

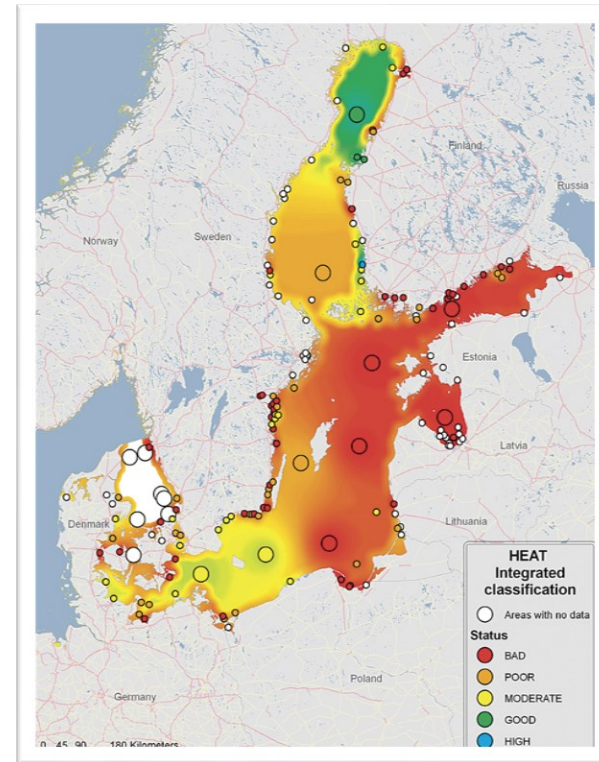
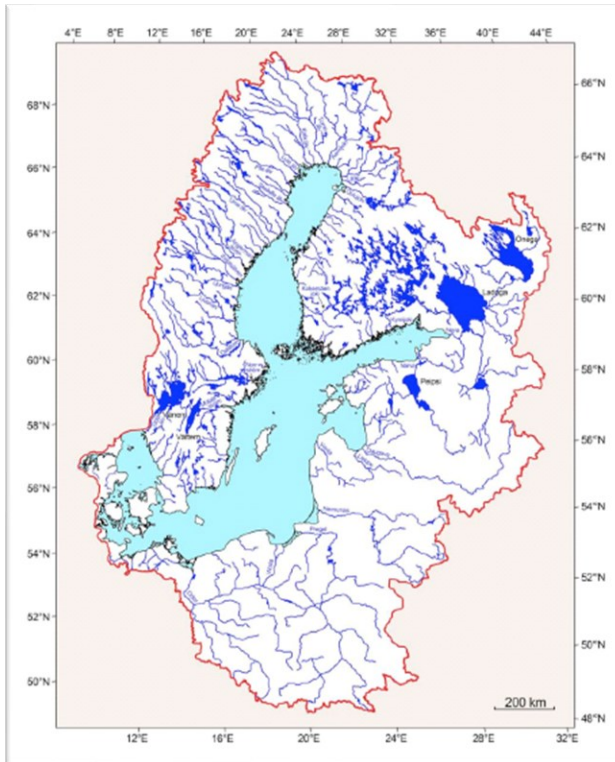


Potential use of algae and invertebrates for nutrient sequestration and removal from the Baltic Sea

Jonne Kotta

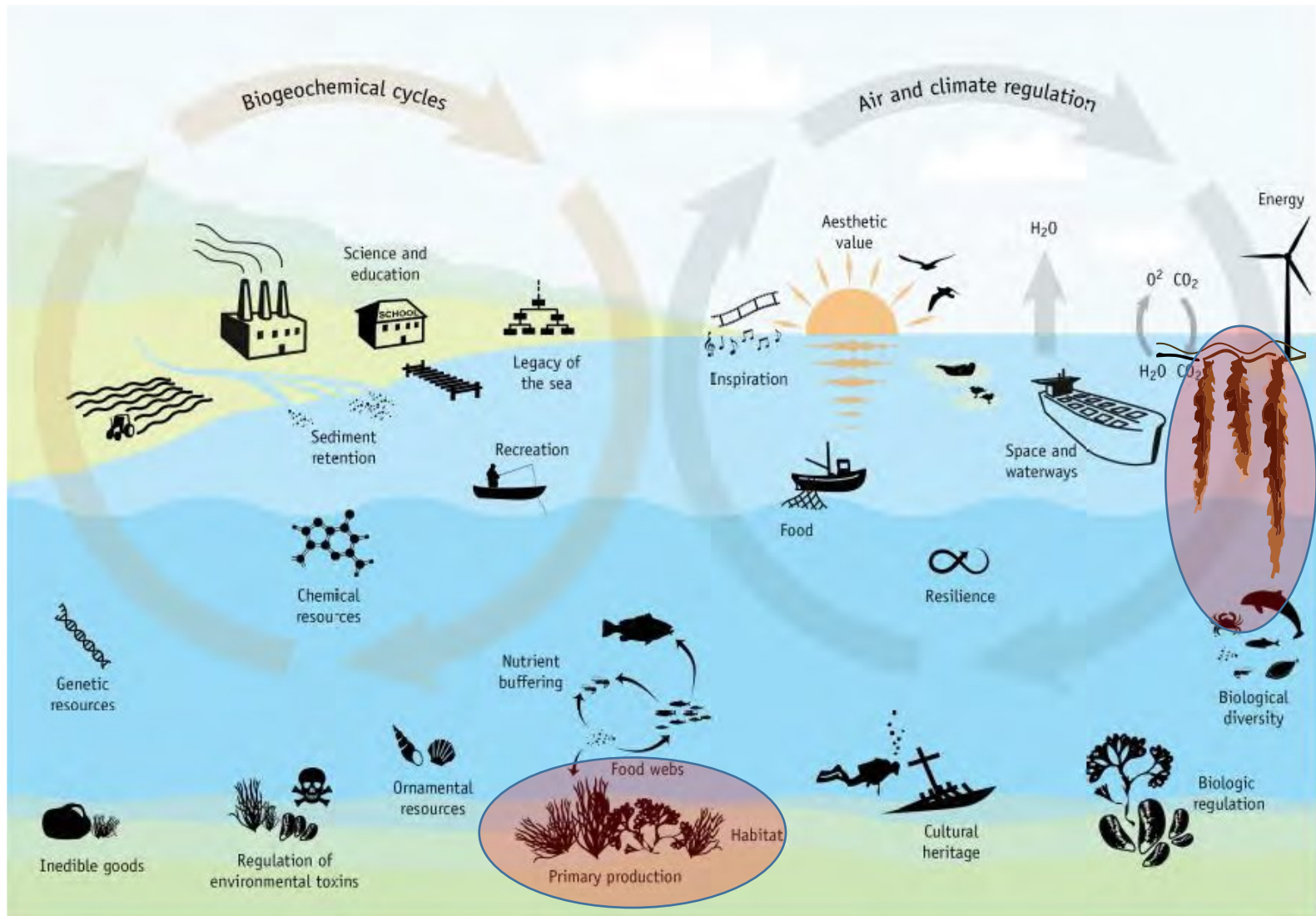
Estonian Marine Institute, University of Tartu

Large watershed area & legacy nutrients → eutrophication problems



Source: HELCOM

Ecosystem goods and services provided by the Baltic Sea ecosystem



Source: BalticSTERN 2013

The need for process-based and quantitative estimations of ecosystem services

Most of our *current understanding of the spatial flow of services* from marine ecosystems relies on the *presence of structural components of ecosystems and the qualitative* (or semi-quantitative) *assessment of their contributions* to specific services.

