An overview of Finnish nature conservation management and occurrences of four threatened species in the northern Bothnian Bay

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Summary

The Baltic Sea is a sea with numerous unique biotic and abiotic characteristics across its surface body. The limited water exchange with the Atlantic Ocean, combined with the discharge of freshwater from more than 200 rivers, creates a unique salinity gradient across the whole Baltic Sea. As a result, the distribution of marine and freshwater species in the Baltic Sea is unlike any other marine environment. Species in the Bothnian Bay are adapted to the brackish water and experience limited distribution opportunities. Therefore, threats to their habitats such as dredging, eutrophication and climate change can have serious negative effects on their ability to survive as a species. To protect habitats and species from threats, Finland has implemented European directives such as the Habitats Directive and conventions such as the Helsinki Convention in its national laws. To make ecological sustainable decisions according to the law, policy makers in the northern Bothnian Bay need sufficient knowledge about the marine environment. The SEAmBOTH project's goal is to provide this knowledge, aiming to ensure the conservation of the biodiversity, habitats and ecosystems in the northern Bothnian Bay in both Finland and Sweden.

This study aims to contribute to the SEAmBOTH project by providing information about differences in nature conservation management and analysis of threatened species occurrence in the Finnish northern Bothnian Bay. Information about differences in nature conservation management showed that strict habitat definitions occasionally limit the ability to protect areas in close vicinity of nature reserves. Making it difficult to pre-emptively protect habitats which do not fit the habitat definition but can become a habitat befitting the strict habitat definition if certain measures would be executed. Analysis of threatened species occurrence during the timespan of the SEAmBOTH project in the northern Bothnian Bay showed that the highest densities of threatened species occurrences were found in nature reserves. The highest densities were observed in the Kemi river estuary, northside of Ulkokrunni and Kempeleenlahden ranta, where on average one threatened species occurred every 1 km^2. However, for further conclusive results the sample size of threatened species occurrences needed to be higher. Therefore, this study can be used as an incentive to gather more data and perform more analyses about threatened species occurrence. Recommended would be to conduct a long-term study of monitoring occurrences of threatened species in a systemic order in an area inside a nature reserve and outside the nature reserve in close vicinity. Another possibility could be to examine threatened species occurrences before the implementation of the European wide nature reserve network, the Natura 2000 network, and compare it to new occurrences after the implementation of the Natura 2000 network. The final recommendation is to explore the idea of citizen science to gather more observations of threatened species in the northern Bothnian Bay.

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1. Introduction

1.1 The Baltic Sea

The Baltic Sea is an arm of the Atlantic Ocean and lies in Northern Europe. It is a continental nontidal brackish sea, i.e. the Baltic Sea is a semi-enclosed sea that has limited water exchange with the Atlantic Ocean whilst having no tides and a lower salinity level than marine seawater, but higher than that of freshwater (Snoeijs-Leijonmalm, Schubert, & Radziejewska, 2017). The Baltic Sea encompasses all seas shown in Figure 1, excluding the North Sea and the Skagerrak. Although, the Skagerrak is of importance due to it being the only natural body of water in which water exchange with the Atlantic Ocean takes place. Artificial waterways such as canals have been made to link the Baltic Sea Area to the North Sea through the Kiel Canal, the White Sea through the White Sea – Baltic Canal and even to the Caspian Sea through inland waterways. The water exchange through the canals is negligible, but it enables water pollution and the exchange of non-indigenous species through human activities (HELCOM, 2010). The Baltic Sea has a surface area of 420,000 km^2 (HELCOM, 2018), making it one of the world's largest brackish water areas, together with the Caspian Sea and the Black Sea.

Due to its geographical size and location, the Baltic sea displays different environmental gradients across its surface body. In the south the climate is temperate. Whereas in the north, there is a subarctic climate (Snoeijs-Leijonmalm & Andrén, 2017). The Bothnian Bay is covered in ice for almost half a year, creating a drastically different environment compared to the temperate southern Baltic Sea. Not only the temperature changes across this gradient, the surface-water salinity is affected as well. The salinity in the southern Baltic Sea can be between 7.6 – 11.3 Practical Salinity Unit (PSU, based on conductivity and roughly corresponds to g salt / kg seawater), while the salinity in the Bothnian Bay is around 1.8 – 3.9 PSU (Andersen, et al., 2015). The salinity being lower than an actual marine environment is caused by the limited water exchange combined with the freshwater runoff (Ojaveer, et al., 2010). Over 200 rivers discharge into the Baltic Sea, bringing freshwater, sediments and nutrition into the Baltic Sea (Kautsky & Kautsky, 2000).

1.2 The northern Bothnian Bay

Through abiotic characteristics such as its geographical location, amount of freshwater runoff and a weather dependent tide instead of a lunar dependent tide, the northern Bothnian Bay can be seen as a unique marine environment. On top of those characteristics another process called land uplift, as result of the release of pressure from ice during the last glacial period, is changing the environment ever so slightly. Lifting the land by an average 1.5mm every year, creating new isolated water bodies in the northern Bothnian Bay (Kautsky & Kautsky, 2000).

Variances in these abiotic characteristics combined with biotic characteristics along terrestrial and aquatic areas are widespread in the northern Bothnian Bay (Snoeijs-Leijonmalm & Andrén, 2017). Areas distinguished by these characteristics are henceforth called natural habitats, or habitats for short. Habitats serve as environments in which species can live and thrive (Townsend, Begon, & Harper, 2008). Distributed across the northern Bothnian Bay are eight distinct habitats as described by the European Union Habitats Directive; Sandbanks, Estuaries, Mudflats*, Coastal Lagoons, Large shallow inlet and bays, Reefs, Baltic Esker islands and Boreal Baltic islets and small islands (HELCOM, 2013a; Kontula & Raunio, 2018). Further descriptions of these habitats can be found in Appendix I. Each habitat is a system that provides essential services to its surroundings. For example, Coastal Lagoons act as nurseries for certain fish species or help regulating the flow of nutrients between different bodies of water (Newton, et al., 2018). Habitats are also a key factor determining the dispersion, fragmentation and population growth of species that are adapted to those habitats (Townsend, Begon, & Harper, 2008).

In November of 2018, the Convention of Biological Diversity (CBD) had chosen the northern Bothnian Bay as one of nine Ecologically or Biologically Significant Marine Areas (EBSA) in the Baltic Sea.

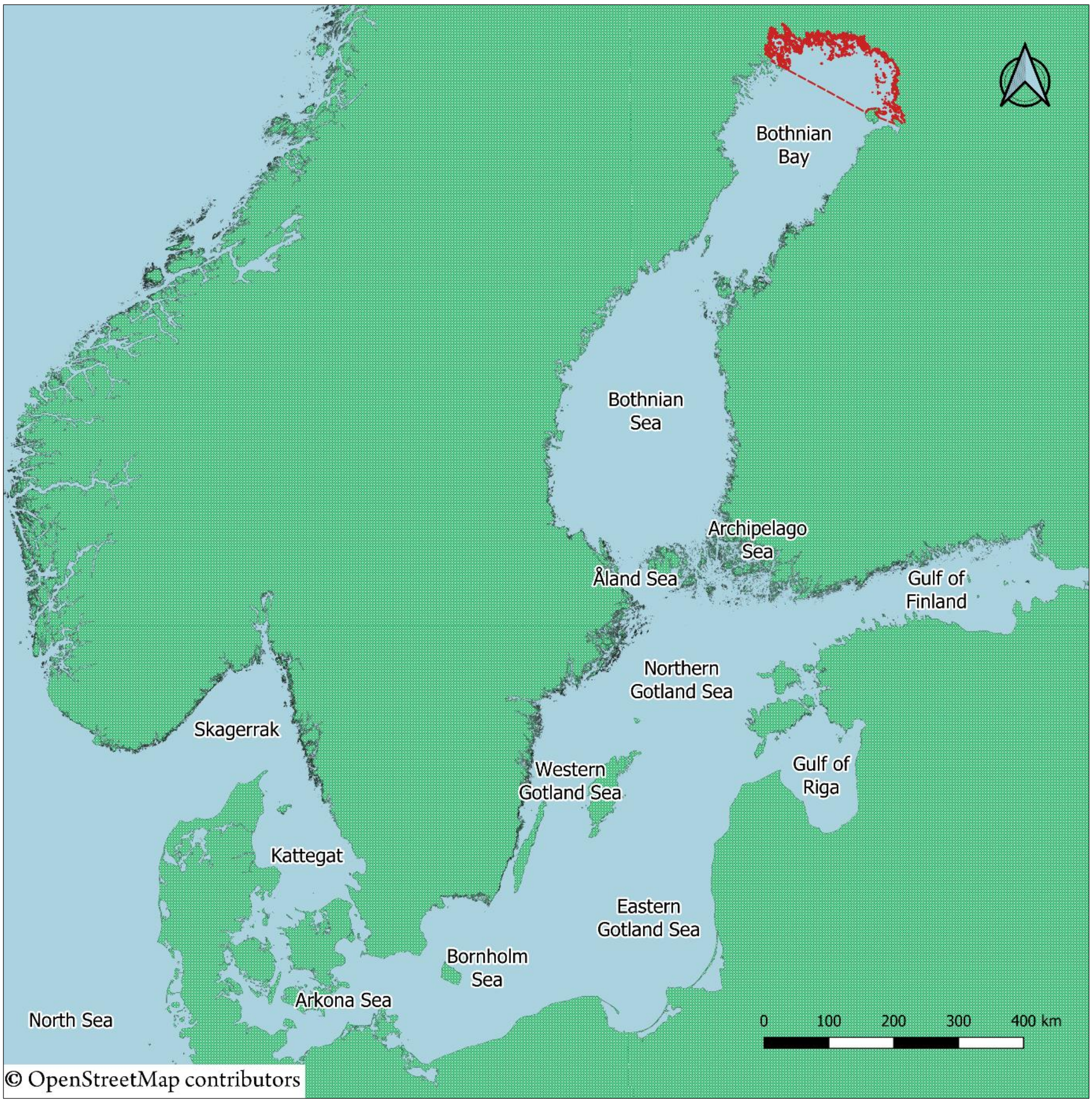

Figure 1: Map of the Baltic Sea Area, showing the different seas. All the portrayed seas except for the North Sea and the Skagerrak are called the Baltic Sea. The Skagerrak and the Kattegat together are called the transition zone. The south of the Baltic Sea consists of the Arkona Sea, Bornholm Sea and the southern part of the Eastern Gotland Sea. The central Baltic Sea consists of the northern part of the Eastern Gotland Sea and the Western Gotland Sea. The Northern Gotland Sea is the northern Baltic Sea, also called the Baltic Proper. The Bothnian Sea and The Bothnian Bay are together called the Gulf of Bothnia. The area outlined in red shows the northern Bothnian Bay and is the SEAmBOTH project area. It crosses the border between Sweden and Finland. Adapted from Snoeijs-Leijonmalm & Andrén (2017)

CBD defines these EBSAs as the following: "Ecologically and biologically significant areas are geographically or oceanographically discrete areas that provide important services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics,". The northern Bothnian Bay was appointed by CBD because of the presence of several unique habitats, high importance for critical life stages of several species and hosting numerous threatened species of plants.

