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## Abstract

The overall objective of WP2 is the specification of the BalticAIMS service chain. This is done by first defining a portfolio of services that the users will be able utilize once the system is operational. Based on the user requirements defined in WP1 the service portfolio is presented here in form of five showcases. Each showcase includes one or more user stories and describes the required data, tools and functionalities.

## Glossary

Chl a / CHL	Chlorophyll a
CMEMS	Copernicus Marine Environment Monitoring Service
CLMS	Copernicus Land Monitoring Service
EO	Earth Observation
HELCOM	Helsinki Commission
HR	High Resolution
GIS	Geographic Information System
JBV	Swedish Board of Agriculture
LC/LU	Land Cover/Land Use
MSP	Marine Spatial Planning
OGC	Open Geospatial Consortium
SLU	Swedish University of Agricultural Sciences
PLC	Pollution Load Compilation
RGB	Reg Green Blue
SPM	Suspended Particular Matter
SST	Sea Surface Temperature
WMS	Web Map Service
WFS	Web Feature Service
WP	Work Package
WQ	Water Quality

# 1 Introduction

## 1.1 Purpose and scope

This document describes the service portfolio of the BalticAIMS system developed in WP2 of the project. The portfolio consists of 5 showcases designed based on the user requirements defined in WP1 (see deliverables *D1.1 User Segmentation and Operational Practices Review* and *D1.2 User Requirements Specification (URS)* for details). These showcases demonstrate how different datasets and technologies can help users in their spatial planning and monitoring work. The showcases share technological components and some datasets but in general are complimentary.

The other documents generated in WP2 are:

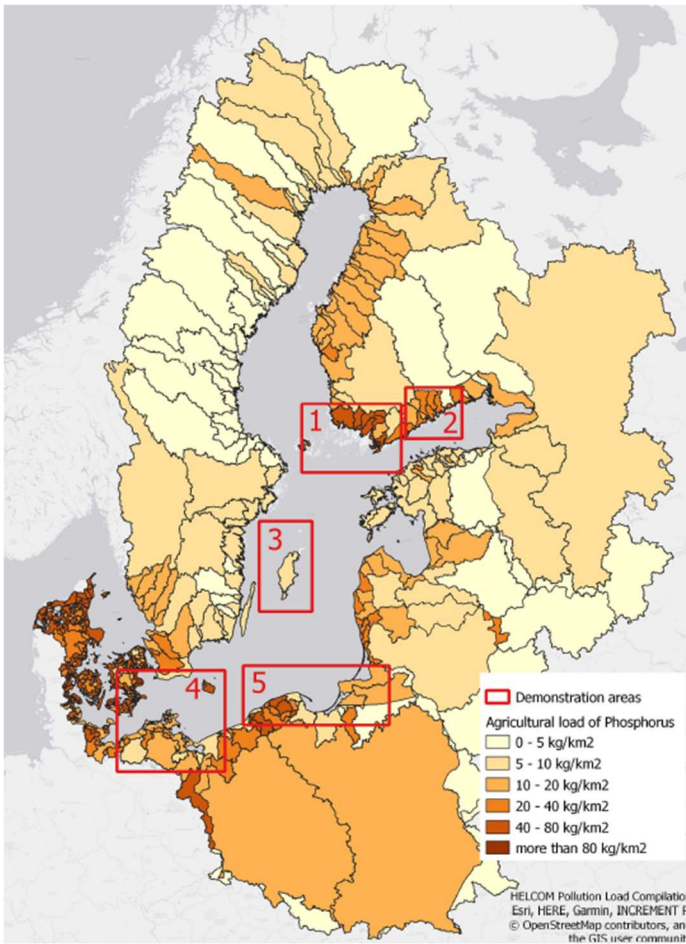
- *D2.2 Data and Platform Provisioning Plan*: Contains descriptions of datasets, system structures, interfaces and deployment strategies required to implement the user service portfolio defined here.
- *D2.3 Service Delivery Chain Specification*: Provides a comprehensive technical description of the end-to-end data acquisition, processing, analysis, delivery and integration capabilities of the system.

## 1.2 Pilot areas

BalticAIMS will focus on five different coastal pilot areas (Figure 1). Table 1 summarizes which pilot areas each showcase covers.

**Table 1. Showcases and pilot areas for the BalticAIMS service portfolio. (x) means that there is user interest but no actual User story (see below) is described.**

ID	Name	Showcases				
		A	B	C	D	E
1	Archipelago Sea	x	x	(x)	x	
2	City of Helsinki	x		x		x
3	Gotland	(x)	x	(x)		
4	Mecklenburg-Vorpommern	x	x		x	
5	Poland	x				



**Figure 1. Demonstration areas for the BalticAIMS-project and material.**

## 2 Showcases

Each showcase presented below starts with an overview describing its central ideas. After these User stories for the particular showcase are described. These are intended to represent actual uses of the system based on the discussion with users and stakeholders interviewed in WP 1. The Datasets section lists the data that are relevant to the users of the showcase. More detailed technical descriptions of the datasets (input formats, preprocessing, data cube requirements) will be given in D2.2. Finally, the Tools and functionality sections describe the system features in detail level that are relevant to the users of the system/showcase. Implementation details will be given in D2.2 & D2.3.

The user stories are given in the order of priority. The BalticAIMS project will implement at least one user story for each Showcase. The rest are implemented depending on the effort required and the availability of resources.

### 2.1 Showcase A: Provide EO based information to be used in user legacy systems for spatial planning

#### 2.1.1 Overview

Most of the terrestrial and maritime spatial planning work is done in GIS systems (e.g. ArcMap). The planners are accustomed in reading materials from data interfaces to their GIS-projects. Thus, providing data through standard interfaces is a suitable way for them to integrate EO materials to their working practices. There is thematic overlap between this and the other showcases. The main difference is that here the users are using their own data analysis and visualization tools, while in the others the service is based on TARKKA.

