Marine protected area management in the Finnish Gulf of Bothnia

Connections between underwater nature, human activity and management

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Declaration

I hereby confirm that I am the sole author of this thesis and it is a product of my own academic research.

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Waltteri Niemelä
Abstract

Marine protected areas are important and useful tools of marine conservation. They have been found to positively affect biodiversity, fisheries, economy, and societies. These effects however are unlikely to become concrete without sound, rigorous management. This management should be based on the highest quality of knowledge on the site in question, taking into consideration the environment, economy, and society. Finland has been in the forefront of MPA establishment, reaching international coverage goals very early on. This thesis sets to assess if this relatively high coverage of MPAs is planned and managed well from the perspective of underwater nature. Nine MPAs were chosen from the Gulf of Bothnia, from various regions and ecosystem types, to study the level of protection in different sites, and get an overall image of the nationwide management approach. These sites were explored using data of ecology, human activity and management. The ecology was studied using the newly published data collected by the Inventory Programme for the Underwater Marine Environment (VELMU) of the underwater environment covering the Finnish Baltic Sea. Human activity data was then used to evaluate the pressures the areas face. The management was studied using any available account of the MPAs, including management plans and legislation applied to the sites. All this was pooled together to form a profile of the sites, which was then evaluated in its management efficiency. The MPA management at these sites was found to be general, with only three of them having a management plan and all of them being managed and regulated with legislation mostly. Further investigation of the management documents and legislation confirmed that the conservation action taking place in the MPAs mostly considered terrestrial and shoreline species, and birds, and largely disregarded the underwater environment. Hence most likely it does not protect the aquatic nature effectively. The effort already put into the MPAs in Finland shows promise of great potential and improvement, but more emphasis should be put on the protection of underwater marine species and habitats.
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Acronyms

BB = Bay of Bothnia  
BS = Bothnian Sea  
BSPA = Baltic Sea Protected Area  
CBD = Convention on Biological Diversity  
EEA = European Environment Agency  
EEZ = Exclusive Economic Zone  
EIA = Environmental impact assessment  
ELY Centre = Centre for Economic Development, Transport and the Environment  
EPA = Environmental Protection Act, Ympäristönsuojelulaki  
GoB = Gulf of Bothnia  
HELCOM = Helsinki Commission, also known as the Baltic Marine Environment Protection commission  
HD = Habitats Directive  
HMPA = HELCOM MPA, formerly known as BSPA  
LUBA = Land Use and Building Act, Maankäyttö- ja rakennuslaki  
MPA = Marine protected area  
MSFD = EU Marine Strategy Framework Directive  
MSP = Marine spatial planning  
MSPD = EU Marine Spatial Planning Directive  
N2K= Natura 2000  
NCA = Nature Conservation Act, Luonnonsuojelulaki  
NHS = Natural Heritage Services, Metsähallitus  
PA = Protected area  
SAC = Special Area of Conservation  
SCI = Site of Community Importance  
SPA = Special Protection Area  
WFD = EU Water Framework Directive
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1 Introduction

1.1 Marine protected areas as conservation tools

The European Environment Agency (EEA) defines marine protected areas (MPAs) as “geographically distinct zones for which conservation objectives can be set” (EEA, 2015). Their establishment and popularity as a conservation management tool has grown greatly in the past few decades. In the Baltic Sea, coverage of BSPAs (Baltic Sea Protected Areas) grew by 200% in 2004-2013 (HELCOM, 2013b). With growing global human populations leading to heightened pressure on marine ecosystems, there is also a growing need for ocean conservation and MPAs are useful solutions for this, if managed, planned and enforced properly. The Convention on Biological Diversity (CBD) is an international treaty covering global environmental conservation and restoration, signed in Rio de Janeiro in 1992 (SCBD, n.d.). The convention produced multiple goals and targets. One of these targets (known as “Aichi targets) included improvement of the coverage and quality of MPAs (Aichi target 11, (SCBD, 1992).

The Baltic Marine Environment Protection Commission (HELCOM) has Baltic Sea specific goals besides the Aichi targets of the CBD. Since the specific MPA coverage target of 10% protection was reached in 2010 (HELCOM, 2013b), HELCOM looks to improve the BSPA network further. In the Commission’s Recommendation 35/1 targets are set to reach 10% protection in each sub-basin of the Baltic Sea, and for the management of these areas to be developed and implemented (HELCOM, 2014). HELCOM also aims to improve the BSPAs in order to form a coherent network. The features of HELCOM’s own criteria for the coherence include:

- Representativity
- Replication
- Adequacy
- Connectivity (HELCOM, 2016)
These factors were assessed in HELCOM report in 2016. The report concluded the representativity and replication factors to be “at acceptable levels”, whereas adequacy and connectivity were deemed lacking (HELCOM, 2016). Whilst the Baltic Sea seems to be a front runner in MPA establishment, it seems there are points of improvement before a fully coherent network of reserves are reached.

MPAs can act as a sanctuary and a type of refuge for organisms as areas with little or no human impact (Stobart et al., 2009). One of the most researched results of this type of conservation is the increase in organism richness. A global review of MPA effects by Lester et al. (2009) showed a mean change of 446% in biomass, 166% in density, 28% in size, and 21% in richness in response ratios; and noted that whilst there is much variety, positive effects are more common than negative or no effects (Figure 1). The 'spill over effect', where fish densities increase outside the perimeters of the MPA, has been observed in many studies globally and can replenish and benefit a local fishery by creating a gradient of fish numbers outwards of the MPA (Harmelin-Vivien et al., 2008) An experimental study in Cuba found the emigration from the MPA to the outside areas to be twice as much as the immigration into the MPA (Amargós et al., 2010). Fish in MPAs have been found to grow larger and have increased reproductive rates (Gell & Roberts, 2003). Research also suggests that MPAs make ecosystems within them more resilient towards the effects of climate change (Hannah et al., 2007).
The Baltic Sea has a large amount and coverage of protected areas (Piekäinen et al., 2007). As one of the first seas to reach and surpass the Aichi target of protecting at least 10 per cent of marine areas (SCBD, 1992), the efforts by the Baltic Sea states as well as their cooperation is impressive. In 2015 however, the EEA stated that these numerous MPAs are inefficient in conservation. According to EEA, almost all protected areas in the Baltic Sea are too small, not managed efficiently, the connectivity within the MPA network is not cohesive, and there are not enough open sea areas protected (EEA, 2015). HELCOM has brought up similar issues in the BSPA network, specifically that of lack of management plans and the scarcity of regulation and prohibitions (HELCOM, 2013b), besides the ecological coherence inadequacies mentioned above.

The Baltic Sea faces a large number of challenges from different sources. Simply the fact that there are 90 million inhabitants in nine countries with coastline is a possible cause of
conflict. Organisations such as the Helsinki Commission (also known as HELCOM, or The Baltic Marine Environment Protection Commission) work to bring these states together and facilitate “[…] common environmental objectives and actions” (HELCOM, n.d.-a). The environmental issues in the Baltic Sea include eutrophication, hazardous substances (e.g. POPs and heavy metals), shipping and oil spills, energy-related activities, overfishing, invasive species, litter, climate change, and regime shifts (BalticSTERN, 2013).

Whilst the effort is impressive, there is the question if all this conservation is as the EEA suggests, ineffective. The need for improvements need to be specified and investigated especially in the light of numerous new legislation and conservation goals in recent times, as well as the year 2020 approaching, which is the year for many of these goals to be reached. Agardy (2000) emphasized the knowledge gaps present in MPA designation, management and placement. She stressed especially the biological information, but also the variety of information concerning the goals of the conservation action. Research on what makes an MPA efficient is abundant and diverse globally, but minuscule in the Baltic Sea. It is uncertain if the MPAs in Finland consider the underwater nature and ecology in their management or planning, making their usefulness as fully effective marine protected areas or as tools of nature conservation questionable. This questioning is based on the assumption that management seems to be low or non-existent and the data and knowledge of underwater nature is relatively new. Due to the lack of research on both the effects and benefits of Finnish MPAs, and the justification of conservation action, the level and efficiency of conservation of the underwater nature is uncertain. The connection between management and scientific knowledge and underwater ecology is something this thesis sets out to explore.

1.2 MPAs in Finland

Finland has a large role in the conservation of the Baltic Sea, with having a major proportion of the coastline (~1,250 km.), and being a key player in cooperative efforts to improve the state of the sea. There is a large number and variety of protected areas in Finnish waters. In 2013, 9.5% of the seas including EEZ were protected and 14.6% of the territorial seas (Blankett, 2013). This includes Natura 2000 areas, Ramsar sites, national parks, government and privately owned conservation areas, and HELCOM MPAs (Blankett, 2013). Areas often overlap, making one specific location able to contain
multiple different types of protected areas. HELCOM stresses the importance of creating and implementing management plans in these areas (HELCOM, 2013b) whilst the common scientific consensus, along with the European Commission and various conservation organisations agree and demand the coverage of MPAs to be 20% (WWF, 2010). Natura 2000 areas (Figure 2) and HELCOM MPAs (formerly BSPAs) have the largest coverage (Blankett, 2013).

Natura 2000 (N2K) sites are nature protection areas that aim to “ensure the long-term survival of Europe’s most valuable and threatened species and habitats” (EC, 2016b). The N2K network is subject to the Habitats Directive (HD), under which Sites of Community Importance (SCIs) are proposed and designated by Member States. Under the Directive, specific species and habitats to be protected are listed in different Annexes and measures are to be taken in order to protect them. Proposed and accepted SCIs can be designated to become Special Areas of Conservation (SACs) (EC, 2016a). These areas under the HD focus on the existence of habitats, species and specific features which form the basis of decision-making. Key-species, ecosystem functioning and local importance are not taken into account.
Figure 2 Natura 2000 sites in the marine and coastal areas of Finnish and Åland territories
HELCOM MPAs (HMPAs) on the other hand have a more overarching list of selection criteria of establishment. Based on the Joint HELCOM / OSPAR Work Programme on Marine Protected Areas (Bremen, 2013), the objectives and criteria includes aspects such as high biodiversity, importance and uniqueness of species and habitats, ecological significance, and threatened and declining species and habitats (HELCOM, n.d.-b). The HELCOM criteria also include the Birds and Habitat Directives by stating the habitats and species in the specific HD Annexes as something to protect. Other conservation goals, objectives and policies come from entities and treaties such as: The Convention on Biological Diversity (CBD), The EU Biodiversity Strategy, EU Marine Strategy Framework Directive, and national legislation.

Preparing management plans and the approach to the conservation is the responsibility of the separate authorities managing the MPA. HELCOM, whilst not providing rules that apply to all HMPAs, provides information and guidance on effective and good management and planning processes (HELCOM, 2006). Natura 2000 areas also have no set restrictions of activities for example, but there are provided guidelines and examples of good management available. These rules and restrictions will be made according to the threats and aspects of each separate MPA.

The large variety, number and coverage of MPAs in Finnish waters need effective planning and management in order to be a useful asset to Finnish nature conservation. Any environmental conservation requires diligent management regimes and clear development strategies in order to be effective (Kelleher & Kensington, 1991). These aspects of MPAs are often lacking and oftentimes can even be non-existent. In some cases even with specific legislature there is a discrepancy between enforcement and planning (Jennings, 2009). In a report on Europe’s MPAs, EEA (2015) raised issues of especially size, isolation and enforcement connected to European MPA network. The NEOLI features are five parameters of MPAs that relate to the effectiveness of the conservation: no-take, enforcement, age, size, isolation. Theorized and studied in Edgar et al. (2014), they are considered to be both good assessment factors, as well as general overarching requirements for MPAs that should be implemented, if the goals of the conservation of said areas are to increase the overall ecosystem health and quality. When three or more of these fulfil certain criteria, the protection of the area will yield results. MPAs should be no take areas, be well enforced and managed, be older than ten years old, larger than 100km², and
spatially isolated. Although not the main focus of this thesis, these factors are good indicators MPA functionality.

Finland’s MPA network spans the entire coastline and the Finnish Baltic Sea areas. This makes the development of an MPA network that works in its conservation goals, and is cost-efficient in its management, both challenging and important. The environmental gradients in the Baltic Sea and the different habitats require adaptive management that conserves all types of the underwater nature, whilst simultaneously being clear, concise and thorough. Recent and long-term advancements in marine science have created and developed a strong basis for the possibility of the interdisciplinarity of science and management. The question is, whether this basis has fully been taken into account.

1.3 Legislation behind Finnish marine protected areas

The MPAs in Finland are under various legislatures that govern their management and give the conservation a possible legal standpoint. This can be considered highly beneficial or possibly counterproductive to the management efficiency of the MPA. The latter is something witnessed in many MPAs around the world in the form of paper parks, and even in the Baltic Sea, according to the ocean conservation organization Oceana (Paulomäki et al., 2014). This section will shortly describe these statutes and legislatures and explore how they affect MPAs specifically. Note that in multiple cases in this section, some English translations are made by the author, when an official translation has not been found. Finnish titles and names, as well as legislate codes are provided throughout.

1.3.1 Nature Conservation Act (1996/1096)

The Nature Conservation Act (NCA, “Luononsuojelulaki”) of Finland is a law used to govern various issues regarding the Finnish nature. The act states its goals to be:

1. To maintain biodiversity
2. To cherish aesthetic values of natural and scenic beauty
3. To support sustainable use of natural resources and environment
4. To increase knowledge of nature and general nature recreation
5. Promotion of research of nature
With 12 chapters and 77 sections it outlines the legalities of the conservation and restoration of nature and scenery, and provides official definitions and meanings.

Protected areas are specifically dealt with in Chapter Three of the act, titled “Nature reserves and natural monuments”. It lists national parks, nature reserves and other nature conservation areas; ‘nature reserve’ (“luonnonpuisto”) being a specific type of a PA often conserved for research purposes. In §13 the NCA lists various activities as prohibited in the areas legislated by the act:

- The construction of buildings, structures and roads
- The extraction of soil and minerals and damage to the soil and bedrock
- Canalization
- Take or damage fungi, trees, shrubs or other plants and their parts
- Catch, kill or harass wild vertebrate animals or destroy their nests; or catch or collect invertebrates
- Practice other activities that adversely affect the area’s natural conditions, scenery or survival of organisms

§14 goes into exceptions to the restrictions set in §13. It lists two exceptions specifically applicable to the marine environment: (exception 5) fishing is allowed under the Fishing Act in accordance with general fishing rights (“yleiskalastusoikeus”) as is the maintenance and upkeep of maritime safety infrastructure and transport channels, and small scale dredging required for these activities. In §7 of the Fishing Act it states that anyone is free to angle fish and ice fish herring (Clupea harengus membras) with a single vertical line with no fees, with exceptions in specific areas such as those where fishing has been prohibited ("Kalastuslaki," 2015).

