Template for Submission of Scientific Information to Describe Areas Meeting Scientific Criteria for Ecologically or Biologically Significant Marine Areas

THE KVARKEN ARCHIPELAGO

Abstract

Kvarken is a narrow (26 km) strait between Sweden and Finland in the northern Baltic Sea. The proposed area encompasses a mosaic archipelago on the Finnish side, which consists of ca. 5600 islands and skerries. A large part of the area is a World Heritage site, which is characterized by its unique landscape formed during the last glaciation (10.000 – 8.000 BP), including large fields of De Geer moraines. The isostatic land uplift is still ongoing at a rate of 8 mm per year. The land uplift creates approx. 1 km^2 new land each year and affects all underwater biotopes and habitats by constantly bringing new areas up into the photic zone. The relative latitudinal change in salinity is the largest in the Baltic Sea, and the area is a transition zone, where marine fauna and flora rapidly change into freshwater ones. E.g., the southern side is characterised by marine algae, while the species richness of aquatic vascular plants and charophytes (including rare species) is higher on the northern, less saline, side of the area. A large number of bird species nest or stop on their migration in the area.

Introduction

The Kvarken Archipelago exhibits a unique combination of characteristics that can be found nowhere else, which is also the basis for the World Heritage Site nomination. According to UNESCO, "the area affords outstanding opportunities for the understanding of the important processes that formed the glaciated and land uplift areas of the Earth's surface." http://whc.unesco.org/en/list/898

The Kvarken Archipelago is located on the crystalline bedrock, which forms a unique, brackish shallow water marine environment with a number of moraines (Fig. 5 & 6). Especially the washboard-like De Geer moraines and boulder fields found both on terrestrial and submarine areas characterize the landscape of the Kvarken, and contribute to its high geodiversity (e.g. Breilin et al., 2004; Kaskela & Kotilainen, 2017; Kotilainen & Kaskela, 2017). The isostatic land uplift is still ongoing at a rate of 8 mm per year. The land uplift creates approx. 1 km^2 new land each year. Combined with the ongoing land uplift, the moraines lead into succession of the elevated structures from the seafloor to land.

The seabed of the shallow Kvarken Archipelago includes silt, sand and hard bottoms, often in a small-scale mosaic pattern. The geological formations create additional variation by affecting the exposure (from highly sheltered to highly exposed within a small spatial scale).

Salinity in the area is low, from 3 to 5 psu, increasing towards the south (Fig. 8). The relative change in salinity per distance from the northern to the southern part of the area is the largest in the Baltic. Salinity also varies depending on variation of sea level on the two sides of Kvarken, and is affected by the outflow from the Bothnian Bay, which in turn depends on the river discharge into the Bothnian Bay. The consequent "river" flowing through the Kvarken has a yearly mean slightly above 3000 m^3/s. As the Kvarken strait is both narrow and shallow, the outflow takes the form of an intermittent current which can reach a speed of several knots. The salinity is also affected by a counter clockwise current in the Bothnian Sea, which brings water with higher salinity into the Kvarken area from the south.

The area is covered by annual sea ice (Fig. 10), but the number of ice days has been steadily declining in the open sea areas due to recent warming up of the climate (Haapala et al. 2015).

Regular monitoring of the ecological state of the sea takes place in the area. The Finnish Inventory Programme for Marine Underwater Environment (VELMU) has conducted extensive biodiversity inventories in the area. The inventories done in 2004-2017 have included dive lines and drop videos, benthic sampling, fish larvae sampling, and echosoundings. Observation data for hundreds of species is available. Also, species distribution models (SDMs) have been made for many species (below

referred to as “VELMU data”; viewable in https://paikkatieto.ymparisto.fi/velmu). Spatial data on birdlife and seals also exist.

Location

The Kvarken Archipelago (Fig. 1 & 2) is located in the Gulf of Bothnia, northern Baltic Sea. The total area of the proposed EBSA is 7151 km^2 and its sea area is 6517 km^2. The mean depth of the area is 21 m, with the deepest point in the open sea being 101 m (Fig. 7).

The area is within the Finnish territorial waters, and is within national jurisdiction.

Feature description of the proposed area

The area encompasses a World Heritage Site, several Natura 2000 areas and Important Bird Areas (IBAs), as well as a Ramsar site (Fig. 11).

The shallow area of the Kvarken Archipelago includes silt, sand and hard bottoms, often in a small-scale mosaic pattern due to a topography consisting of Ice Age formations. The geological formations create additional variation by affecting the exposure (from highly sheltered to highly exposed within a small spatial scale), in turn further generating comparatively high local biodiversity.

Due to the low salinity (3 to 5 psu) and the steep salinity gradient (Fig. 8), the area is a transition zone zone between marine and freshwater fauna and flora. E.g., the northern side has a high diversity of aquatic vascular plants and charophytes (including rare species), while the southern side is characterised by algal communities (Fig. 18). Several marine species, for instance bladderwrack *Fucus vesiculosus* and the blue mussel *Mytilus trossulus*) reach their northernmost distribution in the Kvarken area.

As in the rest of the Baltic Sea, there is a continuous evolutionary pressure on species to adapt along the salinity gradient (from fresh water to saline water and vice versa). The unique topography of the Kvarken area coupled with the land uplift facilitates this process by creating a multitude of variations (depth, substrate, exposure, salinity), all of which are under constant change. Of special importance is the flad-glo lake succession (a flad is a coastal lagoon), which transforms topographically enclosed sea areas into freshwater lakes (over a period of 200 years), usually forming a connected system of small water masses in different successional stages. Many flads and glo-lakes are biodiversity hotspots for vascular plants and charophytes. They are also important spawning areas for fish, as they warm up faster and earlier than the surrounding sea while at the same time offering a sheltered environment.

The Kvarken area is productive, due to an overall shallowness and abundance of light (Fig. 9), as well as continuously changing water currents that transport nutrients and mix the water. The area is important for several fish species. Due to many flad bays it forms a very important reproduction area of perch (*Perca fluviatilis*) in Finland. This area is also an important corridor for migrating anadromous European whitefish (*Coregonus lavaretus sl.*), salmon (*Salmo salar*) and sea trout (*Salmo trutta*) (Kallio-Nyberg et al. 2017). Some of the most important breeding areas for archipelago birds in the Baltic are situated in the area, including the island groups of Norrskär, Valassaaret and Rönnskären.

In the inner archipelago the global warming affects the thickness of the ice. This is of great importance for the ringed seal (*Pusa hispida botnica)*, which depends on the annual ice for reproduction.

Table 1. Number of species in different sea areas listed by HELCOM (HELCOM 2012). The total number of species in the Baltic Sea is 2730 of which 1898 species are invertebrates. Total number of species in the table excludes bird species.

	Gulf of Finland	Archipelago Sea	Kvarken Archipelago	Bothnian Sea
Macrophytes	187	68	162	116
Benthic invertebrates	482	122	96	132
Fish & lamprey	87	68	51	48
Marine mammals	3	3	2	2
Total number of species	759	261	311	298
Share of species in the Baltic Sea	27.8 %	9.6 %	11.4 %	10.9 %

Feature condition and future outlook of the proposed area

The naturalness of the area is high, due to low degree of building in the area, and short summer period when most of the tourism activities take place. The overall condition of the area is better than that of the more southern areas of the Baltic Sea, because the anthropogenic nutrient loading is intermediate, and the continuous movement of water flushes organic material towards the Bothnian Bay in the north and the Bothnian Sea in the south, alleviating the negative effects of nutrient loading in the area. North-south and east-west ship traffic concentrate in a narrow area due to the strait and cause some disturbance to the area. A wrecking of ships carrying oil or chemicals is a serious threat to this shallow archipelago area.

Climate change will affect the effects of the ongoing land uplift as a result of sea level rise. While the isostatic rebound (land uplift) will continue at approximately the same speed (8 mm per year) and will eventually generate a topographic height increase of 140 meters (compared to today), an increasing sea level will counteract the process (Grinstedt, 2015), and slow down the natural succession of flads to freshwater and terrestrial environments. This will change the characteristics of the area from a biological and evolutionary viewpoint.

Assessment of the area against CBD EBSA Criteria

CBD EBSA Criteria (Annex I to decision IX/20)	**Description** (Annex I to decision IX/20)	**Ranking of criterion relevance** (please mark one column with an X)			
		No information	**Low**	**Medium**	**High**
Uniqueness or rarity	Area contains either (i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features.				X

HIGH. The Kvarken Archipelago is a unique area on Earth, and a large part of the proposed area belongs to the World Heritage of Kvarken Archipelago and High Coast. The area features unusual ridged washboard moraines, 'De Geer moraines', formed by the melting of the continental ice sheet, 10,000 to 24,000 years ago. The Archipelago is continuously rising from the sea in a process of rapid glacio-isostatic uplift. As a consequence islands appear and unite, peninsulas expand, and lakes evolve from bays and develop into marshes and peat fens. According to UNESCO, "the area affords outstanding opportunities for the understanding of the important processes that formed the glaciated and land uplift areas of the Earth's surface." http://whc.unesco.org/en/list/898.

Kvarken Archipelago contains several endemic and/or rare species, several threatened species and facilitates the evolutionary process of adapting to marine conditions (for freshwater species) or alternatively to freshwater conditions (for marine species).

General aspects

- Several EU Habitat Directive Annex I habitats, such as coastal lagoons (1150), reefs (1170) and large shallow inlets and bays (1160), are typical to the Kvarken archipelago. The area contains most coastal lagoons in the Baltic (Fig. 3 & 4)
- An extremely complex archipelago, due to ice age formations and general shallowness. Also continuously changing, due to isostatic land uplift, and the effect of land uplift is the largest in the world, due to the topography (> 1 km^2 new land each year).
- Unique combination of geological and biological features and processes (World Heritage site).
- Annual ice cover (due to extensive archipelago also in the future despite climate change) (Fig. 10)
- Diversity of habitats (measured as different HUB classes) is high, both overall and on a local scale
- Salinity from nearly zero to ca. 5 psu, and a most acute drop in relative salinity in the Baltic (Fig. 8)
- Marine habitat-forming species at their biogeographical margin, ecological switch from marine species dominated biotopes to freshwater species dominated biotopes

Mammals

- The Bay of Bothnia population of ringed seal (*Pusa hispida botnica*) inhabits the area and the existence relies on good ice winters (nests on the ice)
- Grey seal is common in the outer archipelago
- Nathusius's Pipistrelle bat (*Pipistrellus nathusii*) unique northwards migration (after breeding) to Kvarken (from central Europe) in order to utilize extreme autumn food production (Chironomidae).

Birds

- Several threatened bird species.
- Up to 50 % of the Baltic population of scaup (*Aythya marila*) and 30% of the Baltic subspecies of black guillemot (*Cepphus grylle grylle*). Most dense population of white-tailed sea eagle (*Haliaeetus albicilla*) in the Baltic
- Unique local bird communities due to complex topography and small-scale ecosystem mosaics
- Includes 2 IBAs (Fig. 11)

Fish

- Important reproduction area for many fish species, including perch, pikeperch, Baltic herring and smelt (Fig. 29-35)

Invertebrates

- The Baltic blue mussel that occurs in the area is genetically distinct from both Atlantic *Mytilus edulis* and Atlantic/Pacific *Mytilus trossulus*, and probably has rapidly evolved to a new local taxon, as an adaptation to the peculiar Baltic Sea environment. The species is nowadays described either as *Mytilus trossulus* x *M. edulis* hybrid swarm, or simply *M. trossulus* (Väinölä & Strelkov 2011). This highlights the importance of these low-salinity Baltic Sea areas as centers of species evolution.

Plants

- The species richness of both aquatic vascular plants and charophytes is higher on the northern, less saline side of the Quark and the diversity of macroalgae is higher on the southern, more marine side of the Quark
- Fresh water species, especially many charophytes and vascular plants are plentiful in the inner archipelago and lagoons. Plant species composition varies over time due to land uplift.
- Unique spatially "moving" zones (with distinctive biotopes), due to land uplift.

Geology

- Thousands of rocky reefs (Fig. 3)
- De Geer moraine fields, facilitating small-scale habitat change.
- Rocky seafloor is typical (Fig. 5 & 6)
- Land uplift creates rapid succession and unique environment.

Special importance for life-history stages of species	Areas that are required for a population to survive and thrive.				X

HIGH. The area is an important reproductive area for several fish species. It is an important breeding area for archipelago birds as well as an important staging area for migrating birds. The Kvarken Archipelago is one of two areas in the Baltic where sea ice will reliably form in the near future (according to the current IPCC status and regional 100 year predictions on effects). This makes the area of extreme importance for the ringed seal (*Pusa hispida botnica)*, which breed on the annual ice cover.

Mammals

- A population of ringed seal (*Pusa hispida botnica*) lives in the area and the existence relies on good ice winters (nests on the ice)
- Autumn feeding ground for Nathusius's pipistrelle (*Pipistrellus nathusii*), a bat which migrates northwards to Kvarken (from central Europe) after breeding in order to utilize the extreme autumn food production (especially nonbiting midges, Chironomidae). Rare connection between bat species and marine production.

Birds

- High diversity of breeding birds, in the top 3 breeding birds archipelago areas in the Baltic.
- Important migration route during spring migration, important staging area during autumn migration. (Fig. 12)

Fish

- Important reproduction areas, such as lagoons, bays and inlets, for many fish species, including pike, perch, pikeperch, Baltic herring, whitefish, vendace, roach, bream, smelt and gobies.

Importance for threatened, endangered or declining species and/or habitats	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.			X	

MEDIUM. The area contains habitats and populations of several threatened species (Fig. 13 & 14)

- Flads are important hotspot areas for charophytes, fish and birds.
- The area is very important for the nominate Baltic subspecies of black guillemot *(Cepphus grylle grylle*) with 6700 pairs in the Kvarken area that is about a third of the Baltic population (Birdlife DataZone).

Threatened bird species (in the Kvarken Archipelago) breeding and/or staging during annual migration

- *Aquila chrysaetos* (VU), *Bubo bubo* (EN), *Bubo scandiaca* (CR), *Calidris alpina schinzii* (EN), *Circus cyaneus* (VU), *Dendrocopos leucotos* (VU), *Emberiza hortulana* (EN), *Falco peregrinus* (VU), *Gallinago media* (CR), *Haliaeetus albicilla* (VU), *Milvus migrans* (CR), *Pernis apivorus* (EN), *Phalaropus lobatus* (VU), *Philomachus pugnax* (CR), *Podiceps auritus* (EN), *Acrocephalus arundinaceus* (VU), *Anas acuta* (EN), *Anas querquedula* (EN), *Anser fabalis* (VU), *Anthus cervinus* (VU), *Arenaria interpres* (EN), *Aythya ferina* (EN), *Aythya fuligula* (EN), *Aythya marila* (EN), *Buteo buteo* (VU), *Calidris maritima* (EN), *Calidris minuta* (EN), *Calidris temminckii* (EN), *Cepphus grylle* (EN), *Eremophila alpestris* (CR), *Larus fuscus* (EN), *Larus ridibundus* (VU), *Melanitta fusca* (EN), *Tadorna tadorna* (VU), *Tringa totanus* (VU), *Turdus torquatus* (EN), *Anas penelope* (VU), *Delichon urbicum* (EN), *Lagopus lagopus* (VU), *Mergus merganser* (VU), *Mergus serrator* (EN), *Parus cristatus* (VU), *Parus montanus* (VU), *Plectrophenax nivalis* (EN), *Riparia riparia* (VU), *Somateria mollissima* (VU)

Other threathened species

- *Pipistrellus nathusii* (VU), *Coregonus lavaretus* f. *lavaretus* (EN), *Coregonus lavaretus* f. *pallasi* (VU), *Thymallus thymallus* (sea spawning) (CR), *Salmo salar* (VU), *Anguilla anguilla* (EN), *Salmo trutta* (CR), *Crassula aquatica* (VU), *Macroplea pubipennis* (VU), *Hippuris tetraphylla* (EN)

Vulnerability, fragility, sensitivity, or slow recovery	Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.			X	

MEDIUM. There are habitats inside the area that are very sensitive to human disturbance, including flads and glo-lakes, as well as breeding and staging areas for birds. The area overall is, however, characterized by a comparatively large annual change and additionally by extensive water movements, and is as such fairly resilient. There are some pressures inside the area (dredging, fisheries, hunting, wind farm development, marine traffic, summer cottage usage in the inner archipelago), but most severe pressures, such as nutrient loading, originate from human activities outside the area.

- Many marine keyspecies, e.g. *Fucus vesiculosus*, *F. radicans* and *Mytilus trossulus*, live on the edge of their distribution and are sensitive to eutrophication and effects of climate change
- Macrophytes occurring in the edge of their range generally reproduce asexually, which may result in increased clonality in local population and thus reduce the populations capability to acclimate into environmental changes
- Many aquatic vascular plants and charophytes are sensitive to sedimentation and destruction of a habitat due to dredging and deposit of sediments
- Many of the rare species recover slowly. These species include, e.g., ringed seal, waterfowl and other birds and charophytes
- The reproduction of ringed seal is ice dependent. Kvarken archipelago together with the northernmost Bothnian Bay the only two areas where ice will reliably form during the next hundred years.

Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.			X	

MEDIUM. The area is very productive during summer (with over 20 hours of sunlight), but less so in winter (with annual sea ice covering the area).

- Important reproduction area for many fish species, including pike, perch, pikeperch, Baltic herring and smelt (Fig. 29-35)
- Large shallow areas where many key species inhabit wide areas (Fig. 22, 24-27)
- The biomass of benthic invertebrates is intermediate in the area (Fig. 21, 23 & 28)

Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.			X	

MEDIUM. Due to the extreme characteristics of the area the species-based diversity is relatively low; on the

other hand the species composition of the biotopes and ecosystems is a mix of freshwater and marine species (Fig. 16-20).					
Naturalness	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.			X	
Explanation for ranking MEDIUM. The human-induced pressure level is intermediate (Fig. 36-38), and there is human presence throughout the area, but mostly in the summer. Large parts belong to the Natura 2000 network or the World Heritage site, which will limit further development (e.g. building of summer cottages and dredging). Some inner archipelago areas are eutrophicated due to nutrient loading from the watershed. Building of wind farms and development of aquaculture may become a larger threat in the future.					

