BUILDING GIS ASSESSMENT PORTAL PLANWISE4BLUE: FACTUAL APPROACH TO DECISION MAKING

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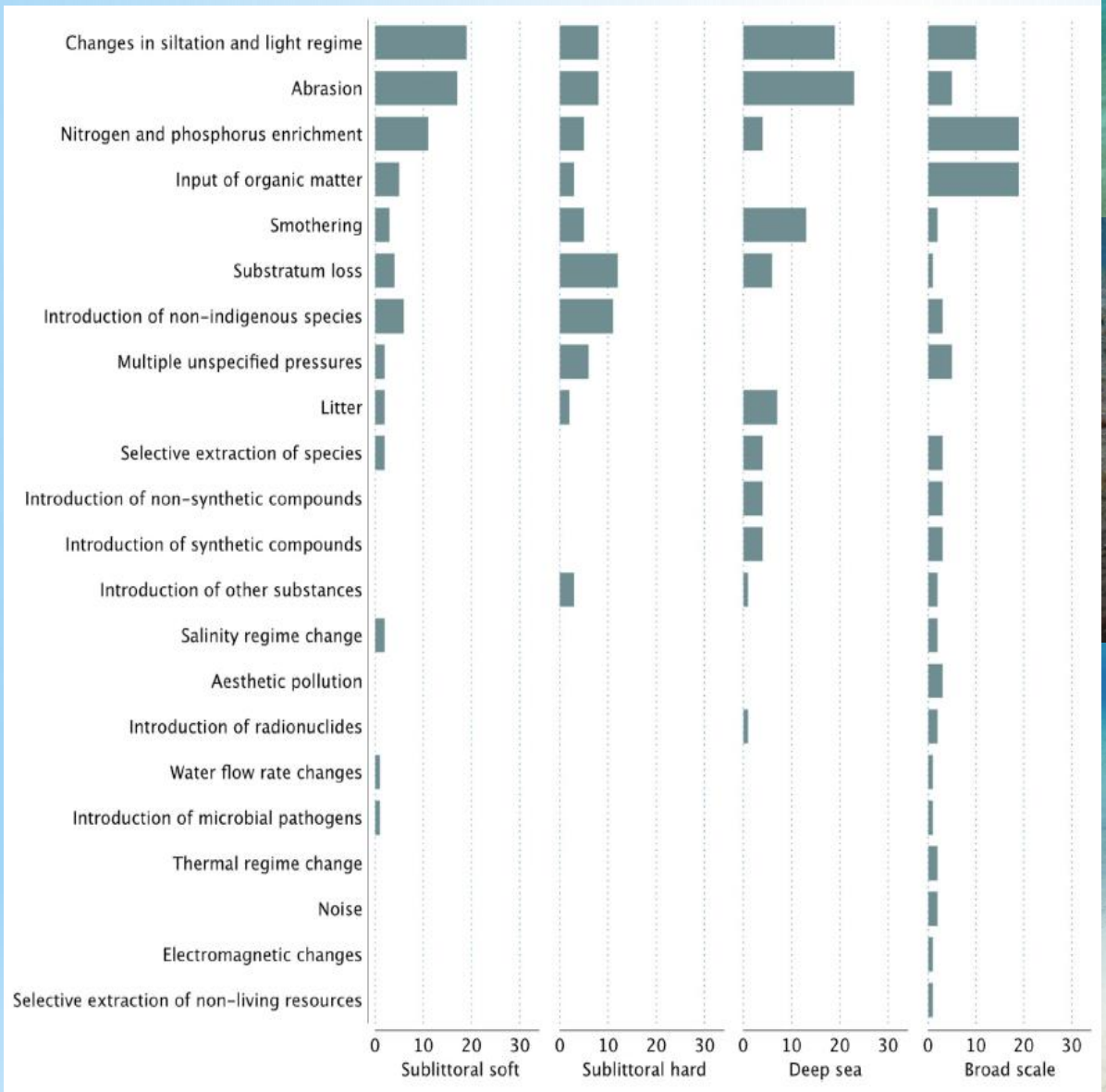
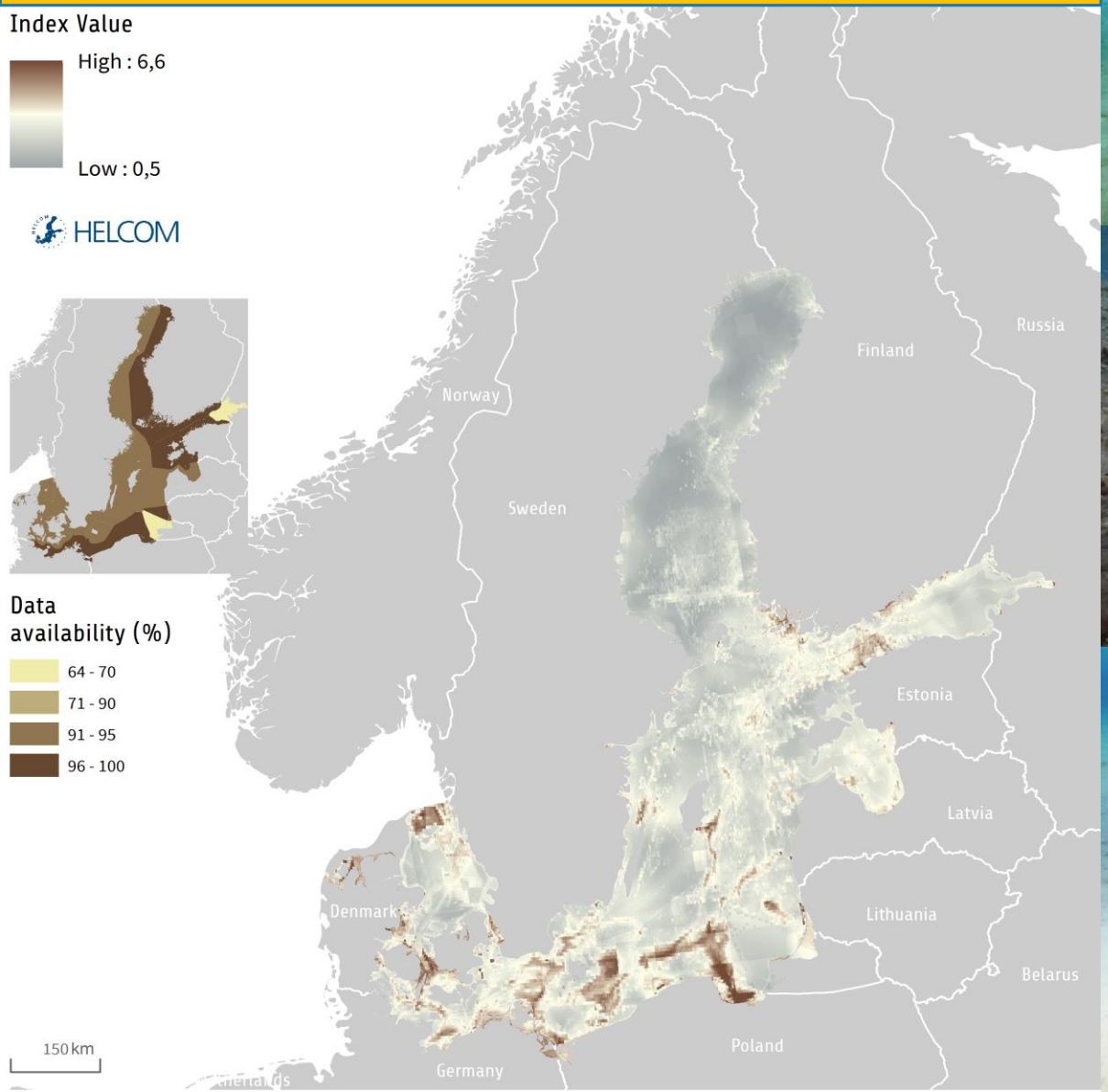
HUMAN ACTIVITIES HAVE IMPACTS

Human induced pressures become more intense and diverse and result in the loss of habitats



