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Article

Barriers to Effective Eutrophication Governance: A Comparison of the Baltic Sea and North American Great Lakes

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Abstract: The Baltic Sea and the North American Great Lakes are two transboundary watersheds that are at risk from similar environmental stressors including nutrient enrichment, hydrologic modifications, chemicals of emerging concern, and the overarching stressor of climate change. Although located in different geographical regions of the world, both watersheds are governed in a multilevel governance setting with many layers of decision makers including global, national, governmental, regional, municipal, and community levels. Despite governance innovations, such as the Helsinki Convention in 1974 and the Great Lakes Water Quality Agreement in 1972 and their updated versions, both transboundary waters are under increasing stress from eutrophication. There are provisions in both the Helsinki Convention and the Great Lakes Water Quality Agreement for nutrient abatement measures, yet algal blooms abound in both waters, especially after precipitation events. This paper looks at the governance processes in both transboundary ecosystems, with the aim of highlighting governance barriers to eutrophication mitigation using four analytical lenses. A comparison of the two systems and the governance barriers shows that similar and unique challenges are faced in both regions, and the choice of analytical lens affects the perception of barriers and implementation actions. This is useful for policymakers in planning intervention strategies to tackle the stressor of nutrient enrichment in both regions.

Keywords: North American Great Lakes; Baltic Sea; governance; barriers; analytical lens; eutrophication; nutrient

1. Introduction

The Baltic Sea and the North American Great Lakes are two large transboundary water systems that operate in a similar multilevel governance framework that emerged in the 1970s under different settings. The Helsinki Convention 1974 was signed after the cold war, with a key focus on diplomacy. In contrast, the Great Lakes Water Quality Agreement was signed in 1972 by US and Canada with the aim of reviving a dying Lake Erie from nutrient enrichment. Despite the long history of governance innovations, both transboundary ecosystems are under stress from a number of anthropogenic sources, including nutrient enrichment leading to eutrophication. Eutrophication is the term given to anthropogenic excess nutrient loading to water bodies and has been cited as one of the leading causes of ecosystem degradation in both the Baltic Sea [1,2] and the North American Great Lakes [3]. Excessive phosphorus and nitrogen in both the Baltic Sea and the Great Lakes cause increased nuisance algal growth and concomitant oxygen depletion and increased turbidity. Phosphorus is the limiting nutrient for eutrophication of freshwaters such as the Great Lakes [3], whilst both phosphorus and nitrogen are limiting nutrients for brackish environments such as the Baltic Sea [2], depending on the seasons. However, this does not cause significant differences in the governance processes to disqualify a comparison.

Whilst both these water systems occur in a water-secure, developed-world context, they both face the threat of reducing biodiversity, with eutrophication as one of the causes. This has been well documented in the seminal article and map on 'Global threats to human water security and river biodiversity' [4] as documented in the journal 'Nature' (Figure 1).

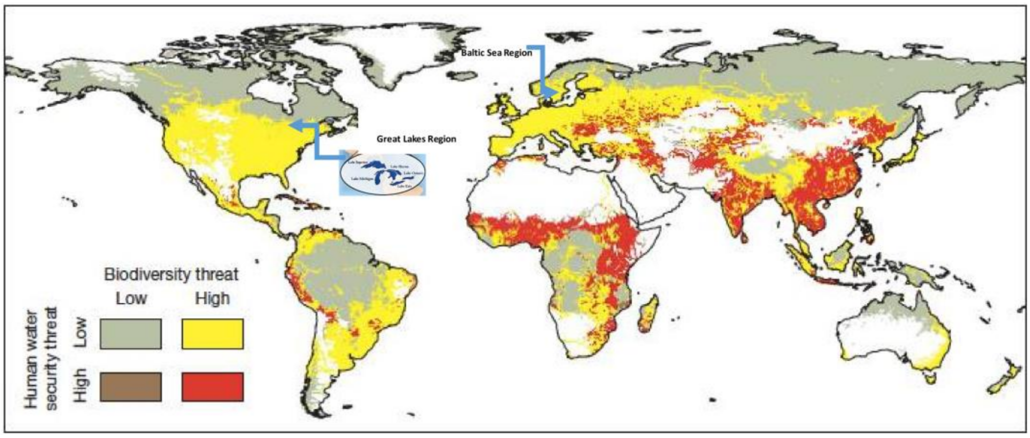

Figure 1. This is a figure showing the prevailing threats to human water security and biodiversity [4]. Adjusted human water security threat is contrasted against incident biodiversity threat.

As can be seen in Figure 1, both the Baltic Sea and the North American Great Lakes are located in the yellow regions of the Map, where there is adequate quantity and quality of water for human needs (water security), but where the challenge of reducing biodiversity and protecting biodiversity is present as well. This can be contrasted with the red regions, where there are threats to both human water security and biodiversity, as is characteristic of the developing world. International goals for biodiversity protection lag behind in expectations and global investments. These are not matched to the needs, which results in a highly vulnerable ecosystem, such as those of the Baltic Sea and the Great Lakes [4]. In developed regions of the world, existing human water security infrastructure will require rethinking to protect biodiversity whilst retaining human services. This points to a failure of governance, which also leads to problems such as eutrophication [4].

A failure of governance has been used to explain the widespread eutrophication instances of both the Baltic Sea [4] and the North American Great Lakes [5]. More specifically, it can be explained as a failure of governance evidenced by implementation deficits exacerbated by poor actor coordination and institutional fragmentation in the multilevel governance framework of both transboundary governance systems [4,5]. Eutrophication governance is further exacerbated due to the complexity of its abatement being one of the goals of government, and not the government's primary aim. The literature on eutrophication governance has documented the failures in the design and execution of the governance process, actors' actions, and institutions [4–6] using one analytical lens to document the problems. This is what has been called the 'problem solving lens' by Bovens and Paul't Hart [7] in their examination of policy fiascos. Seen through this lens, the governance of eutrophication can be seen as the intentional act of selecting the best options to solve the problem of nutrient enrichment of the Baltic Sea and the Great Lakes in the most effective and efficient manner. This perspective sees good governance as the key to delivering resiliency back to these ecosystems, where good governance involves properly designed and implemented rules to guide nutrient reduction measures. An example of good governance through this lens would be the implementation of the Great Lakes Water Quality Agreement 1972, which resulted in measures to reduce point sources of nutrients to the Great Lakes such as upgrades of wastewater treatment plants and banning of phosphorus in detergents, resulting in reductions in eutrophication of Lake Erie [3]. Through this analytical lens, barriers to governance are seen as atypical phenomena (such as non-point source pollution from agriculture that results in nutrient enrichment of the Great Lakes) that need to be identified and removed, and can be explained by failures in the planning and implementation of the governance processes.

Whilst this is a useful analytical framework with which to analyze barriers to eutrophication governance, the climate adaptation literature contains other analytical lenses that can provide an alternative means of framing the governance problem [8,9]. This can help in reducing the bias in research that comes from choosing one analytical lens over another [10]. The way in which the problem of eutrophication governance is framed will influence the solutions or strategies and policies that are designed to provide solutions. Despite this, there has been a gap in the literature on the different analytical lenses that guide the scientific research and policy practice on the governance of eutrophication. As such, this paper examines the barriers to eutrophication governance through four analytical lenses, using the analytical framework from the climate adaptation literature [7,11]. It looks at how the different barriers are derived from four different analytical lenses which perceive governance as (i) problem solving, (ii) competing values and interests, and (iii) an institutional interaction and as dealing with structural constraints. It does this for both the Baltic Sea and the North American Great Lakes region, with the view of comparing and contrasting barriers to shed light on similarities and differences. This paper uses key informant interviews to provide insights into some of the views held by key stakeholders in the Baltic Sea and Great Lakes Region.