§ 15 list exceptions to the set restrictions, which are subject to permits. These are not to interfere with or jeopardize the goals of the establishment of the PA. Activities that may be allowed with permit include:

- Extracting and collecting resources (living or non-living) for research or other scientific purpose, or for education
- Lower the threat created by alien species, or other possibly threatening species
- Remove game that outside the PA could pose a threat to human safety or property
• Take custody of dead game in the area
• Fish in other ways than in §7 of the Fishing Act (see above)
• Build infrastructure related to reindeer herding
• Conduct geologic survey and search for ores
• Land with an aircraft
• Maintain and upkeep structures and infrastructure

§17 provides rules more specifically for other types of PAs (than national parks and nature reserves). Its first section states that the previous rules and regulations (above, §13-15 and §16 section 1), unless stated otherwise. The fourth section of §17 deals with fishing. It states that in a PA fishing is allowed according to §8 section 1 of the Fishing Act; meaning anyone with permits and paid fees can practice fishing. However the Finnish Government can form restrictions on fishing in areas if it threatens the goals of establishment of the PA, and these restrictions can be spatially and temporally varying. These restrictions are often made on case by case basis, and are often connected to migratory paths of specific species (ELY-Keskus, 2016)

§18 presents the rules for movement within PAs. It is stated that only designated areas, roads and paths are allowed for access, set by the specific responsible authority. It is also stated that these prohibitions and restrictions are to be set in the document of establishment or codes of conduct. §19 speaks of the management plans (“hoito- ja käyttösuunnitelma”). It states that they must be drafted for national parks and can be done for other types of PAs as well. §20 says the same thing about the code of conduct (“järjestysäännöt”). These two differ in the sense that the management plan is directed more towards the management and official side of the PAs, whereas the codes of conduct are directed towards all users, specifically the general public.

Chapter 4 is titled “Protection of biotopes” and its first section §29 lists the biotopes\(^1\) that are to be conserved. The nine that are mentioned, whilst they include sandy beaches in their natural state, seaside meadows and sand dunes with little or no trees, do not include underwater marine areas of any kind.

\(^1\) “Biotope” is a term the Habitats Directive uses in place of “habitat”
Chapter 5, “Protection of organisms”, sets the legislation for protected species. Its statutes however do not apply to commercial fish stocks (§37). Protection of plant species is set so it is forbidden to pick, collect, and cut or in other ways harm a protected plant species (§42). This is especially important in many of the MPAs in Finnish waters.

Chapter 8 (“Prohibition measure, constraints and sanctions”) §55 states that the Centre for Economic Development, Transport and the Environment (ELY Centre) can prohibit activities threatening the conservation goals for up to two years. §57 obligates the ELY Centres to take action to minimize or prevent threats and harmful impacts to the environment as soon as possible, with sanctions and counter-action. The NCA gives no direction or examples of these.

Specific regulation and rules for the Natura 2000 network are provided in Chapter 10. This includes the SPAs under the Birds Directive and approved and established SCIs under the Habitats Directive. §64 forbids the significant impairment of the natural values and 65 § requires the assessment of the impacts, if an undertaking (building, extractive activity etc.) threatens these values. The fulfilment of the Natura 2000 sites and their goals must be pursued by official agencies (such as the NHS and ELY Centres) according to 68 §. This should be done via management plans and codes of conduct.

1.3.2 Land Use and Building Act (132/1999)

The Land Use and Building Act (LUBA, “Maankäyttö- ja rakennuslaki”) aims to organise the use or space in a way that keeps development ecologically, economically, socially and culturally sustainable. The spatial planning of the use of areas has goals concerning interactive planning and assessment. The goals related to the environment are:

- to conserve biodiversity and other natural values
- to promote nature conservation and minimise environmental threats and damage
- the sparing use of natural resources

LUBA deals largely with the spatial placement of a variety of different zones, not only concerning the environment, but also of urban planning etc. This section will cover and summarize the parts relating to the marine environment and possibly the management of MPAs.
In the general plans ("yleiskaava") for a municipality, the ecological resilience must be taken into account (§39), and the general land use plan can even be used to restrict or prohibit the use of or construction in an area where it could be deleterious (§41).

Chapter 8a is titled “Marine spatial planning”. This chapter is a recent amendment to the statute, added in summer of 2016. Although a short chapter, it lays out information and regulation on the purpose, content and process of a marine spatial plan (MSP). It defines an MSP similar as the previous parts of LUBA define as spatial planning, but in a marine and coastal context. This includes but is not limited to the planning and assessment of marine based human activities, such as shipping, energy, fishing, recreation etc. §67 c calls for the possibility for stakeholders to be part of the planning of the MSP and §67 d requires the plan to be available online for anyone.

Special regulations concerning the coasts and coastal areas are dealt with in Chapter 10. Any building or construction happening in the coastal zone must be in accordance with the general plan, or allowed by it via permits. This however does not include construction necessary for the fishing industry and maritime traffic. Concerning residential infrastructure in the coastal zone, §73 states that environmental protection and conservation are to be considered when planning for an area. A (coastal) land owner may also create and submit a plan of their own, although it must be in accordance or complementary to the general regional plan ("maakuntakaava") (§74).

Chapter 10a speaks of wind power, and the specific regulations with regards to building infrastructure related to it. However the chapter is short and sets out few guidelines, besides that the construction of wind power structures should be coherent with the environment.

1.3.3 Water Act (587/2011)
The Water Act ("Vesilaki") aims to

- Promote, organise and integrate the use of water resources and the aquatic environment in a socially, economically and ecologically sustainable way
- Prevent and minimise negative impacts caused by the use water and the aquatic environment
- Improve the state of water resources and the aquatic environment
§11 in Chapter 2 of the Act, prohibits the endangerment of certain types of biotopes. These are lagoons, flads and springs of less than ten hectares. In chapter 3, §2 the detrimental change of nature is deemed prohibited without an official permit, as are activities harmful to fishing and fish stocks. Some activities always require a permit (chapter 3, §3). These include, but are not limited to, the transformation of a major transportation channel, performing large dredging activities and dumping of dredged material, and taking soil from the bottom of an aquatic area for anything but normal household use.

Chapter 10 deals with aquatic shipping channels. This chapter mostly involves rules and regulations about establishing a shipping channel and the infrastructure and processes involved. However §4 states that shipping channels can be slightly changed, if there is an important justification, an example being the upkeep of maritime safety.

1.3.4 Environmental Protection Act (86/2000)

The Environmental Protection Act (EPA, “Ympäristönsuojelulaki”) aims to *inter alia* prevent environmental pollution and the threat of, prevent and minimize threats caused by pollution, prevent environmental damage, promote the sustainable use of natural resources and decrease the amount and harmfulness of waste. It is to be applied to industrial or other activity that cause or may cause pollution in the environment. It is applied to some MPAs in Finland in their management. The legislation deals with emissions and discharges that it defines as an impact caused by humans as matter, energy, noise, vibration, radiation, light, heat or smell, led into the environment (air, water or soil).

The EPA requires operators to act precautionary to prevent environmental damage, or at least minimize it. Specifically of interest with regards to this thesis; aquaculture is included within these operations. Although there is no mention of PAs specifically, §11 says that the source of pollution should be spatially placed considering the minimisation of the impact.

§18 has specific restrictions concerning the sea. The first subsection states that activities that may harmfully impact the seas outside the Finnish EEZ are prohibited in all areas in Finland. Dumping and release of substances of any kind (besides snow) is prohibited. However the placement of dredging material is governed in the Water Act.
1.3.5 EU directives relevant to MPAs

The Finnish MPA management and establishment follow the EU-directives and agreed treaties. This thesis deals specifically with Natura 2000 sites (although as discussed above, there is a large amount of overlap with other types of PAs), which cover more area than the other types (such as HELCOM MPAs, private PAs etc.) (Blankett, 2013). These areas are based on the EU Habitats and Birds Directives, which both have unique features and requirements for the PAs established under them. Sites of Community Importance (SCIs) are established under the Habitats Directive (HD) (EC, 2016a). As the name suggests, the directive focuses on the conservation of natural habitats (whereas the Birds Directive focuses on birds and their habitats), and areas that support ecosystems altogether (EC, 2016a).

The HD lists species and habitat-types (referred to sometimes as “biotopes”), out of which nine are marine, Annex II species (about 900) which inhabit the SCI areas, Annex IV species (over 400, but overlaps with Annex II species) which require strict and effective protection across EU, and Annex V species (over 90) that require protection in specific Member States (EC, 2016a).

Article 12 of the HD states: “Member States shall take the requisite measures to establish a system of strict protection for the animal species listed in Annex IV in their natural range, prohibiting:

   a) all forms of deliberate capture or killing of these species in the wild
   b) deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration
   c) deliberate destruction or taking of eggs in the wild
   d) deterioration or destruction of breeding sites or resting places” (EC, 2016a)

The HD places a large amount of responsibility to the Member States. Article 6 states: “Member States shall establish the necessary conservation measures involving, if need be, appropriate management plans specifically designed for the sites or integrated into other development plans” (EC, 2016a). This means that the EU and the Directive give no direct conservation orders, but trusts in the Member States’ assessment of the conservation and the management of said habitats and species. This is protocol for EU directives, which are
goals that Member States should achieve, but they themselves will implement these goals into legislation (EUROPA, n.d.).

The EU Water Framework Directive (WFD) (Directive 2000/60/EC) aims to improve and maintain the status of European water bodies in a variety of criteria (biological, chemical and physical) ("WFD," 2000). The directive is extensive and comprehensive, dealing with a variety of topics and issues. Article 6 is titled “Register of protected areas”, and calls for the registration of “areas lying within each river basin district […] requiring special protection” ("WFD," 2000). Furthermore, Annex IV lists areas that should be in said register, including areas designated for economically important species and areas designated for conserving habitats and species, specifically where the protection of the water status is key to the conservation ("WFD," 2000).

The Marine Strategy Framework Directive (also referred to as Marine Directive and MSFD, Directive 2008/56/EC) further aims for the protection and improvement of European water bodies, building on the basis of the WFD, but placing a large emphasis on the socio-economic side of the marine sector and water based human activities ("MSFD," 2008). Its statements of MPAs include promoting the CDB goals and the Habitat and Bird Directives of the EU, as well as stating that these goals and actions promote the aims of the MSFD but it mostly provides no input of its own to the matter.

The Marine Spatial Planning Directive (MSPD, Directive 2014/89/EU) aims to promote and build the basis marine spatial planning (MSP) in European seas. Its most important decree is the requirement for Member States to develop and enforce marine spatial plans by 2021 ("MSPD," 2014). It lists protected areas and conservation sites as one of the areas of consideration in making plans ("MSPD," 2014). Whilst the Directive gives no direct specific directions for the establishment of MPAs it does give recommendations on the approach to formulating and implementing their management plans. Most importantly it calls for consideration from all aspects of maritime activities and sectors, i.e. the management and planning should be overarching, including all viewpoints and uses of areas, as well as use the best information possible to make decisions regarding spatial planning ("MSPD," 2014).
1.4 The Baltic Sea environment and nature

The Baltic Sea is a shallow brackish water body in Northern Europe, reaching 53°-66° N and 10°-30° E. There are 9 countries with coastlines on the Baltic Sea: Finland, Sweden, Denmark, Germany, Poland, Russia, Lithuania, Latvia, and Estonia. The sea can be divided into sub-basins, out of which Finland has territories and EEZ on the Bothnian Bay, the Bothnian Sea, the Gulf of Finland, the Archipelago Sea and the Northern Baltic Proper. There is a seawater input source from the North Sea through the Danish Strait, and freshwater inputs from rivers from all around the coastline. The water exchange with the North Sea in the Baltic Sea is generally low, making pollution related pressures, such as eutrophication and hypoxia, very serious threats (Conley et al., 2009). Eutrophication and its related impacts are discussed often and it is often regarded as the most severe and pressing threat of the Baltic Sea (HELCOM, 2009a).

The salinity gradient of the Baltic Sea is one of the most important determinants of its ecology. The salinity decreases with the distance to the North Sea, making the sea brackish. This also results in a gradient of marine species and freshwater species, as well as clear boundaries and ranges for marine species such as bladder wrack (*Fucus vesiculosus*), blue mussel (*Mytilus edulis*), vendace and *Crangon crangon* (HELCOM, 2009a). Large inflows of saline water from the North Sea (sometimes referred to as ‘saline pulses’), have an effect on the biota of the Baltic Sea, with more marine species in different areas, as well as new, oxygenated water (MacKenzie et al., 2007). The northward temperature gradient creates variation in the conditions. Other species are dependent on the winter sea ice, whilst others may be unable to inhabit the colder regions of the sea.

The Gulf of Bothnia (GoB) is the northernmost part of the Baltic Sea, with coastline belonging to Sweden and Finland. Being furthest from the Danish Strait (the opening to the sea, and the source of saline seawater), and the northernmost part, it faces challenging environmental conditions. This includes the high gradient in salinity (0-6 per mille) and strongly seasonal weather conditions, with ice, snow and wind conditions changing throughout the year (Sörlin, 1982). As a result, there is a large variety in the ecology of the GoB, and many species are observed to have their range limits in the area as well as transitional zones and mixes of communities, with marine and freshwater species (HELCOM, 2009a).
1.4.1 Habitats and species

The Finnish Baltic Sea consists of bed rock, hard bottom complexes, sand, hard clay and mud seabed sediment types (HELCOM, 2009a). The Bay of Bothnia has a high coverage of sandy seafloor, where the Bothnian Sea has hard clay, but both have hard bottom complex and mud sediments. Out of the Natura 2000 habitat types, sandbanks, estuaries, coastal lagoons, large shallow inlets, reefs, Baltic esker islands and Baltic narrow inlets are present, and out of which all are endangered according to HELCOM 1998, and none are under ‘favourable conservation status’ (HELCOM, 2009a). The Gulf of Finland and the Bothnian Sea have a slightly higher salinity with 5-7.5 psu, compared to the Bothnian Bay < 4 psu (HELCOM, 2009a). These factors create what is often referred to as a ‘biogeographic boundary’ at the Quarken area, in the middle of the GoB. Due to the rapid land rise (~1 cm year-1), the GoB is changing constantly, along with the coastline and its associated nature (SYKE, n.d.).

