Strengthening ecosystem-based approach in MSP and supporting sustainable blue economy
Helsinki, Finland, 13-15 June 2023

Balancing the use of the marine space

-nature-inclusive design for offshore wind farms now and in the future

Katriina Juva, Elina Virtanen, Louise Forsblom, Niko Kallio, Lauri Kuismanen, Marco Nurmi

Elina Virtanen/ SYKE

Developing offshore wind power in Finland (MeriTV)

BIODIVERSEA

VELMU
The Finnish Inventory Programme for Underwater Marine Diversity

Future MARES

Suomen ympäristökeskus
Finlands miljöcentral
Finnish Environment Institute

Renewable and Sustainable Energy Reviews
Volume 158, April 2022, 112087

Balancing profitability of energy production, societal impacts and biodiversity in offshore wind farm design

E.A. Virtanen [a b], J. Lappalainen [a], M. Nurmi [a], M. Viitasalo [a], M. Tikanmäki [c], J. Heinonen [c], E. Atlaskin [d], M. Kallasvuo [e], H. Tikkanen [f g], A. Moilanen [b h]

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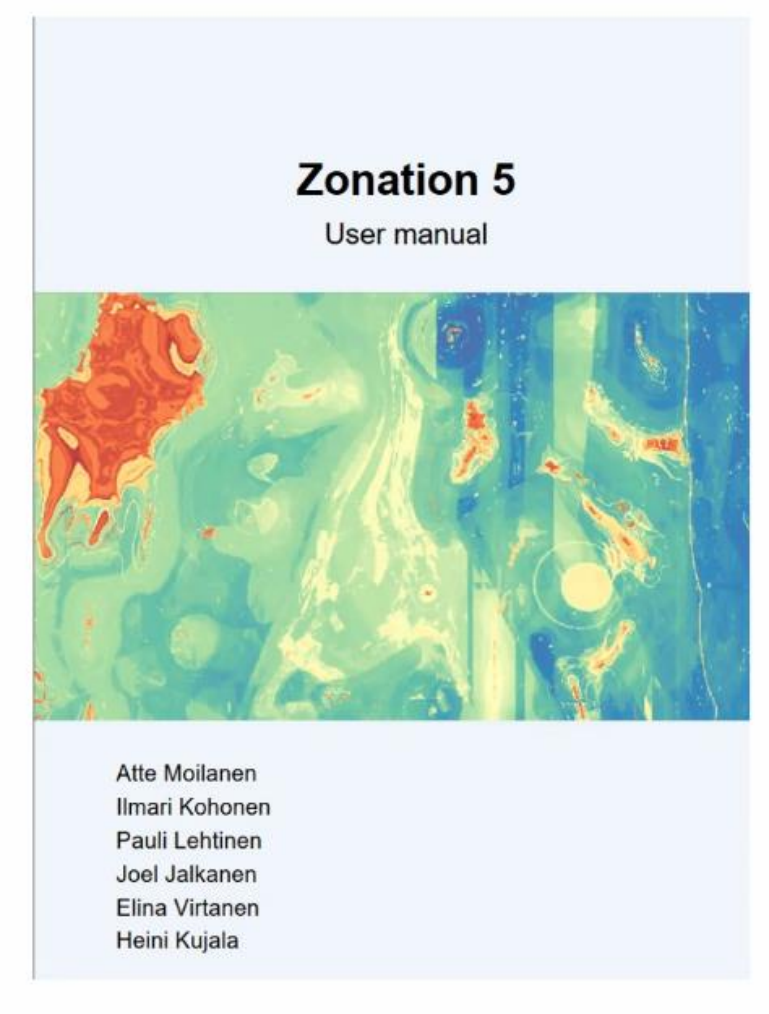
Zonation



Decision support-tool for ecologically based land use planning

Moilanen et al. 2022,
check Zonation 5 (zonationteam.github.io)

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Environment

Restrictions

Where to locate OWFs?

Societal impacts

Economic Profitability

Enablers

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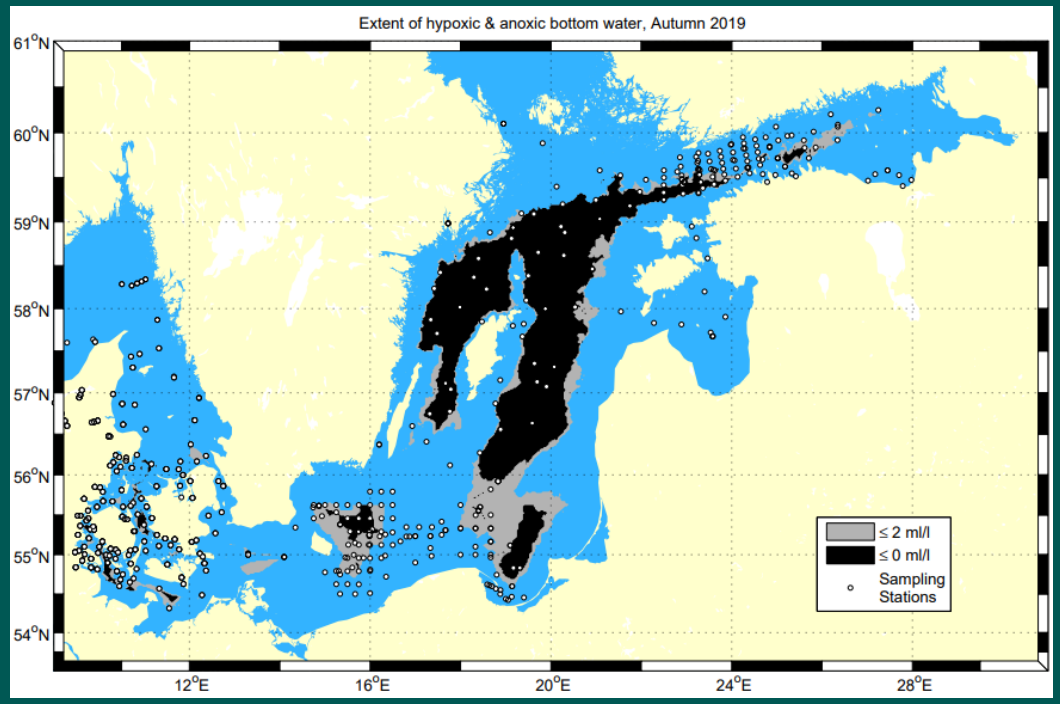
Enablers