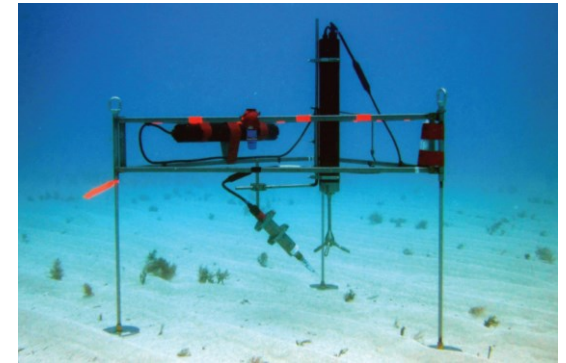


Photo by Uli Kunz

Source: Inácio et al. (2020)

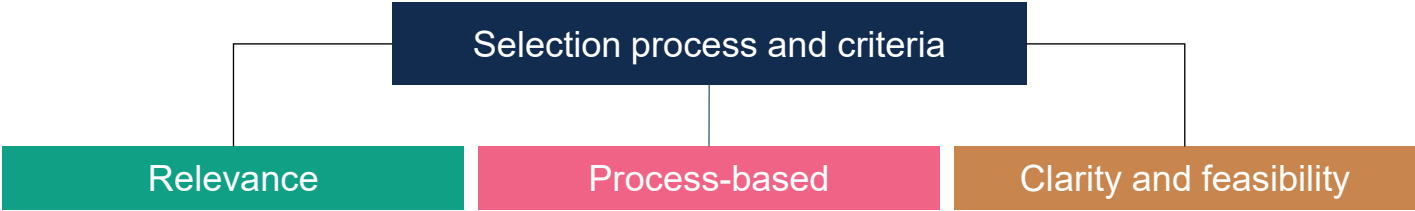
The need for process-based and quantitative estimations of ecosystem services

Spatially-defined and quantitative estimates of the flow of marine ecosystem services are needed more than ever *if we want to assess and predict expected changes of various management scenarios under current and future climate conditions.*



Source: Wahl et al. (2015), Pansch and Hiebenthal (2019), Berg et al. (2022)

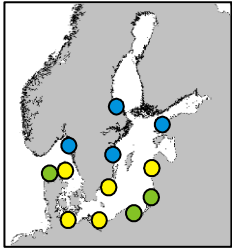
The need for process-based and quantitative estimations of ecosystem services



General modelling approach

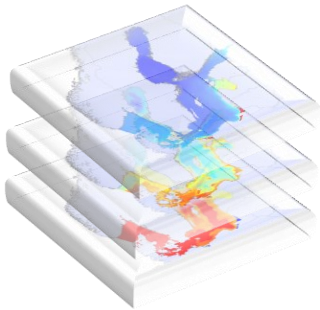
Structure:

e.g., **point data** of species biomass



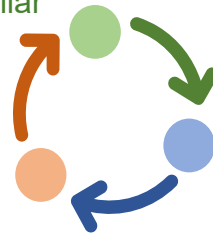
Environment:

GIS-layers of environmental data



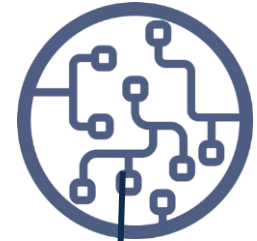
Functioning:

e.g., primary production, nutrients assimilation and content, growth
deploying **Dynamic Energy Budget** modelling and similar



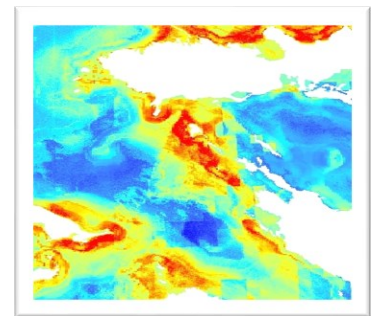
Machine learning

e.g., **BRT**

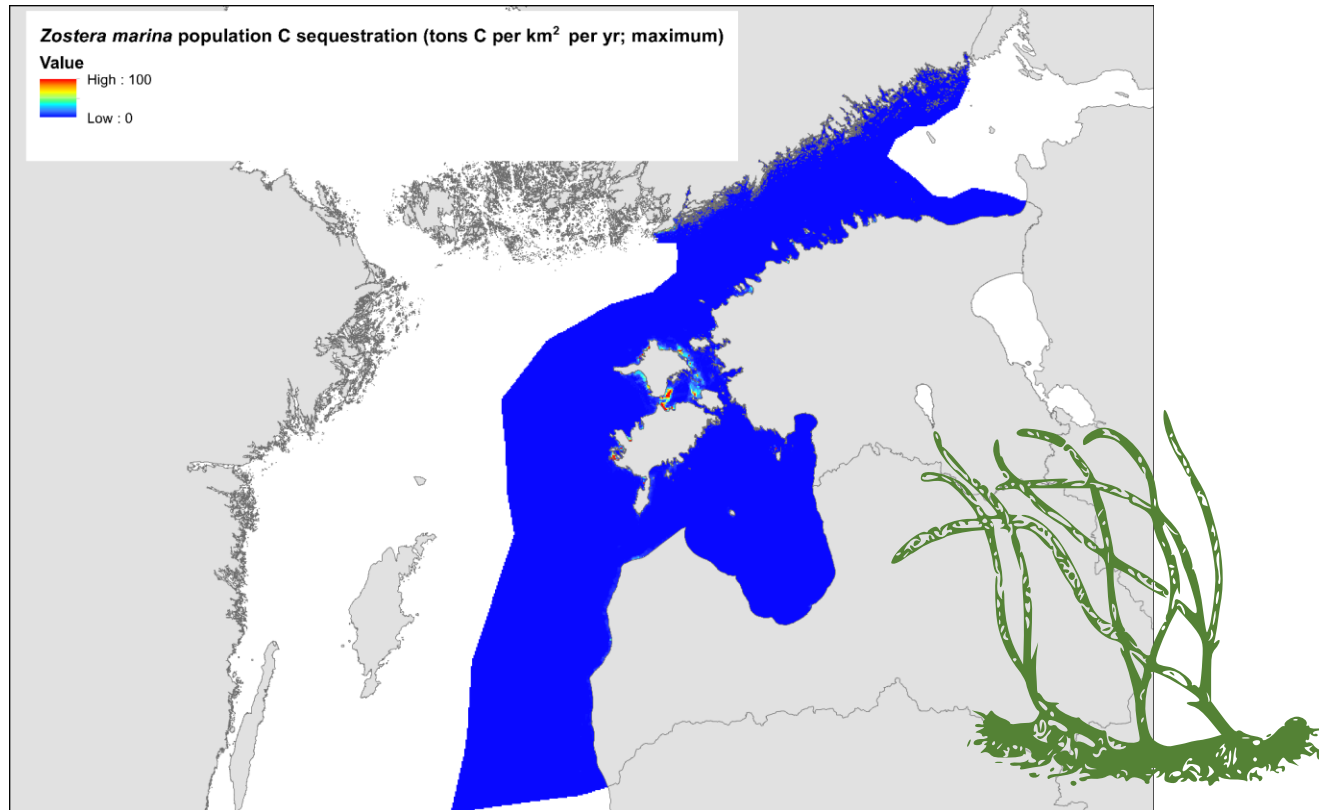


Spatial prediction:

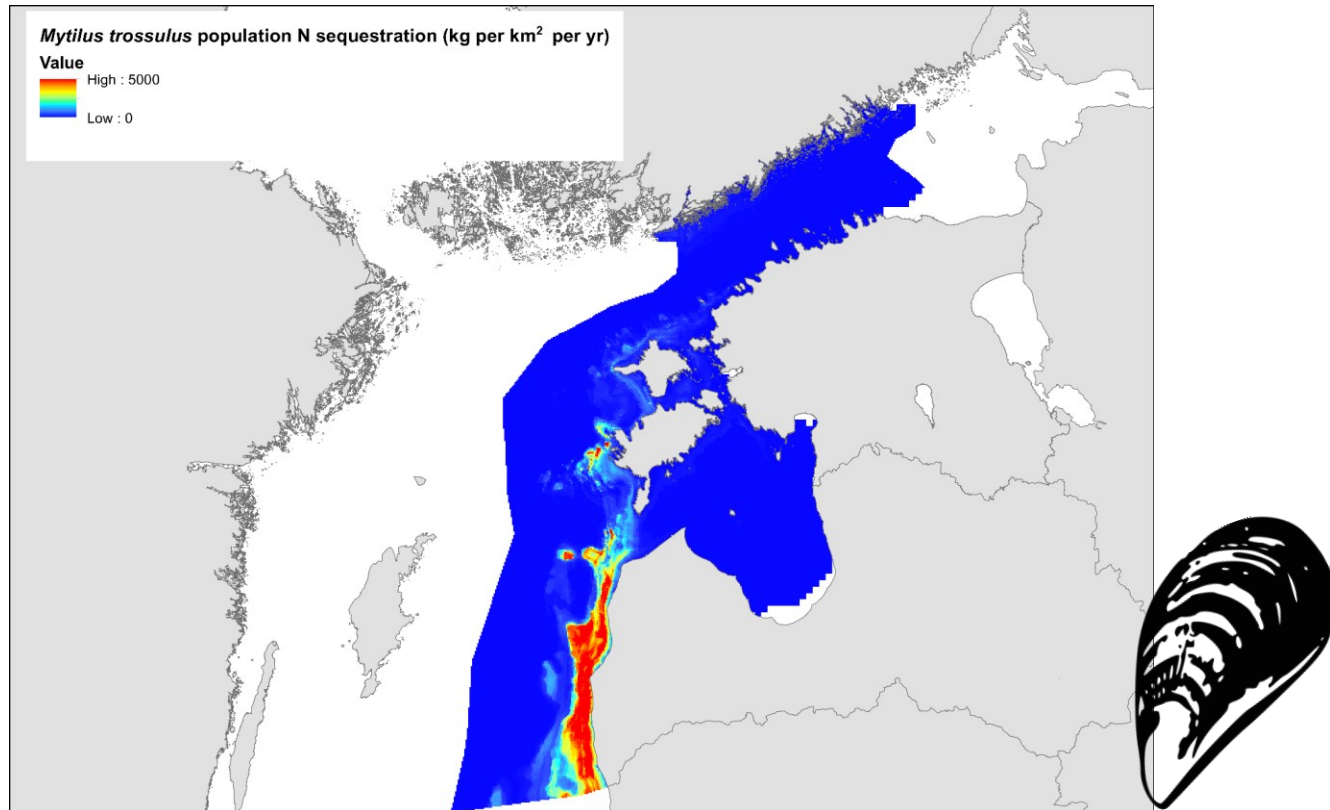
e.g., **NPC sequestration** maps



Regulating and maintenance



Regulating and maintenance

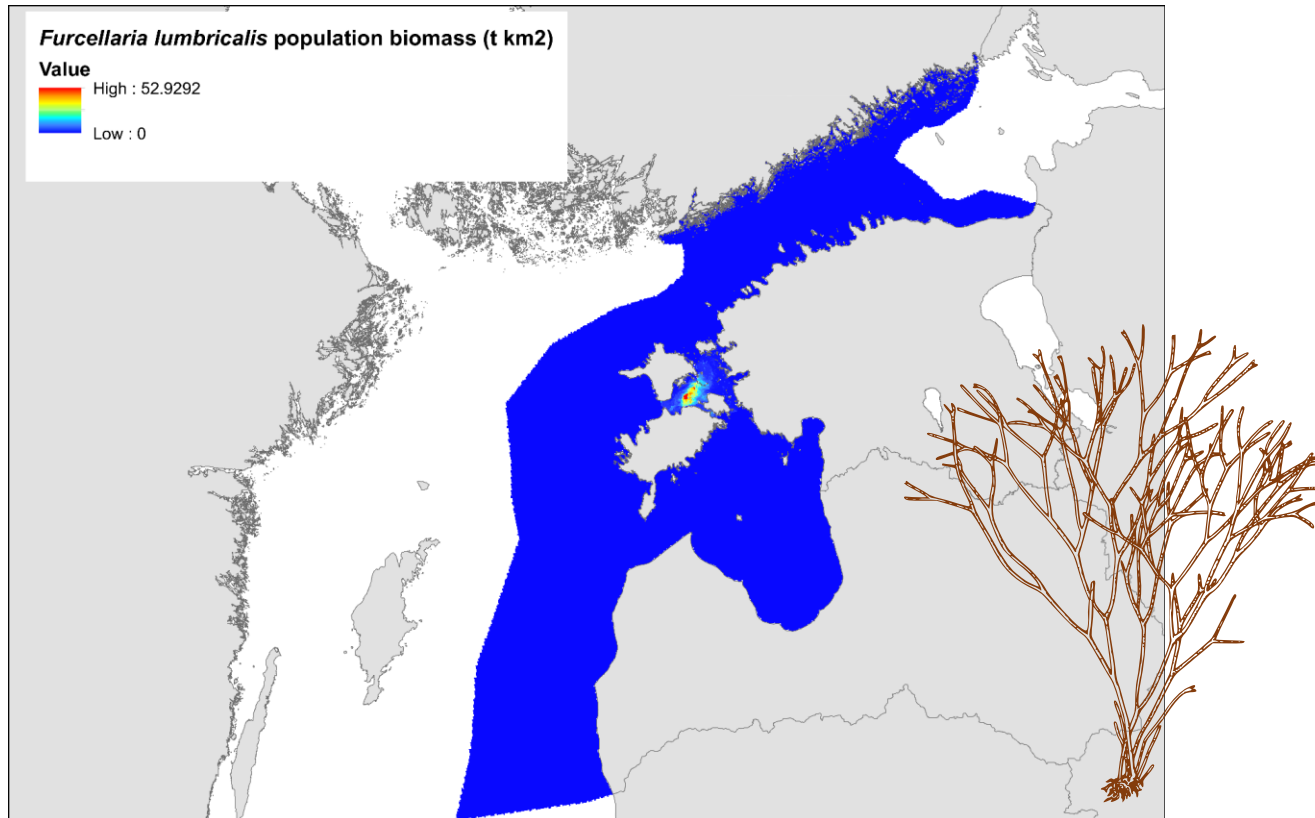


Accelerate blue economy solutions

(1) Economic benefits + (2) Restoring valuable habitats



Provisioning services (harvesting)