#### 2.1.2 User stories

**User story A1: Review MSP Plan:** A spatial planning expert from Finland/Sweden/Germany wants to review the MSP plans published in 2020/2021 and see how satellite observations and planned maritime activities look, when they are shown/overlaid simultaneously. This is particularly interesting for accounting EO in the forthcoming years, when the recently published plans are being monitored. During the service period of BalticAIMS, she can start to imagine, what are the materials she will need in the future more extensively. Using the instructions prepared by the BalticAIMS team she connects her ArcMap/QGIS application to the BalticAIMS demonstration data cube. She accesses the monthly/seasonal EO turbidity, chl-a, algal bloom and sea surface temperature products stored in the cube and the relevant MSP related GIS material she has in the local/shared environment. The combination of EO datasets and GIS material highlights which of the coastal human activities are clearly affecting the coastal water quality.

**User story A2: Human impact:** In the longer perspective, the expert will need more background information to separate human impacts from natural changes in the water quality/RGB illustrations on e.g. ice cover extent, dredging and dumping and coastal activity like boating during summerly season. She wants to know, how ice typically covers the coastal waters and what is the variation between warm (2019-2020) and cold (2020-2021) years. She also wishes to see how large-scale dredging events look like in satellite images and how many observations typically are received from an event that can last for the whole open-water (ice-free) period. She also wants to see examples on other human activities, like boating in coastal waters. She utilizes the EO material as a background information on changes between the seasons (winter, spring, summer) on basic level (background, natural changes). She then compares this basic level information to the identified changes caused by the human activity (cases of dredging events, shipping activities) in the coastal waters. Dredging events typically last one-two years, but regular shipping routes are permanent. She then utilizes these case examples for further planning on how to account EO in the long term in maritime spatial planning.

**User story A3: Hotspots:** A spatial planning expert has been given a task of updating the list of nutrient input hotspots. The task is based on one of the objectives of the German chairmanship of HELCOM. The last list of hotspots dates back to 1992 and the hotspots are identified either facilities that contribute to increased nutrient and pollutant inputs into the Baltic Sea or particularly sensitive areas that are heavily polluted (e.g. the Oder Lagoon, Finnish archipelago). The first step is to define criteria for the designation of new nutrient input hotspots.

Information from remote sensing data/Earth observations, including land cover / land use on the one hand, and on water quality on the other hand, on their footprint could be included here.

### 2.1.3 Datasets

The following datasets are relevant for this showcase:

- Turbidity and its seasonal changes in high resolution
- Chl-a and its seasonal changes in high/medium resolution
- Algae blooms in high and moderate resolution
- Sea Surface Temperature in high and moderate resolution

Details about the dataset are available in the Annex.

### 2.1.4 Tools and functionality

The users require value added data, not satellite raw data. These data should be made available as integrable information layers into their GIS tools. Today, these are QGIS and ArcGIS, mostly. Users would like to rely on accessible online repositories for the data but are not prepared to keep large quantities of data at their premises. This implies the need to provide good functionality to explore the archive incl. documentation (pdf + meta data in the data) = **data archiving, exploration and downloading tool**.

Thus, the integration should take place via **meaningful products**, web mapping services or via online tools. Interfaces via **Jupyter notebooks** are conceivable, especially if they are existing notebooks that can be parameterised according to one's own questions. These notebooks should allow producing graphics which are ready to use in their reports, i.e. png or jpg.

Thus, the data is delivered in various methods. We provide standard OGC interfaces that technical users may use directly in their legacy systems. These interfaces are documented with step-by-step instructions on how to use them in the most common GIS software. In addition, traditional download of products, i.e. geoTIF and shapefile, per ftp or http is needed.

In addition to the written instructions, a simple plugin for adding the data layers into QGIS is provided. This tool can be used to list and import the datasets into QGIS projects without technical expertise.

A tool to convert raster data into vector data, and vice-versa is also needed since a user wants the right to request information in either form.

Published interfaces will include WMS, WFS, and support time-dependent queries.

## 2.2 Showcase B: Monitor the effects of nutrient flow from the drainage basin to the coastal waters

### 2.2.1 Overview

Showcase B demonstrates material related to identifying the effects (and potential changes) of nutrient flow from the drainage basin to the coastal waters. The demonstrations focus on identifying visible changes in water quality through EO estimated turbidity and algal growth (eutrophication) and available GIS material. Users interested in this showcase want to visualize and combine information layers about agriculture production, land cover, in situ sensor data, statistical information on activities on drainage basin and coastal water quality. In the long run, the users can estimate e.g. the effectiveness of agriculture management practices and find correlations between agriculture production and the status of coastal waters.

### 2.2.2 User stories

**User story B1: Impact of agriculture:** An ongoing project group (including national top scientists and HELCOM PLC group members) is identifying the effects of drainage basing nutrient loading to coastal water quality in the Finnish archipelago region, which is on the HELCOM hot spot area list. The drainage basins are one of the most relevant agriculture production areas in Finland and also in the Baltic Sea scale. The group examines the demonstration material in TARKKA-interface. They combine GIS information on the land use of the drainage basin (national Corine, agricultural load of phosphorus from drainage basin) and its long-term statistics (e.g. drainage basing percentage of agriculture). They can also visualize automated river station observation on phosphorus and turbidity(daily) and combine these observations to coastal (estuary) EO-observed turbidity and annual riverine impact areas (based on EO turbidity, annual max and median levels). From this information the group can evaluate, how they can utilize this combined information and account the EO material in the forthcoming HELCOM agri/PLC-group work and in national evaluation of human impact on coastal water eutrophication. They are interested in seeing, if the agricultural practices and also the status of eutrophication in the coastal waters has changed during the past 20 years and can EO data be used in addition to other available material to make conclusions on this change.

**User story B2: PLC subgroup:** The user wants to assess the influence of the nutrients to the coastal waters of the southern Baltic Sea. PLC reports provide information about inflows from point pollutants (measurements) as well as from surface inputs of nutrients (mainly agriculture). The latter is estimated by modelling (MoRE model), which is already using EO data via the CORINE data set. Mecklenburg Vorpommern is characterized by intensive agricultural use. In order to assess the influence of the nutrient inflow, the user wants to combine the results of the MoRE model and the nutrient information from point sources with the chlorophyll concentration in the coastal water. Here, seasonal trends over certain regions are relevant. The User wants to define the regions (pre-defined or by drawing an ROI) and derive aggregated long-year and seasonal trends. A relation between the PLC nutrient loads and the chlorophyll information will be assessed via statistics and graphs. For this, the information from EO can be downloaded from a system on which the regions have been defined → regional statistics over time in a csv file.