- Proximity of industrial areas
  - spoilt landscapes
- Persistently anoxic areas
  - no ecological potential

→3 layers

Hypoxic and anoxic areas in 2019



SMHI, Oxygen Survey in the Baltic Sea 2019

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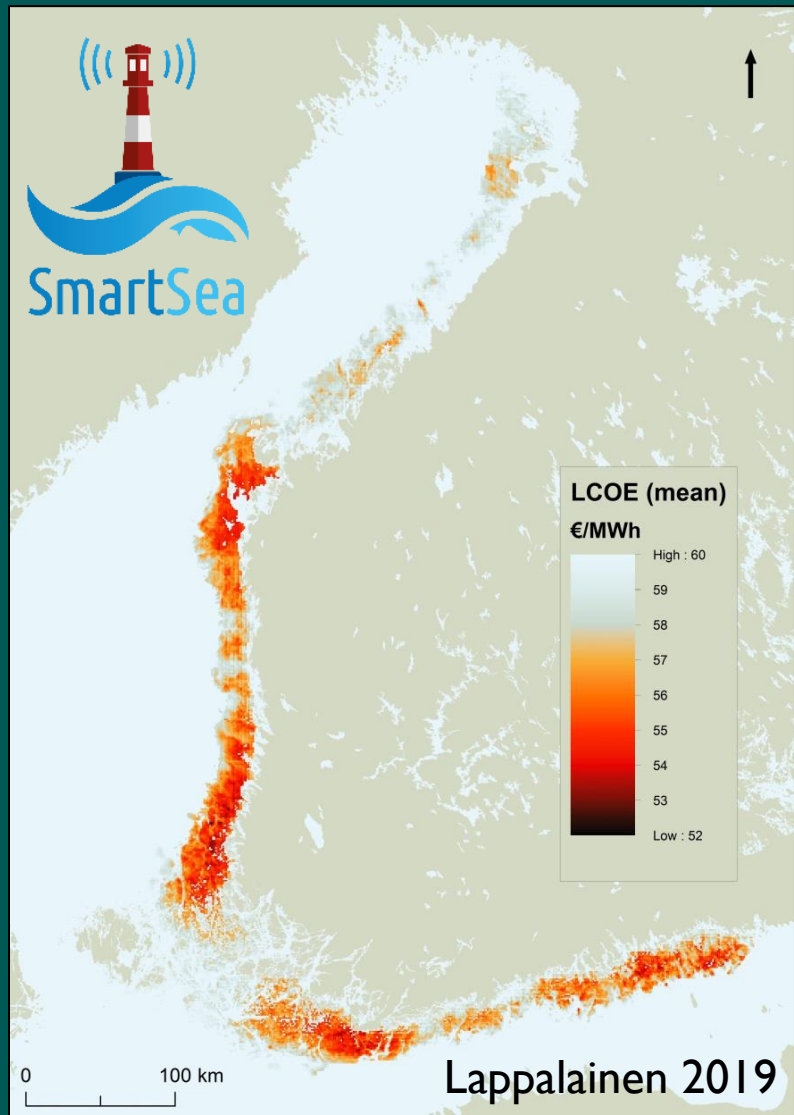
Profitability

- Spatial Life Cycle Cost analysis
  - Includes all costs during the project lifetime

→5 layers

Spatial nature of costs: where affordable to produce offshore energy?