Source: BalticSTERN 2013

A potential of algal and mussel farming

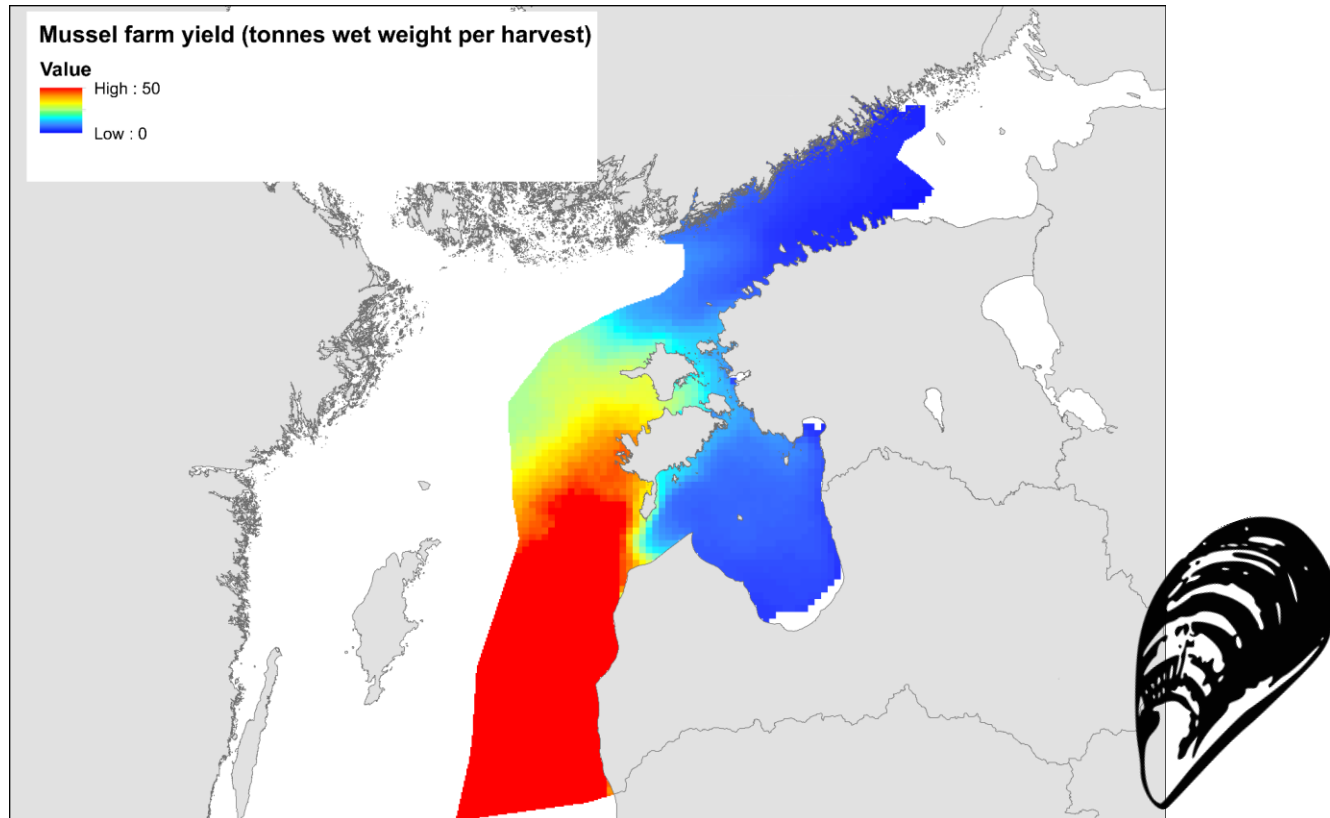
legacy

NP



$$\text{NP}_{\text{farm yield}} = \text{NP}_{\text{content}} \times \text{growth}$$

Provisioning services (cultivation)

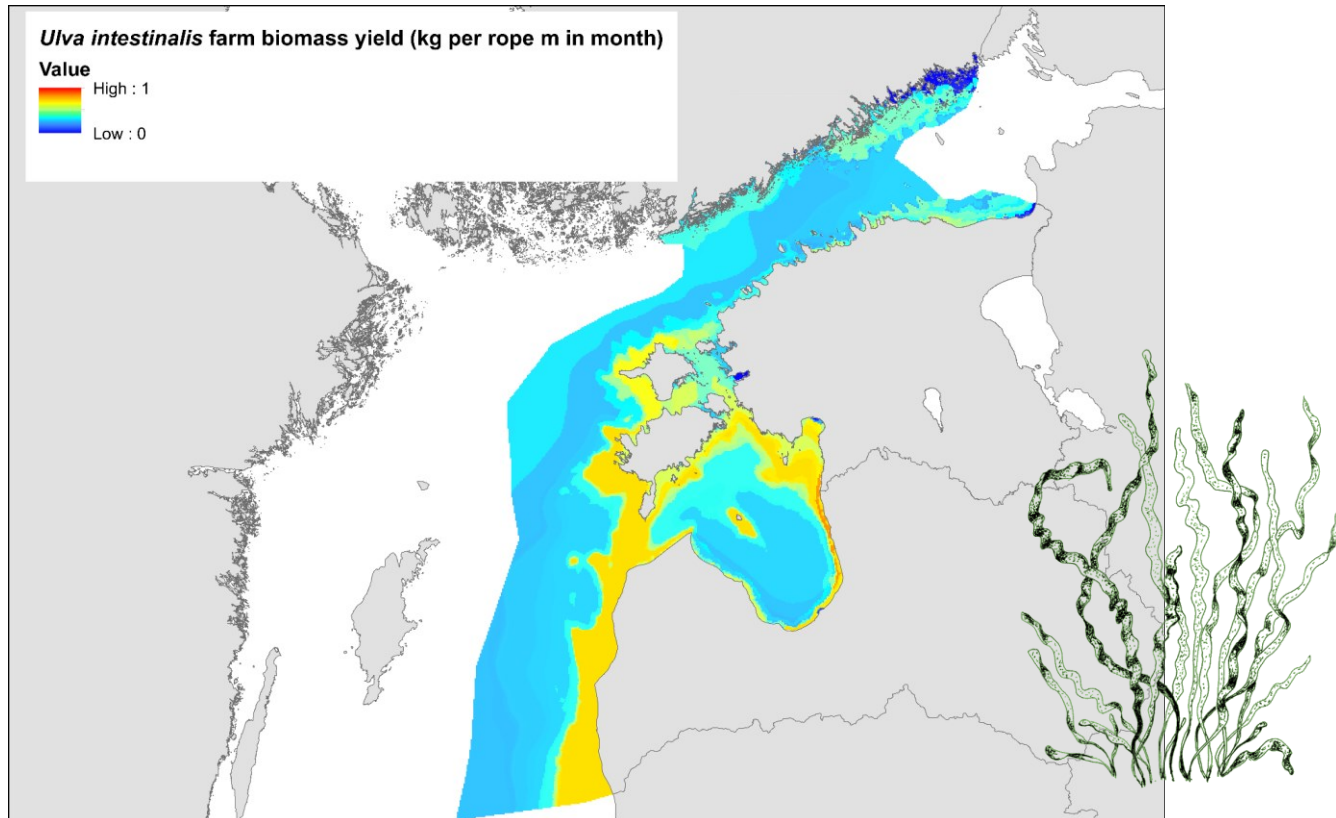


Blue innovation (small mussels)