Sharing experiences and information applying other criteria (Optional)

Other Criteria	**Description**	**Ranking of criterion relevance** (please mark one column with an X)			
		Don't Know	**Low**	**Medium**	**High**
Add relevant criteria					

References

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Maps and Figures

Figure 1. EBSA proposal for Kvarken Archipelago.

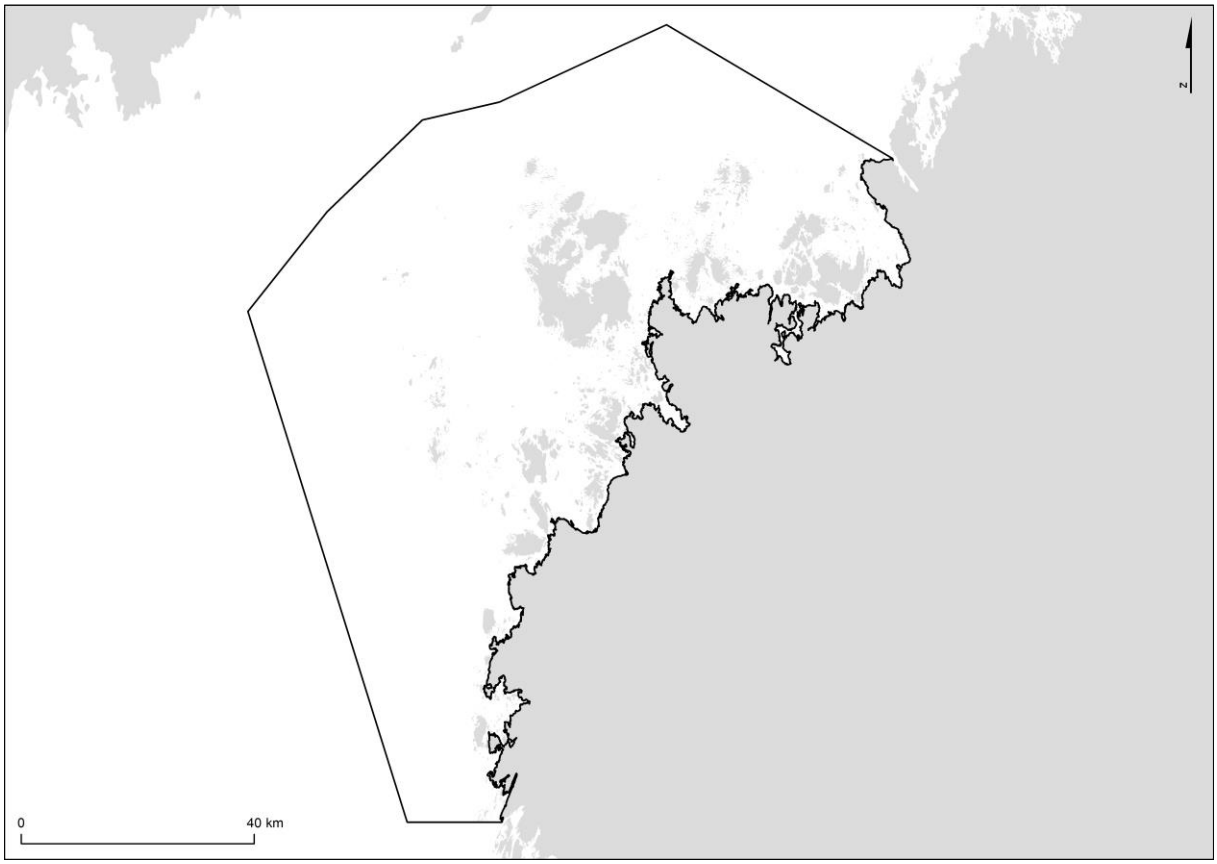

Figure 2. EBSA proposal.

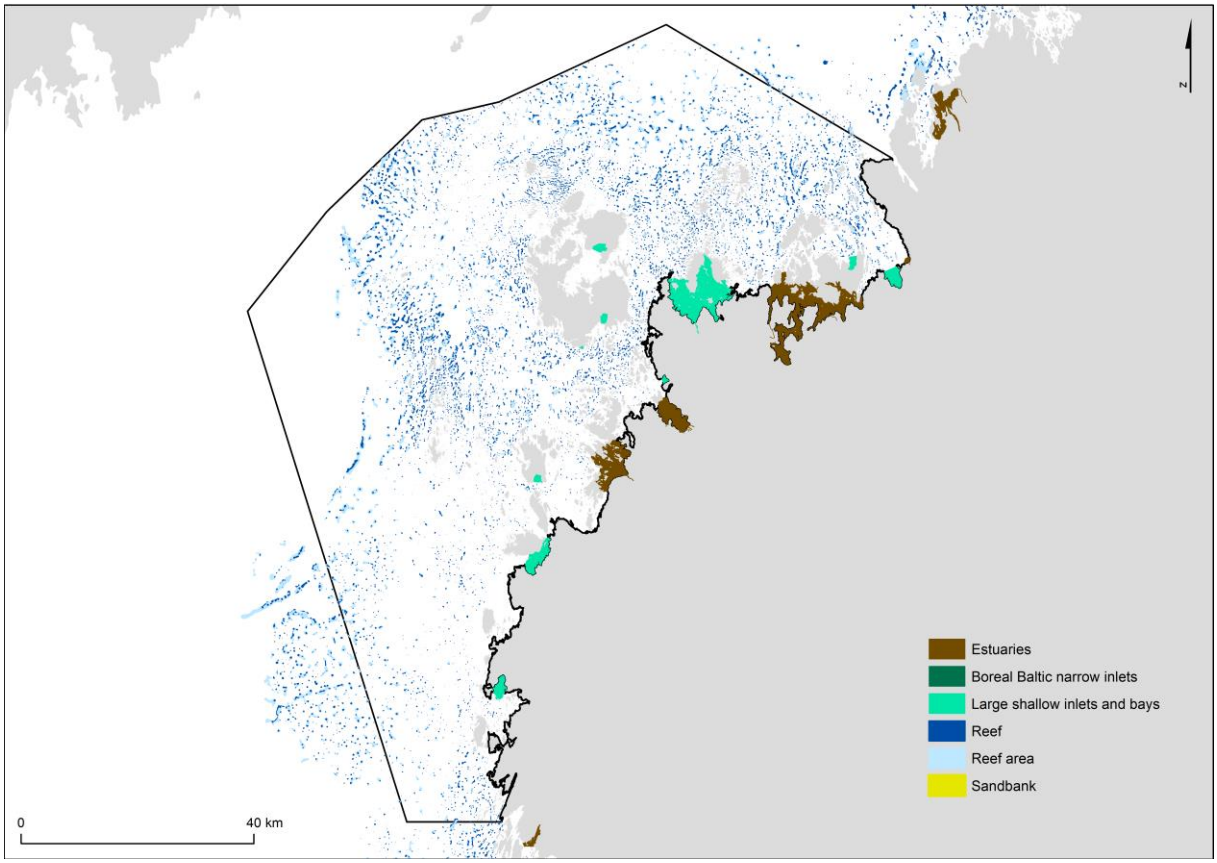

Figure 3. Potential habitats described by EU Habitats directive (92/43/EEC). Finnish Environment Institute & Geological Survey of Finland.

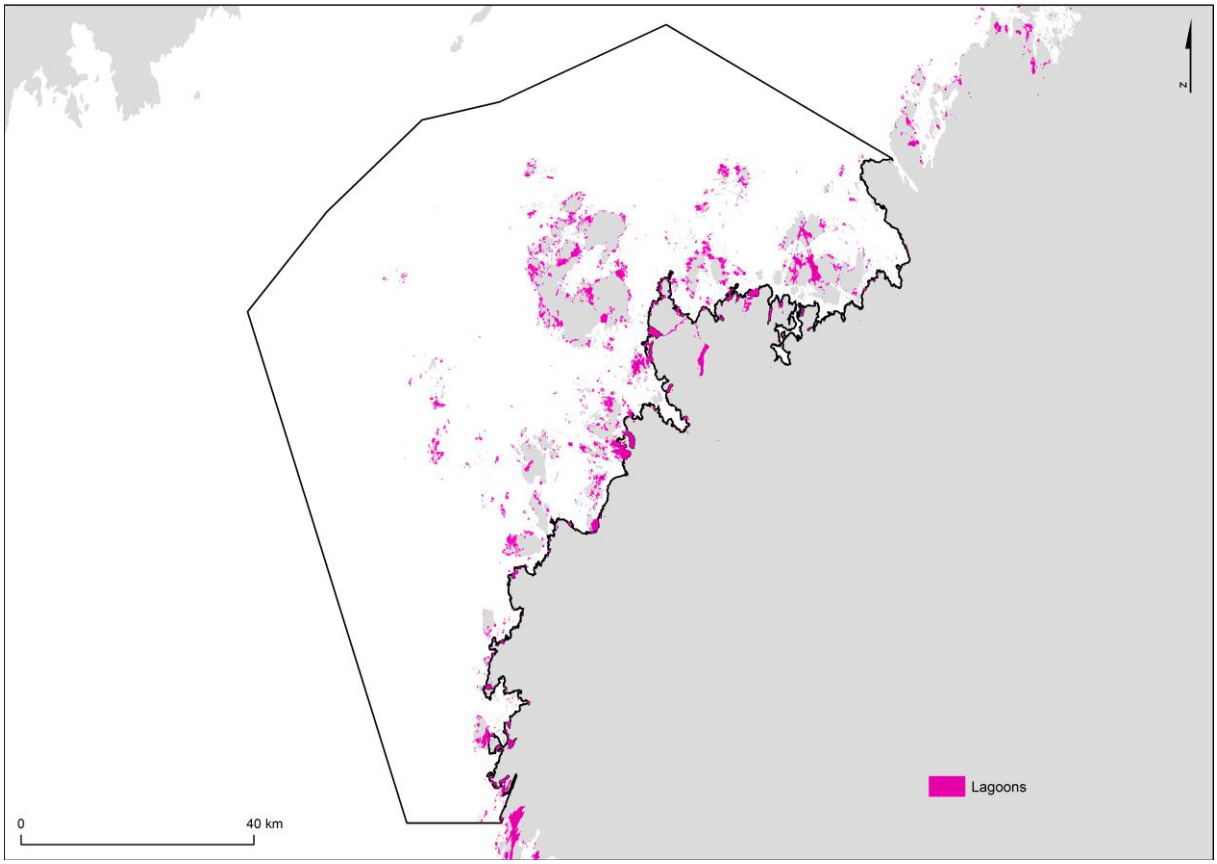

Figure 4. Potential coastal lagoons (1150) described by EU Habitats directive (92/43/EEC). Finnish Environment Institute.

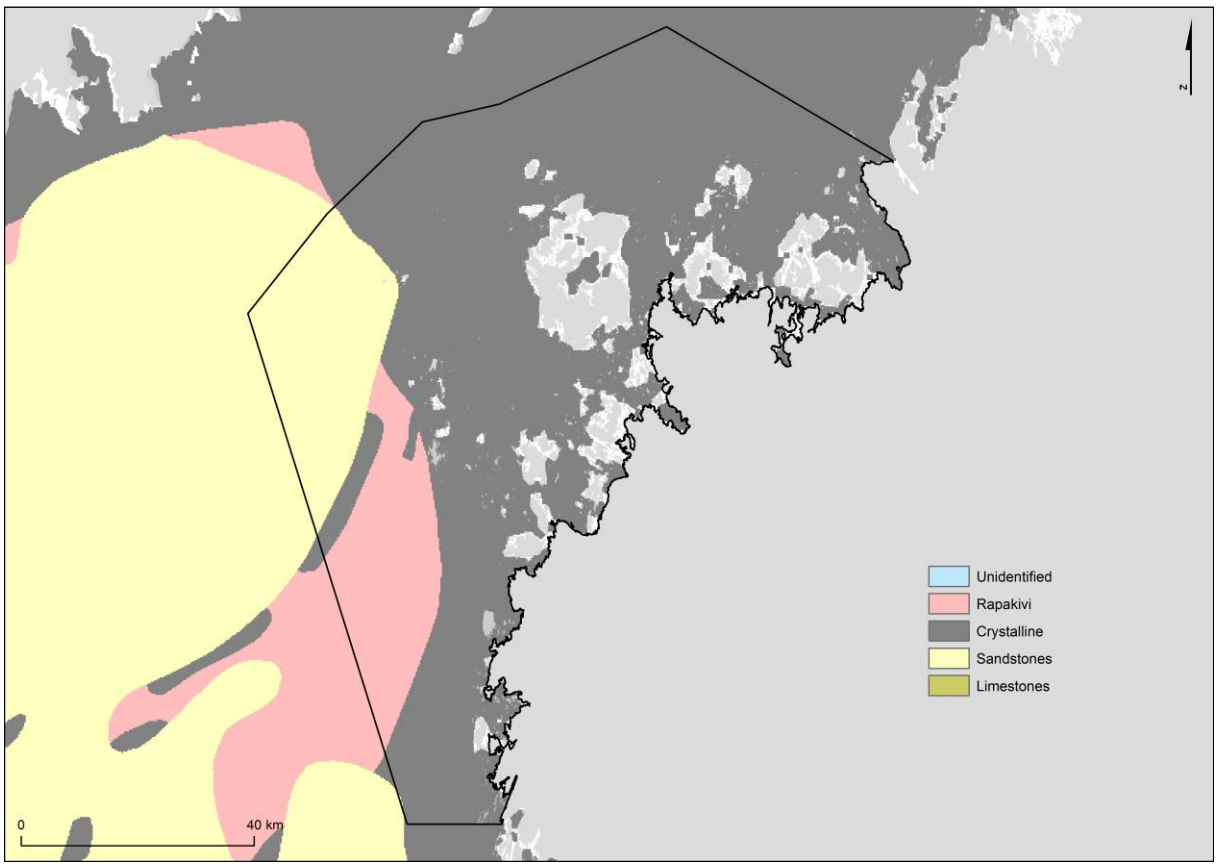

Figure 5. Rock type. Geological Survey of Finland.

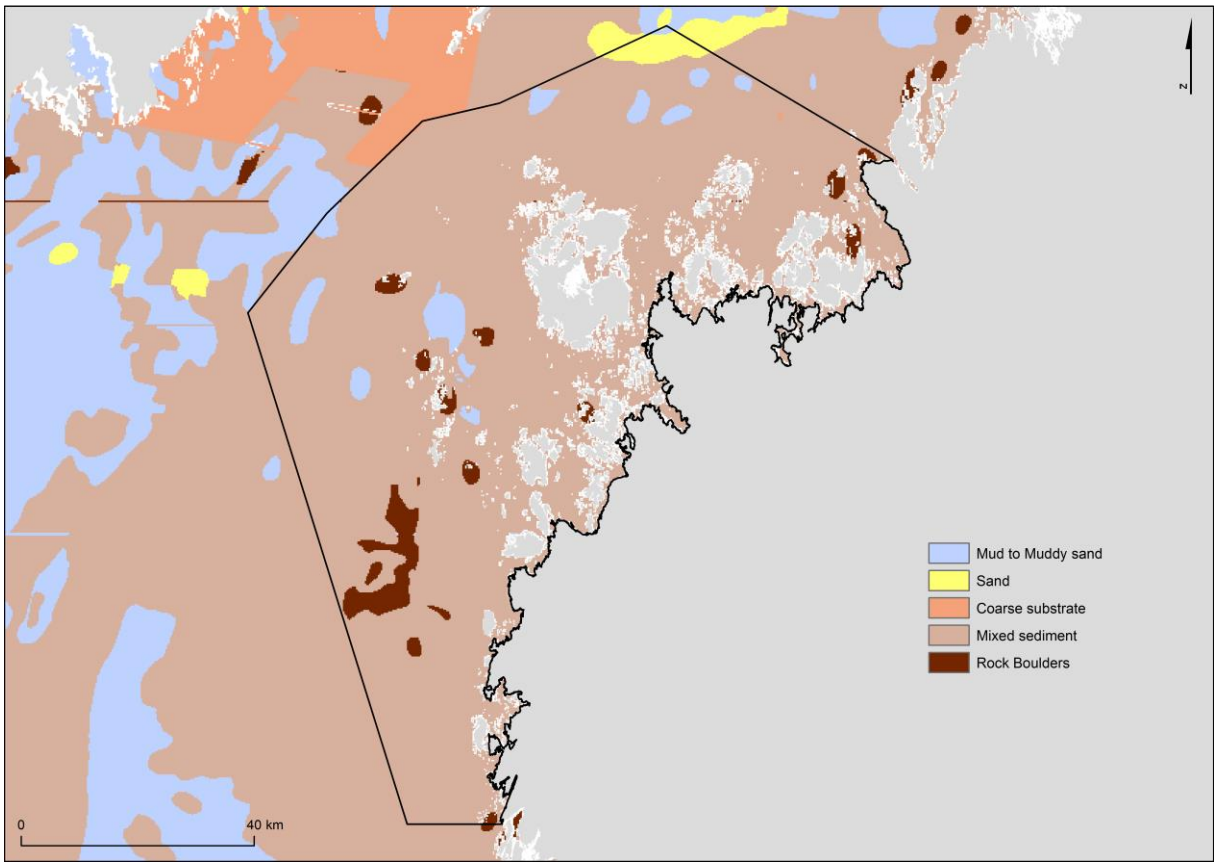

Figure 6. Seabed substrate. Geological Survey of Finland.