Economically profitable areas for wind power

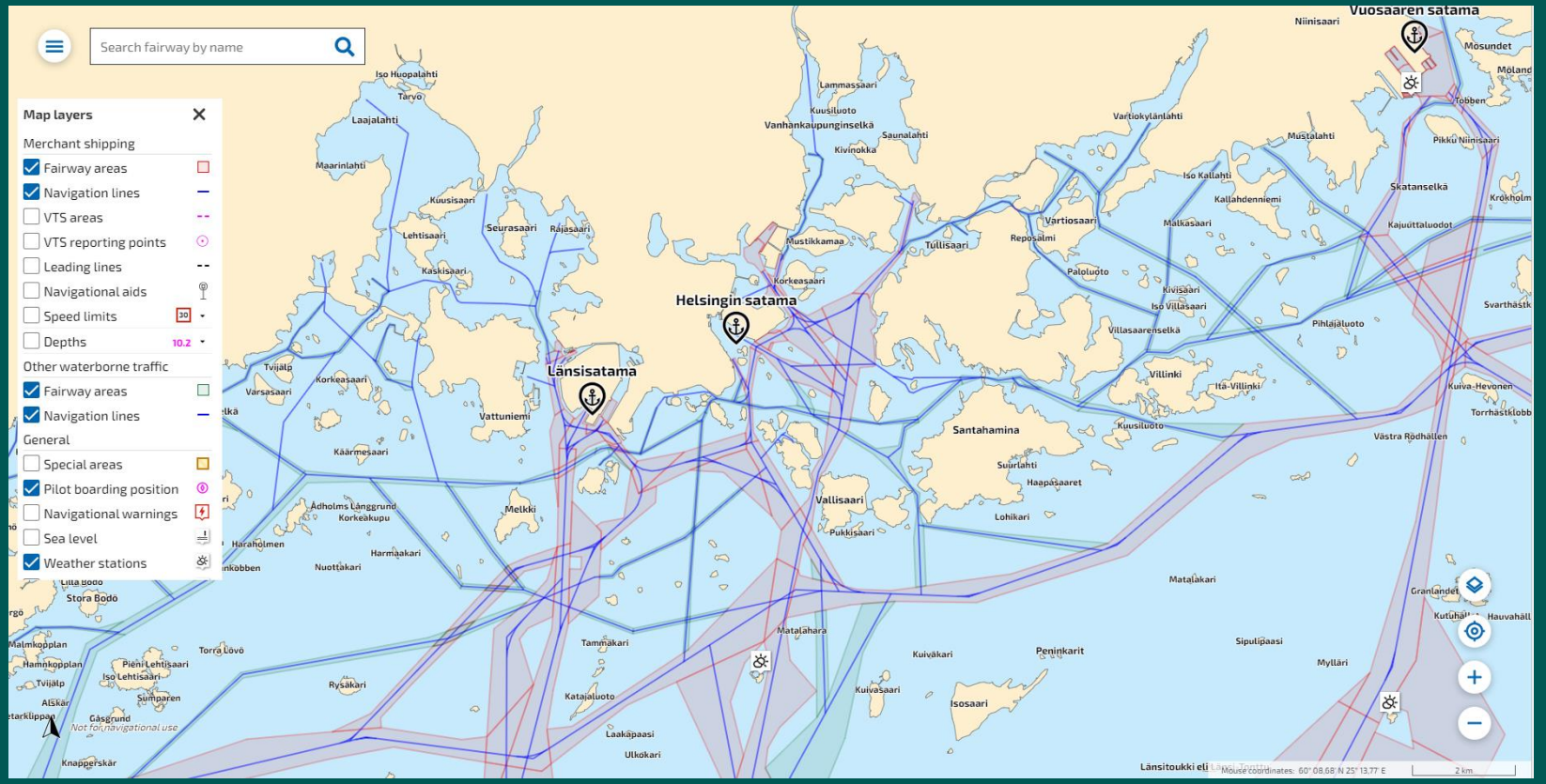


Restrictions

- Army areas
- Conservation areas
- Shipping lanes
- Anchoring areas
- Weather radars

→16 layers

Shipping lanes around Helsinki archipelago



Digital Fairway Card (vaylapilvi.fi)

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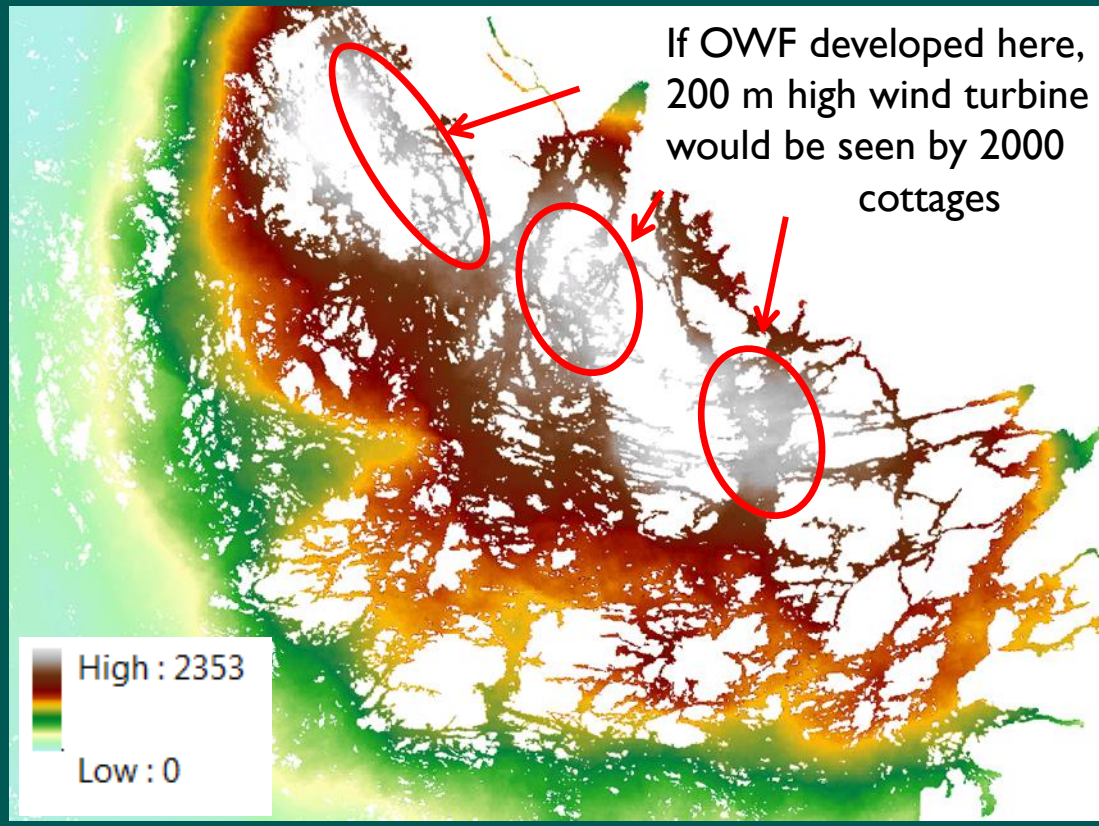
Societal impacts

- Visual and noise impacts
- Livelihoods, e.g.
  - Commercial fishing
  - Aquaculture
  - Coastal fishing areas
- → 25 layers

Where would OWF be seen?