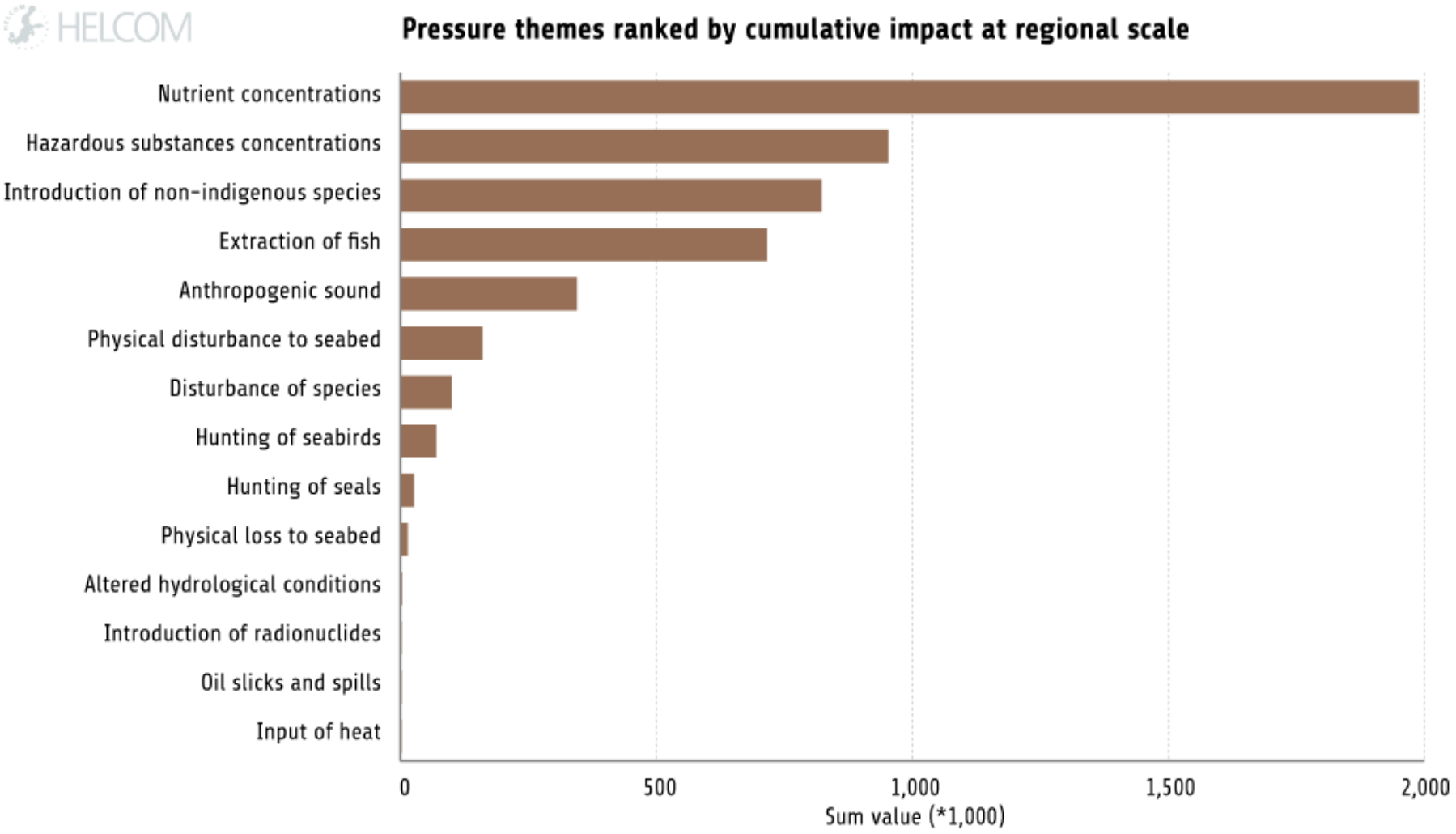
HELCOM: The Baltic Sea pressure index

All pressures are treated similarly
Difficult to convert this index to actual consequences

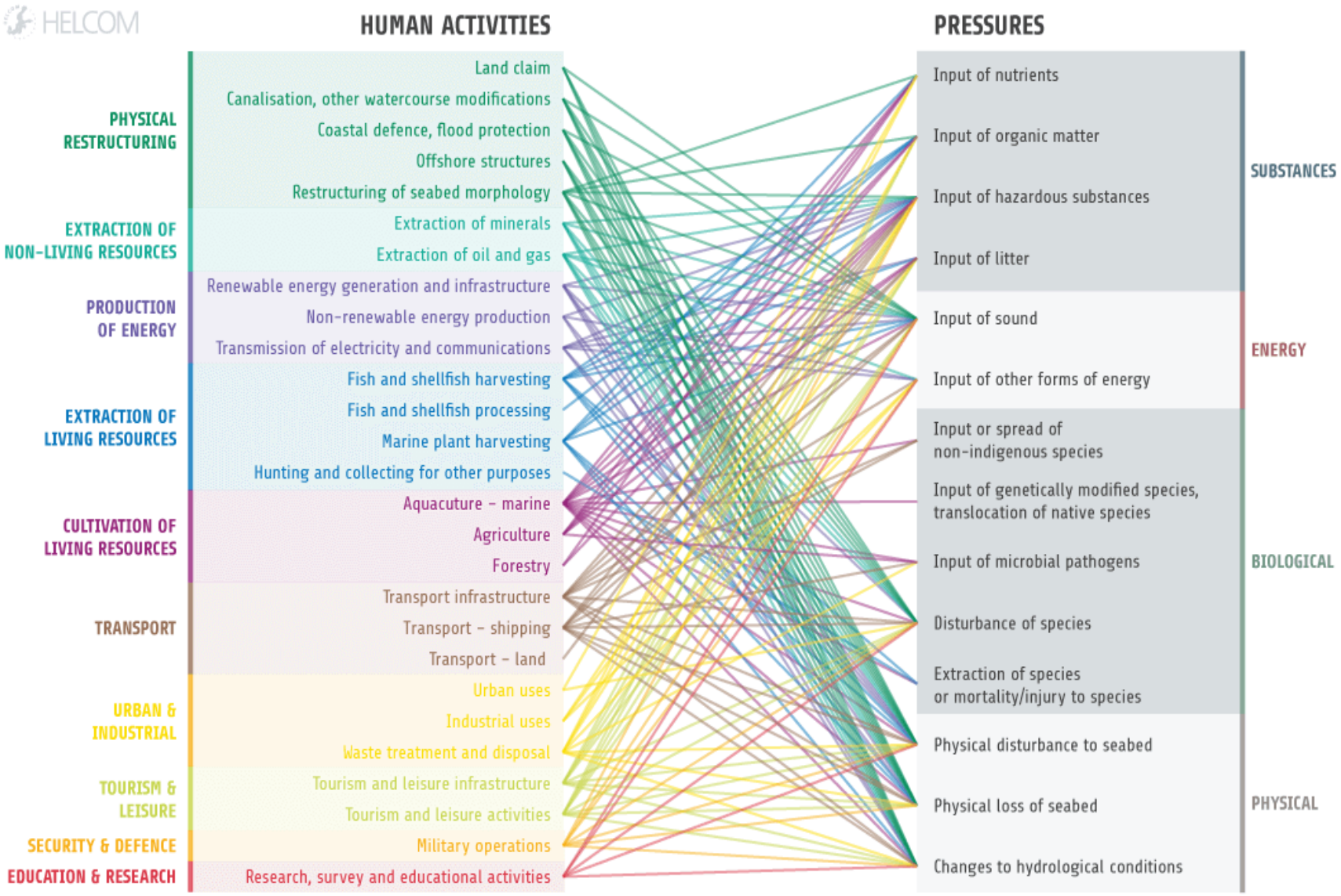


Human pressures in the Baltic Sea

Each pressure has unique consequence(s) for each nature value



Human activities and related pressures in the Baltic Sea



HELCOM HOLAS: environmental objectives for BSAP

Eutrophication

Baltic Sea unaffected by eutrophication

- Clear water
- Natural level of algal blooms
- Natural distribution and occurrence of plants and animals
- Natural oxygen levels

Biodiversity

Favourable status of Baltic Sea biodiversity

- Natural marine and coastal landscapes
- Thriving and balanced communities of plants and animals
- Viable populations of species

Hazardous substances

Baltic Sea undisturbed by hazardous substances

- Concentrations of hazardous substances close to natural levels
- All fish are safe to eat
- Healthy wildlife
- Radioactivity at the pre-Chernobyl level

But how?

Maritime activities

Enviromentally friendly maritime activities

- Enforcement of international regulations – no illegal discharges
- Safe maritime traffic without accidental pollution
- Efficient emergency and response capabilities
- Minimum sewage pollution from ships
- No introductions of alien species from ships
- Minimum air pollution from ships
- Zero discharges from offshore platforms
- Minimum threats from offshore installations

Assessing cumulative impacts → informing management → data and knowledge driven environmental decisions

Cumulative impacts: Impacts on the environment that result from pressures of several human activities acting together, as caused by past, present or any possible foreseeable future actions

REAL WORLD

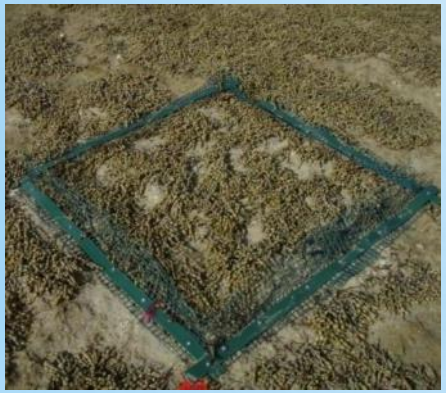
Need for **data and analysis** demanding assessment schemes

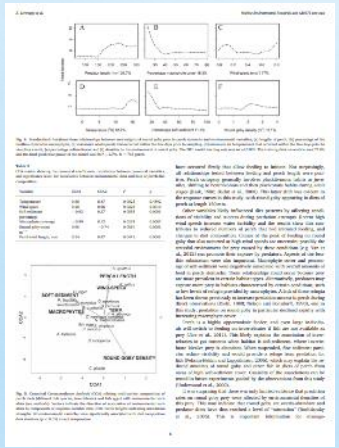
There are **disconnections of** flow from **science** (too specific) to **policy** (too large scale)

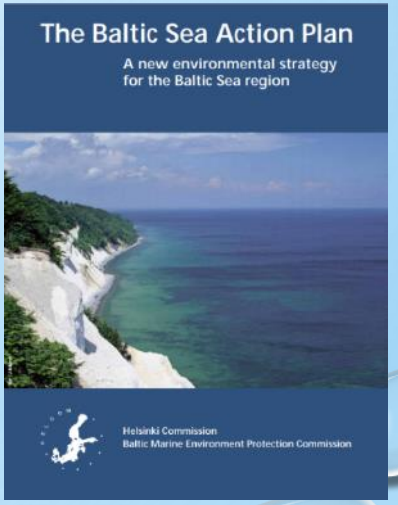
FEATURE ARTICLE

Gradients of disturbance to an algal canopy and the modification of an intertidal community

David R. Schiel*, Stacie A. Lilley



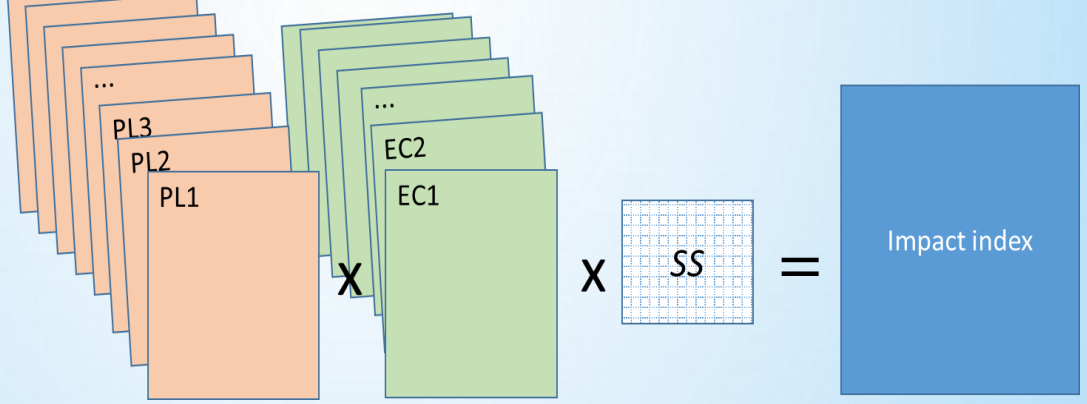




How to communicate?