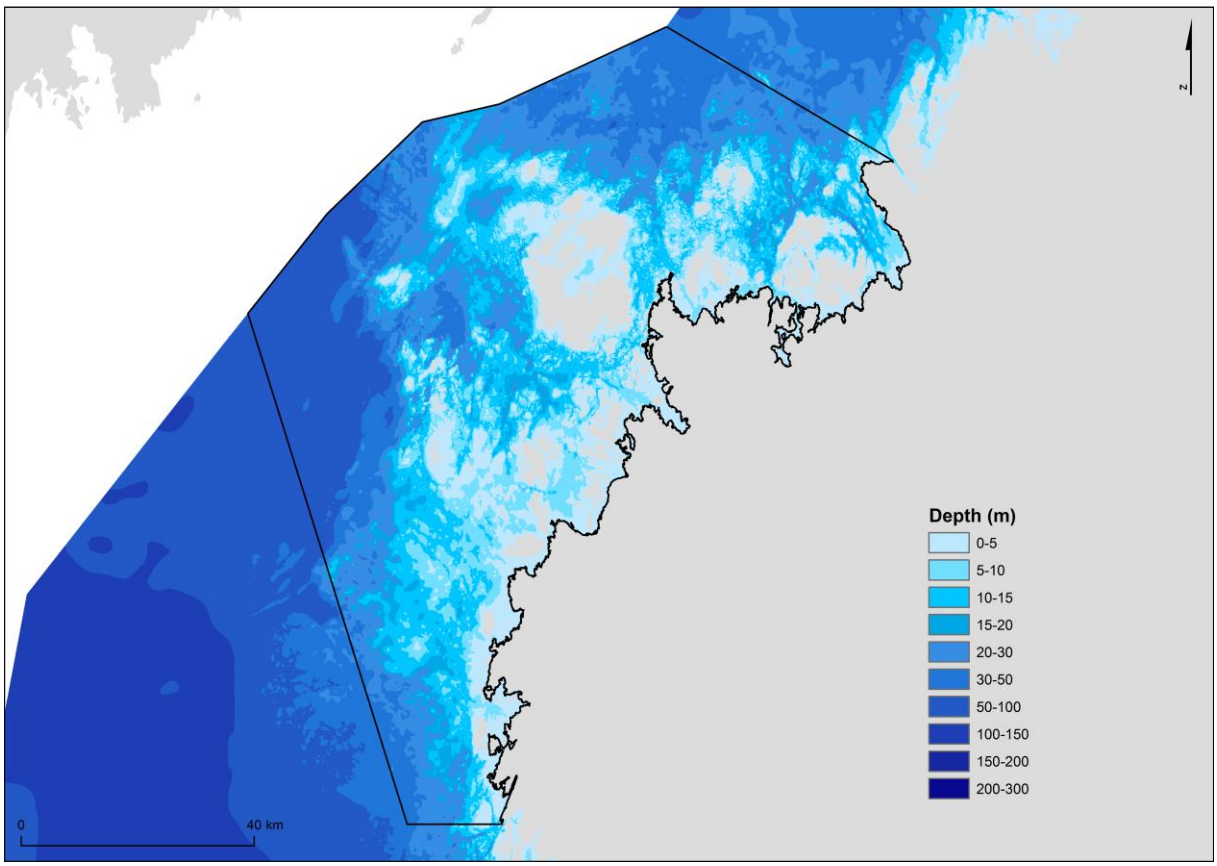

Figure 7. Water depth. VELMU / Finnish Environment Institute.

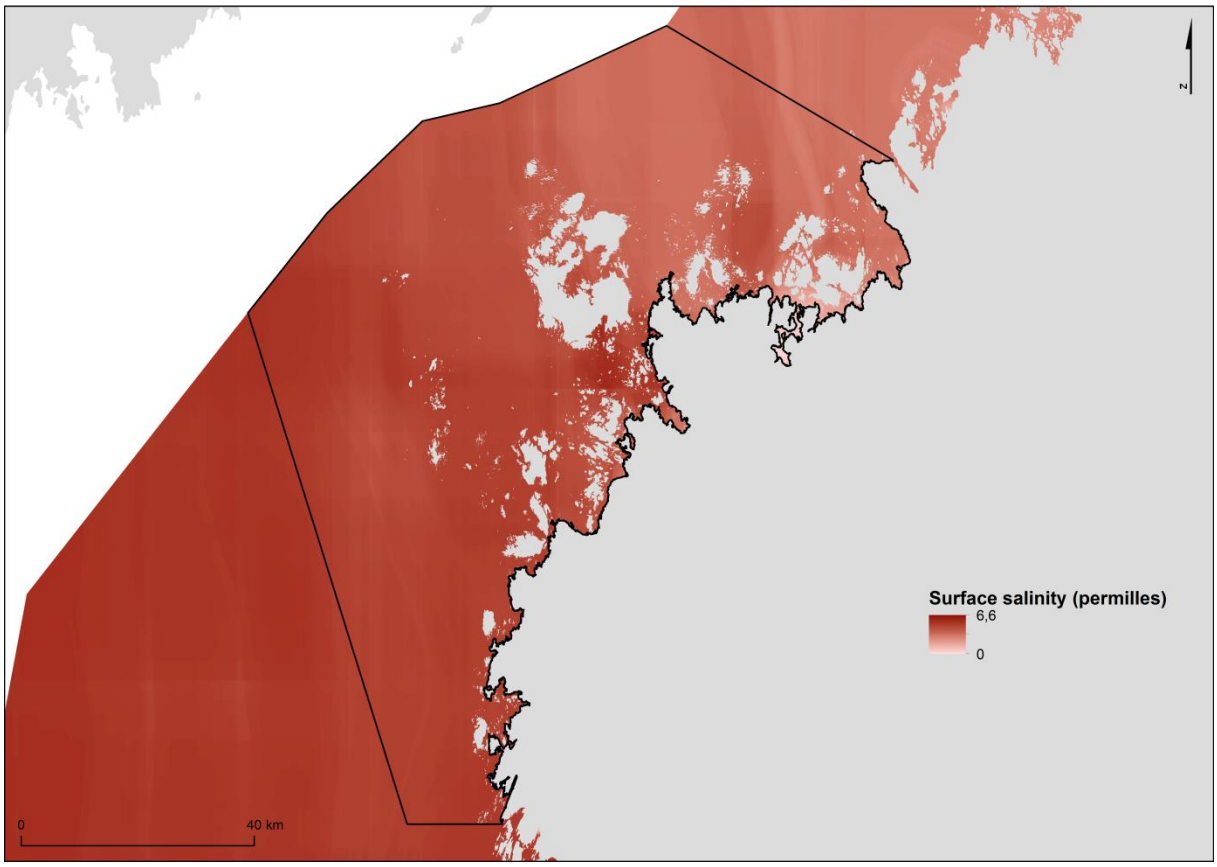

Figure 8. Surface salinity. VELMU / Finnish Environment Institute.

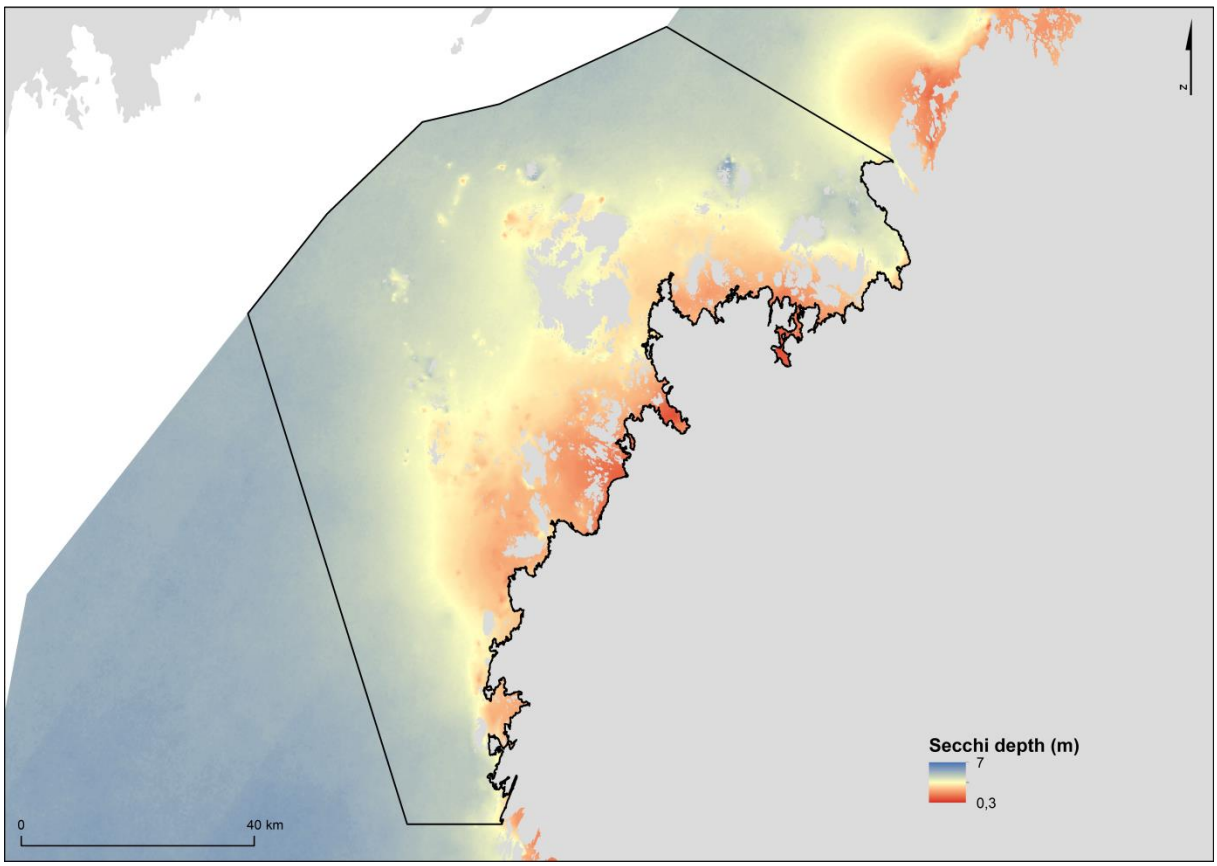

Figure 9. Secchi depth derived from Envisat-1 MERIS satellite images for the summer period 2003-2011. VELMU / Finnish Environment Institute.

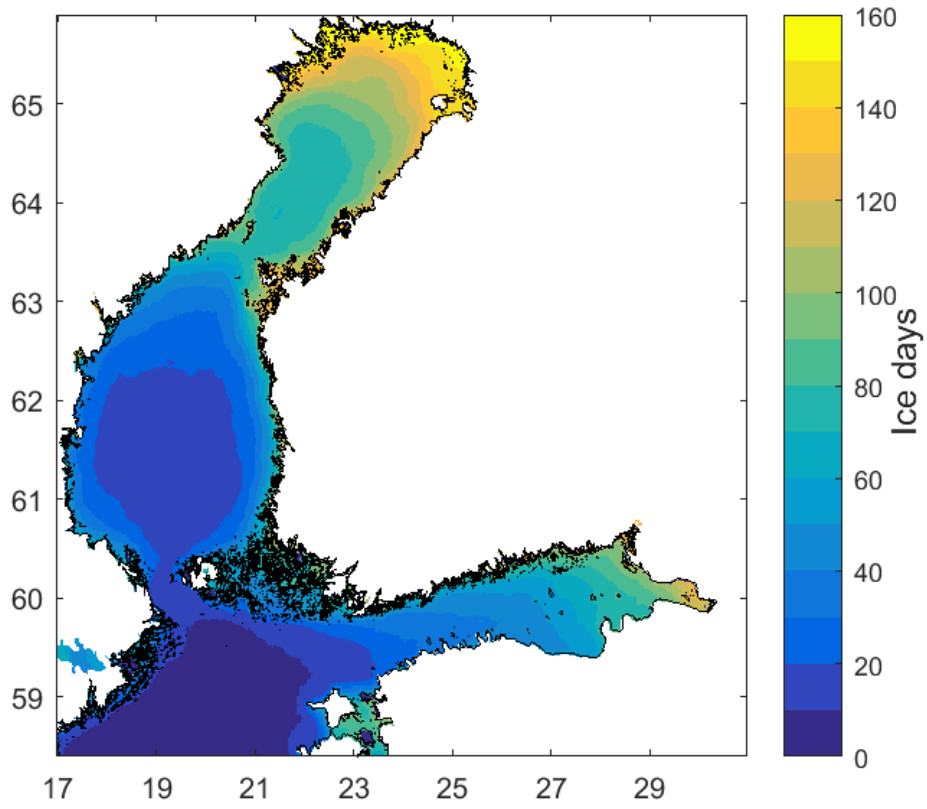

Figure 10. Average number of ice days during winters 2002...2003-2015...2016. Finnish Meteorological Institute.

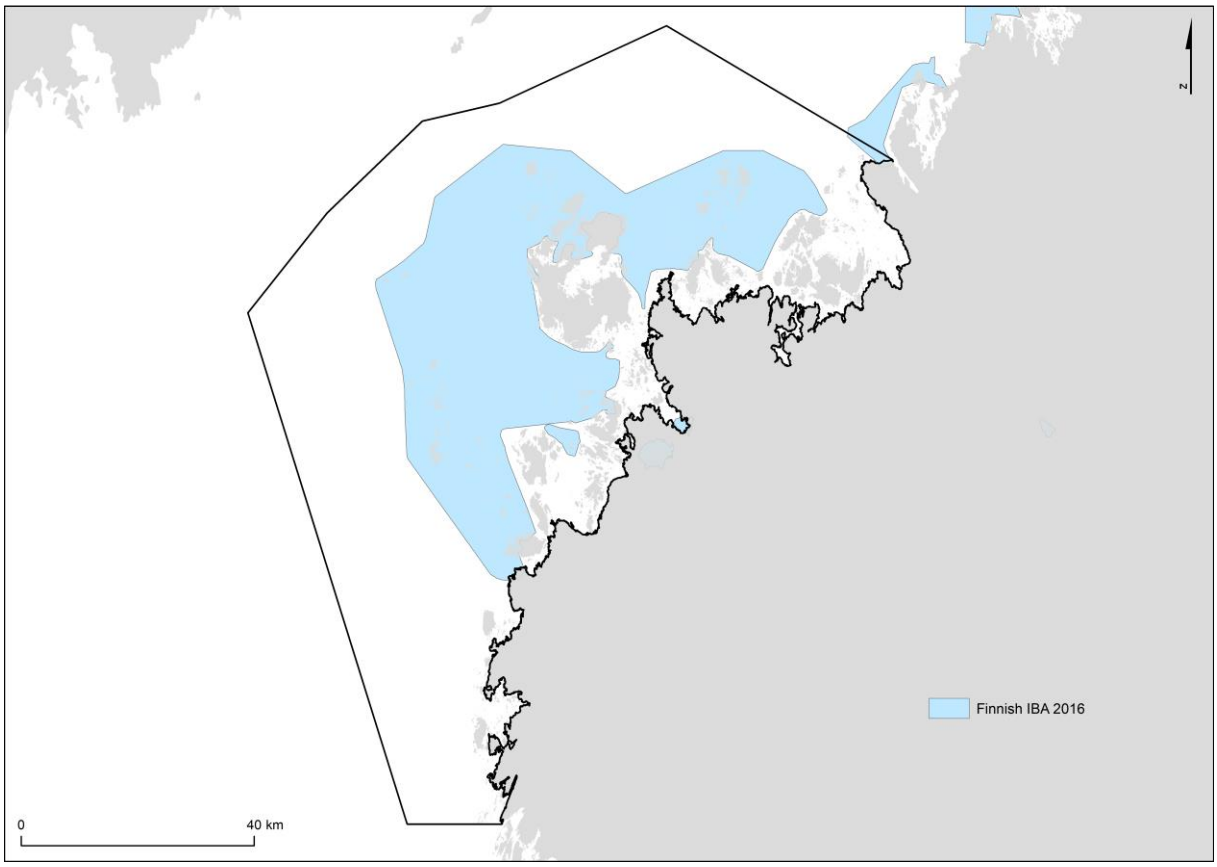

Figure 11. Important Bird and Biodiversity Areas (IBA). BirdLife Finland.

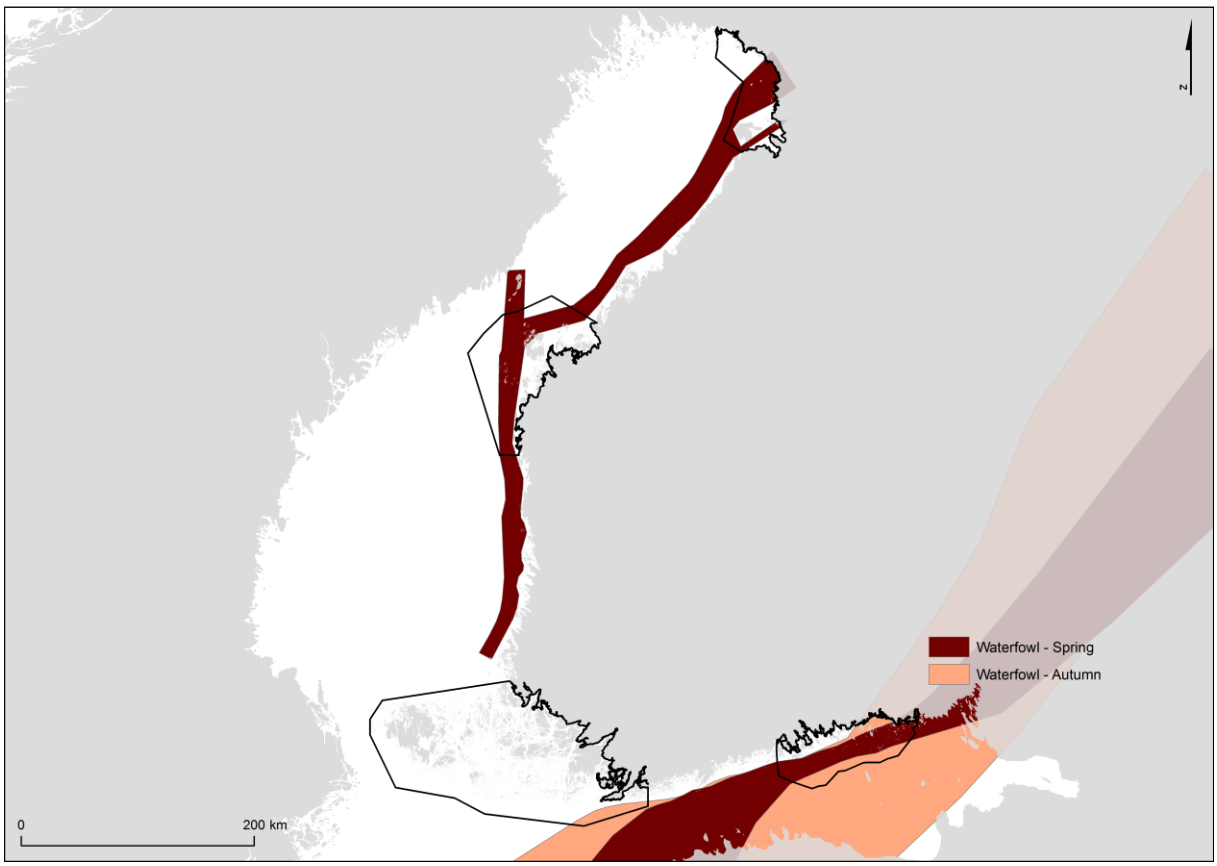

Figure 12. Migration routes of waterfowl. Birdlife Finland.

