A4.1 Deliverable - Maps showing valuable marine nature in the whole Finland

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Introduction

This deliverable is part of the BIODIVERSEA Action 4: Analysing the sufficiency of the marine protected area network and presents preliminary results of sub-action 4.1. Analysing the ecological sufficiency of the present MPA network.

In 2018, the sufficiency of the Finnish marine protected area network (MPA) was evaluated (Virtanen et al. 2018). The analysis concluded that the performance of the MPA network could be considerably improved with relatively small additions. Under the BIODIVERSEA sub-action 4.1., these analyses have been redone with updated data and new tools, resulting in the identification of ecologically valuable marine areas as a key outcome.

Since 2018, the biological inventory database has grown significantly (see Forsblom et al. 2024), with new data from offshore areas becoming available. Combined with high-resolution satellite bathymetry (Kulha et al. 2024), which enables the creation of more detailed species distribution models, biological models were updated between 2021 and 2023. These updated models were used in this sub-action. Additionally, the development of new threat models (Action 7) has allowed for a more realistic identification of ecologically valuable areas worth conserving.

Data and methods

To identify the most valuable areas, we used the spatial prioritization tool Zonation 5 (Moilanen et al. 2022), developed for conservation and ecologically informed land-use planning. As data inputs we used the new species distribution models developed for algae, vascular plants, water mosses and invertebrates (n=208, Supplementary Table 1) together with threat models (n=23, Supplementary Table 2), which describe in detail coastal infrastructure and land use (e.g. dredging) that have likely contributed to the loss and disturbance of marine habitats. These were available from BIODIVERSEA Action 7 (Virtanen et al. in prep.), developed based on aerial image interpretations and object detection methods (Kuismanen and Husa 2020, Sahla et al. 2020, Mäyrä et al. in review).

Zonation ranks areas based on conservation importance, with values closer to 1 having more importance for conservation, while pixels receiving values close to 0 lower value (e.g. ecologically deteriorated areas). Zonation has in-built meta-algorithm, which orders how cells are removed from the landscape, and sub-algorithms where user can control how pixels are valued and therefore removed from the analyses. We used the Core Area Zonation CAZ2 as marginal loss rule, to emphasize relatively high average coverage of features (Moilanen et al. 2022). We assigned equal positive weights to species and mild negative weights to human activities, with the latter adjusted based on expert judgment regarding the detrimental impact of those activities (Virtanen et al. in prep.).

Results and discussion

A map of valuable marine nature areas is presented in Figure 1. Purple indicates the top 5% of the highest ranked cells, dark orange highlights the top 20%, and light-yellow values closer to 0 with lower importance for marine nature. Most of the important areas are located near the shore in shallow areas, and offshore in reef areas. In general, human activities exert more pressures on marine biodiversity in shallower areas and in coastal areas, while the offshore areas have lower human influence. It should be noted that the analysis lacks information on habitat use of fishes, mammals, and important seabird areas, for which detailed spatial information is not presently available.

These results are used by managers when planning for new conservation actions. Especially in Åland Islands, where the areal protection of the sea is very low (< 4%), these results will be compared to conservation planning analysis made with the Marxan software by (Weckström et al. 2024). The deliverable is also important part of Action C2 that concentrates on the development of strategic roadmap for expanding the Finnish MPA network. Results will also be used in A9; planning for future restoration of underwater habitats and species, which is related to the new restoration law and its implementation. Further, the national restoration plan to be produced in A9.1 strongly benefits from these results.