**User story B3: Monitoring of nutrient reduction measures:** A local project coordinator or representative from the environmental authority is interested in the effects of local measures attempting to reduce the nutrient leakage from agricultural areas to the coastal waters. Through collaboration with local farmers or landowners several potential measures, such as construction of new wetlands or dams to retain nutrients or treating agricultural fields with gypsum, can be made upstream. Sensors in upstream water courses will be used to monitor the fluctuations in nutrients over time and with high frequency. In addition, water quality samples will be collected in the recipient coastal waters. Both type of measurements will be collected before, during and after the measures are implemented in a stepwise manner. Satellite products (Chl-a and TURB) will be added to the project data set to 1) evaluate the correspondence and/or time shift between the sensor and field data and 2) to increase the spatial and temporal availability of data in the coastal waters.

To support these activities and facilitate the evaluation, the satellite data and products will be complemented with a number of ancillary geodata layers in the Baltic AIMS cube. Although HELCOM data is used on national level (reporting etc.), this information is not detailed enough to support local user needs for planning and monitoring of activities (Figure 2). A combination of local ancillary data and a Sentinel-2 turbidity product is shown in Figure 3.



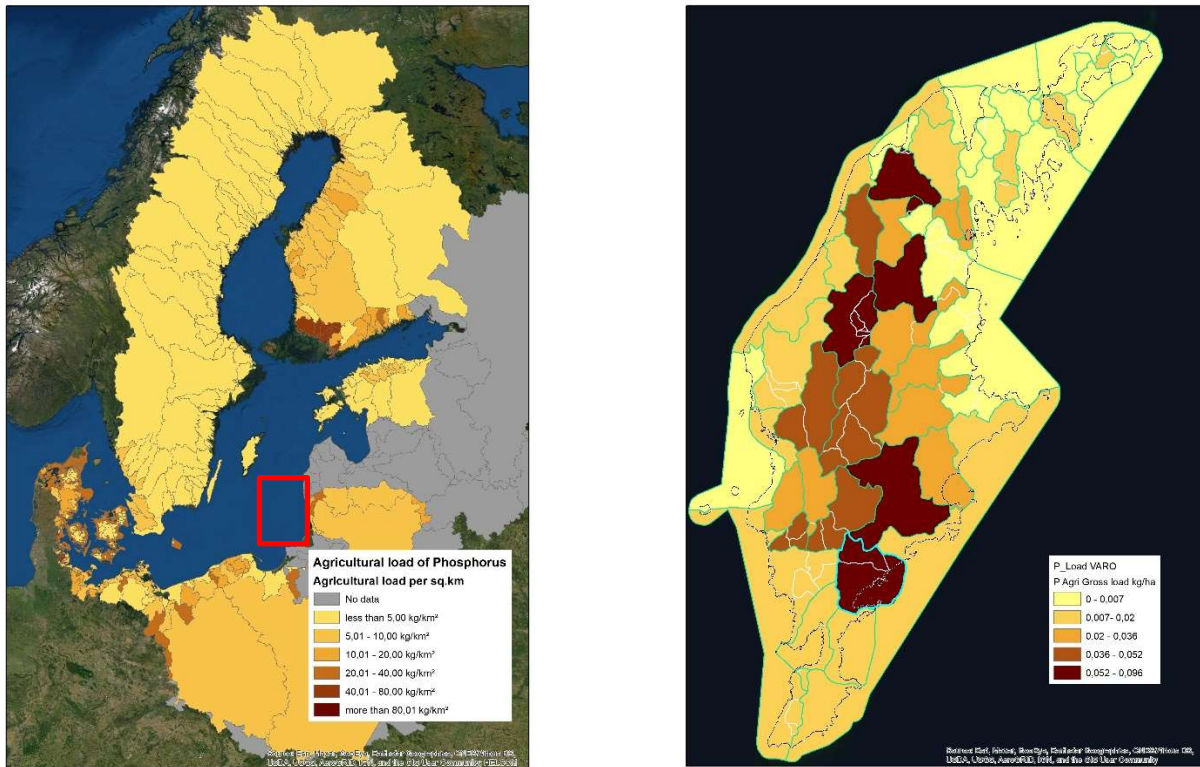


Figure 2. HELCOM P load from agriculture for the Baltic Sea compared to national coastal water catchment based P load data for Gotland.

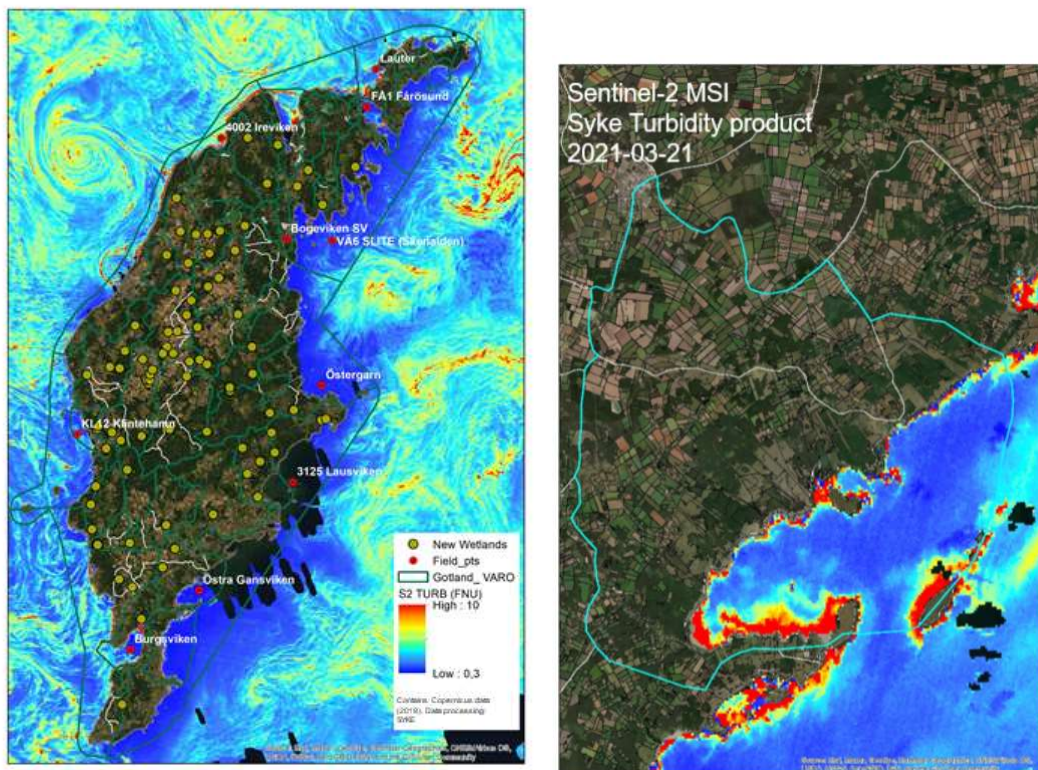


Figure 3. Left) Gotland with nutrient reductions measures (new wetlands – olive pts), monitoring points (red pts) and coastal water body catchments (VARO green lines) and a turbidity product derived from Sentinel-2 MSI image (2019-07-25). Right) enlargement near the coastline.