HELCOM cumulative impact assessment in the Baltic Sea

$$\sum_{i=1}^{n}\sum_{j=1}^{m} PLi(x,y) * ECj(x,y) * SSi,j$$



Challenges

- Too simple to capture the existing complexity of the real world examples
- Arbitrary scale: cannot tell us the extent of habitat losses
- Each human action assessed separately but joint impact ≠ sum of all impacts
- Assumes that human impact is constant within impacted area
  But catching one fish ≠ loss of all fish stock
- Always assumes that humans have only negative impacts on nature values
  The assessment scheme cannot incorporate mitigation actions

SOLUTION

Simple-to-use web tool

The tool quantifies cumulative human impacts on key ecosystem elements at 1 km^2 spatial scale

Collaboration among multiple projects (e.g. RaM, RITA, ADRIENNE, MAREA) each targeting different analyses, tools and functionalities

Key building blocks of the tool

1. Updated maps of nature values

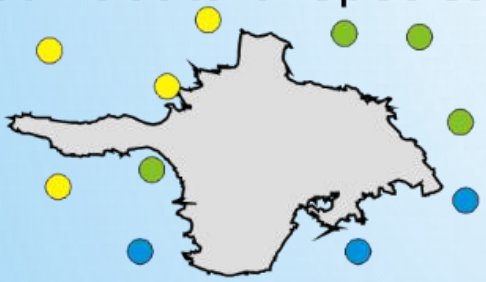
2. The best available knowledge on human impacts

3. Innovative algorithm predicting environmental impacts

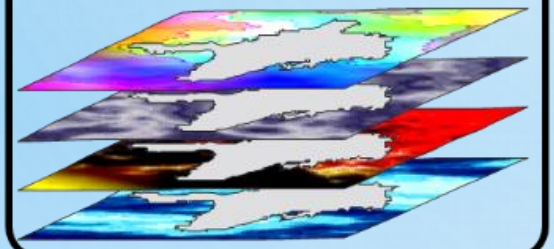

geo+graphy
MAP
GEOGRAPHY
Earth

Nature values:
Mapping and spatial modelling of the biota

Response variable:
point data of species

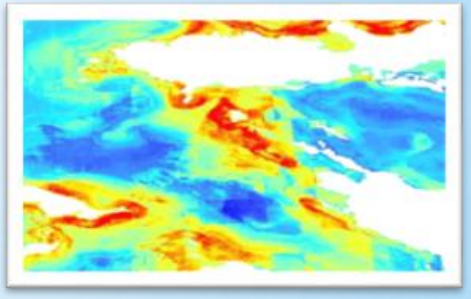


Predictor variables:
GIS-layers of environmental data



Spatial modelling algorithm

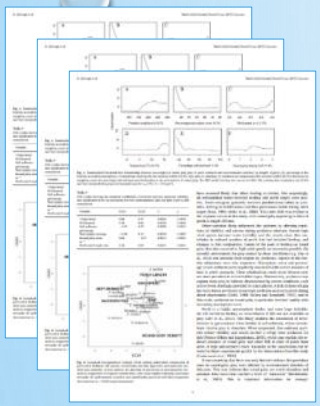
Prediction:
species densities



Model assessment

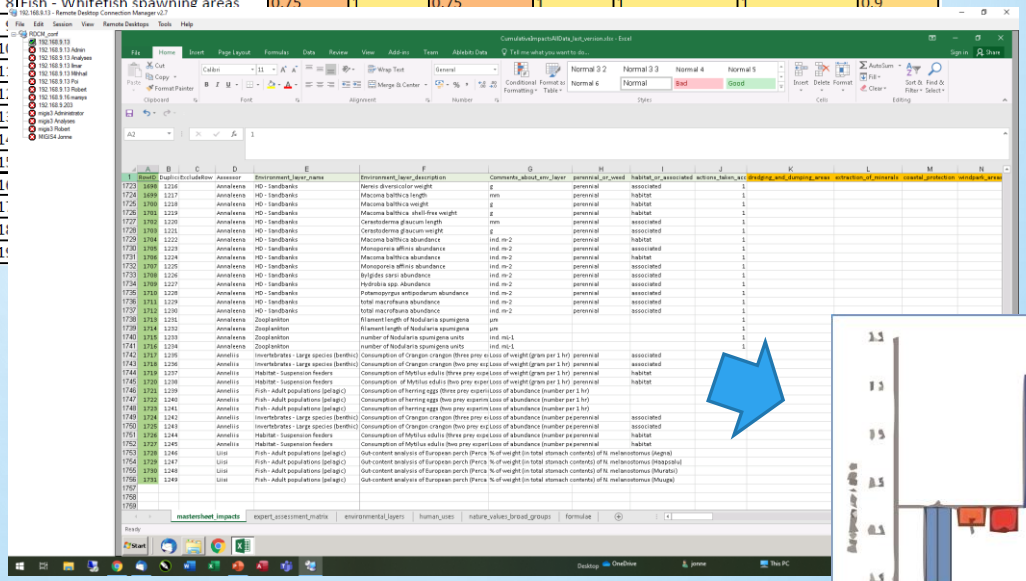
- importance of predictors
- relationships between predictors and response
- model validation

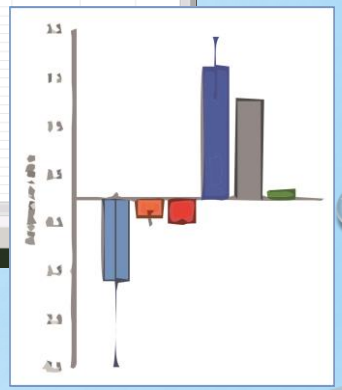
Knowledge inventory: solid data and expert assessment



Extract data from relevant publications and datasets

Nature value ID	env_layer_name	dredging	windpark	fish farming	shipping	underwater cable	commercial fishi	harbours
1	Bird - Benthos feeders	1	1	1	0.9	1	1	0.9
2	Bird - Fish feeders	0.75	1	0.9	0.9	1	0.9	0.9
3	Bird - Migration routes	1	0.75	1	0.9	1	1	1
4	Bird - Wintering areas	1	0.75	0.9	0.9	1	1	0.9
5	Bird - Herbivores	0.7	0.85	0.7	0.9	1	1	0.8
6	Fish - Herring spawning areas	0.75	1	0.9	1	1	1	0.9
7	Fish - Pikeperch spawning areas	0.75	0.9	0.9	1	1	1	0.9
8	Fish - Whitefish spawning areas	0.75	1	0.75	1	1	1	0.9





Meta-analyses and calculation of effect sizes

Innovative algorithm: Creating impact matrix

```
################################################################################
################################################################################

#INPUT #NB! NUMBER OF AND ORDER OF VARIABLES IN THE PUBLICATION DATA
MATRIX IS IMPORTANT!!! IF IT CHANGES THE NEXT CODE SECTION ALSO NEEDS
CHANGING
################################################################################
################################################################################
#
nvorder=data.frame(read_xlsx("CumulativeImpactsAllData_last_version.xlsx"
,sheet="environmental_layers"))[,2] #nature value order
humanorder=data.frame(read_xlsx("CumulativeImpactsAllData_last_version.xl
sx",sheet="human_uses"))[,2] #human pressure order
nvgroups=data.frame(read_xlsx("CumulativeImpactsAllData_last_version.xlsx
",sheet="nature_values_broad_groups"))[,3] #human pressure order
expertmatrix=data.frame(read_xlsx("CumulativeImpactsAllData_last_version.
xlsx",sheet="expert_assessment_matrix"))[,3:(length(humanorder)+2)]
improving=12 #order number of the human pressure that can improve the
nature (mussel cultivation)
improvement=data.frame(read_xlsx("CumulativeImpactsAllData_last_version.x
lsx",sheet="expert_assessment_matrix"))[,2+improving]
sisendandmed=read_xlsx("CumulativeImpactsAllData_last_version.xlsx",sheet
="mastersheet_impacts",guess_max=3000) #cumulative impacts all data xlsx
andmed=subset(sisendandmed,!is.na(sisendandmed$Environment_layer_name))
andmed$nv=factor(andmed$Environment_layer_name)
if(any(!(levels(andmed$nv)%in%nvorder))){print("Faulty nature values in
publication data matrix!");print(paste0("Faulty levels: ",
paste0(levels(andmed$nv)[which(!(levels(andmed$nv)%in%nvorder))],collapse
=", ")))} #warns about faulty publication data matrix naturevalue
categories
andmed=subset(andmed,andmed$nv%in%nvorder) #keep only rows with correct
naturevalues
abi=andmed[,11:32] #columns from the publication data matrix with human
ssure indicators
.na(abi)]=0
```

