

# Marine Protection in the Baltic Sea

An Analysis of the Implementation Duration  
for Marine Protected Areas

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## Abstract

This project examines the problem of why there is often a long duration between proposing a marine protected area (MPA) and implementing the MPA. The European Union has a vast network of proposed MPAs, but not enough are implemented to create an effective network. By analyzing the Baltic Sea, whose marine network is overseen by the regional body HELCOM, this project seeks to define what factors lead to implementation being delayed or expedited. Fisheries, regional governance, EU governance, and geographic concerns were some of the variables included. Data limitations made it difficult to find definitive conclusions, but the results of the duration analysis did reveal that EU and regional marine protection measures can help speed up implementation of MPAs.

Keywords: marine conservation, duration analysis, Baltic Sea, regulation

## Introduction

As humans exert increasing pressure on important marine environments and biodiversity levels drop, effective management of the world's oceans has become an international priority. A wide range of policy measures has been enacted in response to this conservation crisis, but perhaps none as controversial as the marine protected area (MPA). MPAs are praised as being a key policy measure for protecting marine ecosystems because they often are designated to protect huge swaths of area from human influence entirely. However, they have also been harshly criticized by members of industry for locking away precious resources as well as by conservationists for the challenges of implementation. Despite these critiques, MPAs have become a widely used conservation tool, especially in the European Union (EU). The EU has designated huge areas in all four marine regions to become MPAs in hopes of creating ecologically coherent networks. An ecologically coherent network is a system of MPAs covering enough ecosystem and that are well connected enough to protect the ecosystem as a whole instead of merely individual habitats. While large areas have been designated or proposed as MPAs, only some of these areas are implemented as MPAs.

Understanding why these areas go from proposed to implemented is important for understanding how future marine protection can be effectively brought about, but a variety of political, social, and economic factors go into MPA implementation. This raises the question, what factors bring about the implementation of marine protected areas? The puzzle of why some MPAs go from proposed to implemented and others do not requires a broad scope of factors to be examined. MPAs are the product of a host of interests and policy drivers, and many stakeholders are interested in marine areas for reasons other than conservation. The Baltic Sea is a region where many MPAs go unimplemented or unmanaged. The Baltic Sea, whose marine

protection is governed by an EU regional convention called HELCOM, is noteworthy within the EU for surpassing the goal of 10% protection of terrestrial and EEZ waters, but still has not reached ecological coherence (EEA). Some of the 9 countries that border the Baltic are better than others at implementing and managing MPAs; as can be seen in the table below:

*Table 1: Breakdown by Baltic country of how many protected areas have been implemented, the percent total of the country's marine area that has been implemented as an MPA, the percent of sites that have a management plan created by an enforcement agency, and the percent of MPAs that are being monitored based on the management plan*

Country	Number of MPA sites implemented	Percent of total marine area implemented as an MPA	Percent of sites with management plans	Percent of sites with monitoring programmes
Denmark	66	23	94	97
Estonia	6	16	83	No data
Finland	28	8	86	No data
Germany	7	30	57	88
Latvia	6	15	67	86
Lithuania	33	15	36	No data
Poland	12	24	17	No data
Russia	9	4	No data	100
Sweden	7	5	No data	50

(WWF, 2016)

The significant differences in implementation and management draw into question the effectiveness of the network and how the network was created, making the research question even more crucial.

To test this research question, I chose several variables that I argue would explain how long it takes for MPAs to be implemented, and then tested that model with a duration analysis. Many different factors were considered for the model, including several country-level covariates, EU directives, different measures of fishing intensity, and geographic concerns. Through research, I found ways to measure the concepts that I believe are most significant to MPA implementation, and estimate the model based on those measurements. Specifically, I expected areas with commercial interest would be implemented more quickly than those without because of the lack of MPA management. For example, an MPA with high fishing intensity, if the MPA is typical of the Baltic and not no-take, may be implemented more quickly because there is stakeholder support. I also hypothesized that areas fulfilling EU directives would be implemented more often because the EU has greater enforcement power than HELCOM. The EU marine protection directives contain funding mechanisms and have the weight of the EU community behind them, while HELCOM has no ability to enforce its members' promises to implement marine reserves. The sparse data, small sample size, and incomplete records for proposed MPAs made it difficult to run a complete analysis, but there are still some conclusions that can be made about why some Baltic MPAs are implemented when others are not.

## Background

There is extensive debate over whether or not MPAs are an effective conservation tool, and there has been extensive literature trying to answer that question. The supporters of MPAs as

a management plan point to the effectiveness of a coherent MPA network in protecting an ecosystem as a whole, and some studies have found that MPAs increase fishermen's catch when they fish close to the border of an MPA. However, MPAs are difficult to designate and regulate in international waters because they require a concerted effort to regulate, there have been very few coherent networks realized due to difficulties in establishment, and many studies have found that the theoretical benefits to fishermen are rarely realized. One barrier to finding a definitive answer to the effectiveness of MPAs is that there are many types of MPA management plans, which changes the way an MPA operates. An MPA can cover a broad range of conservation requirements; some MPAs are no take, with no commercial fishing, recreational fishing or motorized vehicles allowed, while others allow commercial fishing, recreational fishing, or motorized vehicles in certain amounts or at certain times of the year (Hyrenbach 2000).

*Why do we use MPAs for marine conservation?*

MPAs as a form of marine conservation come from a long history of thought about how science, policy, and management can come together to effectively protect the environment. This has led to a number of different theoretical frameworks for marine conservation over the years that gain and lose popularity or evolve out of each other. The Baltic system of MPAs is based on ecosystem based management (EBM) but there is a long history of how the Baltic region came to implement an MPA network.

The ecosystem based approach to conservation has existed since the 1950s, but became prominently used much more recently. Aldo Leopold wrote in 1949-1950 about land health and how natural communities and their diversity need to be valued if they are to thrive in the long run, forming the basis of thought that would later become EBM. The ecosystem approach came into prominence in the 1990s. The 1992 Earth Summit in Rio de Janeiro was the first time it

entered a major convention; the Convention on Biological Diversity (CBD) contains goals based on EBM. The seminal work in defining ecosystem management was published by Grumbine in 1994. He explains that ecosystem management is a response to the biodiversity crisis; the previously used theoretical framework, species-level management, was failing to answer the problems of biodiversity loss (Grumbine, 1994). Grumbine outlines the five major goals of conservation that encapsulate ecosystem management: maintaining viable populations of native species *in situ*, representing all native ecosystems across their natural range within protected areas, maintaining evolutionary and ecological processes, managing ecosystems over long enough periods of time to maintain evolutionary potential, and still accommodating human use and occupancy (1994). Grumbine's work defining ecosystem management and outlining how management plans can achieve these goals has heavily influenced both land and marine conservation ever since.

EBM creates conservation objectives, but management plans need a way to achieve these objectives. There are 6 main principles that allow EBM to go from theory to practice in conservation. The precautionary principle is most important to MPAs; it states that human activities should not be conducted until they are known not to be harmful, so excluding certain human activities from an area serves to avoid known or possible harmful actions. MPAs serve the precautionary principle by serving as a "hedge against inevitable management limitations" (Lauck, et al. 1998). When MPAs are in place, then states need fewer stock assessments and can allow for depleted stocks to rehabilitate with relatively simple management schemes. The other five principles of conservation are less directly relevant to MPAs and EBM, but are still important for achieving objectives. Best environmental practices, best available technologies, the



polluter-pays principle, the compensation principle, and the avoidance principle all play roles in implementing EBM.

HELCOM now operates under an ecosystem-based management scheme, but that is not how Baltic countries first approached marine conservation. When the Baltic states first realized the extent of habitat degradation and accompanying loss of biodiversity occurring in the Baltic Sea, they began by trying to tackle specific marine issues such as pollution, hazardous substances, and marine traffic (von Nordheim, Boedeker and Krause 2006). The initial signing of HELCOM in 1974 coordinated these efforts. However, in 2003, HELCOM and the commission created for the North-East Atlantic decided to jointly adopt an ecosystem approach to marine conservation; this fit with their new goals of recognizing the intersectionality of marine issues between the Baltic and North-East Atlantic (von Nordheim, Boedeker and Krause 2006). In 2007, HELCOM adopted the Baltic Sea Action Plan (BSAP) furthered their efforts at EBM. BSAP was a multilateral ministerial declaration that lays out ecological objectives for states to achieve by 2021 (von Nordheim, Boedeker and Krause 2006). Many of these objectives are specific and similar to the original goals of HELCOM, but also included is achieving favorable biodiversity. BSAP also provides support for reaching these objectives through EU funding (Backer, Leppanen and Brusendorff, et al. 2010). As HELCOM embraces EBM, implementation of MPAs and the protection of biodiversity is becoming a higher priority.

In the Baltic region, EBM is directly correlated with MPA proposals and rhetoric discussing marine biodiversity, which exemplifies the close link between EBM and MPAs. However, this relationship is not always like this, and linking MPAs and EBM is not always beneficial (Halpern, Lester and McLeod 2010). MPAs and EBM are often treated as one and the same instead of assessing MPA efficacy through the lens of EBM, as the theoretical framework

is intended. In a survey of marine conservation publications, Halpern et al felt that an important distinction needs to be made clear in MPAs and EBM. EBM is meant to take a holistic approach to conservation- instead of isolating different ecosystem services and species, EBM is meant to recognize the connections between the different parts of ecosystems. MPAs, on the other hand, often have a more specific intent. Most MPAs are meant to exclude or limit a certain type of human activity, usually fishing. This means that MPAs encompass only a small subset of the issues EBM should address. Marine reserves, especially on the coast, are an important part of EBM, but using a single policy strategy to reach a broad goal such as protection of an entire ecosystem is not effective.

Another critique of EBM is that it is not implemented in many cases, although this could also be considered a critique of most marine conservation frameworks. A survey of management plans and academic articles discussed EBM theory since Grumbine found that very few MPAs incorporate monitoring procedures that would lead to ecosystem-level protection and even fewer have adaptive management practices, an important part of the long-term objectives in EBM (Arkema, Abramson and Dewsbury 2006). This brings us back to the idea that policy and management need better tools for putting scientific principles into practice. There is a multitude of criteria that have been discussed for EBM and MPA theory, and all of the different EU and Baltic frameworks and directives exemplify the actions that policymakers take, but the scientific and policy literature is not being brought together through effective management.

However, there are several aspects of EBM that make it an appropriate ideal for Baltic management aspirations. The Baltic is a delicate ecosystem that requires a coordinated regional approach; the combination of brackish and saline environments make the salinity levels volatile, and the combination of fish stocks and endangered species make MPA management challenging

(Backer, Leppanen and Brusendorff, et al. 2010). This makes the Baltic very compatible with EBM, which is why HELCOM adopted it over the integrated species-level approach being debated in the EU. Adding the objective of favorable biodiversity in the BSAP was a novel concept for a marine action plan because biodiversity is not always viewed as an actionable goal the way hazardous substance control or pollution prevention are (Backer, Leppanen and Brusendorff, et al. 2010). One critique of the BSAP is that it has the same goals and rhetoric as the MSFD through the EU so it does not represent an added incentive for Baltic states to implement new management, but the counter made by Backer to this claim is BSAP is acting as a pilot programme for the MSFD with the added importance of the presence of Russia (2010). Given the strong EBM frameworks in place at the EU and regional level, the modeling done in this project was done within the assumptions of the EBM framework. Ecosystem-level components were added to the model on the basis that EBM management plans were being followed, and there were several variables that quantify whether or not a particular MPA is aligned with EU directives on habitat or species level protection. EBM is not just useful for HELCOM policymaking and management, but it also provides a useful framework for evaluating MPA management.

