

BUILDING GIS ASSESSMENT PORTAL PLANWISE4BLUE: FACTUAL APPROACH TO DECISION MAKING

JONNE KOTTA

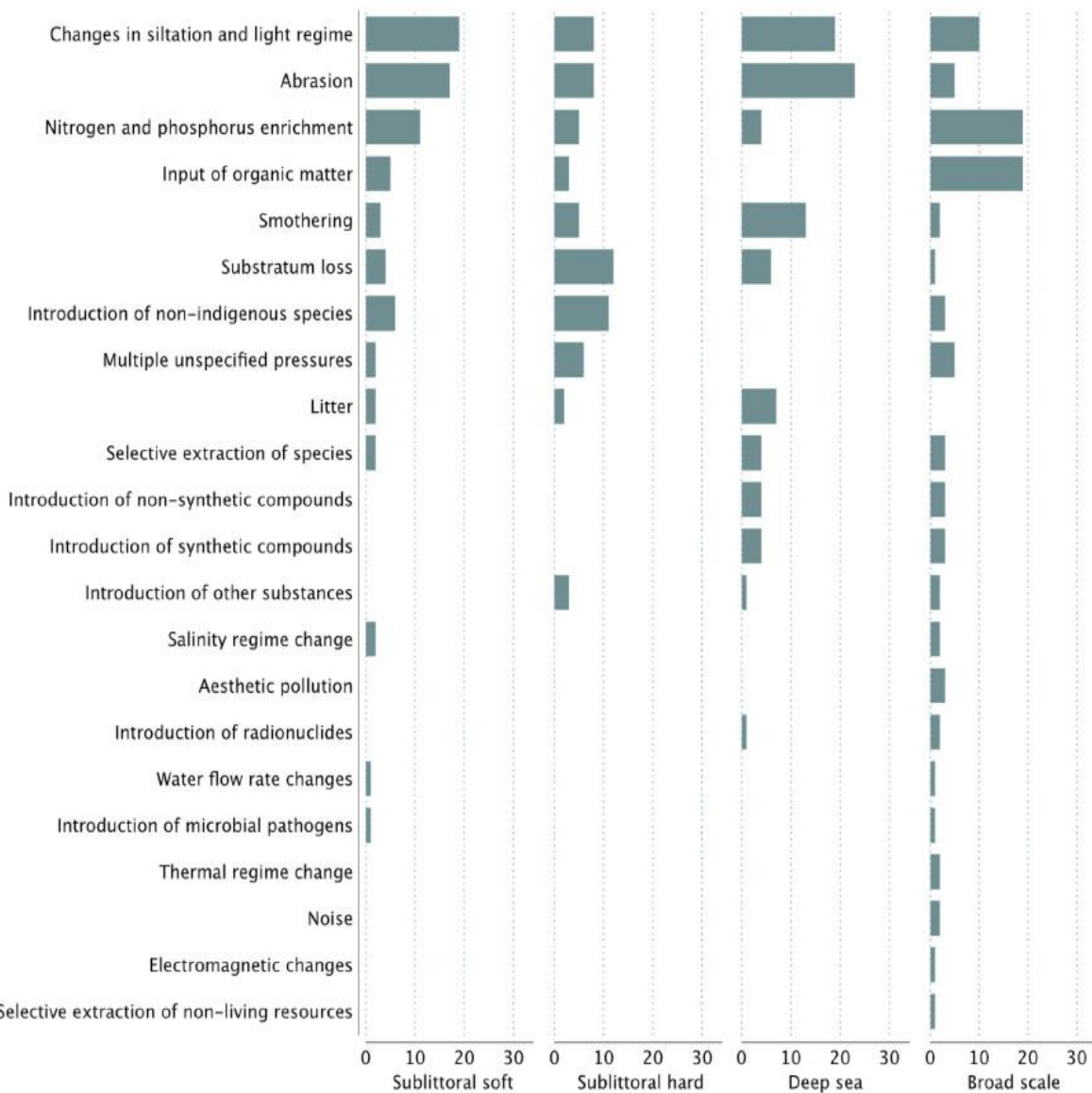
careea

Logo Maurizio Sajeva ©



HUMAN ACTIVITIES HAVE IMPACTS

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



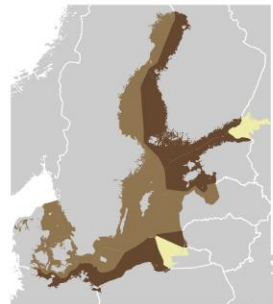
HELCOM: The Baltic Sea pressure index

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

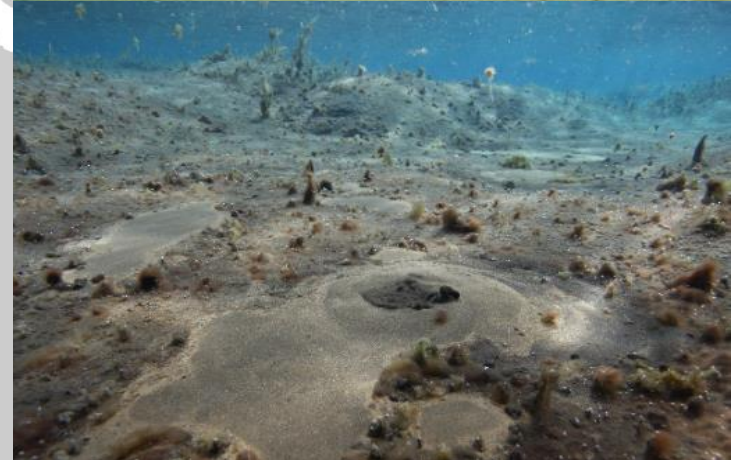
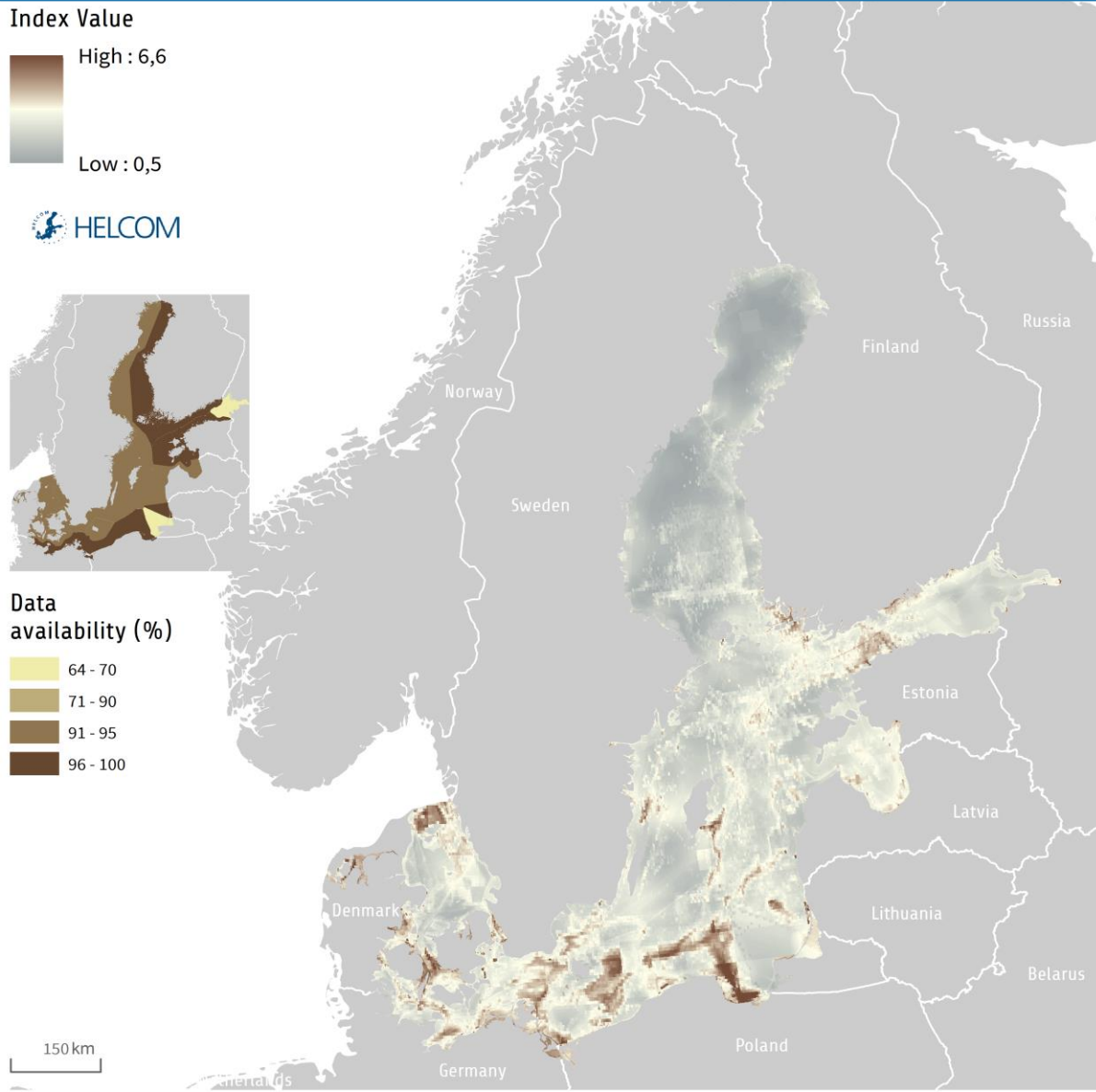
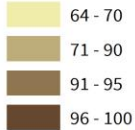
Index Value