1.2.1 Species in the northern Bothnian Bay

Living in the northern Bothnian Bay are approximately 289 different macro-species, excluding bird species (HELCOM, 2012). While the number of species in the northern Bothnian Bay is lower than most other seas in the Baltic Sea, the brackish water and extreme variations in temperature and light result in comparatively more endemic species in the northern Bothnian Bay (CBD, 2018). The low salinity and in some areas, most notably estuaries, the presence of freshwater makes the northern Bothnian Bay suitable for marine and freshwater species (Snoeijs-Leijonmalm, 2017). However, the low salinity is also an important limiting factor on the distribution of marine species, especially in the Bothnian Bay (HELCOM, 2018). Species that occur more south such as common eelgrass *Zostera marina* or the blue mussel *Mytilus trossulus* are not able to survive in the low salinity waters of the northern Bothnian Bay (Korpinen, et al., 2018).

Around 116 macrophyte species occur in the brackish environment in the northern Bothnian Bay (HELCOM, 2012). These species are adapted to the extreme environment of the northern Bothnian Bay despite the different pressures and mosaic like distribution of habitats (Snoeijs-Leijonmalm, Schubert, & Radziejewska, 2017). The following four macrophyte species are present in the northern Bothnian Bay. All four species are categorized as threatened according to the Helsinki Commission (HELCOM, 2013c) and the Finnish Ministry of the Environment (Hyvärinen, Juslén, Uddström, & Liukko, 2019).

***Alisma wahlenbergii* (Holmb.)** **(Habitats Directive Annex II & IV) (Finnish Red List Status: VU)**
Finnish name: Upossarpio **(Criteria: B2b(i,ii,iii,iv,v)c(iii,iv))**

Alisma wahlenbergii is an endemic perennial aquatic plant that grows on soft bottoms comprised mostly of sand with some mud or silt mixed in (Viitasalo, et al., 2017). *A. wahlenbergii* grows in shallow clear brackish waters around 0,05 to 0,45 m deep but can occur in depths up to 1.5 m (HELCOM, 2013). The plant is often found on shallow mudflats. The plant lives almost exclusively underwater during its lifespan (Viitasalo, et al., 2017). The base of *A. wahlenbergii* is rosette shaped with 5-20 emerging leaves. The leaves are 10 to 30 cm long, 1 to 3 mm wide, ribbon shaped and have a dark green color (Mossberg & Stenberg, 2005). The flowers are arranged in panicles, where one stem supports multiple pedicels with a single flower or fruit. The flowers have a white color, whereas the fruits are green. *A. wahlenbergii* usually blooms between July and August and produces seeds in August and September (HELCOM, 2013d).

Alisma wahlenbergii benefits from open habitats due to its low competitiveness (HELCOM, 2013). Reeds can quickly take over a suitable habitat for *A. wahlenbergii*, especially in eutrophicated areas (HELCOM, 2013). Human activities such as dredging and construction are also detrimental to *A. wahlenbergii* due to the increase of water turbidity and pollution (HELCOM, 2013).

***Crassula aquatica* (L.)** **(Habitats Directive Not Included) (Finnish Red List Status: VU)**
Finnish name: Paunikko **(Criteria: B2ab(ii,iii,iv,v)c(iii,iv))**

Crassula aquatica is an annual succulent plant that grows on sandy, silty, clay or pebbly shores (HELCOM, 2013). It grows in slightly brackish or freshwater environments (HELCOM, 2013). *C. aquatica* can occur under water up to a depth of 0,5 m, or on wet banks partially submerged or above water (HELCOM, 2013). *C. aquatica* can be up to 5 cm in height (Mossberg & Stenberg, 2005). *C. aquatica* grows mostly vertically with no branching in the stems (Mossberg & Stenberg, 2005). The leaves are located opposite of each other on the stem with non-altering intervals and needle shaped with a length of 3 to 5 mm (Mossberg & Stenberg, 2005). The leaves can appear reddish when not submerged in water (Viitasalo, et al., Meren Aarteet, 2017). The flowers are located in the petioles and appear white or reddish (Mossberg & Stenberg, 2005). *C. aquatica* flowers between July and September.

Crassula aquatica usually occurs in clay and muddy lakes near or in the water. It can also appear on seaside beaches or meadows and mudflats with grazing as it benefits from an open habitat (HELCOM, 2013). It usually has a patchy distribution in a suitable habitat, but this can very heavily on the conditions in which the seeds were dispersed or kept (HELCOM, 2013). Due to its low competitiveness with species that benefit from eutrophication, such as reeds, it can quickly be taken over when eutrophication occurs (HELCOM, 2013d).

***Hippuris tetraphylla* (L.)** **(Habitats Directive Annex II & IV) (Finnish Red List Status: VU)**
Finnish name: Nelilehtivesikuusi **(Criteria: A2ace+3ce)**

Hippuris tetraphylla is a perennial aquatic plant that grows in shallow slightly brackish waters on soft bottoms (HELCOM, 2013), it's length usually being between 15 and 40 cm (Mossberg & Stenberg, 2005). It usually occurs in sheltered waters such as a bay (Mossberg & Stenberg, 2005), but it is also found in shoreline meadows and mudflats. The stems of *H. tetraphylla* have a red color, both above and under water (Viitasalo, et al., Meren

Aarteet, 2017). The leaves are arranged in whorls consisting of 4 to 6 leaves. The leaves are approximately 10 to 15 mm long and 3 to 5 mm wide, appear oval and are blunt (Mossberg & Stenberg, 2005). The flowers are located in the petioles and appear like red fruits resting on the leaves. *H. tetraphylla* flowers as early as June to August (Mossberg & Stenberg, 2005).

The overgrowth of reeds on shoreline meadows poses a threat for *Hippuris tetraphylla* (Viitasalo, et al., Meren Aarteet, 2017). *H. tetraphylla* cannot compete with the increased growth rate of reeds in areas with high eutrophication (HELCOM, 2013). Furthermore, human activities in bays are decreasing the available habitats for populations of *H. tetraphylla* (HELCOM, 2013).

***Persicaria foliosa* (H. Lindb.)** **(Habitats Directive Annex II & IV) (Finnish Red List Status: EN)**
Finnish name: Lietetatar **(Criteria: B2b(i,ii,iii,iv,v)c(iii,iv))**
Persicaria foliosa is an annual plant that can grow in shallow slightly brackish or freshwater (HELCOM, 2013). *P. foliosa* prefers to settle in soft bottoms composed of sand or a mix of sand and silt, however, it can also be found near more rocky bottoms in the archipelago (HELCOM, 2013). It is a typical plant in river estuaries and mudflats. It can grow to be 40 cm long with the stem usually having a red / pink color (Mossberg & Stenberg, 2005). The leaves are on alternating sides between internodes and can be up to 10 cm long and usually 3 to 5 mm wide (Mossberg & Stenberg, 2005). The leaves are almost flat with them being 0,2 to 0,8 mm thick. The flowers are located in the petioles and can have a green, red or pink color (Mossberg & Stenberg, 2005). *P. foliosa* blooms between July and September (Mossberg & Stenberg, 2005).

Persicaria foliosa is a very weak competitor (HELCOM, 2013). Habitats that experience processes which open up the area, such as grazing, ice-scouring or water level fluctuations are beneficial for *P. foliosa* (HELCOM, 2013). *P. foliosa* is also sensitive to pollution and disturbance due to construction near its suitable habitats (HELCOM, 2013d).

These four species are all considered indigenous to the Baltic Sea Area, occurring in Finland before 1800 (Hyvärinen, Juslén, Uddström, & Liukko, 2019). However, human development around coastal and marine ecosystems in Finland are posing a threat to the future well-being of these indigenous species. Pressures induced by human development such as eutrophication and increasing inflow of non-indigenous species in the environment significantly alter the habitats in these aquatic ecosystems (HELCOM, 2018). Consequently, alteration of these habits and loss of indigenous species can have a negative effect on ecosystem services on which humans rely (Millenium Ecosystem Assessment, 2005).

To prevent further loss of indigenous species and degradation of ecosystem services, they should get a well-defined place in human-placed systems (Crain, Halpern, Beck, & Kappel, 2009). The European Union (EU) and its Member States have taken actions to halt the degradation of biodiversity in Europe. Different EU Directives and national laws from member states on nature conservation have given policy makers frameworks to integrate nature in different aspects of human society.