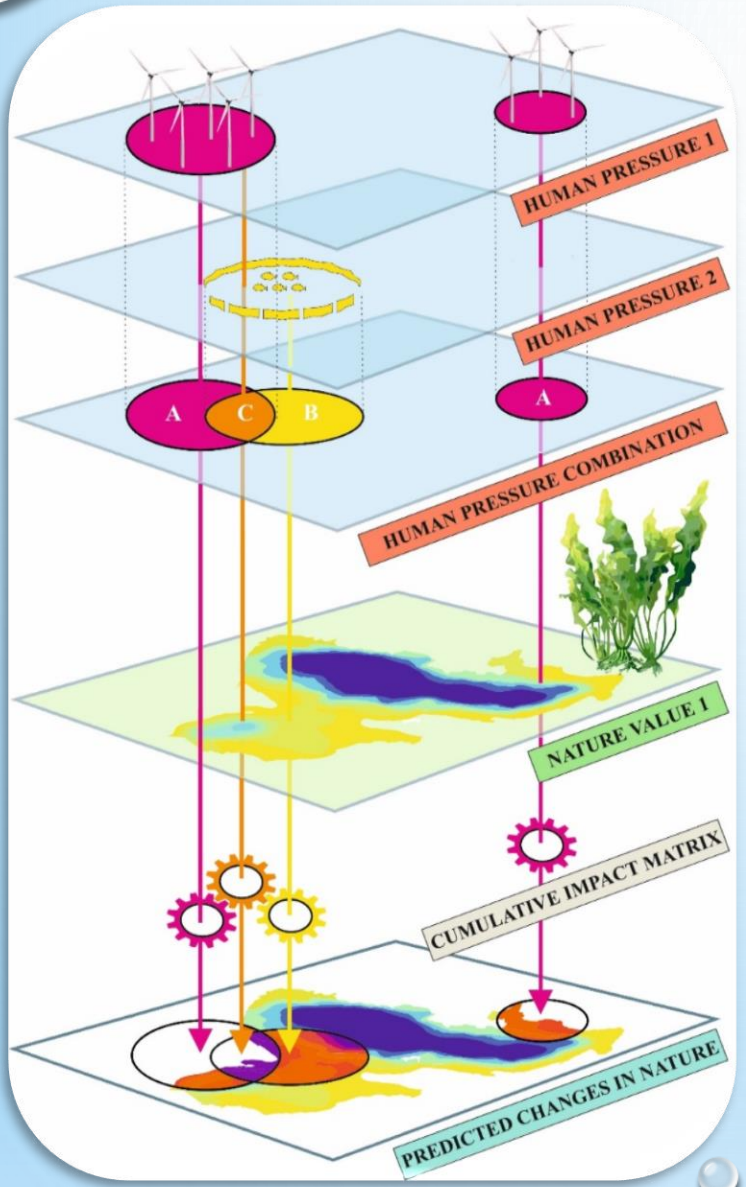
Produces effect sizes for all combinations of nature values and human pressures

Innovative algorithm: Reading scenarios, modelling impacts and publishing maps

```
(sf) #dealing with gdbs
rary(raster) #geotiffs
psgvalue=3035 #epsg code for the projection

loc_in="\\\\NESSIE\\meri\\andmed\\planwise4blue\\human_impact_calculation
\\empty_db2.gdb"
loc_out="\\\\NESSIE\\meri\\andmed\\planwise4blue\\human_impact_calculatio
n"

#loc_in="C:\\Users\\Administrator\\Desktop\\empty_db2.gdb"
#loc_out="C:\\Users\\Administrator\\Desktop"

#read in impact layer
setwd(loc_out)
moju =readRDS("impact_matrix.rds")

setwd(loc_in)
#st_layers(getwd())$name #layer names

#environment layer names
naturelayers=grep("nv\\_[0-9]+\\_TAB",st_layers(getwd())$name,value=T)

#read in interaction layer
inim = st_read(getwd(), layer = "hu_union_1km_TAB")
kombinatsioonid=unique(inim$hu_comb) #what impact combinations are
present
moju=subset(moju,hu_comb%in%kombinatsioonid) #reduce the impact matrix
dataset to relevant only


for (i in naturelayers){ #cycle over all nature layers
setwd(loc_in)
loodus = st_read(getwd(), layer = i) #nature value layer
naturenumber=as.numeric(substr(i,4,5)) #number of the layer
lmoju=subset(moju,nature_value%in%naturenumber) #use only the relevant
part of the impact matrix
loodus=subset(loodus,mean!=0) #non-zero locations only
loodus=subset(loodus,zone_id%in%inim$zone_id) #only locations with impact
loodus$hu_comb=inim$hu_comb[match(loodus$zone_id,inim$zone_id)] #add
```

Writes geotiffs of initial and final values of nature values under a predefined human pressure scenario

Innovative algorithm: GIS perspective



Reading scenario (spatial distribution of pressures)

Reading nature values

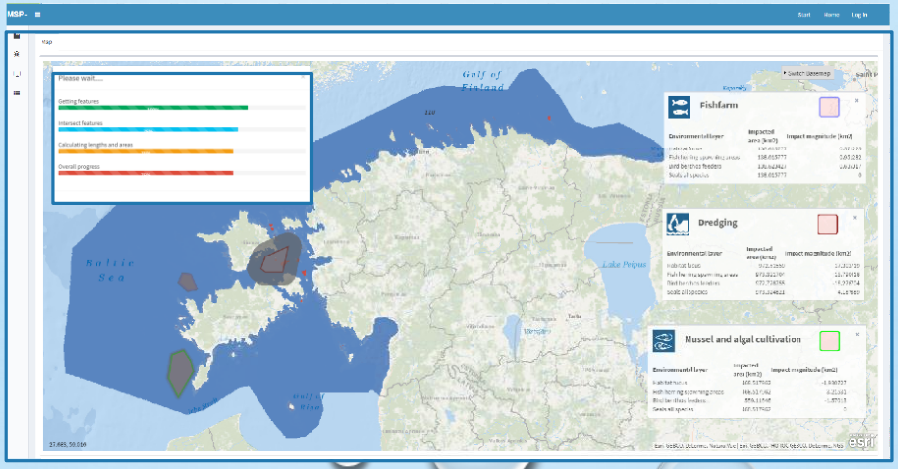
Running GIS modelling

Publishing maps on impacts

CUMULATIVE IMPACT ASSESSMENT

THE GEOPORTAL

1. **COMBINES** LAYERS OF KEY **NATURE ASSET VALUES** (DATA)
2. **CONTAIN RULES** (KNOWLEDGE) ON HOW DIFFERENT HUMAN PRESSURES IMPACT DIFFERENT NATURE ASSETS
3. USERS CAN **USE/EDIT/UPLOAD POLYGONS OF HUMAN USE**
4. TOOL INTERACTIVELY **QUANTIFIES ENVIRONMENTAL IMPACTS OF THESE PRESSURES AT 1 KM² SCALE** BASED ON THE CURRENT BEST AVAILABLE DATA AND KNOWLEDGE



Current list of nature values and human pressures

Nature values

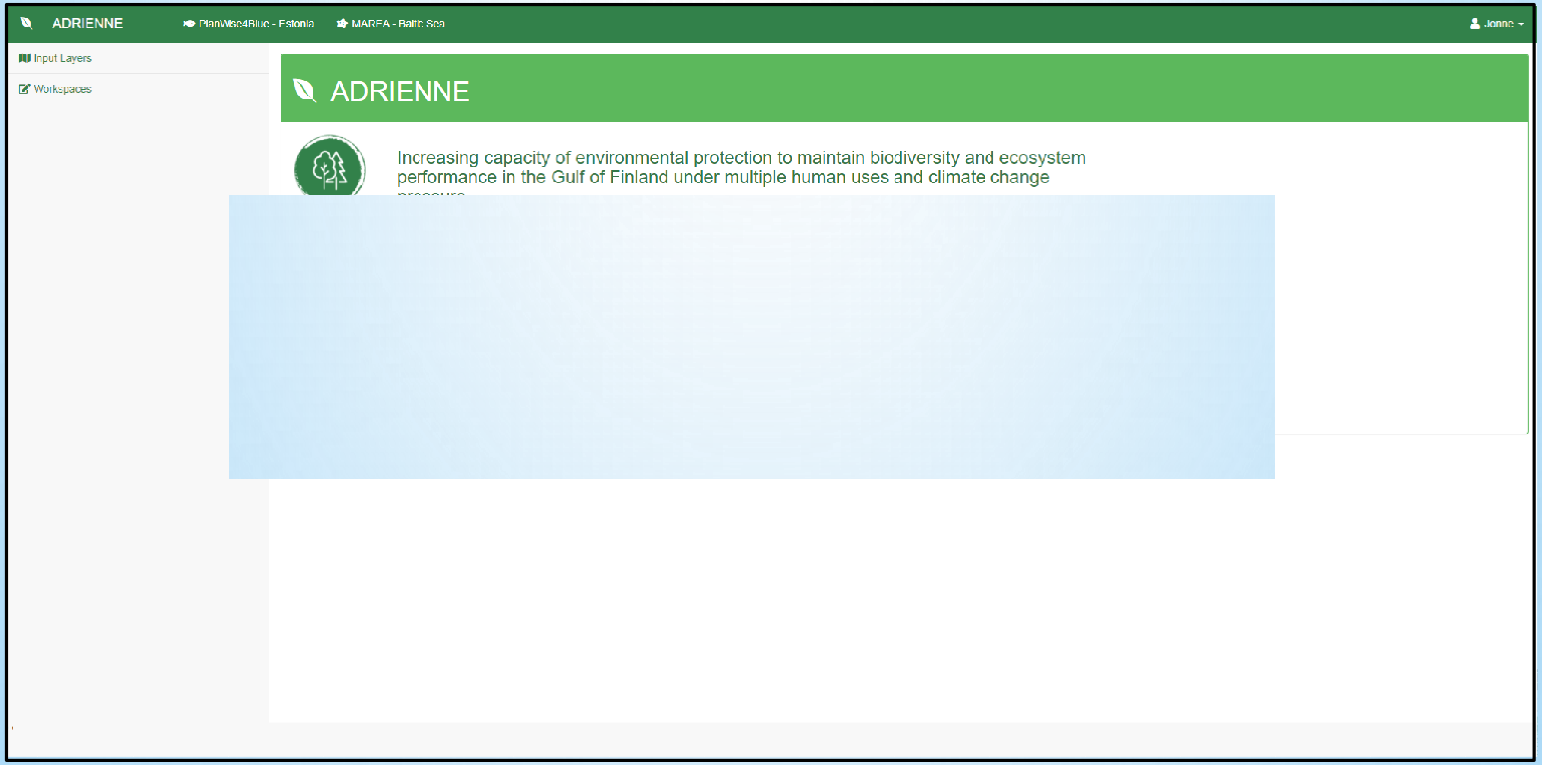
Bird - Benthos feeders
Bird - Fish feeders
Bird - Migration routes
Bird - Wintering areas
Bird - Herbivores
Fish - Herring spawning areas
Fish - Pikeperch spawning areas
Fish - Whitefish spawning areas
Habitat - Charophytes
Habitat - Fucus
Habitat - Furcellaria
Habitat - Higher plants
Habitat - Richness flora and fauna
Habitat - Suspension feeders
Habitat - Zostera
Seals - All species
HD - Sandbanks
HD - Mudflats and sandflats
HD - Reefs