High : 6,6

Low : 0,5



Data availability (%)

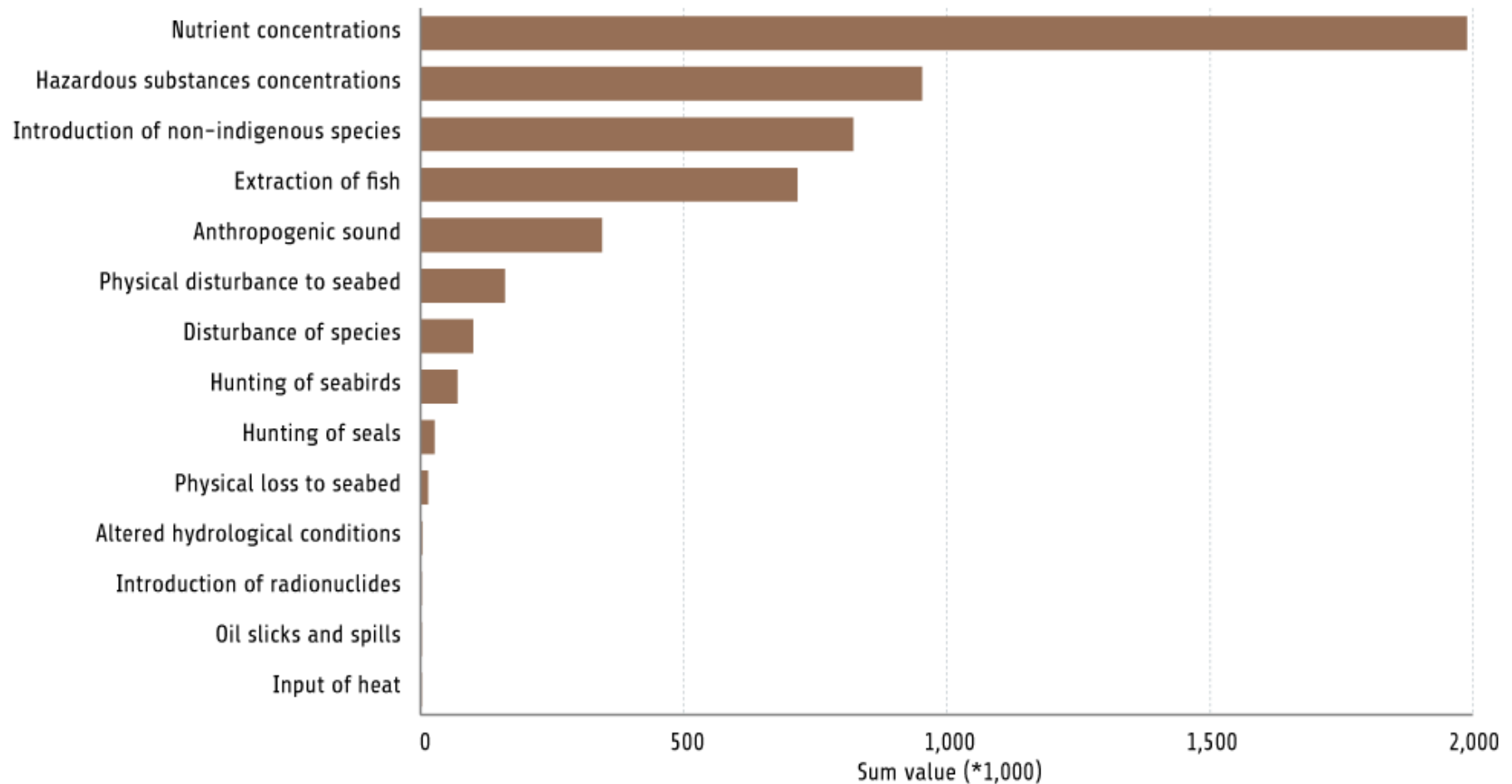


Human pressures in the Baltic Sea

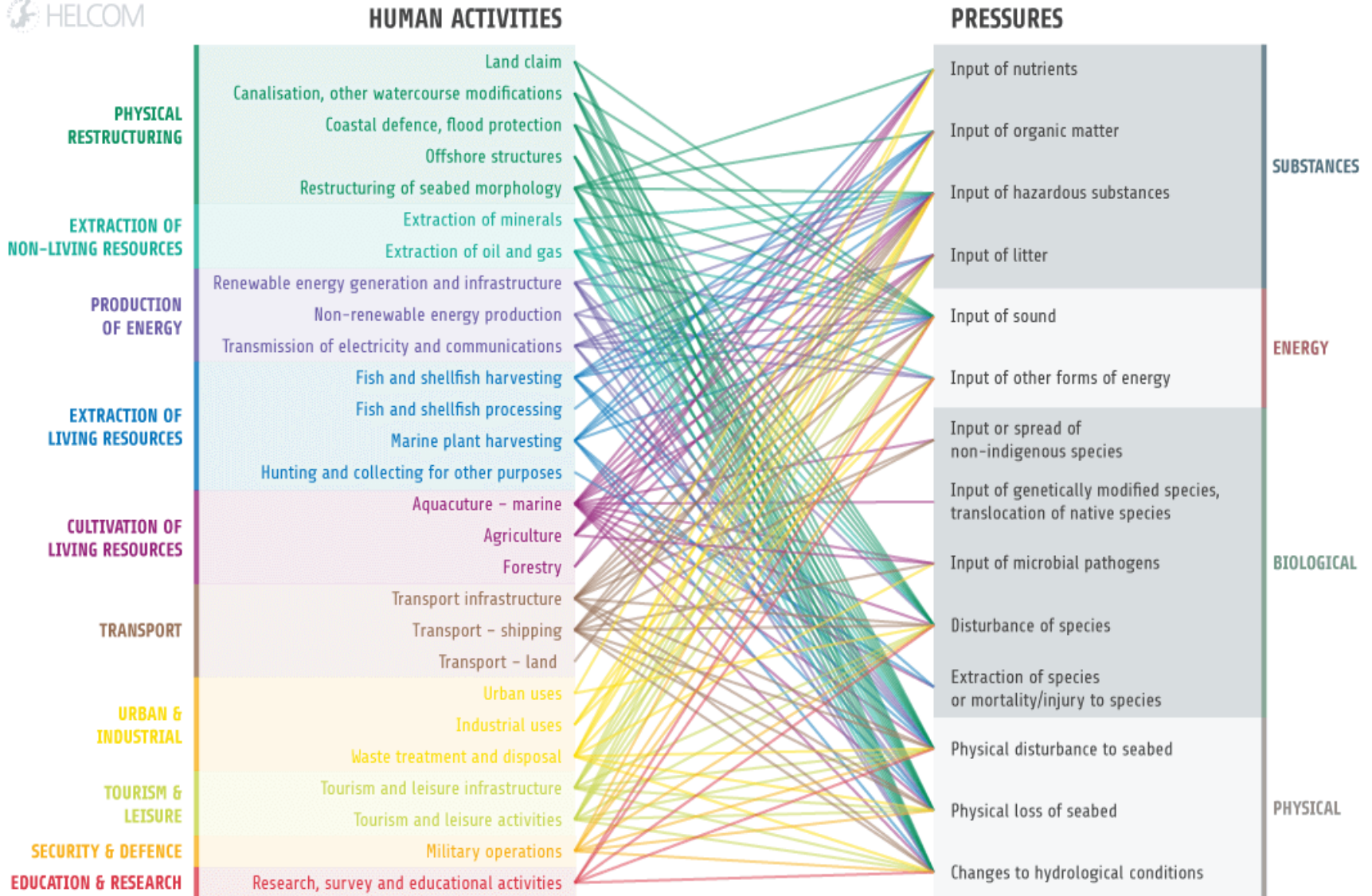
Each pressure has unique consequence(s) for each nature value



Pressure themes ranked by cumulative impact at regional scale



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



Maritime activities

Environmentally 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

But how?