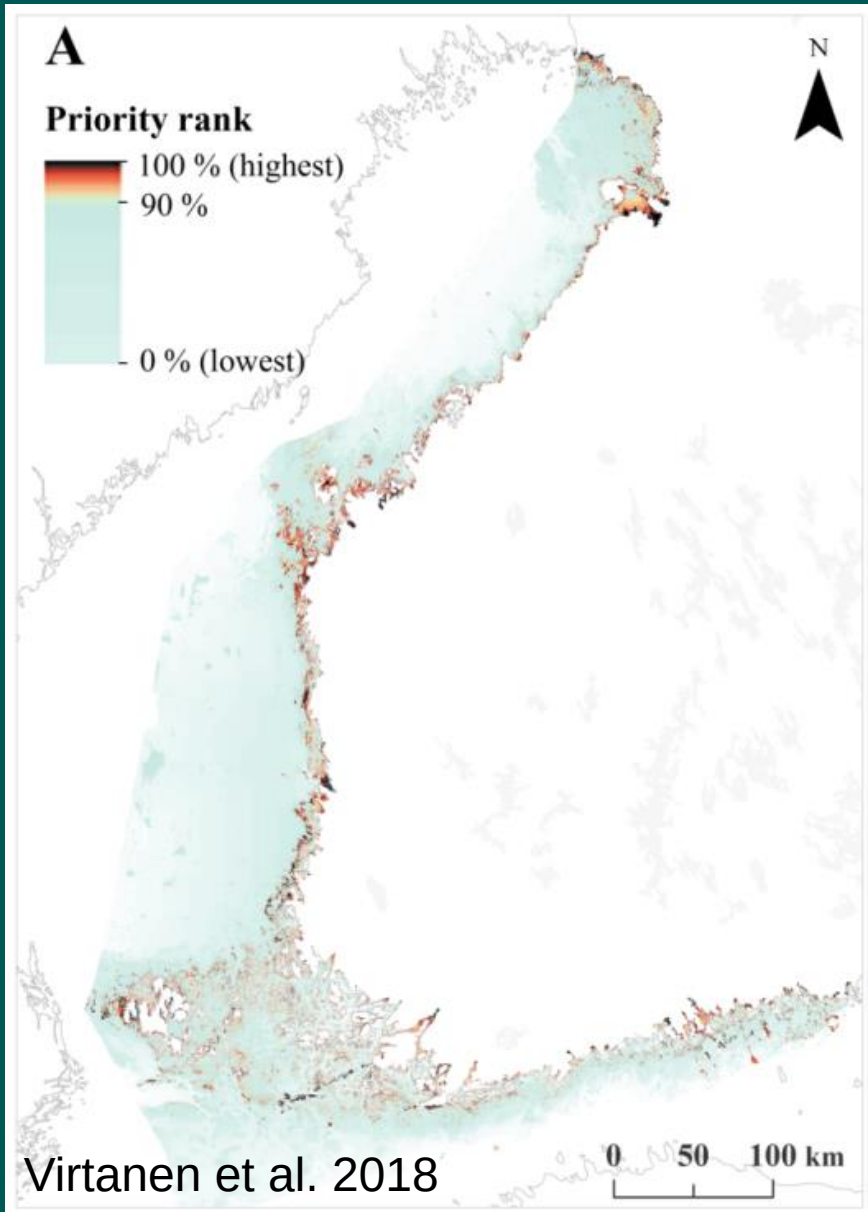


Environment

- Key habitats and threatened species
- EU Habitats Directive habitat types
- Threatened habitat types
- Geologically important areas
- Fish reproduction areas
- Bird migration routes
- Important areas for eagles and seals