HELCOM (2012) reported on the number of species in the subregions of the GoB as follows:

- Bay of Bothnia: 289
- The Quark: 313
- Bothnian Sea: 383

Ojaveer et al. (2010) reports on the number of macrozoobenthos taxa in the GoB sub-regions (different division to HELCOM, the Quarken is not considered as a separate region):

- Bay of Bothnia: 29 marine, 96 freshwater (125 total)
- Bothnian Sea: 44 marine, 77 freshwater (121 total) (Ojaveer et al., 2010)

The common substrate in the Bay of Bothnia is sand, with rocky coastline, which along with the winter conditions of cold temperatures and high ice cover, determine the distribution of species in the Bay (SYKE, n.d.). The underwater fauna is mostly molluscs,
bivalves and oligochaetes, and common flora includes *Cladophora* (algae), *Ceramium tenuicorne* (algae), *Chara* species (algae, also referred to as Charophytes), *Ephydatia fluviatilis* (a type of brackish water sponge) and various vascular plants, which are mostly found in more sheltered areas, for example inlets, lagoons and near the shoreline (SYKE, n.d.).
2 Literature review

The interest in MPAs has been growing as their number and coverage has increased. With goals such as the CBD Aichi target 11 of 10% of marine areas under managed conservation (SCBD, 1992), and furthermore the HELCOM targets of reaching a 10% coverage per sub-basin and increase of off-shore areas (HELCOM, 2013b), the need for information and research about MPAs from all aspects is high. This chapter will cover and explore the background context of the study topic, ranging from MPA management, planning and marine ecological sciences in Finland. The aim of this section is to find what kind of information is already known and studied, and what the knowledge gaps are.

2.1 Research and surveying of Finnish underwater nature

The Finnish Inventory Programme for the Underwater Marine Environment, VELMU has increased knowledge of the Finnish underwater nature greatly. Started in 2004, this nationwide project set out to survey the geologic and biological environment specifically areas under human impacts and of presumed high underwater biodiversity (Viljanmaa & Viitasalo, 2016). This consisted of the coastal and marine areas of the Finnish Baltic Sea, excluding the Åland archipelago and was done by various sampling methods. Most of the sampling points came from underwater videos (either drop-video or ROV) but physical samples of the benthos were also taken for analysis, as well as SCUBA diving transects. The species and habitats were identified from the videos, or, in the case of the diving transects, by the diver underwater.

The Baltic Sea as a whole is a highly studied area, but data and knowledge can often be somewhat dominant in certain areas, and lacking in others (Ojaveer et al., 2010). Can the existing data be used in the management and planning of MPAs and more importantly, has it been used in the process? HELCOM and other parties have surveyed and reported on the status of different biotopes in the Baltic Sea and connected it with assessments of the human impacts, classifying them into a ‘Red List’ according to their level of endangerment (HELCOM, 2009a). HELCOM also noted that “At this time, there are no long-term data available allowing an analysis of trends in the status of the habitats of the Baltic Sea” (HELCOM, 2009a), which suggests that there has not been an adequate amount of information to perform and analysis of the effects of the MPA designations.
2.2 MPAs in Finland

2.2.1 Numbers and statistics
Finland’s MPA network is relatively high in coverage and number of sites. 14.6 % of territorial waters are classified as protected areas (9.5 % if EEZ is included). This consists of different types of MPAs, which are: Natura 2000 sites (12.7 %(territorial)/8.3 %(territorial + EEZ)), Ramsar sites (3.3 %/2.2 %), National parks (2.8 %/1.9 %), sites on government or privately owned areas (2.2 %/1.45 %), and BSPAs (10.2 %/6.7 %) (Blankett, 2013). These sites overlap and a geographic area may be officially classified as multiple different types of MPAs.

In the Gulf of Bothnia, the coverages vary between regions. They are as follows (calculated by author, EEZ included):

- Bothnian Bay: 3.8 %
- The Quarken: 21.5 %
- Bothnian Sea: 4.4 %

The overall coverage of the MPAs in the GoB is 6.5 % of the marine area. This is close to the coverage of the overall Finnish marine territories, however less than the conservation goals of the CBD. The Quarken noticeably raises the total average, whilst the other two regions stand out lower in MPA cover.

2.2.2 Management of Finnish MPAs
HELCOM in 2013 found 65 % of BSPAs to have a management plan in action, and 9 % to have none even in preparation (HELCOM, 2013b). For Finland, this amount is about 11 % (HELCOM, 2013b). The question of the plans’ applicability to the marine areas (as many MPAs have both terrestrial and aquatic areas), and whether the management efficiently covers the marine realm has also been raised, along with the consideration of the restriction of human activities within the MPAs and how they vary (HELCOM, 2013b). An Oceana report in 2014 noted that less than half of the marine Natura 2000 sites in the Baltic Sea have management plans and that there are no offshore MPAs (Paulomäki et al., 2014). The report also criticises the lack of management and information on the control of fisheries related and connected to MPAs.
Planning, management, and enforcement of Finnish MPAs is under the authority of Parks & Wildlife Finland (“Luontopalvelut”) within Metsähallitus (“Administration of Forests”), which is a state-run enterprise that works under the Ministry of Agriculture and Forestry and the Ministry of the Environment, and manages and performs administrative duties related to natural resources (Metsähallitus, 2016).

The basis for Finnish protected area management is the Protected Area Management Principles; a guideline document published by Metsähallitus and updated every 2-3 years (Metsähallitus, 2014). It outlines the legislation, terminology and state of protected areas at the time of writing. The implications of different types of protection classifications are presented and what this means for the regulation and the management of the site. The document also outlines the preferred guidelines for the planning and management of MPAs, and the goals and objectives of the sites under each protection scenario. This refers to the legislation and conservation programmes in place under different protection scenarios. The Nature Conservation Act (“Luonnonsuojelulaki” 1996/1096) is most commonly referred to, as it lays down the legal framework under which PAs operate. Some sites have individual management plans, which contain a more detailed account of the allowed activities as well as spatial and temporal restrictions in the area. Management plans are mandatory for national parks, and optional for other conservation areas (“Luonnonsuojelulaki,” 1996).

Evaluation, assessment and monitoring of MPAs is discussed and presented in little literature there is concerning the Finnish MPA network. Metsähallitus ordered an official evaluation of the performance of the protected areas of Finland (Management Effectiveness Evaluation, MEE). This report however included very few marine areas, including only four national parks (Gilligan, 2005). The report however acknowledges that many Natura 2000 sites are merely proposed to be protected, but not established nature reserves. This means the PA establishment is still underway and many are not fully done in their management process. The methods and scope of the evaluation were thorough and dealt with multiple aspects of management and planning. The report analyses many factors explored in this thesis, specifically the threats PAs face, science and criteria behind PA designation and establishment and management planning (Gilligan, 2005).
The 2005 MEE report asks: “Question 1.6: Are the threats to PA system values well documented and assessed?” (Gilligan, 2005). The situation in this point was evaluated as “fair to good”. More specifically it is said that there has not been an analysis of the threats in MPAs, but the nature of the threats are understood well. For example, it is said that “the most serious threats to biodiversity […] are external” (Gilligan, 2005). Recommendations include analysis and monitoring of threats. Regarding the science and designation of areas, a question discussed is: “Question 2.2: Are individual protected areas designed and established through a systematic and scientifically based criteria and process with a clearly articulated vision?” (Gilligan, 2005). This has been ranked as being “good to very good”, praising the systematics and justification of selection of protected areas. Not much criticism is put on this process, besides the underrepresentation of some habitats. There is no specific mention of coastal and marine habitats, except for the need for more high seas habitat protection (Gilligan, 2005).

Another question posed by the MEE report states: “Question 2.3: Are established reserves covered by comprehensive management plans?” and is evaluated as being “fair” (Gilligan, 2005). There is a large number of PAs with no management plans, and whilst the report says this is possibly due to the large rapid increase in numbers of PAs, it also says that they are urgently needed (Gilligan, 2005). No distinction is made between terrestrial and marine protected areas. The last question of the report relating to this thesis is: “Question 2.5: Are protected areas located in the places with the highest or most diverse biodiversity values?” This has been evaluated as “fair”, and a “general under-representation of marine and freshwater systems” is pointed out (Gilligan, 2005). Since the MEE report is from the year 2005, it speaks of the future often when speaking of MPAs. Under Question 2.5, it speaks of the completion of Finnish Natura 2000 network proposal and the VELMU programme that were to be concluded after the publishing of the MEE report. MPAs are therefore assessed to be in need of more science to justify their placement.

Another Metsähallitus publication about PA management in Finland highlights issues of changing water quality, hydrological deviation and water level modification (Heinonen, 2007). Community and population effects come from invasive species, including the introduction of foreign supplementary fish stocks (Heinonen, 2007). The issue of displacement and outside pollutants are also problems with spatial conservation in any aquatic area, and in the Baltic Sea eutrophication and hazardous substances create large
issues and threats (Heinonen, 2007). Regarding the management evaluation, the report refers back to the MEE report discussed above. It does however note that Metsähallitus marine strategy involves influencing and supervising the use of protected areas (Heinonen, 2007).

2.3 Management of MPAs and efficiency

Efficient management and planning is vital and necessary for MPAs that reach the goals of the reserves. The non-existence of management is not uncommon around the world, and some authors claim a bias in the citing of field research that focuses on positive effects of MPAs. The effects of ‘paper parks’ (PAs with no management that have simply been established to e.g. fill a quota) are rarely discussed (Jameson et al., 2002), possibly creating a false view of MPAs inherently benefitting the environment.

Efficient management is reliant on the design and planning of the MPAs, which is dependent on the information available and used in the initial phases of the establishing. Ecological information is vital with management goals related to the habitat and nature of a site (Friedlander et al., 2003), and effective conservation management is impossible without knowledge of the ecosystem and other biotic factors. Agardy (2000) points out that management and human activities are factors that can be controlled within MPAs, and that scientifically we can only study the effects of conservation and management of MPAs. She speaks of the connection between the goals of the MPA and how this relates or should relate to the management and planning of the area. With regards to the threats MPAs face, she discusses how they are often managed in a precautionary or restorative manner, again relating to the original goals of the protection. Not only this, but the management must also be highly associated with the unique area itself and its functions and properties (Agardy, 1997).

On the other hand, if the management of PAs should rely on best information, data and research available in order for it to be efficient (Cicin-Sain & Belfiore, 2005), establishing MPAs without said features available may turn out to be questionable in their reasoning. This however highlights the importance of adaptive management, which not only allows for changes in the environment and human impact level to mould the management, but also can improve with new information about the area (e.g. biodiversity and habitat data).
Wilson et al. (2007) conclude that effective conservation of biodiversity not only establishes specific areas and designs them under protection, but focuses also on the threats to the environment in question. Therefore variability in the threats and impacts should lead to variability in the MPA management and conservation action. In the paper by Wilson et al. (2007), a framework is developed that relies on a number of inter-disciplinary factors, such as resources, ecological information, threats to the area, and feasibility of conservation.

There are numerous ways in which MPA management can be and has been evaluated. The question of whether certain management approaches will be successful is vital to the validity of the management. Pomeroy et al. (2004) emphasizes the goals of the MPA establishment and if these goals have been met are in progress of being met. Specific goals all require specific indicators for their assessment, and Pomeroy et al. (2004) speaks of socioeconomic and governance goals as well (as biophysical and ecological goals being more common, especially in research). For example, if an MPA has goals of protecting biodiversity, one must look into the possible change in the biodiversity of the area, in order to understand the effectiveness of the management. IUCN report from 2006 about management effectiveness concludes similar issues. Management evaluations should place a large emphasis on the goals of the specific MPA and assess from there how effective the management decisions are, or whether they need to change (Hockings et al., 2006).

It should also be noted that management efficiency might not relate to ecological effects on the area. In thorough evaluations these should be interconnected, but this would require a very specific evaluation, possibly regarding the entirety of aspects related to the MPA, from ecology to management.

### 2.4 Human impacts in the Finnish Baltic Sea area

Having a highly populated coastline and catchment area, the Baltic Sea is under a large amount of a variety of threats, pressures and impacts (HELCOM, 2010). Korpinen et al. (2012) performed an estimation of the human impacts and their levels in the Baltic Sea, as required by the MSFD. Whilst calculating pressure indices of over 50 different types, categories are listed as: physical loss of seabed, physical damage to seabed, other physical disturbance, interference with hydrological processes, contamination by hazardous
substances, nutrient and organic matter enrichment and biological disturbance (Korpinen et al., 2012). The mean pressure indices were found to be low in both BB and BS, compared to the rest of the Baltic Sea, and fishing, nutrient inputs and non-synthetics to have the highest indices within the two areas (Korpinen et al., 2012). The question remains if these pressures have a high relative impact regardless of the low index, when considering the state of the environment and the (hydrologic, oceanographic, bathymetric etc.) features of the specific areas. Another question is whether what is considered ‘low’ on the scale of Korpinen et al. (2012), is truthfully low impact in light of the environment, or simply lower than other (possibly very high) areas comparably. This can also be said considering different species as well, and whether they experience different impacts in a different way.

Andersen et al. (2015) studied the possible correlations between human impact levels and biodiversity statuses. Whilst limited in spatial resolution and sample size, their studies suggested a negative correlation between levels of human impact and biodiversity status, with BB and BS as low impact and pressure areas, as well as areas of high biodiversity status (Andersen et al., 2015). These results connect management and ecological information, as the authors conclude. Guarnieri et al. (2016) argues that whilst expert opinions and modelling can be a powerful and useful tool in large areas, it may not represent the reality of especially smaller-scale effects.

Arguably the most discussed anthropogenic impact on the Baltic Sea is eutrophication. It certainly affects large areas in a long time-scale and spread easily around the Baltic Sea with varying and numerous sources, making management related to eutrophication difficult (Vahtera et al., 2007). Eutrophication, along with other factors such as noise pollution and large ecological changes can originate from outside the MPA but have massive effect within the area (Agardy et al., 2011). These effects may in turn compromise the conservation action, altering the possible changes in the MPA, no matter how effective the management (Jameson et al., 2002).

With regards to the Gulf of Bothnia, threat levels are in general lower than in most other parts of the Baltic Sea, as discussed above and in the paper by Korpinen et al. (2012). HELCOM’s eutrophication assessment (‘HEAT’) concluded the GoB to be in a better eutrophication status than the rest of the Baltic Sea, with few poorer spots of worsened status, which are generally near larger population centres (HELCOM, 2009a). What should
also be noted is that often in literature the status and quality of the water itself (chemistry and physics) have been highlighted, whereas the ecological and biological side have a paucity of research, especially regarding the impacts and threats they face.

2.4.1 Future impacts
The Plan Bothnia, an MSP project for the Bothnian Sea, highlights the following sectors as growing demands for the Bothnian Sea:

- Maritime traffic
- Fishing and aquaculture
- Energy (especially wind energy)
- Sand and gravel extraction
- Tourism and recreation

Other growing aspects of human activity and influence in the BS are PAs, defence and scientific research, and cultural (Backer & Frias, 2012).

