Akademi University. Her research interests include marine ecosystem functioning, global change and socio–ecological interactions.

ORCID

Nina Tynkkynen http://orcid.org/0000-0003-4579-1363

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