1. Optimize farming and harvesting technology
2. Low energy meat extraction

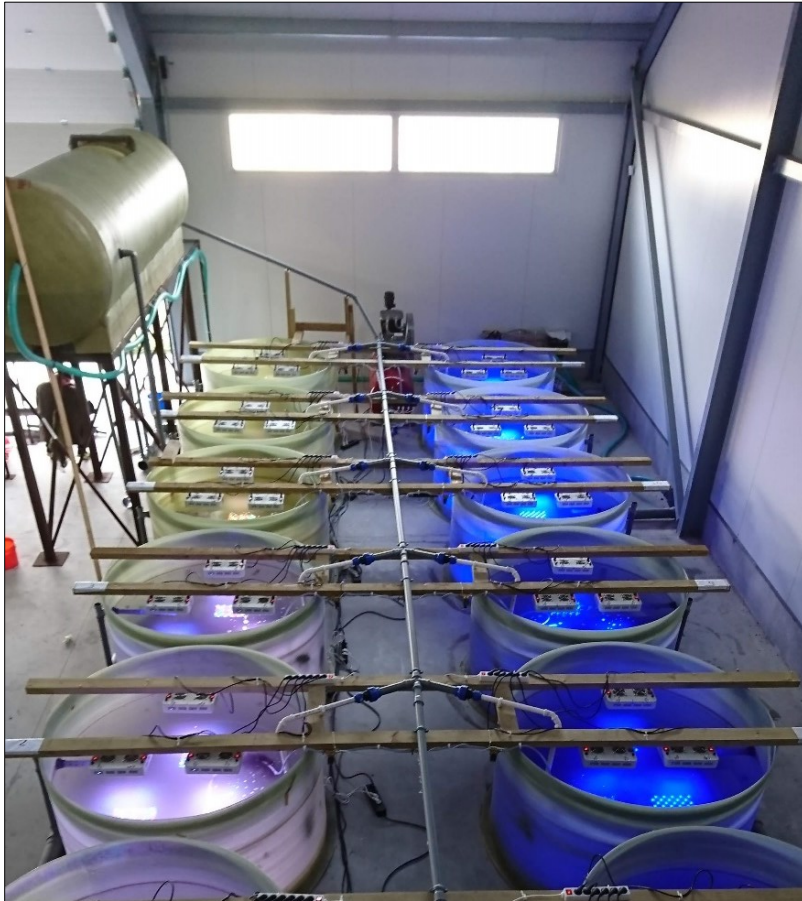


Provisioning services (cultivation)



Blue innovation (first cultivation trials)

Cultivation on land and at sea



ODSS – Operational Decision Support System

BBG
GRASS

Menu ▾



Interreg
Baltic Sea Region
Baltic Blue Growth

EUROPEAN UNION
EUROPEAN
REGIONAL
DEVELOPMENT
FUND

Initiating full scale mussel farming in the Baltic Sea
Baltic Blue Growth establishes fully operational mussel farms to counteract eutrophication and create new blue growth opportunities.

Operational Decision Support System (ODSS)

The application for the Baltic blue mussel and macroalgal farming - a platform enabling upload, analysis and sharing of information



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GRASS: Growing Algae Sustainably in the Baltic Sea

<http://www.sea.ee/bbg-odss>

ODSS – Operational Decision Support System



Helps different end-users to **make effective decisions about algal and mussel farming in the Baltic Sea**