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

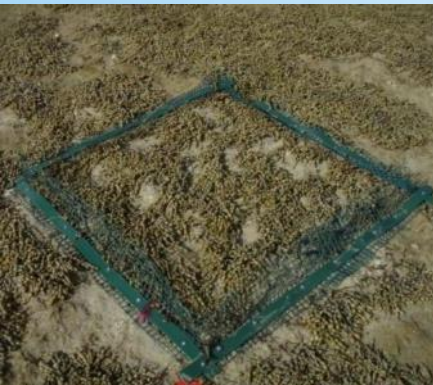
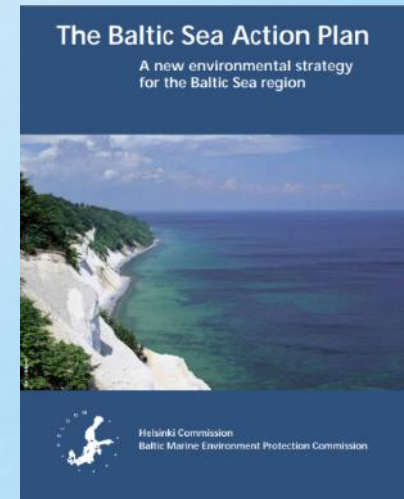
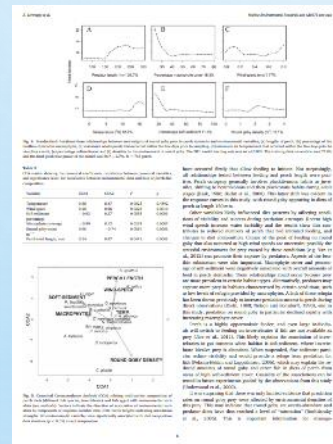
Cumulative impacts: Impacts on the environment that result from pressures of several human activities acting together, as caused by past, present or any possible foreseeable future actions



REAL WORLD

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

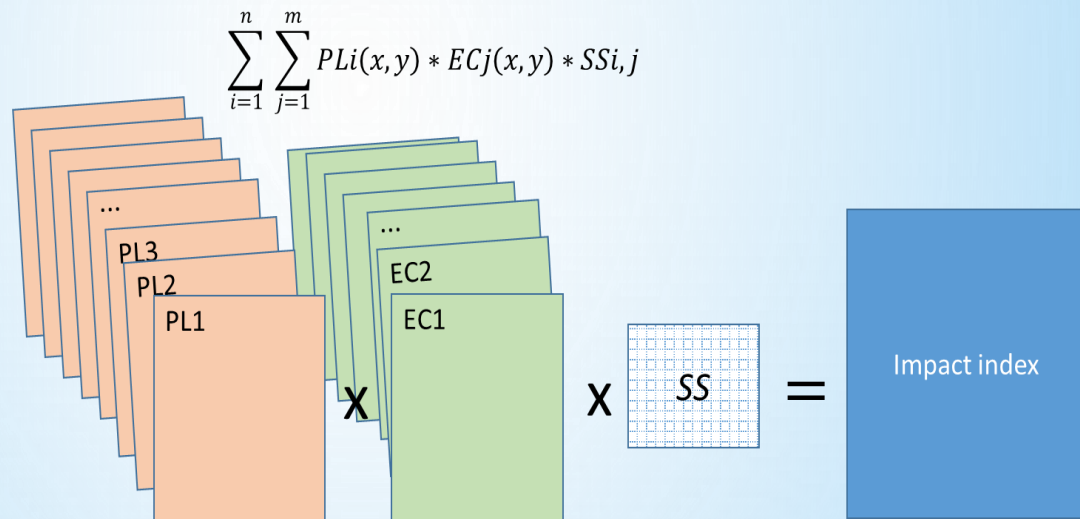
There are **disconnections of flow from science** (too specific) to **policy** (too large scale)



How to communicate?

HELCOM cumulative impact assessment in the Baltic Sea

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 \neq sum of all impacts

Assumes that human impact is constant within impacted area

But catching one fish \neq 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

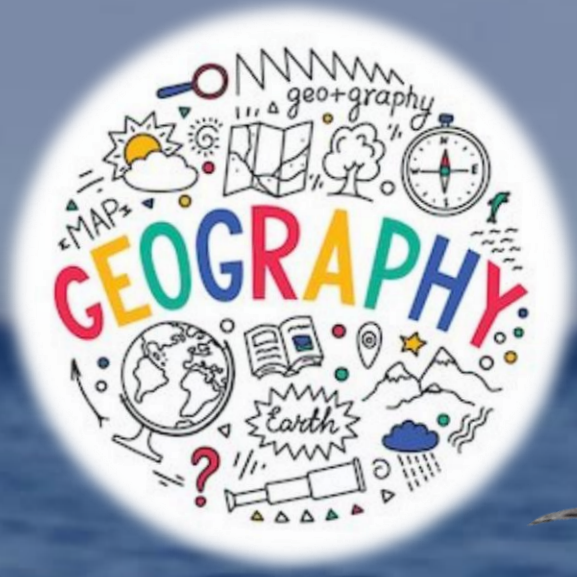
The tool quantifies cumulative human impacts on key ecosystem elements
at 1 km² spatial scale