### 2.2.3 Datasets

These showcases will include a selection of the following datasets:

- Coastal water quality data (turbidity, Chl-a) from EO
  - Daily products and longer-term aggregates
  - Time series analyses
  - Riverine impact areas (annual maximum and average level) on coastal waters
- In situ sensor data of water quality, phosphorus and/or discharge in streams and coastal waters
- Agriculture production data
  - E.g. crop type shares, fertilizer use
- Agricultural blocks (JBV) with yearly crop types (2012-2021)
- Production places (JBV, animal husbandry)
- Anthropogenic gross P and N loadings from different sources including agriculture, forestry, and effluents
- Land cover data
  - Corine
  - Coastal Zone 2012, 2018 and change layers
  - Riparian Zones
  - National land cover and land use
- Assessment of areas at risk for eutrophication (streams, soils) (JBV/SLU)
- Accompanying HELCOM material e.g.
  - Pressures
    - Land based pollution → waterborne land based pollution →
      - Agricultural load of Phosphorus
  - Hot spots
  - Top 40 rivers with highest phosphorus concentrations

Details about the dataset are available in the Annex.

### 2.2.4 Tools and functionality

The EO datasets will be made available using TARKKA web map service as a frontend to the data cube layers. In addition, they are delivered through OGC interfaces (see showcase A for details). TARKKA will allow the user to browse the catalogue of raster data and select one of them for visualization. The user can explore the temporal range of data if that is available (e.g. in case of EO datasets). Locations of in situ sensors and drainage basin data will be shown with markers on the map. Clicking a marker opens a popup window that contains the datasets the user can select for visualization. With time series type data (e.g. the in situ water quality sensor data) the user can pan and zoom the data. Ancillary raster and vector data will also be visualized via the TARKKA interface including some as WMS services as best applicable. There may be a need to visualize EO datasets with ancillary local layers; most efficient ways of doing this need to be discussed further down the track.

## 2.3 Showcase C: Monitoring the impacts of coastal activities

### 2.3.1 Overview

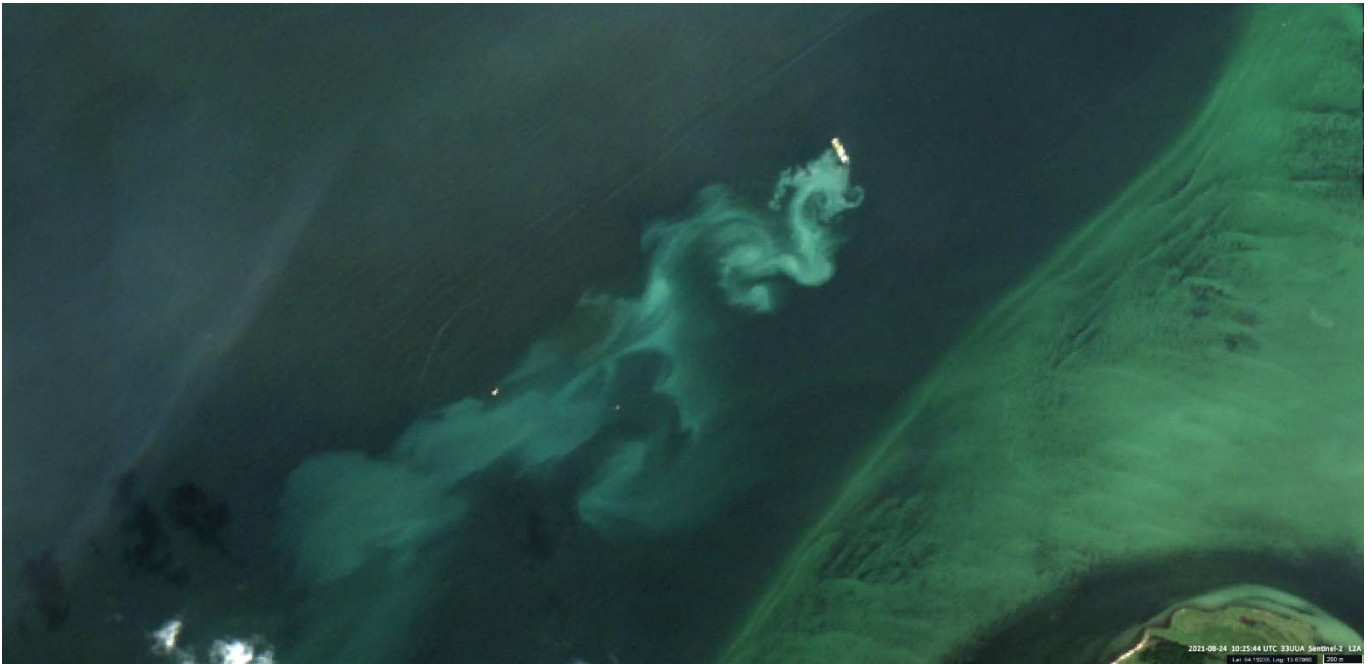
Here the focus is on finding and when possible quantifying the effects of human activities on coastal water quality in the local level. The activities include dredging and dumping of dredged material, ship and boat traffic, and coastal construction work. The common effect of these activities is resuspension of sediments into the water column, which is visible in true color satellite images as turbidity plumes (areas of brighter pixels, Figure 4 and Figure 5). By estimating the area covered by the turbid water and the values of turbidity it is possible to analyze the effects of the activity on the coastal environment. Due to the fragmented nature of coastal areas it is necessary to utilize high resolution observations in this showcase.