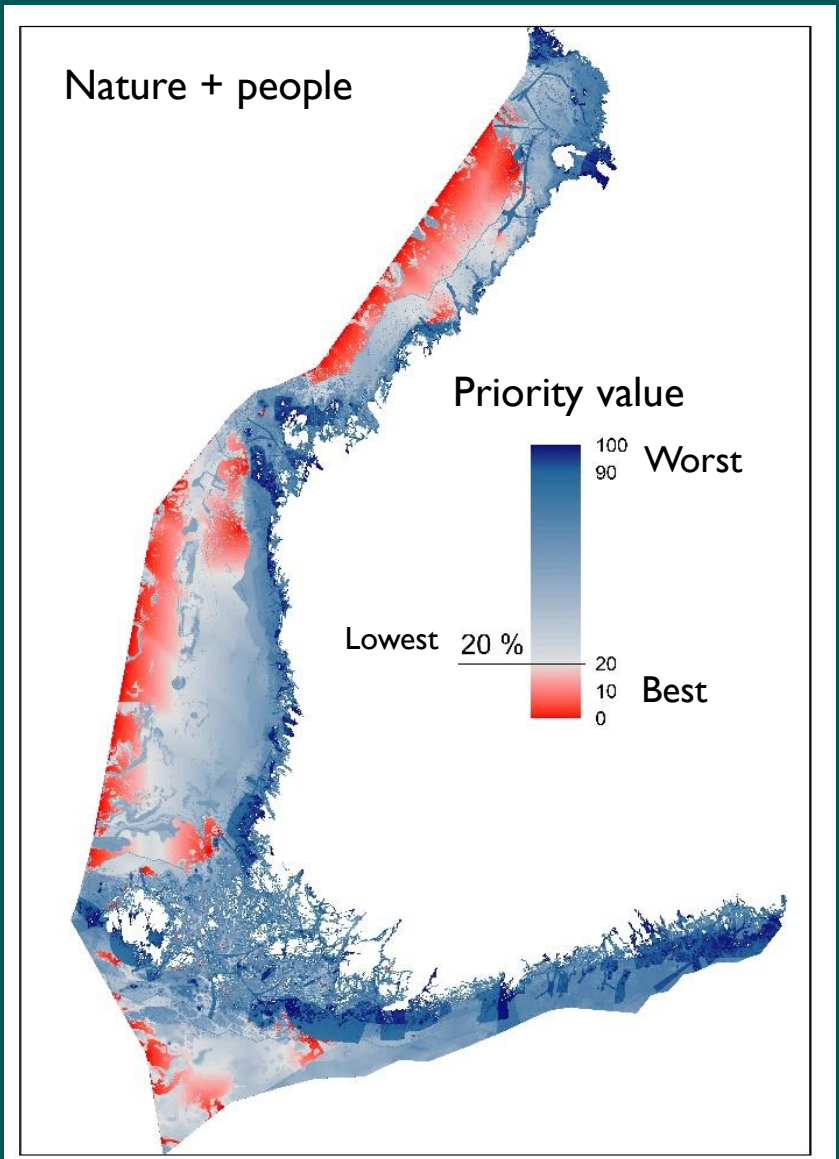
→ 122 layers

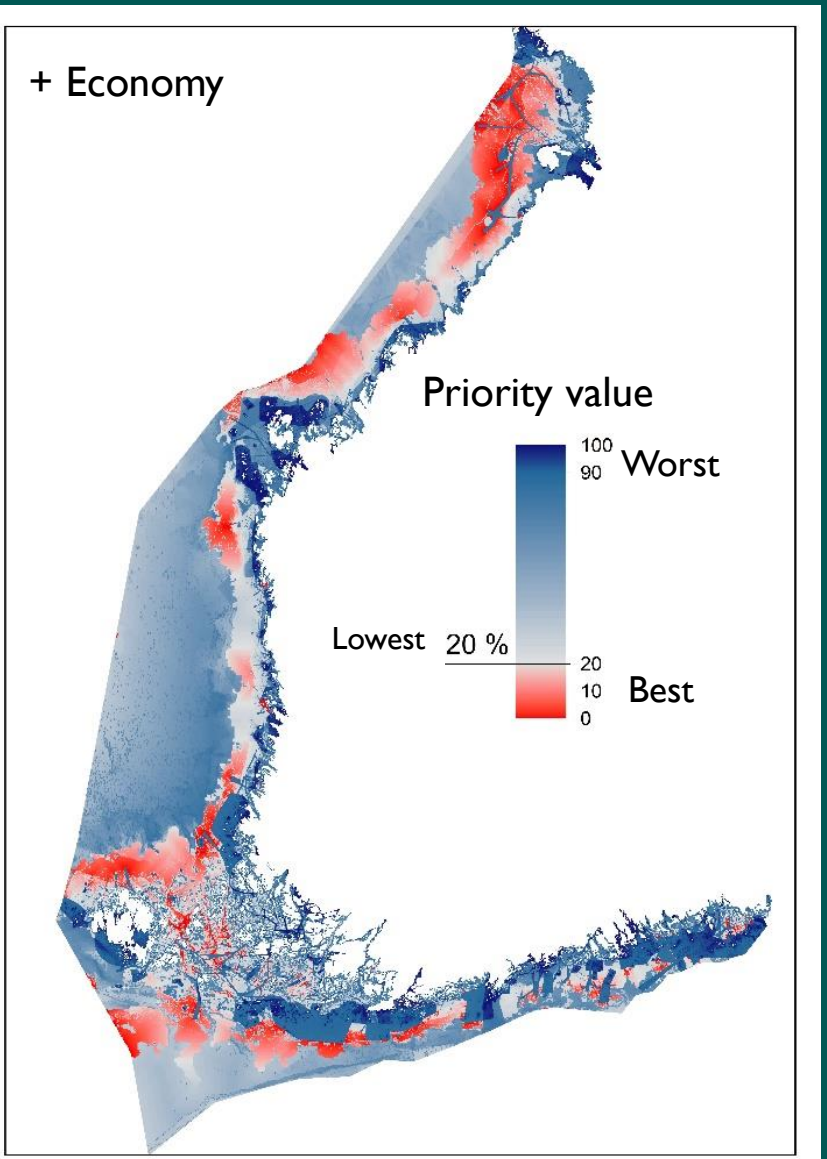
Locations of the nature values



Virtanen et al. 2018

Optimal areas for offshore wind farms





Most potential areas located in the Bothnian Sea and Bothnian Bay

Virtanen et al. 2022

Update of the work is ongoing

What is new

- Updates for existing datasets

(e.g. geological data has changed drasticly)

- New biodiversity layers (underwater nature + important bird areas)
- Ecosystem services

(provisioning, regulation & maintenance, cultural ES)