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

Key building blocks of the tool

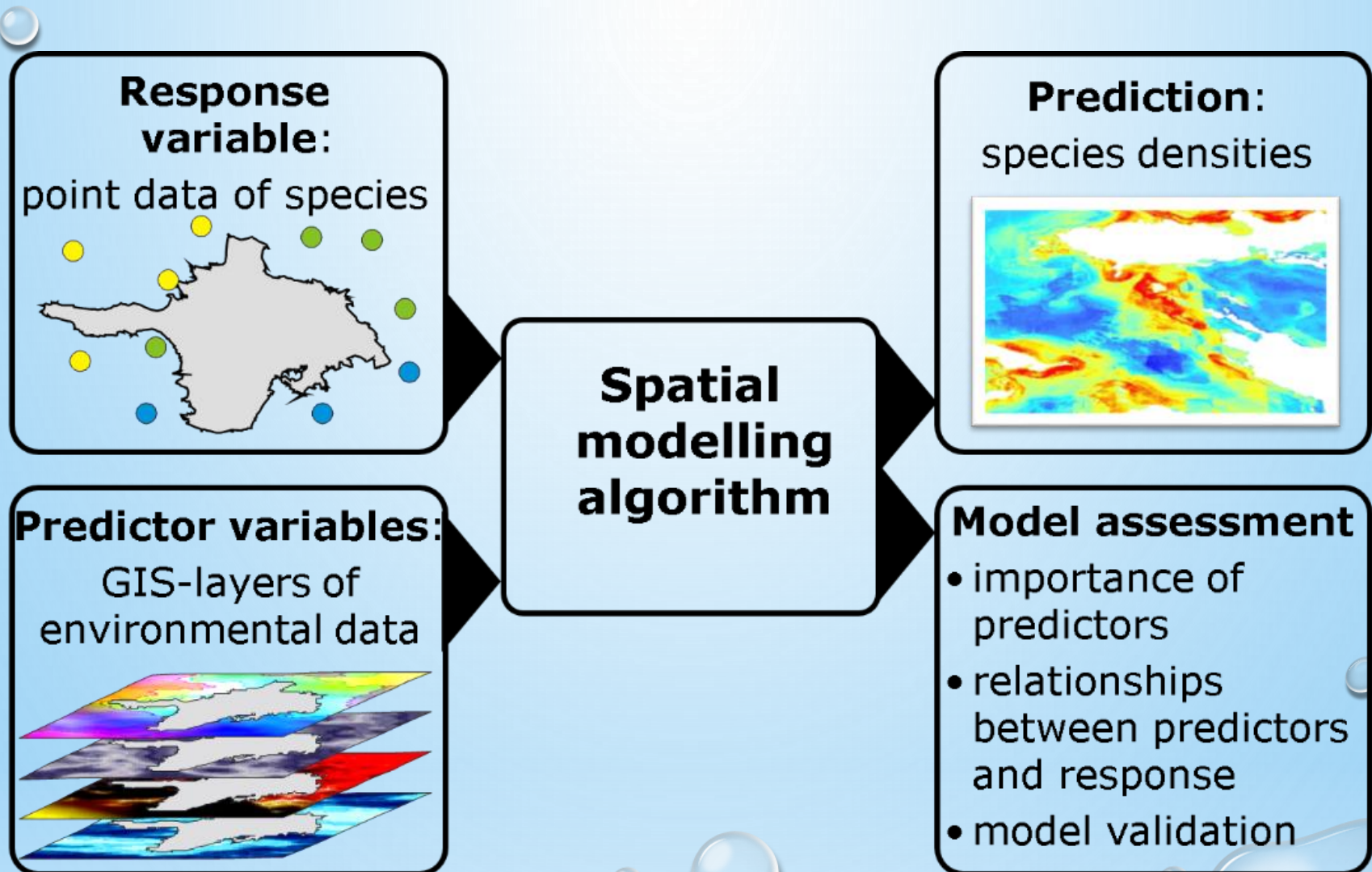
- 1. Updated maps of nature values**
- 2. The best available knowledge on human impacts**
- 3. Innovative algorithm predicting environmental impacts**





Nature values:

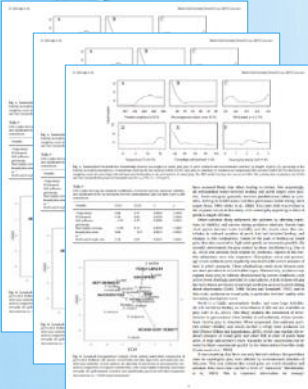
Mapping and spatial modelling of the biota



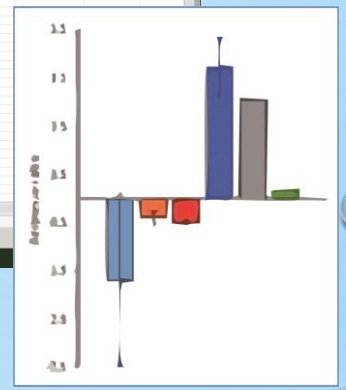
Knowledge inventory: solid data and expert assessment

Nature value ID	env_layer_name	dredging	windpark	fish farming	shipping	underwater cable	commercial fish	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

The screenshot shows an Excel spreadsheet with the following columns: A, B, C, D, E, F, G, H, I, J, K, L, M, N. The data includes environmental layer names (e.g., 'Amstelkanaal'), nature value names (e.g., 'Mussel abundance'), and various metrics (e.g., 'Mussel abundance', 'Herring spawning areas'). The spreadsheet is used for data management and analysis.



Extract data from relevant publications and datasets



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  
pressure indicators  
andmed[is.na(ab)] =0
```

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

Innovative algorithm: Reading scenarios, modelling impacts and publishing maps

```
...y(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

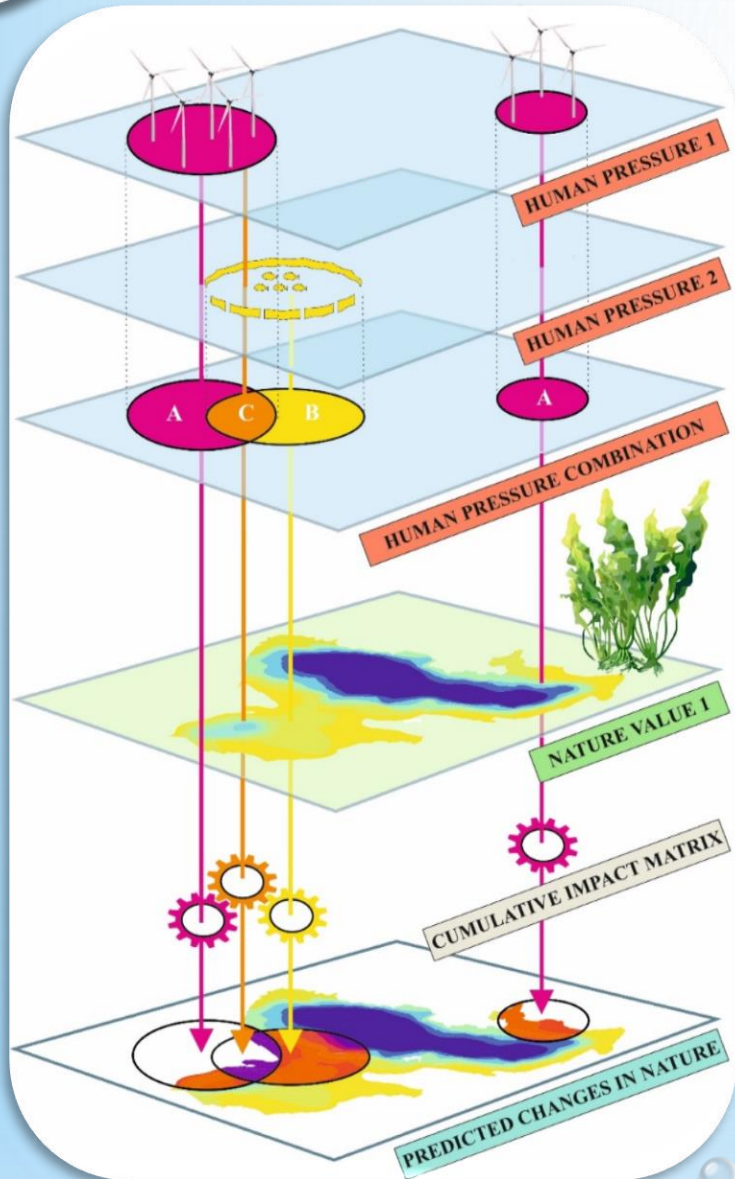
#environment layer names
naturelayers=grep("nv\\_[0-9]+\\_TAB",st_layers(getwd())$name,value=T)