1.1. Governance and Philosophies Underlying Research

Governance has evolved as a field in the literature, and there are many disciplinary lens through which this term is defined and researched. A common thread in the definitions is that governance is the inclusion of other actors with the government in steering societal decision making processes. However, there are many different assumptions and frameworks that underlie research conducted on governance. Bovens and Paul't Hart [7] identified three patterns of normative ideas and empirical claims about the processes of policymaking in the public policymaking literature that they termed 'philosophies of governance'. These philosophies of governance attempt to convey shared paradigms by researchers on the activities of governance, the key players, what constitutes good governance, and the outputs and outcomes of governance [7]. These philosophies of governance inspire particular sets of evaluation principles and empirical analysis, but there is no direct one to one correlation. As such, these philosophies cannot be substantiated but are key to understanding how governance barriers are conceived [11]. These philosophies are termed: the optimists, the realists, and the pessimists.

The optimists philosophy of governance has its roots in the Enlightenment [7], characterized by scientific and intellectual progress and the expectation that the sciences would improve human life. Governance is a means of solving public problems; eutrophication can be solved through scientific understanding used to design sound governance arrangements. Good governance is characterized by specialization, research, capacity building, and constant improvement in management and decision making techniques. Governance barriers are conceptualized as errors in the machinery of governance such as poor execution of the governance process or lack of competence of actors or poor design of the institutions of governance. This is an optimistic view, as it implies that these errors in governance can be self-corrected through better governance, such as capacity building, allocation of resources, and improvements in institutions [10].

The realists philosophy of governance sees human nature in a negative manner, seeing actors as self-centered, cognitively limited, and egocentric, leading to endemic failures of governance that are prevented only through checks and balances in the governance process. Governance barriers are not seen as such, but as conflicts, impasses, or struggles that arise from governing wicked or complex problems [11]. This results in setbacks, reversals, and miscommunications, with government no longer as the key leader of society. Governance consists of interaction processes between governmental and non-governmental actors and formal and informal rules of institutions that guide these interactions [11]. This approach assumes that complexities cannot be reduced but embraced through management, leadership, and communication, as these prevent the conflicts and impasses from getting worse [11].

The pessimists are in agreement with the realists' views on the endemic forces that lead to policy failures, but take it a step further; they believe that good governance cannot save the day and that system failures are bound to occur [6]. Eutrophication is characteristic of a complex problem that consists of interactions across spatial and temporal scales, and can be seen as a consequence of the society's use of high risk technology or the design or implementation of projects, where errors are structural and, as such, are bound to occur [7]. This philosophy sees eutrophication governance failures as inevitable in this process of social experimentation, especially in cases where social and political costs are high. The aim of governance is to take measures to limit the scope, number, and harmful impact of system failures. As such, governance barriers are perceived as the explanatory features of governance failure [11]. In this philosophy of governance, researchers investigate the sources of barriers that lead to failures in the governance of eutrophication, through the learning process of experimentation and trial and error. This is in contrast to the optimists' view, in which problem complexity can be reduced through rational processes. Pessimists embrace systems thinking in order to gain insights into interconnectedness between system parts in order to elucidate insights into governance failures [11].

1.2. Governance of Eutrophication

1.2.1. The Baltic Sea Eutrophication Governance

The Baltic Sea is one of the world's largest brackish bodies of water. It is located in northern Europe and is shared by nine coastal countries: Denmark, Sweden, Finland, Germany, Poland, Latvia, Lithuania, Estonia, Russia, and five other countries in the catchment area (Norway, Czech Republic, Slovak Republic, Ukraine, and Belarus). The Baltic Sea has a surface area of 420,000 square km, with a drainage area four times this size, and is home to 85 million inhabitants [12]. This results in several anthropogenic pressures to the Baltic Sea ecosystem, including nutrient enrichment, overfishing, aquatic invasive species, hydrologic modifications, and hazardous substances pollution [12]. Nutrient enrichment leads to cultural eutrophication, which is one of the most significant stressors to the Baltic Sea ecosystem, with a degradation cost of 3.8–4.4 billion euros annually [13]. Nutrients enter the sea via emissions to air and subsequent deposition, discharges from point sources, and losses from diffuse sources. There are also the accumulated internal loadings, which are phosphorus reserves in the sediments of the seabed that are released in anoxic conditions. According to an integrated assessment for 2011–2015 [13], 97% of the Baltic Sea still suffers from human induced nutrient loading, resulting in enhanced phytoplankton growth, reduced fish habitats, increased turbidity, oxygen depletion, increased toxic algal blooms, and increased internal nutrient loading and increased incidents of toxic algal blooms. These problems will be exacerbated under the influence of climate change. Although the report indicates that there is regionally reduced nutrient loading, this is not reflected in the measures of the integrated eutrophication status assessment and is attributable to the effects of past and current nutrient inputs that dictate the overall status [13].

Nitrogen and phosphorus are identified as the limiting nutrients in Baltic Sea eutrophication; they increased in many areas of the Baltic Sea (Figure 2) until the late 1980s, mainly due to increased nutrient loading from land since the 1950s [14]. There was reduction in loading in some areas in the 1980s and 1990s due to innovations in wastewater treatment, and in the 1990s due to better agricultural practices, but nutrient runoff from agriculture continues to be a major source of nutrient to the Baltic Sea [14]. This is reflected in the map showing eutrophication of the Baltic Sea (Figure 2), where it is evident that only a few coastal areas are unaffected by eutrophication, such as in the Green Belts. Measures of integrated eutrophication assessment showed improvement in only one area, whereas 17 open sea assessments showed more degraded conditions since the last assessment period of 2007–2011 [13]. Whilst there has been reduction in nutrients to the Baltic Sea, this has not been translated into improved water quality of the Baltic Sea [2].

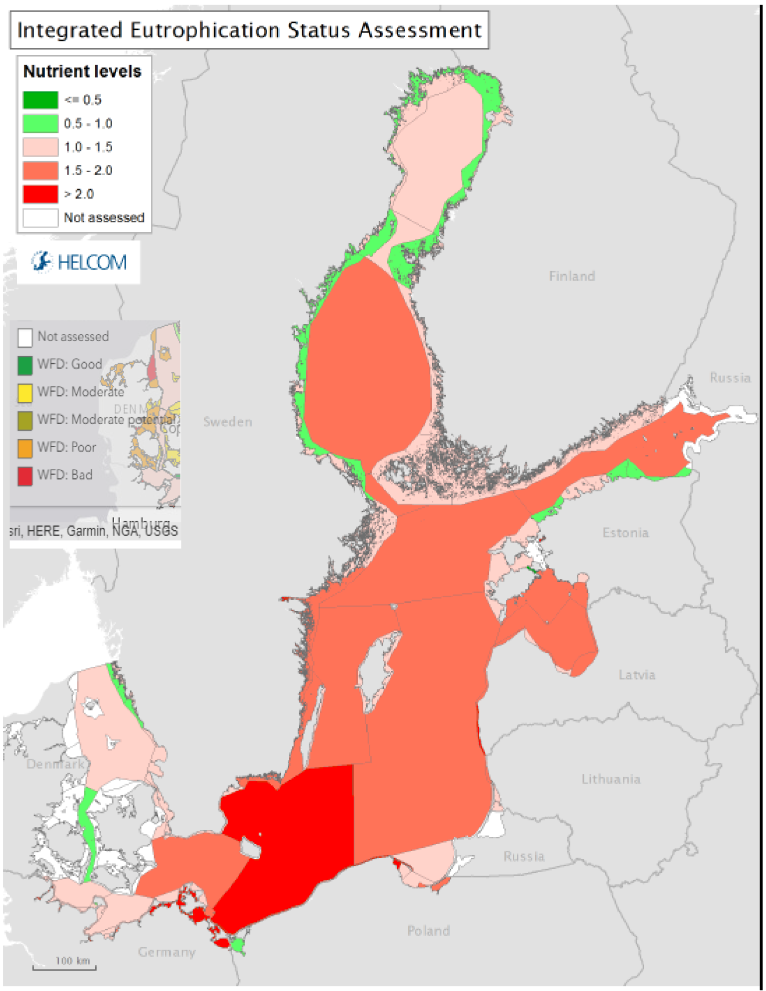

Figure 2. Map of the Baltic Sea showing coastal countries and results of integrated eutrophication assessment [12]. The integrated assessment of eutrophication was done using the HEAT modeling tool by HELCOM, which aggregates the indicator results into a quantitative estimate of overall eutrophication status. Green colour denotes good status and red not good status [12]. The values show the eutrophication ratio of nutrients.