The future development in the area calls for adaptive management. This is the management approach in which both the natural and anthropogenic development in and related to natural sites and areas are taken into consideration in real time (DEFRA, 2008). This allows for the adaption of the management action in the area, creating stronger conservation that responds to what is happening specifically in each conservation area (Grafton & Kompas, 2005).

2.5 Research questions & aims
Based on the theory, current situation, and future prospects laid out above, the following research questions for this thesis were formulated:

- What is the nature of Finnish marine protected areas in the Gulf of Bothnia with regards to management and planning?
- How are Finnish MPAs managed and how were they planned with regards to
  - the underwater nature;
  - the human impacts in the area;
  - and the connection between the two?
The aim of this thesis is to explore the selected MPAs in the Finnish Gulf of Bothnia, their management, planning and framework. This will be done by exploring both scientific data of the areas, as well as their management, such as management plans and legislation. The underlying goal is to discover how efficient the MPAs are in conserving and protecting the underwater nature.
3 Methods

3.1 Scope of the study

This thesis focuses specifically on the marine protected areas under Finnish management in the Gulf of Bothnia (GoB) in the Baltic Sea (Figure 1). This thesis also contributes to SmartSea, a development project that provides science-based answers and solutions to issues and possibilities specifically in the GoB (Siiriä, 2016). With a myriad of MPAs in the area, nine were chosen in order to achieve a representative sample of the different ecosystems and habitats in the region. A spread of MPAs was also chosen in the different sections of the GoB: Bothnian bay (BB), The Quark and the Bothnian Sea (BS), in order to see if there are or to compare any regional differences.

This thesis focuses on the underwater environment and its conservation management. The former can be very species and population specific, but the viewpoint of spatial ecology in this thesis is more holistic, looking at larger scale ecosystems. The nine MPAs were chosen based on the availability of VELMU data points from, as they provide comprehensive information of the seafloor and benthos.
Figure 3 Gulf of Bothnia and the nine marine protected areas studied in this thesis (in red). 1: River Li estuary, 2: Bothnian Bay islands, 3: Kirkkosalmi, 4: Bay of Liminka, 5: Luvia archipelago, 6: The Quarken, 7: Bay of Preiviiki, 8: Uusikaarlepyy archipelago, 9: Kulju
3.2 Data

There is a large amount of various data throughout the Baltic Sea that can be combined to form an analysis of the MPA management and its parameters. Data used will consist of ecological data, human impact data and legislation data related to the chosen MPAs.

Ecological data used to form a profile of the underwater nature consists of:

Table 1 Ecological data used in this thesis, details about each data and organizations and people responsible of the data

<table>
<thead>
<tr>
<th>Data</th>
<th>Details</th>
<th>Responsible organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>VELMU</td>
<td>Thorough survey of the underwater benthic nature and quality of the entirety Finnish Baltic Sea</td>
<td>• Ministry of the Environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Finnish Environment Institute (SYKE)</td>
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<td>• Parks and Wildlife Finland (Metsähallitus)</td>
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<td></td>
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<td>• Natural Resources Institute (LUKE)</td>
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<td>• Geological Survey of Finland (GTK)</td>
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<tr>
<td></td>
<td></td>
<td>• Åbo Akademi University</td>
</tr>
<tr>
<td>Habitat Directive habitats</td>
<td>Spatial information of where marine biotopes listed in the Habitat Directive occur</td>
<td>• Parks and Wildlife Finland</td>
</tr>
<tr>
<td></td>
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<td>• Finnish Environment Institute</td>
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<td></td>
<td></td>
<td>• GTK</td>
</tr>
<tr>
<td>HELCOM Underwater Biotope Classes</td>
<td>HELCOM classification of habitat types based on abiotic and biotic characteristics</td>
<td>Matti Sahla, Parks and Wildlife Finland</td>
</tr>
</tbody>
</table>

(HELCOM HUB)
Many The VELMU data of the underwater nature of Finland will be used to assess the ecology of the MPAs. The methodology of VELMU mapping is described below (see: 3.3 Methodology). As a concise biodiversity survey, it provides ample information and data about the ecosystems of the Baltic Sea, and a thorough base for data exploration. VELMU’s species absence-presence data were combined with literature about both habitat and biotope, and species-specific, specifically relating to what impacts and pressures affect them, and their importance in conservation action and management. The processed and analysed VELMU data were also used, where appropriate. This includes for example habitat, biotope and species models.

The human pressure and impact data comes from various sources. The most important and utilized data is spatial data of human activities in the MPAs. This included aquaculture, shipping lanes and wind power turbines and more. A comprehensive list of these, their details and sources is provided in a table in Appendix 1. Other human pressure data comes from accounts and documents such as MPA management plans and site descriptions. However as these can be lacking in detail, they are more difficult to analyse and assess.

The data of the MPA management will come from governing bodies, Natural Heritage Services (NHS) and the Ministry of Environment. Natura 2000 site descriptions come from www.ymparisto.fi, the “joint website of Finland’s environmental administration”. There one can find information about the sites, such as their area, codes, municipalities, descriptions, conservation programmes and legislations of implementation, as well as coverage of Habitat Directive biotopes and Bird and Habitat Directives’ listed species. Management plans are published by NHS. The EEA’s Natura 2000 dataforms (from http://natura2000.eea.europa.eu/Natura2000) provide more numerical information of the site.

Legislations used in the implementation of the areas can be found on Finlex Data Bank http://www.finlex.fi, which is an “online database of up-to-date legislative and juridical information of Finland”.

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3.3 Methodology

The methodology of this thesis research relies on the extraction of information from a variety of sources relating to the MPAs in the study area, and the combination and critical analysis of these data and information, including its availability. The Finnish Environment Institute’s (SYKE) VELMU map service (http://paikkatieto.ymparisto.fi/velmu/) was used in assessing the MPAs, although ArcGIS was also used for more thorough analysis of the areas, with shapefiles and data provided by the Finnish Environment Institute SYKE.

Species and habitat data were gathered from within the MPA boundaries exclusively. These data were used to form a profile of the underwater environment and features of the areas. All available data were utilised in this. Human impact data was used in much the same way, but data of the vicinity of the area was included to a degree. For example, in the case of an estuarine MPA, a waste water treatment facility or dredging activity upriver (not included within the MPA perimeters) was regarded as an external impact source. The management regulations on the outside activities are different, since they are not within the MPA management area, which should be included in their assessment.

The human impact and ecological data was combined to assess the specific threat to the area. This was done by using existing literature relating to the ecology or the human impact, and assessing the level of threat to the communities and habitats in the area. Management was assessed by looking at the information of the sites and their jurisdiction, planning, goals and other features related to them. This provided an indication of how the management of the MPA(s) affect the human impact in the area, i.e. can the regulations and management practices implemented prevent or alleviate the human impacts in the MPAs.

All the spatial data was laid out on GIS (ArcMap 10.3.1), along with the spatial boundaries of the selected studied MPAs. This allowed for the assessment of both ecological data and human activity data within the MPA, and the formation of the profile of the MPA. This profile would be a list of human activities along with their quantities and qualities (e.g. type and amount of dredging, what kind of aquaculture). Human activity was point data, except for shipping which was in line format. The basic VELMU presence/absence data was in point format, whereas the habitat and community models (Table 1) were polygon.
Combining the human activity data with ecological data and the literature information of the threats to the specific ecosystem, an assessment of the conservation needs of the sites were formed. The literature (such as the Helcom Red List Biotope Information Sheets) provided the information necessary for analysing the (theoretical) threats to the specific ecosystems. The legislation and management was used to see how the threats were and are being managed and mitigated within the sites. Connecting the ecosystem and ecological data, theoretical threats from literature, the spatial human activity data, and the management solutions and regulations, an indication of the MPAs management efficiency and appropriateness can be formed. This method was used to see how are these factors connected and if the

This type of MPA management assessment methodology based on multiple factors is used and promoted by the IUCN, WWF (Leverington et al., 2008), NOAA (NOAA Coral Reef Conservation Programme, 2011) and the World Bank (Hatziolos & Staub, 2004) among others.
4 Results

In the following results sections, “management plans” ("hoito- ja käyttösuunnitelma") are only considered valid when they are comprehensive and describe the MPA in question specifically (or a group of MPAs in the region). Other sources of management information and data are however included in the analysis of the protection, but for example the legislation and general national protected area management plans are not considered as management plans per se, since they have no specific consideration of the area.

Some of the Natura 2000 areas are sometimes both Sites of Community Importance (SCI) and Special Protection Areas (SPA) within the same geographical space. SPAs are established and designated under the Birds Directive and their establishment and management technically does not include the underwater nature. However as there is much overlap in the Finnish MPAs, and a site can (and often will) be both of importance to birds and overall ecosystems, the chosen MPAs (Table 2) are all SCIs, but some also contain SPAs, although this does not affect the analysis of the management. In these cases, if there are separate regulations from the SCI standpoint, these are explored as well, since they will merge with the management of the SCI. In Finnish PA management, the area is managed spatially as opposed to according to the type of PA in question.

4.1 MPAs

Nine MPAs were chosen for the management assessment. To represent a variety of regions, ecosystems and habitats, and threats and impacts, MPAs were chosen from different parts of GoB and different types of aquatic environments. Four were chosen from Bothnian Bay, two from the Quark, and three from the Bothnian Sea (Figure 1). Table 3 provides a summary of the main points of management and related features of the MPAs. Details of this have been provided in the text under each MPA account. Note also that not all human activity data is shown in the maps, with regards to data availability.
Table 2 MPAs studied in this thesis, grouped by region. Name in Finnish and English (translated by author), Natura 2000 network code, area in hectares, legislation(s) used in the implementation of the MPA, and the presence of a management plan are also provided. Legislation: LUBA = Land Use and Building Act, WA = Water Act, EPA = Environmental Conservation Act, NCA = Nature Conservation Act. “Area” refers to the complete area of the MPA, not the specific studied section.

<table>
<thead>
<tr>
<th>Region</th>
<th>MPA name (in Finnish)</th>
<th>English name</th>
<th>Natura code</th>
<th>Area, ha</th>
<th>Legislation</th>
<th>Management plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOTHNIAN BAY</td>
<td>Iijoen suisto</td>
<td>River Ii estuary</td>
<td>FI1100601</td>
<td>1661</td>
<td>LUBA, WA, EPA</td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>Perämeren saaret</td>
<td>Bothnian Bay Islands</td>
<td>FI1300302</td>
<td>7136</td>
<td>NCA, LUBA</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Liminganlahti</td>
<td>Bay of Liminka</td>
<td>FI1102200</td>
<td>11823</td>
<td>NCA, WA</td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>Kirkkosalmi (Hailuoto)</td>
<td></td>
<td>FI1100202</td>
<td>1019</td>
<td>NCA, WA</td>
<td>YES</td>
</tr>
<tr>
<td>THE QUARK</td>
<td>Merenkurkun saaristo</td>
<td>The Quark archipelago</td>
<td>FI0800130</td>
<td>128162</td>
<td>NCA, WA, LUBA</td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>Uudenkaarepyn saaristo</td>
<td>Uusikaarepyn archipelago</td>
<td>FI800133</td>
<td>3210</td>
<td>NCA, WA, LUBA</td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>Luvian saaristo</td>
<td>Luvia archipelago</td>
<td>FI0200074</td>
<td>7602</td>
<td>NCA, WA, LUBA</td>
<td>NO</td>
</tr>
<tr>
<td>BOTHNIAN SEA</td>
<td>Preiviikinlahti</td>
<td>Bay of Preiviiki</td>
<td>FI0200151</td>
<td>4613</td>
<td>NCA, WA, LUBA</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Kulju</td>
<td></td>
<td>FI0200041</td>
<td>472</td>
<td>NCA, WA, LUBA</td>
<td>NO</td>
</tr>
</tbody>
</table>
Table 3 The major human impacts, an overview of the underwater environment, the focus and justification of the conservation, and the main management program or statute behind each of the studied MPAs. “Underwater environment/habitats” information is both from written PA profiles and the VELMU map service. “Conservation action and focus” is from written accounts.

<table>
<thead>
<tr>
<th>MPA</th>
<th>Human activities</th>
<th>Underwater environment/habitats</th>
<th>Conservation action and focus</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Ii Estuary</td>
<td>Dredging, boating,</td>
<td>Lagoons, estuary, sandbanks, vegetation,</td>
<td>Habitat Directive biotopes. Mitigation of high</td>
<td>Regional land use plan.</td>
</tr>
<tr>
<td></td>
<td>aquaculture</td>
<td><em>Potamogeton &amp; Stuckenia</em></td>
<td>levels of human impact.</td>
<td>Management plan.</td>
</tr>
<tr>
<td></td>
<td>windpower</td>
<td></td>
<td>holistic approach to conserving a collection of</td>
<td>Water Act (in aquatic areas).</td>
</tr>
<tr>
<td>Bay of Liminka</td>
<td>Dredging, aquaculture,</td>
<td>Estuary, coastal lagoon, inlet/bay, diverse</td>
<td>Bay rich in birdlife. Habitat Directive biotopes.</td>
<td>Regional land use plan.</td>
</tr>
<tr>
<td></td>
<td>windpower, underwater</td>
<td>vegetation</td>
<td>biotopes. Endangered and threatened species.</td>
<td>WHCP.</td>
</tr>
<tr>
<td></td>
<td>cable, boating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>aquaculture, nearby</td>
<td></td>
<td>and rare species.</td>
<td>WHCP.</td>
</tr>
<tr>
<td></td>
<td>dredging</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>underwater cable and</td>
<td>including algae, cnidarians, crustaceans, sponges, <em>Mytilidae</em>,</td>
<td>Importance to conservation of endangered species,</td>
<td>World Heritage Site.</td>
</tr>
<tr>
<td></td>
<td>water pipeline, nearby</td>
<td>mixed communities etc.</td>
<td>management of fish stocks, scientific research,</td>
<td>Regional land use plan.</td>
</tr>
<tr>
<td></td>
<td>aquaculture, nearby</td>
<td></td>
<td>recreation and tourism.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>industry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uudenkaarlepyyn saaristo</td>
<td>Shipping lane, bathing</td>
<td>Coastal lagoon, reef, <em>Chara</em></td>
<td>Conserving an area of low human impact</td>
<td>Shore Areas Conservation Programme</td>
</tr>
<tr>
<td></td>
<td>beach, waste water,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>underwater cable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preiviikinlahti</td>
<td>Bathing beach, underwater</td>
<td>Coastal lagoon, inlet/bay, reef, algae, rooted</td>
<td>Rich birdlife and an important migratory bird</td>
<td>Regional land use plan.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Zostera</em>, <em>Fucus</em>, <em>Chara</em>, epibenthic communities</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>epibenthic communities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 4 Marine protected areas studied in the Bothnian Bay. Note that the Bothnian Bay Islands MPA shown here is only a part of the MPA complex.
4.1.1 River Ii estuary - Iijoen suisto

The River Ii estuary is a Natura 2000 area in the Bothnian Bay, in the northern most part of the Baltic Sea. It is a relatively large estuary and the area included in the Natura site is large (1661 hectares) and complex with various types of habitats. Many of its ecosystems are under threat due to a large number of human infrastructure and activity. A significant share of the impact comes from power plants in the area. In close proximity of the MPA is the city of Ii, with a population of approximately 9662 (31st July 2016). The MPA of River Ii estuary’s means of implementation are the Land Use and Building Act (132/1999), Water Act (587/2011) and the Environmental Protection Act (527/2014). These legislatures govern the restrictions and rules within the area. A management plan does not exist for the MPA (Natura 2000 site database, 2000a)

The site is a shallow, soft-bottom area (GTK, 2016). Common to all estuaries, environmental gradients are evident in the MPA. The salinity gradient moves from an area of low salinity/freshwater (from the river input) to more saline (in the sea) the low salinity of the Bothnian Bay makes this gradient less pronounced in more oceanic estuaries (SYKE, 2016). Exposure, wave activity and temperature gradients are also present, with more exposure and wave activity, and lower temperature towards the BB (SYKE, 2016). The underwater ecosystem is abundant in a variety of aquatic plants, such as Potamogeton sp. and Charophytes.