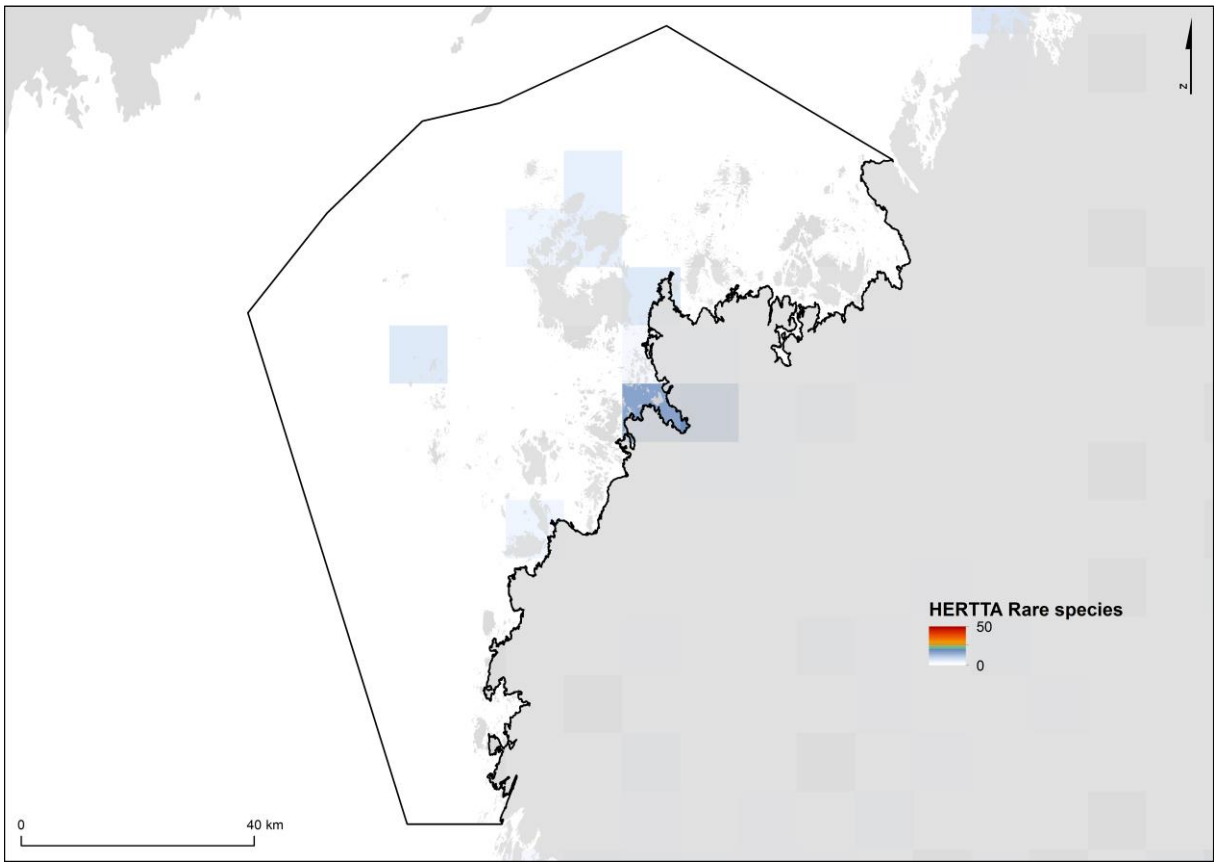

Figure 13. The number of observed rare species (Red list: RE, CR, EN, VU, NT) derived from HERTTA database for the years 1990-2015. Please note that all taxa from HERTTA database are included, also terrestrial species. Finnish Environment Institute.

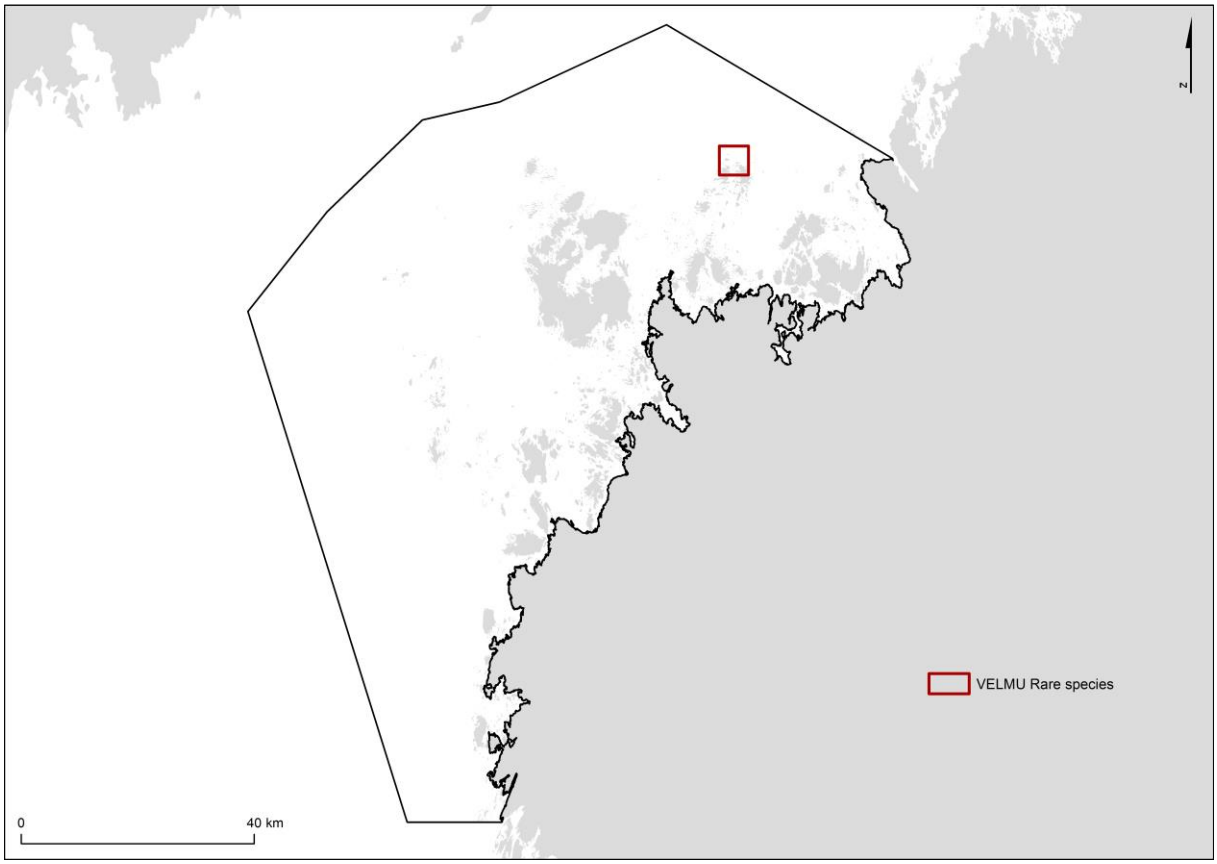

Figure 14. The occurrence of rare aquatic vascular plants and charophytes observed by VELMU programme. VELMU / Finnish Environment Institute.

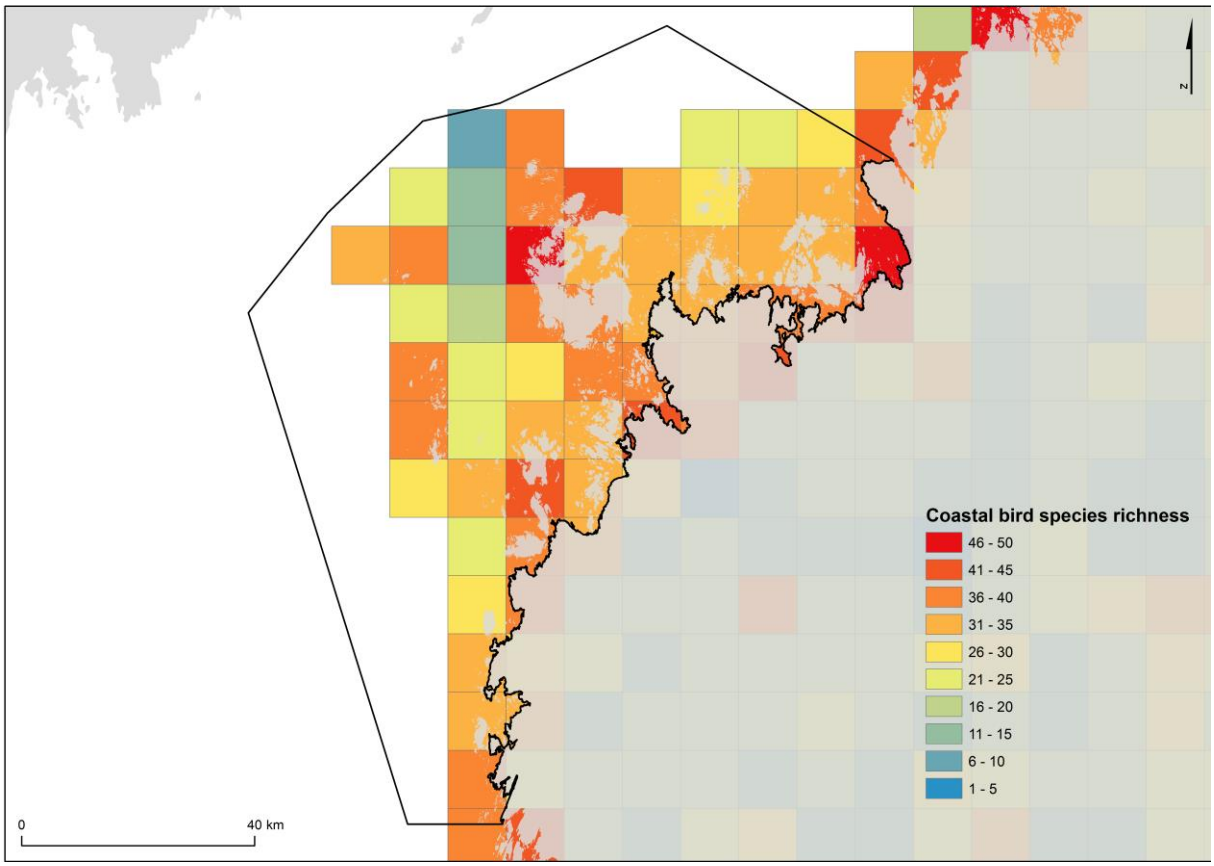

Figure 15. The number of breeding coastal birds. Finnish Bird Atlas & Metsähallitus Parks and Wildlife Finland.

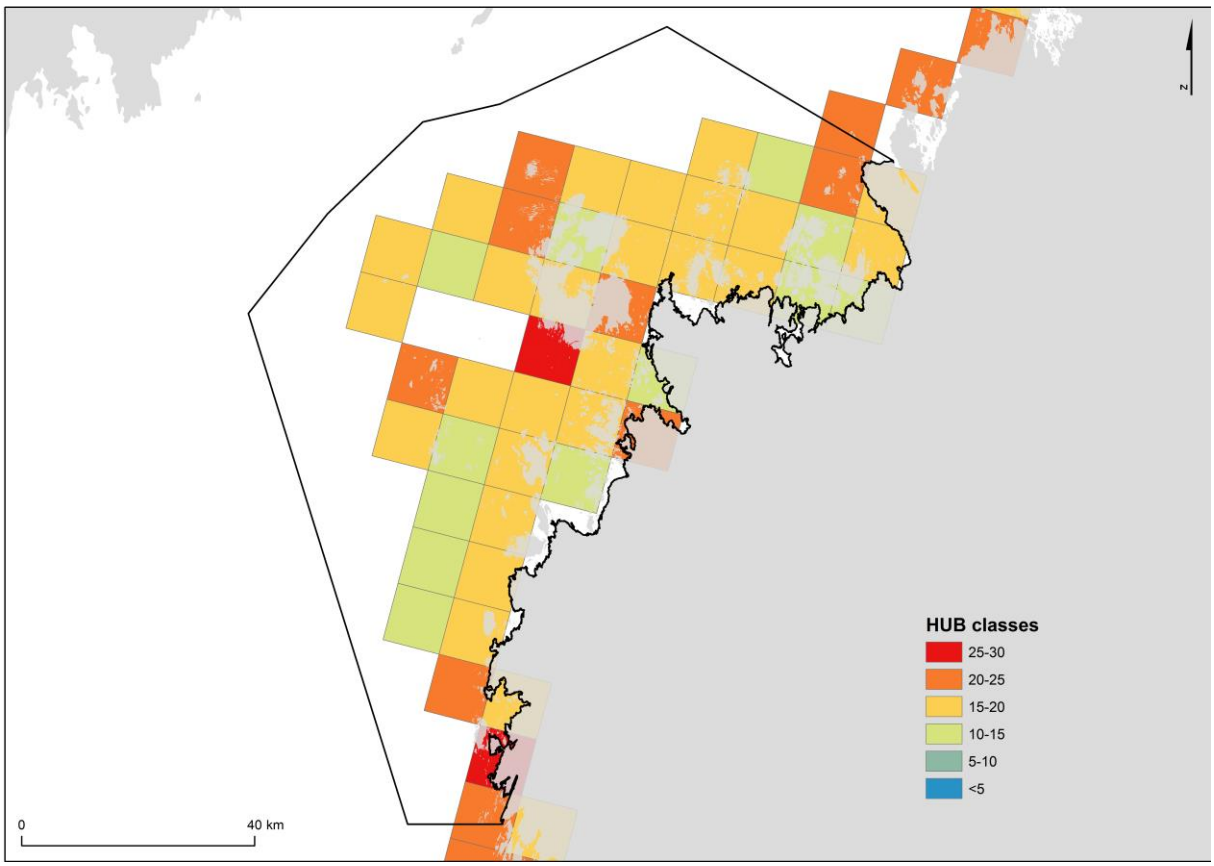

Figure 16. The number of observed HELCOM HUB classes. Based on VELMU inventories 2004-2016. Metsähallitus Parks and Wildlife Finland & Finnish Environment Institute.

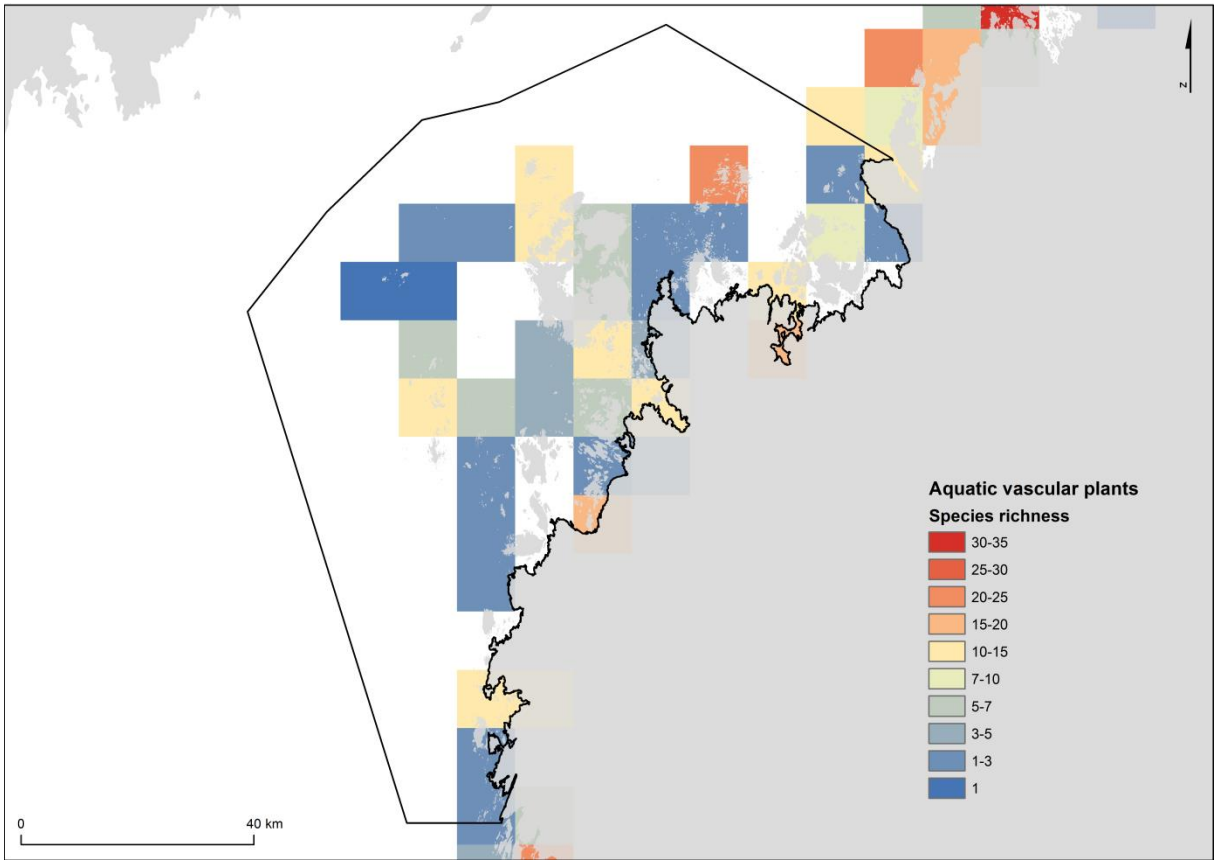

Figure 17. The species richness of aquatic vascular plants. Based on VELMU inventories 2004-2016. VELMU / Finnish Environment Institute.