This reflects the complex nature of eutrophication, classified as a wicked problem further complicated by uncertainty, competing values, and interests, compounded by climate change and internal loadings. The complex nature of eutrophication has been translated into an equally complex governing system, in a multilevel governance setting characterized by overlapping institutions both on the horizontal (linkages within same levels) and vertical (linkages between higher and lower levels) levels. Baltic Sea governance evolved from 1974 in the aftermath of the cold war, with the signing of the Helsinki Convention on the Protection of the Baltic Sea Area (the Helsinki Convention) by all littoral states [12]. This established the Helsinki Commission (HELCOM) as the governing body, with key functions of environmental policy maker and oversight body to support and monitor the implementation of its recommendations by member states. HELCOM's actions to combat eutrophication were evident in 1992 when a list of heavily contaminated areas (through inadequate wastewater treatment), designated 'hot spots', were identified and led to upgrade in wastewater treatment and delisting of these hot spots [15].

The current instrument used by HELCOM to combat eutrophication is the HELCOM Baltic Sea Action Plan (BSAP), which relies on the integrated ecosystem approach to achieve the objective of good environmental status and environmental sustainability [16]. BSAP aims for a Baltic Sea unaffected by eutrophication by 2021, evidenced by almost natural levels of nutrients, clear water, natural levels of algal blooms, natural distribution of plants, and animals and natural oxygen levels. Natural levels refer to levels where human-induced eutrophication is minimized; HELCOM has set eutrophication indicator targets (nutrient concentrations) indicative of natural levels in each sub-basin of the Baltic Sea [2]. It hopes to achieve this through imposed nutrient reductions for member countries, subject to their local implementation [16]. The highest phosphorus and nitrogen load reductions are set for Poland (8760 and 62,400 tonnes, respectively, compared with 150 and 1200 respectively for Finland) with Russia following with the second highest required phosphorus reduction (2500 tonnes), both agriculturally intensive and poorer counties in the region. Whilst other European Union (EU) instruments can be used in tandem with BSAP for nutrient reduction measures, they cannot be used with Russia, which is the only country that is not a member of the EU. However, the EU is also a contracting party to HELCOM.

In an effort to foster the network approach to Baltic Sea protection, the EU introduced the first macroregional strategy on the Baltic Sea in 2009 (the EU strategy for the Baltic Sea Region EUSBSR), with the aim of achieving an environmentally sustainable Baltic Sea Region. This strategy consists of thirteen policy areas and four horizontal actions to save the sea, connect the region, and increase prosperity [17], each with targets and indicators. Operating under the principles of no new funding, institutions, or legislations, the strategy is designed to mobilize EU funding and connect key stakeholders in the Baltic Sea and EU multilevel governance system. Eutrophication, which is one of the thirteen policy areas, is coordinated by the Finnish Ministry of the Environment and the Polish Chief Inspectorate of Environmental Division; these coordinators are working on agreeing on a common approach, the division of work, and the next steps and on implementation of flagship projects [17].

1.2.2. The Great Lakes Eutrophication Governance

The North American Great Lakes are an important transboundary water resource that contains 20 percent of the world's surface freshwater and is home to 30 million Americans and 11 million Canadians [18]. These five lakes, Lakes Huron, Ontario, Michigan, Erie, and Superior, have a total surface area of 244,106 square km, the largest surface area covered by any freshwater body in the world [19]. This large population and surface area support manufacturing, farming, transportation, tourism, recreation, and other forms of economic growth for Canada and the United States (US) and exert much anthropogenic stress on the ecosystem of the great lakes. The Great Lakes were deemed as 'fair to unchanging' in a recent assessment of the progress of the state of the Great Lakes conducted by Environment Canada and the US Environmental Protection Agency [18]. The report found that whilst progress was made with regard to reducing toxic chemicals, it is still very challenging to reduce aquatic invasive species and nutrients input [18]. For the indicator, nutrients, and algae, the status of the Great Lakes is 'unchanging to deteriorating', with nutrient enrichment leading to Harmful algal blooms, a continuing concern in Lake Ontario, Saginaw Bay, Green Bay, and most concerning in Lake Erie, which is given an overall rating of 'poor' for nutrient enrichment [18]. These toxic algae blooms are particularly evident in the western basin of Lake Erie and some parts of Lake Ontario since 2008, adversely impacting ecosystem health, commercial fishing, recreational activities, and municipal drinking water systems [3,18]. These Harmful algal blooms, including '*Microcystis*' (a type of cyanobacteria) that contaminated Toledo drinking water supply in 2014 [20], need warm temperatures and nutrients nitrogen and phosphorus to grow, conditions that are exacerbated by climate change. More recent increase of algae blooms in Lake Erie has been attributed to increase in agricultural nonpoint sources of bioavailable phosphorus (concentrations as high as 0.05 mg/L as shown in Figure 3), the presence of invasive mussel species ('Dreissena rostriformis bugensis'–quagga mussels, 'Dreissenia polymorpha'–Zebra mussels), and internal phosphorus loading to Lake Erie's central basin which increases with hypoxic conditions [3].

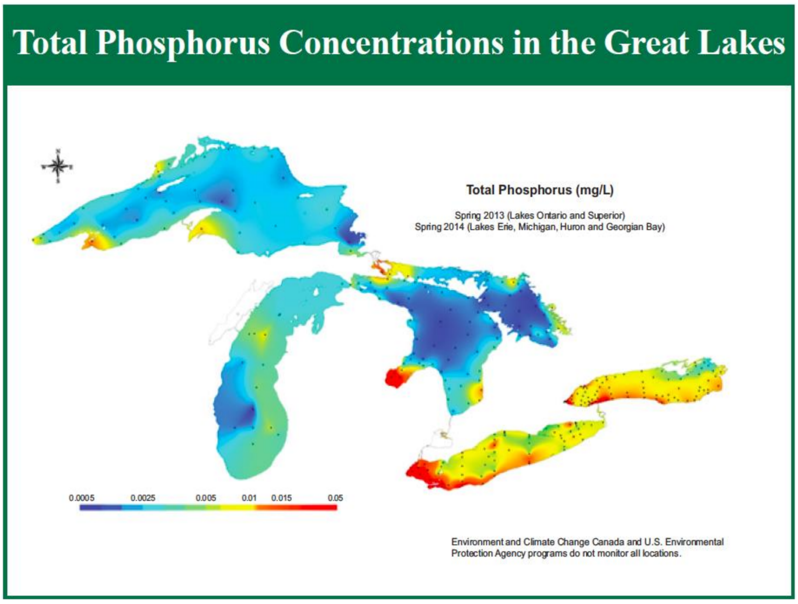

Figure 3. Figure showing total phosphorus concentrations in the Great Lakes [18].

The eutrophication of Lake Erie has historically been a source of great concern and cooperation, as it is the shallowest of the Great Lakes and is the most prone to pollution. Excess phosphorus from point and nonpoint sources in the 1960s and 1970s led to nuisance algal blooms, an increase in water turbidity, and extensive dead zones, spurring actions that led to the signing of the Great Lakes Water Quality Agreement in 1972 between Canada and the USA to protect the waters of the Great Lakes [20]. Some of these actions included the regulation of phosphorus in detergents, upgrade of sewage treatment plants, and implementation of best management land practices to control nutrient runoff from the watershed, and led to reduced nutrient runoffs and improved lake conditions in the 1990s [18]. However, the conditions in the lake have deteriorated, with increased oxygen depletion, algal biomass, and hypoxia. This spurred action in the renewed Great Lakes Water Quality Agreement Protocol of 2012 (the Protocol) in the nutrients Annex, which commits Canada and the United States to coordinate binational actions to manage phosphorus concentrations and loadings and other nutrients that enter into the waters of the Great Lakes.