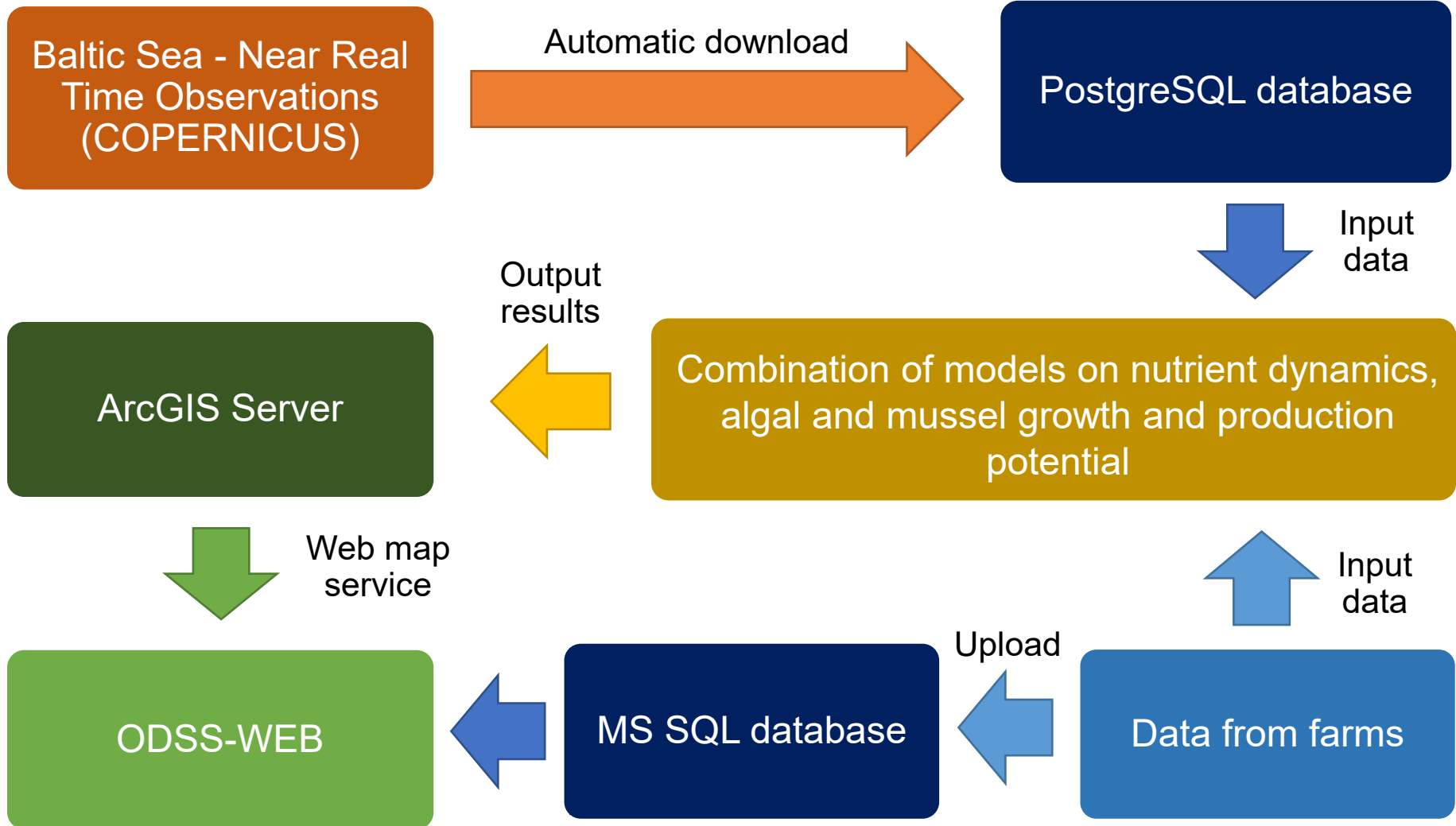


These decisions are **based on the best monitoring and modelling data**



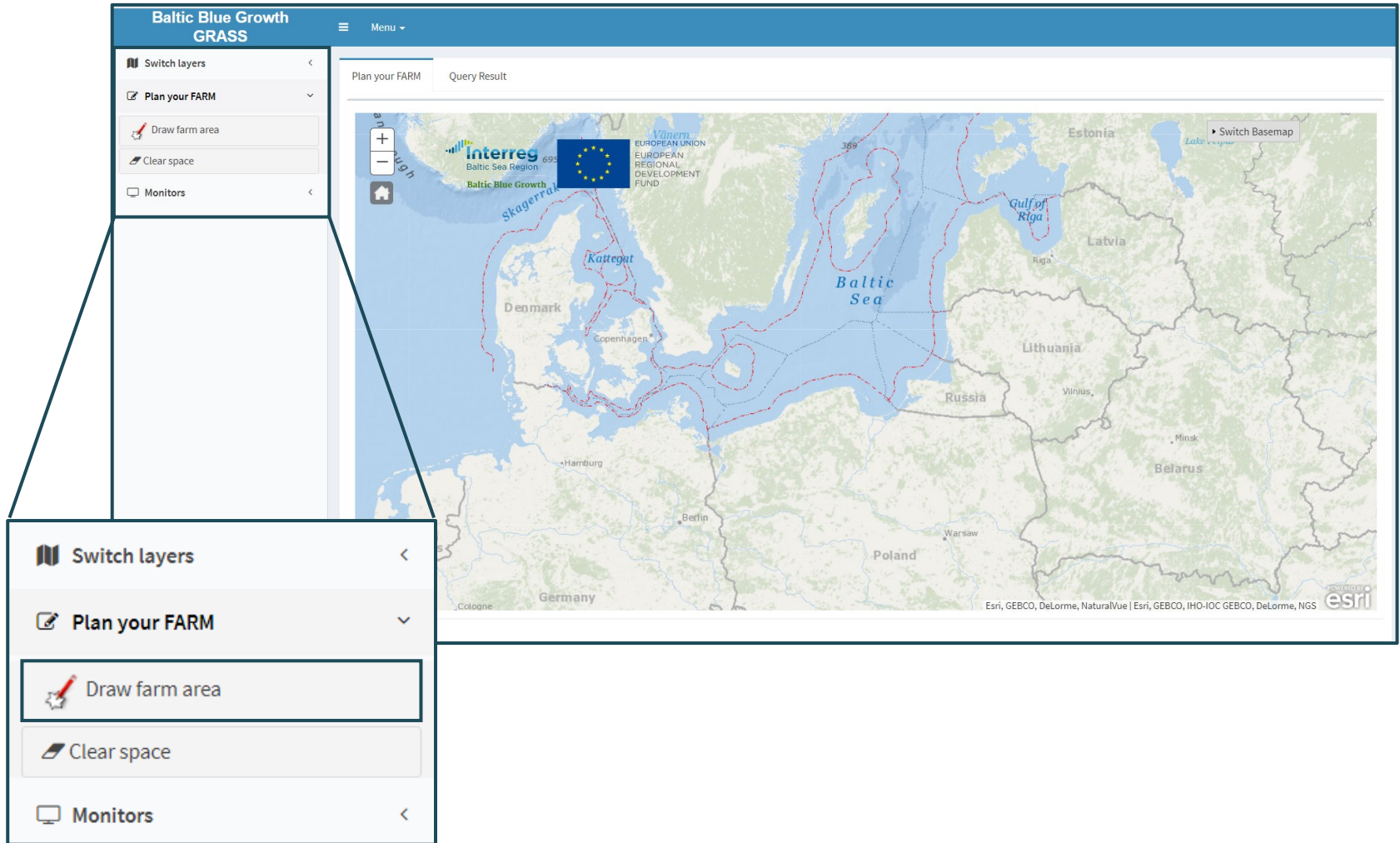
Raises the capacity of different users to **make decisions along the environmental, economic and socio-economic dimensions of LTA**

ODSS data flow



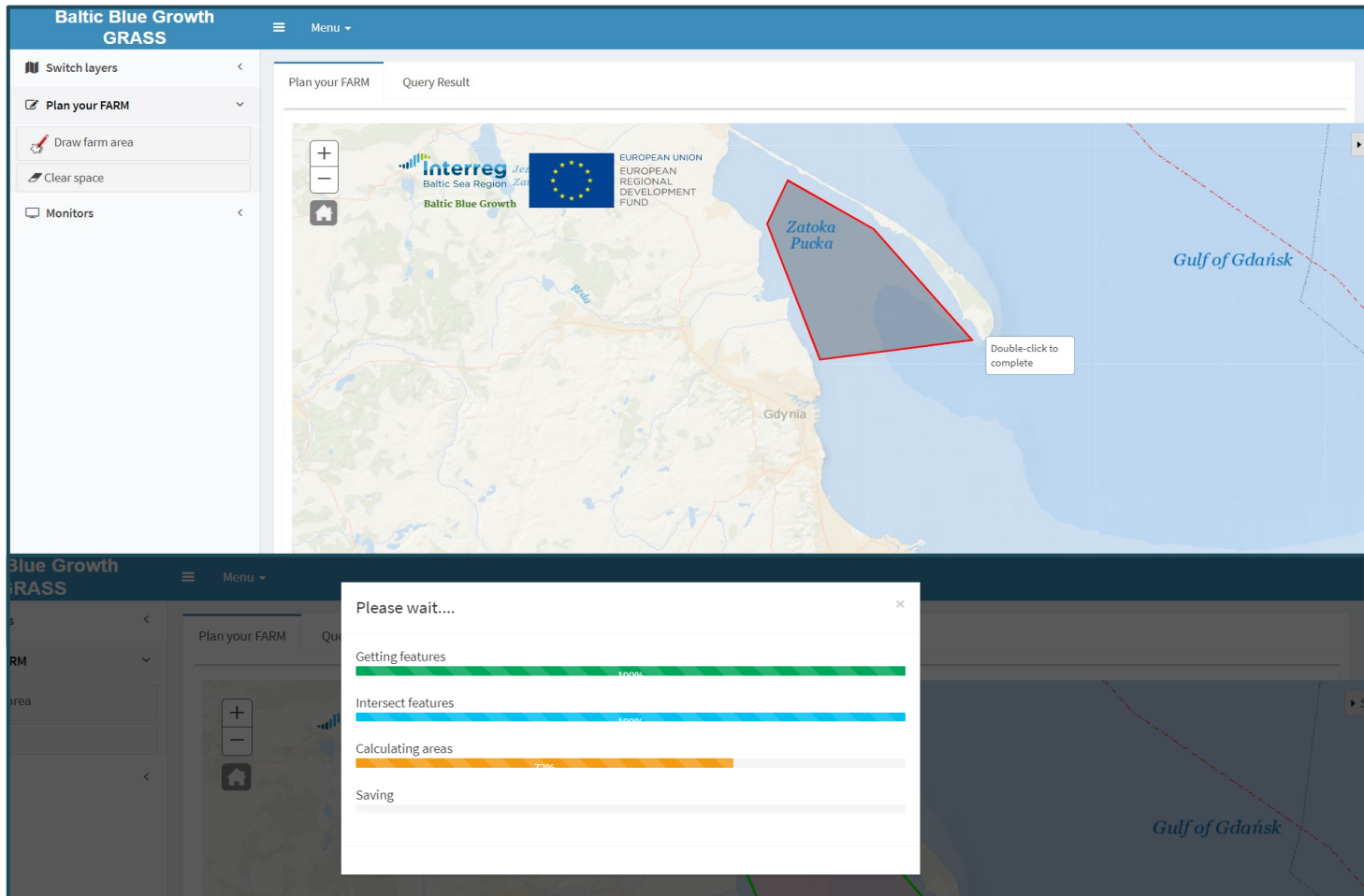
ODSS in action

Draw the area of the farm using the integrated tool



ODSS in action

Given the selected area the tool will gather the associated information and calculate the features of the planned farm



ODSS in action

Human activities - current use

Name	Average	Area (km2)	Percent (%)	Count
Pipelines				10
Fishing effort all gear types 2013	3.86	69.56	34.89	7
AIS Shipping Density (2016)	5.07	199.43	100	78