#### *What makes an MPA*

There are many ideas about what physical criteria a successful MPAs should meet; many argue that MPAs should be no-take zoned, well-enforced, old, large, and isolated by deep water or sand (Graham 2014; Hastings 2003). Proper enforcement means a clear distinction between take and no take zones and methods of protecting the no-take zones; a number of MPAs are “paper-only” parks without even a management plan (Fenberg 2012). These unmanaged parks also distort our ability to analyze the effectiveness of MPAs because, if these parks are assumed

to be part of a network, they can give the appearance of wider protection than is actually in place. MPAs need to be guided by an understanding of natural history and ocean habitats, and Hyrenbach argues that if entire ecosystems are to be protected then there needs to be a holistic management scheme to protect the different kinds of habitat each species needs to survive (2000).

MPAs are governed in one of five ways: by the government under a clear legal framework, by the government with decentralization or private influences, by local communities under collective management arrangements, by the private sector or NGOs, or with no clear framework in place (Jones, Qiu and De Santo 2013). The most common problem in MPA governance is a lack of legal incentives that ensure the state's capacity to enforce MPAs, which can be solved by having a diverse group of institutions built in to governance systems. Other common challenges identified are formalizing conservation practices in the government, producing integrated policies, and comprehensive stock taking, which has been especially problematic with Spain and Germany (Thiel 2013). The EU attempts to solve some of these issues by creating a theoretical framework around which regions and countries can establish policies. In the Baltic, one framework, the Marine Strategic Framework Directive, has been especially influential and will be further described in the following section.

Because of the challenges of analyzing if an MPA network is coherent, this analysis does not examine whether or not the Baltic Sea MPA network is adequate or even how effective any of the MPAs are at protecting species. Instead, this analysis will focus on how MPAs become reality in the first place. Many of the problems with MPAs mentioned above stem from the challenges of establishing MPAs; if it were better understood how MPAs come to be implemented, then researchers will be able to focus on analyzing MPAs that have these

characteristics as indicative of what we can expect from future MPAs. Europe has a complicated system of environmental protection, which provides material to analyze, but also makes it difficult to tease out what factors are truly significant in changing how long an MPA takes to be established. To provide a framework for this analysis, I will lay out the different facets of European marine protection from global conventions, to EU directives, to the regional HELCOM agreement, to how some of the Baltic states operate.

### *International Regulation of MPAs*

MPAs, and marine protection in general, stem from the obligation that states have to protect marine environments located in their exclusive economic zone (EEZ) as mandated by the United Nations Convention on the Law of the Sea (UNCLOS) (Czybulka 2006). A state's exclusive economic zone is usually defined as all of the sea from the shore to 200 nautical miles from the coast, which includes territorial waters extending 12 nm from shore. The Baltic Sea is unique in being so narrow that countries' EEZs cannot extend the full 200 nm, so many EEZs are determined by bilateral treaties. While UNCLOS gives coastal states sovereign rights within the EEZ, it also lays down an obligation to protect marine environments beyond that 200 nm if the area would be affected by human activity, such as shipping issues (von Nordheim, Boedeker and Krause 2006). These protections are worked out at the global level by approaching the International Maritime Organization, or at the regional level through an organization such as HELCOM. UNCLOS is important in that it establishes the ecosystem approach for managing human activities in marine areas at the international level, which in theory should lead to the protection of all fragile ecosystems even beyond the direct jurisdiction of a state (Czybulka 2006). However, the lack of specificity and the lack of enforcement power makes it difficult for the UN to ensure that these measures are carried out (Czybulka 2006).

### *EU Regulation*

The EU has two specific environmental protection directives that are more specific to EU environments and are more easily enforced than a broad UN convention. The Habitats Directive and the Birds Directive have been essential in allowing the EU to create an MPA network across all four marine regions that are part of the EU: the Baltic Sea, the North-East Atlantic Ocean, the Mediterranean Sea, and the Black Sea (Czybulka 2006). The Birds Directive of 1979 established Special Protection Areas (SPAs) as areas for the protection of Europe's native and migratory bird species (Czybulka 2006). Later, in 1992, the Habitats Directive established Special Areas of Conservation (SACs) as areas for the "continuation of a favourable conservation status" of natural habitats and native fauna and flora of community importance (Czybulka 2006). These SACs are selected from a larger pool of Sites of Community Importance (SCIs). SPAs and SACs together are what is considered the Natura 2000 network of protected areas. In 1999, it was ruled that Birds Directive and Habitats Directive are to be applicable to the EEZ of all member EU states, an issue which was briefly under contention (Czybulka 2006). When selecting sites as an SPA or SAC, member states are not allowed to consider issues other than nature conservation; economic or structural considerations should not be taken into account. However, getting states to designate MPAs within the EEZ and further out than their territorial waters is a challenge that has not been solved (Czybulka 2006). As of 2004, only Portugal, Denmark, and Sweden had designated SPAs or SACs outside of their territorial waters. The EU Directives have been a powerful tool for establishing MPAs; they have allowed states to cooperate in creating a network that, if fully implemented, would approach ecological coherence (Czybulka 2006). However, it has also been a slow instrument of policy. Based on the initial guidelines set out for implementation of the Natura 2000 network, all sites should have been established by 1998.

Later targets for full implementation have also come and gone without reaching their goal. In the end, it was the pressure of the Birds and Habitats Directives that led to the site proposals for the Natura 2000 system, site proposals that have led to hundreds of protected areas being established.

Broad directives are not the only approach the EU has taken to marine protection; in recognition of the challenges of cross-boundary conservation, EU member states have set up Regional Sea Conventions (RSCs) for each of the four marine areas to help combat the effects of pollution, lessen the effects of other human activities, and protect marine biodiversity. Each of these RSCs has its own network of sites designated under their own mechanisms, and while large overlaps exist between the Natura 2000 sites and the RSC sites there are some differences due to different methods of designation (von Nordheim, Boedeker and Krause 2006). The Baltic Sea is governed by the Helsinki Commission (HELCOM), which was signed in 1974 and extensively revised in 1992. HELCOM was the first of the four seas to meet the UN 10% MPA coverage target, but it was still found in 2010 that the Baltic MPA network could not be considered ecologically coherent (EEA 2015). The North-East Atlantic Ocean is governed by the OSPAR Convention, established in 1974. OSPAR's reach was extended in 1998 and now almost 18% of the Greater North Sea is within an MPA (EEA 2015). OSPAR and HELCOM cover some of the same area, so in 2003 the two bodies cooperated on reevaluating their site designations to create a network between them. The Mediterranean Sea and Black Sea are governed by the Barcelona Convention and Bucharest Convention respectively; neither of these areas are close to 10% coverage, let alone ecological coherence (EEA 2015).

In addition to the EU's concrete efforts through directives and RSCs, the EU has put forth a number of marine spatial planning theoretical frameworks to create discussion about the

rhetoric of marine protection. These frameworks are agreed upon by the European Commission and then left to national governments and regional agreements, such as HELCOM, to be carried out. The two most prominent decision making approaches to marine spatial planning are currently the Marine Strategy Framework Directive (MSFD), which takes a holistic approach to protecting entire ecosystems, and Integrated Maritime Policy (IMP), a soft sustainability approach where the needs of different sectors are balanced to ensure fewer negative consequences to one specific sector (Qiu and Jones 2013). The IMP is more likely to make conservation concessions to protect the fisheries industries, whereas the MSFD demonstrates a concerted effort to put ecosystem protection first (Fenberg 2012). Within these frameworks, MPAs are part of a wider marine spatial plan, which helps bring an integrated approach to marine protection but also necessitates a wide range of goals must be taken into consideration (Fenberg 2012).

While there has been debate in the European community between the MSFD and IMP, in the Baltic region the MSFD has been the more prominently used model. The Baltic Sea Action Plan (BSAP) was modeled on the MSFD policy landscape and is being used as a pilot for the process outlined in the MSFD (Backer, Leppanen and Brusendorff, et al. 2010). Because the MSFD and HELCOM's objectives span beyond MSP, the policies in the BSAP also go beyond creating more MPAs. Many of these efforts have not been successful. The initial attempts to curb pollution failed, most likely because the eastern Baltic economy, especially the agricultural industry, revived soon after implementation (Backer and Leppanen 2008). The focus of the action plan actually lies in reducing nitrogen and phosphorous input to the Baltic Sea, which would further marine conservation goals if it were performing. The marine goals are to protect biodiversity by filling in protected areas to develop an ecologically coherent network by 2010



(Backer and Leppanen 2008). BSAP includes a novel approach to intergovernmental MSP because of the close borders on the Baltic and the added complication of Russia being a part of HELCOM but not the EU (Backer, et al. 2010). Despite initial governance failures, it is still believed that the MSP process in the BSAP will make a more integrated regional framework when it comes to marine conservation (Backer, et al. 2010).

#### *European Regional Regulation: HELCOM*

HELCOM was established in 1974 to cover the maritime area of the Baltic Sea, Belt Sea, and Kattegat, and includes all territorial seas and EEZs located within those areas. It initially aimed to assess and combat marine pollution for coastal states, but protection biodiversity began to be discussed in the 1980s (von Nordheim, Boedeker and Krause 2006). A “new” HELCOM was signed in 1992 with member states and the EU with the express purpose of protecting vulnerable species and habitats (von Nordheim, Boedeker and Krause 2006). A 1993 working group on Marine Conservation and Biodiversity led to the 1994 system of BSPAs, which are sites within and outside of Natura 200 that HELCOM members were required to implement (von Nordheim, Boedeker and Krause 2006). Out of the 11 member states, only Lithuania has actually implemented all of the BSPAs set out in this 1994 decision (WWF 2016). In 2003, OSPAR and HELCOM had a joint meeting about pressures from human activities leading to continuous destruction of marine areas and the two RSCs committed to protecting Kattegat, the area where the two RSCs overlap, together (von Nordheim, Boedeker and Krause 2006). The Baltic Sea is unique among marine ecosystems, not only in Europe but the rest of the world’s seas. The marine environment in the Baltic is classified as brackish because there is extensive freshwater runoff and significant salinity differences between sub-basins, creating very different environments across the Sea. There is very little influx of water into the Baltic; the Danish straits

provides an inflow of 740 km<sup>3</sup> per year, and river basins provide 450 km<sup>3</sup> in freshwater inflow. This makes the marine environment highly vulnerable (Taufe 2012).

HELCOM has led to extensive marine protection in the Baltic, but not so much as would be considered a coherent network. One of the major faults of the Baltic MPA network is its inconsistency; some states have followed the guidelines and implemented their proposed MPAs, while others have not. For example, Germany has the highest percent coverage of their marine area by MPAs at 30 percent, while Russia's MPAs only cover 4 percent and Sweden's only covers 5 percent (WWF 2016). Even when states implement their MPAs on paper, they are not necessarily enforcing those regulations. Only 17 percent of Germany's implemented sites have a management plan whereas 94 percent of Denmark's sites have management plans (WWF 2016). Beyond simply having a management plan, there are varying degrees of restrictions in place; while some reserves may be full "no-take" reserves, many allow some degree of human activity. Swedish MPAs only have 50 percent monitoring coverage and only 32 percent of their sites have fishing restrictions in place (WWF 2016). Latvia, Estonia, Finland Lithuania, and Poland all reported very little data on their management activities to HELCOM, which is a problem in and of itself (WWF 2016). Overall, individual states are not following many of the guidelines set out by HELCOM, and the lack of cooperation with HELCOM guidelines casts doubt on achieving full network implementation.