The International Joint Commission is tasked with oversight of the implementation of the terms of the Protocol, including reporting on and recommending actions to achieve Annex 4, the nutrient annex objectives. Accountability for the implementation actions lies with the Great Lakes Executive Committee (GLEC), called for under the Protocol to help coordinate measures to achieve its purpose. GLEC is tasked with helping the parties to cooperate and collaborate; to develop programs, practices, and measures for better understanding of the Great Lakes ecosystem; and to reduce threats to the waters of the Great Lakes [18]. GLEC is also tasked with obtaining and providing the US and Canada (the Parties) with input from federal agencies, state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, and local public agencies on Great Lakes matters. To assist in the execution of this task, GLEC has appointed Annex specific sub committees for each of the ten annexes to the Protocol, led by two persons, one from each country.

This nutrient Annex is implemented by a subcommittee including members of national, subnational, community and public organizations, and stakeholders: Agriculture and Agri-food Canada; Conservation Ontario; the Great Lakes and St. Lawrence Cities Initiative; the Indiana Department of Environmental Management; the Michigan Department of Environmental Quality; the New York State Department of Environment Conservation; the National Oceanic and Atmospheric Administration; the Ohio Department of Agriculture; the Ohio Department of Natural Resources and

Forestry; the Ohio Environmental Protection Agency; the Ontario Ministry of Agriculture, Food and Rural Affairs; the Ontario Ministry of the Environment and Climate Change; the Pennsylvania Department of Environmental Protection; and the United States Department of Agriculture [18]. These stakeholders work together to establish binational phosphorus load reduction targets for Lake Erie, which were adopted by US and Canada in 2016, including a 40% load reduction of total phosphorus entering the western and central basins of Lake Erie from the US and Canada (3655 tonnes and 234 tonnes, respectively) [18]. Both countries committed to develop action plans by 2018 that will outline strategies for meeting these targets. The draft Canada-Ontario domestic action plan was made public in March 2017, obtaining public comments that will be incorporated into the final document to be released in 2018 [18]. The draft US domestic action plan was released in August 2017 for public comment and included the actions federal agencies and states are taking to engage stakeholders and develop domestic action plans. Both countries also committed to identifying priority watersheds that are hot spots for algae growth and implementing management plans to reduce phosphorus loadings from rural, urban, industrial, and agricultural sources [18].

2. Materials and Methods

2.1. Governance Barriers

The optimist, realist, and pessimist philosophies of governance provide good frameworks to group assumptions that guide the study of barriers to governance. These studies have been undertaken by researchers in many disciplines including sociologists, psychologists, economists, system theorists, political scientists, lawyers, philosophers, public administrators, etc., using different concepts and methodologies [6]. Using the philosophies of governance to frame the comparison of these approaches, a comprehensive review of policy failures uncovers unifying empirical and methodological assumptions that are called analytical foci [6]. The optimist, realist, and pessimist philosophies of governance are operationalized into four analytical lenses that view governance as: Problem solving, competing values and interests, institutional interaction, and dealing with structural constraints [11] through which to analyze barriers to the governance of eutrophication.

These analytical lenses are used in this study of barriers to eutrophication governance. The barriers to eutrophication governance are chosen as the focus of this study, because eutrophication is a serious problem that (1) is one of the leading causes of water quality impairment and ecosystem degradation worldwide; (2) results in excessive growth of phytoplankton, microalgae, and macroalgae, which leads to other ecosystem impacts such as loss of subaquatic vegetation, low dissolved oxygen, and the concomitant formation of dead zones [2]; (3) is complex and is further complicated by stressors such as climate change and aquatic invasive species [2]; (4) is more difficult to prevent or reduce and becomes more expensive as governance actions fail due to the increasing nutrients in bottom sediments; (5) can impact human health when governance actions fail, as seen in the Toledo water crisis in which half a million persons were left without potable water due to contamination by the toxin microcystin from algae in the source water [20]. Water bodies around the world, such as the Baltic Sea and the Great Lakes, continue to be degraded due to governance failures in eutrophication. As such, identification of governance barriers through different analytical lens can influence how the problem is framed and hence guide intervention actions.

2.2. Governance Barriers Analytical Lenses

The philosophies of governance influence research on governance barriers, as each philosophy of governance leads researchers to prioritize particular levels of analysis over others. The four analytical lens that provides a basis for theory building and testing of hypothesis about causes of governance failure is discussed further here [11]: Governance as problem solving (optimist), governance as competing values and interests (realist), governance as institutional interaction (realist), and governance as dealing with structural constraints (pessimist). Both governance as competing values and interests and governance as institutional interaction start from the realist philosophical tradition but the former focuses on the actor level, whilst the latter hones in on the institutional environment [11]. A description of each analytical lens follows.

2.2.1. Governance as Problem Solving

This analytical lens is entrenched in the optimist philosophy of governance and holds procedural rationality as the dominant organizing principle [7], as it tries to find the best options for nutrient abatement. It views policymaking as a deliberate, scientific activity using rational steps to ascertain the cause of eutrophication and using carefully designed and implemented policies to solve the problem [7]. Through this lens, barriers to governance are due to incompetent actors and institutions resulting in the poor performance of the governance process evident by resource unavailability, lack of knowledge or policy guidelines, and distorted social and organizational processes [21]. Barriers can be removed through optimization of the governance processes, e.g., through institutional strengthening, through staff development and training, through hiring of knowledgeable staff, and through resource access and mobilization, resulting in win-win situations for all actors [21].

2.2.2. Governance as Competing Values and Interests

This analytical lens is embedded in the realist philosophy of governance and views governance as the social and political process evolving around the articulation and adjudication of competing values and interests of actors involved [7]. Actors' choices are influenced by personal preferences, core values and beliefs, their knowledge and awareness (of eutrophication), their acknowledgment of nutrient enrichment as an urgent threat to water bodies, and their personal motives for acting [11]. Governance barriers refer to the escalation in differences in values and interests that can result in an impasse or conflicts, and the task of governance is to prevent these situations or prevent them from escalating. This analytical lens does not aim to reduce complexity through rationalization as does the optimist lens, but rather to understand complexity and diverging viewpoints [11]. Governance looks at the ways in which differences are traded off, integrated, or dealt with in the policymaking process.

2.2.3. Governance Institutional Interaction

This analytical lens is also rooted in the realist philosophy of governance but focuses on institutions rather than actors. For eutrophication governance, there is organizational complexity in the sheer number or organizations involved, each operating under enabling or constraining conditions of the institutional rules. Institutions can be defined as practices and procedures (both formal and informal) that were once new and contested but through use have become institutionalized and accepted [22]. Seen through this lens, governance barriers will be construed as those rules in the institutional game that allowed policy failures to occur and involve looking at amending the rules of the game so as to prevent recurrence [7]. Governance barriers can arise from failed institutional rules [23], institutional conflicts that arise when new ideas clash with prevailing institutional environment [24], path dependencies, locked in effects, institutional inertia [24], lack of dedicated institutions to eutrophication governance or lack of institutional leadership, and management of the policy games that cause these processes to stagnate [25]. As such, intervention strategies involve removing these barriers through better institutional rules, designing better institutions, changing institutions to prevent inertia, better institutional leadership, and better management strategies that cause networks to function and processes to sustain themselves.

2.2.4. Governance as Structural Constraints

This analytical lens is rooted in the pessimist philosophy of governance and views governance as 'political-economic process beset by tensions and contradictions embedded in the social, economic, and political structures of society' ([7], p. 106). This lens involves questioning the construction of the human society as a whole, looking at societal dilemmas such as the capitalist system that created the problem of eutrophication for solutions to the problem, as is evident with governance of common pool resources [26]. Governance barriers are seen as flaws in the generic properties of the system [11], with constructs such as neoliberalism and capitalism resulting in nested and interrelated governance systems that increase vulnerability and exposure to risks [27] such as nutrient enrichment. Other barriers include the collective failure of market mechanisms, the failure of the democratic system, and the limits of democratic mechanisms in governance of environmental issues in which vested interests limit consensual decision making, barriers in system, and subsystem properties accumulating to system failure as a whole [11]. It would be impossible to overcome structural constraints, as it would require a radical departure from the status quo. Further, improving performance of the parts does not result in improved overall performance. This view sees dealing with structural constraints as inevitable and accepts system failure; intervention strategies only provide temporary relief through mitigating the influence of barriers on a smaller scale [11].

