HiSea Deliverable D3.8

Report on end-users' needs and requirements

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Executive Summary

The main objective of this deliverable is to extensively map end users' activities and interests with a focus on their specific data and information needs. Different users and stakeholders from HiSea's target groups: port and aquaculture sectors, have been contacted and informed about the HiSea service capacities and the potential benefits HiSea can bring to their activities and businesses. Particularly, for the port activities, members of the Stakeholders Advisory Board (SAB), established as part of Task 2.1: "Establish partnerships with end users (Stakeholder Advisory Board) and identify key questions of interest" has been consulted. This is an external high-level group of experts of industry representatives and other stakeholders who are potential users of the future HiSea services. Their role is to collaborate with the HiSea project team to help design and fine tune the services using their experience to provide suggestions and feedback. Moreover, as potential users of the future HiSea services, SAB members are interested in cooperation with the project activities (additional information is detailed in D2.1: Report on the Users Feedback, which is the initial analysis of user requirements, summarize the output of two HiSea Users' Workshops held for the purpose of extensively mapping both port and aquaculture-user's activities, interests, data and information needs).

The SAB for ports is composed of four Port Authorities:

- Port Authority of Valencia (Spain);
- Port Authority of Melilla (Spain);
- Port Authority of Piraeus (Greece);
- Port Authority of Ravenna (Italy).

Results of the extensive mapping showed that the main requirement of the Port Authorities is to have water quality information both at the surface and through the water column. This improved level of control and monitoring is possible through continuous observations. Forecast of water quality and weather conditions as well as identification of oil spills movements, therefore the provision of early warning systems, are also an important need for the users

For aquaculture users' needs and requirements, Selonda, a member of the HiSea consortium and one of the potential users of the HiSea services, has been consulted. Selonda provided suggestions and feedback based on their experience. Furthermore, aquaculture needs and requirements have been integrated by Argans-FR using their experience acquired in previous projects employing Earth Observation (remote sensing and model outputs) for aquaculture support (Smart-Innovator, SAFI-H2020, IMPAQT-H2020, Neptune, etc.).

The main aquaculture requirements are to have an "Area control and monitoring" of the water quality on and around the farms both at the surface and the water column which can be obtained through continuous

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observations at high spatial resolution. Aquaculture professionals need alarms for abnormal water quality detection and bad weather conditions. Similar to the requirements of the ports, forecasting of water quality and weather conditions are very important to mitigate risks and prevent losses in aquaculture.

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I. Introduction

This document presents the end-users' needs and requirements for HiSea data-based services in the areas of ports management and aquaculture activities. Stakeholder partners lead the Stakeholder Advisory Board (SAB) for their sectors, where Valencia Ports Authority represents the ports sector and the Selonda company represents the aquaculture sector. The SAB for ports is composed of four members (Port Authority of Valencia (Spain), Port Authority of Melilla (Spain), Port Authority of Piraeus (Greece) and Port Authority of Ravenna (Italy)). For aquaculture Selonda is the end user and serves as the SAB to guide development for this sector.

Two end-users meetings were held by the HiSea project: the Port Authority of Valencia held the first meeting on the 10th and 11th of June 2019 for ports, and Selonda hosted the second meeting, focused on aquaculture, at the Selonda headquarters in Athens on the 27 and 28th of June 2019. During those meetings, users' needs and requirements were discussed and a first document was written to describe the first analysis of the information acquired (Deliverable 2.1: Report on the Users Feedback).

The information obtained during those meetings was used to extensively map the requirements that would add value to their sector, and is presented as Deliverable 3.8: Report on end users' needs and requirements. For aquaculture the information is completed by feedback obtained from other farmers in the frame of international projects lead by Argans-FR or in which Argans-FR was a partner for Earth Observation in support of aquaculture.

The stakeholder requirements are listed and classified according to priority (high, medium and low priority). The analysis of the results leads to prototypes of services needed by end users, that will be put in place in the framework of use cases. The parameters and services that can be provided by HiSea are also presented to fulfil the expectations of the end users.