The presence of the endangered Persicaria foliosa is evident from the texts and publications (Metsähallitus website and Natura 2000 database) concerning the protected area. This aquatic plant has a restricted distribution, and is threatened and in decline in Finnish waters. It has relatively specific habitat requirements, with regards to depth, bottom type and habitat. In an environmental statement from 2013 (Kalleinen, 2013) relating to the general regional plan, the endangerment of P. foliosa can be attributed to its specific habitat requirements and the proximity of human settlement and infrastructure to these habitats, which have led to them becoming compromised (Kalleinen, 2013). The closing off of some areas to the sea has been attributed in the past as reasons for the species distribution.

Another characteristic of the PA is the existence of several different biotopes in the area, a number of which are included in the Habitat Directive, and of priority for conservation.
These have been highlighted alongside of the *P. foliosa* in the descriptions of the area, and are likely to have contributed to the establishment of the conservation. Of the underwater biotopes coastal lagoons (code: 1150) make up 5% of the cover of the area and are indicated as “priority habitat types” (EC, 2016a).

The landscape plan of the region shows no claim of the SCI as a protected area, but does include the SPA, which overlaps a small part of the SCI. There are parts of the plan designated as areas of conurbation (“taajamatoimintojen alue”), and more specifically as a traffic area and an area of high cultural and scenic value. In the close vicinity of the MPA is an area of urban centre activity.

The human impact data (Figure 3) shows three important prominent sources of human impacts: dredging, shipping, and aquaculture. There is also a point source input of nitrogen and phosphorus as well as a waste water treatment facility close to the border of the MPA (< 1 km). Dredging activity has happened all throughout the estuary, all of which have either happened before 2010, or the start year is not known.

![Figure 5 River Il estuary MPA and its human activities](image-url)
4.1.2 Bothnian Bay Islands - Perämeren saaret

The Bothnian Bay Islands is a scattered MPA (c.f. one singular area). It is also located in the northernmost part of the Baltic Sea. To make analysis clearer only the area of Santapankki (Figure 2) was used in the data analysis. The protection of the MPA is implemented via the Nature Conservation Act and the Land Use and Building Act. There is also management plan that was published in 2009, which also includes the Bothnian Bay National Park and the Röyttä Natura 2000 area. The Natura 2000 data form of the site states 63% of the area to be private nature reserve and the remaining 27% to have no protection status.

Santapankki is a shallow area further out into the sea, about 20 km away from land. The low-lying sandbanks are surrounded by water of 0-5 m deep. There is both soft and hard seafloor in the area (GTK, 2016) and the area is very open to wave action (SYKE, 2016). The area is abundant in aquatic plants and other primary producers, such as Charophytes, Potamogeton and Stuckenia species (SYKE, 2016). The surrounding waters also house polyps and Saduria entomon, a large benthic isopod, as well as Ephydatia fluviatilis, the brackish water sponge (SYKE, 2016).

There are multiple Habitat Directive biotopes within the entirety of the MPA. The underwater biotopes include sandbanks (1110), estuaries (1130) and the priority biotope coastal lagoons (1150). The management plan states that whilst the coverage of coastal lagoons is little (<1 %), a majority of them (62 %) are classified to be of excellent representativeness. It also includes habitats and ranges for many species listed in Article 4. The greater planning area of the management plan is also a common habitat area of the seal species grey seal (Halichoerus grypus) and ringed seal (Phoca hispida botnica), both of which are classified as “Near threatened”. It is stated that especially the grey seal population has increased due to the protection, but no details or reference have been provided.

The management plan claims that the Bothnian Bay Islands MPA work together and compliments the Bothnian Bay national park MPA, by adding to the coverage of protected habitats in the area (Metsähallitus, 2009). The management plan states that the justifications for adding the Bothnian Bay Islands into the protected area registry were the
aquatic biotopes, Baltic water-plantain (*Alisma wahlenbergii*), fourleaf mare’s tail (*H. tetrphylla*), *Persicaria foliosa* and the birdlife in the area (Metsähallitus, 2009).

The management plans outlines the current (2009) uses of the Bothnian Bay area and specifically the protected areas. In the Bothnian Bay Island’s MPA there are approximately 4000 recreational visitors a year, although this varies often e.g. due to general weather condition especially during winter (Metsähallitus, 2009). Visitation numbers seem to also be skewed to specific islands in the MPAs, probably due to infrastructure and features on said islands. Fishing happens throughout the area and is done in a commercial, recreational and subsistence manner. There are major shipping channels situated on the MPA. The cities of Oulu and Kemi are destinations and origins of especially industrial cargo. This creates the risk of oil pollution in the area.

There are future prospects of wind power in the Bothnian Bay in the vicinity of the MPA zones and partially on the area too (Figure 4). These projects however are subject to EIAs and consideration of nature and scenery in the planning phase. There are also plans of sand extraction and nuclear power industry in the area (Metsähallitus, 2009).
Figure 6 Bothnian Bay Islands MPA and its human activities (no presentable data was found of the present impacts in the area, therefore only planned future wind power is shown here)

Besides the threats caused more directly by the aforementioned human impacts, the overgrowth of shallow habitats such as flads and gloe lakes is mentioned in texts. These are the habitats that many of the endangered plants inhabit, and that are of great importance to many other species and communities. The human disturbance of birdlife and nesting areas is mentioned and discussed (Metsähallitus, 2009). This can be assumed to reach the underwater environment to some extent as well.

As the MPA is included in the Natura 2000 PA network, its main goal is to either maintain or restore a favourable level of protection. This means that the natural wild species inhabiting the area can live in its natural range on a long time scale, and that species and the functioning of the ecosystem are preserved ("Luonnonsuojelulaki," 1996). The special conservation goal of the Bothnian Bay Islands is stated to be the protection of its birdlife, whilst the goals of the entire management plan area (including BB islands, BB national park, and Röyttä PAs) is the integration of conservation, culture, recreation and tourism, science, and awareness (Metsähallitus, 2009).
In the Bothnian Bay Islands the protection has been done via zonation of the MPA. The zones are (translated by author): peripheral zone, recreational zone, restriction zone and cultural zone. In the peripheral zone, whilst available for recreational activities, there is no building of infrastructure for such activities (except for structures absolutely necessary for visitor safety). The recreational zone is directed towards visitors and tourism, with infrastructure for it. The cultural zone is established to conserve cultural and historical sites and features. These zones however are only marked to contain the islets and islands in the PA and no zonation of the marine area is mentioned. The restriction zone aims to upkeep the natural values of the area, with restrictions on movement and use of the area. They are enforced with the code of conduct and the NCA. According to the management plan, in the Bothnian Bay area, these are most often habitats and ecosystems that are most threatened or most in need of these restrictions (Metsähallitus, 2009). These areas have restriction concerning landing and movement bird near nesting sites during nesting periods.

The Santapankki area has four distinct parts. In the management plan they are designated as recreational zone, restriction zone and a peripheral zone. Due to map resolution issues it is not clear whether the zonation and the conservation reach the underwater environment. The studied area is relatively small and the map in the management plan is of low resolution.

The most important goal of the ecological management in practice is the restoration of overgrown habitats, and the prevention of overgrowth in areas that are threatened by it. The management plan states that there are two hectares of coastal lagoon areas in the entire management area, in which practical restoration action is taken. This does include MPAs that are not within the Bothnian Bay Islands MPA. There are also multiple areas where restoration of habitats of threatened plants is done. The removal of the common reed (*Phragmites australis*), is done on and near the beaches of gloe lakes and flads (Metsähallitus, 2009). In the explanation of this activity, the bird habitats are directly referred to, instead of the underwater nature.

### 4.1.3 Bay of Liminka - Liminganlahti

The Bay of Liminka is a shallow bay in the Bothnian Bay, by the municipality Liminka, neighbouring the larger city of Oulu. The bay and its coastal areas and habitats changing constantly due to the high level of post-glacial rebound (Pohjois-Pohjanmaan ELY-
There is a multitude of coastal habitats within the bay, and it is a diverse region of ecosystems, with shallow waters, reed beds, and small islets etc. Habitat directive’s biotopes in the area include estuaries, lagoons and inlets and bays.

The Bay of Liminka is one of the most important aquatic areas for birds in Finland, with nearly ten endangered species nesting in the area, and near 20 000 individual migrating birds resting at one time (Pohjois-Pohjanmaan ELY-Keskus, 2013b). The bay is in the national Waterfowl Habitats Conservation Programme (“lintuvesiensuojeluohjelma”). Baltic water-plantain (A. wahlenbergii), lamprey (Lampetra fluviatilis), P. foliosa and fourleaf mare’s tail (H. tetraphylla) are some aquatic species from the Habitat Directive Annex II that are found in the bay. It has a high importance for fisheries, being an important spawning ground and nursing area (Natura 2000 site database, 2005b).

The bay is relatively species-rich judging from the VELMU data (SYKE, 2016). A high abundance of primary producers, e.g. Charophytes, Vaucheria, Eleocharis, Callitriche, Myriophyllum and Potamogeton is found in the bay. Duck mussels (Anodonta anatina), polyps, Oligochaeta worms (SYKE, 2016). Fish species found in the bay include perch, smelt, goby, herring and pike-perch (SYKE, 2016). The data suggests that the bay is of high biodiversity value and an especially important habitat.

The VELMU map service shows human impacts currently within the MPA to be aquaculture and wind power turbines (not shown in Figure 5). There are also plans of future wind power development. Dredging activities have happened in the area, before 2010 and multiple incidences where timing is not known. In the area nearby to the MPA there are other impacts. These include shipping lanes (shortest distance: 580 m), industry, energy production, and waste water treatment (6300 m to the MPA boundary, 1660 m to a river that leads into the bay) Figure 5).
Figure 7 Bay of Liminka MPA and its human impacts

The Natura 2000 dataform states 93% of the Bay of Liminka to have no protection status and 7% private nature reserve (Natura 2000 site database, 2005b). No explanation of “no protection status” was found, but it is assumed that this means that the PA has been established spatially but there is no specific conservation happening. This assumption is made based on the other options for designation types on the dataform. The protection of the site comes from its status as a statutory protected area under the NCA in the terrestrial areas, and from the Water Act in the aquatic areas.

4.1.4 Kirkkosalmi

The Kirkkosalmi MPA is a part of the PA complex on and around the Island of Hailuoto in the Bothnian Bay. The MPA is a narrow bay on the south side of the island, and reaches an inner aquatic area inland, that has stayed connected to the sea due to the canalization done between the water and the bay (Pohjois-Pohjanmaan ELY-Keskus, 2013a). This small site has a range of habitat types and is very popular amongst birdlife. Albeit only 1019 hectares, almost 25% of this consists of coastal lagoons, and 30% sandbanks (Natura
2000 site database, 2005a). An additional 15 % is inlets and bays. These underwater biotopes form a considerable majority of the coverage of the area.

Kirkkosalmi has aquatic plants and algae such as Charophytes, *Eleocharis*, *Potamogeton*, sago pondweed (*Stuckenia pectinata*) and *Zannichellia* (SYKE, 2016). Duck mussels (*Anodonta anatina*) has also been observed in the bay (SYKE, 2016). The MPA is mostly soft bottom (GTK, 2016), with varying degrees of environmental variables, such as wave exposure (SYKE, 2016), most likely due to the shape of the area (Figure 6).

The management plan of the Hailuoto island includes Kirkkosalmi, and four other MPAs, which together form a kind of micro-network of PAs that complement each other, whilst still allowing for the residence and recreation in the island. The management plan sets out general values (V), goals (G) and threats (T) to the entire MPA complex. Relevant ones of these are:

- (V) The protection of the species in the Habitat Directive Annex II, including *H. tetrphylla* and Baltic water-plantain
- (T) The threat of overgrowth
- (T) The impact of recreational activities on the island
- (T) The impact of canalization and improving places where impact has been negative
- (G) Mitigating and minimizing the impact of recreational and residential infrastructure on nature and especially the birdlife
- (T) The impacts of future wind power establishments
- (G) Underwater biotopes and species are well known
- (G) Recreation and tourism, and infrastructure associated with it is done without compromising the integrity of the environment, but also in a way that the protected areas are an attraction to visitors

Kirkkosalmi’s protection is done via the Nature Protection Act, the Water Act in places, and it is included in the national Waterfowl Habitats Conservation Programme. Its management plan provides justifications for its protection, with different reasoning for different protection programmes. These include the presence of species listed in the Habitat Directive and the Bird Directive (Natura 2000), the importance to bird
communities and populations (WHCP), the protection of natural values that are present (private protection areas).

Similar to the Bothnian Bay Islands MPA, Kirkkosalmi consists of zonation dividing the area with varying restrictions and designations of activity. The zones present in Kirkkosalmi are recreational zone, peripheral zone and an area of restricted movement at certain times of the year. In the latter, moving in and going to the water 10th August – 31st October is prohibited for the protection of birdlife. The MPA also has a number of small privately owned protected areas, adding to 907.81 hectares. All of these have their own rules and regulations as their management is done by the landowners. Most of them however prohibit forestry, extraction of soil, building, sports activities, hunting, taking firewood, agriculture, water deviation, and off-road traffic (Metsähallitus, 2015). Fishing is prohibited in only one 1.9 hectare area within a privately owned reserve. No explanation or justification is given for this.