2.3. Comparative Case Study

This research uses the case study approach to investigate governance barriers through the different analytical lenses. The case study approach allows an in-depth examination of eutrophication governance of each selected transboundary water system. It involves the analysis and synthesis of the similarities, differences, and patterns of governance across these cases that share the common goal of nutrient abatement for ecosystem resiliency. It also uses the comparative case study approach to research governance barriers of two cases in order to produce generalizable knowledge about barriers to eutrophication governance. This study investigates governance barriers to eutrophication in the Baltic Sea and North American Great Lakes. Even though these water bodies are located in different geographical context and the governance regimes emerged from different motivations, there are sufficient similarities to render this comparison useful. Sections of both water bodies are under intense stress from eutrophication, with Lake Erie (one of the five Great Lakes) classified as re-eutrophified [3], and the Baltic Sea entire open area being classified as eutrophied with the exception of the Bothnian Bay [2].

2.4. Data Collection

This comparative study uses qualitative data to further the goal of generating a more comprehensive understanding of barriers to eutrophication governance in both the Baltic Sea and the North American Great Lakes Regions. Data triangulation is used to increase the research rigour. Methods used include fieldwork visits, observation, 25 key informant interviews conducted in both the Great Lakes and Baltic Sea Regions in 2014, and document analysis of the European Union, HELCOM, and other Baltic Sea policy documents and policy documents by the International Joint Commission (IJC), the Great Lakes Executive Committee, and other Great Lakes sources. A thorough review of the primary literature also helps in data triangulation. The analysis across cases ventures beyond similarities and differences to using them to support or refute propositions on why the particular governance barrier exists. This comparative case study would be useful to policy makers for understanding and explaining how context influences barriers to eutrophication governance and, as such, better informs interventions that are context specific to increase the probability of successful implementation actions.

3. Results and Discussion

Governance Barriers

The governance barriers are summarized in Table 1, which shows an example as applied to the case study. More detailed explanations can be found in this section.

Table 1. Illustration of governance barriers as applied to cases.

Analytical Lens/Applied to Cases	Governance as Problem Solving	Governance as Competing Values and Interests	Governance as Institutional Interaction	Governance as Dealing with Structural Constraints
Governance Philosophy	**Optimist**	**Realist**	**Realist**	**Pessimist**
Sources of barrier—Baltic Sea	Lack of capacity by HELCOM to be effective in its role as oversight body. Lack of resources and accountability mechanisms, and lack of knowledge on internal loading.	Process of developing loading reduction for BSAP did not take account of different economic realities of countries. Differing values on environmental protection in the Baltic Sea region, and differing values as to the importance of nutrient reduction measures.	This multiplicity of institutions and EU directives can lead to ambiguity of operations and overlapping mandates. Farmers believe that the institutional environment in which they operate is unfair and does not take into consideration optimal conditions for farming.	Key structural barrier is that Russia is not a member of the EU and is not a signatory to any of the EU directives. Different economic realities of Baltic Sea coastal countries have affected development of BSAP loading reduction targets and potentially impede implementation.
Sources of barrier—Great Lakes	Missing accountability mechanisms and changing role of the International Joint commission. View that there are not adequate resources for implementation actions.	Differing values of the International Joint Commission and the Parties (Canada and the US) that lead to delay or lack of implementation of actions necessary for nutrient reduction.	The multiplicity of institutions and institutional complexity in eutrophication governance means that there is much crossing of institutional boundaries, which is fertile ground for conflicts. Voluntary actions not effective in combating eutrophication.	Confined animal feeding operations (CAFOs) are encouraged through federal subsidies, which produce a significant amount of animal waste that is a source of nutrients to the Great Lakes.

3.1. Governance as Problem Solving

3.1.1. The Baltic Sea

Whilst the Baltic Sea has a long history of governance innovations dating from the Helsinki Convention in 1974, there are still challenges to governance that the problem solving lens aims to identify by providing more information on the barriers to good governance. Whilst some recognize HELCOM leadership, e.g., through the BSAP, in the region in bringing countries together and working on solutions, others think that HELCOM lacks accountability mechanisms, impeding the governance process. HELCOM has leadership, but its political weight is not efficient enough to hold countries responsible (author interview with Baltic Sea NGO, BS3). This is seen as the lack of capacity by HELCOM to be effective in its role as the oversight body for implementation of nutrient reduction actions. There is also a gap in knowledge, as “there is a struggle to integrate science into the decision making process” (author interview with Baltic Sea NGO, BS2). Another key limitation when looked through the problem solving lens is the lack of adequate resources to implement measures necessary to combat eutrophication. This is particularly notable for some countries, for example in Russia, where lack of adequate monitoring resulting in usable data posed problems for setting loading reduction limits as part of the BSAP process. Russia is unable to access EU funding, as it is the only Baltic Sea coastal country that is not a part of the European Union. According to an author interview with a Governmental Environmental official who is part of the Nutri coordinating group (BS5), “our priority area is finding funding for the projects to implement the measures”.

This key informant reiterated the knowledge gap as a key barrier, saying that “one innovation and knowledge gap in eutrophication is that the internal phosphorus loading of the Baltic Sea is not well known, and the methodology and technical skill is under development as we are having discussion on whether the method is accessible and the possible harmful impact of it”. This is a barrier to the implementation of the EUSBSR, for which the Nutri group is part of the coordinating team. Whilst the EUSBSR has at its core aim of strengthening cooperation between bordering countries of the Baltic Sea in order to meet common challenges and maximize on opportunities, there are key barriers to involving local regional authorities. Only a few members of municipalities are members of steering groups for PACs and HALs of the EUSBSR [28]. This disconnect with the local level makes it difficult to engage and obtain the necessary commitment to implement nutrient reduction measures from farmers. Lack of knowledge by the farmers on the link between nutrient enrichment and eutrophication leads to distrust of the measures that are necessary for nutrient reductions to the sea from agriculture (author interview with Baltic Sea Farmers Association, BS5). However, in Finland farmers are aware of the issue, as they are used to discussions on environmental issues (author interview with representative of farmers association in Finland, BS10).

3.1.2. The Great Lakes

Similar to the Baltic Sea, the Great Lakes have a long history of governance innovations dating back to the 1972 Great Lakes Water Quality Agreement, but there are still challenges to the governance system that contribute to eutrophication of the lakes, especially visible in Lake Erie. As with HELCOM, the IJC leadership was recognized, but the accountability mechanisms are missing and leadership role is also changing. According to one leading Great Lakes Expert:

“In the 70s, IJC functioned as a watchdog and it had teeth, it had clout. The Canadian and US governments and state and province were then accountable to the IJC. In the 1980s the IJC no longer had power which was devolved by the US and Canada government to the community. Resources never came down with it. Give me the magic power for one day I will create a strong IJC” (author interview with Great Lakes Expert, GL1).

This quote represents a view that a strong IJC is critical to good governance of the Great Lakes. However, this is not a view shared by the government, as one government official noted that “Looking back at the 1970s, the IJC facilitated government to government interaction. It was a key factor at that time. Today, do we need IJC to play the same role now—not really" (author interview with federal agency representative, GL9). Whilst the 2012 Protocol mandates the IJC to seek public input into its triennial report, in the first report published, the IJC acknowledged that it was unable to "research or incorporate in its recommendations all the public's concerns" ([29], p. 5). This leads to a knowledge gap, as the public's construction of the problem and inputs are not fully incorporated into the recommendations of the IJC.