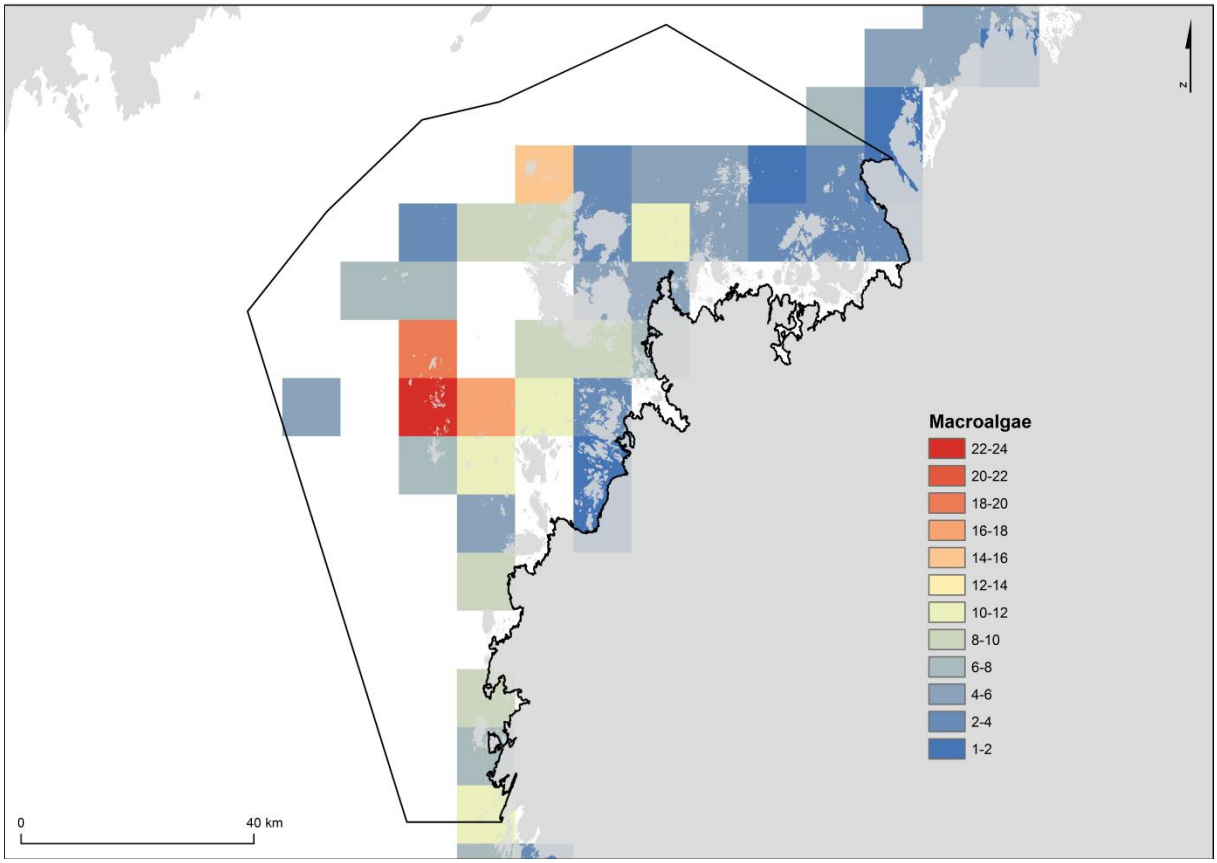

Figure 18. The species richness of macroalgae. Based on VELMU inventories 2004-2016. VELMU / Finnish Environment Institute.

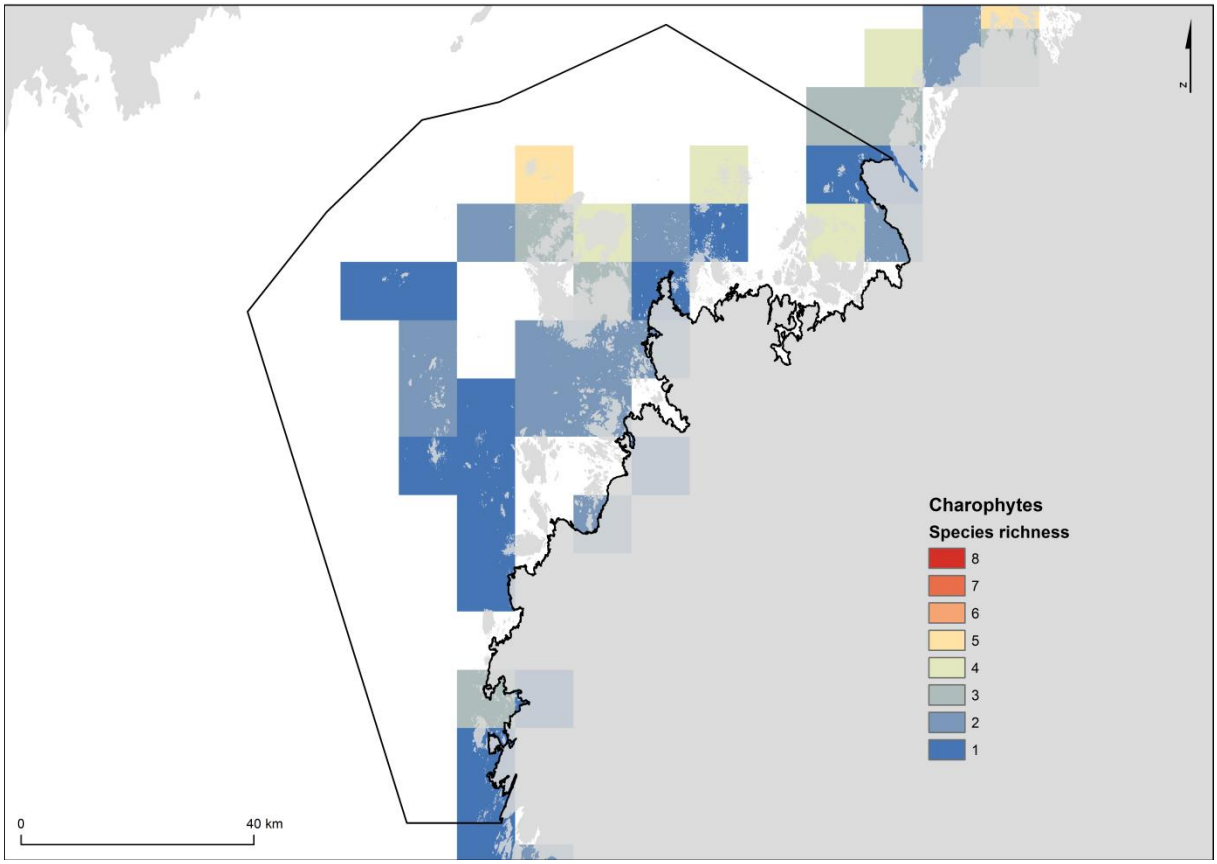

Figure 19. The species richness of charophytes. Based on VELMU inventories 2004-2016. VELMU / Finnish Environment Institute.

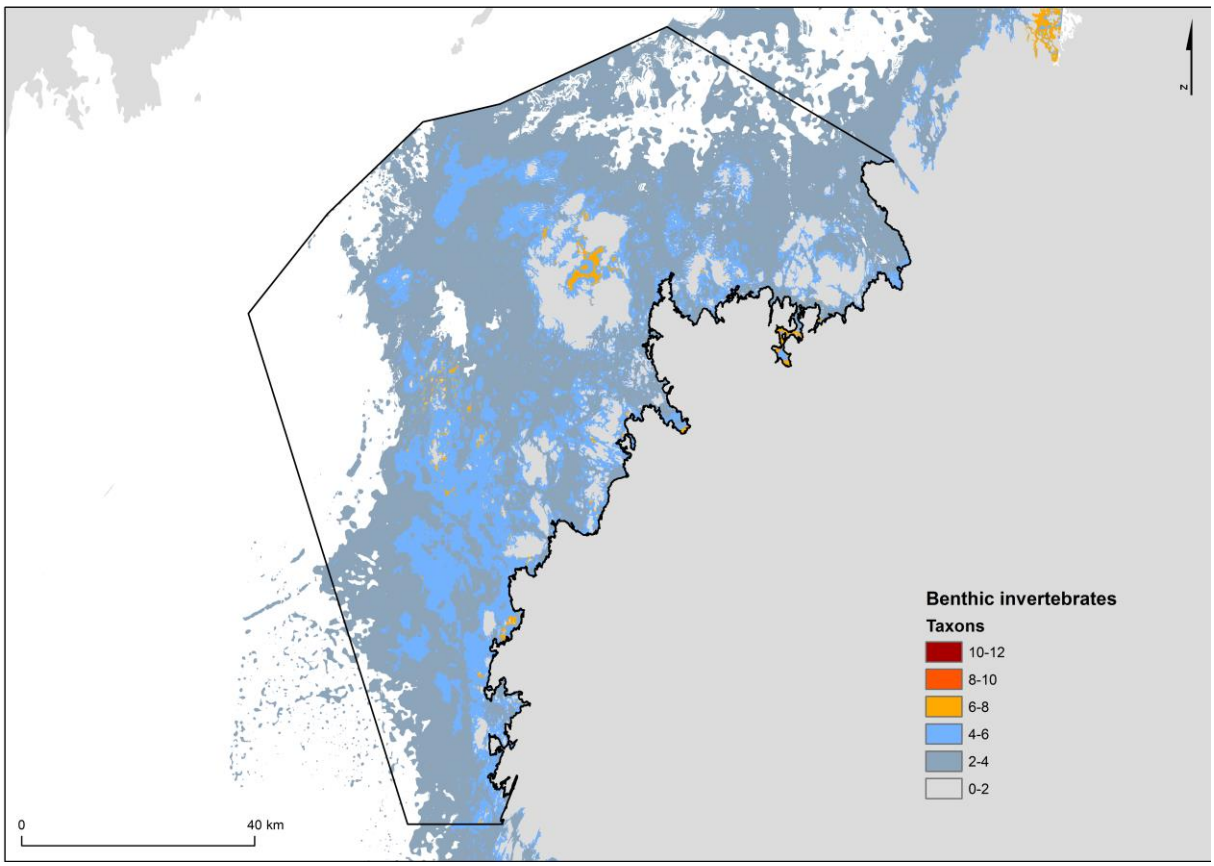

Figure 20. Modelled number of benthic invertebrate taxa. Based on VELMU inventories 2004-2016 and HERTTA Pohje database. Finnish Environment Institute.

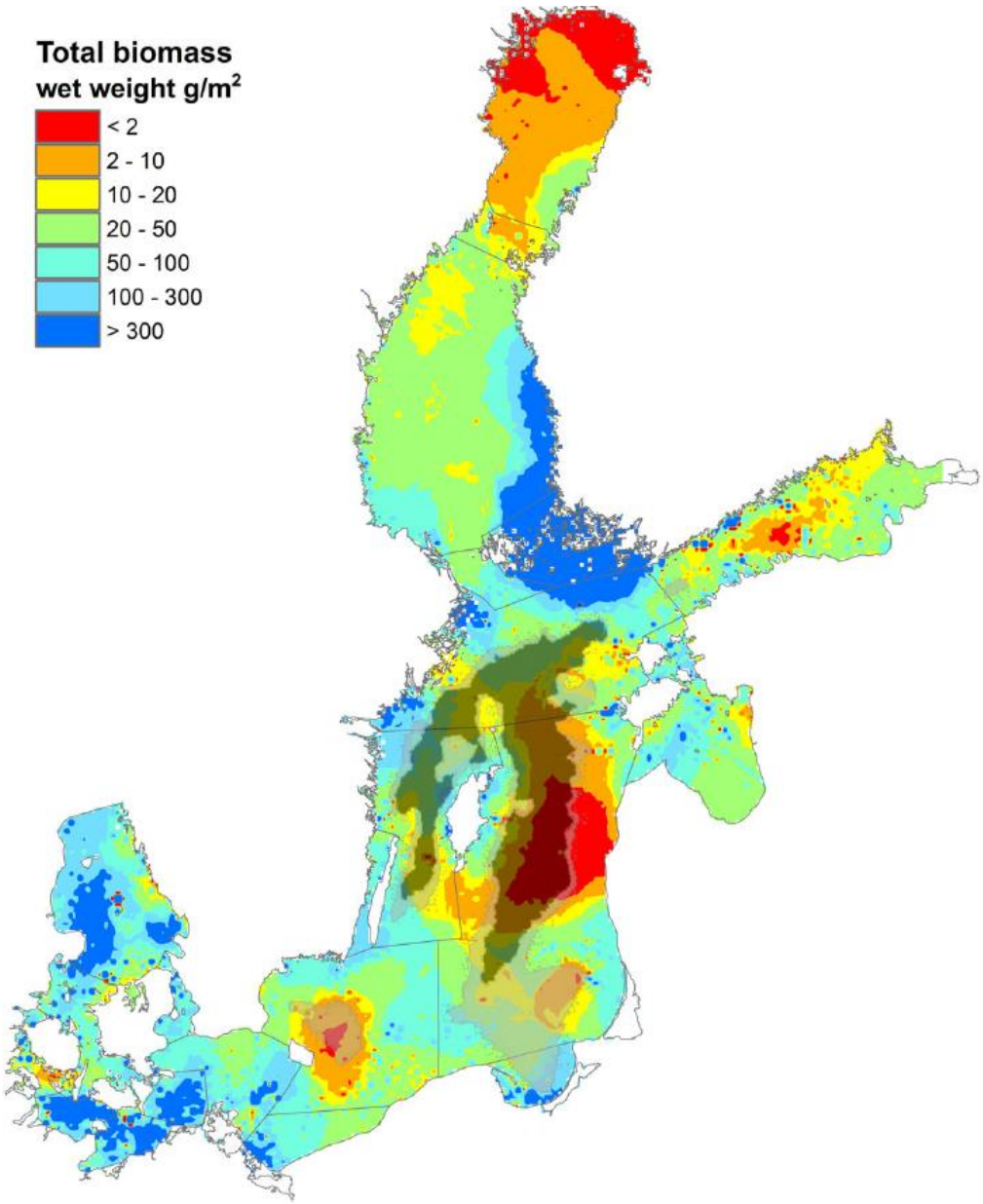

Figure 8. Distribution of interpolated total wet weight biomass, derived using ordinary kriging interpolation of available biomass data averaged per 5 × 5 km grid cell. Transparent light grey and dark grey areas mask out the deep water hypoxic and anoxic oxygen conditions. Note that at the areas where biomass data are lacking interpolation artefacts are evident, for instance, values at the shallow parts of the Eastern Gotland Basin at the west coast off Latvia are presumably too low. This figure is available in black and white in print and in colour at *ICES Journal of Marine Science* online.

Figure 21. Total biomass of benthic invertebrates. Gogina et al. 2016.

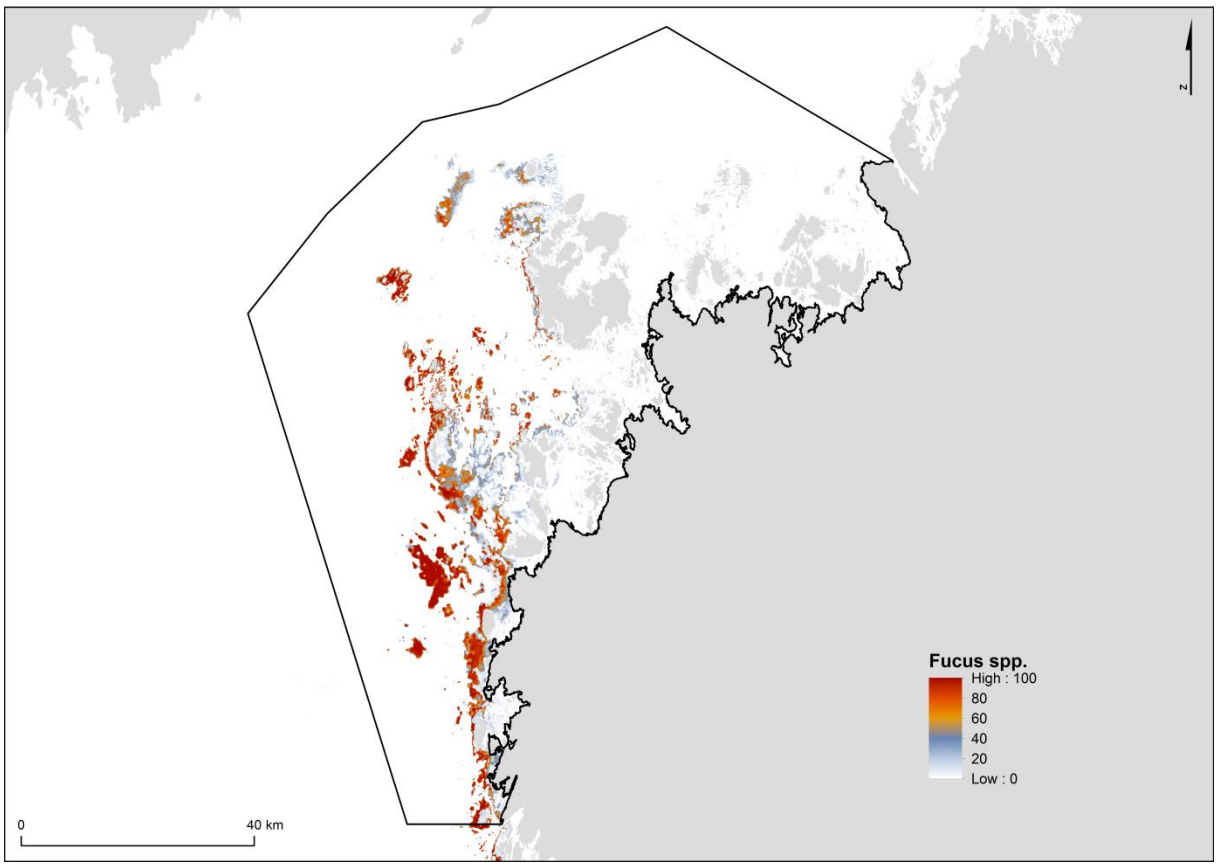

Figure 22. Modelled distribution of bladder wrack (*Fucus* spp.) as probability of occurrence (0-100%). Based on VELMU inventories 2004-2016. Finnish Environment Institute.