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II. Port users' needs and requirements

1. Data needs

This chapter presents the "environmental" parameters identified together with the SAB members who cooperated by sharing their experience and providing valuable feedback.

a Ports requirements

Attending user interests and SAB feedback, and based on the expectation of each port, the environmental ports requirements are classified into three levels:

- *Critical* Desirable means that it is a requirement having high impact on daily port activities;
- *Desirable* indicates a requirement which would be helpful nice to fulfil; lastly,
- *Low* indicates that such requirement might be useful (based on our expertise) but it has not been explicitly expressed.

Table 1: Environmental ports requirements listed by parameter type and priority level for each port

Parameters	Priority	Port Location
Physics		
Temperature	Critical	Valencia, Melilla
Oxygen	Critical	Valencia, Melilla
pH	Low	Valencia, Melilla
Salinity	Low	Valencia, Melilla
Biology		
Turbidity (SPM)	Critical	Valencia, Melilla
Chlorophyll-a (phytoplankton)	Critical	Valencia, Melilla
Meteo-oceanographic		
Water current	Critical	Valencia, Melilla, Ravenna

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Wave	Critical	Valencia, Melilla
Rainfall	Low	Valencia, Melilla, Ravenna
Air information (pressure, T°, humidity)	Low	Valencia, Melilla, Ravenna
Chemistry		
Nitrate	Desirable	Valencia, Melilla
Ammonium	Desirable	Valencia, Melilla
Phosphate	Desirable	Valencia, Melilla
Others		
Oil spill	Critical	Valencia, Melilla
Floating debris	Desirable	Valencia, Melilla, Ravenna
Bathymetry	Desirable	Valencia

b Requirement synthesis

The analysis of table 1 shows that the priority is focused on water quality parameter, meteo-oceanographic data, and pollution monitoring. In case of ports, meteo-oceanographic variables (waves, currents) that drive water quality status represents relevant information for increasing the operations efficiency and for improving safety. Moreover, water quality information facilitate compliance with regulation.

The following table details and prioritises the parameters needed by ports.

Table 2: Priority by parameter for ports

Parameters	Priority	Comments
Temperature	High	All
Oxygen	High	Valencia, Melilla
Turbidity	High	Valencia, Melilla

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Chlorophyll-a	High	Valencia, Melilla
Water currents	High	All
Wave	High	All
Wind	High	All
Pollution (oil)	High	Valencia, Melilla
Floating debris	Medium	All
Nutrients (Ammonium, N, P)	Medium	Valencia, Melilla
pH	Low	Valencia, Melilla
Salinity	Low	Valencia, Melilla
Air information (pressure, T°, etc.)	Low	All

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2. Products that could be provided by models and remote sensing for Ports

This chapter presents the parameters required by users that could be provided by models and remote sensing.

Table 3: Products that could be provided for Ports

Parameters	Products Sources
Temperature	CMEMS model outputs Remote Sensing Observation Local Model
Oxygen	CMEMS model outputs Local Model
Turbidity	CMEMS model outputs Remote Sensing Observation Local Model
Chlorophyll-a	CMEMS model outputs Remote Sensing Observation Local Model
Water Current	CMEMS model outputs Local Model for a higher resolution
Wave	CMEMS model outputs Local Model for a higher resolution
Wind	Remote Sensing Observation (ASCAT) Local Model or observation from local station for a higher resolution

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Oil Spill	Remote Sensing Observation (Radar) Local Model for Spill derivation forecast
Floating debris	Remote Sensing Observation (Radar) Local Model for derivation
Nutrients (Ammonium, N, P)	CMEMS model output Local Model
pH	CMEMS model output Local model
Salinity	CMEMS model output Local model for a higher resolution

3. Services needs by Ports

This chapter presents the specific types of services needed by ports, as

To keep the traceability of the user requirements based on a first analysis of the Deliverable 2.1, users' requirements have been translated first into technical requirements and later into service requirements (more information is detailed in Deliverable 3.6: Report on technical requirements for the service platform). Hereafter, the extracted 9 services are reported.