Human uses

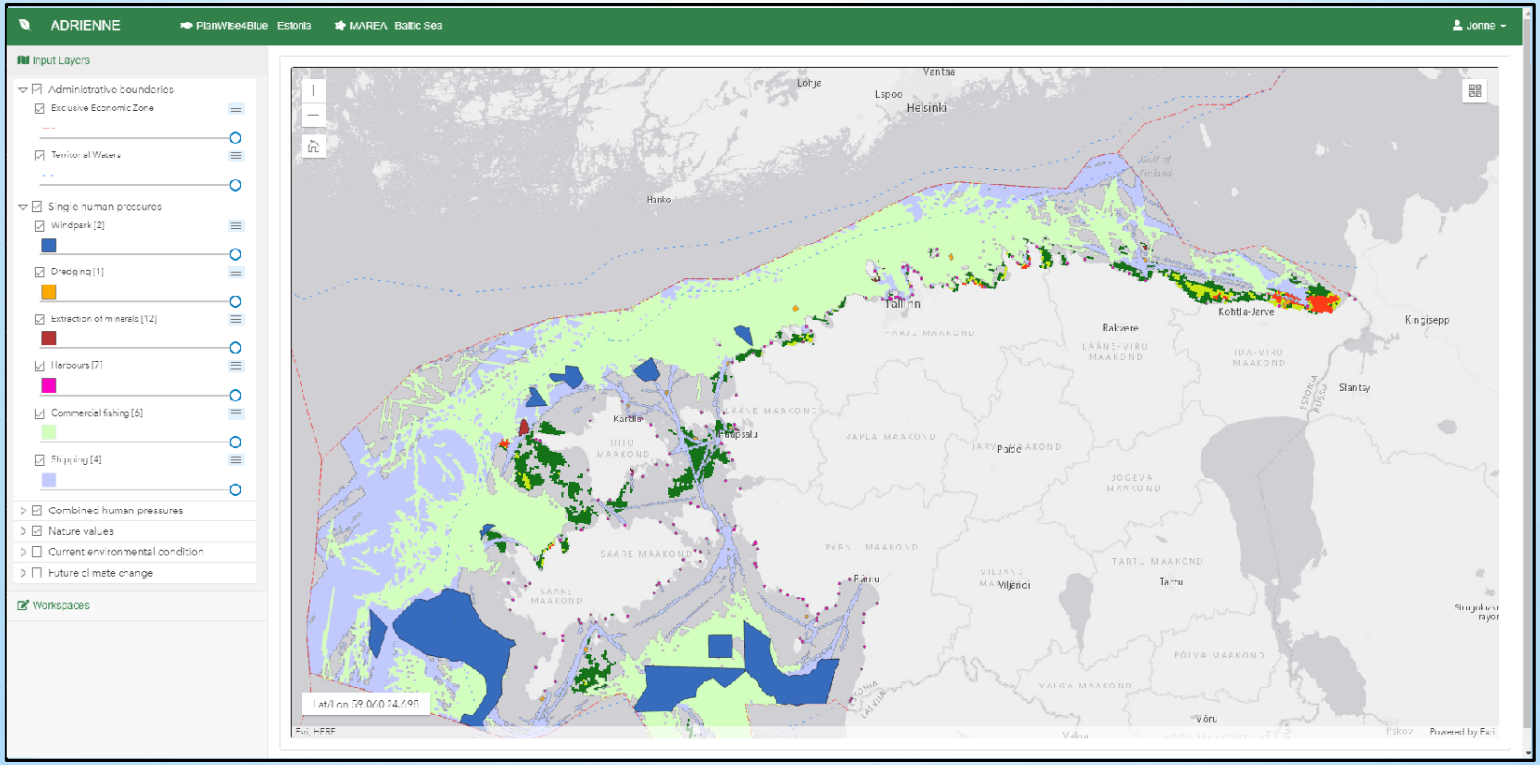
dredging
windpark
fish farming
shipping
underwater cables
commercial fishing
harbours
military activities
wastewater discharge outlet
mussel and algal cultivation
coastal defence
extraction of minerals
marine plant harvesting
tourism and leisure activities
Invasive species - round goby
Invasive species - mud crab