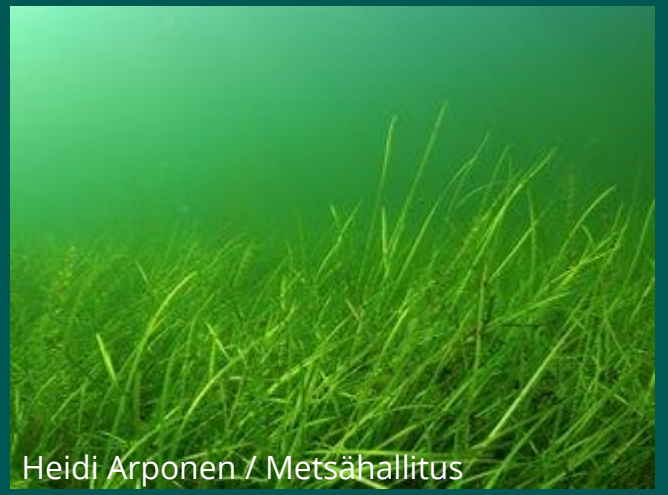
- Climate change


Jamina Vasama / Metsähallitus

Analysis integrates 30 by 30 target

- Potential conservation area expansion candidates excluded

  → Impacts of offshore windfarms avoided


Heidi Arponen / Metsähallitus

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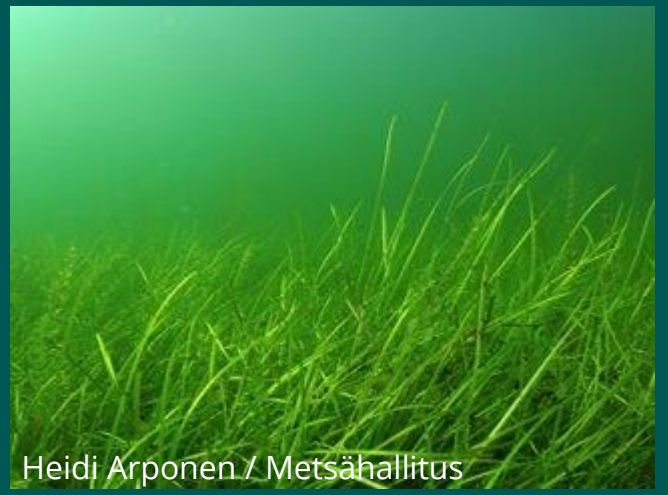
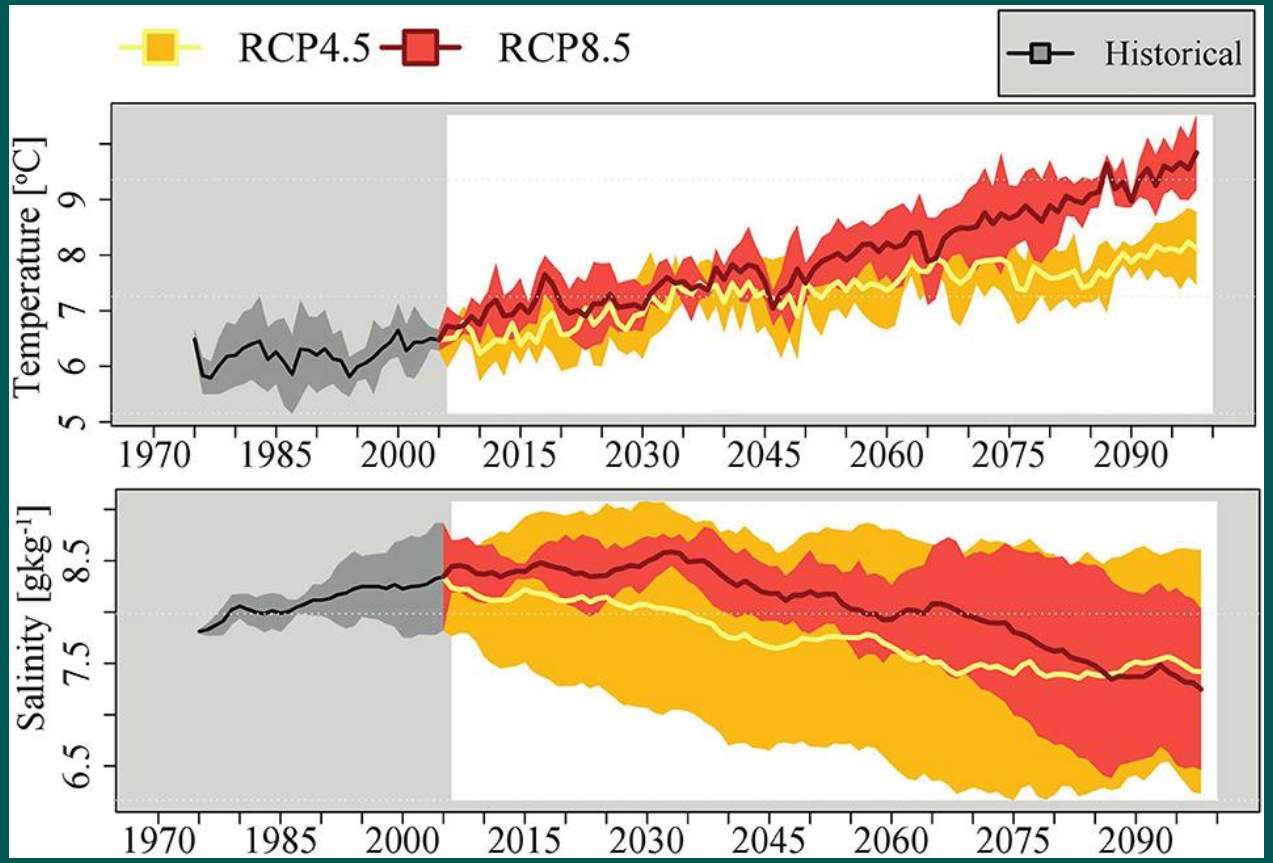
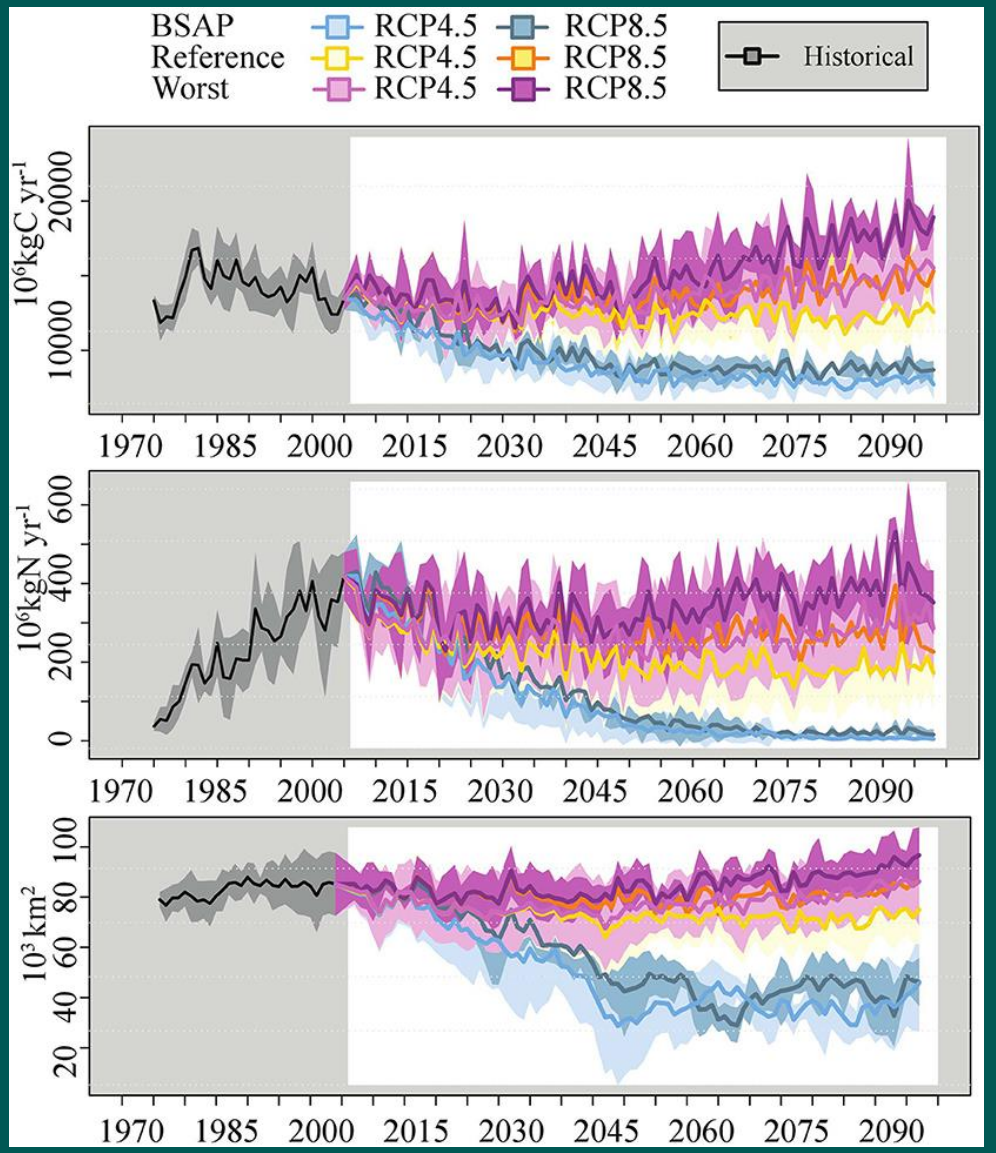