Table 4: Services needed by ports

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Service ID	Service Definitions	Priority
S001	**Water and Weather Analytics Service** A service to monitor the environmental measurements (chemical, biological and physical) for water quality and allows to set periodical measurements. • Phytoplankton (Chlorophyll-a) • Oxygen • Temperature • Turbidity [Suspended sediments] • Currents • Waves • Weather data (wind, rainfall, air t°…)	High
	• Nutrients (Ammonium, Phosphorous and Nitrogen) • Chemicals • Etc.	Medium
S002	**Water and Weather Forecast Service (Same as Analytics)** A service to forecast the environmental variables (chemical, biological and physical) for water quality and also triggers alarms for quality losses. • Phytoplankton (Chlorophyll-a) • Oxygen • Temperature • Turbidity [Suspended sediments] • Currents • Waves • Weather data	High
	• Nutrients (Ammonium, Phosphorous and Nitrogen) • Chemicals	Medium

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	• Etc	
S003	**Oil and debris Analytics Service** A service that analyses the surface of the water, including a location detector and a forecast based on weather and current conditions • Detect waste on the surface of the water and present it visually on a map • Detect dangerous flotsam or other pollutants • Identify and locate oil spills at night • Management tools for spill/debris trajectory modelling	High
S004	**Morphology Service** A service to detect underwater sediments (high priority) and bathymetry (medium priority).	High
S005	**Harmful Location Service** A service to warn users about environmentally harmful locations (Backtracking)	high

4. Characteristics of the services needed by Ports

Based on a first detailed analysis of ports' needs, this chapter presents the characteristics of the users' specified services that could be provided by HiSea. Those have been validated by SAB members and will be refined during the next steps of the project. Attending user interests and specific needs, the first phase of HiSea service development and design, consider the possibility of providing water quality information to facilitate compliance with regulation and ensure continuous measurements of environmental parameters, both on the surface and in the water column. A need of early warning system for abnormal water quality parameters and weather conditions (waves, wind) has also been identified as critical from many ports and therefore will be provided as one of the HiSea services. In order to do develop an early warning system, high resolution water quality models will be set up to forecast water quality parameters, waves conditions, and in case of necessity to foresee oil spill movements.

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III. Aquaculture users' need and requirements

1. Data needs

This chapter presents the environmental parameters needed for different types of aquaculture. Argans-FR has summarised information provided by Selonda (the end users of the project for aquaculture), and included information acquired in several projects on the subject of using Earth Observation for aquaculture support (Smart-Innovator, SAFI-H2020, IMPAQT-H2020, etc.).

a Farmers requirements

The results presented in the following table are based on needs expressed by farmers from France, Ireland, Scotland, The Netherland, Turkey, Greece, Italy, Morocco and China.

The species farmed are very different, and therefore are divided into the following categories:

- ***Seaweed***: *Alaria esculenta, Ulva rigida, Saccharina latissima*, *Alaria esculenta* (*Laminaria hyperborea, Palmaria palmata, Ulva spp.*) ...
- ***Finfish***: Atlantic salmon (*Salmo salar*), Lumpfish (*Cyclopterus lumpus*), Wrasse (*Labrus bergylta*), European sea bass (*Dicentarchus labrax*), Seabream …
- ***Shellfish***: European Lobster (*Homarus gammarus*), Abalone (*Haliotis*)
- **Mussels** (*Mytilus edulis, Mytilus galloprovincialis*),

Requirements are identified for each of the above described categories and as shown in Table 5, they can differ based on the cultivated species as well as in case of polyculture (multitrophic aquaculture). As previously done for the ports, the requirements are classified according to three levels:

- *Critical* indicates a requirement having high impact on daily aquaculture activities;
- *Desirable* indicates a requirement which would provide value. Lastly,
- *Low* indicates a requirement which might be useful (based on expertise of the consortium) but has not been explicitly expressed.