Baltic Blue Growth GRASS

Plan your FARM Query Result

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Physical features

Name	Average	Area (km2)	Percent (%)	Classes
Sediments				Mud,Hard bottom complex,Sand
Summer chlorophyll (mg m-3)	2.92			
Salinity (psu)			7.5 - 11 psu	
Simplified wave model (m2 s-2)	4113.23			
Temperature (°C)	18.19			
Baltic Sea Ice		190.33	95.47	

Nutrient removal, mussel and algal growth (model)

Name	Average	Area (km2)
N Removal by mussels (Mytilus, g/m rope @ 2 years)	0	199.42
P Removal by mussels (Mytilus, g/m rope @ 2 years)	0	199.42
Mussel growth (kg/m rope @ 2 years)	1.47	199.42
Fucus growth (daily growth rate in %)	0.62	199.42
Ulva growth (daily growth rate in %)	11.38	199.42
Areal N removal estimate by alga (Fucus)	54.05	199.42
Areal P removal estimate by alga (Fucus)	10.81	199.42
Areal N removal estimate by alga (Ulva)	278.03	199.42
Areal P removal estimate by alga (Ulva)	42.69	199.42

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PlanWise4Blue to run cumulative impact assessment analyses

Home PW4B - Estonia PW4B - Estonia vers 2021 PW4B - Gulf of Finland Home Log in

Input Layers
Sustainability compass
Cumulative impact model

MAREA

MAREA v.2 - Cumulative Effects Assessment
Mihhail Fetissov

system accounting to integrated governance for sustainable planning of marine and coastal areas

SUMMARY OF THE PROJECT

The ecosystem-based approach to policy for the integrated management of land, coastal and living resources that promotes their conservation and sustainable use in an equitable way, EBM, is a cornerstone of marine law. It provides a tool to guide there is no clear guidance on how to implement it in practice, for instance, in the maritime spatial planning processes.

Ecosystems are linked to human well-being through the flow of ecosystem services, i.e. the benefits the marine environment and its resources deliver to society such as, the production of commercially exploitable bioresources. A local integration of society and ecosystem results in a development of economic activities from the functioning of ecosystems. Current ecosystem approaches hardly capture the cumulative impact of different human activities on ecosystem services thereby failing in the achievement of sustainable use of natural resources.

The MAREA project will develop and test novel concepts of ecosystem services mapping, environmental accounting and sustainability assessment, as well as novel tools, which will be the PlanWise4Blue portal capable of supporting sustainable planning solutions in two transitional pilot areas: Finland-Estonia in the Gulf of Finland and Estonia-Latvia in the Gulf of Riga.

The main result of the MAREA will be: (1) the realisation of a system of accounting of marine environment and the benefits they deliver, which in terms of regulating services for climate and ecosystem sustainability; and (2) a connected model of integrated sustainable governance in the use of natural resources and marine space. The ecosystem accounting models as well as sustainability assessment tools developed and applied through participatory learning including multi-stakeholder engagement the MSP and marine management planning, environmental impact and general public.

Interreg Central Baltic
EUROPEAN UNION European Regional Development Fund

04:00 vimeo

on and sustainable use in an
e, in the maritime spatial planning

deliver to society such as, the
from the functioning of ecosystems.
achievement of sustainable use of

ment as well as embed these
in the Gulf of Finland and Estonia-

terms of regulating services for
marine space. The ecosystem
responsible for MSP and marine

<https://gis.sea.ee/marea>

PlanWise4Blue in action

The screenshot displays the PlanWise4Blue web application interface. At the top, a teal navigation bar contains a home icon, three workspace tabs labeled 'PW4B - Estonia', 'PW4B - Estonia vers 2021', and 'PW4B - Gulf of Finland', a 'Home' button, and a user profile icon for 'msp@sea.ee'. The main content area is divided into a left sidebar and a central workspace.

Left Sidebar:

- Input Layers
- Sustainability compass
- Cumulative impact model
- Enter new workspace name... [+]
- Workspace list table:

Workspace	Timestamp
new scenario	21.06.2022 08:57:28
EST workshop	19.08.2022 23:55:53
MEM Tõötuba	07.09.2022 21:24:04
MAREA Helsinki	25.10.2022 09:55:47
MAREA Final Event	30.10.2022 12:49:42
	02.11.2022 10:48:48

Central Workspace:

The workspace is titled 'Overview' and contains four main sections:

- Human pressures:** A button labeled 'not ready'.
- Ecosystem Services:** A button labeled 'not ready'.
- Model results:** A button labeled 'not ready'.

Below these sections is a heading 'How to prepare and run model' followed by explanatory text: 'One can prepare and run several human impact scenarios. Scenario consists of lists of human pressures and nature assets. To prepare a new scenario user can create a new workspace on the left side pane. With selected workspace user can start preparing the lists of human pressures and nature assets on the corresponding tab page. Please select existing workspace from the left side pane or create a new one.'

Below the text is a form with two fields: 'Workspace name' and 'Timestamp', with the value '02.11.2022 10:48:48' displayed next to the timestamp field.

At the bottom of the workspace, there are two input fields: 'Human pressures' and 'Nature assets'. To the right of these fields is a section titled 'Human impact calculation' with a 'Run model' button labeled 'not ready'.

PlanWise4Blue in action

Selecting human pressures for our scenario

The screenshot displays the PlanWise4Blue web application interface. The top navigation bar includes a home icon, workspace names (PW4B - Estonia, PW4B - Estonia vers 2021, PW4B - Gulf of Finland), and a user profile (msp@sea.ee). The main content area is titled "MAREA Final Event" and features several tabs: Overview, Human pressures (not ready), Ecosystem Services (not ready), and Model results (not ready). A sidebar on the left contains "Input Layers", "Sustainability compass", and "Cumulative impact model". Below these is a "Workspace" table with columns for "Workspace" and "Timestamp".

Workspace	Timestamp
new scenario	21.06.2022 08:57:28
ESP workshop	19.08.2022 23:55:53
MEM Töötuba	07.09.2022 21:24:04
MAREA Helsinki	25.10.2022 09:55:47
MAREA Final Event	29.10.2022 12:10:10

The main interface shows two panels for selecting human pressures:

- Available human pressures:** A list of 19 pressures, including "Wastewater discharge outlet [10]", "Nutrient load [11]", "Mussel and algal cultivation [12]", "Coastal defence [13]", "Extraction of minerals [14]", "Marine plant harvesting [15]", "Tourism and leisure activities [16]", "Round goby [17]", "Mud crab [18]", and "Modified wave climate [19]".
- Human pressures in workspace:** A list of selected pressures: "Fish farming [3]", "Windpark areas [2]", "Nutrient load [11]", and "Mussel and algal cultivation [12]".

Buttons for adding, removing, and moving items are visible between the two panels. On the right, there are buttons for "Save list" (not saved), "Build combinations" (not ready), and "Run model" (not ready). A map of the Gulf of Finland region is shown at the bottom right, with an "Editor" overlay for "Lappeenranta" and "Kotka" featuring "Edit feature" and "Add feature" options.

PlanWise4Blue in action

Selecting nature assets

The screenshot displays the PlanWise4Blue web application interface. The top navigation bar includes a home icon, workspace names (PW4B - Estonia, PW4B - Estonia vers 2021, PW4B - Gulf of Finland), and user information (Home, msp@sea.ee).