#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

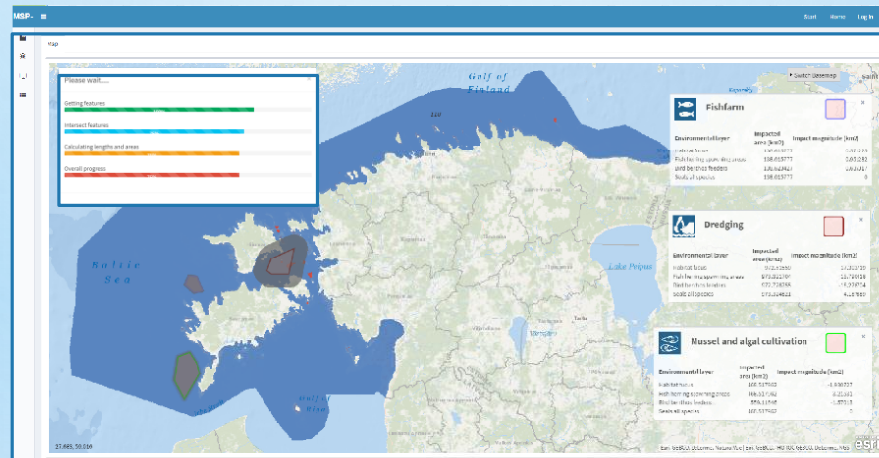


Publishing maps on impacts

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

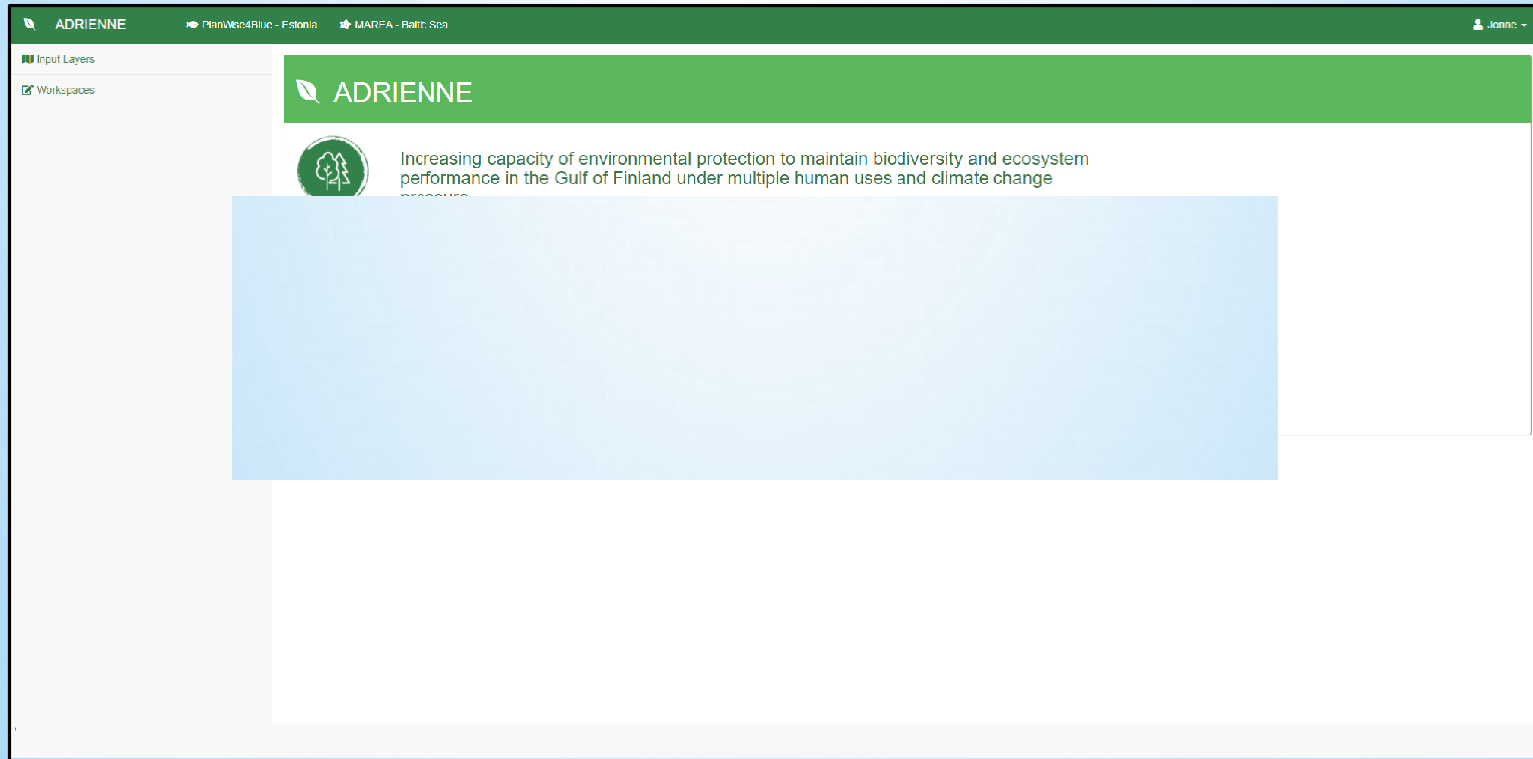
Bird - Benthos feeders
Bird - Fish feeders
Bird - Migration routes
Bird - Wintering areas
Bird - Herbivores
Fish - Herring spawning areas
Fish - Pikeperch spawning areas
Fish - Whitefish spawning areas
Habitat - Charophytes
Habitat - Fucus
Habitat - Furcellaria
Habitat - Higher plants
Habitat - Richness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

Human uses

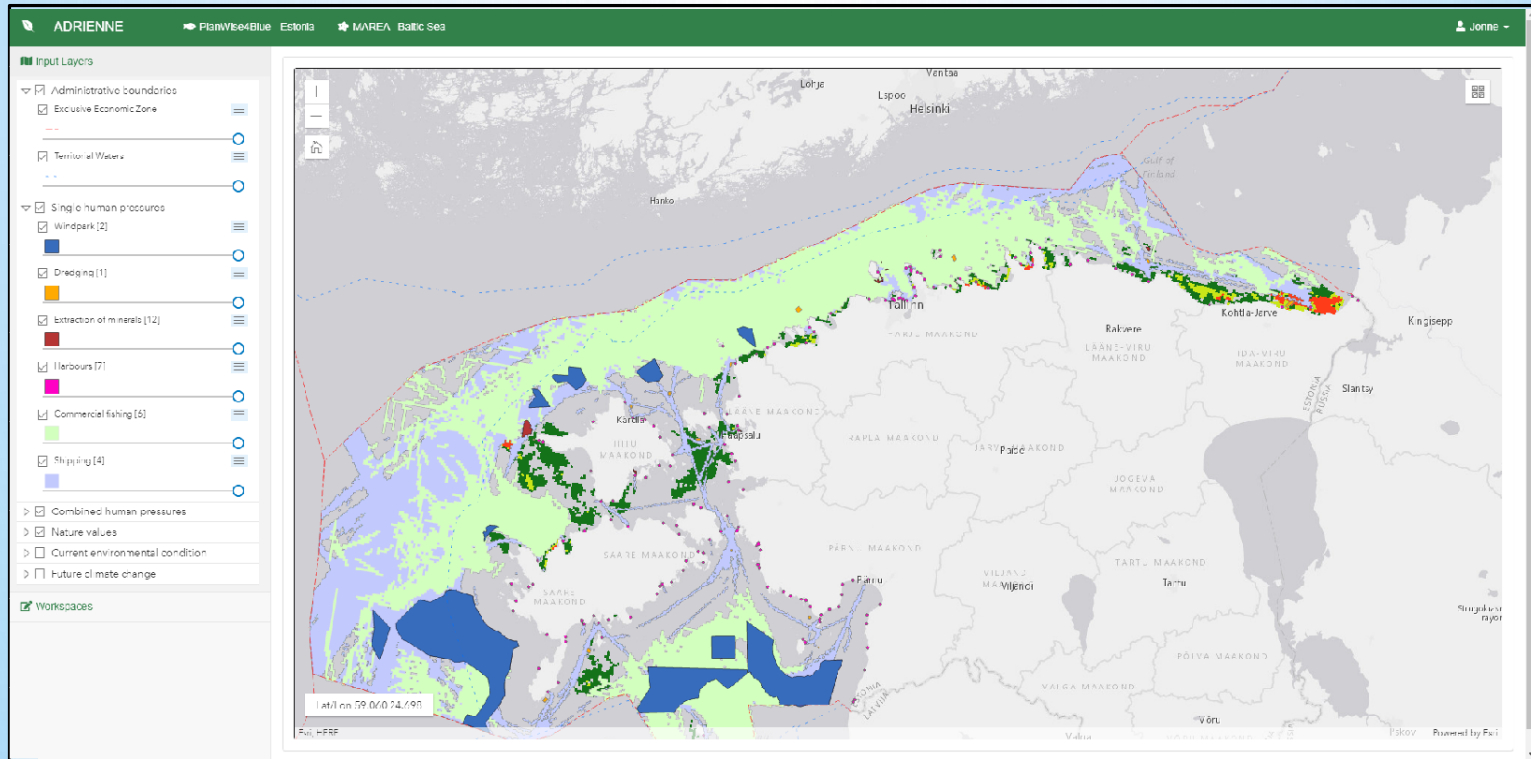
dredging
windpark
fish farming
shipping
underwater cables
commercial fishing
harbours
military activities
wastewater discharge outlet
mussel and algal cultivation
coastal defence
extraction of minerals
marine plant harvesting
tourism and leisure activities
Invasive species - round goby
Invasive species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