Table 5: Environmental parameters needed by different types of aquaculture farming

Parameter	Priority level per species farmed			
	Seaweed	Mussels	Finfish	Shellfish
Temperature	Critical	Critical	Critical	Critical
Salinity	Critical	Critical	Critical	Critical
Dissolved Oxygen	Critical	Critical	Critical	Critical
Ph	Low	Low	Desirable	

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Light	Critical	Critical	Low	Should
Photosynthetically active radiation (PAR)	Desirable	Must	Must	Desirable
Water colouration (Secchi Depth)	Desirable	Desirable	Desirable	Desirable
Turbidity	Desirable	Critical	Critical	Critical
Chlorophyll-a	Critical	Critical	Critical	Critical
Suspended Matters (SPM)	Desirable	Low	Low	Desirable
Harmful Algae Blooms (HABs)	Low	Critical	Desirable	Critical
Particulate Organic Matter (POM)	Low	Low	Low	Low
Dissolved Organic Carbon (DOC)	Desirable	Desirable		
Particulate Organic Carbon (POC)	Desirable			
Pollutant/Bacteria	Should			
Water current	Critical	Critical	Desirable	Must
Wave	Critical			
Wind	Desirable	Critical	Desirable	Critical
Rainfall	Desirable	Desirable	Critical	Desirable
Cloud coverage	Low	Low	Low	Low
Hour daylight	Desirable		Desirable	
Solar radiation	Desirable	Critical	Critical	Critical
Air temperature	Desirable	Low	Low	Low
Air pressure	Critical	Critical	Critical	Critical
Moisture	Critical	Critical	Critical	Critical
Nitrate	Critical	Critical	Critical	Critical
Ammonium	Desirable	Desirable	Critical	Critical
Phosphate	Desirable	Desirable	Critical	Desirable
Stock biomass	Critical		Critical	
Stock density	Critical			

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b Requirement synthesis

The analysis of the upper table shows that priority can differ according to the type of farming. However, some parameters have been solicited with high priority by the majority of farmers. Farmers globally need high resolution data, real time and historical data, forecasting and alerts for:

- oxygen concentration
- temperature
- salinity
- sea state (waves, etc.)
- water quality (turbidity, chlorophyll-a, HABs…)

Oxygen and temperature are indeed two of the main parameters that affect fish, shellfish and seaweed welfare, robustness, growth rate. Optimal water temperatures result in higher fish growth rates and feed intake. The ability of the farmers to adjust the feeding when water temperature levels rise results in improved growth and financial benefits. Also, when the temperature drops it is important to reduce feeding to avoid feed waste and financial loses. Temperature rise, and low oxygen levels are many times linked to fish disease outbreaks.

For shellfish and seaweed, turbidity, chlorophyll-a and nutrients (nitrate and ammonium) concentration are very important for health and growth. Moreover, the monitoring of Harmful Algal bloom is very important to prevent the catastrophic impact (high mortality rate) on fish and shellfish farms.

Meteo-oceanographic parameters such as currents, winds and waves are vital for sea farm production and for the protection of the infrastructure of the farm. Currents, waves and winds can affect oxygen levels that are often more favourable for the fish when currents are stronger. Also, winds and currents determine the timing of harvesting using vessels. Forecasting winds, currents and wave would allow scheduling the harvesting so that the weather conditions would not affect the supply chain.

The following Table 6 classifies and summarises the priority of the parameters needed by farmers.

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Table 6:Priority by parameter for farmers

Parameters	Priority	Comments
Temperature	High	All
Salinity	High	All
Dissolved Oxygen	High	Fish/Shellfish farmers
Light/PAR/Solar irradiance	High	All*.
Turbidity	High	All
Chlorophyll-a	High	All
Water current	High	Depend on the type of specie farmed
Nitrate	High	All
Ammonium	High	Almost all
Wind	High	Depends on the type of species farmed
Wave	High	Needed by one farm
HABs	High	Finfish and Shellfish
Phosphate	Medium	All
Rainfall	Medium	Depends on the type of specie farmed
Air information (pressure, T°,)	Medium	Depends on the type of species farmed
Suspended Matters	Medium	All
Cloud Coverage	Medium	All
Jellyfish observation	Medium	Depends on the type of specie farmed
POC/DOC	Medium	All
Pollution/Bacteria	Medium	Needed by one farm
pH	Medium	Depends on the type of species farmed
Particulate Organic Matter (POM)	Low	Needed by one farm

* the requested parameter is not exactly the same from a farmer to another

2. Products that could be provided by models and remote sensing for Aquaculture

This chapter presents the “environmental” parameters needed by users that could be provided by models and remote sensing.