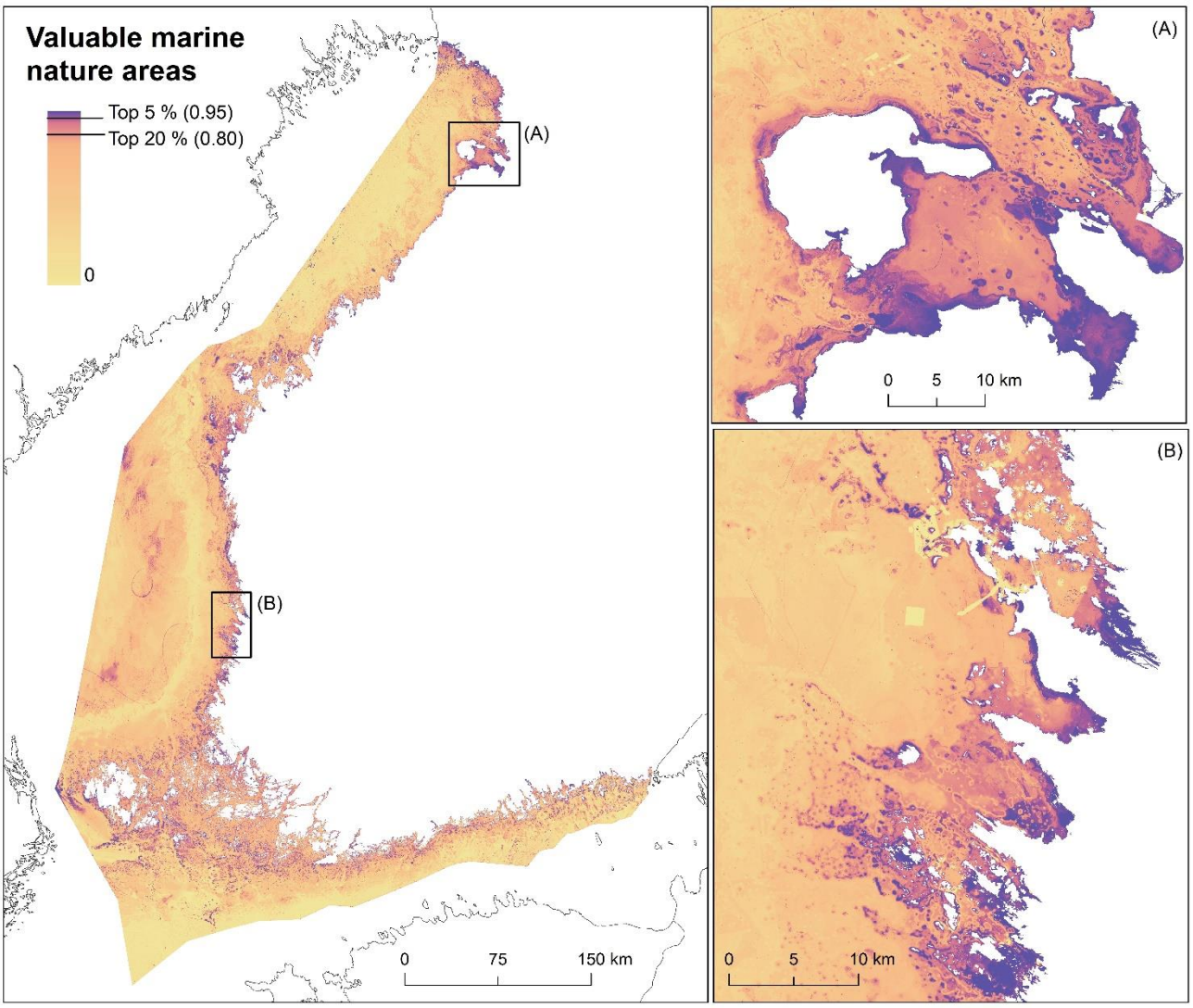

Figure 1. Valuable marine nature areas identified based on the spatial prioritization software Zonation 5. Purple color indicates top 5% of important areas, darker orange top 20% and yellow values close to 0 higher human impact, with less importance for biodiversity. For example, the yellow geometric areas in panel B show lower conservation importance for the Tahkoluoto offshore windfarm area, commercial harbour, dredging area for the shipping lane, as well as for the dedicated area for dumping dredged material.

References

Forsblom, L., E. A. Virtanen, H. Arponen, R. Boman, J. Haapamäki, J. Hoikkala, N. Kallio, V.-J. Karvinen, A. Kaskela, and E. Keskinen. 2024. Finnish inventory data of underwater marine biodiversity. Scientific data **11**:1297.