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

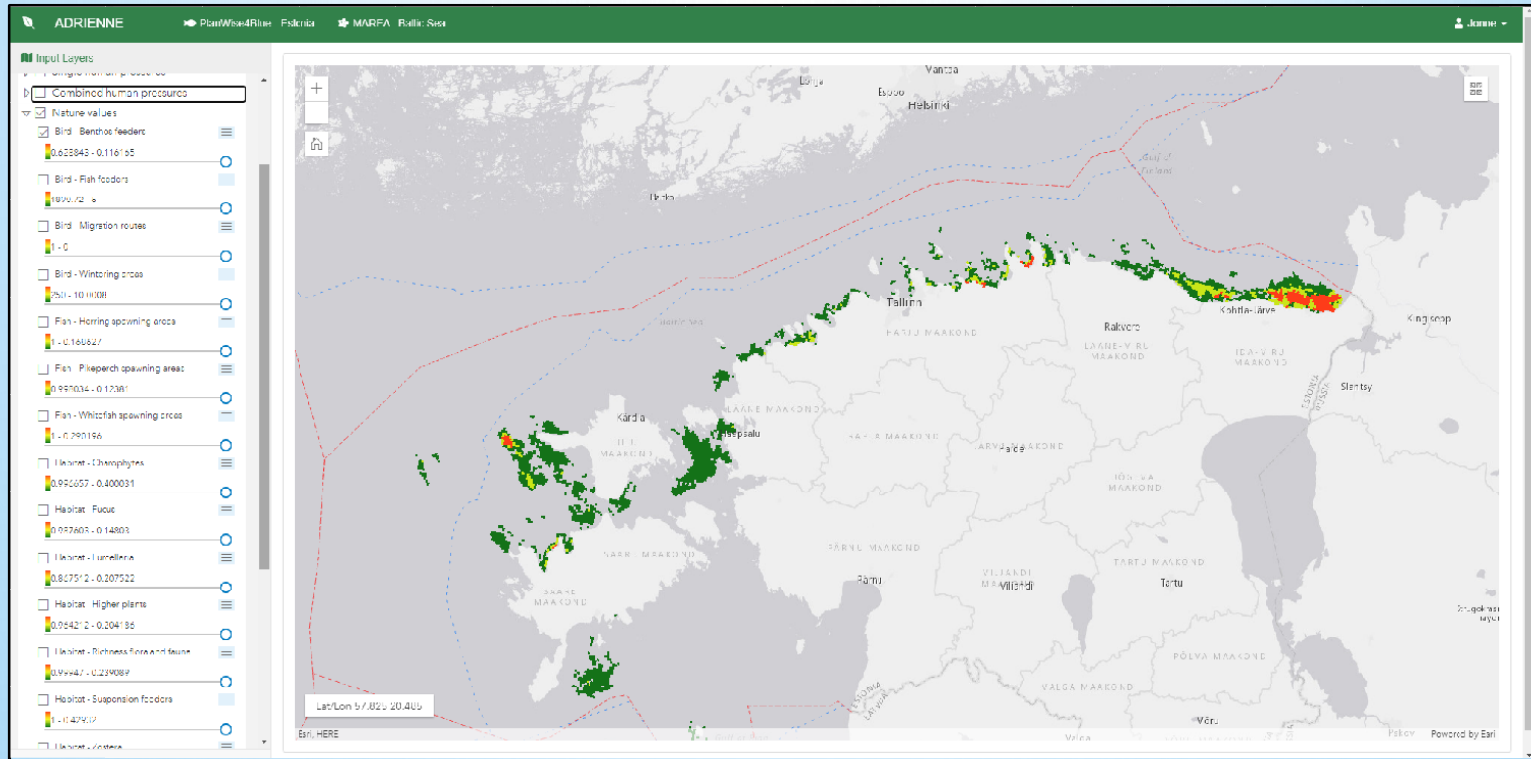
Welcome window



Existing data – maps of human uses

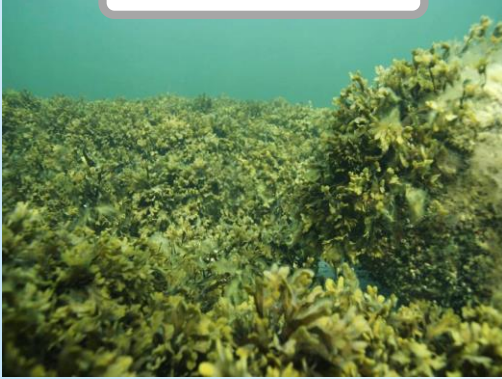


Existing data – maps of nature values



Existing data – maps of nature values

Reefs



Sandbanks



See nature values behind the maps

User-specific workspaces

ADRIENNE PlanWorkspace - Estonia MAREA - Baltic Sea Jorric

Inout Layers

Workspaces

- Single human pressures
 - Windpark [2]
 - Dredging [11]
 - Extraction of minerals [12]
 - Harbour [7]
 - Commercial fishing [6]
 - Shipping [4]
- Nature values
 - Uic - Uenthos reedbeds
 - 0.12845 - 0.116765
 - Uic - Fish reedbeds
 - 0.59022 - 5
 - Bird - Migration routes
 - 0 - 0
 - Dic - Wintering areas
 - 0.20 - 10.0008
 - Fish - Herring spawning areas
 - 0.0168227
 - Fish - Herring spawning areas
 - 0.599234 - 0.12381
 - Fish - Whitefish spawning areas
 - 0.028016

Enter new workspace name +

Workspace	Timestamp
Scenario with windparks	20.10.2020 08:15:30
Scenario without windparks	06.11.2020 11:05:03

Latitude: 61.728251363
Latitude: 59.830126500

Powered by Esri

Workspaces – selecting nature values

The screenshot displays the ADRIENNE web application interface. At the top, the header shows 'ADRIENNE', 'PlanWise4Blue - Estonia', 'MAREA - Baltic Sea', and a user profile 'Jonne'. The main interface is divided into several sections:

- Input Layers:** A sidebar on the left containing a 'Workspaces' section with a 'Nature values' checkbox. Below it, several layers are listed with checkboxes and range indicators: 'Bird - Benthos feeders' (0.628843 - 0.116165), 'Bird - Fish feeders' (1890.72 - 5), 'Bird - Migration routes' (1 - 0), and 'Bird - Wintering areas' (250 - 10.0008).
- Available nature values:** A central panel with a list of nature values and their counts: Bird - Benthos feeders [1], Bird - Fish feeders [2], Bird - Migration routes [3], Birds - Wintering areas [4], Birds - Herbivores [5], Fish - Herring spawning areas [6], Fish - Pikeperch spawning areas [7], Fish - Whitefish spawning areas [8], Habitat - Charophytes [9], and Habitat - Fucus [10]. Navigation arrows (right, double right, left, double left) are positioned to the right of the list.
- Nature values in workspace:** A panel on the right showing the selected values: Bird - Benthos feeders [1], Bird - Fish feeders [2], Bird - Migration routes [3], and Birds - Wintering areas [4]. A 'Save list' button is located to the right of this panel.
- Map:** A map of the Baltic Sea region showing the coastline of Estonia and surrounding areas. Green and red markers are placed along the coast, representing the selected nature values. Labels on the map include Stockholm, Tallinn, Pärnu, Tartu, Kingisepp, and others.

Workspaces – selecting and editing human uses

The screenshot displays the ADRIENNE software interface, which is used for managing human uses in a workspace. The interface is divided into several sections:

- Header:** Shows the user name "ADRIENNE" and the project name "PlanWise4Blue - Estonia" with a sub-project "MAREA - Baltic Sea".
- Input Layers:** A list of input layers with checkboxes, including "Extraction of minerals [14]", "Harbours [8]", "Windpark [2]", "Dredging [1]", "Pelagic trawling [6]", and "Shipping [4]".
- Workspaces:** A section for managing workspaces, currently empty.
- Human Uses Management:** Two lists are shown:
 - Available human uses:** A list of human uses with their counts: Dredging [1], Windpark [2], Fish farming [3], Shipping [4], Underwater cables [5], Pelagic trawling [6], Benthic trawling [7], Harbours [8], Military activities [9], and Wastewater discharge outlet [10].
 - Human uses in workspace:** A list of human uses currently in the workspace: Shipping [4], Pelagic trawling [6], Dredging [1], Windpark [2], Harbours [8], and Extraction of minerals [14].
- Map:** A map of the Baltic Sea region showing the coastline of Estonia and surrounding areas. The map is overlaid with a grid and colored areas representing human uses. The colors include light green, dark green, and blue. Key locations labeled on the map include Turku, Helsinki, Tallinn, Pärnu, Tartu, and Saint-Petersburg.
- Buttons:** There are two main buttons: "Apply Edits" (blue) and "Build combinations" (orange).