### 2.3.2 User stories

**User story C1: Dredging Helsinki:** An environmental expert from the Centre for Economic Development, Transport and the Environment is responsible for monitoring the effects of a dredging work near the City of Helsinki. The expert launches TARKKA in a browser and navigates to the target area. The disturbances caused by the dredging are easy to see as elevated values of turbidity, so the expert activates the EO HR turbidity product. The expert sees a clear turbidity cloud extending from the dredging site. The expert then activates a GIS vector data layer that shows the nearby protected areas and sees that the turbidity has not yet reached the forbidden zone but might do that soon. The expert notifies the dredging company and asks them to monitor the extent of the dredging work more closely with in situ sampling. The expert can also check the dredging and dumping areas from RGB (true color) images that are useful material also for the partially cloudy dates, where turbidity material is not available.

**User story C2: Water quality Uusimaa:** An environmental expert from the Centre for Economic Development, Transport and the Environment is responsible for monitoring the coastal human activities that affect the water quality within the area of Uusimaa. The expert goes to TARKKA-demonstration interface and checks the material related to this topic. In particular, the expert wants to evaluate the human actions that bring up suspended material and other (possibly harmful) material from the bottom to the surface waters. The expert wants to see, if the coastal activities that are related to e.g. the effects of regular ship traffic in the harbors (route between Helsinki and Tallinn) are identifiable from EO turbidity or RGB images. The route is in intensive and regular use 24/7 and the mixing of harbor water is daily. The environmental expert is also obligated to estimate the effects of other coastal human activities, like the effects of the intensive leisure boating in boating harbors and islands reserved for recreational use during summer time. The expert looks at identified cases of these from TARKKA-interface. These two cases are human activities mixing the water (and material from the bottom) nearby the city of Helsinki. The abovementioned human activities are visualized in TARKKA demonstration material with a few demonstrative & identified RGB image cases. The expert then takes these into consideration in his/her further work and uses them as background material on the MSP work and/or reporting actions related to coastal human activities (city, regional level).

**User story C3: HELCOM dredging & dumping:** A HELCOM expert is in progress of combining material related to coastal human activities at Baltic Sea level. One of the materials is related to dredging and dumping areas. At present, this material is delivered to HELCOM by countries and the submitted material has spatial and temporal gaps (aggregated over HOLAS assessment years, e.g. HOLAS II: 2011-2016). The expert wants to see, if these materials can be updated/upgraded in the future with summaries of EO observations of identified dredging and dumping locations that are not part of the reported material by each country. The expert opens TARKKA demonstration material of previously submitted material (HOLAS II: HELCOM GIS layers and compares those to the demonstration cases identified from EO case examples and also national dredging material from demonstration area 2. With the BalticAIMS demonstration material, she/he can start to plan how this type of material could be utilized as Baltic Sea wide material in the forthcoming years.



**Figure 4. Ship releasing dumping material North of Island Rügen, Germany. Acquisition date: 24.08.2021, 10:25; 33UUA. The image shows a ship close to a sediment plume which could be dumping material. An overlay of dumping sites will be done in order to find out if the event is within the dedicated zones.**

**User story C4: HELCOM human pressures:** A HELCOM expert is in progress of combining material related to coastal human activities at Baltic Sea level related to the summaries of human pressures/impact areas in the coastal areas and the aggregated pressure layers, that contain human impacts clearly visible in the surface waters. The expert opens TARKKA demonstration material of coastal turbidity (selected turbidity material, with identified cases of human impacted changes in turbidity and possible changes identified based on these). For this the expert can evaluate the usefulness of these combinations in her/his work. The expert can then start using the same datasets accompanied with her/his own material in GIS environment and combine EO observations of regular/periodical/momentary events there in more detail.

### 2.3.3 Datasets

The following datasets are relevant for this showcase:

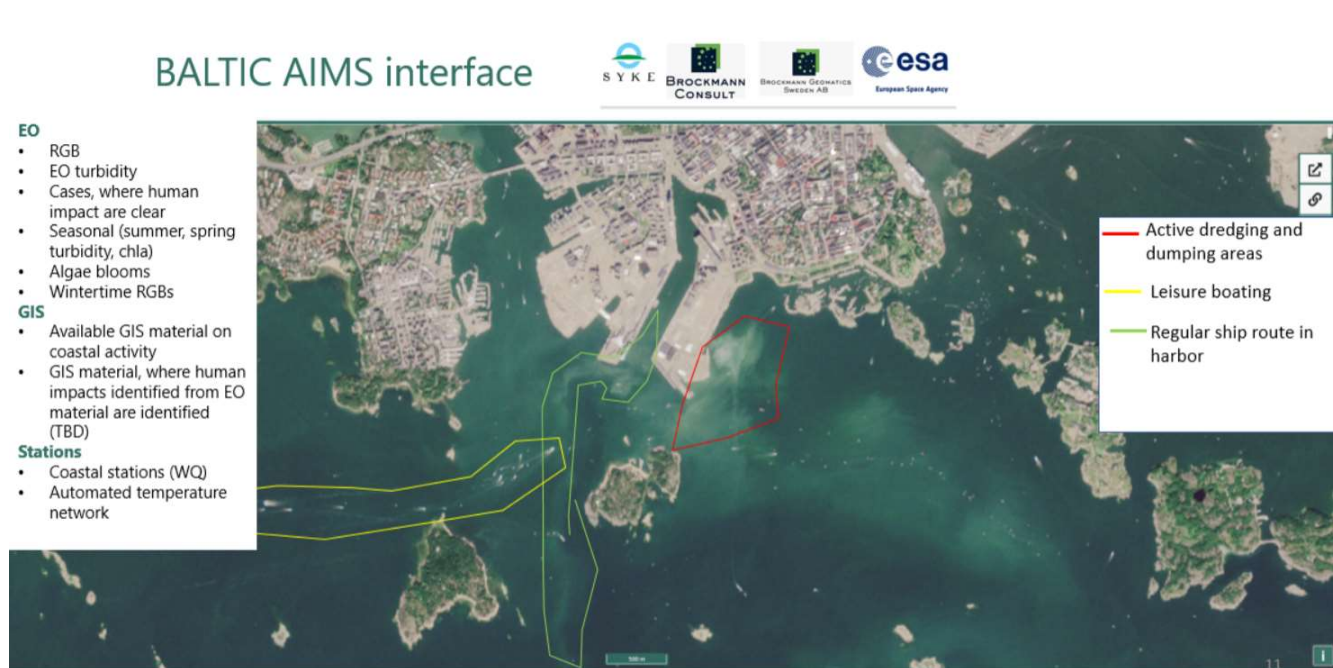
- A selection of EO true-color observations, where regular shipping routes, leisure boating and dredging and dumping events are identified
- EO HR turbidity, seasonal aggregates
- A list of EO HR daily turbidity maps where human activity events (e.g. dredging and dumping, shipping routes and other human activities are clearly visible and identified)
- GIS material identifying cases of human activities that have been identified from EO RGB or turbidity
- In situ turbidity observations from reference stations (a selection from national database)
- GIS data of protected areas, shipping routes, other accompanying publicly available material
- GIS data (vector/point) of national dredging material (years 2016-2021), demo area #2 (to be submitted to HELCOM for HOLAS III in spring 2022)
- HELCOM data dredging material (HOLAS II: years 2011-2016) Part of HELCOM GIS material related to human activity (a selection from aggregated pressure layers, like Disturbance of species due to human presence).