The process for proposing and implementing MPAs in the Baltic is complicated by the interplay between HELCOM designated sites and Natura 2000 designated sites. Before HELCOM, a site would be designated as a SAC or SPA through Natura 2000 and enter the Natura 2000 network as a "designated site." Then, it was left to the state to implement the designated site by creating a management plan and carrying out that plan. If a site has been

recognized by the state as a protected area, then it is implemented. However, not all implemented sites are managed- domestic environmental agencies sometimes do not create management plans even when a governing body has officially recognized a protected area, or those management plans are not carried out. HELCOM sites, BSPAs, are proposed through a commission meeting or through research that stemmed from a commission meeting (HELCOM Recommendation 15/5 1994). The proposed sites are general suggestions instead of concrete spatial sites, so HELCOM gives countries leeway in defining the exact boundaries of protected areas within HELCOM guidelines (HELCOM Recommendation 15/5 1994). Each country in HELCOM should report on the establishment and management of the BSPAs proposed at commission meetings a year after they were proposed and every three years following. Because of the way BSPA recommendations are structured, it is likely that the HELCOM MPA network covers a wider range of marine species, habitats, biotopes, and natural processes than the areas in the Natura 2000 network (Ranft, et al. 2010).

## Literature Review

In marine conservation, MPAs are a popular option for balancing conservation values, fisheries, and other human uses of the ocean. Previous empirical and theoretical research on MPAs heavily focuses on a few themes: what impact MPAs have on fishermen, how an optimal marine reserve is modeled, and whether MPAs are effective conservation tools. There has not been a significant amount of research on why MPAs are established, which is a segment of the social science literature that is lacking. However, the research that has been done heavily contributed to the decisions made about the variables included and excluded in the model for why MPAs are implemented; therefore, this project is a product of much of the research that has been done in the past.

### *MPA Effectiveness*

The first question that should be asked when evaluating MPAs is are they an effective conservation tool? The literature on this topic can be divided into two main groups: studies that argue for the effectiveness of MPAs based on different types of surveys, and studies that say MPA conservation effectiveness is not being evaluated correctly. One characteristic of note about conservation studies, and much of the research on MPAs in general, is that there is a heavy oversampling of the parts of the world that are very different from the Baltic. Many of the surveys done on MPAs, and in general many MPAs, are located in coral reef environments; this is because coral reefs have high biodiversity, are often the locations for spawning and growth of fishery species, and are susceptible to overexploitation. However, the coral reef physical environments, human stressors, and management needs are very different from the Baltic environment. This does not mean that the literature is without meaning, but applying the conclusions made about non-Baltic environments to the Baltic should be done with care.

When studies are designed to test if fish biomass increases with a marine reserve, they often find that MPAs have a positive effect. This follows the theory of why MPAs are established in the first place, which was effectively stated by Agardy when MPAs were first becoming less about recreation and more about effective management. Agardy says that MPAs allow for valuable ecosystem management and evoke the precautionary principle in conservation (1994). They also allow for adaptive management, leading to feedback between science and management, and species based management for a focus on keystone species. Many of the largest and recent studies on MPA effectiveness found compelling evidence for protection of many species (Jameson, 2000; Halpern et al, 2002; Harrison, 2012). Jameson summarized several studies on MPA effectiveness by stating that “the usefulness of appropriately sized, well-

managed MPAs is not in question” (2000). More specifically, Halpern et al measured 80 reserves and evaluated the temporal patterns of MPA impacts. They found significant ecological benefits were reached between 1-3 years in almost all reserves and maintained over the lifespan of the reserve (up to 40 years) (Halpern et al, 2002). Harrison also conducted a large survey of Great Barrier Reef MPAs and found increased reproductive potential of fishery species; two species saw 55 and 83 percent increased export of larvae (2012). This is strong evidence that MPAs lead to the replenishment of depleted fishery stocks.

Other authors, such as Sale and Pomeroy call into question the effectiveness of MPAs by critiquing the methods used for evaluating them. Sale states that there are “significant gaps in scientific knowledge” that need to be filled for no-take marine reserves to be used for fishery management (2005). We still do not have a nuanced understanding about what the ecosystem level impacts of fishing are. Sale lists how trophic cascades from marine reserve implementation can change the community structure of an ecosystem, which challenges assumptions that populations of fishery species will become more abundant, larger, and older, as an important example of this (2005). Pomeroy provides a solution for filling these gaps of knowledge by outlining four steps for MPA evaluation: selecting indicators, planning the evaluation, conducting the evaluation, and adapting measurement (2005). These indicators include socioeconomic factors, biophysical factors, and governance factors. If evaluations of MPAs do not follow these guidelines, then it is difficult to see if MPA goals and objectives are being met by the reserve (Pomeroy, 2005). Without feedback on MPA effectiveness, management cannot adapt to achieve the goals of conservation. If we are not evaluating MPAs correctly, then it is difficult to conclude whether or not they are effective.

Evaluating the conservation effectiveness of Baltic MPAs is outside the scope of this project; however, many of the conclusions reached in this literature are important for evaluating why MPAs are implemented. Conservation interest groups support or disregard MPAs on the basis of this literature, and therefore this was taken into consideration when choosing important factors to test in the model. Some of the methods for evaluating MPAs can also be applied to the variables used in this analysis, which provide a frame of reference for comparing the variables. Finally, the research arguing for the effectiveness of MPAs in protecting marine species provides a foundational motivation for this research. If MPAs were known to be ineffective, then there would be little reason to determine why they are implemented with the goal of more MPAs being effectively implemented and managed.

#### *Economic Costs and Benefits of MPAs*

There have been a number of economic analyses on the possible benefits of MPAs for fishermen; analyzing the costs and benefits to MPAs could be called the dominant portion of the literature. These economic analyses have not led to consensus on whether or not MPAs are beneficial or costly for fishermen, and a consensus will most likely never be reached because the effect MPAs have on fishermen is highly contextual and dependent on many things endogenous and exogenous to the MPA. Many researchers believe that MPAs will be beneficial to fishermen because of the spillover effect. When an MPA is closed to fisheries, it allows fish populations in the area that were previously exploited to rebuild. That biomass can then spill out past the boundaries of the MPA into area where fishermen can legally fish, giving them greater catches; fishermen are known to “fish the line” right along the border of the MPA because it can bring larger catches. Roberts et al found evidence of this effect in a study done on marine reserves in Florida and St. Lucia (2001). 5 years after the creation of a small reserve network in St. Lucia,

artisanal fishers' catch increased between 46 percent and 90 percent, despite a 35 percent decrease in the area of fishing grounds (Roberts, 2001). In Florida, a long-term protected area has led to record-breaking fish being regularly caught since 1985 (Roberts, 2001). Gell et al analyzed data from several MPA networks and found that they were effective at protecting more mobile animals; in the Mediterranean, New Zealand, Australia, the Bahamas, and Canada lobster stocks increased inside MPAs and remained high (2003). Fish biomass also increased in several locations; population buildup increases reproductive capacity within the reserve, which helps ensure that the benefits spill out past the boundaries. These studies suggest that the benefits of MPAs for fishermen are first felt close to the border and through spillover of juveniles and young adult fish, but the longer the reserve is in place the wider the range of the effect (Gell et al, 2003). Harmelin-Vivien et al confirmed this pattern in their Mediterranean study, which found patterns of fish spillover (2008). The 6 MPAs surveyed in this study found most of the spillover benefit on the scale of within 100s of meters of the MPA, but 4.7 times the fish biomass was recorded inside the MPA compared to adjacent fishing grounds (Harmelin-Vivien, et al. 2008). These studies, and others surveying the effect of MPAs on fish biomass and populations, have led some researchers to conclude that MPAs must be beneficial to fishermen.

However, other research has concluded that MPAs do not provide economic benefits to fishermen when analyzed as a whole. A study of no-take MPAs within the Great Barrier Reef found that expansion of the MPAs to large-scale closures did not enhance fishery production. Nine years after the expansion, the average total catch for the Great Barrier Reef was effectively reduced by around 39 percent (Harrison, et al. 2012). Crustacean catches showed no recovery within this period, which is triple what the recovery time for crustacean stock should be. The authors concluded that the data does not support the general assumption that the negative effects

of fishing ground closures are minimal and short term, and recommend that careful analysis of the costs and benefits of closing fishing grounds should be done for each location (Harrison, et al. 2012). Smith et al also found a downward trend in catch after marine reserve establishment in the Gulf of Mexico (2006). In addition, they suggest that many retrospective analyses of marine reserve catches make assumptions that should not be made for large-scale fishery management (Smith, Zhang and Coleman, 2006). Retrospective analyses should “control for curvature in fishing production technology, coexistence of multiple policy layers, heterogeneity across vessels, space, and time, and...selection effects of fishing vessels in treatment and reference groups” (Smith, Zhang and Coleman, 2006). Smith and Wilen previously discussed economic assumptions leading to over-optimistic conclusions about marine reserves when they developed a bioeconomic model of the sea urchin industry in northern California and showed that economic behavior is critical to determining the impact of reserves (2003). Overall, economic analyses of MPAs are much more ambivalent about their effects on fisheries than the survey analyses. This suggests that MPAs may lead to physical increases in fish supply, but the benefits do not always carry over to the fishing industry.

The prominence of this literature on the economic costs and benefits of MPAs had a definite influence on the variables selected for this analysis. Many of the Baltic MPAs are *not* no-take reserves, which means that the conclusions from several of these papers cannot be directly applied. However, this means that Baltic fisheries can receive directly many of the benefits of marine reserves by fishing inside areas protected from other forms of human stress. This expected benefit of having marine reserves is expected to make fishing intensity, a measure of how much an area is fished, an important variable when measuring how long it takes an MPA to be implemented.



### *MPA Design*

Another rich section of the MPA literature discusses how MPA locations are chosen and designed, from both a conservation and economic standpoint. From a conservation standpoint, MPA design should be guided by the natural history and habitat variability in the ecosystem. It is generally agreed MPAs should be no-take zoned, well-enforced, old, large, and isolated by deep water or sand for them to have the maximum positive effect on depleted populations (**Graham, 2014**; Hastings, 2003). These characteristics are supported by research on coral reef MPAs, which found that MPAs like this led to greater fish biomass, especially large fishes, and greater species richness of all fishes. This study included 87 MPAs, which allowed for the researchers to study the interactive effect of the different reserve characteristics; they found that having all five increased the effectiveness of the MPA (Hastings, 2003). A study on ocean basin management, which is marine protection on a very large scale, emphasized the importance of understanding the physical mechanisms occurring in the area when designating MPAs (Hyrenbach, Forney and Dayton 2000). However, taking what is best biologically can lead to cost and stakeholder challenges. Hastings and Botsford compared reserve designs for maintaining fisheries yield and conserving biodiversity in an idealized setting and found that the two can be mutually exclusive; the best designs for increasing biomass and meeting the fishery goal are not the same (2003). Bioeconomic spatial models take information on fish population dynamics, open access models, and fishing effort. Sanchirico and Wilen developed a model that includes two important features: the model is continuous in time but discrete over space, and embeds behavioral assumptions about how fishermen respond to profit opportunities (2001). Their conclusion after running the model is that reserve design must consider biological and economic factors. Conrad and Smith formulated a different open access model by working

indiscrete time rather than continuous time, and found that spatial dynamics of a reserve can change the payoffs received by fishermen (2012).