Workspaces – running cumulative impact models based on custom data

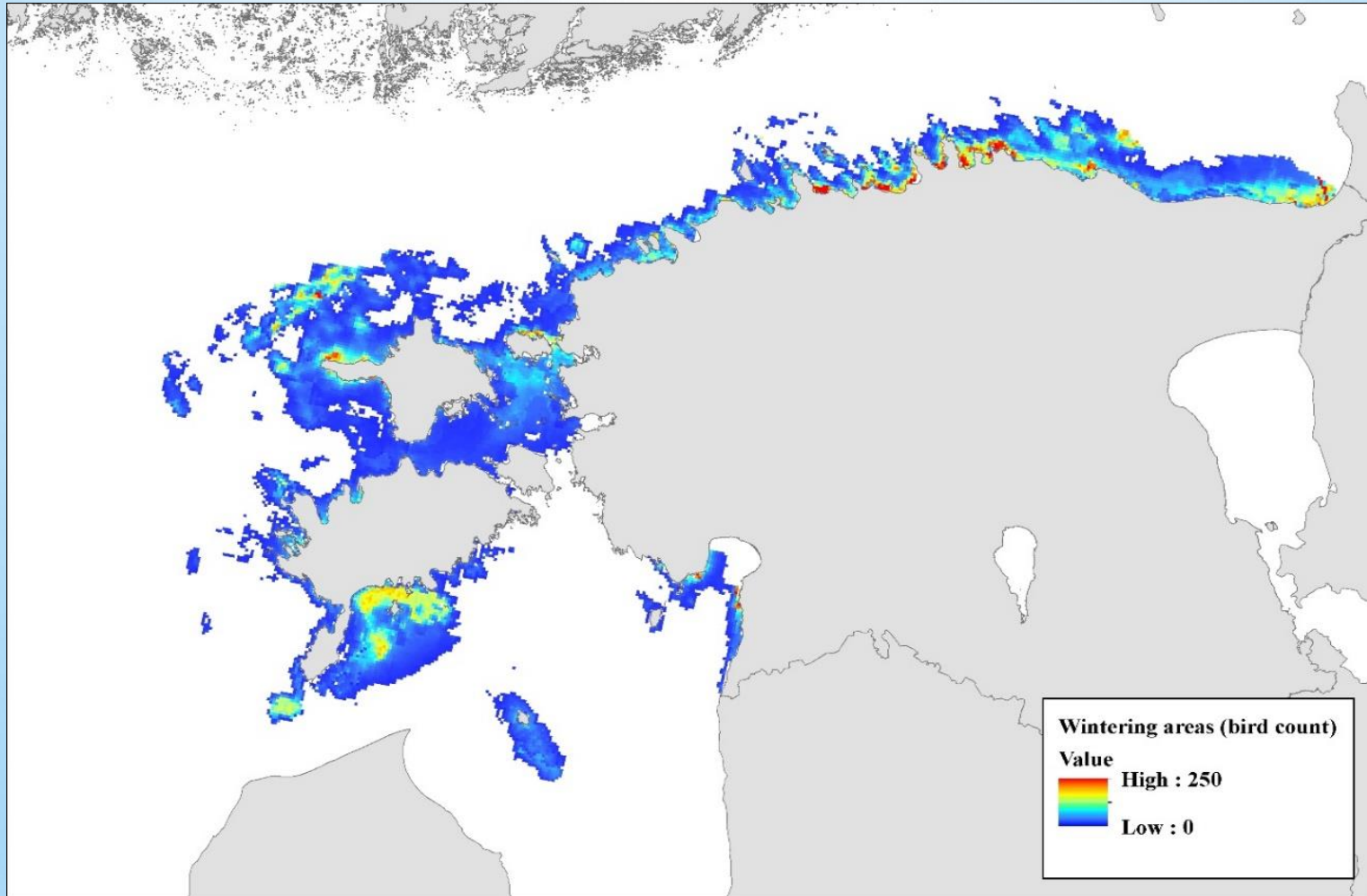
The screenshot displays the ADRIENNE software interface, which is used for running cumulative impact models. The interface is divided into several sections:

- Input Layers:** A sidebar on the left lists various input layers, categorized into "Workspaces", "Single human pressures", and "Nature values". Each layer has a checkbox and a color-coded legend.
- Workspace Management:** A central panel allows users to create and manage workspaces. It includes a text input for "Enter new workspace name...", a "Workspace name" field (currently "Scenario with windparks"), and a "Timestamp" field (currently "28.10.2020 08:15:33"). A table below lists existing workspaces:

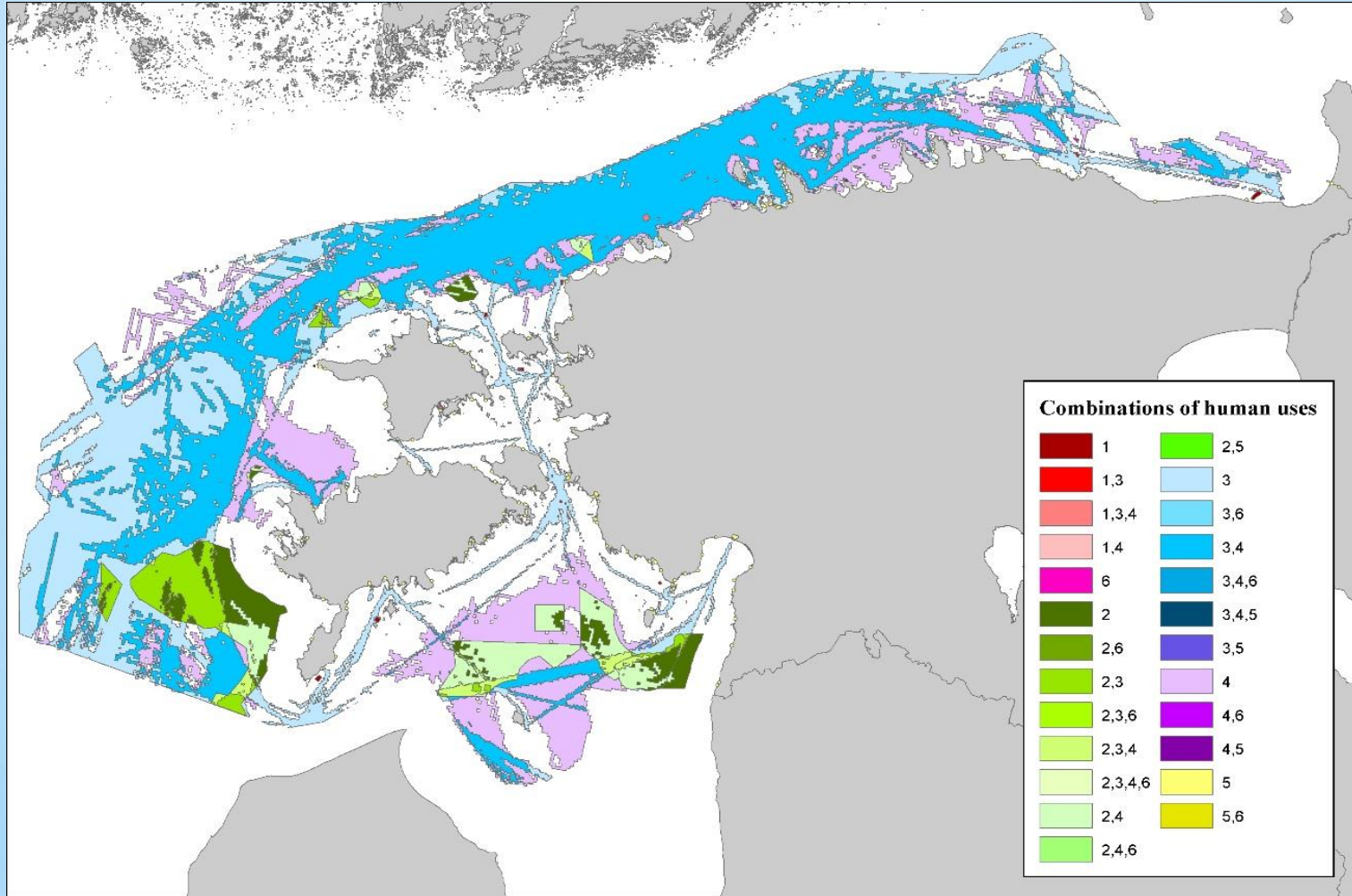
Workspace	Timestamp
Scenario with windparks	28.10.2020 08:15:33
Scenario without windparks	06.11.2020 11:09:03