Kuismanen, L., and S. Husa. 2020. Coastal human activity on the Åland Islands interpreted using aerial photographs. Marine Research Centre, Finnish Environment Institute, Helsinki, Finland and ….

Kulha, N., L. Ruha, S. Väkevä, S. Koponen, M. Viitasalo, and E. A. Virtanen. 2024. Satellite bathymetry estimation in the optically complex northern Baltic Sea. Estuarine, Coastal and Shelf Science **298**:108634.

Moilanen, A., P. Lehtinen, I. Kohonen, J. Jalkanen, E. A. Virtanen, and H. Kujala. 2022. Novel methods for spatial prioritization with applications in conservation, land use planning and ecological impact avoidance. Methods in Ecology and Evolution **13**:1062-1072.

Mäyrä, J., E. Virtanen, A.-P. Jokinen, J. Koskikala, S. Väkevä, and J. Attila. in review. Mapping Recreational Marine Traffic from Sentinel-2 Imagery with Yolov8. Available at SSRN 4827287.

Sahla, M., T. Turkia, A. Nieminen, T. Räsänen, J. Haapamäki, J. Hoikkala, F. Suominen, and J. Kantanen. 2020. Ilmakuvakartoitus ihmispaineista Suomen rannikon merialueilla. Meriluonnonsuojelu, Luontopalvelut, Metsähallitus. URL: https://ckan.ymparisto. fi/dataset/ihmispaineiden-ilmakuvakartoitus-suomen-ja-ahvenanmaanrannikon-merialueilla.

Virtanen. et al. in prep. Impacts of human activities on benthic biodiversity for marine conservation and management in Finland.

Virtanen, E. A., M. Viitasalo, J. Lappalainen, and A. Moilanen. 2018. Evaluation, gap analysis, and potential expansion of the Finnish marine protected area network. Frontiers in Marine Science **5**:402.

Weckström, K., H. Rinne, M. Häggblom, and S. Salovius-Laurén. 2024. Rapport no 169: Marine inventories to support ecosystem-based management and the expansion of the MPA network in the Åland Islands–Final report of the ÅlandSeaMap project (2019–2023).

Supplementary Table 1. Species included in the analysis.

Acrosiphonia arcta	Lysimachia thyrsiflora
Aegagropila linnaei	Macroplea pubipennis
Aglaothamnion roseum	Manayunkia aestuarina
Alderia modesta	Marenzelleria
Alisma plantagoaquatica	Monoporeia affinis
Alisma wahlenbergii	Monostroma balticum
Amphibalanus improvisus	Monostroma grevillei
Anodonta anatina	Mya arenaria
Audouinella	Myriophyllum alterniflorum
Bacillariophyta	Myriophyllum sibiricum
Bangia atropurpurea	Myriophyllum spicatum
Batrachospermum	Myriophyllum verticillatum
Battersia arctica	Mytilopsis leucophaeata
Beggiatoa	Mytilus trossulus
Bithynia tentaculata	Najas marina
Boccardiella ligerica	Najas tenuissima
Bolboschoenus maritimus	Neomysis integer
Bryophyta	Nitella flexilis
Butomus umbellatus	Nitella hyalina
Bylgides sarsi	Nitella wahlbergiana