Details about the dataset are available in the Annex.



### 2.3.4 Tools and functionality

The EO datasets will be made available using TARKKA web map service as a frontend to the data cube layer, thus at least the same functionality as in Showcase B is required. In addition, possibility to view monitoring station data and extract time series of EO observations from user-defined locations (“virtual stations”) is needed. OGC interfaces and file download service for selected datasets is also required to support working in expert’s own environments.



**Figure 5. A true color S2 image (15.08.2020) showing the effects of various human activities (delineated with GIS vector areas) in the coast of Helsinki.**

## 2.4 Showcase D: Combination of Coastal Zone mapping and CMEMS coastal water quality material

### 2.4.1 Overview

The Copernicus Services provide a large variety of products. Users often find it hard to find the relevant information for their applications. Therefore, dedicated collections of service products are needed.

This showcase is a demonstration of harmonized material that exists from all demonstration areas and gives examples for the users on material available beyond Baltic Sea. As e.g. the Coastal zone material consists of 70 layers, only relevant ones are chosen. The selection of the relevant layers will be done in co-operation with part of the users and land use experts. The information layers are even more valuable for the users if they are combined with GIS material available from other sources, such as HELCOM maps and databases.

### 2.4.2 User stories

**User story D1: Wind park:** MSP expert at Mecklenburg-Vorpommern admin is tasked to make an assessment if a **wind park** which is ready now, influences the water quality. There are potential effects, from increased turbidity leading to reduced light field and thus less favorable conditions for phytoplankton and fish, to the opposite: decrease of current velocity leading to favorable conditions for phytoplankton + mussels populating at wind mills, all leading to more favorable conditions for fish. The expert is using water quality, temperature and currents, and compares the conditions in the area of the wind park with those outside the wind park. (S)he uses different times corresponding to different conditions, probably related to the wind (to be found out). Finally, he draws conclusions, which can be: no spatial differences in WQ, or there are.



**Figure 6: effects of windfarms on the roughness of surface and on turbulences in the atmosphere. The images shows regular pattern behind (lee) of the wind farm piles. If the effect is within the atmosphere or on the water surface, further investigation is needed. No influence seems to be on the water constituents.**

**User story D2: Aquaculture footprint:** Aquacultures (AQC) will increasingly play an important role in the Baltic Sea and it is of great interest to be able to better monitor the impact of the facilities. On the German Baltic Sea coast, no AQC have been reported in coastal waters so far. An expert at the German Environmental Protection Agency wants to check if remote sensing could be used to detect plants and their potential impacts (e.g. increased chlorophyll-a concentrations) in principle. The detectability depends on the size of the plants. Detectability could initially be tested in Danish waters near Bornholm and in the Danish Straits or also in the Finnish Archipelago, as

many plants are operated here. The facilities are also an important source of nutrient inputs and the aim is to capture these inputs in the HELCOM Pollution Load Compilation (PLC) reporting.

These are the questions (s)he is going to try to answer: (Aquaculture questions):

- Are facilities detected that are not reported?
- Is there an ecological impact of the facilities on the surrounding water body? -> Footprint of the facilities
  - o Spatial - temporal investigation of higher resolution remote sensing data on water quality.
  - o Relevant parameters: CHL, TUR
- Could EO play a role in defining a recommendation for best technique of monitoring?

The expert will first assess at what size installations can be detected and what sensors are needed to do so. (s)he will investigate the impact of known plants in any case.