By December 2021 we add 57 benthic species to the assessment portal

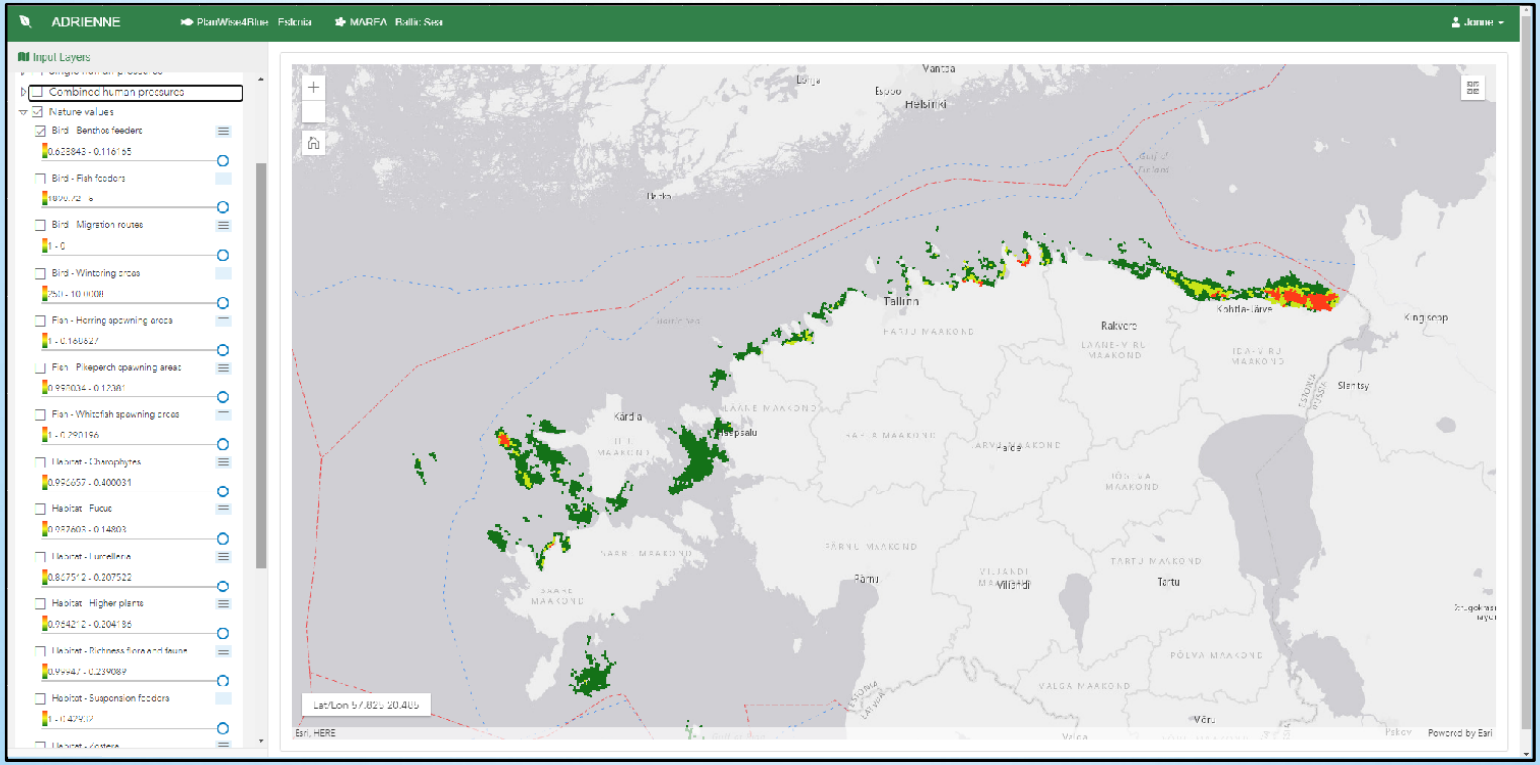
Welcome window



Existing data – maps of human uses



Existing data – maps of nature values



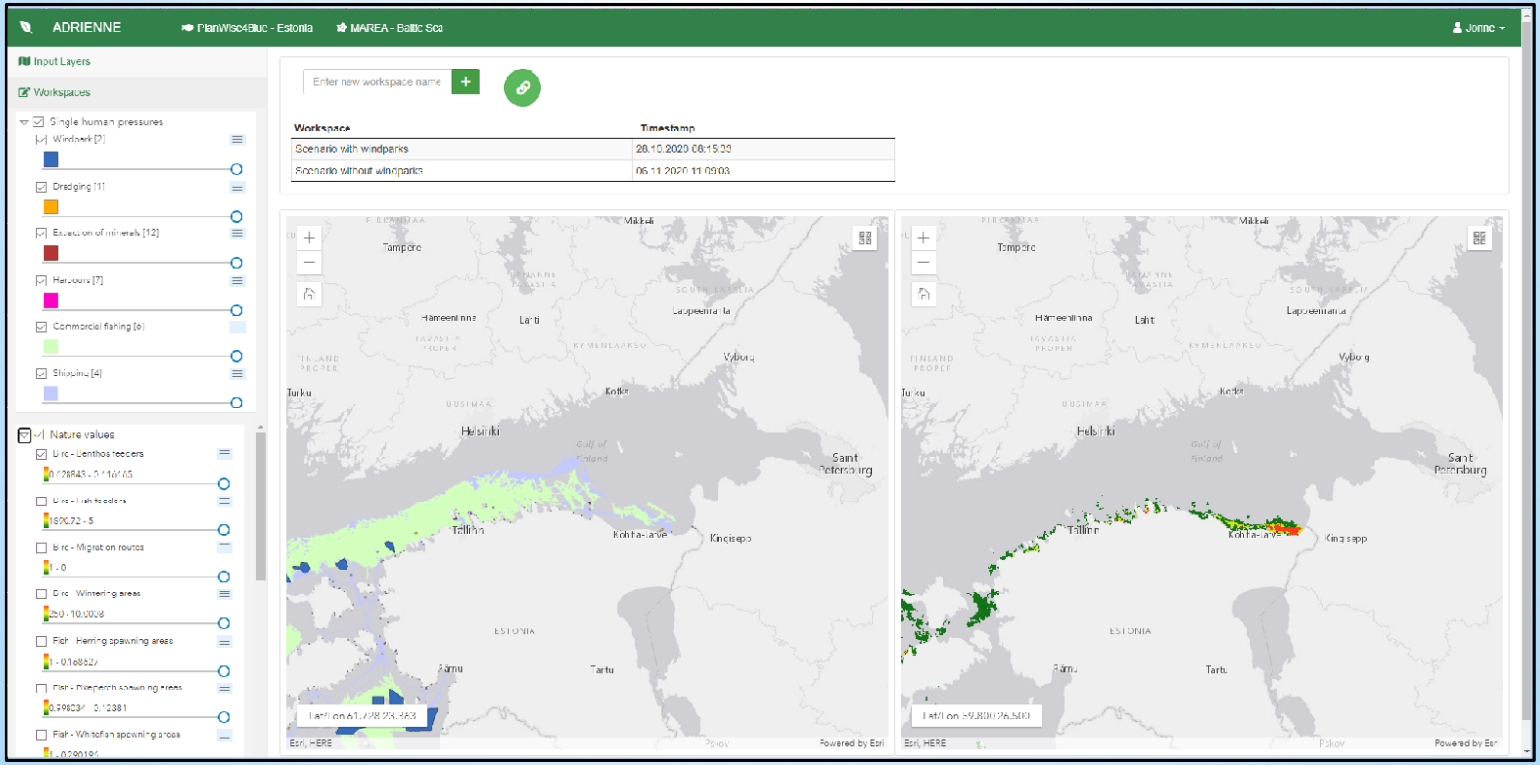
Existing data – maps of nature values

Reefs

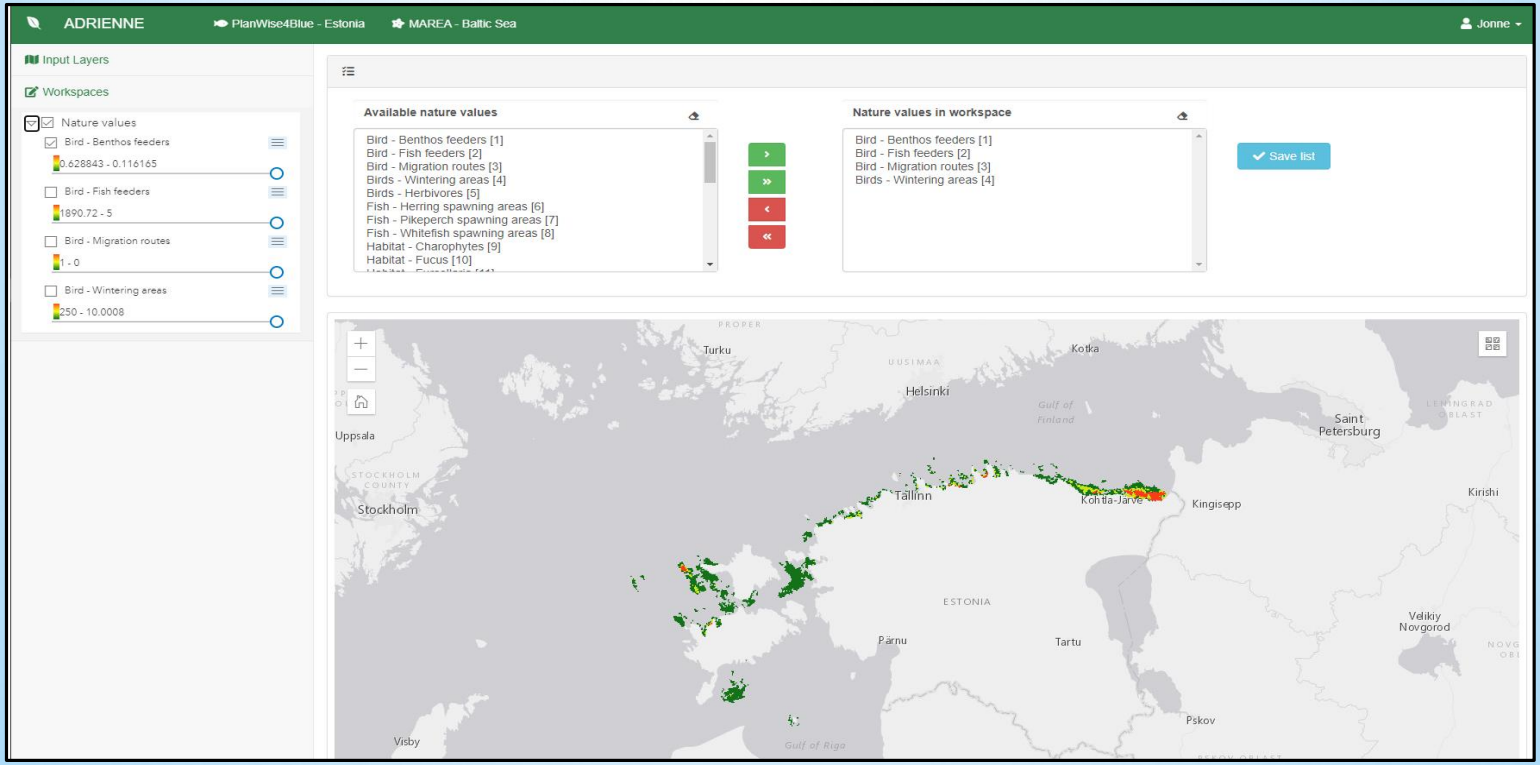
Sandbanks

See nature values behind the maps