### *Marine Spatial Policy*

Finally, once the effectiveness of MPAs has been analyzed and it has been decided how an MPA is to be implemented, MPA policy is left to be analyzed. There is a surprising lack of social science literature about MPA and marine reserve policy. The main policy topic researched is the tension between science and policy: scientific studies have resulted in specific guidelines for where MPAs should be implemented and how they should be managed, but those guidelines are rarely directly implemented into policy. Agardy et al explains that policymakers often apply simplistic solutions to marine conservation problems, which can lead to polarization of interests and eventually threatens real progress in marine conservation (2003). Because of this, scientists have an ethical duty to map out management plans for policymakers and use MPAs for promoting long-term conservation. Gray and Campbell also discuss the tension between science and policy by surveying divergent attitudes towards the role of science and scientists in policymaking (2008). They found that many scientists hesitate to engage in policy processes for fear of ruining the credibility of science and blurring the distinction between fact and value (Gray and Campbell 2008). The counter to this for many people is that as long as the distinction between data and opinions is made, scientists have an ethical duty to act as advocates because of their deeper understanding of the policy issues (Gray and Campbell 2008). MPAs are a particularly important area where “the boundaries between science and advocacy are being contested” because of the history of science-based approaches to MPA design not being implemented in the sociopolitical management (Gray and Campbell 2008). These types of

analysis do provide some insight into why some MPAs are implemented while others are not- the disconnect between science and policy- but not in any quantifiable way.

## Theory

This analysis is attempting to quantify why some MPAs are implemented at a certain speed and why some MPAs fail to be implemented at all. In order to do so, we must first understand why regulation occurs and why legislative bodies implement some policies but not others. George Stigler's theory for why states have regulation argues that regulation comes from demand by the industry and is designed to benefit industries (Stigler 1971). The state's largest resource in regulation is the power to coerce, which is unique to the state, and this allows political bodies to order resources to be moved and certain economic decisions to be made without firms' consent; environmental regulations can prevent fishermen from fishing in a certain area even if there are valuable stocks in that MPA (Stigler 1971). Industries have the ability to demand regulation, but this does not mean that the industry gets all of what it wants- the political party must find a "coalition of interests more durable than the anti-industry side of every industry policy proposal" (Stigler 1971). Under Stigler's theory, we would assume that MPAs would be demanded by the industries that would benefit from them: tourism, conservation groups, possibly fishermen. Once the MPAs are proposed, however, it would be a "coalition of interests" that would dictate which MPAs are implemented and which are not.

Stigler's model of regulation was modified by Peltzman's analysis of supply-side factors to regulation. Peltzman tries to balance Stigler's theory of demand-side regulatory politics and factors that motivate regulations that benefit consumers. This argument could better fit with why MPAs are implemented even when they are harmful to industry. He argues that legislators want to remain in office so legislation and regulation will be made to maximize political support, and

that interest groups offer political support to legislators in exchange for favorable legislation (Peltzman 1976). This theory gives more room for environmental interest groups to have a role in MPA legislation: the interest groups can influence marine conservation legislation by supporting political groups. There is an equilibrium between the supply for regulation and the demand for regulation that Peltzman describes with marginal political costs and marginal political gains (Peltzman 1976). Additional protection brings benefits to an industry, but protection also reduces consumers' surplus; the regulation is at the equilibrium between industry benefits and consumer costs (Peltzman 1976). This means that MPAs are implemented at the equilibrium between the cost to industries like fishing, mineral extraction, and fossil fuel drilling, and the benefits to consumers such as tourism and concern for the environment.

Peltzman began to quantify how to measure when regulations are implemented, but Laffont and Tirole created a more sophisticated metric in their analysis on why public decision makers regulate industries. They assume that there is a single public decision maker, or the agency, and a single regulated firm who has a natural monopoly (Laffont and Tirole 1990). The model contains a four-party hierarchy: firm, agency, founding fathers, and consumers. The founding fathers in this model are assumed to give all regulatory agencies the mandate to maximize utility (Laffont and Tirole 1990). Consumers are assumed to have be too dispersed to intervene in the regulatory process (Laffont and Tirole 1990). The model goes on to test how industry and consumers can act as watchdogs over regulations, but the quantification of variables is important because it subdivides legislation on paper and regulatory agencies. MPAs are often mired in regulatory problems; the legislative act of going from proposed to implemented, and then the bureaucratic management of the implemented MPA, lead to many of the problems in the use of marine

reserves. Quantifying the difference between the regulation on paper and the regulation in action is important to understanding what causes MPAs to be implemented at a certain time.

In theory, why regulations are put in place can be divided into these four clearly delineated categories, but in practice there are too many factors to accurately describe precisely why each MPA is implemented. However, for Baltic MPAs, there are two categories that I feel are particularly influential and would expect to be significant in the model. The commercial fishing value should be important because fishing is one of the most important industries in the Baltic seascape in the absence of significant fossil fuel extraction. So many of the marine reserves in the Baltic are not managed as no-take that I would also expect fishermen to demand MPA regulation since there are benefits with no cost. This leads to the first hypothesis:

*Hypothesis I:*

Areas in the Baltic Sea with high commercial fishing value are likely to be protected in less time because many reserves are not designated completely no-take.

Second, the “founding father” impetus for marine protection could also be significant because of the number of EU directives that specify the need for marine protection. EU Directives come with the weight of all EU countries behind them and have been more firmly established in the legislative landscape, while HELCOM Action Plans and convention decisions have fewer countries behind them and do not have the long history of environmental conservation decisions. Because of this, I would expect EU directives to be more significant than the regional agreements, leading to the second hypothesis:

*Hypothesis II:*

Areas fulfilling EU directives will be implemented more quickly because the EU has more enforcement power over Baltic states than HELCOM.

A number of factors are included in the analysis, but these two hypotheses sum up the expectations I have from the literature and political theory.

## Research Design

To evaluate why some MPAs go from proposed to implemented while others do not, a Cox proportional hazard analysis was chosen. The Cox model is useful in this case because it estimates the relationship between the hazard rate and explanatory variables without having to make any assumptions about the shape of the baseline hazard function. In this case, the parameter that we are estimating, the hazard rate, is the chance of an MPA being implemented given a set of explanatory variables. A number of variables were researched, and the ones chosen for the final models were chosen based on the literature and theory surrounding MPAs and the Baltic region.

Some of that research revealed important intrinsic characteristics of HELCOM and its MPA system that are important to this analysis. A parameter unique to HELCOM is the various shifts in marine policy and the accompanying waves of MPA proposals. After HELCOM's establishment and the two subsequent conservation paradigm shifts, many new MPAs were proposed and added to the list of MPAs to be implemented by countries. However, HELCOM does not have a unified system for tracking these proposed MPAs- only the ones officially implemented by countries. This means that very few proposed but unimplemented MPAs could be included in the dataset because there is a total lack of information about them, with the exception of a proposed Russian MPA. The bias in the data set, but focusing only on the MPAs that were proposed and implemented still gives important information about the variation in MPAs that have been implemented.

The dependent variable in this analysis is the implementation duration of the MPA. This is the amount of time the MPA took to go from “proposed” status to “implemented.”

Implemented is not necessarily the final step for an MPA- many of the implemented MPAs do not have their own management plan- but it does mean at least one country is making an effort to enforce the boundary.

A number of independent variables were selected for testing:

*Is there extraction of the seabed or subsoil?* This was determined by the information given for what human activities occur in each MPA by the HELCOM Database on MPAs (HELCOM). It is a binary categorical variable representing “yes” and “no.”

*Was the MPA established because of terrestrial values?* This was determined by the information given for what characteristics are important for each MPA by the HELCOM Database on MPAs (HELCOM). It is a binary categorical variable representing “yes” and “no.”

*Was the MPA established to protect the habitats of the species listed in the Habitats Directive Annex I?* This was determined by the information given for what characteristics are important for each MPA by the HELCOM Database on MPAs (HELCOM). It is a binary categorical variable representing “yes” and “no.”

*Was the MPA established to protect natural habitat types listed in the Habitats Directive Annex I and II?* This was determined by the information given for what characteristics are important for each MPA by the HELCOM database on MPAs (HELCOM). It is a binary categorical variable representing “yes” and “no.”

*What quantity of fish did the country consume per capita in 2010?* This was determined by the information given for what characteristics are important for each MPA by the HELCOM Database on MPAs (HELCOM). It is a binary categorical variable representing “yes” and “no.”

*What percent of the population lived within 5km of the ocean in 2010?* This is a country-level covariate that represents the population's interest in protecting the marine environment based on proximity (Eurostat). It is a continuous variable that ranges from 7 percent to 46 percent of the total population

*What was the GDP per capita in 2010?* This is a country-level covariate that represents the country's wealth (World Bank). It is a continuous variable that ranges from 13,781 USD to 61,304 USD.

*What was the surface, subsurface, and total fishing intensity?* This is a measure for how much fishing activity occurs in an area measured both spatially and temporally (HELCOM). For each MPA, the fishing intensity data was analyzed to give both a mean and a maximum. The range of total intensity, which is the sum of subsurface and surface fishing, is from 0 to 17.43.

*What was the general public opinion regarding environmental, especially marine, protection?* Country-level information on the importance of the environment and environmental protection was taken from the published results of the post-materialism surveys that occurred in much of the world. However, because there was no data for Russia, Finland, Denmark, Latvia, and Lithuania, none of this information could be tested in any of the models.

*What are the geographic and political characteristics of HELCOM states?* The inclusion of Russia in HELCOM, despite the fact that Russia is not in the EU, and the membership of some HELCOM states in OSPAR makes the geography and politics of the region important to the analysis. These were represented by two categorical variables: whether a country is in the EU or not, and whether a country is in OSPAR or not.

The Cox Hazard survival analysis was run to develop a model that can shed some light on the hypotheses, as well as provide any other information on what characteristics are important to the



hazard rate of implementation for Baltic MPAs. The Cox model is a nonparametric method to analyzing survival experiences that is especially useful when data is censored, which often happens with survival data. The survival analysis models factors that influence the time to an event, which in this case is time from an MPA being proposed to being implemented. A Cox model also allows us to model the hazard rate to illustrate how different factors influence the time to implementation; the hazard rate graphs show the relative likelihood of implementation occurring at a time if the MPA has not yet been implemented. This type of analysis enables us to make statements on how a certain variable may shorten or lengthen the time an MPA takes to be implemented once proposed. One of the main assumptions of the Cox model is proportionality, so one must verify that a model satisfies the assumption of proportionality. To test this, the scaled Schoenfeld residuals were graphed and can be seen in Appendix II. Since the graphs show a general slope of 0, the predictors were assumed to be proportional.

## Results

The results of the Cox-Hazard analysis are presented in Tables 2 and 3 below, followed by several survival functions based on the models. Not all of the variables that were expected to be significant in duration analysis were found to be significant in any of the regressions, but comparing the different models tested does show some interesting results in regard to when some variables are significant versus insignificant. Some of the variables in the model had an unexpectedly substantial hazard ratio, which led to more changes being made to what variables are included in the models.