- Model inputs:** Buttons for "Edit Human Uses" and "Edit Nature Values" are provided.
- Human impact calculation:** Buttons for "Run model" and "View results" are available.
- Maps:** Two side-by-side maps of the Baltic Sea region are shown. The left map displays the "Scenario without windparks" with a light green overlay, while the right map displays the "Scenario with windparks" with a darker green overlay, indicating higher cumulative impact. Both maps show major cities like Helsinki, Tallinn, and Stockholm, and geographical features like the Gulf of Finland.

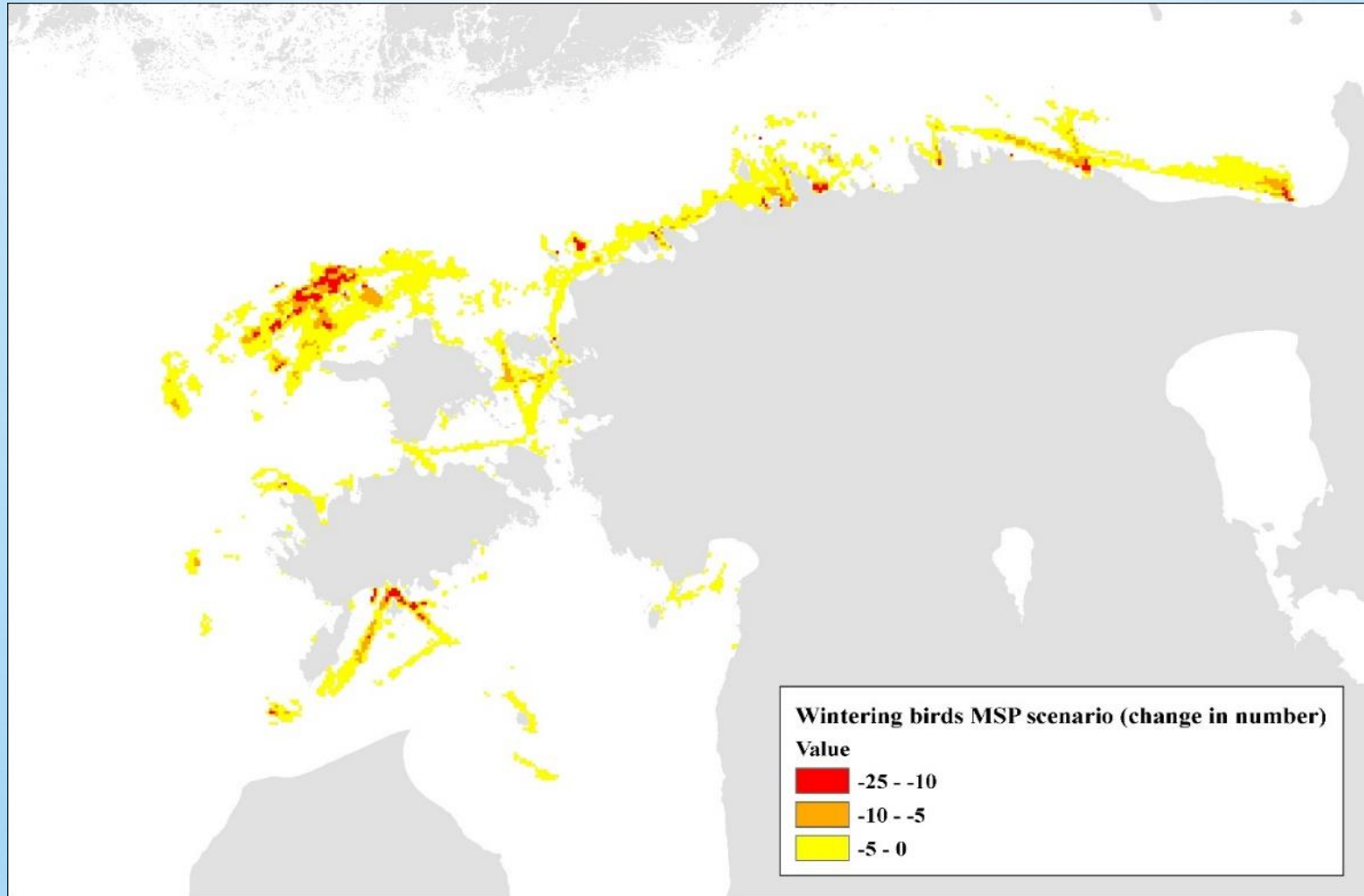
ESTONIAN MARITIME SPATIAL PLANNING



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

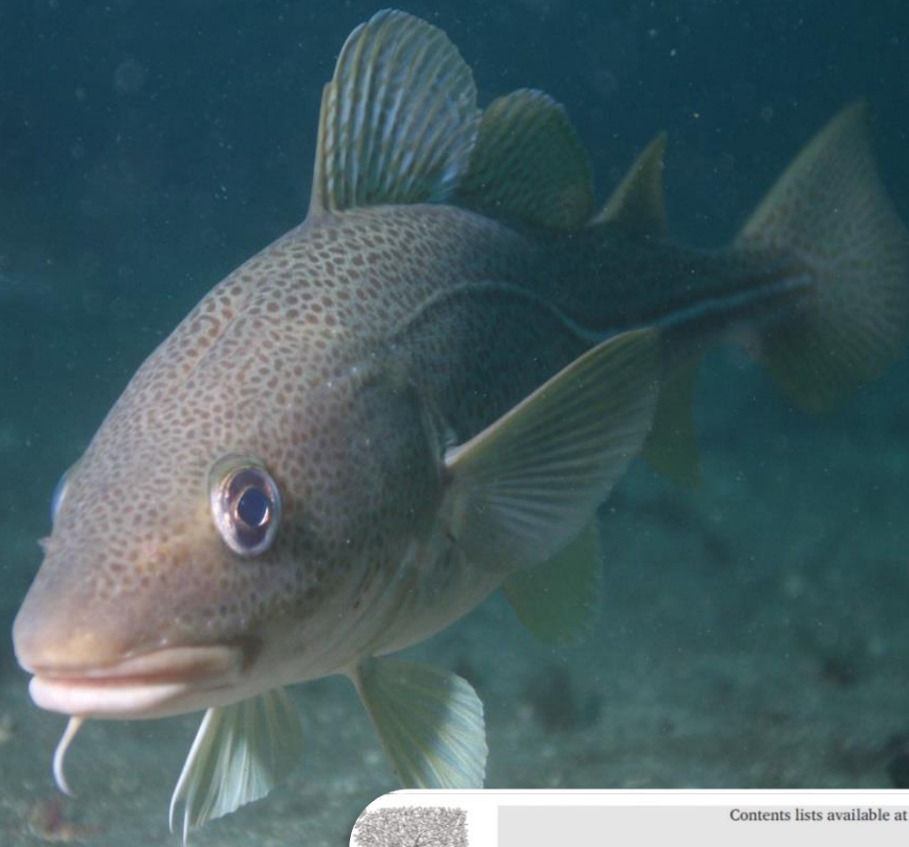
We add climate change and nutrient reduction scenarios by December 2021

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>



Contents lists available at ScienceDirect

Environmental Advances

journal homepage: www.elsevier.com/locate/envadv



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



J. Kotta*, M. Fetissov, R. Szava-Kovats, R. Aps, G. Martin

Estonian Marine Institute, University of Tartu, Mõeluse 14, Tallinn 12618, Estonia