There is also a gap in resources that was highlighted during this process. It was felt that power was taken away from the IJC and given to the other levels in the multi-level governance structure, but resources were not transferred for implementation actions. In the words of a great Lakes Expert (author interview, GL1) "There has been a devolution of responsibility from government—responsibility being pushed down to provinces then to municipal level. However, resources are not being passed down". This lack of resources is highlighted as a problem for the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem (COA), the agreement between Canada and the province of Ontario that is aimed at helping Canada to meet its GLWQA commitments and at helping the province of Ontario to carry out the Great Lakes strategy. According to one key informant "Today's COA will do certain things but there is no dollar transfer. The first couple of COAs were critically important to Canada but the current one needs funding to be effective" (author interview with Great Lakes Stakeholder, GL4). This lack of resources as an impediment to overall implementation of actions, such as nutrient reduction measures as called for in the GLWQA, was echoed by the IJC in its 1st triennial assessment of progress report: "To continue and improve successes in GLWQA implementation, the IJC recommends that the governments' financial investment in improving the water quality of the Great Lakes continue at current or higher levels". This lack of adequate resources by governments is also impeding implementation of better stormwater management systems in urban areas and retarding the use of green infrastructure [29]. However, the IJC acknowledges funding by United States in the form of the Great Lakes Restoration Initiative (GLRI) grants since 2010, stating that about one third of the annual US $300 was dedicated to cleaning up most heavily contaminated areas and that progress made in controlling invasive species to the Great Lakes can be credited to the GLRI grants [29]. Whilst the US has committed funding to the Great Lakes restoration activities through the GLRI, more resource allocation is needed for implementation of nutrient abatement efforts.

3.2. Governance as Competing Values and Interests

3.2.1. The Baltic Sea

This analytical lens recognizes that the way knowledge or truth is constructed is subjective, depending on the actor's perspective or framing of reality. In analyzing Baltic Sea eutrophication governance from this lens, there are key instances of conflicting values and interests in nutrient reduction actions and planning. Whilst the Helsinki Convention is a common framework for governing the Baltic Sea, and the BSAP is a key tool, it makes assumptions regarding the abilities of the countries to undertake implementation actions. The very process of developing the loading reduction requirements was based on science and relied heavily on MARE NEST modeling but took no consideration of the differing economic and social realities of the different countries. One of the poorer countries, Poland, has the highest loading reduction for nitrogen and phosphorus (8760 and 62,400 tonnes, respectively) under BSAP [1]. The funding for implementation actions or the implementation of actions required for nutrient reduction such as reducing runoff from agricultural activities can be viewed as being contrary to their economic development (author interview with Baltic Sea NGO BS7). The financial burden for the implementation of BSAP is greatest for the poorest countries (poor Baltic States and Poland), estimated at €3975 million, with highest portions for Russia, Poland, and Lithuania and lowest for Finland and Estonia [30]. This can translate into poor motivation for implementation of BSAP, as funding for implementation actions competes with funding for other activities.

This division is also reflected in differing values with regards to the environment in the more developed Baltic Sea countries and the poorer ones. According to an interview with an environmental professional in the region (interview BS8), "the importance of environmental issues on people's mind, as compared with other interests, is still divided following the old iron curtain—Western Scandinavian and German opinions differ, with the Eastern countries being more negative on environmental issues, with the views following economic development to a large extent". The biggest barrier to the successful implementation of BSAP is the commitment of all relevant parties, and this requires people, but it is limited by different cultures, institutions, and societies (author interview with Baltic Sea NGO, BS9). Also, in Russia, where the greatest loading reduction is required for phosphorus, the public is not as committed to environmental issues. The public involvement in Russia is different to other EU or western countries, as the public pays less attention to environmental problems and issues than western countries (author interview with Baltic Sea Agency representative, BS4). This differing implementation by different nations has a negative impact on farmers, as farmers in Finland feel that there has been a lot of progress i this respect. The farmers' view in Finland is "why should we keep reducing our fertilizer while nothing is being done in Russia and Poland; Poland is a big problem and they do not want to commit to anything concerning the Baltic Sea, so why should we?" (author interview with farming association representative in Finland, BS10).

Competing values are also evident in emphasis and role of science as perceived by the farmers. According to the Farmers Association (BS10), not all science has guided decisions, as it should be focused on practical solutions to give farmers feedback rather than looking backwards at history to say what agriculture has been doing wrong. Farmers would be more amenable to implementing agricultural solutions if the scientists showed that these solutions were effective in combating eutrophication. According to this key informant, farmers feel that buffer strips are not as effective as treatment of wastewater and would like to see more data on the cost effectiveness of reducing phosphorus in different ways, e.g., from sewage treatment, agriculture, and atmospheric depositions. Science drives decision making, but sometimes political compromises need to be made, as what is best from the environmental point of view might not be best in the interest of the farmers. Farmers also feel that nutrient trading offers a potential solution for driving nutrient reduction measures, but there is a gap in science in the area of nutrient trading, as not a lot of information is available on it. They feel that this might help to even out practices that are not consistent for EU member countries and lead to an unfair competitive advantage. For example, Denmark has 5 million persons and 20 million pigs, whereas Finland has a comparable population but one-tenth the number of pigs (2 million pigs). Also, under the EU nitrates directive, Finland has a specific period that it is not allowed to spread manure, whereas in Cyprus and Greece you can grow all year (Author interview BS10).

3.2.2. The Great Lakes

Since the Great Lakes governance is in a similar multi-level governance architecture as the Baltic Sea, there are similarly conflicting values and interests in eutrophication governance. One of the key conflicts that arises from differing values of the International Joint Commission and the Parties (Canada and the US) that lead to delay or lack of implementation of actions necessary for nutrient reduction. Recommendations by the IJC to the Parties in 2014 were still not implemented in 2017, actions that could significantly reduce nutrient loadings to Lake Erie. As stated in the Triennial report of the IJC, "The IJC recommends that the parties further act on advice from the IJC's 2014 report on Lake Erie, with respect to the need for enforceable standards governing the application of agricultural fertilizer and animal waste, along with better linkage between agricultural subsidies and farm operator use of conservation practices that are demonstrably effective at curbing phosphorus runoff" ([29], p. 13).

Like the Baltic Sea, the process of developing loading reduction targets for Lake Erie relies heavily on modeling scenarios. The accuracy and utility of the model depend on the assumptions that are made and the accuracy of the data that is put into the model. These models used emerging science on the bioavailability of different forms of phosphorus, particularly soluble reactive phosphorus (dissolved phosphorus). These models also did not take into consideration costing information or the economic realities of the inhabitants or look at alternative livelihoods. Rather, nine different computer simulation models were used by modeling experts in Canada and the United States to correlate levels of phosphorus with levels of algal growth: by comparing and contrasting the results of these models, draft phosphorus load reduction targets were developed for Lake Erie [31]. These models considered emerging science on the bioavailability of different forms of phosphorus, particularly soluble reactive phosphorus. The very process of developing these loading limits lends itself to competing values, based on different scientific interpretations. Additionally, whilst the parties developed these models using the data they had available, the IJC has underscored in its triennial report that there is need for more data to understand complex linkages that drive eutrophication. According to the IJC, "data are needed to understand the linkages between storm events, agricultural and urban runoff, combined sewer overflows, and Harmful algal blooms in order to develop effective prevention and mitigation strategies" [29].

This increased monitoring and more data will help in increasing confidence in the loading reduction values required for each basin of Lake Erie and for each Lake. As in the case with the Baltic Sea region, there is still skepticism by farmers that their practices are contributing to the pollution of the Great Lakes. This skepticism by farmers has been an inspiration for collaboration by national, regional, and local agencies; organizations; and universities to find a solution to convince farmers across the Great Lakes region to implement sustainable farming practices. Great Lakes Commission Program Director, Victoria Pebbles acknowledged that it is a difficult task, stating that "farmers are proud, they're private and they feel like the finger's being pointed at them, and most of these people are honest and hardworking people who are just trying to do their best" [32].

3.3. Governance as Institutional Interaction

3.3.1. The Baltic Sea

Baltic Sea eutrophication governance operates in a multilevel governance setting, with subnational, national, municipal, and non-governmental actors. This multiplicity of institutions can lead to ambiguity of operations and overlapping mandates. This is evident with the many EU directives that have relevance to nutrient reduction, as well as directives such as the Urban Wastewater Treatment Directive, the Nitrates Directive, the National Emissions Ceilings directive, the Birds and Habitats Directive, and the MSFD, for which there is no clear evidence of a cooperative and unifying mechanism [33]. There are measures in some policies that are conflicting, as, for example, the Common Agricultural Policy (CAP) encourages agricultural productivity without adequate consideration for environmental protection. The CAP encourages farmers to increase agricultural production through large scale farming and increasing area under cultivation, as in the call to increase cultivation of energy crops [34]. This seems to work against environmental protection in the EUSBSR, where limiting nutrient input into the sea is vital for eutrophication control. Farmers would want to increase their production, as they see this as making them more competitive than other countries where the environmental regulation is not so strictly enforced (author interview BS10). This has the potential to weaken environmental protection efforts aimed at reducing nutrient runoff from fields.