Table 2: Results from Cox models 1-3

	Model 1 96 Observations Log likelihood= -295.22		Model 2 96 Observations Log likelihood= -317.90		Model 3 96 Observations Log likelihood= -336.70	
Independent Variable	Hazard Ratio	Std. Err.	Hazard Ratio	Std. Err.	Hazard Ratio	Std. Err.
OSPAR member	.615	.189	.432**	.123	.395**	.112
Not Russia	2.543	1.728	3.741*	2.536	3.259*	2.157
Max Surface Fishing Intensity	1.040	.037	1.049	.0358	1.037	.0362
Percent Coastal Population	1.003	.014	.992	.0141	1.009	.0141
MPA includes terrestrial	1.578*	.370	1.416	.337	1.050	.241
EU HD Annex I	.679	.313	.667	.287	1.168	.467
EU HD Annex II	2.214*	1.022	3.386**	1.697	1.605	.692
EU Birds Directive	.321*	.195	.431	.266	.603	.334
Proposed between 1994 and 2003	13.670***	8.761	-	-	-	-
After 2003	143.318***	107.701	-	-	-	-
After 1994	-	-	17.811***	11.497	-	-

\*\*\*p&lt;0.01, \*\*p&lt;.05, \*p&lt;0.1

The first set of models in Table 2 differ in how the different eras of HELCOM policy are treated. There have been two major shifts in HELCOM policy, once in 1994 when marine protection was prioritized, and again in 2003 when HELCOM began cooperating with OSPAR. In Models 1-3, whether or not the MPA country is part of OSPAR was included in the model. Model 1 tests both shifts in HELCOM policy by separating out the 1994-2003 period and post 2003. Model 2 combines these two and thus only tests the 1994 shift in policy. Model 3 does not include any of the date related variables because the hazard ratio for the date cutoffs were so large in the first two models. Model 3 illustrates what happens when that large pull on the model is removed; one major change is none of the EU directives are significant anymore.

Table 3: Results from Cox models 4-6

	Model 4 <i>96 Observations</i> <i>Log likelihood=-296.43</i>		Model 5 <i>96 Observations</i> <i>Log likelihood=-341.60</i>		Model 6 <i>162 Observations</i> <i>Log likelihood=-618.43</i>	
Independent Variable	Hazard Ratio	Std. Err.	Hazard Ratio	Std. Err.	Hazard Ratio	Std. Err.
OSPAR	-	-	-	-	.597**	.120
Not Russia member	1.687	1.058	1.344	.811	4.383**	2.638
Max Surface Fishing Intensity	1.041	.0365	1.052	.0348	-	-
Percent Coastal Population	1.004	.0145	1.012	.0146	.972 ***	.00952
MPA includes terrestrial	1.561*	.367	.941	.212	1.094	.198
EU HD Annex I	.924	.396	2.292**	.819	.646	.219

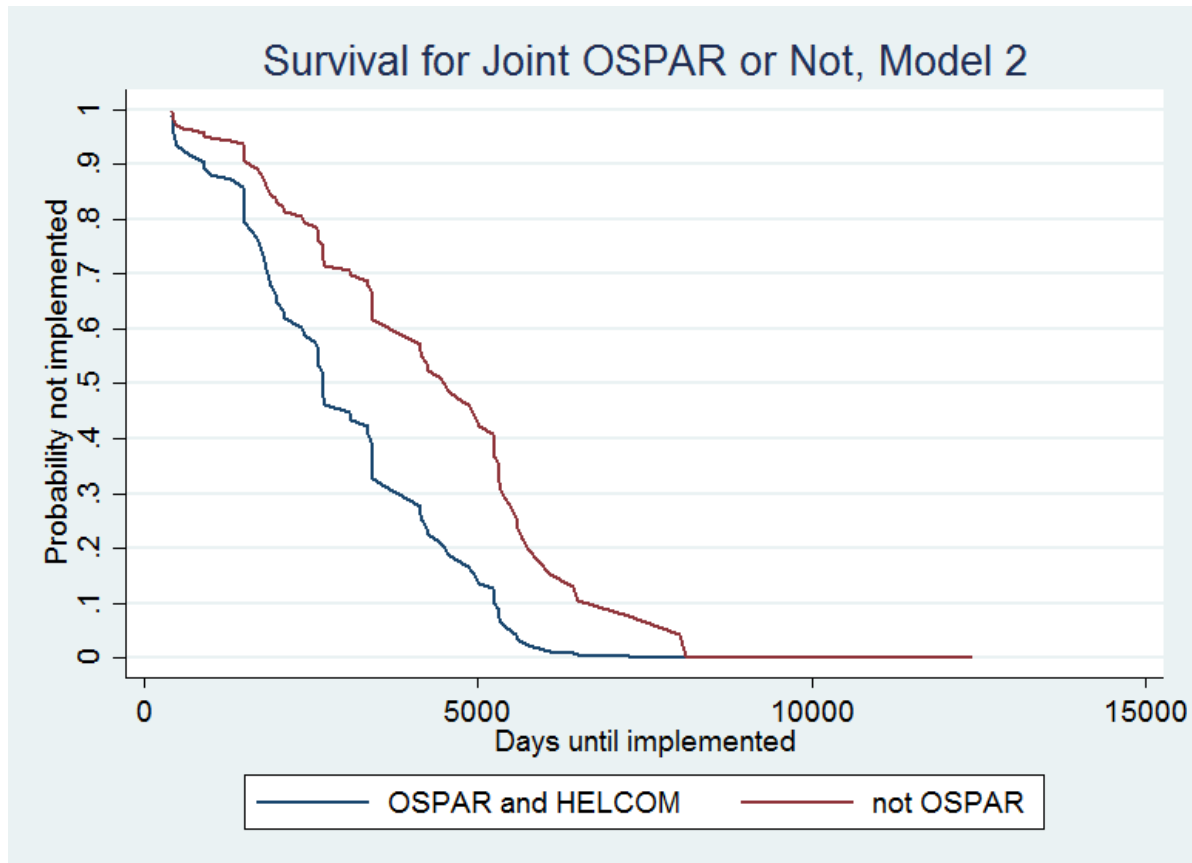
EU HD Annex II	2.368 *	1.116	1.531	.668	2.059**	.738
EU Birds Directive	.282 **	.171	.5256	.295	1.052	.411
Proposed between 1994 and 2003	14.179 ***	9.091	-	-	-	-
After 2003	157.874 ***	111.230	-	-	-	-
After 1994	-	-	-	-	33.116***	21.042

\*\*\*p<0.01, \*\*p<.05, \*p<0.1

The second set of models looks at what happens when other variables are removed from the model, although the date cutoffs are still included in some and excluded in others. Being an OSPAR member or not was excluded from Models 4 and 5. Model 6 is particularly interesting because it removes the fishing intensity variable which is the limiting factor for the number of cases in the model. Models 1-5 have 96 cases because of the sparse fishing intensity data, but Model 6 has 162 cases because fishing intensity is removed. Once fishing intensity is removed, the percent population that lives within 5km of the ocean becomes significant for the first time in the model. Model 6 has the highest number of significant variables out of all the models, with OSPAR membership, not Russia, percent coastal population, EU HD Annex II, and after 1994 all passing the p<.05 threshold.

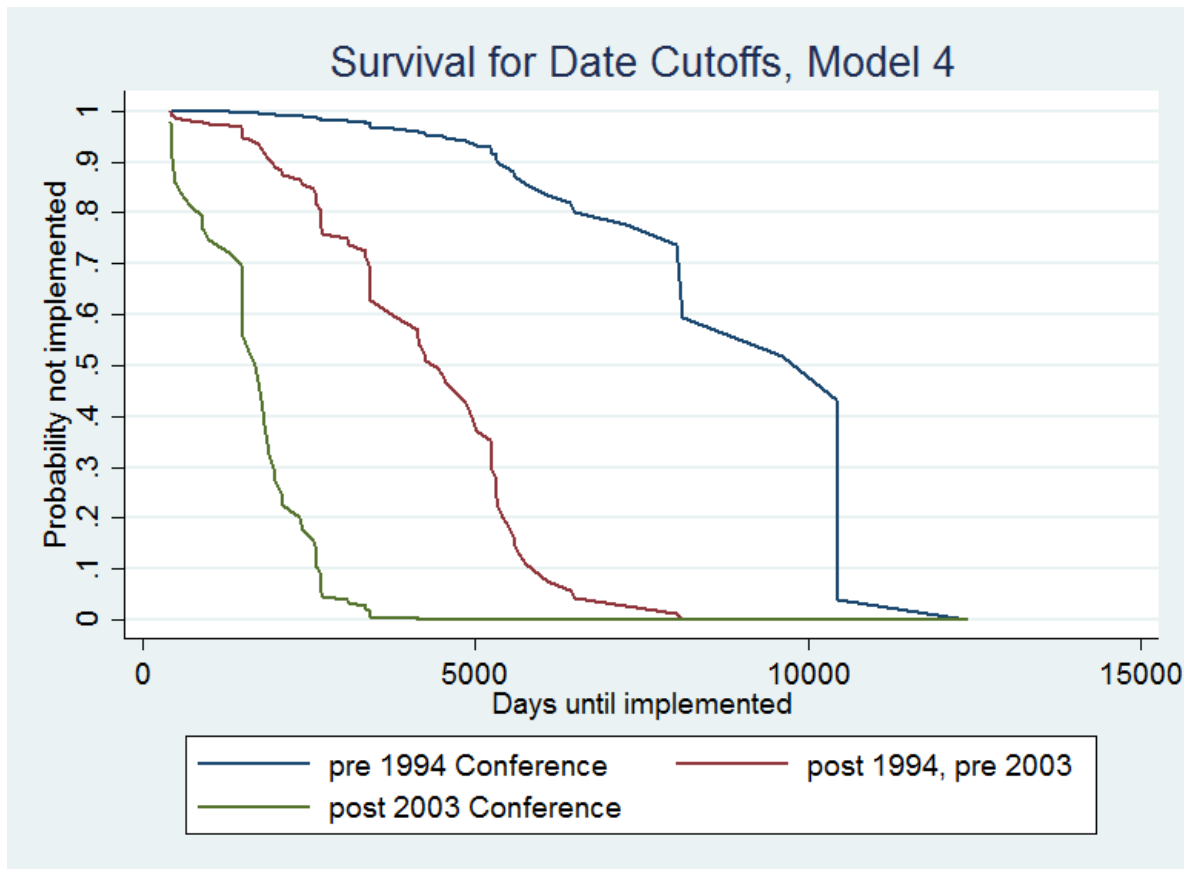
In order to more clearly illustrate the results of these models, several survival functions were graphed by manipulating one or more variables on one of the models. For each of these functions, all of the variables except the one being manipulated were held at their mean value.

Figure 1: Survival Function for Joint OSPAR-HELCOM Membership or Not



In Figure 1, the survival function for OSPAR versus not OSPAR is shown based on Model 2. This illustrates that being a member of OSPAR and HELCOM leads to slightly slower implementation of proposed MPAs, but that the two scenarios follow the same trend for the duration length.

Figure 2: Survival Function for 3 eras of HELCOM Policy



In Figure 2, we see what happens to the hazard ratio in the three different HELCOM policy eras. In the pre-1994 time, when MPAs were not a priority and HELCOM was focused on preventing marine pollution, the function has a very different shape than any of the other survival functions modeled. Almost all of the MPAs proposed in the pre-1994 era take a very long time to be implemented. In the time between 1994 and 2003, which is after the 1994 shift in priorities but before HELCOM began cooperating with OSPAR, the functions follows a fairly typical trend that is close to the other moderate functions in Figures 1 and 3. However, after the 2003 conference when HELCOM began cooperating with OSPAR, we see that MPAs have a very short time between being proposed and implementation.