Callitriche cophocarpa	Nitellopsis obtusa
Callitriche hamulata	Non-attached form of Fucus
Callitriche hermaphroditica	Nupha rlutea
Callitriche palustris	Nymphaea alba
Caltha palustris	Oligochaeta
Capsosiphon fulvescens	Osmerus eperlanus reproduction area
Ceramium tenuicorne	Oxyrrhynchium speciosum
Ceramium virgatum	Perca fluviatilis reproduction area
Cerastoderma parvicardium	Percursaria percursa
Ceratophyllum demersum	Peringa Ecrobia
Ceratophyllum submersum	Persicaria foliosa
Chara aspera	Phragmites australis
Chara baltica	Pisidium sphaerium
Chara braunii	Planorbidae
Chara canescens	Polyides rotunda
Chara connivens	Polysiphonia
Chara globularis	Polysiphonia fibrillosa
Chara horrida	Polysiphonia fucoides
Chara tomentosa	Polysiphonia stricta
Chara virgata	Pontoporeia femorata
Chironomidae	Potamogeton alpinus
Chorda filum	Potamogeton berchtoldii
Cladophora fracta	Potamogeton compressus
Cladophora glomerata	Potamogeton crispus
Cladophorarupestris	Potamogeton friesii
Coccotylus truncatus or Phyllophora pseudoceranoides	Potamogeton gramineus
Corophium volutator	Potamogeton lucens
Crassula aquatica	Potamogeton natans
Cyanophthalma obscura	Potamogeton obtusifolius
Dictyosiphon chordaria	Potamogeton perfoliatus
Dictyosiphon foeniculaceus	Potamogeton praelongus
Dreissena polymorpha	Potamogeton pusillus
Drepanocladus aduncus	Potamogeton x nitens
Drepanocladus sordidus	Potamopyrgus antipodarum
Ectocarpus siliculosus	Protohalopteris radicans
Einhornia crustulenta	Pseudolithoderma
Elachista fucicola	Pygospio elegans
Elatine hydropiper	Pylaiella littoralis
Elatine orthosperma	Ranunculus baudotii
Elatine triandra	Ranunculus circinatus
Eleocharis acicularis	Ranunculus confervoides
Eleocharis mamillata	Ranunculus reptans
Eleocharis palustris	Ranunculus schmalhausenii
Eleocharis parvula	Rhithropanopeus harrisii
Eleocharis uniglumis	Rhizoclonium

Ephydatia fluviatilis	Rhodochorton purpureum
Equisetum fluviatile	Rhodomela confervoides
Eudesme virescens	Rivularia
Fabricia stellaris	Ruppia maritima
Fissidens fontanus	Ruppia spiralis
Fontinalis antipyretica	Saduria entomon
Fontinalis dalecarlica	Sagittaria sagittifolia
Fontinalis hypnoides	Sagittaria x lunata
Fucus	Sander lucioperca reproduction area
Furcellaria lumbricalis	Schoenoplectus lacustris
Gammarus oceanicus	Schoenoplectus tabernaemontani
Gammarus salinus	Scytosiphon lomentaria
Gammarus zaddachi	Sparganium emersum
Gonothyraea loveni	Sphacelaria
Grania efflorescens	Spirogyra
Halicryptus spinulosus	Spirulina
Halosiphon tomentosus	Spongomorpha aeruginosa
Hediste diversicolor	Stictyosiphon tortilis
Hilden brandia	Stuckenia filiformis
Hippuris tetraphylla	Stuckenia pectinata
Hippuris vulgaris	Stuckenia vaginata
Hydra	Stuckenia x suecica
Hydrobiidae	Subularia aquatica
Hydrozoa	Theodoxusfluviatilis
Idotea balthica	Tolypella
Idotea chelipes	Triglochin maritima
Isoetes echinospora	Turbellaria
Isoetes lacustris	Typha latifolia
Jaera albifrons	Ulothrix
Jaera praehirsuta	Ulva
Leathesia marina	Utricularia
Lemna minor	Valvatidae
Lemna trisulca	Vaucheria
Leptocheirus pilosus	Zannichellia major
Limapontia capitata	Zannichellia palustris
Limecola balthica	Zannichellia palustris var palustris
Limosella aquatica	Zannichellia palustris var pedicellata
Lymnaeidae	Zostera marina
Lysimachia maritima	Zygnema sp

Supplementary Table 2. Human activities and pressures used in the analysis.

Anchoring areas
Areas reserved for dumping of dredged materials
Breakwaters with two size classes
Bridges and causeways
Built, artificial shores
Coastal infrastructure
Commercial harbors
Dredging footprints with three size classes
Dredging of shipping lanes
Extraction areas for marine minerals
Jetties with two size classes
Marinas
Offshore windfarms
Underwater cables with three different cable types