1.3 Legislation

1.3.1 European Union

The Habitats directive is a European wide directive concerning the nature status across all European member states. The Habitats Directive was not the first Directive from the European Union (EU) concerning the environment. The Directive on the Conservation of Wild Birds 79/409/EEC was the first directive to be accepted by the council. Through the Directive on the Conservation of Wild Birds, member states had to asses and assign important habitats for these birds (Council of the European Union, 1979). This established a network of Special Protection Areas (SPAs). In 1992, SPAs became a part of the Natura 2000 network set up through the Habitats Directive. (Council of the European Union, 2013).

The Natura 2000 network aims to conserve rare and characteristic habitats and the species that inhabit them. The Habitats Directive has assigned approximately 200 habitats to be protected in Annex I. About 900 species to be protected within areas that are crucial for their lifecycle in Annex II and around 400 species that are to be protected inside and outside of Natura 2000 sites in Annex IV (Council of the European Union, 2013). The aim is to reach a favorable conservation status (FCS) for these listed habitats and species. According to the European Commission Directorate-General for Environment (2007), FCS can be described as: "A situation where a habitat type or species is doing sufficiently well in terms of quality and quantity and has good prospects of continuing to do so in future." (p. 9). Nature areas that are crucial for the survival of species listed in Annex II or IV of the Habitats Directive can be listed as a Site of Community Importance (SCI). SCIs could also be habitats from Annex I of the Habitats Directive that are losing their FCS. However, it is up to each member state to assign SCIs and SPAs.

To adopt a SCI, a member state must fill in the Natura 2000 Standard Data Form (SDF) for the proposed SCI. The Commission then decides, together with the member state that delivered the Natura 2000 SDF, if the proposed site can be adopted in the Natura 2000 network (Council of the European Union, 2011). When the SDF, and thus the SCI, gets approved, the member state must designate them as a Special Area of Conservation (SAC). The member state has six years for the process of designation and subsequently starting conservation measures (Council of the European Union, 2011).

Next to the Directive on the Conservation of Wild Birds and the Habitats Directive, the EU has written other legislation concerning marine areas. The Maritime Spatial Planning Directive is directed towards the economic uses of European marine areas in a sustainable method (Council of the European Union, 2014). The Marine Strategy Framework Directive (WSFD) and the Water Framework Directive (WFD) are aimed at achieving a good environmental status (GES) on European bodies of water (Council of the European Union, 2000; Council of the European Union, 2008). The Marine Strategy Framework Directive is the first directive regarding the protection of biodiversity in marine areas. It requires Member states to make an assessment on the state of the environmental status, proceeded by taking measures to reach GES by 2020. According to the MSFD, GES is when the status of marine waters "provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential uses and activities by current and future generations." (Council of the European Union, 2008). Under the Marine Strategy Framework, regional cooperation is encouraged to reach GES for seas through the regional sea conventions. The Convention for the Protection of the Marine Environment in the Baltic Sea Area of 1992 – Helsinki Convention, is the regional sea convention in the Baltic Sea Area.

1.3.2 Helsinki Convention - HELCOM

The basis of the Helsinki Convention was originally drafted in 1974, aiming to protect the marine environment of the Baltic Sea from pollution through cooperation (HELCOM, 1974). Ultimately, a new version of the convention from 1992 was entered into force in 2000 after it was ratified by all contracting parties; Denmark, Estonia, the European Union, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden (HELCOM, 2014). Through the Helsinki Convention, HELCOM had taken form. HELCOM is the administrative body of the Helsinki Convention. HELCOM observes the implementation of the Helsinki Convention by the contracting parties. Furthermore, HELCOM is also responsible to give advice to contracting parties, define pollution criteria and to perform scientific and technological research among others. All while promoting close cooperation between the contracted parties (HELCOM, 2014)

The main tool of HELCOM to protect the Baltic Sea environment through the Baltic Sea Action Plan (BSAP) and with the assignment of Marine Protected Areas (MPAs). MPAs aim to protect areas with threatened species and habitats, unique geological or geomorphological features, high sensitivity or ecological significance among others (HELCOM, 2016). Each contracting party is asked to take measures for these areas. However, the Helsinki Convention is non-binding and HELCOM only acts as an advisory for the contracting parties. It is up to each contracting party to implement the intents of the Helsinki Convention in their national laws.

1.3.3 Finland

In Finland, the Finnish Government is responsible for partaking and signing of treaties and conventions such as HELCOM or the CBD. Moreover, they are also responsible to draft bills or amendments for whenever a new EU Directive gets approved by the EU Council, or when an existing Directive gets amended. For both the ratification of treaties and approval of new bills, a majority is needed in the Parliament of Finland (*Suomen Eduskunta*). When a bill passes, or treaty is ratified it becomes Finnish law. Thereafter, the competent Ministry, its Minister and its agencies are responsible for preparing legal matters, executing and enforcing the new law.

The most important law concerning FCS of nature areas in Finland is the Nature Conservation Act (*Luonnonsuojelulaki* 1096/1996). It implements the intentions of both the Birds and Habitats Directive (Finnish Parliament, 1996). The responsibility to enforce the Nature Conservation Act lies with the Ministry of the Environment (*Ympäristöministeriö*). The Ministry of Environment directs, among others, the Centres for Economic Development, Transport and the Environment (*Elinkeino-, Liikenne- ja Ympäristökeskus, ELY Keskus*), the Finnish Environment Institute (*Suomen Ympäristökeskus, SYKE*) and Parks & Wildlife Finland (*Metsähallitus*). ELY centres and Metsähallitus are responsible for nature areas that fall into their scope. The responsibilities include drafting management plans, monitoring, assessing and implement measures to maintain or achieve FCS. The Nature Conservation Act specified four different types of nature reserves: national parks, nature reserves on state-owned land, nature reserves on private-owned land and strict nature reserves. Whether an ELY centre or Metsähallitus is responsible for the nature reserve depends on the type. The following descriptions of the type of nature reserve are primarily from Principles of Protected Area Management in Finland (Metsähallitus, 2016) and the Nature Conservation Act (Finnish Parliament, 1996)

National Park

A national park (*Kansallispuisto*) is a nature reserve on state-owned land designated through the Nature Conservation Act. The top priority of national parks is nature conservation, aimed at the abiotic and biotic natural features of an area. This includes species and ecosystems as well. Protection in a national park may be lenient depending on traditional ways of living in the area. Activities such as reindeer husbandry, ice fishing or picking berries, mushrooms and herbs can be allowed when they do not result in significant or lasting damage. Furthermore, national parks must also contribute to nature education, nature awareness, recreation and scientific research.

Metsähallitus, Parks & Wildlife Finland, is responsible for the management of the national parks. Due to the geographical size of Finland and its many different natural environments, plans are individually drafted for each national park.

Nature reserves on state-owned land

Nature reserves (*Luonnonsuojelualue*) other than a national park on state-owned land can vary in their conservation or management aims. These areas can be: mire conservation areas, herb-rich forest areas or old-growth forest areas. But also, areas deemed with any particular natural or cultural feature that needs to be conserved. The Ministry of the Environment is authorized to assign these areas. Metsähallitus is responsible for managing these assigned nature reserves. Management plans are written for categories of nature reserves, such as mire conservation areas, or individually when it has a unique feature.

Nature reserves on private-owned land

A nature reserve can also be established on private-owned land through the Nature Conservation Act. These private-owned nature reserves are designated by the regional environment centers (ELY centers). The landowner can be a private citizen, enterprise, association or even a municipality for example. ELY centers are responsible for establishing the contract with the private landowner. As well as stating the objective of the nature reserve, e.g. conservation of species, recreation or heritage.

ELY centers coordinate the management and acquisition of new nature reserves on private-owned land. However, the role of Metsähallitus in these activities has grown in recent years. Either ELY centers or Metsähallitus participate in management measures on these nature reserves together with the landowner.

Strict nature reserves
For strict nature reserves (*Luonnonpuisto*) the aim of nature conservation is the top priority. A strict nature reserve has a significant role in the landscape or ecosystem and guarantees that ecological succession can take place. They must also provide a significant role in scientific research or education. Most of the strict nature reserves are managed by Metsähallitus. The remaining strict nature reserves are managed by the state-owned Finnish Forest Research Institute (LUKE) (Tuomainen & Parviainen, 2004).

The restrictions in strict nature reserves are stricter compared to the other nature reserves. Access is usually restricted to marked paths or entrance is only allowed with permission of the responsible administration. Recreation is not an aim for strict nature reserves, as they need to be kept as close to their natural state as possible.

The Nature Conservation Act also defines topics such as when building activities are permitted, how permits are granted, how species are to be protected, drafting of management plans and how the assignment of Natura2000 functions. The Nature Conservation Act is legally the leading document for terrestrial nature reserves and for aquatic nature reserves. However, another Finnish law is written for matters that only apply to the use of aquatic areas; the Water Resource Management Act.

Water Resource Management Act
The Water Resource Management Act (Water Act) concerns the use of all bodies of water in Finland. The Water Act defines the rights Finnish citizens and corporations have with bodies of water, what alterations are allowed to bodies of water, when permits are needed and what is not allowed among other things. However, the Water Act itself does not mention conservation measures. Instead, the Water Act states the following in §2.2 "The provisions laid down in or under the Nature Conservation Act (*Luonnonsuojelulaki* 1096/1996), … shall be complied with when applying this Act and otherwise acting in accordance with this Act.". Whenever a project involves a body of water the project also must follow the Nature Conservation Act, thus incorporating conservation measures. The Water Act does cover specific aquatic habitat types that were not covered in the Nature Conservation Act. The natural state of Coastal lagoons (*flada*) not bigger than 10 ha, a lake created by land uplift (*kluuvijärvi*), springs, streamlets, and ponds or lakes not bigger than 1 ha are not to be endangered. However, it is possible to get an exception for a project if it is projected to not endanger these habitat types.

A Finnish law more focused on the ecological status of aquatic (marine) environments is the Act on the Organisation of River Basin Management and the Marine Strategy (Act River and Marine). The purpose of the Act River and Marine is to provide provisions to organize river basin managements, to improve the ecological status of the Baltic Sea, to keep water sustainable for human use, to protect marine, aquatic, wetland and terrestrial ecosystems directly connected to aquatic ecosystems. Most of the responsibilities are given to the regional ELY centre. However, Metsähallitus and SYKE also have some responsibilities regarding conservation and monitoring of aquatic habitats as long as it is within their sphere of operation.