Figure 3: Survival Function for if all 3 EU Directives Apply or no EU Directives Apply to the MPA

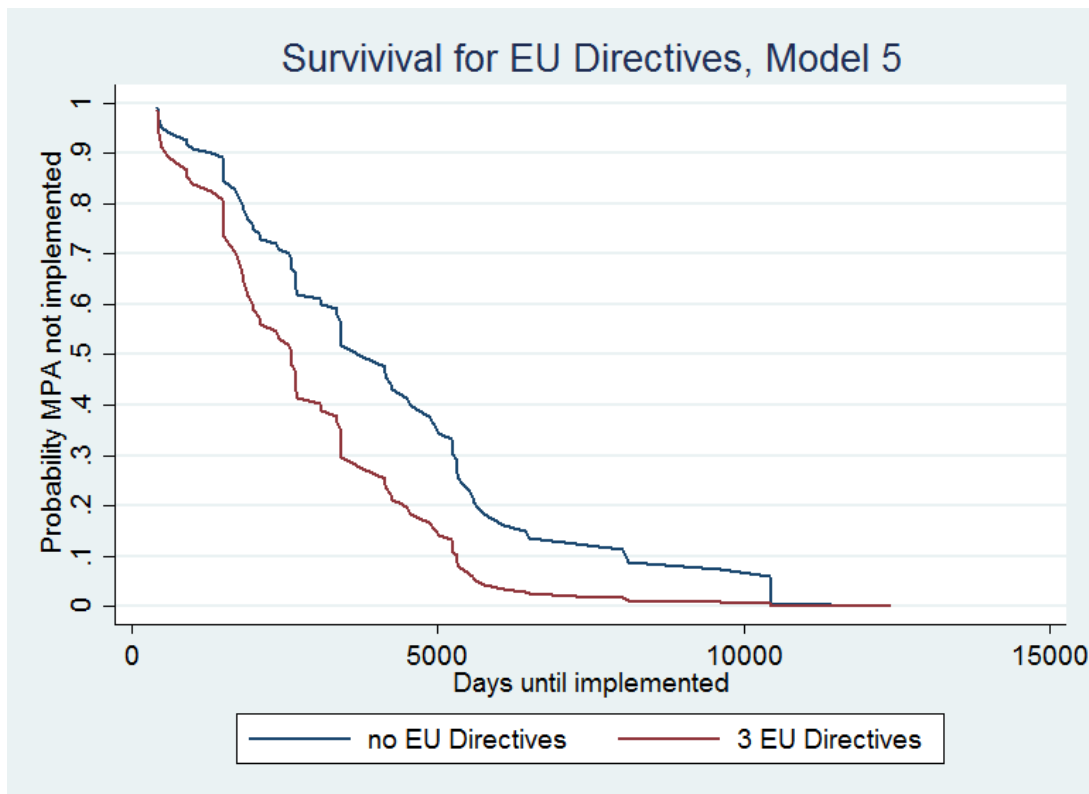


Figure 3 illustrates what happens when an MPA fulfills objectives in all three major EU directives (Habitat Directive Annex I, Habitat Directive Annex II, and the Birds Directive) versus when an MPA fulfills none of these directives. When the MPA helps objectives in all three directives, it leads to slightly faster implementation. However, this function serves to illustrate how small the effect of these three variables is- changing all three at the same time has a relatively small effect on the survival function. When only one directive is changed, so that an MPA fulfills one or two directives' goals, it has almost no visible effect on the survival function.

## Discussion

The results found through these analyses were surprising and unexpected- many of the variables that I expected to be significant were not, and some of the variables had unexpectedly large or small hazard ratios. However, even finding no results can tell something about the data. Each of the variables included in the six models reveals a key aspect of MPA implementation that can be further examined by future studies to find out why some MPAs are implemented while others are not.

### *OSPAR membership*

OSPAR member ship was expected to speed up the implementation time of MPAs because of the added weight of OSPAR to the effect HELCOM has in encouraging MPAs to be implemented, and this was supported by the data. All four of the models that contain the variable OSPAR have a hazard ratio of less than one for the variable, indicating that when a country is not part of OSPAR, it takes longer for MPAs to be implemented. Additionally, the effect was significant in models 2, 3, and 4. This suggests that the policies and directives of OSPAR do carry some weight in getting MPAs implemented; otherwise, there would have been no effect and no significance. The hazard ratios of less than one also show that the partnership between OSPAR and HELCOM is effective. Joint management by two regional bodies could lead to more complications for countries in implementing MPAs, or could send mixed signals as to what the MPA priorities are. Since OSPAR members implemented MPAs more quickly than HELCOM only members, this was not the case in the Baltic. Much of the literature about MPAs focused on the ability of EU directives to encourage MPAs and did not always support the efficacy of smaller regional bodies (von Nordheim, Boedeker and Krause 2006). This evidence does not



unequivocally show that OSPAR and HELCOM also carry significant weight in getting MPAs implemented, but OSPAR's significance is certainly supported by this data.

### *Russia versus EU Countries*

Russia is in the unusual position within the HELCOM framework of not being an EU state and therefore not being subject to EU environmental Directives, but being a signatory of HELCOM and agreeing to their policies. Because of this, I expected Russian MPAs to be implemented on a different, most likely slower, timeline than the rest of the countries' MPAs. The data supported a significant difference between Russia and the rest of HELCOM, and non-Russian countries' MPAs are implemented more quickly. The not Russia variable had a hazard ratio between 1.7 and 4.3 in all of the models, which could mean that other countries implement MPAs up to 4 times faster than Russia. However, there is a significant caveat to this result: there are only six Russian MPAs in the dataset of between 96 and 162 MPAs. Russia overall has fewer MPAs proposed than the other countries, and that lowers the number that are implemented and are available for this analysis. Russia's coastline also spans both sides of the continent, so it is possible that their marine protection efforts are focused on the Pacific side rather than the Atlantic side. Most analyses of the Baltic and overall European marine protection have very little information on Russian efforts; a recent WWF report had no data on how many Russian MPAs in the Baltic have management plans (WWF, 2016). Getting more data from Russia about their marine protection efforts seems unlikely, but a better understanding of Russian MPAs is necessary to implementing a coherent network in the Baltic.

### *Fishing Intensity*

Fishing intensity was expected to be a strong influence on MPA implementation because fishermen are one of main stakeholders who use the Baltic for commercial gain. I expected

fishing intensity to have an effect, although I was not sure what that effect would be because the economics-based literature is unsure whether fishermen do better or worse with MPAs in place. The actual result was surprising because fishing intensity had very little impact and was not significant in any of the models. The specific measure chosen for fishing intensity was the maximum surface fishing intensity. The maximum intensity was analyzed because the area with the most fishing in the MPA would likely influence the entire MPA's likelihood of being implemented, and averaging the intensity across the MPA would dampen that signal. The surface fishing intensity was used instead of subsurface fishing intensity because more surface than subsurface fishing occurs in the Baltic, so this would also be the stronger influence on if an MPA is implemented. The p-value for fishing intensity was never below the  $p < 0.1$  threshold and was generally above 0.2, so it never approached significance. Furthermore, the hazard ratio for fishing intensity was always around 1, which means it never had more than a very slight effect on speeding up the implementation of MPAs.

The insignificant results from fishing intensity could be a product of the mixed perception of MPAs by fishermen demonstrated in the literature. There have not been significant surveys of Baltic fishermen's response to marine reserves, but Zhang and Smith found mixed responses by fishermen when asked if reserves are a bad way to manage fisheries. 32 percent of the fishermen were uncertain, 28 percent agreed, and 30 percent did not agree (Zhang and Smith, 2011). There are many more factors to consider if fishermen's preferences for marine reserves are to be taken into consideration, including what their historical catches are near reserves and in general. Finding no significant effect from fishing intensity in this analysis may further illustrate the disparate responses fishermen have to marine reserves.

*Percent Coastal Population*

Percent coastal population was included as a measure for how much the general population may care about marine protection, as countries with higher populations near the coast could see more pressure from the electorate to implement MPAs. I did not expect it to have a significant impact on implementation duration because I expected fishing intensity to be a more important measure of people's interest; the average citizen does not have as big of a stake in marine protection as a fisherman. For the most part, coastal population did not show significance; in models 1 through 5, it did not reach the p-value threshold of  $<0.1$ , and the hazard ratios were slightly over 1. However, when fishing intensity was dropped in model 6, coastal population did reach the significance threshold. This time, the hazard ratio was 0.97, which means that having a high percent coastal population slightly slowed the implementation of MPAs. Having coastal population appear significance after fishing intensity was dropped from the model suggests that there could be greater interaction between those two variables than previously expected. Some linkage was expected, but very few Baltic countries have high coastal populations, which made me expect little interplay between fishing interests and coastal population interests. Still, with a hazard ratio so close to one and coastal population only being significant in model 6, it is difficult to conclude how important a high coastal population is to MPA implementation. The conclusion we can draw is that there could be unexpected connections between coastal population and other variables that require further exploration.

### *Terrestrial*

The terrestrial variable measured whether an MPA extended to the coast and the tidal region on land, which shows if the area is easily accessed by people for recreational use or not. Terrestrial was expected to be a significant variable because people are more likely to put on pressure for protecting environments that they can see and use, especially considering how few

HELCOM MPAs exclude all access. However, terrestrial conformed to those expectations in only a few of the models. The variable was significant in model 1 and model 4, both times with a hazard ratio around 1.5. Models 1 and 4 are the only ones to contain the date cutoff variables which delineate the different shifts in HELCOM policy. I would not expect those variables to interact significantly, but a possible explanation is that HELCOM's other priority of preventing marine pollution led to terrestrial areas being protected because it could help address the source of marine pollution from on land. The other four models did not have terrestrial as a significant variable, and the hazard ratios fluctuate between 1.4 and slightly less than 1. It could be that the terrestrial variable was not significant in changing the rate at which MPAs are implemented, but when the date cutoffs are present it makes it appear that the terrestrial variable is having a large impact. The inconsistencies with the terrestrial variable make it difficult to draw conclusions about what effect it is having on reserve implementation and, apart from the strategic framework's concern with pollution, there is very little literature to draw upon for why these results appear. However, marine spatial planning theory suggests that there should always be some reserves on the coasts and others in open sea, and it is especially important for EBM. This means that, whether or not the terrestrial variable is significant, there will be MPAs that fall into this category.

### *EU Directive Objectives*

The HELCOM database characterized MPAs on whether they fit the objectives of EU Habitat Directive Annex I, Habitat Directive Annex I, the EU Birds Directive, or some combination of the three. These variables were analyzed separately because the different objectives of each directive lead to different MPA characteristics being encouraged, which would put pressure on different MPAs to be implemented. Annex I is habitat-based protection, so

an MPA established to protect one of the habitat types listed in the directive would fall under this category. Annex II is species-based protection, which means an MPA that contains one or more of the species listed in the directive would be part of this category. The Birds Directive proposed special protection areas that would protect all species of migrating and native birds in the EU, so if an MPA contains bird habitat it would fall under this category.

The three directives had very different results in the different models. Annex II was the most significant; in four of the six models, it exceeded the minimum significance threshold. Directive II also always has a hazard ratio greater than one, which means MPAs that fall under Directive II are implemented more quickly; the largest hazard ratio for Annex II is 3.4, which means that in this model, being part of Annex II makes the MPA become implemented 3.4 times more quickly than other MPAs. It is interesting that Directive II is the most significant variable of the three because Annex II is species-based management. This goes directly against what the strategic plans for HELCOM and the EU, BSAP and MSFD respectively, strategize for effective marine protection. This suggests that species-level protection may be more effective for getting MPAs implemented than ecosystem-level priorities, possibly because it is easier to illustrate the importance of protecting an endangered keystone species, such as the grey seal, than the importance of a certain type of habitat in the larger scope of the ecosystem.