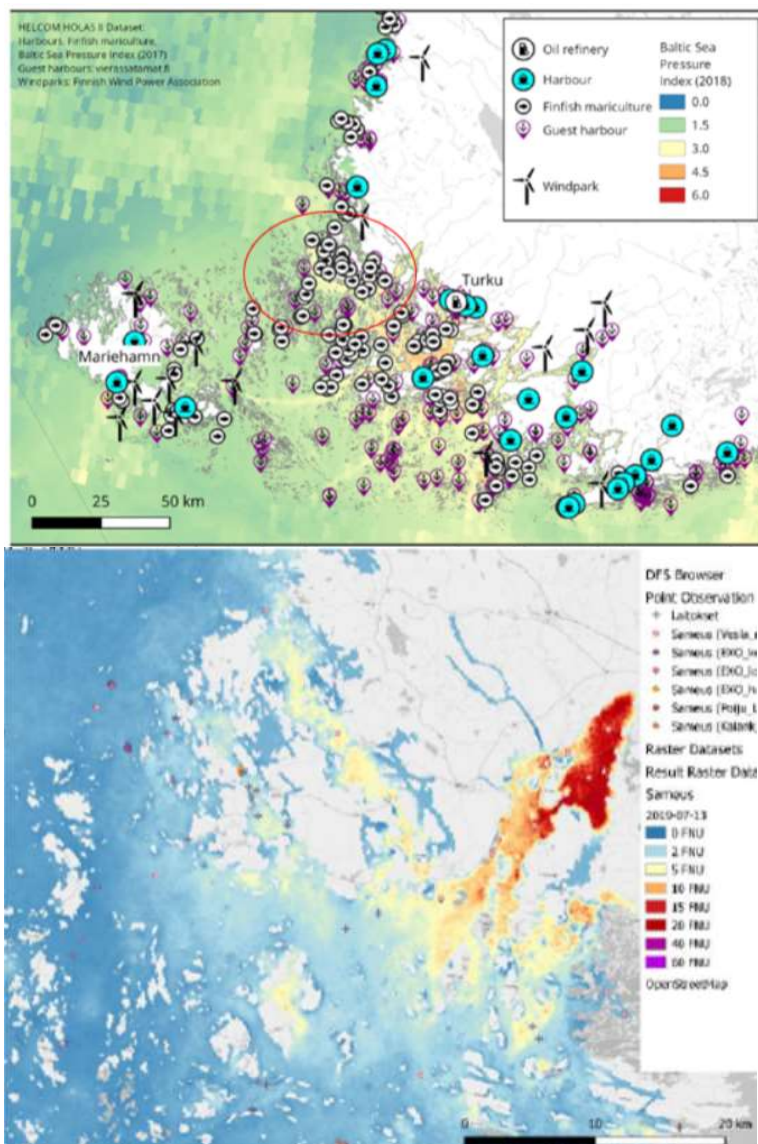


Figure 7: Aquaculture-rich archipelago area, where EO and autonomous monitoring methods have been utilised to generate data fusion (data assimilation) maps showing the effects of aquaculture near the fish farms.

**User story D3: Coastal land use:** SYKE expert is interested in comparing the Coastal Zone mapping material (that is consistent within EU) to some national GIS material on coastal land use. The expert also wants to evaluate, how practical the material is for this particular study on drainage basin impacts on coastal water quality. The expert activates the CZM material and some cases of coastal EO water quality and combines them with information on drainage basins (GIS vector layers) and largest rivers (GIS material on covering the Baltic Sea drainage basin).

### **2.4.3 Datasets**

The following datasets available from Copernicus services are relevant for this showcase:

- CMEMS CHL, SPM, SST and currents
- CLMS LC/LU classes and changes since previous product
- GIS material from pilot areas 1 and 4

Details about the dataset are available in the Annex.

### **2.4.4 Tools and functionality**

The datasets will be made available using TARKKA web map service as a frontend to the data cube layers and all requirements from Showcase B apply here too. In addition, the EO datasets are delivered through OGC interfaces (see showcase A for details). TARKKA will allow the user to browse the catalogue of raster data and select one of them for visualization. The user can explore the temporal range of data if that is available (e.g. in case of EO datasets). Locations of in situ sensors and drainage basin data will be shown with markers on the map. Clicking a marker opens a popup window that contains the datasets the user can select for visualization. With time series type data (e.g. the in situ water quality sensor data) the user can pan and zoom the data.



## 2.5 Showcase E: Monitoring of temperature anomalies

### 2.5.1 Overview

Temperature anomalies are caused by natural phenomena such as upwellings where cold and nutrient rich water from deeper layers is brought to surface by wind action, and human (industrial) activities such as the condensation waters of power plants which increases the local water temperature. Both can affect the local environment. Upwellings can lead to increased algal growth while warm water from a power plant may affect the species composition in the area. Monitoring temperatures near the coast requires measurements with good spatial resolution. Most of the global Sea Surface Temperature (SST) products are too coarse (resolution 1 km) to be efficiently used in the fragmented Finnish coastline. We will demonstrate the benefits of new high-resolution SST products in combination with more traditional medium resolution products and both manual and automated in-situ observations. Continuous in situ measurements can complement the satellite data by providing data during cloudy days and days without satellite overpasses and provide calibration data if needed. In addition to various observations, also modeled SST data is provided to the users. This service will be demonstrated for Helsinki region (#2) only.

### 2.5.2 User stories

**User story E1: Helsinki city temperature:** An expert from Helsinki City's environment office has been given a task to analyze if and how satellite-based water temperature data can supplement the current in situ observations. This is relevant for the expert's work on evaluating human impacts on water temperature and also identifying natural changes related to water temperature (certain species living conditions and ground water). The expert launches TARKKA in a browser and navigates to the target area. The expert activates the in situ observation layers and views the timeseries measured by a network of automated sensors. The expert then activates the moderate resolution and high-resolution SST layers in order to see if there are spatial features the in situ sensor net cannot resolve Figure 8. The latest images have been partially cloudy, so the expert also activates the data fusion SST layers and views the gap free data. The EO temperature time series show good correspondence with in situ data and elevated values in one bay near Helsinki. This may be a long-term heat anomaly related to human activities. The expert marks the area for further investigation.

The expert then views the SST values from areas where ground water is known or suspected to seep into the coastal water. From the low temperature values the expert notices that this is the case on some of the days. The expert can utilize this information to evaluate the living conditions of certain coastal species.

While looking at the temperature data the expert notices areas of cold water a bit farther from the coast. the expert opens more temperature layers (e.g. CMEMS model results) and confirms that an upwelling event is ongoing in the area. The cold bottom water brings nutrients to the surface which can lead to cyanobacteria blooms. An alternative effect of upwelling during cyanobacteria blooms is that as the water cools down in the surface waters, the cyanobacterial blooms calm down. The expert notifies the relevant authorities about the situation.

**User story E2: Climate change:** In the topic of climate change, the consideration of temperature in the Baltic Sea is of interest for the environmental protection agencies. Experts in these agencies have to provide input to decision taking to their management. They are studying the time series of temperature and other marine parameters. The questions to be addressed are: Are there spatio-temporal temperature anomalies? Are these coupled with other water parameters (e.g. CHL)? For example, a temperature anomaly product could be superimposed on the development of chlorophyll concentration. The insight gained by these investigations will be compiled in synthesized graphics and prepared in reports for decision takers.