1.4 SEAmBOTH

The Seamless Mapping and Management of the northern Bothnian Bay project (SEAmBOTH) is an international project between Finland and Sweden. It is funded by the Regional Council of Lapland in Finland (*Lapin Liitto*), the Swedish Agency for Marine and Water Management, and by Interreg Nord, an EU Financing program for local regions in the EU. Metsähallitus, a state-run enterprise, coordinates the project and numerous other organizations are involved; the Finnish Environment Institute (SYKE), the Centre for Economic Development, Transport and the Environment (ELY) of Lapland and North-Ostrobothnia, the County Administrative Board of Norrbotten (Länsstyrelsen Norrbotten), the Geological Survey of Finland (GTK) and the Swedish Geological Survey (SGU). It started in the spring of 2017 and is projected to end early 2020.

The SEAmBOTH project's main goal is to ensure the conservation of the biodiversity, habitats and ecosystems in the northern Bothnian Bay. To reach the main goal, SEAmBOTH aims to create maps showing the distribution of vulnerable habitats and species, maps of human pressures, geological maps of the area and

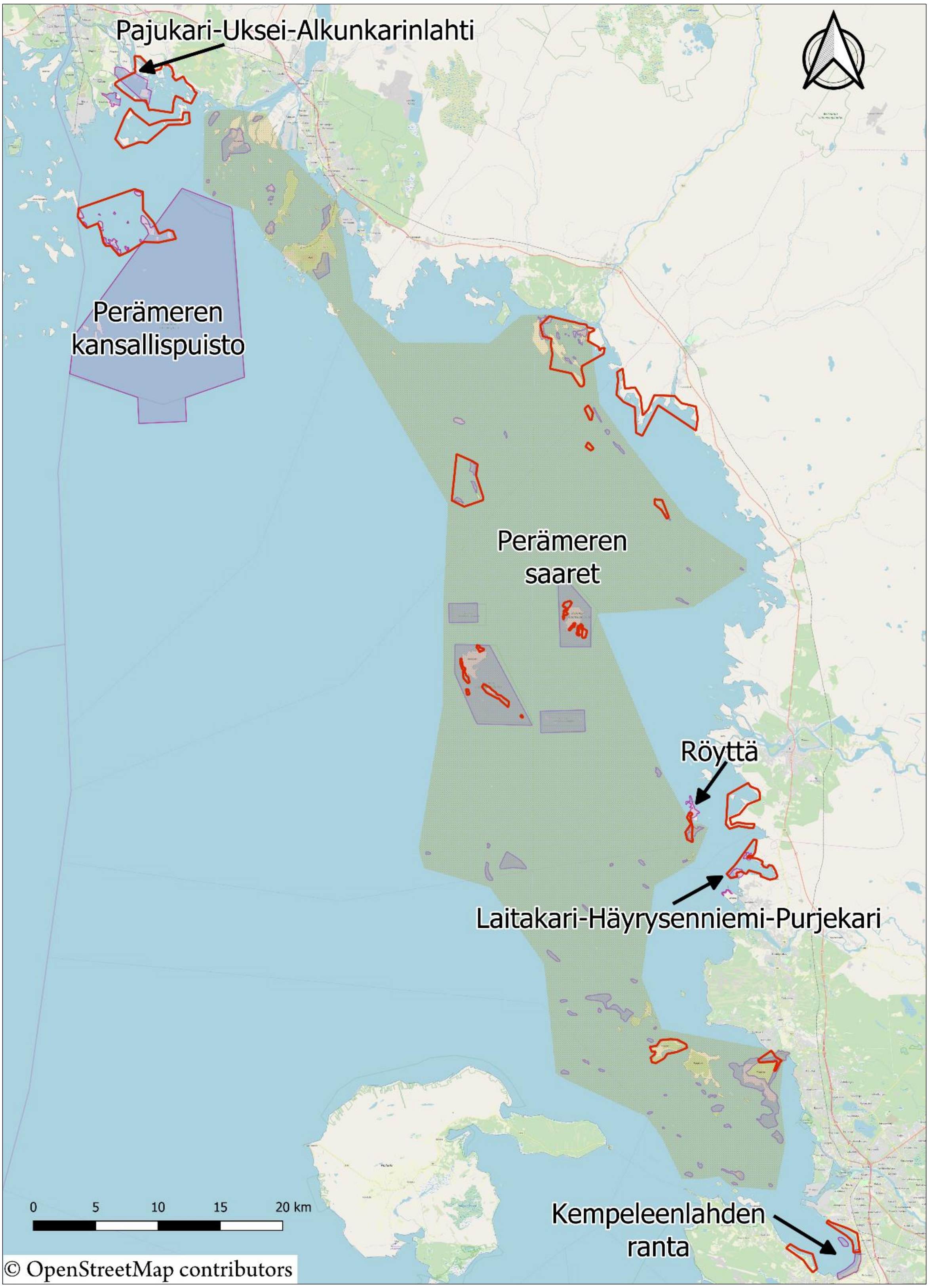

Figure 2: Map of the Finnish side of the SEAmBOTH area. The red outlined areas are the sites that were investigated during field work in 2019. The purple areas are all Natura 2000 areas in which field work was done in 2019. The yellow area indicates the stretch of the Natura 2000 area "Perämeren Saaret". Pajukari-Uksei-Alkunkarinlahti is a Natura 2000 area in the north. It also contains small areas of private-owned nature reserves. Perämeren kansallispuisto is a Natura 2000 area and a national park in the Baltic Sea. It is a fully managed HELCOM MPA. Röyttä is a Natura 2000 on an island near the coast. Except for one small part of the island, the whole island is considered a Natura 2000 area. Laitakari-Häyrysenniemi-Purjekari is a collection of three separate Natura 2000 areas. It is bordered by private-owned nature reserves and non-managed areas in the same bay. Kempeleenlahden ranta is a Natura 2000 area that is completely private-owned. Perämeren Saaret is a Natura 2000 site with areas in the south to the north of the SEAmBOTH area. It features multiple different habitats and is state-owned in some areas and private-owned in others.

by raising the general awareness about the marine environment. Another objective of SEAmBOTH is to harmonize definitions and assessments of nature values across Finland and Sweden in the northern Bothnian Bay. These harmonized assets and maps can then assist authorities, local policy makers, and citizens, whenever they need to make decisions where nature is involved. Enabling sustainable development in the region (SEAmBOTH, 2018).

In this study, the current legislative situation of Finland and occurrences of threatened species occurrences inside and outside nature reserves were to be studied. Through international conventions such as the Helsinki Convention, international legislation from the European Union such as the Habitats Directive and national legislation such as the Nature Conservation Act and the Water Act, Finland is taking measures to ensure minimal loss of habitats and biodiversity. The SEAmBOTH project aims to assist in the decision-making process of those measures. Therefore, additional knowledge about the bureaucratic side of nature conservation in Finland could be beneficial for the SEAmBOTH project when delivering the end products. Additionally, knowledge about threatened species occurrence is also valuable for decision making. Not only for measures and projects inside nature reserves, but also outside nature reserves. The aim of this study is to investigate these topics to provide knowledge for the SEAmBOTH project with the following research questions:

1) What are the differences between the management levels on nature reserves in Finland?
2) Do threatened species occur in new places outside nature reserves in Finland?
    a. Is the rate of newly occurring threatened species higher inside nature reserves compared to outside nature reserves?
    b. Does the modeled distribution map accurately predict new occurrences of threatened species?

2. Materials and Methods

2.1 SEAmBOTH area

The Finnish side of the SEAmBOTH area in Figure 2 is where the field work for this study took place in the summer of 2019. The red areas indicate the sites in which data about species were collected. These sites had been appointed by Suvi Saarnio, planner and team leader of the Metsähallitus marine team of the SEAmBOTH project. The criteria for these appointed sites were a) Deficient data in that area b) of interest due to the natural environment, e.g. estuaries and lagoons c) Modeled distribution maps of species showed high probabilities of threatened species occurrence d) In close vicinity of human pressures and e) Contained different type of nature reserves or areas near nature reserves.

Within these sites different points were placed where data collection would take place. Satellite imagery was used for placing the points, ensuring that they would be in suitable and reachable aquatic areas. Usually the distance between each point in a site would be kept approximately the same. Exceptions were made for the purpose of two studies, including this study, and when the environment would not allow it. In figure 3 a part of the Simo river estuary, part of the "Perämeren saaret" Natura 2000 area, is shown with the planned points for the field work in 2019. The 'Thesis Points 2019' are the additional points planned for this study. The *Alisma wahlenbergii* and *Crassula aquatica* Probability Distribution Models show the probability that one of these species might be present here based on environmental factors. The 'Thesis Points 2019' were placed inside and outside private owned Natura 2000 sites and on locations with high probability of one or multiple threatened species occurring. The same was done for the site "Laitakari-Häyrysenniemi-Purjekari". Furthermore, additional points were placed during field work whenever situations allowed it.