Annex I and the Birds Directive, while less frequently significant than Annex II, still give valuable insight to how EU directives affect MPA implementation. The Birds Directive was significant in model 1 and model 4 along with Annex II, except the Birds Directive almost always had hazard ratios less than 1. This means that the Birds Directive almost always slows down the implementation of MPAs. Annex I was only significant in model 5, and the hazard ratios varied significantly from 0.65 to 2.3. It is difficult to make any concrete conclusion about

Annex I from this data. However, considering Annex I is the habitat-based protection more closely aligned with BSAP and MSFD, not getting a clear result is important in this case. It could mean that the EU and HELCOM are not putting their rhetoric about EBM into practice, or that their efforts to protect marine environments based on EBM is not translating to domestic politics. Overall, the Birds Directive and HD Annex I did not have the significant effect that the literature suggested in speeding up MPA implementation.

### *Date Cutoffs*

The final set of variables in the models is the different sets of date cutoffs, based on shifts in HELCOM strategy. In the data, these are divided into MPAs proposed before 1994, which spans the beginning of HELCOM through 1994; MPAs proposed between 1994 and 2003, which goes from the reorganization of HELCOM in 1994 to 2003; and MPAs proposed after 2003, which goes from the first joint conference between HELCOM and OSPAR to the present. For two of these models, these were collapsed into just pre-1994 and post 1994. These variables were significant in every model they were included in, but every time they also had extremely high hazard ratios. The hazard ratios for these three variables range between 13.7 and 157, while the next highest ratio is 4.4. This means that these three time periods certainly have an effect on the implementation of MPAs, but the hazard ratios are so high that the effect is not likely to be exclusively from the shifts in HELCOM policy. One challenge in this regard is that the date cutoff variables are proxies for other time-dependent changes in the political economy. So, it is not possible to parcel out their explanatory power to specific causal mechanisms.

Another problem with these variables may be the different sample sizes between the date cutoffs. Between 1994 and 2003 has the most observations with 100 cases, after 2003 has 43, and before 1994 has 20. This means that after 2003 is most likely skewed by having a few cases

where the MPA was implemented extremely quickly. When the two are combined into pre and post 1994, post 1994 contains an overwhelming majority of the cases, so there is very little control to compare against. Despite these challenges in the data, the shifts in HELCOM policy are still likely to be important to MPA implementation. Each new set of priorities changes why MPAs were proposed and brought a spike in the number of MPAs proposed, both of which would affect how quickly states implement the new MPAs.

## Conclusion

### *Hypotheses*

The two broad hypotheses presented were that commercial interests and EU objectives would speed up MPA implementation due to the intrinsic pressure these two facets put on states to implement marine protection. For the commercial interests, the results were inconclusive. Fishing intensity did not have any significant effect in speeding up or slowing down implementation, and the percent coastal population only became significant when fishing intensity was removed. Further delineation between the different commercial interests, and including things like mineral and oil extraction and what specific areas are used for tourism could bring more conclusive results about this issue. It is important that the effect of commercial interests is included when finding out why MPAs are implemented because commercial interests do not always match up with conservation interests. The strength of commercial interests in affecting implementation could help managers ensure that the network planned will truly be implemented and managed.

The second hypothesis did have more conclusive results. Of the three EU directives, the most consistently significant effect on implementation came from Annex II, which is species-

based protection. This is in conflict with many of the past and current efforts to focus on EBM, which suggests that EU Directives may have less influence than many previously thought. The general insignificant effects of Annex I and the Birds Directive support this possibility. On the other hand, the effect of cooperation between OSPAR and HELCOM had a surprisingly strong impact on the results. Countries that were part of OSPAR implemented MPAs more quickly than ones who were not, and the final time period, post-2003, saw the most rapid MPA implementation. This means that regional agreements may have more effect than previously held, which is surprising given the little enforcement power these organizations have.

### *Broader Impacts*

Larger studies with more specific covariates and many more MPAs are needed before actual conclusions can be made about why MPAs go from proposed to implemented, but there are some aspects of this study that yield important inferences. For one, MPAs need to be better tracked from when they are first proposed to implemented to managed. This study had a severe lack of MPAs that were proposed but not implemented because, while the locations of some of these MPAs were found, the covariates such as what EU directive they fall under, if they include terrestrial area, and when they were proposed was nearly impossible to find for any. The fishing intensity data was a limiting factor in the number of cases the analysis used because almost 70 MPAs had no fishing intensity data available at any time, which is significantly more MPAs than are managed as no-take reserves in the Baltic. Better monitoring programs would not just ensure that MPAs are being managed effectively, but would also give more accurate insights into the political process of reserve implementation.

The main conclusion from this analysis that warrants more study is the effect of regional agreements on implementation. The variables in this study were only able to measure this



indirectly, through geographic characteristics and shifts in policy, but future studies may be able to more accurately compare the effect of regional agreements to the EU and broader international initiatives in marine protection. Cooperation is necessary to protect the ocean, so understanding how cooperation between states operates on different levels is key to ensuring that marine reserves are implemented and managed.

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## Appendix I: List of Abbreviations

BSAP- Baltic Sea Action Plan

CBD- Convention on Biological Diversity

CFP- Common Fisheries Policy

EBM- Ecosystem Based Management

EC- European Commission

EEA- European Environmental Agency

EEZ- exclusive economic zone

EU- European Union

HELCOM- Helsinki Commission, also known as Baltic Marine Environment Protection Commission

HD- Habitats Directive

IMP- Integrated Marine Policy

MPA- Marine Protected Area

MSFD- Marine Strategic Framework Directive

MSP- Marine Strategic Planning

OSPAR- Oslo and Paris Conventions, North-East Atlantic Marine Environment Protection Commission

RSC- Regional Sea Convention (includes HELCOM and OSPAR)