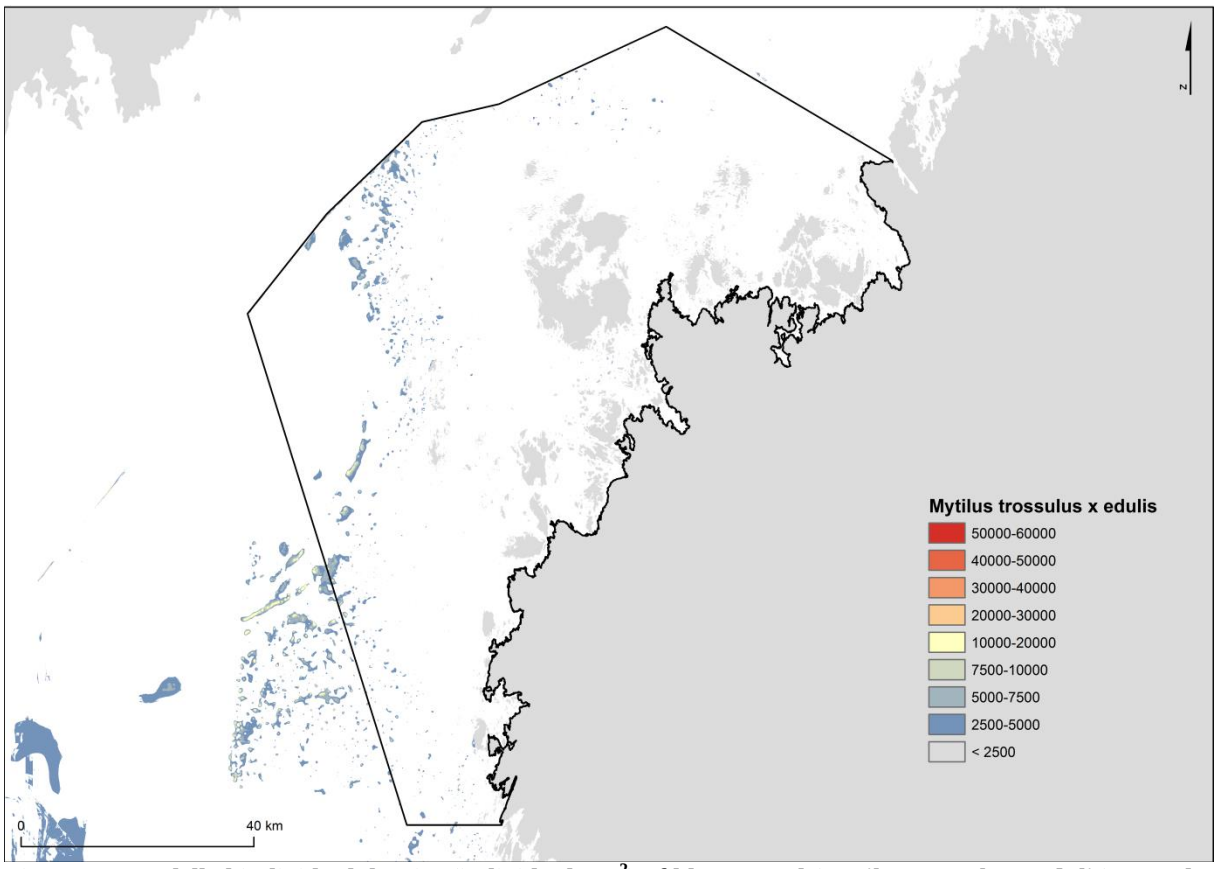

Figure 23. Modelled individual density (individuals m^{-2}) of blue mussel (*Mytilus trossulus* x *edulis)*. Based on VELMU inventories 2004-2016 and HERTTA Pohje database. Finnish Environment Institute.

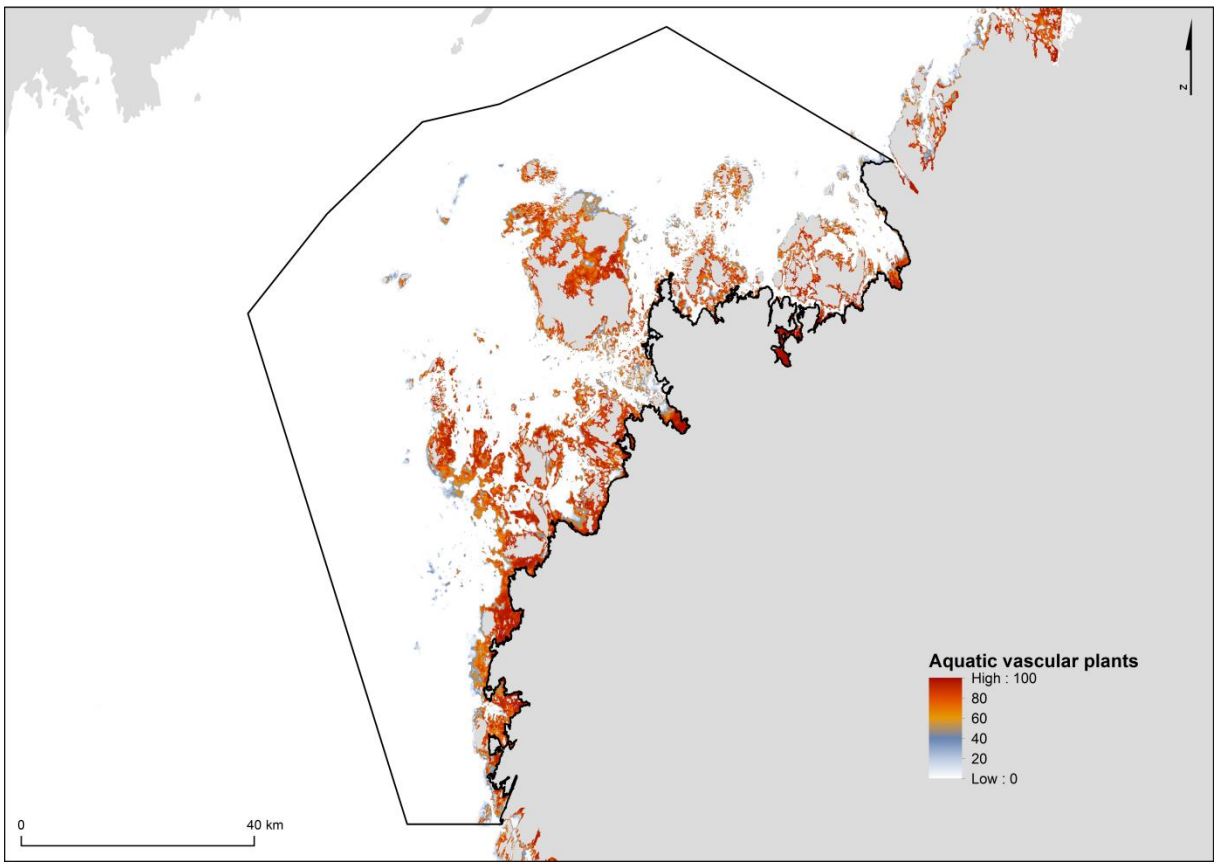

Figure 24. Modelled distribution of aquatic vascular plants as probability of occurrence (0-100%). Based on VELMU inventories 2004-2016. Finnish Environment Institute.

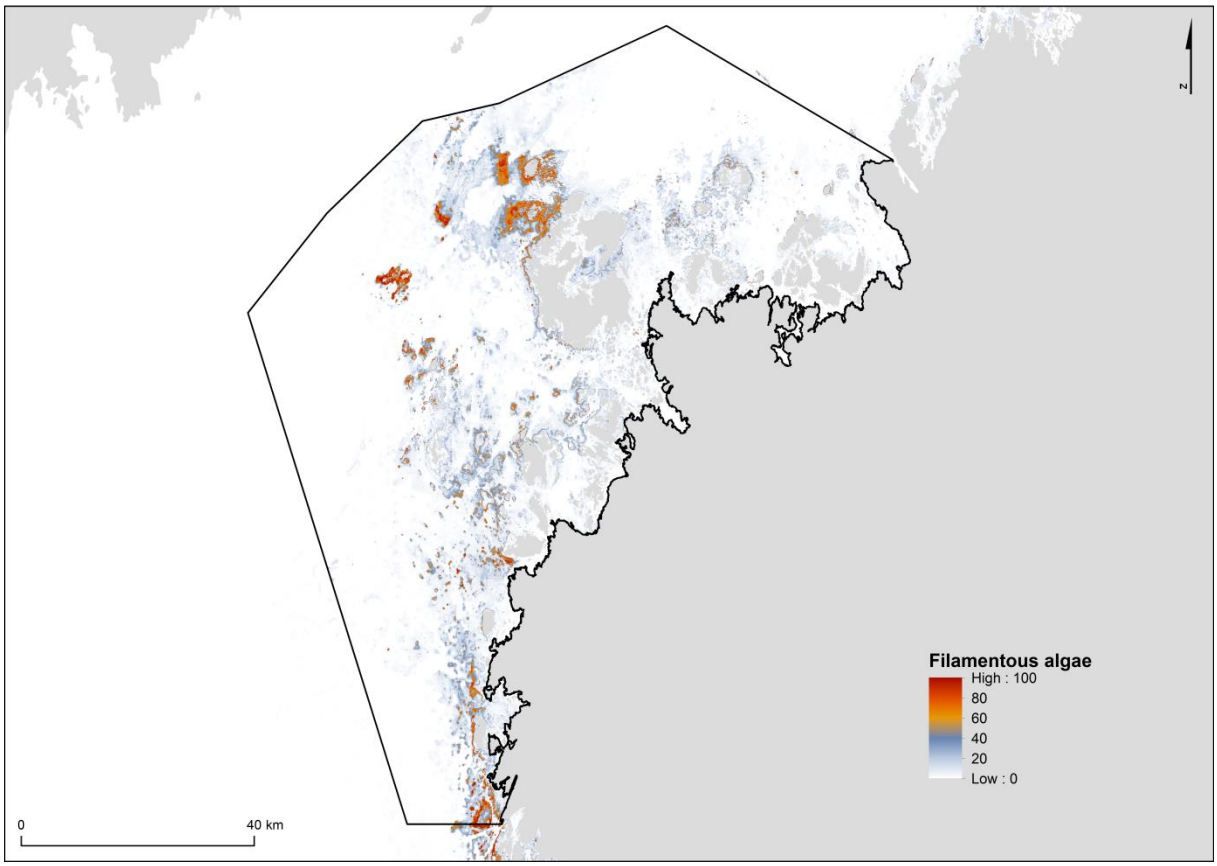

Figure 25. Modelled distribution of filamentous algae as probability of occurrence (0-100%). Based on VELMU inventories 2004-2016. Finnish Environment Institute.

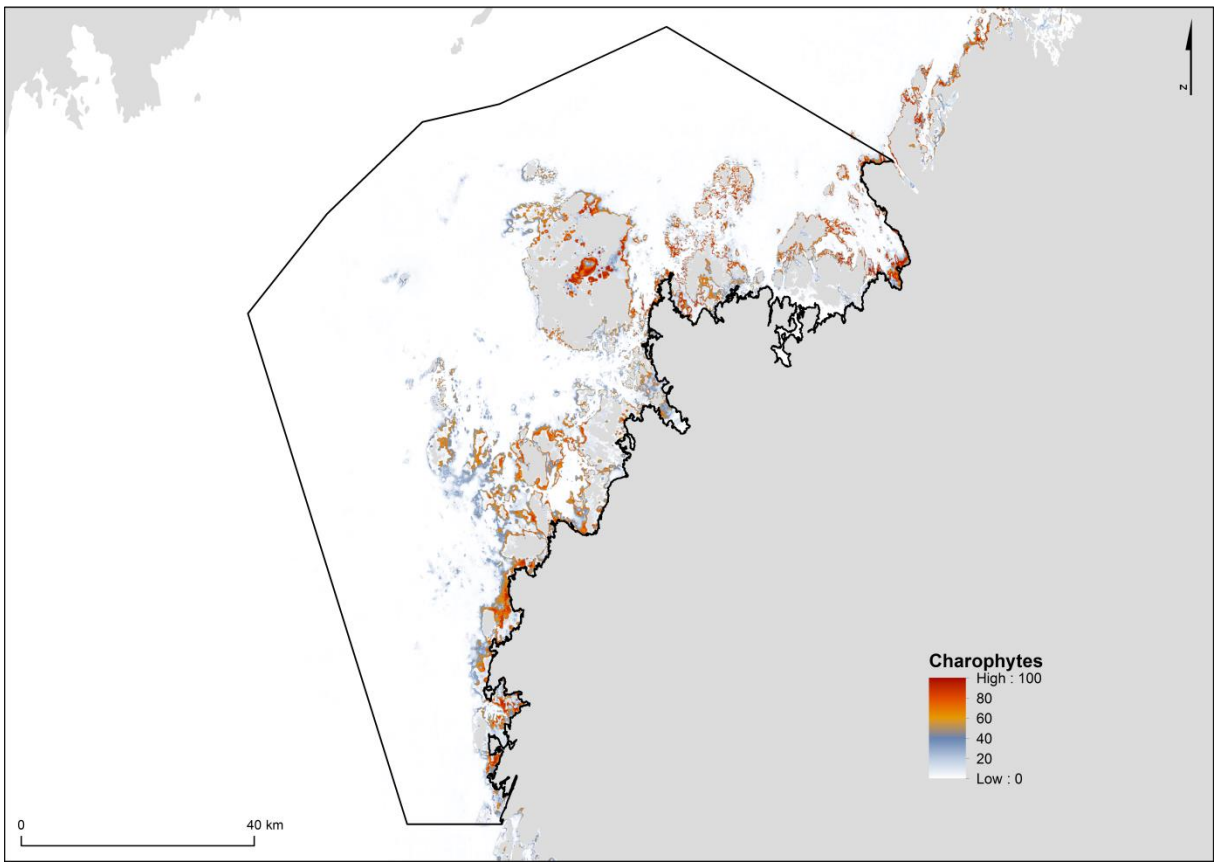

Figure 26. Modelled distribution of charophytes as probability of occurrence (0-100%). Based on VELMU inventories 2004-2016. Finnish Environment Institute.

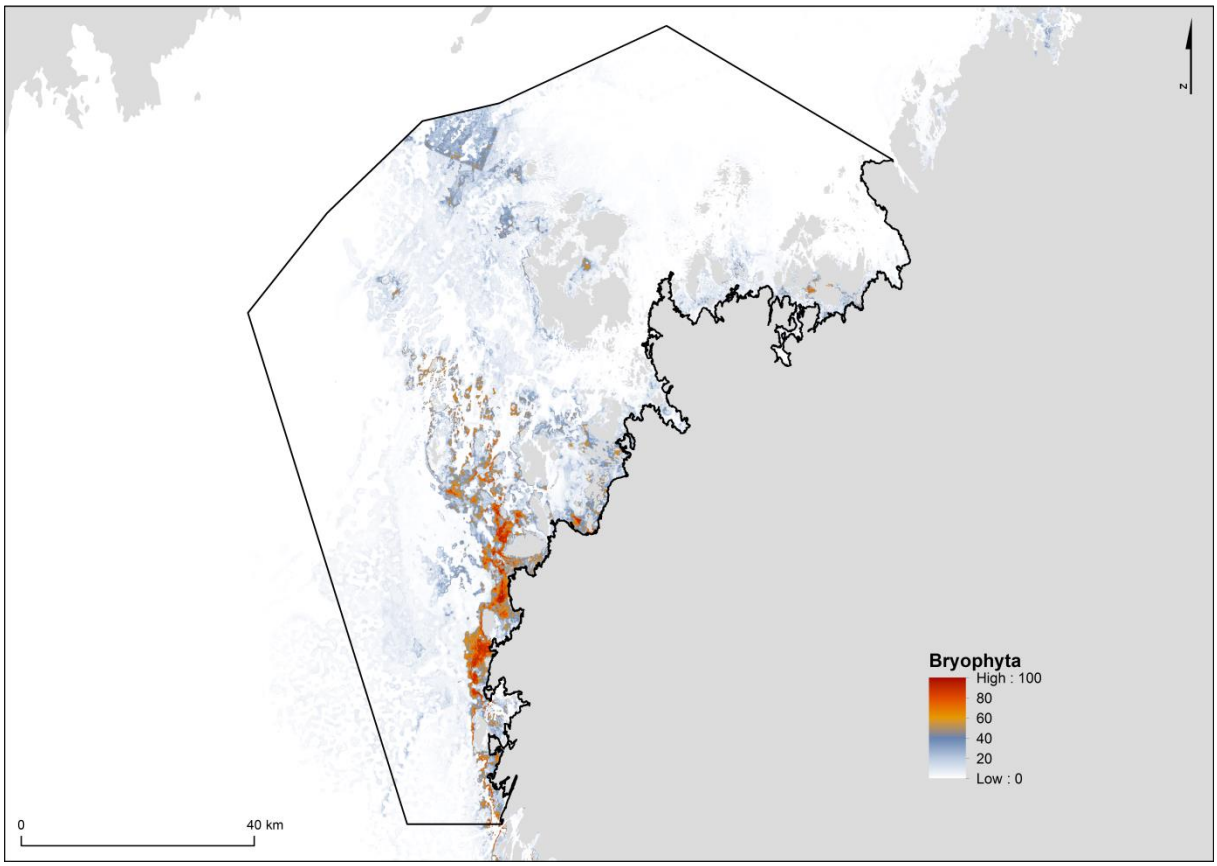

Figure 27. Modelled distribution of water mosses as probability of occurrence (0-100%). Based on VELMU inventories 2004-2016. Finnish Environment Institute.