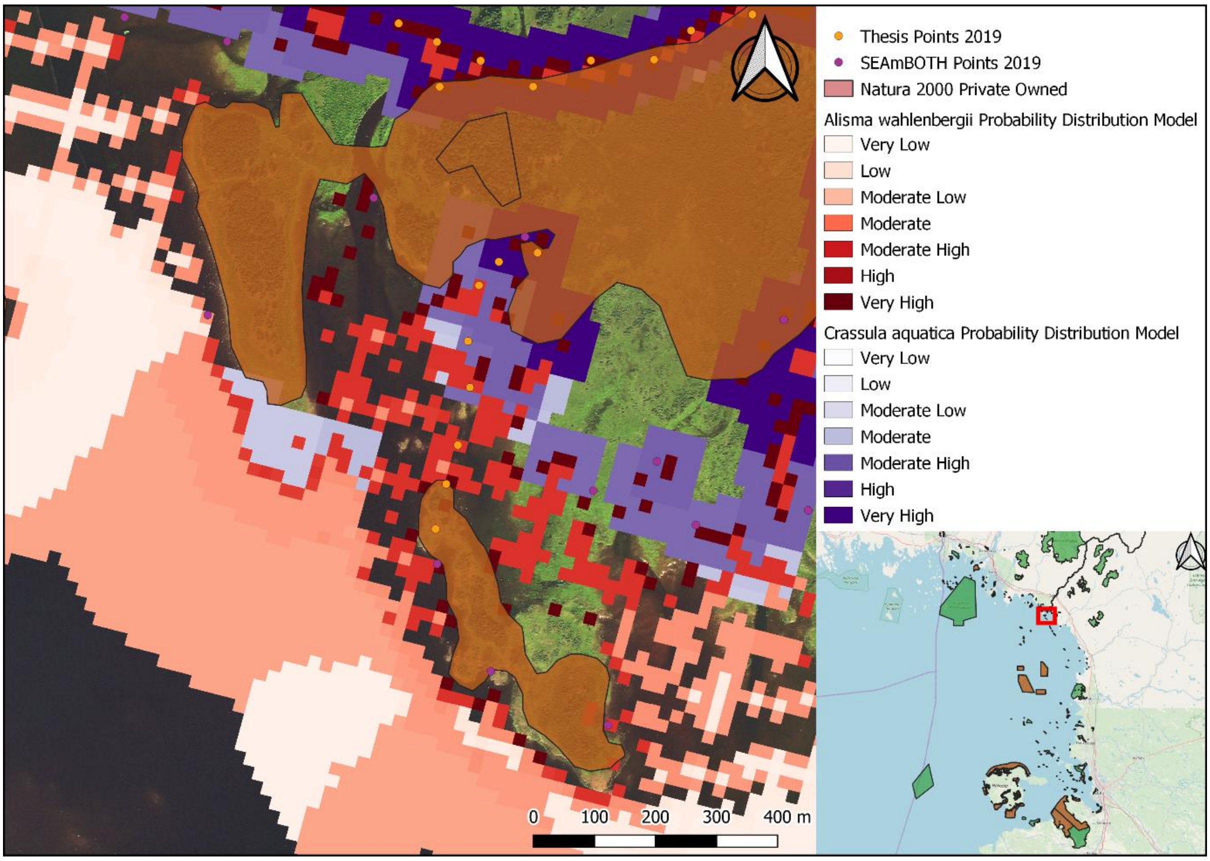

Figure 3: Map of a part of the Simo river estuary, included in the Perämeren saaret Natura 2000 area. Thesis Points 2019 were points planned for the purpose of this study. The Thesis Points 2019 were chosen here to cover high probability areas of *Alisma wahlenbergii* and *Crassula aquatica,* both inside and outside nature reserves. The SEAmBOTH Points 2019 were chosen by Suvi Saarnio according using the following criteria: a) deficient data in that area b) of interest due to the natural environment, e.g. estuaries and lagoons c) Modeled distribution maps of species showed high probabilities of threatened species occurrence d) In close vicinity of human pressures and e) Contained different type of nature reserves or areas near nature reserves. The *Alisma wahlenbergii* and *Crassula aquatica* Probability Distribution Models were made by Jaakko Haapamäki, GIS specialist within the SEAmBOTH project. These distribution models were made based on environmental factors that could indicate the presence of these threatened species.

2.2 Data collection

The SEAmBOTH project uses the methodology of the Finnish Inventory Programme for the Underwater Marine Environment (VELMU) for data collection, analysis and storage. Since 2004, the VELMU method has been used by different organizations in Finland to collect data about the marine environment. The VELMU methodology guide contains extensive information and definitions for different methods commonly used when taking inventory in a marine environment (SYKE, 2019). Therefore, this study will only shortly describe the methods most commonly used during the field work of 2019 in the SEAmBOTH project; wading, diving, and drop videos.

2.2.1 Wading

Most of the data collected in 2019 was done by wading. Wading is performed in shallow areas suitable for walking with an average depth around 1 meter. Equipment used for wading would at least include: Handheld GPS, Water binocular for identifying species and bottom substrate, Waterproof camera, wading forms to document species and the environment (Appendix II), threatened species form to document specifics about encountered threatened species (Appendix III, in Finnish), a thermometer and plastic bags for samples.

Wading was either done at a point or on multiple points along a transect 10 points distributed over100 meters. Every point would have an assessment area of 4m^2 and preferably the shape as seen in figure 4. Arriving at a point the inventory starts with registering the point with the handheld GPS and write it down on the wading form. Thereafter the bottom substrate would be examined and classified using different size fractions, i.e. Boulders, gravel, sand, silt, etc. The coverage of the bottom fractions is noted in percentages and their sum being 100%.

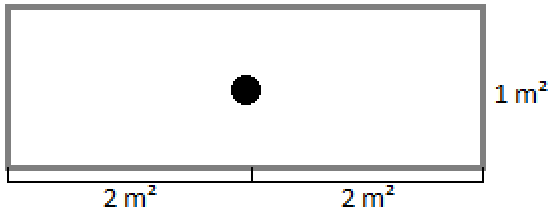

Figure 4: Schematic drawing of the preferred assessment area while doing inventory on a wading point or a point along a transect. Black circle in the middle represents the person taking inventory.

Following the examining the bottom substrate is the biological inventory. Inside the same $4m^2$ area all vegetation were, if possible, identified at species level using their Latin names. Whenever species identification was not possible, a sample was taken in a sample bag with some water. For each plant species the average height and coverage was noted. Coverages of plant species were approximated using percentage of coverage in the $4m^2$ area. The smallest unit of coverage for a plant species was 0,001, meaning that a species was present, either in such small numbers that a higher percentage was not warranted, or that the plant species was outside the $4m^2$ area. Higher percentages of coverage would then usually be described in whole numbers up to 100% for each plant species. In areas with abundant coverage of plant species this means that the total percentage of coverage for one point could exceed 100%.

If a threatened plant species was present, additional information about the area was gathered and written on the threatened species form. The information would include if the plant species was previously seen at the point, municipality of the area, point name and GPS point number, general description of the environment and a topographic sketch of the area, number of individuals, life cycle stage and the general state of well-being.

Finally, the water height and temperature are written down and the sedimentation within the area is estimated using a scale from 0 to 3. With 0 being no sedimentation covering plants or anything else in the area. While a 3 indicated that abundant sedimentation covered plants or anything else and was easily suspended in water when disturbing the bottom substrate. Any other abnormalities about the area and thrash are also noted.

2.2.2 Diving

Scuba diving is usually done in deeper waters. But diving can also be done in shallower waters not suitable for wading. Diving is done by a certified team of two divers and a diver's assistant. Equipment used for diving consists of: scuba diving gear, 100 or 200 meter transect rope with anchor and buoy, diving forms (same as the wading forms, Appendix II), threatened species form, diving protocol, handheld GPS and a waterproof camera. Additionally, the diver's assistant had a timer, emergency health kit and supplementary oxygen.

The method for taking inventory of the bottom substrate and vegetation is the same as with wading. However, performing points along a transect differs from the method used while wading. Before the start of the dive, when the transect rope enters the water, a GPS point was taken at both ends of the rope. Thereafter the divers would suit up and information about the dive was recorded in the diving protocol. During the dive the divers start with a point on the beginning of the transect, filling in the same information as with wading. Along the transect this process would be repeated after 10 meters or 50 meters depending if the transect rope of 100 or 200 meter was used respectively. Furthermore, whenever the depth changed 1 meter a new point was made along the transect and analyzed like any other point.

2.2.3 Drop-videos

Drop-videos are used in deeper waters. With underwater cameras, the attributes of an area can be recorded. This method is quicker than diving in deeper waters but is less accurate for determining plant species and their coverage. Equipment used for the drop videos include: GoPro camera, camera-holder, signal cable and rope, dive torch, tablet with GoPro application, drop-video form (Appendix IV), Secchi disc, salinity meter, thermometer, a rake and a handheld GPS.

Drop-videos were usually carried out with three persons present; one person steering the boat, one person viewing the camera footage and writing down information and one person handling the camera. When arriving at a drop-video point the camera would be lowered until the bottom substrate was visible on the footage.

Thereafter, the recording would be started and a starting GPS point would be registered together with the starting time and footage ID. The recording time for every point was approximately one minute. At the end of this timeframe the camera would be dropped on the bottom substrate to determine the sedimentation, followed by registering an ending GPS point and hoisting the camera out of the water.

Immediately hereafter the water salinity and temperature were measured and recorded along with water turbidity using a Secchi disk. To minimize errors with reading the Secchi disk, the measurement would always be done on the shade side of the boat, to avoid glare from the sun.

Furthermore, if the footage showed any vegetation, a rake could be used to try and extract these from bottom substrate. Vegetation raked could then further be identified on the boat and recorded on the drop-video form.

3. Results

3.1 Management of nature reserves in Finland

Overall there are eight different categories of nature reserves defined by various laws, treaties and conventions in Finland as displayed in table 1. The first four categories, MPA, Natura 2000, Ramsar site and UNESCO site can act as a layer on top of the remaining four categories. For example; Bothnian Bay National Park (*Perämeri Kansallispuisto*) is a National Park, but also an MPA and Natura 2000 area. The four remaining categories cannot overlap with each other.

Table 1: Different categories of nature reserves in Finland. The four categories below the double line are categories that are unique and cannot overlap for one nature reserve. The four categories above the double line are categories that are not unique for one nature reserve. A nature area can be an MPA, Natura 2000 site, Ramsar site and UNESCO site all at once.