### 2.5.3 Datasets

The following datasets are relevant for this showcase:

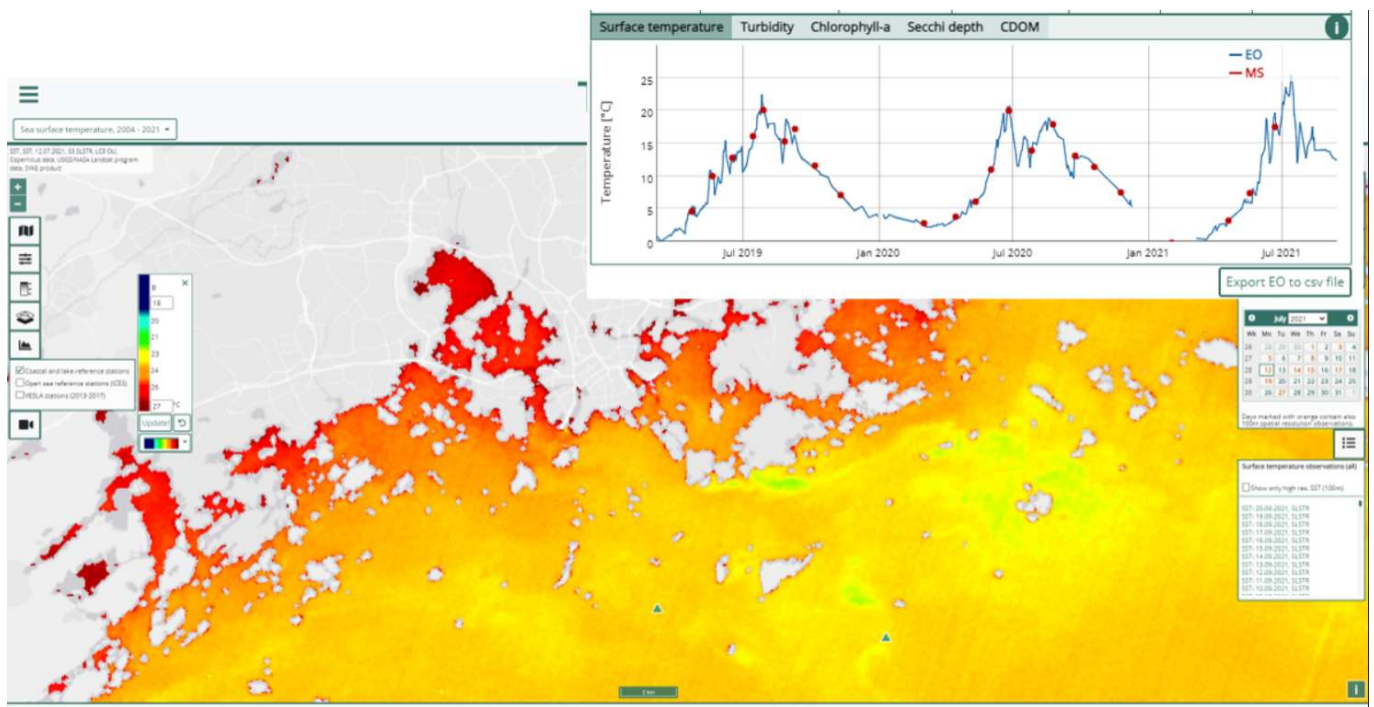
- High and medium resolution sea surface temperature data from Landsat-8 and Sentinel-3

- Automated temperature observations from an in-situ sensor network located at open sea wave buoys and close-to shore at local beaches
- Sea surface temperatures from data fusion. The system provides a gap-filled product by assimilating together all available information, including EO and in-situ observations into optimal estimate of the water temperature
- Modelled temperatures from CMEMS
- A map visualizing the likelihood/occurrence of upwelling incidents

Details about the dataset are available in the Annex.

## 2.5.4 Tools and functionality

Data will be made available using TARKKA web map service as a frontend to the data cube layers. Monitoring of the temperature anomalies requires tools to visualize and detect temporal changes. This requires possibility to trigger certain type of statistical calculations and extraction of temporal profiles from the datasets using TARKKA. Thus, TARKKA shall allow point-wise visualization (dynamic graphs) on all time-dependent EO datasets. In addition to point(pixel)-wise visualization, users shall be able generate region-wise time series from the data layers. The regions of interest (ROI's) can be drawn on the map, or user can select an individual polygon from GIS dataset that has been added into TARKKA as auxiliary data layer. For this ROI, system can be used to compute spatial statistics (mean, std etc.) for each time step that the selected EO data layer includes.



**Figure 8: High resolution Sea Surface Temperature map in the coastal areas of Helsinki (top) and a time-series plot of a station site in front of Helsinki.**

### 3 Functionality and tool requirements

Table 2 provides a consolidated but not complete list of functionalities that need to be provided to fulfill the user interface needs of the user stories in the previous chapter.

Functionalities and tools are divided in two main groups: Properties of Tarkka web user interface (see D2.2, Ch 4.1) and individual tools and services that are used to provide data to the user legacy systems.

**Table 2. List of tools and functionalities.**

	ID	Functionality
<b>TARKKA</b>		
Data selection	TA1	Select Raster layer/data source to view
	TA2	Select vector layer/data source to view
	TA3	Select point-wise data/data source to view
Temporal selection	TA4	Select date for temporal layer
	TA5	Define temporal extent
Map interaction	TA6	Pan & zoom map
	TA7	Change the order of the layers
	TA8	Change the visualization of layers (colorscale)
	TA9	Display several layers at once
	TA10	Compare overlaid layers (swipe)
ROI analysis	TA11	Select polygon from vector layer as ROI
	TA12	Define/draw ROI's
	TA13	Perform spatial statistics for ROI's
	TA14	View and export spatial statistics for ROI's as time series
Metadata	TA15	View metadata for layer/data source
Map/image export	TA16	Export view as image
	TA17	Export product as georeferenced data
Point-wise time series	TA18	View and export time series from raster dataset from selected location

<b>Legacy systems (ArcGIS, QGIS)</b>	LS1	Search datasets in catalogue view
	LS2	BalticAIMS archive exploration tool (select and download)
	LS3	List available layers
	LS4	View metadata for layer
	LS5	Select and import layers from OGC interfaces
	LS6	Select and download layers from web folders
	LS7	Export from datacube to tiff, shapefile
	LS8	Template projects
	LS9	Example Jupyter notebooks
	LS10	Tool to convert raster data to vector and vice versa
	LS11	QGIS Plugin to import data
	LS12	Example Jupyter Notebooks

## **4 Annex**

[A2.1 Datasets Table]

BalticAIMS Dataset Attributes tables, Excel tables, version 2.0 (in progress, retrieved 16.09.2021)

The DatasetAttributes Excel contains more details about the datasets that are of interest to the Showcases described above. Please see the Introduction tab for instructions.