Heidi Arponen / Metsähallitus

The future pathways

The predicted temperature, salinity and nutrients





Meier et al. (2021), doi.: 10.1038/s43247-021-00115-9
Saraiva et al (2019) doi: 10.3389/feart.2018.00244

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The future pathways

RCO-Scobi Regional Ocean Model	One physical-biogeochemical Baltic Sea
GCMs	AR5
Earth System Models (ESMs)	MPI-ESM-LR, EC-Earth, IPSL-CM5A-MR, HadGEM2-ES
Greenhouse Gas Scenarios	Medium (RCP 4.5)-high (RCP 8.5)
Sea level rise	Low-mean-high
Nutrient load scenarios (SSPs)	BSAP-reference-worst
RCSM	RCA4-NEMO
Horizontal and vertical resolution	3.6 km and 3 m

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Climate change hotspots and refugias

Used environmental variables for surface (1.5 m) and bottom

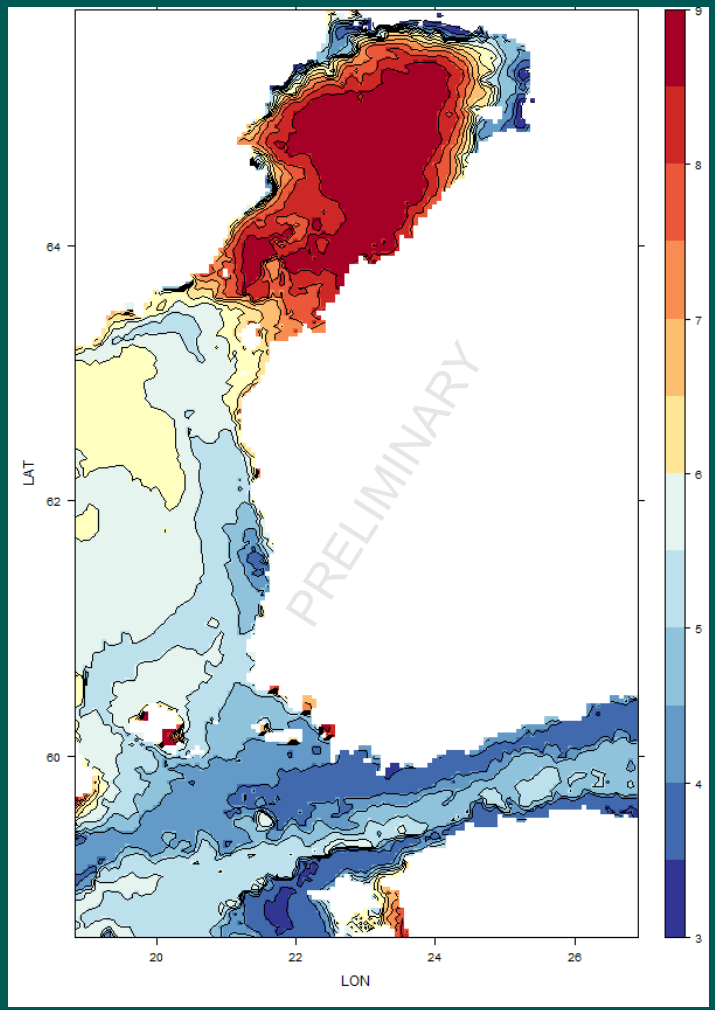
- Annual temperature
- Annual salinity
- Annual oxygen
- Annual phosphorus
- Annual nitrogen
- Annual Chlorophyll-a

Method used

- Standardized euclidean distance (SDE)