Governance barrier also exists, because the farmers believe that the institutional environment in which they operate is unfair and does not take into consideration optimal conditions for farming. For example, the EU nitrates directive stipulates a period when spreading of nutrients is not allowed, which includes periods of decent weather (e.g., in December), which is better for spreading fertilizer (author interview farming association BS10). This inflexibility in the law, which has stipulated dates, does not reflect changing weather conditions that are so much more prevalent with climate change. A more flexible but effective ruling would be a stipulation of no manure on frozen ground and could be incorporated in local environmental acts, where local environmental authority would be able to permit spreading based on changing weather conditions (Author interview with Finnish Farmers

Association, BS10). Institutional complexity in governing discharges is also reflected in the view by a nongovernmental organization that the largest discharges are coming from agriculture, which is regulated by the Ministry of Environment but controlled by the Ministry of Agriculture and Forestry, which usually wins, because it is an economic vs. an environmental problem and farmers have strong lobbying organizations (author interview with Finnish NGO, BS11).

There are also institutional governance barriers that emerge from membership to the EU and the obligations from its directives for the Baltic Sea EU countries. Countries prioritize their own or EU regulations over HELCOM recommendations, as the former are more legally binding. In some cases, lax EU regulations give Baltic Sea countries easier nutrient reduction targets. For example, the UWWTD requires 80 percent reduction of phosphorus as compared to a HELCOM limit of 90 percent for large cities. For some countries, the trend might be harsher national standards than HELCOM set limits. For example, Finland opts for national limits rather than BSAP guidelines, as BSAP ignores the archipelago sea, and national regulations are more binding than HELCOM non-legally binding recommendations, e.g., in 2006, phosphorus removal efficiency from wastewater in Finland was 95.4% (compared to HELCOM's 70–90% recommendation) and organic matter removal from wastewater in 2006 was 96.6% (compared to 80% HELCOM recommendation) [35]. A perusal of the BSAP implementation reports reveals a marked difference in implementation among poorer coastal states, with the latter opting for EU standards. For example, the Polish implementation report stated that in relation to HELCOM recommendation 28E/7 (measures aimed at the substitution of polyphosphates in dishwashing detergents), there are no plans referring to the introduction of legal ban to apply phosphates in dishwashing and cleaning detergents, and that on this scope, Poland will wait for EU legislation [35]. A further perusal of Poland's BSAP implementation shows a list of task categories including legal/coordination/management, control/monitoring, investment/technology, education/training, and research/development. These tasks overlap, and there is more than one institution tasked with their implementation, from a list including Ministries (of agriculture, economy, infrastructure, and environment) and other institutions including other ministries and central offices, marine offices, local governmental administration, territorial self-government units, research and development agencies and units, and business entities and farmers [35]. This institutional complexity could be one explanation for the low implementation of BSAP measures.

3.3.2. The Great Lakes

The institutional complexity in governing nutrient enrichment to the Great Lakes is illustrated by the number of organizations and representatives that are part of the Great Lakes Water Quality Agreement (GLWQA) Annex 4 (Nutrients) implementation sub-committee, which is co-led by the United States Environmental Protection Agency (USEPA) and Environment and Climate Change Canada (ECCC). Other Organizations on the Nutrients Sub-committee include the Great Lakes and St. Lawrence Cities Initiative, Indiana Department of Environmental Management, Michigan Department of Agriculture & Rural Development, Michigan Department of Environmental Quality, New York Department of Environmental Conservation, Ohio Department of Agriculture, Ohio Department of Natural Resources, Ohio Environmental Protection Agency, Pennsylvania Department of Environmental Protection, United States Department of Agriculture, United States Geological Survey, United States National Oceanic and Atmospheric Administration, Agriculture and Agri-Food Canada, Conservation Ontario, Ontario Ministry of Agriculture Food and Rural Affairs, Ontario Ministry of Environment and Climate Change, and the Ontario Ministry of Natural Resources and Forestry [31]. This means that there is much crossing of institutional boundaries, which is fertile ground for conflicts.

The organizational complexity of governing eutrophication involves discussions on the enabling and constraining conditions of the institutions involved. The International Joint Commission is of the strong view that voluntary actions are not enough and that the phosphorous load reduction targets of 40 percent is unlikely to be achieved without enforceable standards for agriculture, to complement voluntary stewardship. Whilst the governments at all levels have utilized incentives and voluntary programs such as implementation of best management practices to reduce nutrients to the lakes, these have not been effective at reducing the frequent Harmful algal blooms to the lakes. The International Joint Commission has advocated for enforceable standards to aid in achieving nutrient reduction targets for controlling the harmful algae blooms. In the first triennial report, the IJC has stated two concerns to the Annex 4 Nutrients Sub-committee process of achieving the nutrient goals: (i) not considering the possibility of recommendations for new regulatory authorities in domestic action plans, despite regulatory programs being one of the measures stipulated in the GLWQA and (ii) the sub-committee's discussion of endorsement of plans developed by Ohio, Michigan, and Ontario pursuant to their Western Basin of Lake Erie Collaborative Agreement as the state and provincial component of the domestic action plans, since the contention that these plans are sufficient to achieve 40 percent load reductions are not convincing. The IJC further stated that these action plans need to include enforceable standards, noting that 'if domestic action plans are not sufficiently rigorous and rely solely on incentive based and voluntary approaches, they are unlikely to deliver the phosphorus loading target reductions' ([31], p. 103). This view is shared by interviewees, with one stating that "Voluntary measures and education go a long way, but they are not working. We need to add regulatory measures to them" (author interview with Great Lakes Compact Interstate agency expert, GL10). This reiterates the need to explore additional legal measures to enforce nutrient reduction measures.

3.4. Governance as Dealing with Structural Constraints

3.4.1. The Baltic Sea

One key structural barrier relates to the question of Russia [36], as Russia is not a member of the EU and is not a signatory to any of the EU directives. This was highlighted in the adoption of the EUSBSR, which can be interpreted as viewing the Baltic Sea as an internal EU sea and ignoring Russia as a key partner. This is further exacerbated by the worsening EU-Russia relations due to the crisis in Ukraine, affecting bilateral relations in an otherwise stable relationship [37]. This makes the Baltic Sea vulnerable to pollution from Russia, as solutions that incorporate Russia seem to be an exception rather than the norm. A further complication is that although it is the biggest polluter of phosphorus into the Baltic Sea, it is not affected by this pollution in its own waters, as these loads are deposited across sub-regions in the Baltic proper due to the anticlockwise water circulation (similarly for the main nitrogen polluter, Poland). This complicates matters, as these main polluters would benefit less from their nutrient reduction policies than countries such as, e.g., Finland where the increased nutrient loads are circulated closer to.

Another barrier that emerges from viewing governance as dealing with structural constraints is the difficulty in modifying wastewater treatment plants to limit nutrient discharges from them. Some of the wastewater treatment plants have been constructed in the past with large capital investments, and these plants may no longer be able to handle the increased loading due to changes in society, resulting in nutrient loading to the Baltic Sea or the fact that plants may have been oversized during design stages. For example, for wastewater treatment plants assessed under the UWWTD, the Ogre plant is Latvia was oversized; treating organic loads accounted for only 29% of its capacity [38]. According to the EU Commission, the sizing of plants is determined by many factors including safety risk factors, seasonal variations, heavy precipitation, and future population growth [38]. This points to the functioning of society as a whole, and also subsystem and the interaction between subsystems, such as immigration systems, migration patterns from rural to urban areas, and climate systems, which all act together to overwhelm the capacity that wastewater treatment plants were designed to operate at. This system constraint places a limit on what current wastewater treatment plants can do to limit phosphorus from the waste streams or to treat more storm water before discharge into the Baltic Sea.