The left sidebar contains navigation options: Input Layers, Sustainability compass, and Cumulative Impact model. Below these is a workspace management section with a table of workspaces and a 'Current workspace's layers' section.

The main content area is titled 'MAREA Final Event' and features a navigation menu with 'Overview', 'Human pressures' (status: success), 'Ecosystem Services' (status: success), and 'Model results' (status: not ready).

The central workspace is divided into two columns:

- Available nature assets:** A list of assets with navigation arrows. The selected asset is 'Aquatic vegetation nutrient storage on hard bott'.
- Nature assets in workspace:** A list of assets currently in the workspace, including 'Mytilus trossulus population N sequestration (kg)', 'Mytilus trossulus population induced N flows (kg)', 'Herring spawning areas', 'Zostera marina population C stock (tons C per k)', and 'Fucus vesiculosus population nitrogen content (kg)'. A 'Save the list' button (status: saved) is visible.

At the bottom, a map of the Gulf of Finland region is shown, with labels for Helsinki, Turku, Vyborg, Saint Petersburg, and Kirishi. The map includes zoom controls and a home button.

PlanWise4Blue in action

Running the model

The screenshot displays the PlanWise4Blue web application interface. The top navigation bar includes a home icon, workspace names (PW4B - Estonia, PW4B - Estonia vers 2021, PW4B - Gulf of Finland), and user information (Home, msp@sea.ee).

The main workspace is titled "MAREA Final Event" and is divided into several sections:

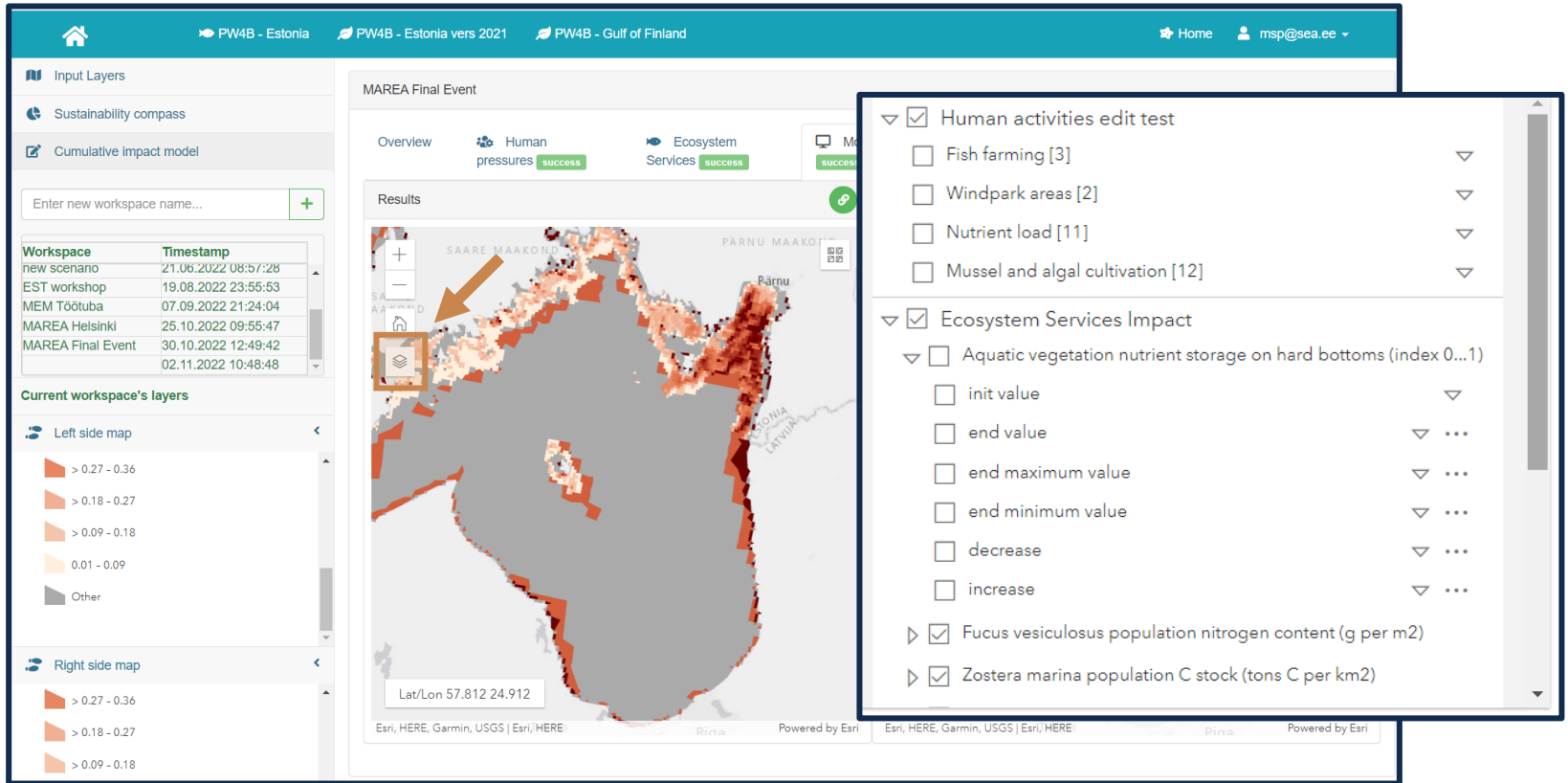
- Input Layers:** Includes "Sustainability compass" and "Cumulative impact model".
- Workspace List:** A table showing various workspaces and their timestamps.
- Current workspace's layers:** Shows "Nature assets" and "Ecosystem Services Initial".
- Model Status:** Shows "Human pressures" (success), "Ecosystem Services" (success), and "Model results" (not ready).
- Available nature assets:** A list of assets with navigation arrows.
- Nature assets in workspace:** A list of assets with a "Save the list" button (saved).
- Human impact calculation:** A large overlay box with a "Run model" button (ready).

The "Human impact calculation" overlay is the central focus, featuring a large blue "Run model" button with a gear icon and a "ready" status indicator. A dashed line connects this overlay to a smaller "Run model" button in the "Human impact calculation" section of the workspace.

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new scenario	21.06.2022 08:57:28
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PlanWise4Blue in action

The results



The screenshot displays the PlanWise4Blue web application interface. The top navigation bar includes a home icon, workspace names (PW4B - Estonia, PW4B - Estonia vers 2021, PW4B - Gulf of Finland), and a user profile (msp@sea.ee). The left sidebar contains sections for 'Input Layers', 'Sustainability compass', and 'Cumulative Impact model'. A table lists various workspaces with their timestamps. The main area shows the 'MAREA Final Event' workspace with a map of Estonia displaying a heatmap overlay. The map includes labels for 'SAARE MAAKONNE', 'PÄRNU MAAKONNE', and 'Pärnu'. A coordinate box at the bottom of the map shows 'Lat/Lon 57.812 24.912'. The right sidebar is a settings panel with the following options:

- Human activities edit test
 - Fish farming [3]
 - Windpark areas [2]
 - Nutrient load [11]
 - Mussel and algal cultivation [12]
- Ecosystem Services Impact
 - Aquatic vegetation nutrient storage on hard bottoms (index 0...1)
 - init value
 - end value
 - end maximum value
 - end minimum value
 - decrease
 - increase
 - Fucus vesiculosus population nitrogen content (g per m2)
 - Zostera marina population C stock (tons C per km2)

Future directions



European
Commission

Horizon 2020
European Union funding
for Research & Innovation





**Funded by
the European Union**

OLAMUR: Grant agreement ID: 101094065