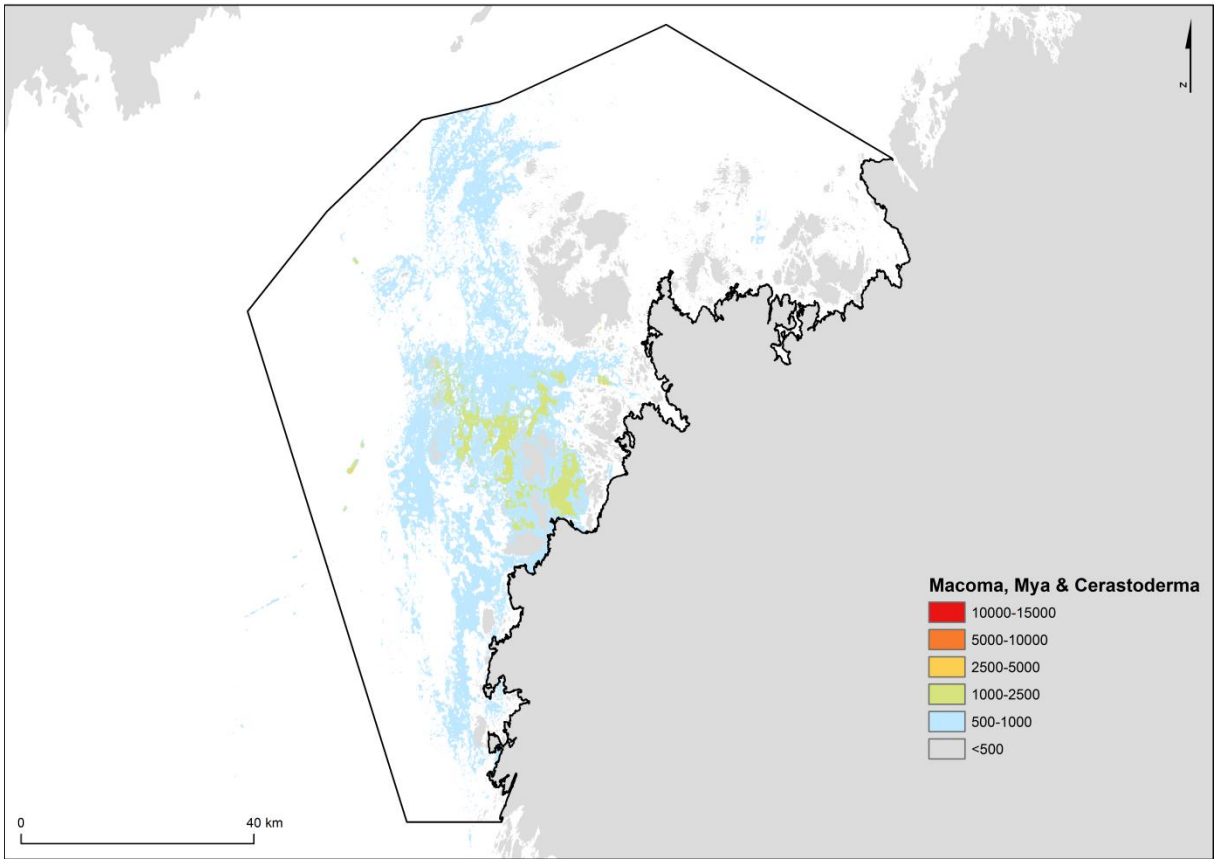

Figure 28. Modelled distribution of infaunal bivalves *Macoma baltica, Mya arenaria* and *Cerastoderma glaucum* as density (Individuals m^{-2}). Based on VELMU inventories 2004-2016 and HERTTA Pohje database. Finnish Environment Institute.

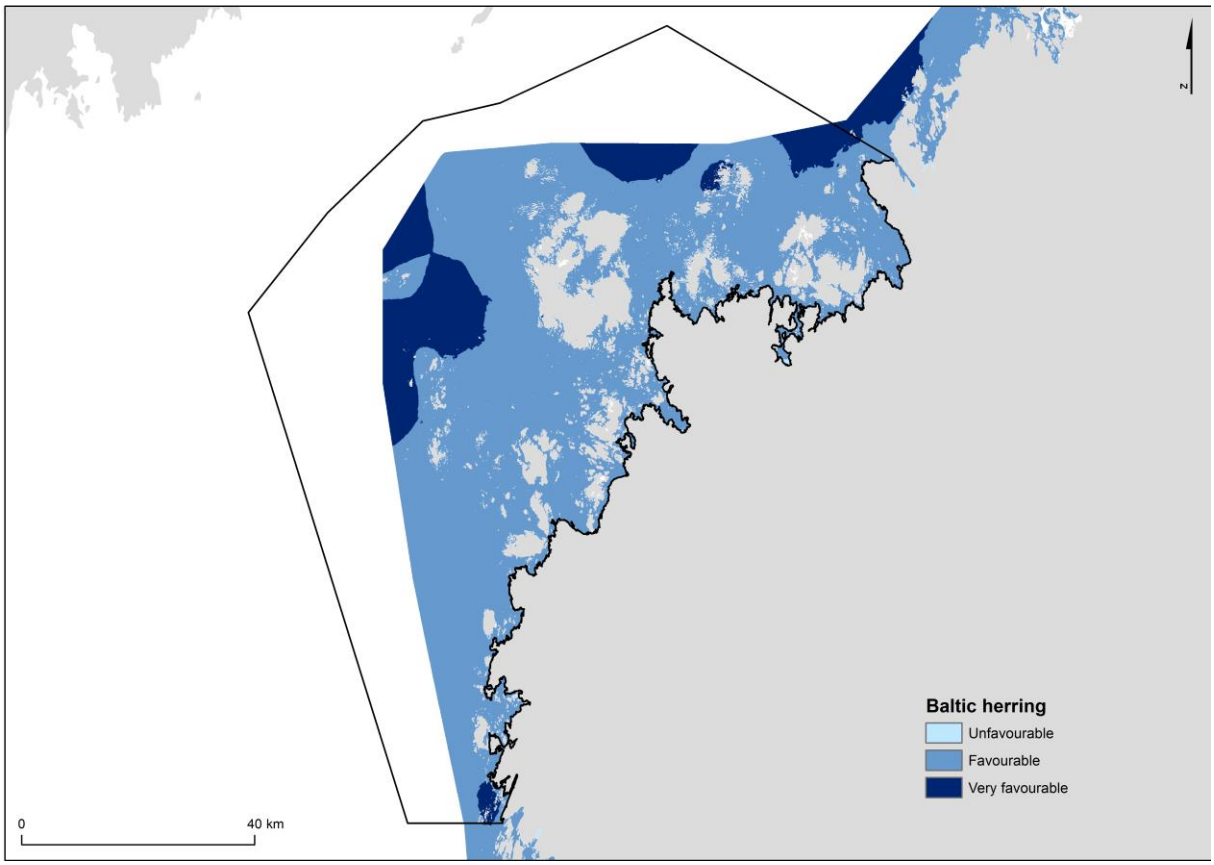

Figure 29. Reproduction area of baltic herring (*Clupea harengus membras*). National Resources Institute Finland & VELMU programme.

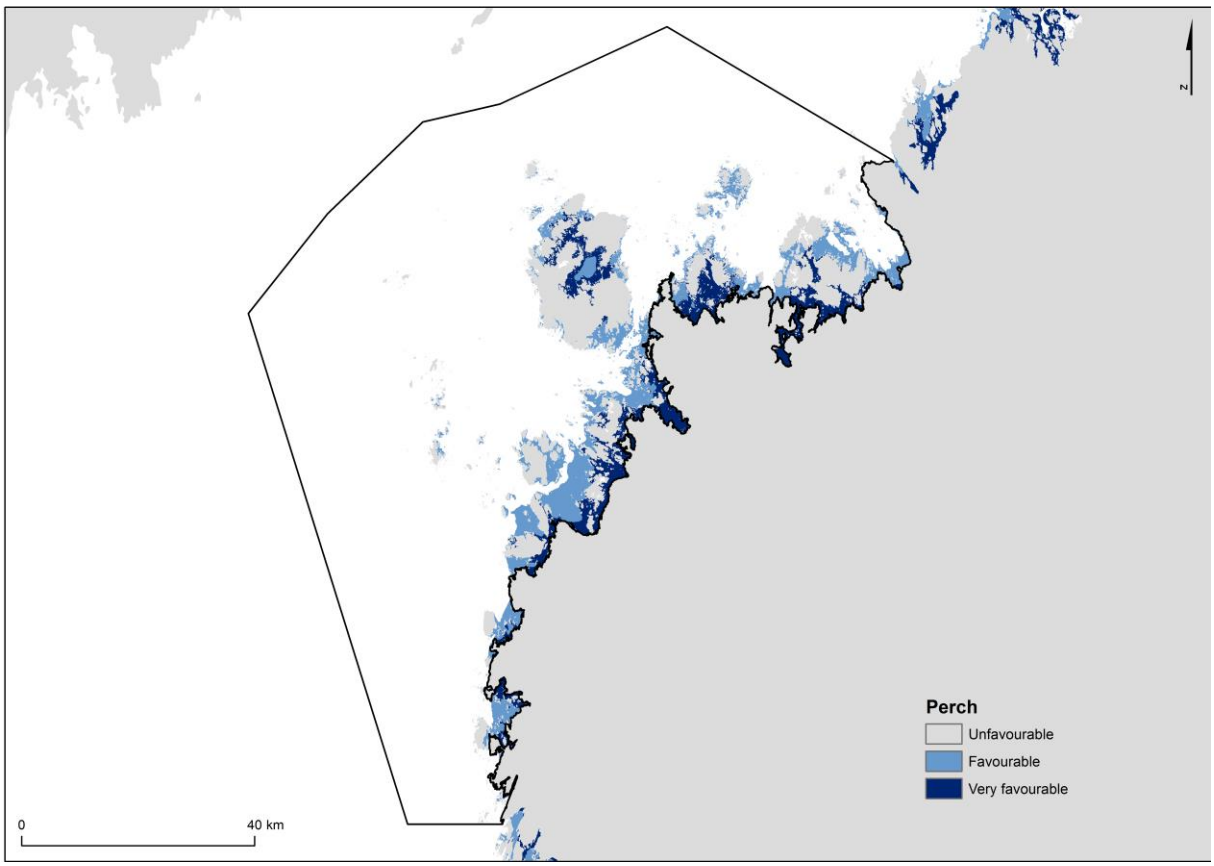

Figure 30. Reproduction area of perch (*Perca fluviatilis*). National Resources Institute Finland & VELMU programme.

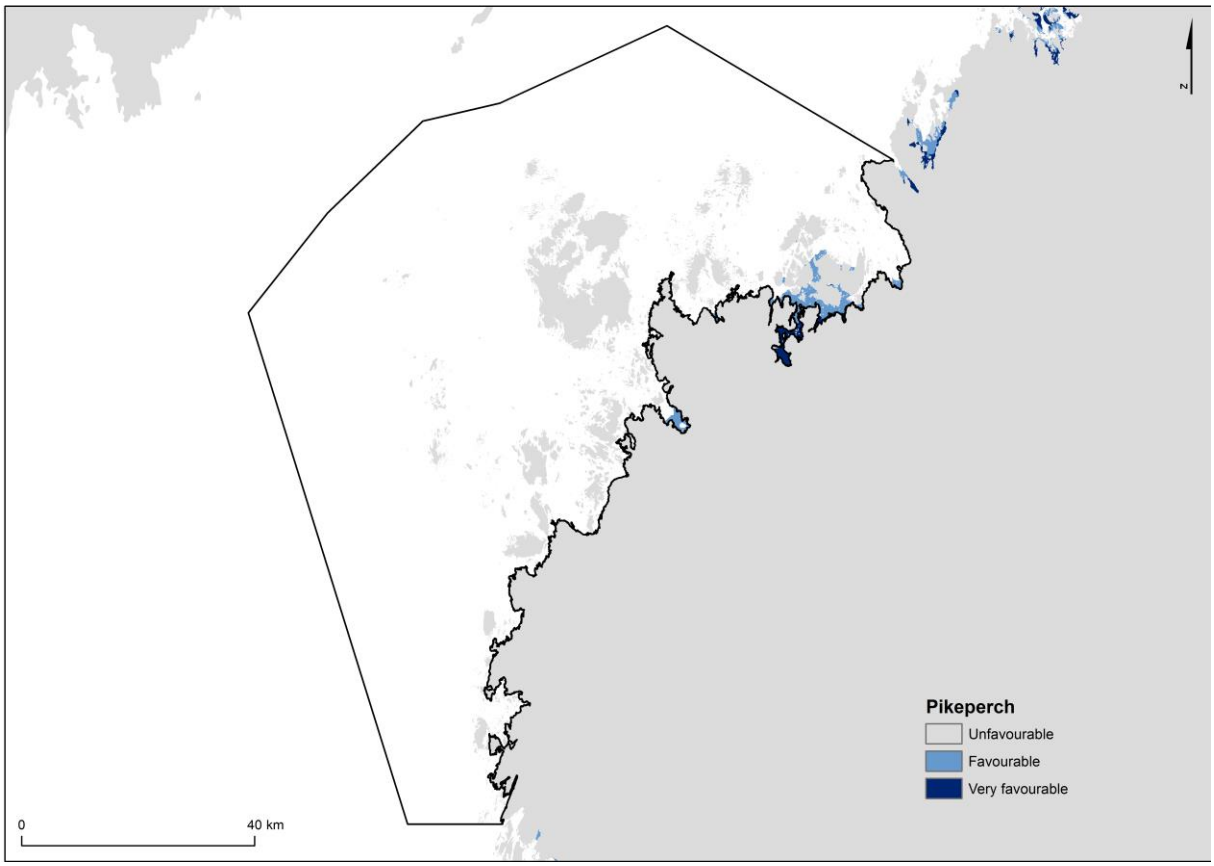

Figure 31. Reproduction area of pikeperch (*Sander lucioperca*). National Resources Institute Finland & VELMU programme.

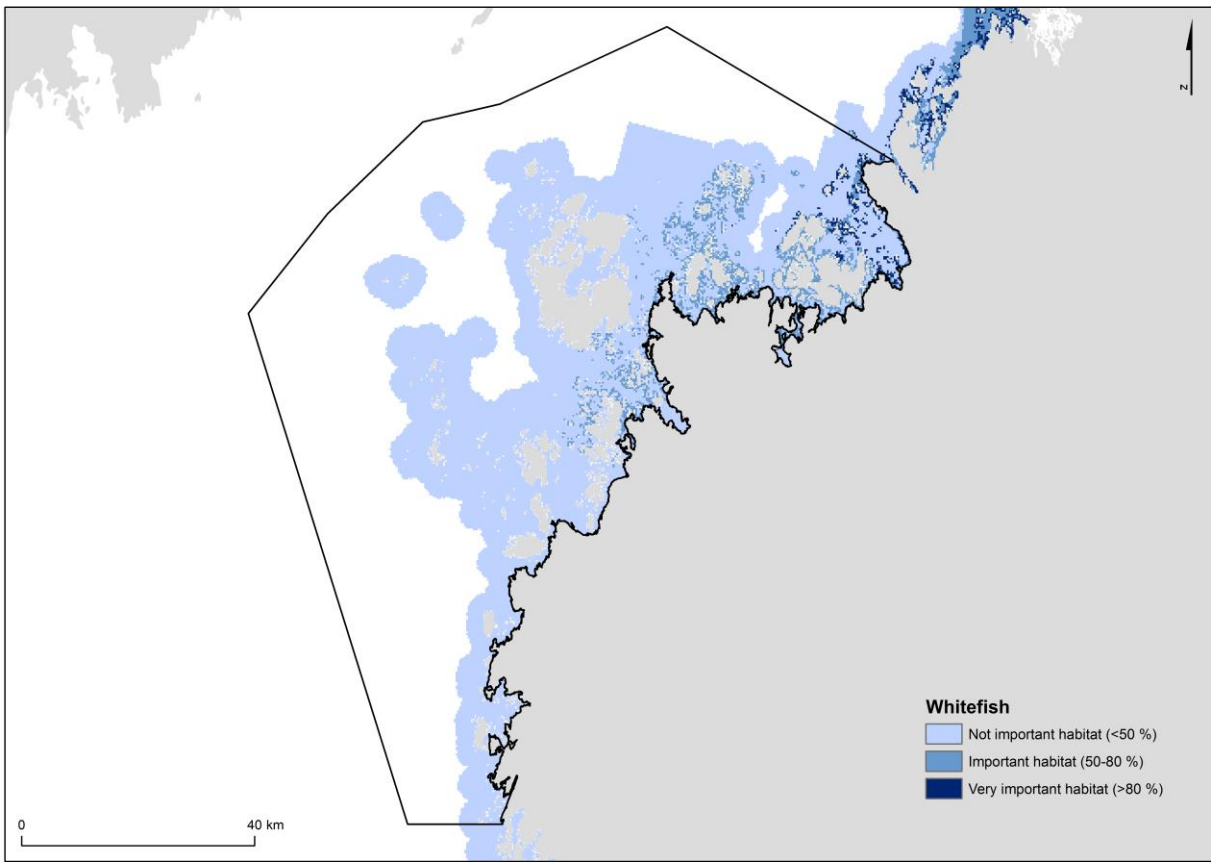

Figure 32. Potential distribution of juvenile whitefish (*Coregonus lavaretus*). National Resources Institute Finland & VELMU programme.

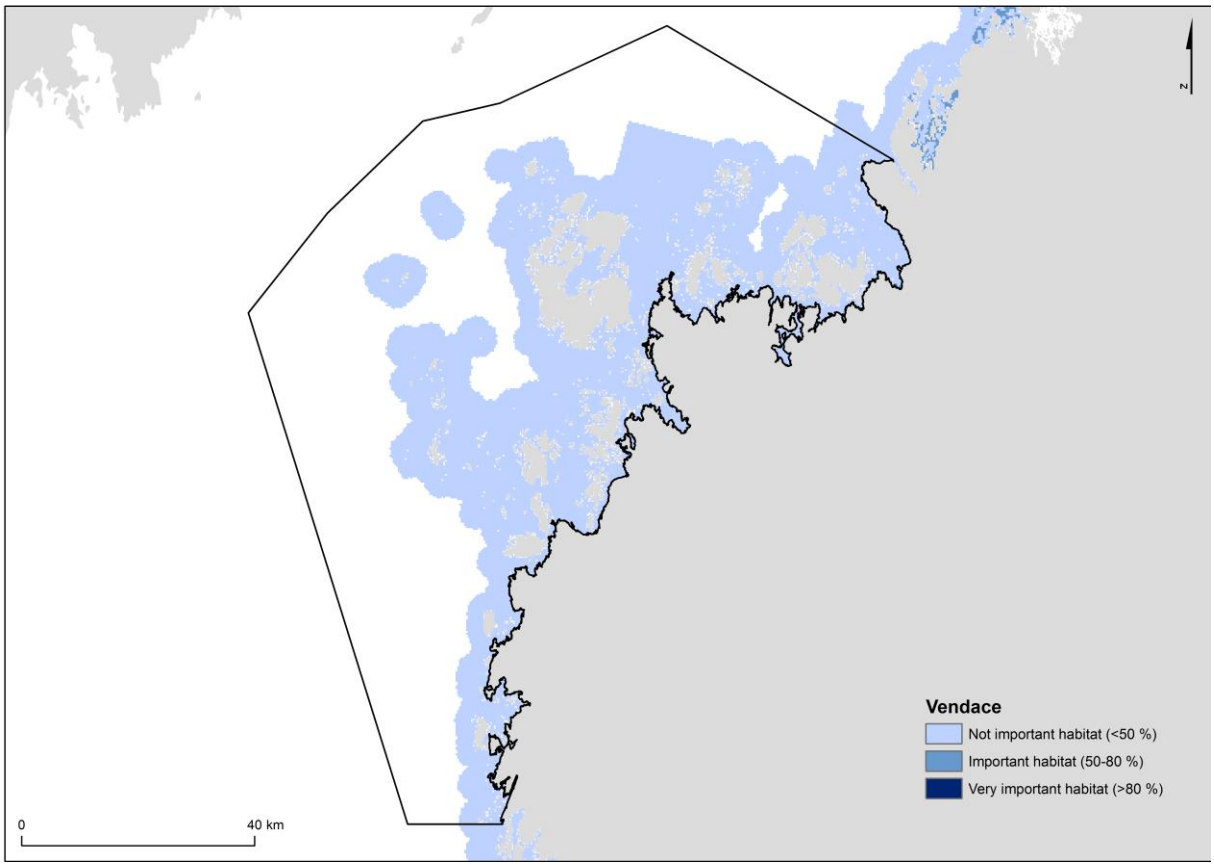

Figure 33. Potential distribution of juvenile vendace (*Coregonus albula*). National Resources Institute Finland & VELMU programme.