![Figure 8 Kirkkosalmi MPA and its human impacts](image-url)
Figure 9 Studied MPAs in the Quarken area. Note that the Quarken Archipelago MPA shown here is only a part of the MPA complex

4.1.5 Uusikaarlepyy Archipelago – Uudenkaarlepyyn saaristo

The Uusikaarlepyy Archipelago is a small MPA in the northern part of the Quark region of the GoB. It consists of three separate islands near each other near the coast and adjacent waters. The MPA does not have a management plan, but its protection comes from the NCA, LUBA and the Water Act (Etelä-Pohjanmaan ELY-Keskus, 2013b). The majority of the sites are also a part of the Shore Areas Conservation Programme (“Rantojensuojeluohjelma”).

As a fragmented MPA with separate parts, one would expect the Uusikaarlepyy archipelago MPA to consist of different environmental variables, but the three segments are relatively similar to each other. There are soft and hard seafloor (GTK, 2016), relatively shallow water (< 20 m), a variety of chance of boulders, and a similar wave exposure index (SYKE, 2016). The MPA is also relatively biodiverse, abundant with several algae species (e.g. Charophytes, *Ceramium*, *Hildenbrandia rubra*, Marimo (*Aegagropila linnaei*), *Cladophora glomerata*, *P. littoralis*, *E. siliculosus*, *Spacelaria*), the

The MPA is said to experience very little human impacts (Etelä-Pohjanmaan ELY-Keskus, 2013b), causing interest in scientists and birdwatchers. Very little human activities are seen within and around the MPAs in the spatial data of the human activities. Aquaculture is present near one of the zones, and a small shipping channel goes through one MPA. There are two harbours next to the southern site, which also houses a bathing beach and a nearby waste water treatment facility (Figure 8).

The textual account of the MPA, the Natura 2000 dataform and the Environmental Administration’s web page do not speak of the underwater nature of the area, even though significant area is water. 27 % of the MPA is privately protected, and 73 % not protected (Natura 2000 site database, 2005c). The dataform states sandy beach and developing dune protection to take place in the area.
4.1.6 The Quarken Archipelago – Merenkurkun saaristo

The Quarken Archipelago is a large MPA in the middle of the GoB. The areas it consists of reach from the mainland coast to the outer open sea areas. These separate areas together make up an area that aims to conserve the diverse environment of the Quarken area. The region is a World Heritage Site for its natural features on top of containing many Natura 2000 sites, Ramsar wetland areas, and being a BSPA. The importance and significance of the region comes from its geomorphology and biodiversity. It is a prominent site of glacial rebound and is a very shallow and narrow part of the GoB. The latter causes a steep salinity gradient, which in turn the area into an environmental transitional zone (Etelä-Pohjanmaan ELY-Keskus, 2013a).

The region has geologically and ecologically representative areas of multiple stages of the process of glacial rebound (Etelä-Pohjanmaan ELY-Keskus, 2013a). This coupled with its shallow bathymetry and salinity gradient causes a diverse environment with a variety of different habitats and communities. Underwater biotopes within the MPA are coastal lagoons, inlets and bay, and reefs. The region is important with regards to the conservation

The VELMU data shows the study area of the Quarken MPA to be very diverse. There is a large variety of primary producers, the most abundant of which include *Ceramium, F. lumbricalis*, Charophytes, Fucoids, *P. littoralis, E. siliculosus*, Ulvales, *Myriophyllum, S. pectinata, Fontinalis* (SYKE, 2016). Fauna in the site includes *S. entomon*, spire snail (*Ecrobia ventrosa*), *E. crustulenta*, *Gammarus, Monoporeia affinis*, bivalves (*M. baltica, M. trossulus x edulis*) (SYKE, 2016). The seafloor in the area is largely hard bottom, with small patches of soft areas (GTK, 2016). As an area in the open ocean the wave exposure of the region is high, as is the physical habitat accessibility (SYKE, 2016). The depth in the site varies 0-15 metres (SYKE, 2016).

Being near the large city of Vaasa, the environment of Quarken is likely to face a multitude of human impacts. Within the MPA there are also a number of vacation homes and residences. The area is important for fisheries (Natura 2000 site database, 2007b) putting pressure on populations in the area. Threats to the environment include boating and its associated impacts (such as pollution), snowmobiling in winter, aquaculture, forestry and canalization as well as the possible future harbour infrastructure construction (Natura 2000 site database, 2007b). The spatial details of these activities are not provided.

The Quarken Archipelago MPA has a management plan which is slightly different from the regular management plans of PAs. Its title translates as “The management and development plan of the Quarken archipelago world heritage site”. The legislative protection of the area happens through LUBA and the Water Act. Land use plans are also put into place to develop and improve conservation. The management plan of the MPA provides no additional rules or regulations to the site to the legislature applied to the area (Table 6).
Figure 11 The Quarken MPA and its human impacts
Figure 12 Studied MPAs in the Bothnian Sea
4.1.8 Bay of Preiviiki – Preiviikinlahti

Bay of Preiviiki is a large shallow bay in the southern part of the Gulf of Bothnia, in the middle of the Finnish Bothnian Sea coast. The area is best known for Yyteri beach, a popular large bathing beach on the northern end of the bay. The rich birdlife and the areas importance for migratory birds, as well as diverse biotopes are possible reasons for the establishment of the MPA (Varsinais-Suomen ELY-Keskus, 2013c).

There are specific areas of the MPA that the NCA is applied to. Other areas are under LUBA and the Water Act. Many spots are marked as nature protection areas in the land use plan, and some are in the Waterfowl Habitat Protection Programme (Natura 2000 site database, 2000b). There are also separate areas within the MPA that are in the Bothnian Sea national park. There is no current existing management plan, but a draft version of a plan from 2012 suggests the direction the management of the area is planned to head towards.

Most of the MPA is of the inlet and bay Natura 2000 biotope (1160), along with smaller sections of sandbanks and coastal lagoons (Varsinais-Suomen ELY-Keskus, 2013c). There are no species of the Habitat Directive Annex II, but there are communities based on underwater plant species, such as Nitella, Potamogeton perfoliatus & Stuckenia pectinata, red algae, and Fucus. As these species and types of species create habitat and support ecosystems it is likely that they harbour a diverse ecosystem.

The seafloor of the bay is mixed, with mostly soft bottom, and patches of hard substrate (GTK, 2016), and a shallow water column, reaching 10-15 m only at the very edges of the MPA (SYKE, 2016). The bay has a variety of organisms, with a diverse community of aquatic plants, algae, benthic organisms, and fish species. Abundant ones include: charophytes, Tolypella nidifica, C. glomerata, spiny water nymph (Najas marina), Myriophyllum, Potamogeton, sago pondweed (S. pectinata), Halosiphon tomentosum, Chorda filum, Pilayella littoralis, Ectocarpus siliculosus, Zannichellia, Polysiphonia, fucoids, ragworm (Hediste diversicolor), Baltic clam (Macoma baltchica), Marenzelleria, bay barnacle (A. improvisus) (SYKE, 2016). Fish in the bay include perch, pike perch, smelt, goby, Baltic herring (SYKE, 2016).

There are few direct human pressures to the Bay of Preiviiki (Figure 11). The Yyteri beach is large recreational attraction, with high visitor counts. It is three kilometres long and is
visited by approximately 180 000 visitors a year (Kuusela, 2013). There is also a pipeline of unknown type in the bay. Possible impact sources nearby include the beef production and the chemical industry (no details found) in the peninsulas surrounding the bay (SYKE, 2016).

Figure 13 Bay of Preiviiki MPA and its human impacts

4.1.7 Luvia archipelago – Luvian saaristo

The Luvia archipelago MPA is situated in the southern part of the Bothnian Sea. A high number of islands and the largest birdlife in the BS are what make this site representative (Varsinais-Suomen ELY-Keskus, 2013b). The island of Säppi is especially biodiverse with reefs and wide Fucus habitats that support a rich ecosystem (Varsinais-Suomen ELY-Keskus, 2013b). Of the Habitat Directive Annex II species, Halichoerus grypus is present in the site. There is a large cover of reefs in the area, as well as some coastal lagoons.

This MPA is of hard bottom (GTK, 2016), has high exposure to waves and with a variable presence of boulders (SYKE, 2016). The biota of the area includes algae and plants (e.g.
Charophytes, *Ceramium, F. lumbricalis, Polysiphonia, H. rubra, Fucoids, P. littoralis, E. siliculosus, Cladophora*), fauna (e.g. barnacle, *E. crustulenta*, blue mussel).

As a busy and growing region for maritime activities and blue growth, the Bothnian Sea and its environment face a multitude of impacts (Figure 12). The Luvia archipelago is a region of multiple impacts, being near cities such as Pori and Rauma. Shipping channels pass through the MPA from multiple places, as well as a few cables and/or pipes. There are also aquaculture activities both within and near the MPA, some of which have been reported as being sources of nitrogen and phosphorus pollution.

In the regional plan, most of the area has been appointed as a protection area, which will be implemented with the NCA, Water Act and the regional land use plan. The site belongs to the national beach protection programme.

Figure 14 Luvia archipelago MPA and its human impacts

**4.1.9 Kulju**

Kulju is a small “strait-like inner bay” in the southern Bothnian Sea (Varsinais-Suomen ELY-Keskus, 2013a). For a small (472 ha) area it has an abundant birdlife and habitat
diversity. The reeds and shallow areas of the site support a variety of waterfowl as well as the endangered Habitat Directive Annex II species *Lutra lutra* (otter).

Most of the area (73 %) is classified as a coastal lagoon, and more specifically as flad lakes in a very natural state (Natura 2000 site database, 2007a). VELMU data shows *Nitella* bed communities in the area, as well as other important ecosystem supporting species such as Charales, *Najas marina* and *P. perfoliatus/S. pectinata* (SYKE, 2016). Fish species such as smelt and goby have also been found in Kulju (SYKE, 2016). This small bay is of soft substrate seafloor (GTK, 2016), very sheltered and low energy, and very shallow (max. 5 m), and relatively warm (12-14 C°) (SYKE, 2016).

Kulju’s protection is implemented via the NCA, LUBA, and the Water Act. In the regional land-use plan the site has been designated as a nature protected area. The area is of a very natural state. There is a short underwater cable on the site, but no other data of human impacts were found. The restrictions of the site come from the legislation in place in the MPA. These restrictions are discussed below (4.4 Management as means of conservation) and presented above (1.3 Legislation behind Finnish marine protected areas). Since there is little human impact in the area (Figure 13), and no planned future development and impacts were found, it is difficult to analyse the management effectiveness of the MPA.
4.2 Biotopes and habitats

The different biotopes and habitats within the MPAs were counted and compared, in order to explore the biotic differences between them. To simplify this, classifications and types of habitats used in literature and legislation were used for this. These included the Habitat Directive Biotopes (most of which are mentioned above under each MPA section), which are used to designate Natura 2000 areas (mapped by Metsähallitus and other VELMU partners), HELCOM HUB classifications (mapped by Matti Sahla in Metsähallitus) and benthic community models (produced in the Finnish Environment Institute).

Five Habitat Directive biotopes were found in the studied MPAs: estuaries (code: 1130), coastal lagoons (1150), sandbanks which are slightly covered by sea water all the time (1110), large shallow inlets and bays (1160), reefs (1170). Coastal lagoons were found in all of the nine studied MPAs and other biotopes in two to four MPAs (Figure 14).
Within the 9 MPAs, 59 different HELCOM Underwater Biotope and Habitat Classification System (HUB) classes were found. It should however be noted that these were classified into different levels and the classification can be very similar, especially in relation to the Habitat Directive biotopes. HUBs are defined by the abiotic (light, depth, salinity, oxygen) and biotic environment (presence or absence of epifauna or macrofauna, dominating taxa etc.) and is used in in understanding the Baltic Sea (HELCOM, 2013). HUBs can be likened to the concept of habitats or biotopes. The “No macrocommunity” classification was excluded from the analysis. The most common habitat type in all the MPAs was “sparse epibenthic communities” and its subclasses with various substrate types. There was a large variety in the number of HUBs in MPAs (5-27) (Figure 15), with a high correlation with area coverage ($R^2 = 0.93$) and similar HUB densities (0.23–3.7 HUBs/km$^2$). Santapankki area in the Bothnian Bay Islands and the Torggrund area in the Quarken had the highest relative HUB densities and Bay of Liminka the lowest (Figure 15).
4.3 Impacts and pressures

Data on human impacts and pressures comes from a variety of sources. Human impacts and threats included in the analysis here are:

- Aquaculture
- Coastal waste water treatment
- Contaminant pollution
- Disposal of waste
- Ditching
- Dredging
- Dumping
- Trenching
- Embankments and artificial beaches
- Energy/power plants
- Enlargement of harbours and marinas
- Fishing
- Marine construction
- Mining and quarrying
- Nitrogen and phosphorus pollution
- Recreation
- Sand and gravel extraction
- Shipping
- Shipping infrastructure
- Water deviation
- Wind power

These however are all the threats and impacts that either a) there is spatial data of within or in the vicinity of the MPAs or b) have been specifically discussed or pointed out in relation to the habitats or species in the literature relating to them.
Table 4 MPAs and the present recorded human impacts within them and nearby, and the potential threats (according to literature) the habitats and biotopes in the area can be compromised by according to literature

<table>
<thead>
<tr>
<th>MPA</th>
<th>Present human activity in the area</th>
<th>Activities threatening the present ecosystems according to literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Ii estuary</td>
<td>Dredging, boating, aquaculture</td>
<td>Marine construction, dredging, contaminant pollution</td>
</tr>
<tr>
<td>Bothnian Bay Islands (Santapankki area)</td>
<td>Underwater water pipeline, nearby future wind power</td>
<td></td>
</tr>
<tr>
<td>Bay of Liminka</td>
<td>Dredging, aquaculture, wind power (present and future), underwater cable, boating lane</td>
<td>Dredging, aquaculture, marine construction</td>
</tr>
<tr>
<td>Kirkkosalmi</td>
<td>Boating lane, nearby aquaculture, nearby past dredging</td>
<td></td>
</tr>
<tr>
<td>Uusikaarleppy Archipelago</td>
<td>Shipping lane, recreation (bathing beach), waste water treatment facility, underwater cable</td>
<td>Contaminant pollution, tourism</td>
</tr>
<tr>
<td>The Quarken Archipelago (Torgrund area)</td>
<td>Shipping lane</td>
<td></td>
</tr>
<tr>
<td>Luvia Archipelago</td>
<td>Aquaculture, shipping lane, underwater cable</td>
<td></td>
</tr>
<tr>
<td>Bay of Preiviiki</td>
<td>Recreation (bathing beach), underwater pipeline</td>
<td>Tourism</td>
</tr>
<tr>
<td>Kulju</td>
<td>Underwater pipeline</td>
<td></td>
</tr>
</tbody>
</table>
Current, past and planned activities are taken into account. Activities that are nearby MPAs that affect the ecosystem were also noted. However the legislation and regulations of the MPAs do not abide to them, but there is a possible negative effect. Full list of sources for impact data are given in Appendix 1. Some human impacts are only discussed in textual accounts of the MPAs, and no spatial or numerical data is available. These are considered as well.