Type nature reserve	Responsible agency
Marine Protected Area (MPA)	ELY / Metsähallitus
Natura 2000	ELY / Metsähallitus
Ramsar site	ELY / Metsähallitus
UNESCO site	ELY / Metsähallitus
National Park	Metsähallitus
Strict Nature Reserve	Metsähallitus / LUKE
Nature Reserve on state-owned land	Metsähallitus
Nature Reserve on private-owned land	ELY / Metsähallitus

Whether a nature reserve is also a Natura 2000 area does not change who is responsible for the nature reserve. Rather, it adds certain goals that must be achieved in the nature reserve that would have not been included if it wasn't a Natura 2000 area. The goals for these nature reserves are usually written in a management plan by the responsible agency. A management plan can be just stating that no measures need to be taken, or a more complex document outlining conservation goals over multiple years. With more complexity added when Natura 2000 goals or MPA goals have to be included as well.

Since recent, the management plans of nature reserves by Metsähallitus include detailed information about the area with maps, habitat types, habitat type status, occurring species, recreation use, conservation reasons, conservation goals, threats and conservation measures. When management plans of an area include nature reserves on private-owned land, alongside those on state-owned land, they are incorporated into the management plan. The mixture of private-owned and state-owned land in one Natura 2000 area makes the Natura 2000 area difficult to manage. Each individual contract with a private-land owner can have different terms on what is possible on their land, e.g. having access to a fairway, boathouse or sauna (Tupuna Kovanen, senior advisor northern Ostrobothnia ELY, personal communication, 21st May 2019). Not only private entities within nature reserves but also outside them can complicate managing a nature reserve. For big projects near nature reserves an environmental impact assessment (EIA) must be carried out. ELY has to review these EIAs and report their findings. However, for smaller projects an EIA is usually not needed. For smaller projects ELY must be notified and issue a statement about their thought of the smaller measure. Tupuna Kovanen,

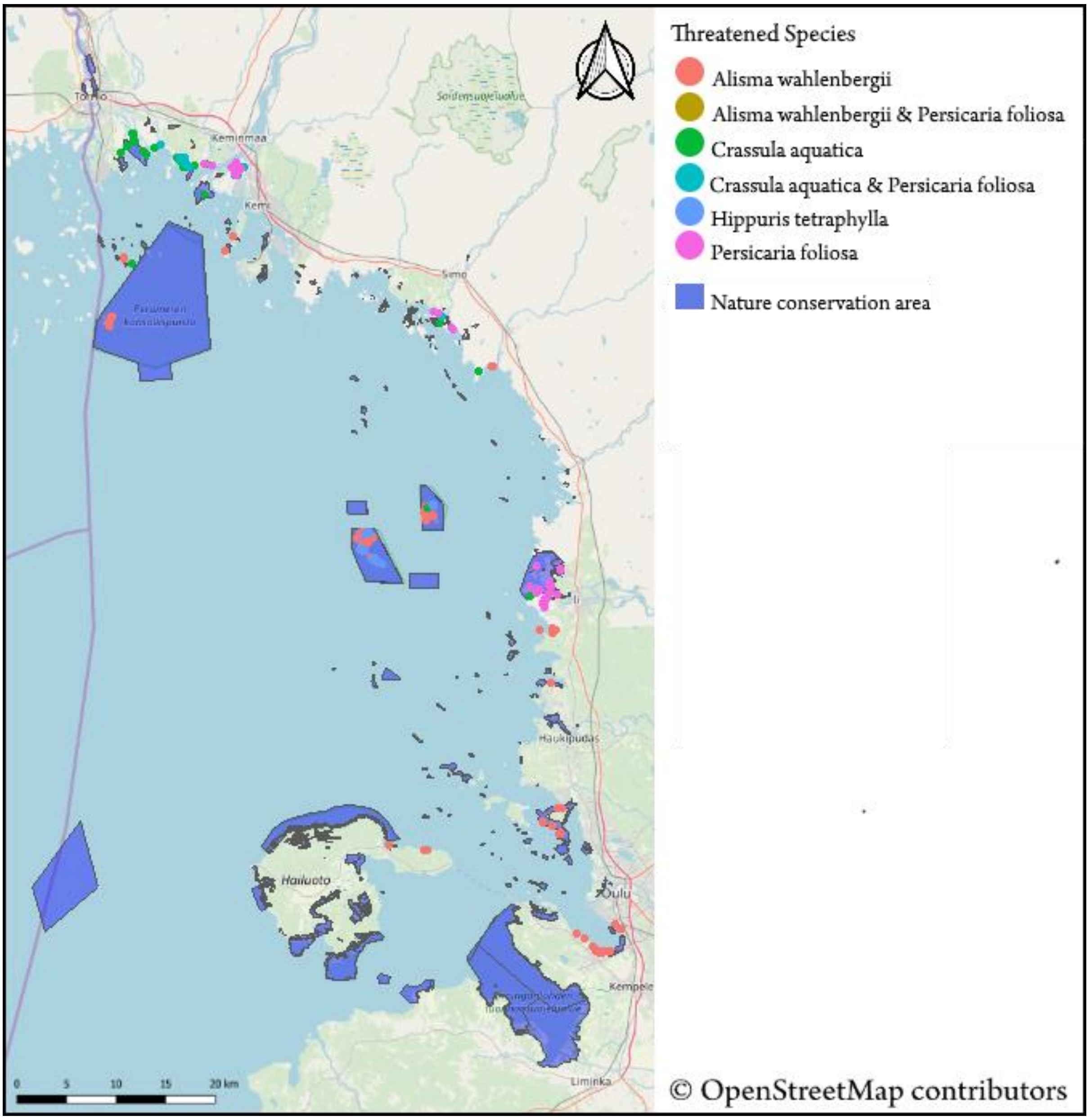

Figure 5: Map of the Finnish side of the northern Bothnian Bay. Displayed are all the occurrences of threatened species that were observed in field work seasons of the SEAmBOTH project from 2017 to 2019.

mentioned that around 1000 of these smaller measures get reported every year (Kovanen, 2019). Most of these smaller measures get accepted because the impact of one smaller measure is usually negligible (small dock for example) and in most cases it would be unfair to deny a smaller measure, if for example one person could not get a small dock while all their neighbors did get a small dock. Herein lies a problem for ELY, the impacts of all these smaller measures can accumulate and eventually produce an effect on the environment. However, it is difficult to monitor all the small measures and evaluate what their combined effect on the environment is (Kovanen, 2019).

3.2 Threatened species occurrences

During the three years of field work (2017 – 2019) of the SEAmBOTH project, a total of 5388 inventories took place in the Finnish side of the northern Bothnian Bay. In 308 (5.7%) of those inventories, one or more threatened species had occurred. The highest number of occurrences was of *Alisma wahlenbergii* with 157. Second, with 91 number of occurrences was *Persicaria foliosa*. Third was the number of occurrences of *Crassula* *aquatica* with 54 observations. Closing the ranks was the number of occurrences for *Hippuris tetraphylla* at 29 observations.

Table 2: Overview of the number of occurrences in the northern Bothnian Bay during 2017 – 2019 in the SEAmBOTH project for the four threatened species; *Alisma wahlenbergii, Crassula aquatica, Hippuris tetraphylla* and *Persicaria foliosa*.

Threatened species	Number of occurrences
Alisma wahlenbergii	157
Crassula aquatica	54
Hippuris tetraphylla	29
Persicaria foliosa	91

On average the ratio of threatened species occurring inside nature reserves, compared to outside nature reserves, was 10 to 1. The ratio of occurrences inside nature reserves compared to outside nature reserves varied between years. With the highest ratio of 27 observed in 2019. Followed by a ratio of 2,9 in 2017 and a ratio of 1 in 2018.

The density of occurrences of threatened species in the northern Bothnian Bay are shown in figure x. The resolution of each cell in the raster shown are 7 x 7 km. The highest density of occurrences with an average of 1 threatened species occurring in 1 km^2 were observed in the Kemi river estuary (1), northwest of the island Ulkokrunni (2) and in 'Kempeleenlahden ranta' (3). Hereafter, the whole area of the Krunnit Islands (4) have a high density varying from 0,55 to 0,3 threatened species per 1 km^2. Noticeable areas with high densities are the Oulu bay area (5) with 0,5, the east coast of Hailuoto (6) with 0,7 and the islands in the Bothnian Bay National Park (7) with a density of 0,3. Final areas are the Simo river estuary (8) and the Ii river estuary (9) with a density of 0,2.

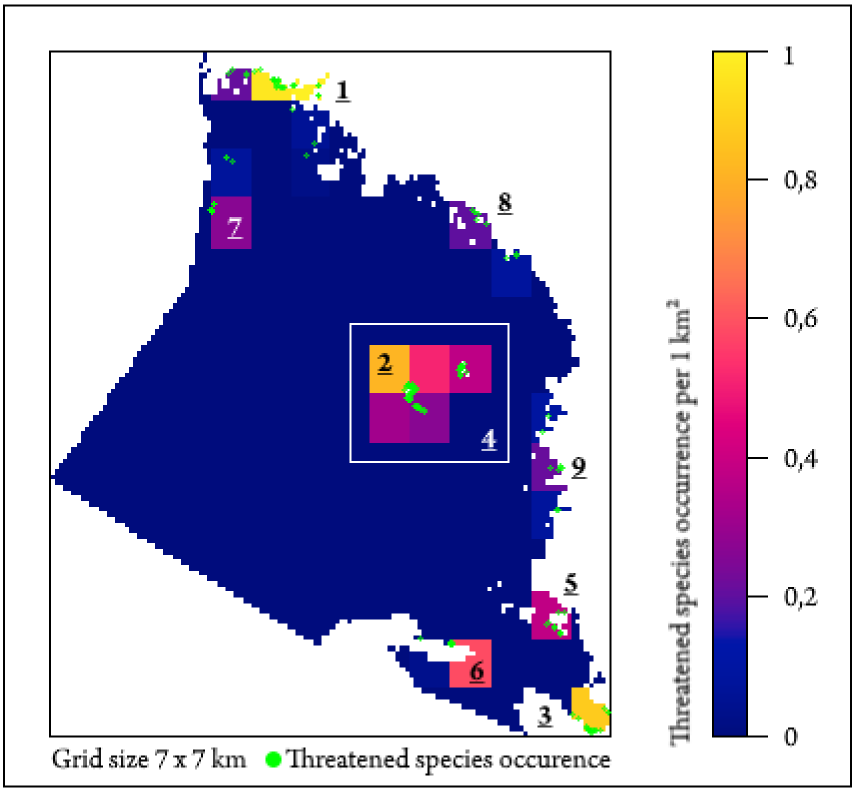

Figure 6: Map of the Finnish northern Bothnian Bay displaying the densities of threatened species occurrences during the SEAmBOTH project. Each cell in the grid represent an area of 7 x 7 km where the density is calculated as average threatened species occurrence per square kilometer. Indicated by the numbers are the different areas in which densities higher than 0,1 were observed. 1) Kemi river estuary; 1 density, 2) Northwest Ulkokrunni; 1 density, 3) Kempeleenlahden ranta; 1 density, 4) Krunnit Islands area; 0,55 to 0,3 density, 5) Oulu bay area; 0,5 density, 6) East coast of Hailuoto; 0,7 density, 7) Bothnian Bay National Park; 0,3 density, 8) Simo river estuary; 0,2 density, 9) Ii river estuary; 0,2 density.