SACs- Special Areas of Conservation

SCI- Sites of Community Importance

SPA- Special Protection Areas

UNCLOS- United Nations Convention on the Law of the Sea

## Appendix II: Proportionality Hazard Tests

Figure 4: Proportionality Hazard Test for Fishing Intensity

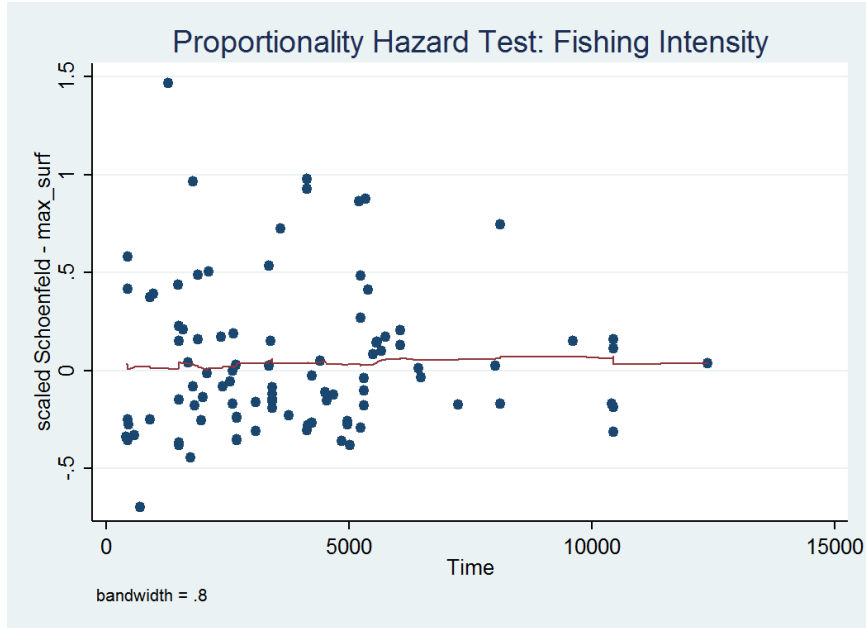


Figure 5: Proportionality Hazard Test for Terrestrial vs Non Terrestrial MPAs

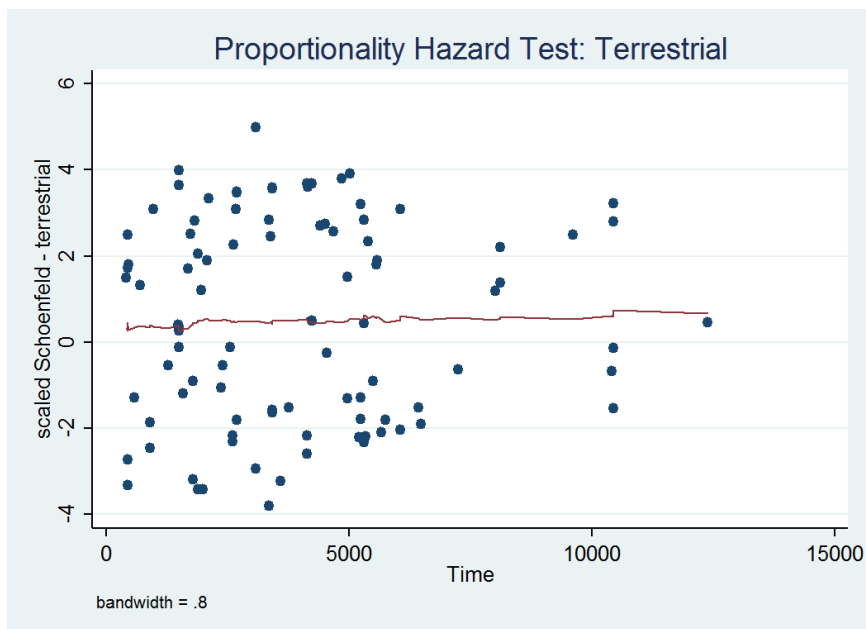


Figure 6: Proportionality Hazard Test for Birds Directive

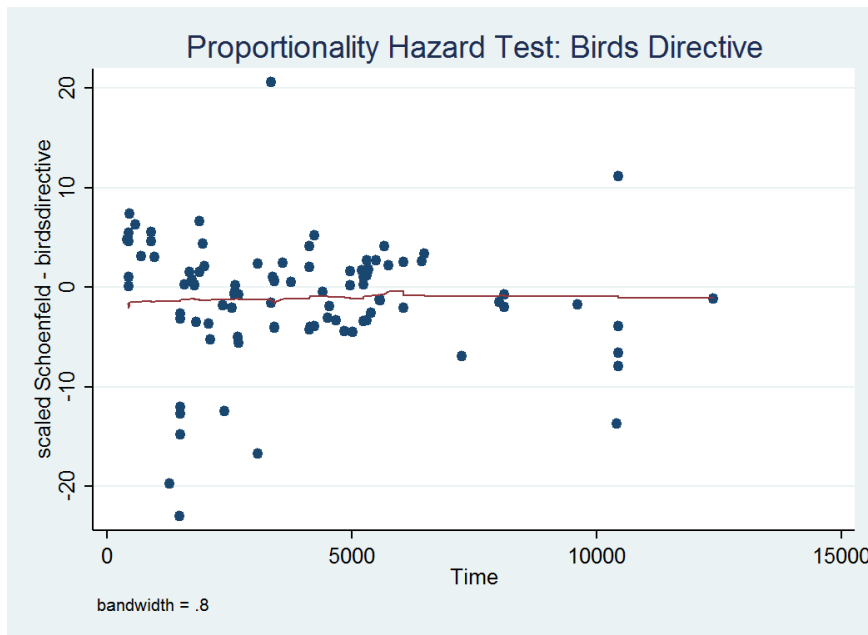


Figure 7: Proportionality Hazard Test for Russian vs Non Russian MPAs

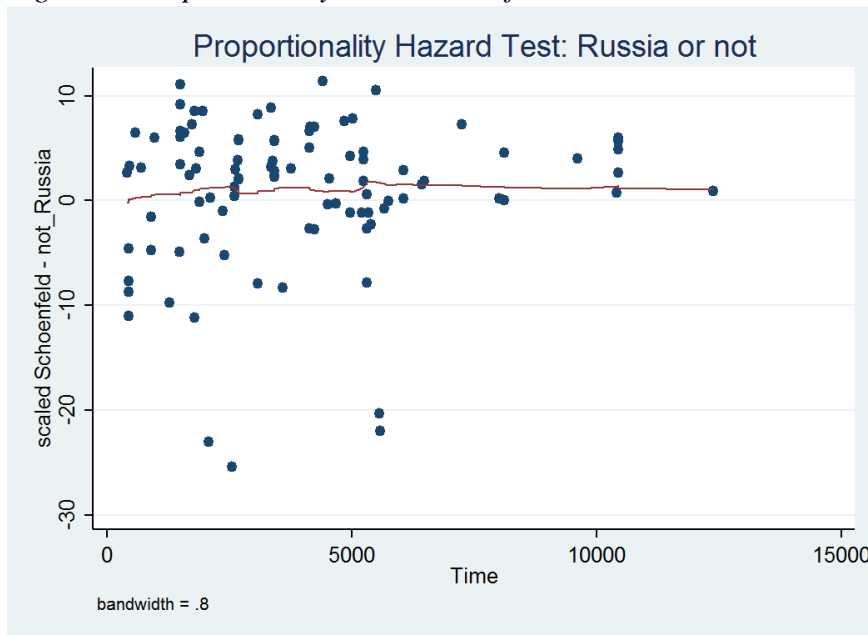


Figure 8: Proportionality Hazard Test for EU Directive I

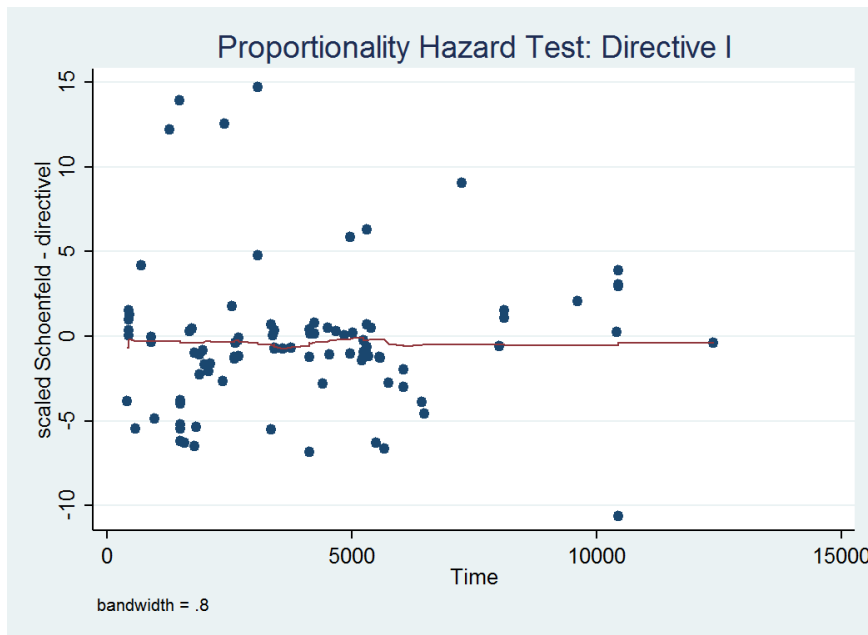


Figure 9: Proportionality Hazard Test for Terrestrial vs Non Terrestrial MPAs

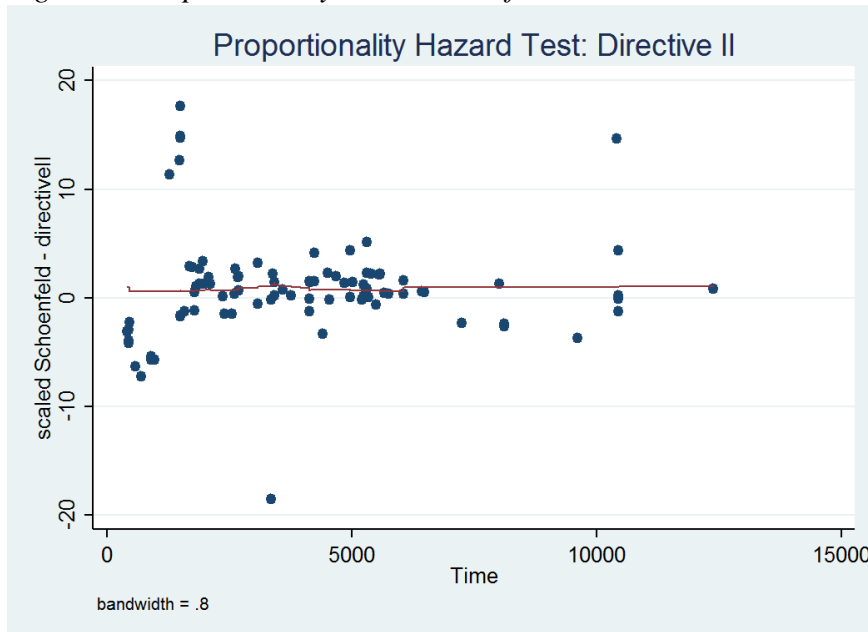




Figure 10: Proportionality Hazard Test for MPAs Proposed Between 1994 and 2003

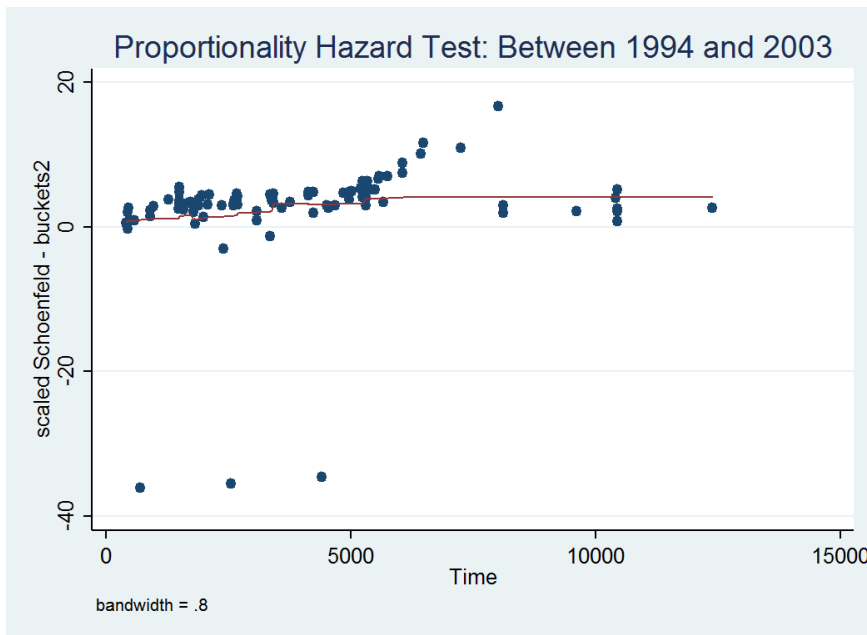


Figure 11: Proportionality Hazard Test for MPAs Proposed After 2003

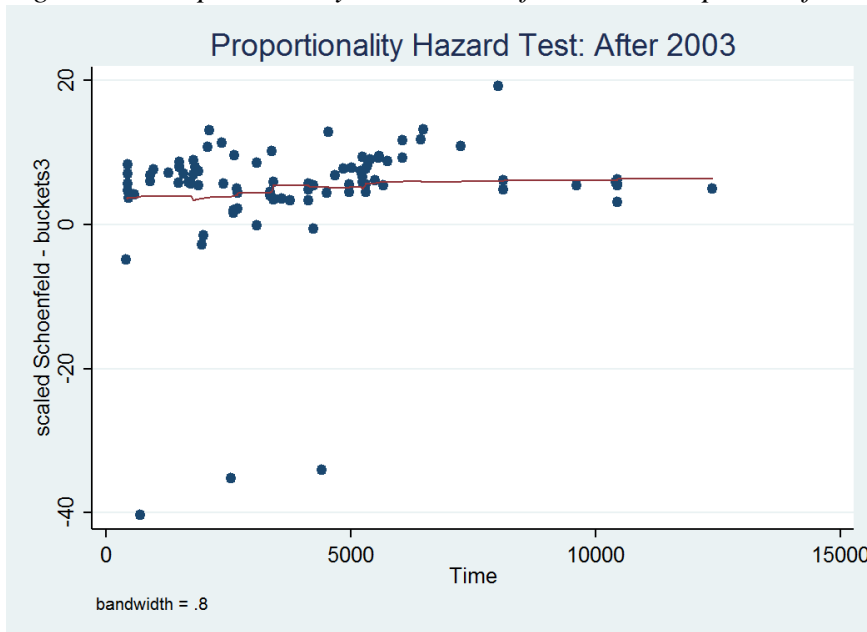


Figure 12: Proportionality Hazard Test for MPAs Proposed After 1994

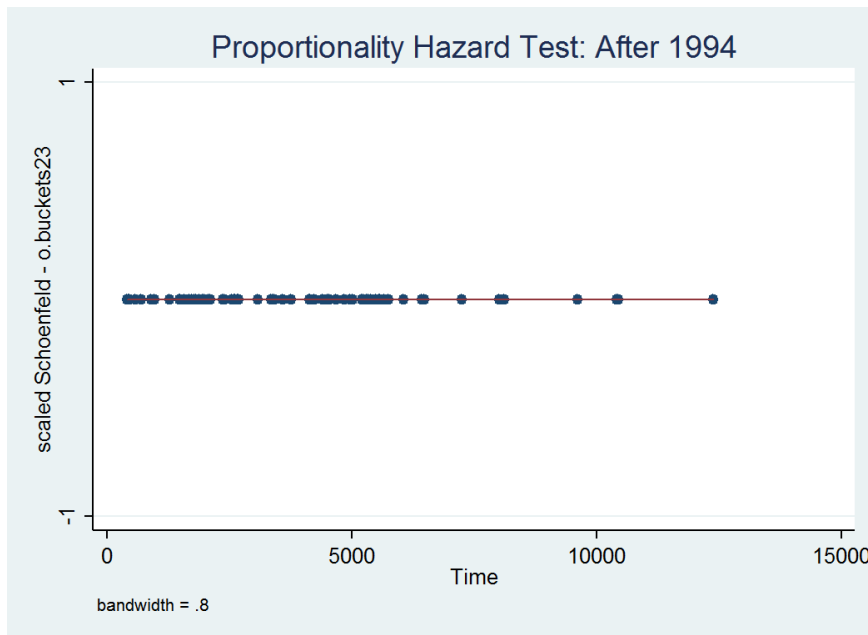


Figure 13: Proportionality Hazard Test for MPAs by Countries in HELCOM and OSPAR