$$\mathrm{SED_i} = \sqrt{\sum_{k=1}^{n} \frac{(h_{ki} - f_{ki})^2}{sh_{ki}}}$$

Local environmental change by 2090-2100 compared to baseline 2005-2015



With species and substrate

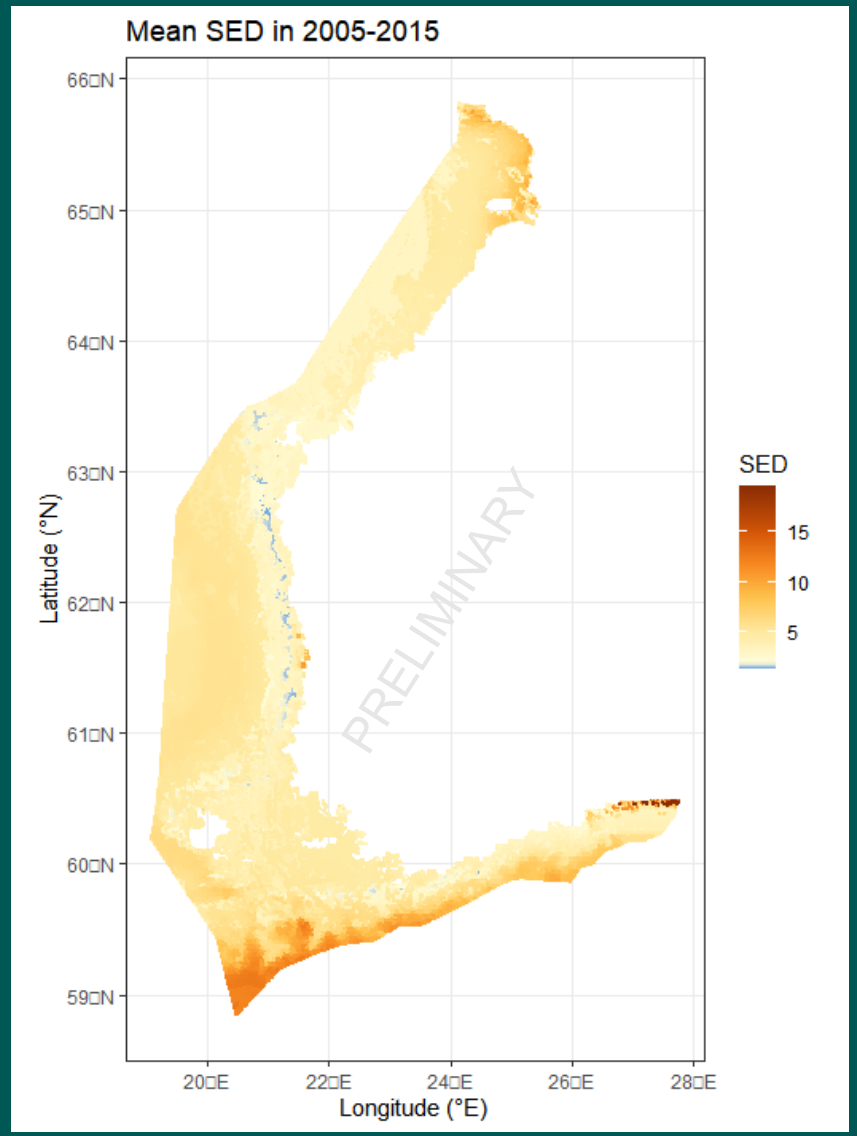
Velmu data with > 170 000 observations

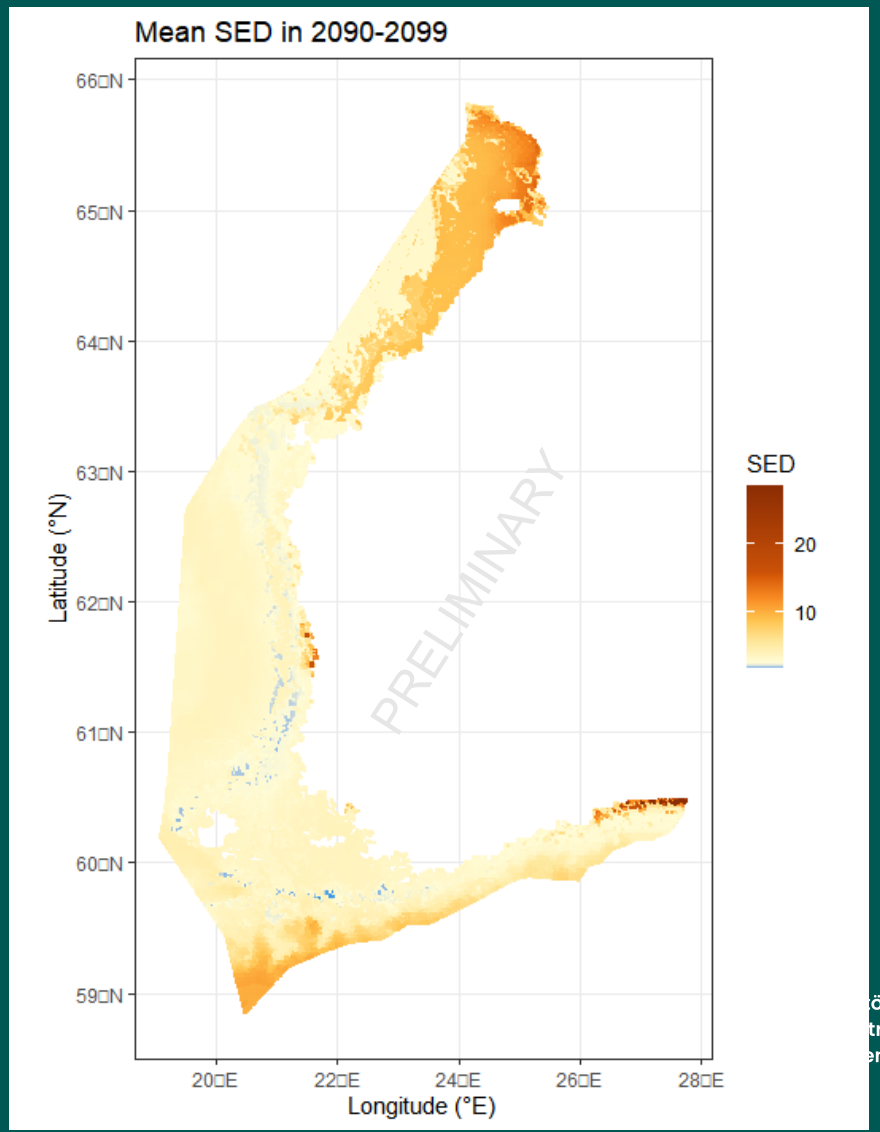
Used data of > 300 species

General environmental living ranges in 2005-2015

Grouped by substrate (hard, sand, mud, coarse and mix)

Preliminary results





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What drives the change?

With reference nutrient scenario, the nutrient levels will decrease by the end of the century to the levels suitable for most species

Also the bottom oxygen levels would increase in the future with current level of nutrient input by the ned of century

Changes in temperature and salinity largest in the northenmost part of the Baltic Sea

In the future, the environmental gradients south from Quarken could smooth out

Extreme events (heat waves) could change this picture

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Thank you for your attention!

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@KatriinaJuva

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