4. Discussion

Finland has taken great steps towards increasing available knowledge about the marine environment through the Finnish Underwater Inventory Programme, VELMU. Indeed, Finland recognizes the importance of the Baltic Sea as a marine ecosystem shown by the implementation of various conventions, guidelines and directives in their national laws (Arnkil, Hoikkala, & Sahla, 2019). However, the existing network of nature reserves only covers approximately 27% of existing marine biodiversity features (Virtanen, Viitasalo, Lappalainen, & Moilanen, 2018). In this study knowledge was gathered as to explain if these existing network of nature reserves, the differences in management, had an impact on new occurrences of threatened species in the Northern Bothnian Bay.

Differences in management of nature reserves are made for: the agency that is responsible for the nature reserve (table 1), naming convention for the nature reserve (table 1), primary goal of the nature reserve as discussed in section 1.3.3 and additional goals for the nature reserve added by conventions or directives (table 1). The intent of the primary goals of nature reserves are defined by the law. However, depending on occurring habitats and species in a nature reserve, measures to conserve these can differ depending on what has been proven to be best practice (Metsähallitus, 2016). Additional goals do not change these implementations, rather they supplement the management plans of areas with additional measures for specific habitats or species. Measures are mapped for every nature reserve. Metsähallitus and ELY centres monitor the situation in almost every nature reserve and document the time each measure has been done. Finland has started a national programme to update management plans for every national park, publishing more information about species, habitats, conservation reasons, goals and threats (Kovanen, 2019).

Since conservation measures are also tailored to specific species it is difficult to determine whether a difference in the management of nature reserves has an impact on new occurrences of threatened species inside or outside these nature reserves. It is more likely that non-management areas around nature reserves are limiting threatened species distribution. Areas adjacent to nature reserves face challenges with monitoring and conservation. The Natura 2000 habitat types as written by the EU Council leaves little flexibility for each member state when assigning Natura 2000 areas. This becomes problematic whenever an area adjacent to a Natura 2000 area does not comply with a Natura 2000 habitat, even though it might show signs that it can become a Natura 2000 area when managed properly. For example: There is an area with the boreal forest habitat type and under protection. Next to the boreal forest is a forest that shows signs of becoming a boreal forest as well. However, because it is not yet a boreal forest, it is not protected under the Habitats Directive. This allows for exploitation of the area so that it will not become a boreal forest, thus losing an important habitat and possibly biodiversity as well.

Estuaries could face a similar problem with definition of habitat types. Estuaries are highly dynamic bodies of water. The transitional zone is affected by tides, wind directions, freshwater runoff and sedimentation. Changes in these variables makes the estuary 'move' over time. Thus, making it difficult to assess and assign an area as an estuary according to the definition of the EU Council. In the northern Bothnian Bay there are different approaches in estuaries. The Ii estuary is completely incorporated in a SAC with the estuary having an area of 660ha. The Simo and Kemi estuary are only partially protected in the SAC Perämeren Saaret with an area of 60ha. Leaving most of the estuary unprotected and mostly unmonitored while following management plans. Thus, it would seem that activities could take place that deteriorate the ecological status of these two estuaries. Therefore, also the ecological status of the protected areas within the Simo and Kemi estuaries.

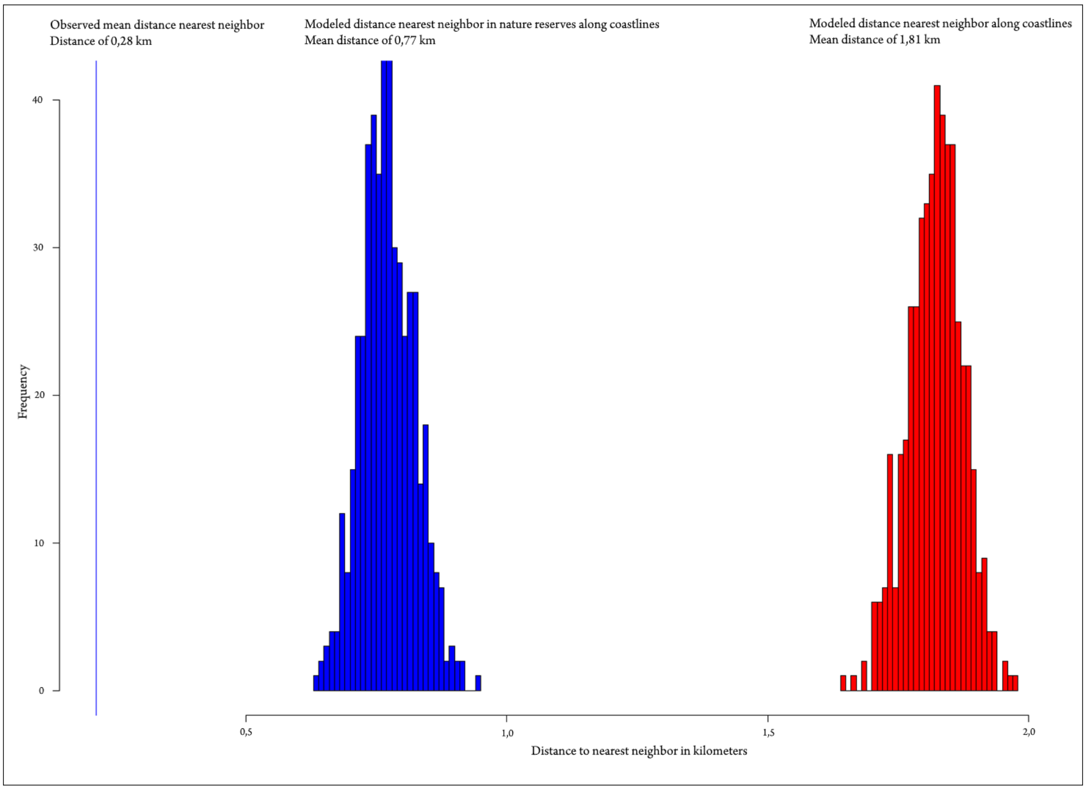

Figure 7: Histogram chart showing observed and modeled distances from nearest neighbor analysis of 308 spatial points in the Finnish northern Bothnian Bay. The first model placed 308 random points along the coastlines in the Finnish northern Bothnian Bay. The mean distance to nearest neighbor was 1,81 km. The second model placed 308 random points along coastlines in nature reserves in the Finnish northern Bothnian Bay. The mean distance to nearest neighbor was 0,77 km. The observed mean distance to nearest neighbor of threatened species occurrences during the SEAmBOTH project was 0,28 km.

Examining the number of occurrences of threatened species in the northern Bothnian Bay, noticeable is the low number of observations in the timespan of three years (table 2). With a total of 308 observations of threatened species after a total of 5388 inventories, it is difficult to conclude whether the rate of new occurrences inside nature reserves is different compared to outside nature reserves. The sample size of threatened species inside and outside nature reserves needs to be at least 100 each to start making comparisons with still relatively low power (0,8) and low effect size in a fitted model using the Poisson point process and a Likelihood-ratio test.

Moreover, checking the accuracy of the modeled distribution map for threatened species was unreliable with the low sample size of threatened species occurrences. For example, in 2019 only eight observations were made for *Crassula aquatica*, too low of a sample size for an area such as the northern Bothnian Bay. Nevertheless, for all points with threatened species occurrences a nearest neighbor analysis was carried out and compared to two fitted random models of threatened species occurrences as shown in figure 6. The first fitted random model (red) was with 308 points randomly distributed along the coastlines in the Finnish northern Bothnian Bay. The second fitted random model (blue) was with 308 points randomly distributed along the coastline in existing nature reserves. The first model showed a mean nearest neighbor distance of 1,81km. Significantly higher than the second model with a mean nearest neighbor distance of 0,77km. However, the observed mean nearest neighbor distance of SEAmBOTH data was 0,28km, significantly lower than the means of both models.

While the observed results of threatened species occurrences and the nearest neighbor distance compared to those of the random fitted models do support the idea that threatened species occur more frequently inside nature reserves compared to outside nature reserves, there might be different reasons for these observations. First, it might be that nature reserves are able to protect threatened species and that the conservation measures are successful at maintaining threatened species occurrences. Second, since nature reserves include habitats on which threatened species rely are usually not found directly outside these nature reserves, threatened species might have difficulties migrating to areas outside nature reserves. This is not a shortcoming of nature reserves. Rather, it might be the result of less knowledge about marine environments outside nature reserves due to less intensive monitoring. Third, when nature reserves were assigned in Finland the presence of threatened species played a role in defining nature reserve areas (Finnish Parliament, 1996). Thus, since the appointment of nature reserves, they always had more threatened species occurrence than areas outside nature reserves. Fourth and final, monitoring and reporting of threatened species in nature reserves is required by national law (Finnish Parliament, 1996). This may result in more observations being made inside nature reserves compared to areas outside nature reserves, creating a bias for observed new occurrences of threatened species inside nature reserves.