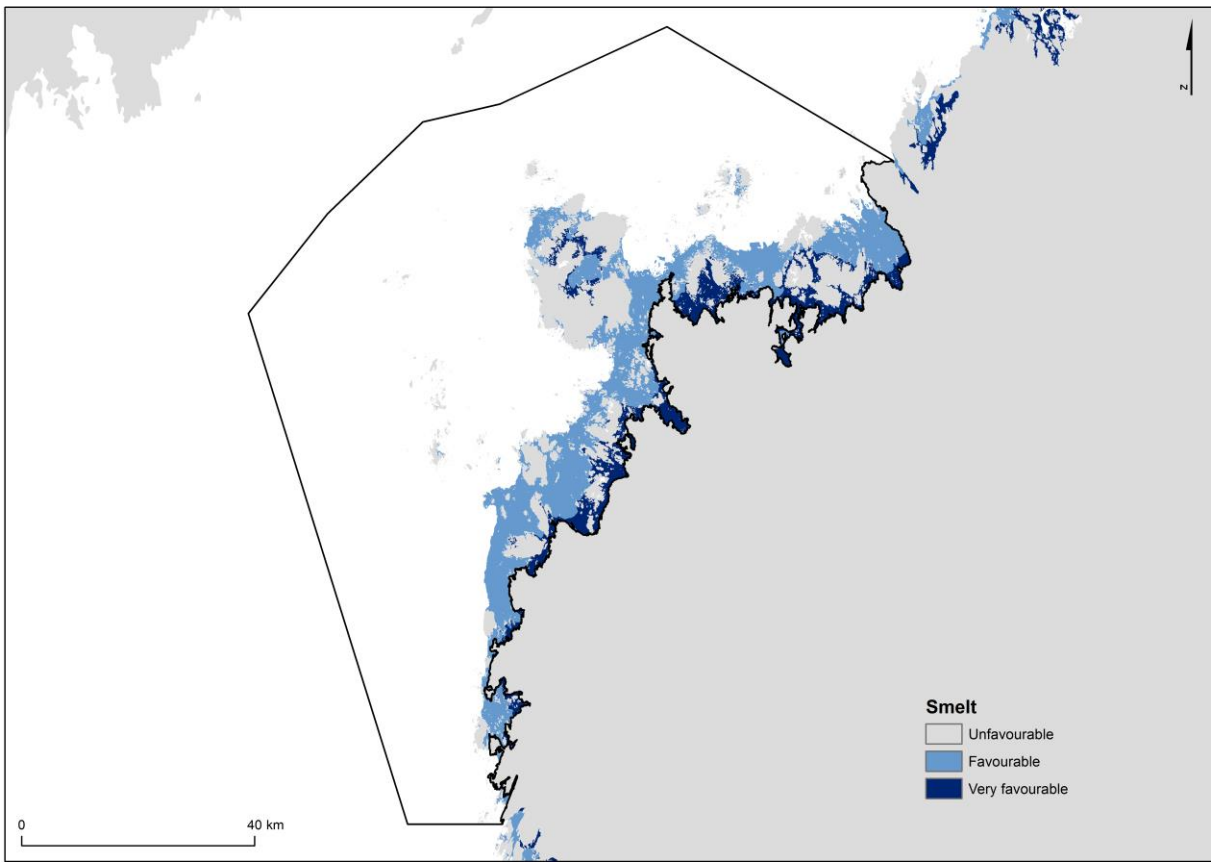

Figure 34. Reproduction area of smelt (*Osmerus eperlanus*). National Resources Institute Finland & VELMU programme.

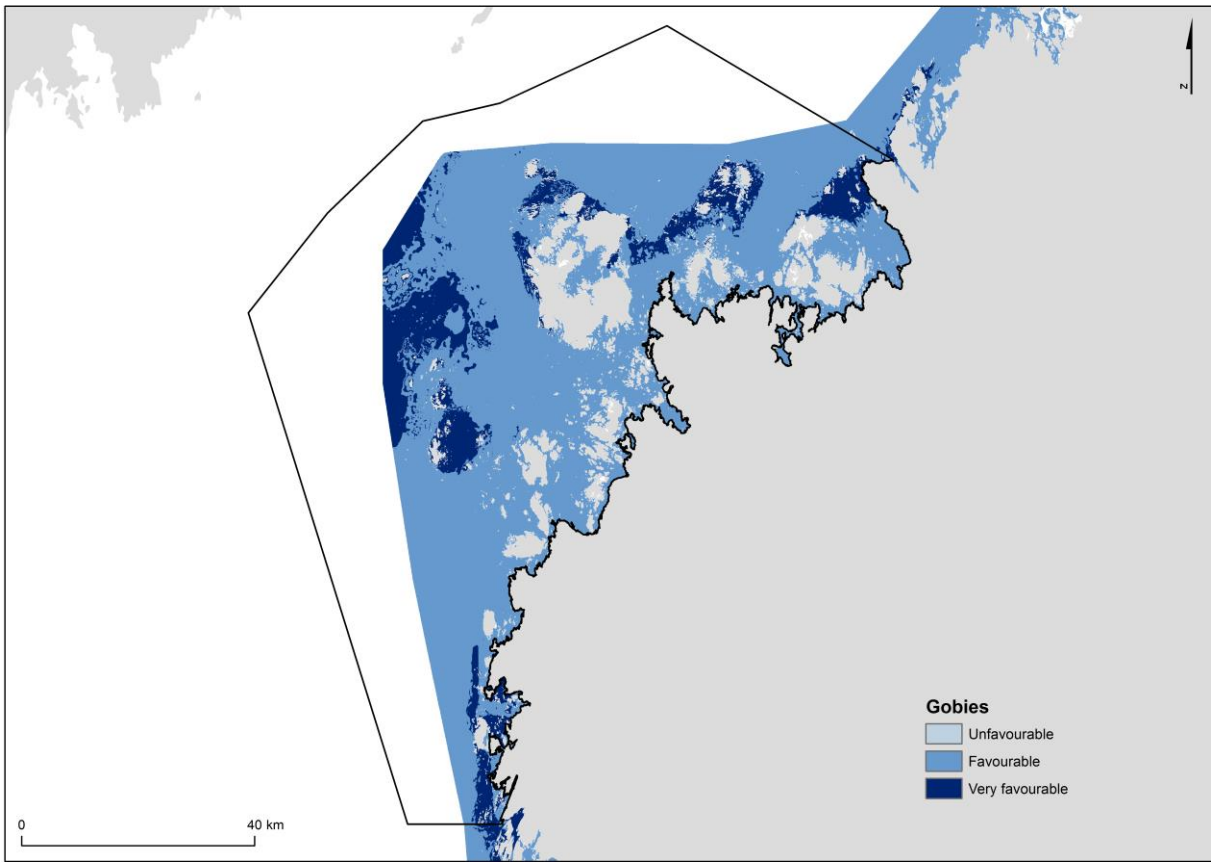

Figure 35. Reproduction area of gobies (Pomatoschistus spp.). National Resources Institute Finland & VELMU programme.

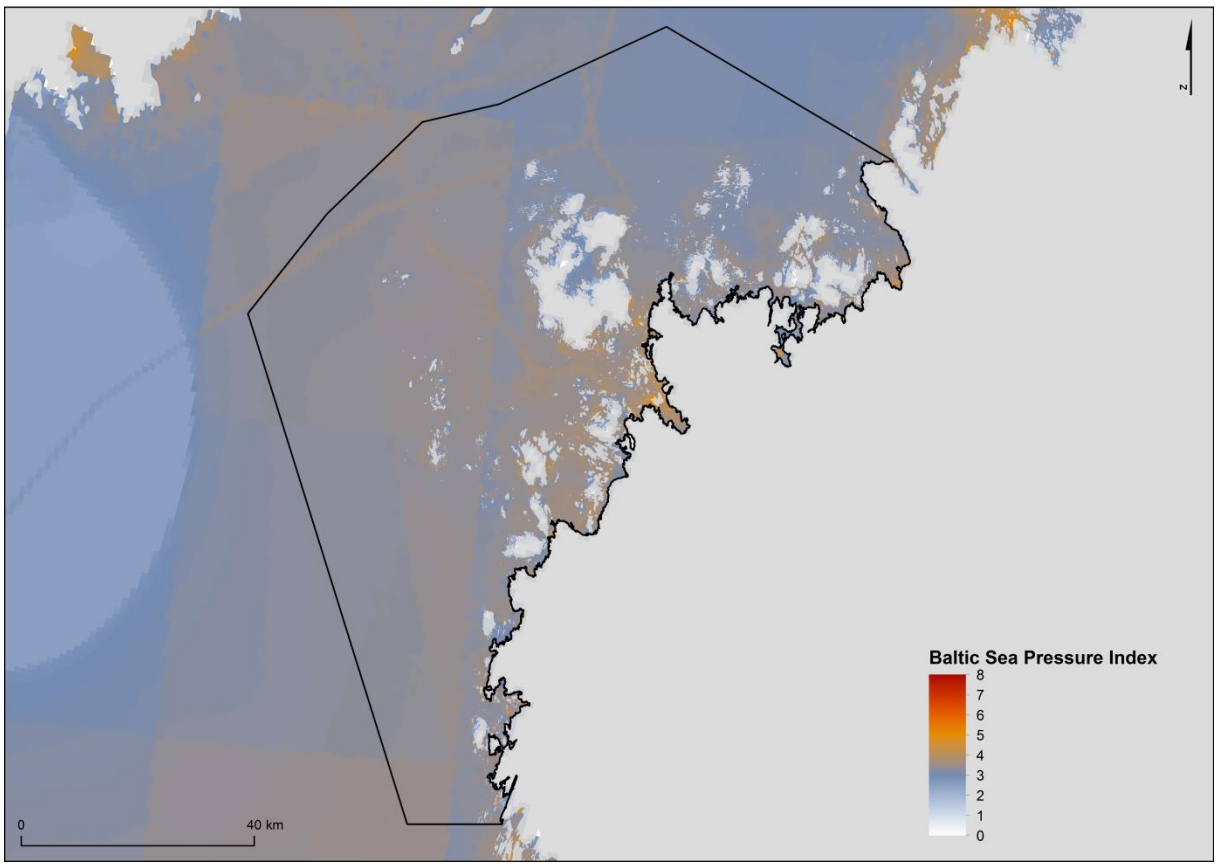

Figure 36. Baltic Sea Pressure Index. HELCOM 2016.

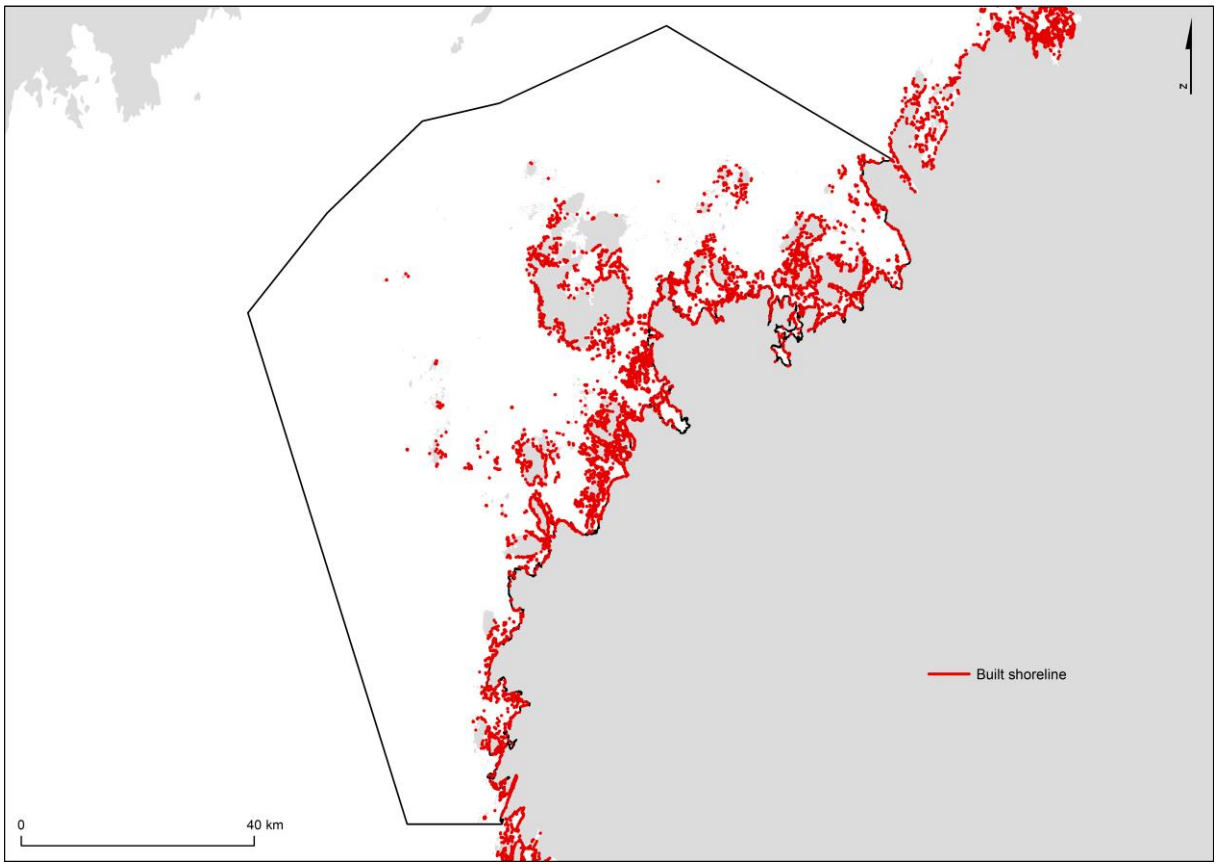

Figure 37. Built shoreline. Data was obtained from Building and Dwelling Register 2016 (BDR) by Population Register Centre. Shoreline having constructions within 100 m buffer zone was classified as built. Finnish Environment Institute.

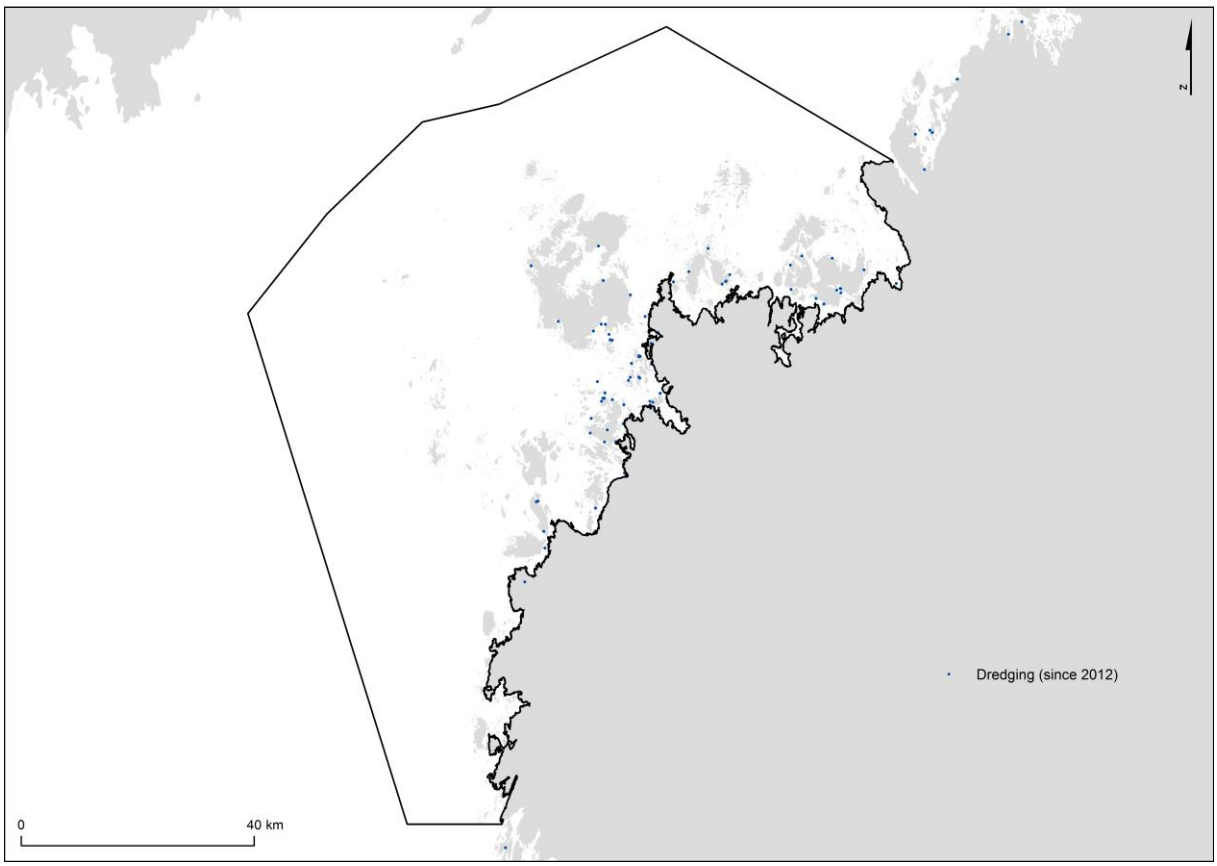

Figure 38. Dredging since 2012.

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