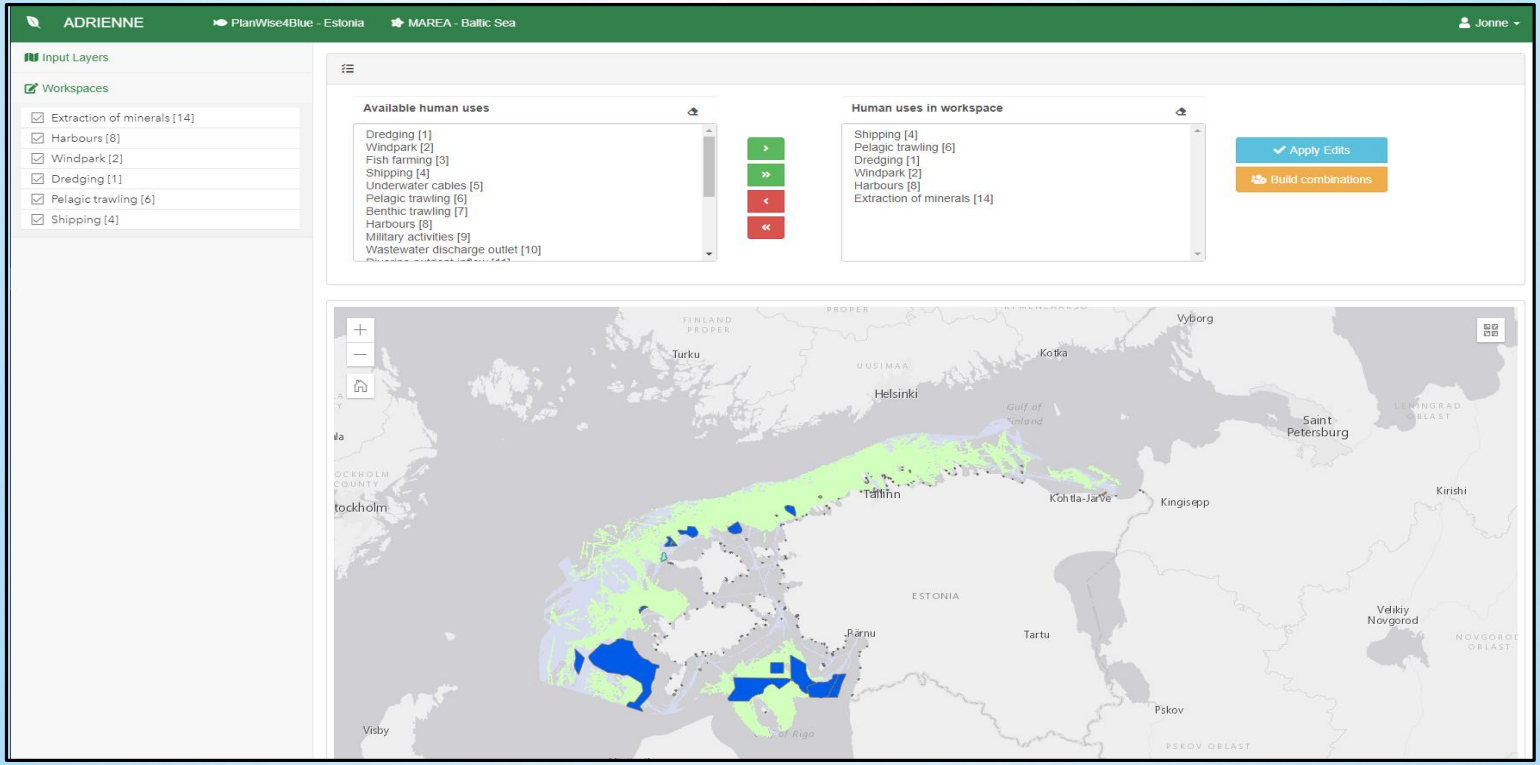
User-specific workspaces



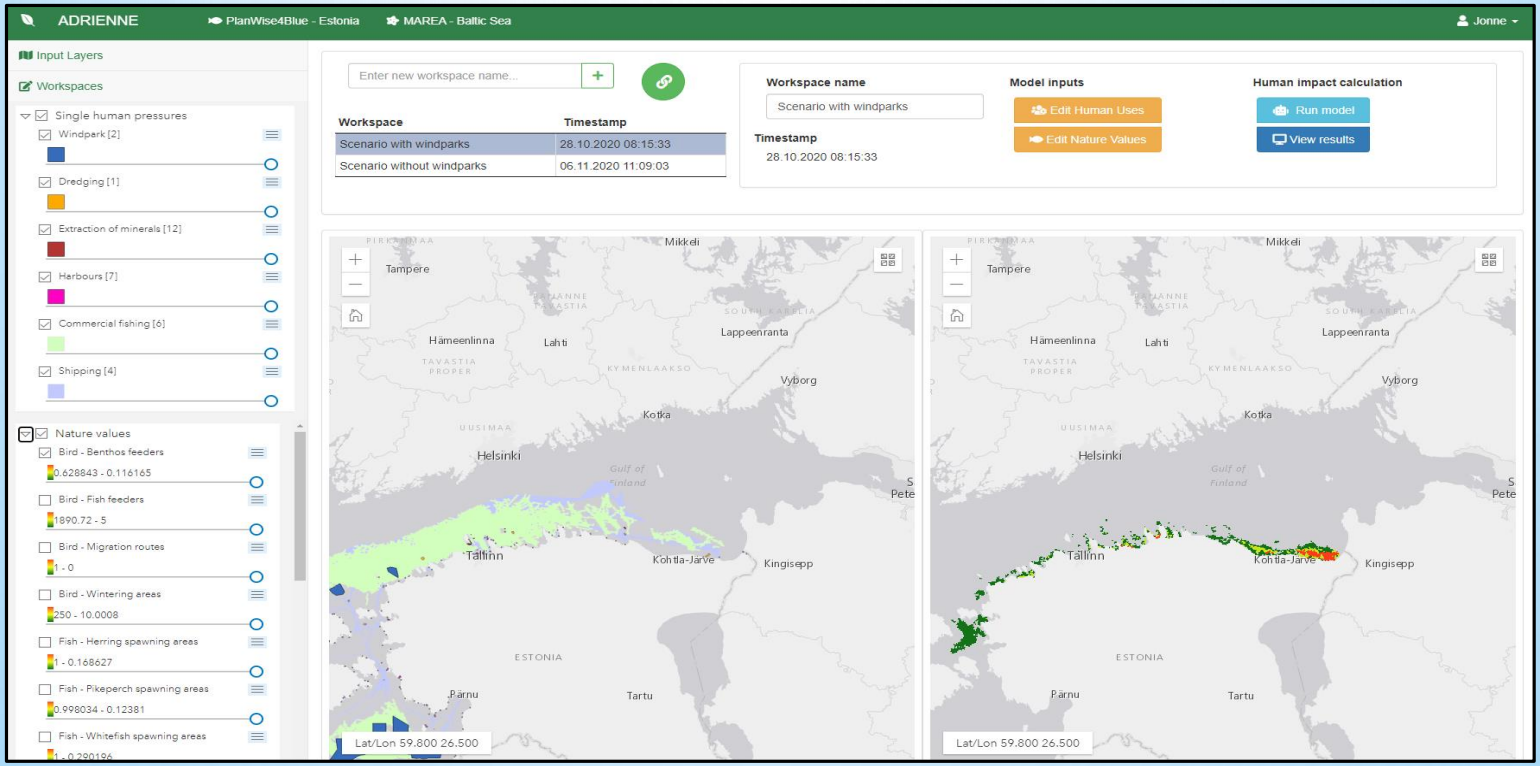
Workspaces – selecting nature values



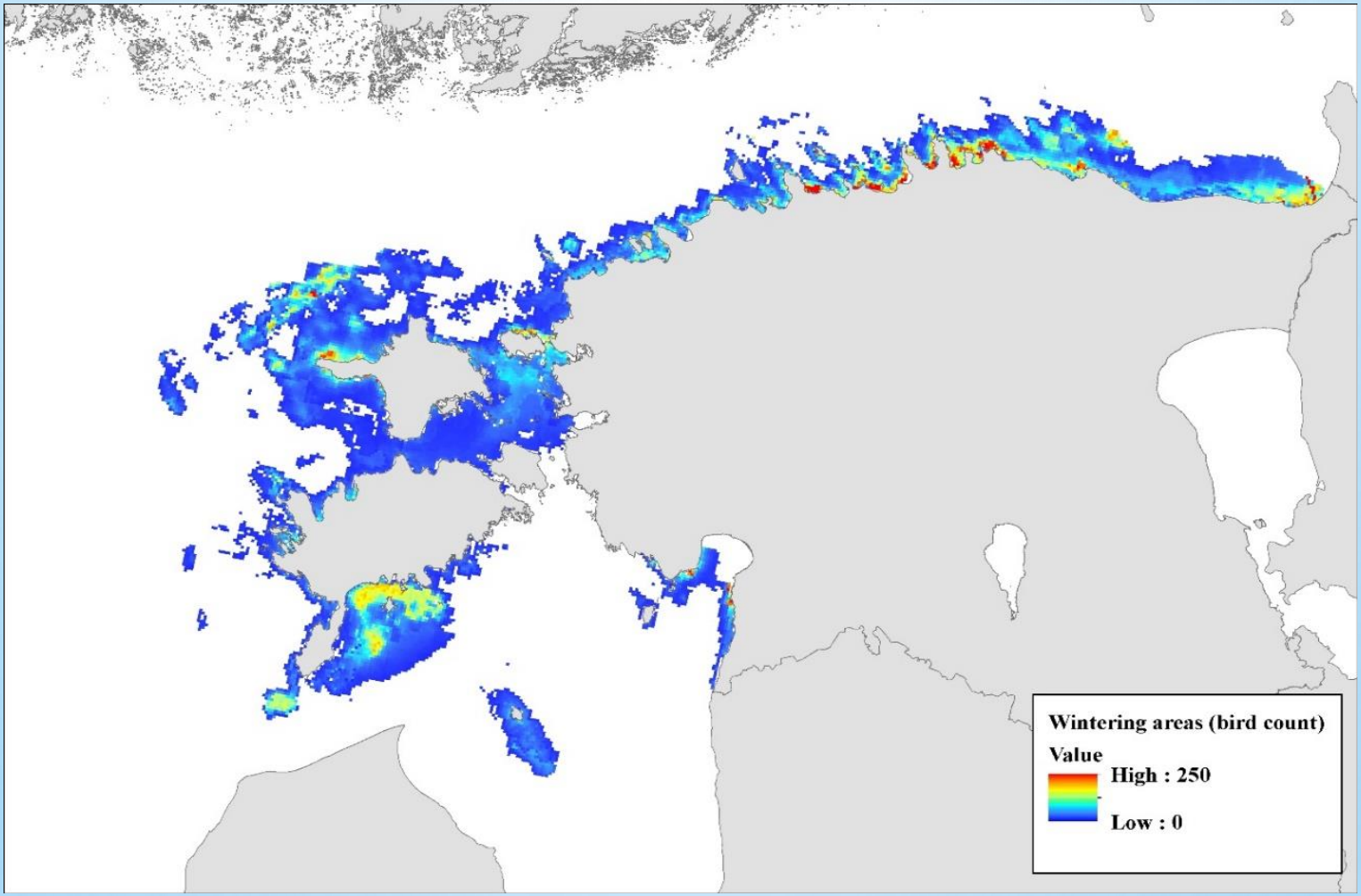
Workspaces – selecting and editing human uses



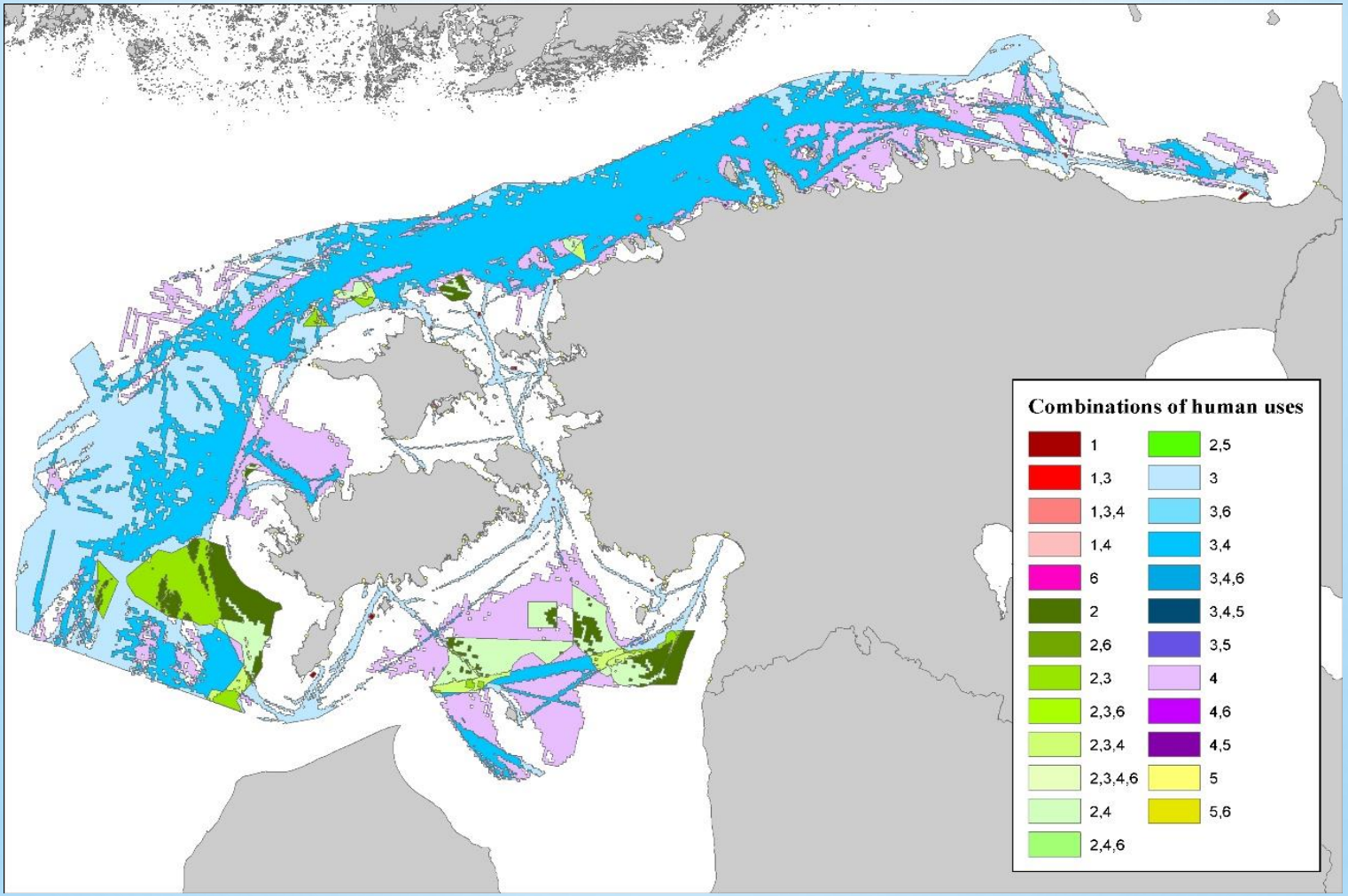
Workspaces – running cumulative impact models based on custom data