Threatened species would not be called threatened species if their occurrences would be common across one or multiple habitats. Data of threatened species occurrences in the SEAmBOTH project express this as well, with 5,7% of all observations in the SEAmBOTH project containing occurrences of threatened species. The results of this study could not provide conclusions for whether new occurrences of threatened species are higher inside nature reserves compared to outside. Likewise, due to the low sample size it no conclusive results could be made about the accuracy of the threatened species modeled distribution maps.

However, this study could be used as a stepping stone for further research about occurrences of threatened species and different kind of nature reserves in the northern Bothnian Bay. Having the knowledge and insight in possible threatened species occurrences inside and outside nature reserves is highly favored by various stakeholders in the northern Bothnian Bay (SEAmBOTH, 2019). To provide this knowledge a few recommendations can be made based upon information and results gathered in this study:

- Conduct a long-term study of monitoring occurrences of threatened species in a systemic order in an area inside a nature reserve and outside the nature reserve in close vicinity.
- Compare the occurrences of threatened species inside and outside nature reserves before the adoption of the Natura 2000 network in the northern Bothnian Bay with occurrences of threatened species inside and outside nature reserves after the adoption of the Natura 2000 network.
    - Further analysis can then be done on the number of new occurrences of threatened species after the adoption of the Natura 2000 network.
- Inclusion of citizen science in future studies. Having citizens help with data collection can be a useful tool to potentially increase the sample size of observations of threatened species while not being as costly as a specialized team.

5. Acknowledgements

I would like to thank Essi Keskinen, project leader of SEAmBOTH for this great opportunity to learn about nature conservation in Finland. I have learned a lot about nature conservation practices and how the bureaucracy involving nature conservation works in general and in Finland. More importantly I gained a tremendous amount of work experience in a marine environment during the field work season in the summer. For the latter I would like to thank Suvi Saarnio, planner and marine team leader during SEAmBOTH, for helping with the planning and coordinating of the field work for my thesis, and for teaching me everything I needed to know to conduct the field work and letting me experience new things such as driving a boat or being a diver's assistant. I thank Mark Smits for the guidance, even from abroad, feedback and giving me the freedom in almost every sense of the word. I thank Ashley Gipson, previous SEAmBOTH project member, for helping me getting started in a new country and a new work environment. I want to thank my other field work team members Eveliina Lampinen, Petra Saari and Teemu Uutela for the great company during the summer field work days. Finally, I would like to thank everyone who helped me by providing information about nature conservation, Finnish legislation and GIS; Tupuna Kovanen, Päivi Virnes, Joonas Hoikkala, Matti Sahla and Jaakko Haapamäki.

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Appendix I – SEAmBOTH Habitat Descriptions

The following habitat descriptions are primarily made using information from the Interpretation Manual of European Union Habitats – EUR28 (European Commission Directorate-General for Environment, 2013).

Sandbanks (Habitats Directive code 1110) are topographic features either submerged or surrounded by deeper water. The sediment is mostly sandy, but larger grain sizes or mud can also be present on a sandbank. Sandbanks are classified as such when the associated flora and fauna are dependent on the sand instead of anything else. Sandbanks are important resting grounds for seals and foraging grounds for several fish species (HELCOM, 2013b).

Estuaries (Habitats Directive code 1130) are transition zones where freshwater of the river meets brackish sea water. An estuary is a dynamic water body. Winds cause irregular tidal effects which shifts the transition zone constantly. Estuaries are usually accompanied by sand and mud flats due to the fine sediments carried downstream. Estuaries can have diverse vegetation and are important as spawning and nursery grounds for some fish species, both marine and freshwater (HELCOM, 2013b).

Mudflats (Habitats Directive code 1140) are patches of sands and muds on the coast of the Baltic Sea or lagoon and are not covered by sea water at low tide. Theoretically these habitats are not present on the Finnish coast, since there is no tide in the Baltic Sea. Nevertheless, areas which fit the remainder of the description with associated flora and fauna have been found. Mudflats are important for waterfowl and waders which hunt for insects and small crustaceans (HELCOM, 2013b). SEAmBOTH also maps mudflats as a habitat in Finland since partner country Sweden recognizes them and are also important for endangered vascular plants.

Coastal lagoons (Habitats Directive code 1150) are shallow bodies of water partially separated from the sea. In the Baltic Sea a special subcategory named Flads is present. These variety of lagoons are small lagoons created by the uplift of the land. Flads can also be very recently separated from the sea. Coastal lagoons can vary widely in their abiotic characteristics such as salinity or water volume. Coastal lagoons serve as an important spawning and nursing ground for several fish species, as well as being rich in biodiversity (HELCOM, 2013b).

Large shallow inlets and bays (Habitats Directive code 1160) are coastal features where, in contrast to estuaries, freshwater runoff is limited. Inlets and bays usually share the same characteristics as the nearby open Baltic Sea but are generally sheltered from waves. These coastal features provide important growing sides for a wide variety of flora. The plant vegetation provides shelter for many aquatic invertebrates and are a suitable food source for larger animals such as birds or fish (HELCOM, 2013b).

Reefs (Habitats Directive code 1170) are collections of rocks or boulders on a solid or softer bottom. The collections of rocks and boulders are compact and are elevated above the sea floor level. They can appear in deep waters or relatively shallow waters. Reefs support a large number of algae, water mosses, benthic animals or sponge animals (HELCOM, 2013b).

Baltic esker islands (Habitats Directive code 1610) are islands created by sand and rougher sediment deposits when the inland ice melted in the last ice age. The brackish water combined with the land uplift create different vegetation successions on the island and its shore. It is a habitat for several threatened and or declining species (HELCOM, 2013b).

Boreal Baltic islets and small islands (Habitats Directive code 1620) are a collection of small islands composed mostly of bedrock or glacial sediments. Larger vegetation types are usually not present on these islands. Therefore, shelter against abiotic factors is limited. It is usually favored by pioneer vegetation communities. Furthermore, these islands are an important nesting site for birds and resting place for seals (HELCOM, 2013b)

Appendix II – Wading form

Date:	Site:	Water level:	Aim:	Air temp:	Water temp:
GPS #:	Persons:	Wind:	Direction (out of shore):	Start # (shore 0 m):	End #:

				Substrate % coverage												Species % coverage & height														GoPro #/Boat:
Point/meters from shore	Depth	Angle (°)/analyser	Sed. (0-3)	Rock	Boulder > 300 cm	Boulder 120-300	Boulder 60-120 cm	Stones 10-60 cm	Stones 6-10 cm	Gravel 0,2-6 cm	Sand < 0,2 cm	Silt	Clay	Soft bottom/mud	Peat															Notes *(trash, endangered sp. info etc.)*

Information in Excel:	Sample taken = 25*/4	Photo taken = (25)/4	Samples checked:	dive/wading points

Appendix III – Threatened species form

Uhanalaiset lajit - kenttälomake

<table>
<tr><td>Päivämäärä:</td><td>Laji:</td><td>Ensikartoitus / Seuranta</td><td>Lajia ei löytynyt:</td></tr>
<tr><td>Havainnoitsija(t):</td><td>Havaintopaikan nimi:</td><td>Kunta:</td><td>GPS # & piste ID:</td></tr>
<tr><td>Yleiskuvaus & habitaatin kuvaus:</td><td>Lajille soveliaan alueen pinta-ala:</td><td colspan="2" rowspan="2">Kartta:</td></tr>
<tr><td>Yksilömäärä, kasvuston koko, kunto, kukinnan vaihe:</td><td>Havaintopaikalla tapahtuneet muutokset ja mahdolliset uhkatekijät:</td></tr>
</table>

- **Ensikartoitus / Seuranta** = ympyröi oikea vaihtoehto
- **Havaintopaikan nimi** = nimetään lähimmän peruskartalta löytyvän paikannimen mukaan, lähekkäisten paikkojen nimen loppuun voi lisätä ilmansuuntia tarkoittavia lyhenteitä, esim. Ulkokrunni NW tai Ulkokrunni NW a. Jos seuranta-kohde, pitää tarkistaa alkuperäinen nimi!!
- **Lajia ei löytynyt** = liittyy seurantaan, eli paikka tuhoutunut, paikka muuttunut, paikkaa ei löytynyt, tai muu syy - mikä?
    - Jos lajia ei löytynyt, tarvitsee täyttää vain päivämäärä, laji, seuranta, lajia ei löytynyt, havainnoitsijat, havaintopaikan nimi, havaintopaikalla tapahtuneet muutokset (jos aiempi tieto saatavilla) ja piirtää kartta tutkitusta alueesta
- **Kartta** = merkitse alue, jolta lajia on etsitty ja jolta lajia on löytynyt (piste/pisteet/alue)
    - Mikäli lajia löytyy laajalti, on hyvä rajata lajin esiintymisalue esim. GPS-pisteiden avulla
- **Yleiskuvaus** ja **habitaatin kuvaus** = mm. paikan avoimuus, pinnanmuodot, ekspositio, kosteus, ravinteisuus, maaperä ja sen käsittelyt)
- **Lajille soveliaan alueen pinta-ala** = esim. neliömetreinä, voidaan esittää myös kartalla
- **Havaintopaikalla tapahtuneet** = muutokset kirjataan, jos aiemmat tiedot pisteestä saatavilla
- **Uhkatekijät** = esim. muu laji, ruoppaus, saasteet jne.

Appendix IV – Drop video form

	Site:				Date:				
	Persons:				Camera:				
	Boat:			DEPTH		GPS #			
	Video ID	Time	Point name	Start	End	Start	End	Secchi	Notes
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