The differing economic circumstances of the Baltic Sea States are tied to the history of the region. The Baltic Sea serves as a good illustration of the rest of Europe, and the division of the Eastern and western parts. This is characterized by much inequality, with significant economic differences that can affect implementation of the BSAP. Not only have the different economic, social, and political circumstances affected implementation of BSAP, but they have also affected the definition of nutrient reduction targets. This problem is particularly acute with the former Soviet states. The BSAP implementation plan for Poland documents this challenge, stating the lack of costing information on costing for implementation measures and actual deadlines makes provision of actual values impossible [35].

3.4.2. The Great Lakes

There are many structural dilemmas inherent in the governing of eutrophication in the Great Lakes region. One example is the confined animal feeding operations (CAFOs) that are encouraged through federal subsidies, but which produce significant animal waste that is a source of nutrients to the Great Lakes. CAFOs confine livestock in large numbers, generating significant amount of waste. There are 146 CAFOs in the watershed of western Lake Erie basin, shared between Michigan, Indiana, and Ohio that houses 12 million dairy, hog, and poultry animals with an estimated waste output of over 2385 million liters (630 million gallons) yearly [39]. In Michigan, grants of subsidies are offered for CAFOs from federal tax dollars, making it difficult for sustainable livestock operations to compete without a level playing field. Under the Farm Bill program in the United States, CAFOs are able to access financial and technical assistance from the Environmental Quality Incentives Program (EQIP), which is designed to help unsustainable agricultural practices become more sustainable and environmentally friendly. More than 15% of the 238 CAFOs operating in Michigan since 1996 have been cited for environmental violations (26 received fines and penalties totaling more than 1.3 million), but these facilities received more than $26 million dollars in federal subsidies from 1995–2011 [39]. There are also thousands of CAFOs operating in Ontario, Michigan, and Ohio that do not require permit registrations with local authorities. This confounds governance of nutrient enrichment to Lake Erie.

Another structural constraint is the impact of renewable fuels policies on eutrophication of the western Lake Erie Basin with agricultural watersheds. These policies provide incentives for biofuels production, potentially influencing ethanol (the main biofuel of Canada and the US) production, which is sourced from corn [29]. A high demand for corn ethanol can potentially stimulate more production of corn over other crops and intensify nutrient applications in an effort to increase yields. Corn is a nutrient-intensive crop and has the highest average phosphorus loss rate through runoff. Over half of the total phosphorus input is for corn and corn silage in the United States (30 kg per hectare and 60 kg per hectare respectively), and approximately 71% of phosphorus applied to corn silage is in the form of manure [40].

4. Conclusions and Recommendations

The Baltic Sea and the North American Great Lakes are large transboundary water systems that are located in water secure regions of the world but face challenges to reducing biodiversity and protecting biodiversity. This illustrates a failure of governance systems that are not able to adequately protect biodiversity whilst retaining human services. This governance failure is also evidenced by widespread algal blooms that are characteristic of eutrophication and that threaten biodiversity through oxygen depletion in both the Baltic Sea and Great Lakes regions. This failure of governance processes in both regions translates into implementation deficits for nutrient reduction programs in both regions, exacerbated by poor actor coordination and institutional fragmentation in both ecosystems multilevel governance frameworks. These barriers to eutrophication governance in the past have been documented as failures in the design and execution of the governance process, using the problem solving analytical lens. Using only one analytical lens to examine barriers to eutrophication governance has the potential to introduce bias that can affect the policy solutions designed to solve the problem. As such, this paper examined barriers to eutrophication governance in both transboundary systems using four analytical lenses that perceive governance as: problem solving, competing values and interests, institutional interaction, and as dealing with structural constraints. Examination of barriers through each lens reveals findings leading to specific recommendations as detailed below.

When looked at through the problem solving lens, there are common barriers to eutrophication governance of both regions. Whilst HELCOM is the oversight agency of the Helsinki Convention and the IJC the oversight agency for the Great Lakes Water Quality Protocol, the leadership and accountability mechanisms for both agencies are questionable for eutrophication governance. Whilst HELCOM's leadership is acknowledged, it lacks accountability mechanisms and political clout to hold countries accountable for measures in the BSAP. Looked at through the problem solving lens, a specific recommendation would be to strengthen the accountability mechanism of HELCOM's member countries in implementation of BSAP loading limits. Countries should have a say in the accountability mechanisms so that there is greater ownership and compliance. However, for the IJC, its role in eutrophication governance is being questioned, and its role as a leader is eroding, and this is perceived as one of the barriers to eutrophication governance of the Great Lakes. For both regions, inadequate resources and a lack of incorporation of knowledge from other stakeholders are also key barriers for implementation of nutrient abatement measures. As such, the recommendation here would be to review the roles of the transboundary commissions and possibly to strengthen them for more accountability in eutrophication reduction measures. An independent assessment of the role of both transboundary commissions and future role in eutrophication governance would be a step forward in bridging this gap.

Under the competing interests and values lens, barriers to eutrophication governance for both regions include the uncertainties and incomplete information incorporated in the use of modeling to determine loading reduction inputs in both water bodies. The MARE NEST model used for the Baltic Sea does not capture the socio economic realities of the countries, leading to inadequate funds for implementation actions in poorer countries where the loading reductions requirements are biggest. The Great Lakes region used nine different models developed by modeling experts in Canada and the United States to correlate levels of phosphorus with levels of algae growth, a process that made assumptions and used emerging science about the bioavailability of different forms of phosphorus. The uncertainty inherent in this modeling process leads to loss of credibility and questioning about the validity of scientific recommendations, especially by the farming community in both regions. Additionally, for the Great Lakes region a difference of values leads to a delay by the governments of Canada and the United States in acting upon recommendations for nutrient reduction measures by the International Joint Commission. Under this lens, a key recommendation for both regions would be to consider mechanisms for incorporating economic data and more monitoring information into the models.

Seen under the governance as institutional interaction lens, barriers to eutrophication governance in the Baltic Sea region include too many overlapping institutional mandates. These include overlapping EU directives, such as the Urban Wastewater treatment Directive, the National Emissions Ceilings Directives, the Birds and Habitats directive, and the Marine Strategy Framework directive, with no clear evidence of a cooperative or unifying mechanism. This leads to conflicting policy measures with adverse impact on nutrient abatement efforts. In contrast, the key barrier to eutrophication governance under this lens in the Great Lakes region is the perception of the missing rules and regulations for nutrient abatement efforts. Whilst the governments have emphasized incentives and voluntary standards to reduce nutrients from agriculture into the Great Lakes, the International Joint Commission believes that the 40 percent loading reductions target will not be achieved without enforceable standards for agriculture, to complement voluntary stewardship. This view holds that the lack of enforceable standards is what allowed policy failures to occur, and as such, filling this institutional void is the only way to achieve the nutrient loading reduction targets to the Great Lakes. The recommendation arising from analysis through this lens would be to conduct a thorough review of the regulations that impact eutrophication governance, with a view to strengthening and streamlining them.

Seen through the structural constraint lens, one of the key barriers to eutrophication governance of the Baltic Sea is the question of Russia. Russia is excluded from all the EU directives that are pertinent to nutrient reduction measures. Further, the EU Strategy for the Baltic Sea Region (EUSBSR) can lend to the interpretation of the Baltic Sea as an internal EU sea, discounting Russia as a key partner. This makes the Baltic Sea especially vulnerable to pollution from Russia (with the highest phosphorus loading requirements), as solutions that incorporate Russia seem to be the exception rather than the norm. As such, careful consideration needs to be given to the role of Russia and how to better integrate it into the Baltic Sea region governance. In the Great Lakes region, the structural constraint to eutrophication governance arises mainly from policies and government subsidies for activities that promote nutrient enrichment of the waters of the Great Lakes. Examples are renewable fuel policies that stimulate the growth of corn, a crop that has the highest phosphorus loss rate through runoff from fields. These need careful review with the aim of consolidating policies so that they strengthen, rather than work against, each other.

In conclusion, these analytical lenses help in the understanding of barriers to eutrophication governance through many perspectives, allowing for intellectual diversity, alternative claims, and increased understandings that can guide policy makers.

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