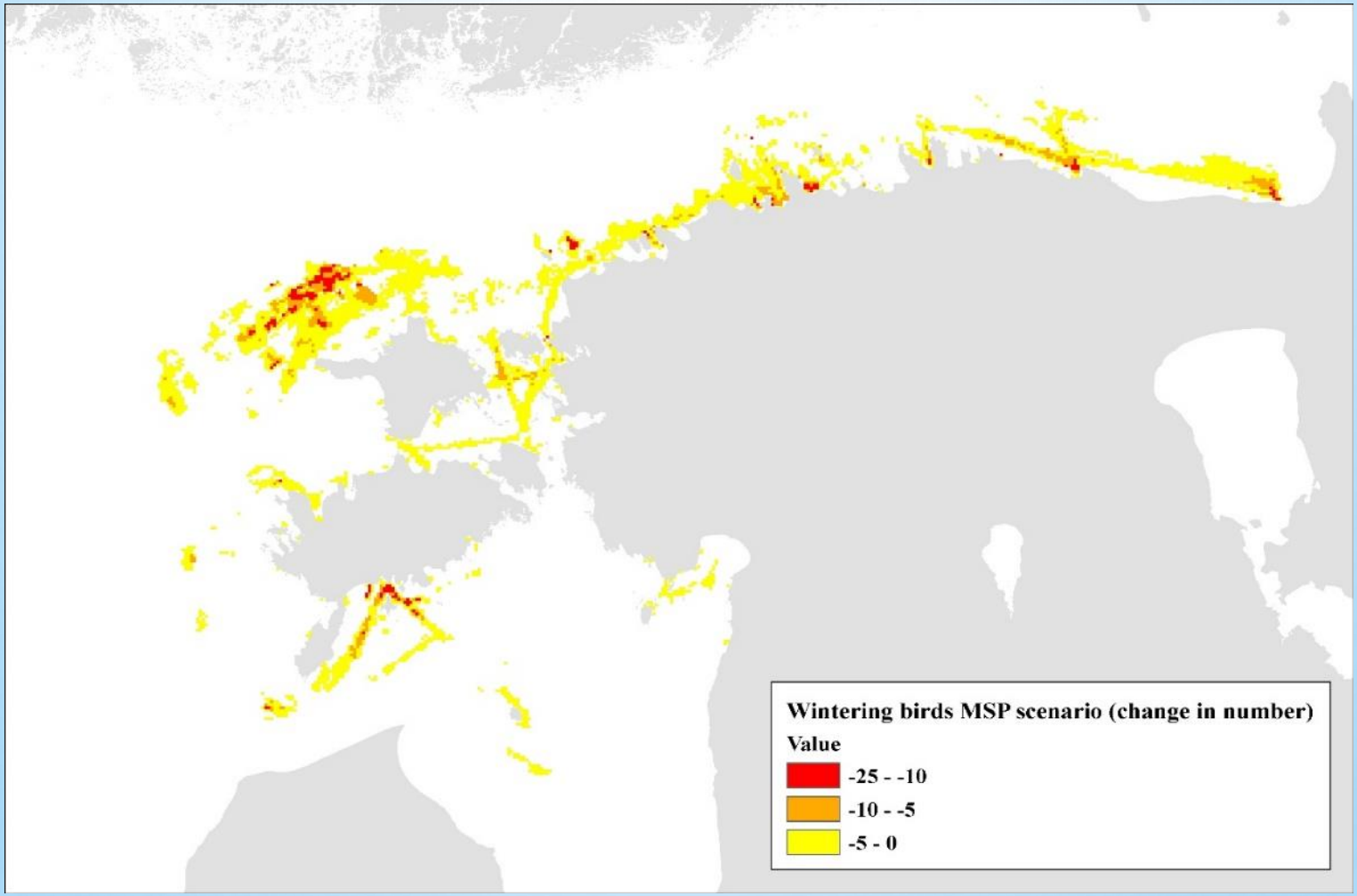
ESTONIAN MARITIME SPATIAL PLANNING



COMBINATION OF HUMAN USES



IMPACT = nature value × impact coefficient



Benefits of the portal

FROM EXPERT JUDGEMENT TO DATA DRIVEN ASSESSMENT

IMPACT MATRIX: SEPARATE AND INTERACTIVE EFFECTS

REGULAR UPDATING OF THE MODEL DATA (KNOWLEDGE AND DATA MINING)

FROM STATIC ASSESSMENT TO USER-SPECIFIED DYNAMIC ASSESSMENT

SPEEDING UP PROCESSES (100 TIMES FASTER)

COMPLEX ALGORITHMS (POWERED BY R SOFTWARE)

USER HAS HIS/HER OWN WORKSPACE AND BUILD CUSTOM SCENARIOS

Near future developments

More complex scenarios

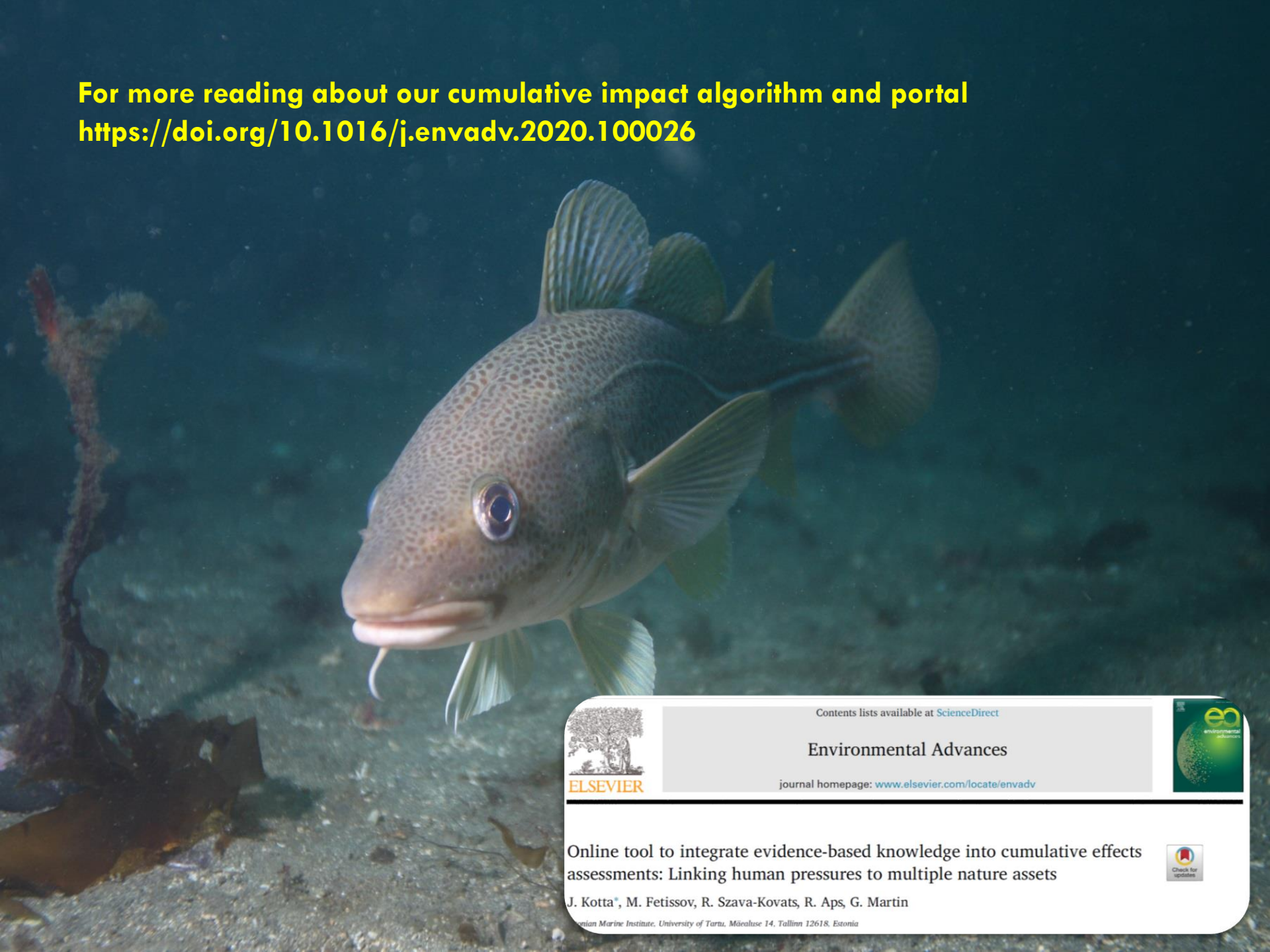
We add climate change and nutrient reduction scenarios by December 2021

More ecosystem service indicators

Collaboration between Adrienne and Marea projects

Training session in Russian during the Adrienne conference in March 2022

For more reading about our cumulative impact algorithm and portal
https://doi.org/10.1016/j.envadv.2020.100026



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Online tool to integrate evidence-based knowledge into cumulative effects assessments: Linking human pressures to multiple nature assets

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