The analysis of human impacts is very complicated since specific data about levels of impact and effect, or the spatial extent of impacts, are not readily available. Here however, impacts are spatially considered in the context of existing and present ecosystems, habitats and species. The focus is on the restrictions of expected impacts rather than realized pressures. Most common human impact in the MPAs were cables and pipelines (presence-absence, disregarding abundance of impacts within MPAs), being present in seven MPAs out of nine (other occurrences of impacts see list above).

Literature regarding the ecosystems, biotopes, habitats and species was used to determine the threats the MPAs underwater nature face. Multiple sources for biotope specific threats were used from multiple sources to form a comparative account of the threat. Many of the habitats have no specific literature concerning their threats, so some generalisation is required. HELCOM’s Biotope Information Sheets (BISs) provide systematic information of both HUBs and Habitat Directive biotopes (in a Baltic Sea context). It lists threats currently happening to the biotopes and future projected threats. Out of the 59 HUB classes, only three were covered in the published BISs. In a separate workshop meeting note, eight of the present biotopes were deemed as “habitats unlikely to require further assessment” (HELCOM, 2015).
Table 5 Human impacts from data and literature, legislation relating to them, MPAs with said impacts present, habitats or biotopes in which the impact is said to be a threat (from literature)

<table>
<thead>
<tr>
<th>Human Activity</th>
<th>Legislation</th>
<th>MPA</th>
<th>Habitat or biotope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquaculture</td>
<td>EPA</td>
<td>River Ii Estuary</td>
<td>Charales, Najas marina</td>
</tr>
<tr>
<td>Coastal waste water treatment</td>
<td>EPA, LUBA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contaminant pollution</td>
<td>EPA</td>
<td></td>
<td>Sandbanks, coastal lagoons, inlets and bays, reefs</td>
</tr>
<tr>
<td>Disposal of waste</td>
<td>LUBA</td>
<td>Uusikaarlepyy</td>
<td>Charales, Najas marina</td>
</tr>
<tr>
<td>Ditching</td>
<td>EPA</td>
<td></td>
<td>Charales, Najas marina, sandbanks, estuaries, coastal lagoons, inlets and bays, reefs</td>
</tr>
<tr>
<td>Dredging</td>
<td>Water Act, NCA</td>
<td>River Ii Estuary, Bay of Liminka, Kirkkosalmi</td>
<td>Charales, sandbanks, estuaries, inlets and bays, reefs</td>
</tr>
<tr>
<td>Dumping</td>
<td>NCA, EPA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dykes</td>
<td>NCA</td>
<td></td>
<td>Najas marina</td>
</tr>
<tr>
<td>Embankments and artificial beaches</td>
<td>NCA</td>
<td></td>
<td>Najas marina</td>
</tr>
<tr>
<td>Energy/power plants</td>
<td>EPA, NCA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enlargement of harbours and marinas</td>
<td>NCA</td>
<td></td>
<td>Estuaries</td>
</tr>
<tr>
<td>Fishing</td>
<td>NCA</td>
<td></td>
<td>Sandbanks, estuaries, coastal lagoons, inlets and bays, reefs</td>
</tr>
<tr>
<td>Marine construction</td>
<td>NCA</td>
<td></td>
<td>Sandbanks, inlets and bays</td>
</tr>
<tr>
<td>Mining and quarrying (e.g. stonefishing)</td>
<td>NCA</td>
<td></td>
<td>Reefs</td>
</tr>
<tr>
<td>N and P point source</td>
<td>EPA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreation</td>
<td>NCA</td>
<td>Uusikaarlepyy, Preiviiki</td>
<td>Estuaries, inlets and bays</td>
</tr>
<tr>
<td>Sand and gravel extraction</td>
<td>NCA</td>
<td></td>
<td>Sandbanks</td>
</tr>
<tr>
<td>Shipping</td>
<td>NCA</td>
<td>River Ii, Bay of Liminka, Kirkkosalmi, Quarken, Uusikaarlepyy, Luvia</td>
<td>Estuaries</td>
</tr>
<tr>
<td>Shipping infrastructure</td>
<td>Water Act, LUBA, EPA</td>
<td></td>
<td>(see Enlargement of harbours and marinas)</td>
</tr>
<tr>
<td>Water deviation</td>
<td>Water Act, LUBA</td>
<td></td>
<td>Charales</td>
</tr>
<tr>
<td>Wind power</td>
<td>EPA</td>
<td></td>
<td>Sandbanks</td>
</tr>
</tbody>
</table>
4.4 Management as means of conservation

The accounts on the MPAs (Environmental Administration descriptions, management plans, EEA dataforms) and their rules and regulations were coupled with the threats the biotopes and the MPAs face. These rules and regulations come from legislation implemented in the area, management plans and codes of conduct. The major pieces of legislations applied to the MPAs are discussed above (see: 1.3 Legislation behind Finnish marine protected areas) along with the repercussions of their implementation on the areas. They provide various rules to the areas that relate to the environment and the use of natural resources and space.

There is slight variation in the legislation applied to the areas (Table 3), but most are implemented by the Nature Act, Water Act, or the Land Use and Building Act. Information from these was drafted with regards to the human impacts discussed above (see: 4.3 Impacts and pressures).

Three of the nine MPAs have management plans. These were analysed to see their applicability for conserving the underwater nature of the sites. The management plans are written by Metsähallitus, so they are all very similar in format. The common style of management plan includes (description of the site (ecology, geology (if applicable), and socio-cultural aspects of the site), zonation of the site (Metsähallitus, 2009, 2012, 2015). The focus of management is clearly on the birdlife in the sites, judging the how this dominated the written accounts of the sites.

The management plans provide a more precise and comprehensive view into the sites, focusing on a single site or a small group of sites. The three plans (Bothnian Bay Islands, The Quarken, Bay of Preiviiki) provided little to no information of the area-specific regulations regarding the underwater environment. There is also much less text about the underwater nature in the descriptive sections of the sites. The text in the management plans generally consists of description of the site, nature and human use, both modern and historical, and the explanation of the site’s conservation and restoration action. Commonly the description of nature includes listing the habitats/biotopes in the area, along with their surface area. Some of the habitats also have percentages of how representative the biotopes are (Metsähallitus, 2009). Not much detail is provided of the role and importance of
different species in the ecosystem or the overall ecosystem function. The regulations appear in the plans with regards to the zonation of the areas (see 4.1.2 Bothnian Bay Islands - Perämeren saaret), although this zonation is only present on land. A large focus is on recreation as a use in the area, rather than an overarching account of all uses and impacts.

Table 5 shows all the human impacts listed in documentation of the MPAs, spatial data of human activities in the MPAs, and from literature concerning the habitats, biotopes and species found in the areas. It also shows the pieces of legislations that have governing issues regarding the human impacts. Listed are also the MPAs in which the human impact occurs, and the species, habitat or biotope that is connected to the human impact and said to be threatened or affected by that activity.

These human activities threaten the species and habitats by affecting the environment into less favourable for them. Aquaculture increases nutrient concentrations in the water, can affect sedimentation and water flow, and even create hypoxia and anoxia (Pillay, 2008) threatening especially primary producers such as Charophytes, in the vicinity of the fish farm (Holmer et al., 2003). Dredging removes large amounts of material from the seafloor creating large direct physical impacts affecting habitat destruction, as well as increased turbidity and sedimentation, threatening especially aquatic primary producers (Erftemeijer & Robin Lewis Iii, 2006) but also many other species and habitats. In this manner, the human activities (Table 5) have an impact on the environmental conditions of the area, threatening the integrity of the ecosystem function.

What Table 5 does not show is the real effect that pieces of legislation and other statutes have on the activity itself, but only the mentioning of said impact. The details of the legislation affecting impacts within MPAs are outlined under their description above (see 1.3 Legislation behind Finnish marine protected areas). Activities completely prohibited are (as stated above):

- The construction of buildings, structures and roads
- The extraction of soil and minerals and damage to the soil and bedrock (presumably this also includes dredging)
- Canalization
• Take or damage fungi, trees, shrubs or other plants and their parts
• Catch, kill or harass wild vertebrate animals or destroy their nests; or catch or collect invertebrates
• Practice activities that adversely affect the area’s natural conditions, scenery or survival of organisms
• Endangerment of specific biotopes, habitats and environments

The reality of these prohibitions is an issue of the enforcement, not explored further in this thesis, but has a great deal to do with the efficiency of the management of the MPAs. Judging by the language used in the legislatures, the above list seems to clearly prohibit virtually almost all directly harmful activities (note that these translations were done by the author, and effort has been put into translating everything as correctly as possible). The prohibitions in the above list at the same time prohibit many activities, but in a vague manner, where a large amount of knowledge and consideration is needed. To deduce whether a certain activity will e.g. “endanger specific habitats” will require research and assessment that is most likely outside of available resources and capabilities. Many of the activities however are currently happening, have happened, or are planned to happen in the MPAs, suggesting their prohibition is not as clear as the legislation suggests. On top of this, there are some activities, that are often assumed to be completely prohibited in MPAs (Allison et al., 1998), such as construction.

The legislatures exclude many activities that affect the state of the MPAs’ underwater nature, most evident of which are fishing, marine traffic, dredging and outside pollutants, such as nutrients. These human activities can result to impacts that have exerted the realized threat to the areas, and they are ultimately the impacts to analyse in order to assess the threat level to the ecosystem. Fishing results in changes in the food web and the structure of the entire ecosystem (Jennings & Kaiser, 1998). Marine traffic affects ecosystem by creating potentially harmful noise and vibration (Erbe et al., 2012), altering water column movement, structure and affecting particle suspension (Erm & Soomere, 2006), and increasing the possibility of pollution and even oil spills (Talley, 2003). Dredging causes physical removal of sediment and benthic organisms, and affects turbidity and sedimentation, potentially leading to smothering (Erftemeijer & Robin Lewis Iii, 2006). Pollutants can have various effects on ecosystem, but especially eutrophication and poisonous effects relating to physiology are important (Clark et al., 1989).
Pollutants from outside sources are a challenge that generally all MPAs face and a key feature separating them from terrestrial PAs. They are also an important criticism of MPAs, threatening their efficiency (Jameson et al., 2002). Similar to this, MPAs do not protect ecosystems from climate change. The EPA deals with pollutants and their release, stating possible spatial decisions regarding polluting human activities ("Ympäristönsuojelulaki," 2014). However not only does it state that this decision is possible (i.e. not mandatory for assessment or consideration etc.), out of the nine studied MPAs only one uses the EPA as statutory guidance. Even if it was, the nature of pollutants in an aquatic environment, especially in water bodies similar to the Baltic (semi-closed system, shallow, low energy), the effect of pollutants can reach huge distances.

Ship traffic and boating is another issue not dealt with within the scope of management in these MPAs. Currently there is no regulations on marine traffic spatially (besides Finnish Defence Forces areas), but there is a possibility that it poses a threat to ecosystems, e.g. through wave generation, resuspension of bottom material, there however is a large paucity of information and research into the topic (Laamanen, 2016). It is believed that lessening the stress caused by marine traffic may improve the state of especially Charophytes and other primary producers and ecosystem key species (Laamanen, 2016). In the operational program of the Finnish marine management plan lays out recommendations for mitigating the effects of boating and shipping, mainly by spatial planning related to especially shipping channels, and speed limits in certain areas (Laamanen, 2016).

In addition, various types of management actions are sometimes recommended in order to maintain or improve the state of the MPA. These can be considered as restoration action in some cases. Actions like this related to the marine environment include clearing and mowing beach dunes, the removal of common reed (Phragmites australis) from gloe and flad lake littoral zone (Metsähallitus, 2009, 2012).
5 Discussion & conclusions

This thesis highlights the state of the Finnish MPA management. The issues and strengths of this type of conservation have not been highlighted much specifically in past literature and research, or the management of specifically marine PAs assessed. This was done by using newly available, comprehensive data to assess the underwater nature of these areas, and it should be noted that this information was not of little detail when the sites were designated and planned. This means there are bound to be issues in the management of the MPAs.

The findings confirmed many assumptions about Finnish (and Baltic Sea) MPAs, especially the lack of management plans and use of scientific information in their establishment (EEA, 2015) for the nine MPAs studied. More specifically the results also showed variation in biota and human activities between the MPAs, but little variation in their management and restrictions within them. The management plans themselves did not provide much addition to the restriction of activities within the sites. It remains to be seen if this is true for the 768 (EEA, 2015) MPAs in Finnish waters. For example, Finland only has 24 Natura 2000 areas with management plans (Paulomäki et al., 2014)

Whilst there was a variety in the ecosystem compositions between the sites, many similarities can be seen. The underwater environment was abundant on aquatic primary producers, with some MPAs having a variety of benthic fauna. Based on the literature, these are threatened by seafloor impacting activities (HELCOM, 2013a), which happen in different ways in the MPAs (dredging in 3, cables and pipelines 7, current operational or future planned wind power 3, waste water input 1). This threat however is hypothetical, and the realised impact of the activities for each habitat, species and area is unknown. This does suggest that management should regard seafloor impacting activities more and they should be regulated, as it is bound to affect the ecosystems. This may jeopardize the management goals related to biodiversity as the dominant species seem to be benthic primary producers dependant on the seafloor integrity (Probert, 1984).
Arguably one of the most common maritime activities affecting habitats in these nine MPAs is dredging. It was not outright prohibited in the legislation or management plans, but regulated and under assessment. It was allowed in small scale projects and cases where maintenance of existing maritime channels was necessary ("Luonnonsuojelulaki," 1996). The decision to allow or prohibit these activities relies on officials and is made based on the permit application. How much and what kind of consideration goes into these decisions is unknown but based on the available human activity data suggesting that dredging is a relatively common activity within the MPAs, it seems declining the permit us uncommon.

Shipping and boating were a very common activity in the MPAs, as it is in the whole of the Baltic Sea (HELCOM, 2009b). Data shows shipping channels in six MPAs, in various ways and intensities. The impact of marine traffic to underwater ecosystems in the Baltic Sea is not very well known specifically, but shipping is known to have a large impact on the marine environment (Korpinen et al., 2013), by increasing noise pollution and affecting sedimentation and water flow amongst other things (Talley, 2003). This is not regulated or managed within the MPAs, and there is not a clear consensus on how marine traffic should be dealt with in MPAs in general (Boersma & Parrish, 1999).

The conclusion from these results is that the current MPA management is not sufficient for conservation of underwater nature as a whole. This assessment is based on the evaluation of the management and its relevance to the human impacts and environmental features of the studied sites. The second research question (2.5 Research questions & aims) asked “How are the Finnish MPAs managed and how were they planned with regards to the underwater nature, the human impacts in the area, and the connection between the two?” Whilst an open-ended question, the results of this thesis answer this as well as it can be. By using nine MPAs an overall image of the MPA management was attempted. As the findings were very similar between the MPAs, it is fair to assume that similar issues are present in Finnish MPAs not studied here. It would however be useful to further this type of management assessment to more MPAs, especially in the Archipelago Sea and the Gulf of Finland.

The methodology of this research was largely based on the combination of features, data and management action. This approach was used to assess the quality and basis of management. Whilst often MPAs are assessed by the effects of their establishment (e.g.
biomass, species richness and abundance (Edgar et al., 2014)), their management should also be assessed, as MPAs cannot be separated from social and economic factors and consideration. The performance of MPAs should be evaluated not only based on their biophysical factors, but also of their impact on society and economics (Himes, 2007). Here, the biological features (species, habitats, ecosystems) of the studied MPAs were used as a presumed basis for management decisions and planning, and the use of these biological features in that decision making was explored and discussed. Studying nine MPAs (out of 768 (EEA, 2015)) goes not without question, but fitted to the timeframe of this thesis. There is also the question with regards to the management information not included in this thesis.

The first research question of this thesis was “What is the nature of the Finnish marine protected areas in the Gulf of Bothnia with regards to management and planning?” This was addressed and explored by looking into the information regarding the matter. The information search was limited to mostly publicly accessible data based on the assumption that the accessibility of information and the level of (or capability of) public participation is vital to and a stern determinant to the success and effectiveness of conservation management (Voyer et al., 2012). The management was studied by looking into documents, legislation, texts and any other available accounts (e.g. research, publications) on the studied MPAs. This method not only gave a fair image into the management, but as said, it also provides assessment to the management itself, based on its availability, clarity and comprehensibility. There is a high possibility of relevant management information not being accessible to the public or to this type of research. Making claims of management flaws with the possibility of management action excluded from the assessment is questionable and debatable. However, transparent management creates a strong basis for conservation, and public participation and conflict resolution (Berkes, 2004).

The overall nature of the Finnish MPA management is complex, official, and comprehensive. However the strengths of it seem to be mostly abstract, instead of concrete. It is also fairly obvious that the management of the MPAs is very unilateral and universal between all the MPAs, meaning they are all managed in a fairly similar way. Whilst this may be beneficial in efficiency and advantageous in a low-resource situation, it can be unfavourable from a management perspective, as individual unique design, planning and management should be made for each individual MPA (Agardy et al., 2011).
This research would have benefited from more detailed information on other aspects of the MPAs. For example much of the human pressure data was lacking in detail, making assessing their impact difficult. Some human impacts had little to no data of them, and some were only mentioned or discussed in a descriptive format, and not in a quantitative manner. Whilst there was the same issue with the management plans and the information of the MPA management itself, this is a result on its own regarding the management.

A research basis on the MPA effectiveness would be useful in assessing the effectiveness of the management; however this does not exist at the moment. As there is a relatively high interest and investment in scientific research in Finland, there is a great potential to build the knowledge base on Finnish, Baltic Sea, and temperate MPAs.

The framework and base for marine protected area conservation in Finland is strong with official levels of operation (e.g. governmental departments) and strict compliance to guidelines and both national and international conservation goals and directives. The results of this thesis emphasize the parts of MPA management that are lacking and areas to improve on. They support the conclusions of other recent publications regarding MPAs in the Baltic Sea (WWF, EEA). Since there has been a clear paucity of information regarding the underwater marine environment, MPA planning, management, establishment and development have likely suffered in their cost-efficiency.

Only three out of the nine studied MPAs had specific management plans, which is often regarded as an integral if not a vital part of any functioning PA (Pomeroy et al., 2004). Besides this, there is also the question of the appropriateness and usefulness of the plan itself. This of course requires detailed information of the area in question, more specifically of the ecological and biological nature. As there has been paucity in this, management plans presumably are not sufficient for underwater conservation. In reality, there is very little management action in the plans regarding anything below sea level.

Many of the MPAs were found to have unclear, often vague, conservation goals. In only a few sites was it clearly stated as to why they were established, making the assessment of their management effectiveness challenging. On the other hand, the goals of agreements and directives are overarching and general, e.g. one of the objectives of HELCOM BSPAs being “A BSPA should give particular protection to species, natural habitats and nature types in order to conserve biological and genetic diversity” (HELCOM, 2013b) does not
have much specificity and can be interpreted and put to action in many different ways. The vagueness of conservation goals makes the overall assessment of their effectiveness difficult, with open-ended conclusions of the successfulness of the site. This on the other hand can be dangerous in the face of overall conservation action with the reinforcement of faulty management approaches.

The underwater environment was largely neglected and minimally described in the written accounts of the MPAs. One could argue that conservation can have positive effect even with little knowledge of the area, but evidence-based conservation is not only a requirement for effective management (Pullin et al., 2004), but vitally important for conservation to be beneficial to the environment (Regan et al., 2005). However if there is no sufficient knowledge, will the conservation action itself, such as the restrictions and regulations applied, be informed enough? This is an important question especially in Finland, where the regulations in MPAs are relatively loose and not many activities are outright prohibited compared to MPAs in many other places.

The overall scientific and educated governmental consensus is that MPAs can be beneficial to the nature (Edgar et al., 2014), fish stocks (Gell & Roberts, 2003) and socio-economic (Badalamenti et al., 2000) within and in the vicinity of the boundaries of the sites. Although these have not been studied in Finnish MPAs, the abundant evidence of these effects suggests that they are possible in Finland as well. This being said, they should be studied not only to find the best management solutions, but to communicate the concrete benefits of MPAs to the public and decision-makers.

The importance of the conservation of specifically underwater conservation comes from not only its intrinsic value, but also its importance to the environment above water (Furness & Camphuysen, 1997) (especially the birds, which are kept in high regard in Finnish MPA conservation), its importance to economy, especially fishing (Bonsdorff & Blomqvist, 1993) and its numerous ecosystem services (Jansson et al., 1999). Approximately 85 million people live in the Baltic Sea’s catchment area (HELCOM, 2009a), with a significant amount of people living in the coastal regions and dependent on the sea. Many of these activities are likely to be dependent on the quality of the marine environment (BalticSTERN, 2013).
Agardy (2000) argues that for well-informed efficient MPAs, the most important piece of knowledge is societal, specifically that of the goals of the MPA establishment. This is because it governs not only what other information one needs for efficient management but also how the site should be managed, as well as how the efficiency should be measured. Albeit varying, the definitions of MPAs are often based on limitations and regulations on resource-use in the area.

Simply the fact that the underwater nature, its species and habitats, is largely neglected in MPA management and planning, suggests that the process has been done with low resources and lacking data. However this provides no insight to the research questions at hand in this thesis. The legislation and management plans have the same issue of neglecting underwater nature. Whilst the existence and application of legislation and statutes are a strong possible basis for management, they should reach the underwater environment and create rigorous management and conservation solutions.

On a very basic level, this thesis concluded that the Finnish MPA management is lacking in many aspects, but that there is great potential for improvement. The results (specifically Table 4 and Table 5) suggest that there is little consideration of the factual activities in the MPAs, and their effect on the underwater environment. Several reports highlight the impressive coverage of Finnish MPAs, and the fast achievement of the Aichi target of 10% cover (Blankett, 2013; SCBD, 1992). However, the mere existence and designation of protected areas do not mean they are protecting the nature in reality. They need to be well managed, planned, executed and researched for them to be actual, realized protected areas, with real-life, vital benefits to the environment and the society dependent on them. If the management is merely administrative (c.f. practical) it most likely does not secure the functionality of the ecosystem.

5.1 Management recommendations and future research

This research suggests that the current management action in place might not be sufficient for the conservation of underwater nature. The legislation, written accounts and management plans neglect the state and value of the underwater ecosystems. Even in areas
primarily established for the protection of birdlife, the importance of the aquatic ecosystem should not be understated, especially their connection to waterfowl (Furness & Camphuysen, 1997).

Due to lack of precise data and shortcomings in its reliability, fishing was not discussed in this thesis, although it clearly has a high impact on marine ecosystems, and is often one of the most discussed topics in MPA discourse. The restrictions on fishing is also lacking in MPAs in Finland, which is generally considered an important tool in fisheries management and conservation (Di Franco et al., 2009; Klein et al., 2010). Strict no-take zones, MPAs where fishing and extraction of any resources are prohibited have been found to be significantly higher in fish density than areas where activities are regulated (Claudet et al., 2008), as well as benefiting the ecosystem structure and functioning (Murray et al., 1999). Establishing no-take zones in Finnish waters would increase the knowledge of MPA management and effects and could potentially be a great development in marine conservation.

One of the main obstacles for improving the MPA management in Finland is the lack of knowledge of the effects of the MPAs specifically in Finnish waters and the paucity of research in the whole Baltic Sea. There has been no study about the effects the MPA establishment has had on the ecosystems. The assumption that merely establishing a PA will be beneficial to the biota in the area is detrimental to both the ecosystem itself and the management action, lowering its cost-effectiveness and validity.

Regarding future MPA development, especially with the open sea MPAs that are to be established and the ones that are to fill the HELCOM goals for Bothnian Bay (HELCOM, 2013b), the planning and execution of the conservation should be efficient and well informed. More data and expertise is needed in the planning, management and research of MPAs in Finland.

The efficiency of these management measures cannot be known without research. Great knowledge gaps were apparent. There is a high need for case studies on all aspects of the Finnish MPAs, from their biological effects to their social implications. Since the majority of literature and research on MPAs is from tropical areas, especially coral reefs, there is a high need for a framework on regions other than the tropics and sub-tropics, as well as one
for a sea as unique as the Baltic Sea. The most important and urgent recommendations of this thesis work are:

- The management of the MPAs should move into what is often considered more efficient management, this includes:
  - The underwater nature must be included in the management of the MPAs
  - More knowledge and communication available to and with the public and stakeholders
  - Use of accurate scientific data in the management decisions
  - Stricter regulations within the MPAs regarding the resource use of the site
  - Clear and concise management plans including the should be implemented in all MPAs that establish efficient conservation
- A study on how well the current MPA network protects the underwater nature; e.g. by analysing if biodiversity hotspots and MPAs coincide in the Finnish sea areas
- A thorough survey and exploration into what parts of underwater biodiversity should be protected with MPAs and to what level of enforcement
- A study on the effects of MPAs on Finland’s underwater biodiversity
- A review or investigation into what are the most effective and/useful MPA management approaches possible in Finland

These studies would form a strong base for the management solutions and approaches outlined above, and they are certainly needed for cost-efficient and successful marine protected area management.
References


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HELCOM. (2013a). HELCOM Red List Biotope information Sheets (BIS): HELCOM.

HELCOM. (2013b). Overview of the status of the network of Baltic Sea marine protected areas.

31.

HELCOM. (2014). HELCOM Recommendation 35/1 (pp. 5): HELCOM.


# Appendices

## Appendix 1

Human impact data sources and descriptions

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
<th>The organisation responsible</th>
<th>Timeframe</th>
<th>Data type, quantity and quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU-directive bathing beaches</td>
<td>Bathing beaches that have visitor counts higher than the criteria set in the EU bathing beach directive. Data starts from 2006 and is updated continuously.</td>
<td>National Public Health Institute of Finland</td>
<td>Dataset started in 2006</td>
<td>Point</td>
</tr>
<tr>
<td>Aquaculture</td>
<td>Aquaculture and net pen farms in the Finnish coastline</td>
<td>Northern Ostrobothnia Centre of Economic Development, Transport and the Environment</td>
<td>Data from February 2016</td>
<td>Point</td>
</tr>
<tr>
<td>Harbours and ports</td>
<td></td>
<td>Northern Ostrobothnia Centre of Economic Development, Transport and the Environment</td>
<td>Data starts from March 1997</td>
<td>Point</td>
</tr>
<tr>
<td>Nitrogen point source</td>
<td></td>
<td>Northern Ostrobothnia Centre of Economic Development, Transport and the Environment</td>
<td>Data starts from March 1997.</td>
<td>Point, with information on amount of nitrogen released in kg year⁻¹</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Source</td>
<td>Data Start/Update Details</td>
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<tr>
<td>Phosphorus point source</td>
<td>Northern Ostrobothnia Centre of Economic Development, Transport and the Environment</td>
<td>Data starts from March 1997.</td>
<td>Point, with information on amount of phosphorus released in kg year(^{-1})</td>
<td></td>
</tr>
<tr>
<td>Windpower</td>
<td>Operational and planned future wind power plants in coastal Finland</td>
<td>SYKE</td>
<td>Data from November 2015, with updates irregularly when possible</td>
<td></td>
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<tr>
<td>Coastal industry</td>
<td>Data of various industry sectors operating in the coastal area, includes, food, chemical, wood and other industries</td>
<td>Northern Ostrobothnia Centre of Economic Development, Transport and the Environment</td>
<td>Data from February 2016. Point, with information on type of industry where possible</td>
<td></td>
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<tr>
<td>Coastal energy production</td>
<td>All non-windpower energy production facilities in the coastal areas</td>
<td>Northern Ostrobothnia Centre of Economic Development, Transport and the Environment</td>
<td>Data from February 2016. Point, energy production in 5-10 km inland.</td>
<td></td>
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<tr>
<td>Dredging</td>
<td>Dredging data including year of operation (if available) and in some cases amount of dredged material</td>
<td>SYKE</td>
<td>Data divided by before and after 2012, and to dredging where year was not known.</td>
<td></td>
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<tr>
<td>Coastal waste water treatment</td>
<td>Residential waste water treatment facilities</td>
<td>Northern Ostrobothnia Centre of Economic Development, Transport and the Environment</td>
<td>Data from June 2014, updated February 2016. Point, waste water facilities in 5-10 km inland.</td>
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