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Table 7: Products that could be provided for Aquaculture

Parameters	Products Sources
Temperature	CMEMS model outputs Remote Sensing Observation Local Model
Salinity	CMEMS model outputs Remote Sensing Observation Local Model
Dissolved Oxygen	CMEMS model outputs Local Model
Light/PAR/Solar irradiance	Copernicus model outputs Remote Sensing Observation
Turbidity	CMEMS model outputs Remote Sensing Observation Local Model
Chlorophyll-a	CMEMS model outputs Remote Sensing Observation Local Model
Nitrate	CMEMS model outputs Local Model
Ammonium	CMEMS model outputs Local Model
Water current	CMEMS model outputs Local Model
Wind	CMEMS observation Remote Sensing Observation (ACSAT) Local Model or observation from local station for a higher resolution
Wave	CMEMS model outputs Local Model for a higher resolution
Air information (pressure, T°, etc.)	Copernicus model outputs (NCEP/GFS or ECMWF)
Suspended Matters	CMEMS model outputs Remote Sensing Observation Local Model
HABs	Remote Sensing Observation Local Model
Phosphate	CMEMS model outputs Local Model
Rainfall	Copernicus Climate Change Service Radar Observation

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	Local Model or observation from local station for a higher resolution
Cloud Coverage	Radar Observation Remote Sensing Observation
Jellyfish observation	Crowd Sourcing
POC/DOC	Remote Sensing Observation
Pollution/Bacteria	Local Model or observation from local station
pH	CMEMS model outputs Local Model

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3. Services needs

This chapter presents the services needed in aquaculture based upon results of the analysis of users' requirements as done in Deliverable 3.6: Report on technical requirements for the service platform.

Table 8: Services needs by aquaculture

Service ID	Service Definitions	Priority
S001	**Water and Weather Analytics Service** A service to monitor the environmental measurements (chemical, biological and physical) for water quality and allows to set periodical measurements. • Phytoplankton (Chlorophyll-a) • Oxygen • Temperature • Turbidity [Suspended sediments] • Currents • Waves • Weather data (wind, rain fall…) • Nutrients (Ammonium, Nitrate and Phosphorous) • Harmful Algal blooms • Etc.	High
S002	**Water and Weather Forecast Service (Same as Analytics)** A service to forecast the environmental variables (chemical, biological and physical) for water quality, and also triggers alarms for quality losses. • Phytoplankton(Chlorophyll-a) • Oxygen • Temperature • Turbidity [Suspended sediments] • Currents • Waves • Weather data	High

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	• Nutrients (Ammonium, Phosphorous, and Nitrogen) • Harmful Algal blooms • Etc.	
S003	**Harmful Location Service** A service to warn users for environmentally harmful locations (Backtracking)	High
S004	**Emergency Control Centre Service** A service that connects to the Emergency Control Centre for farm managers to get data that is used currently.	Low

4. Characteristics of the services needed by Aquaculture

This chapter presents the characteristics of the users' specified services that could be provided by HiSea. Those will be refined during the next steps of the project. The operation of fish farms as aquaculture parks that cover very large areas will become obligatory by law in the next years. The licensing of those parks will demand water quality monitoring of more parameters and with higher frequency. HiSea services can provide the aquaculture sector with the required information on an ongoing basis.

Indexes that incorporate biomass, temperature, oxygen, etc. could also be provided by HiSea so that aquaculture companies can use them to assess site capacity. These indexes are required by the sea farmers for sea farm licensing. Water quality monitoring is required not only for sea farms but also for hatcheries that pump water from the sea. Especially because fish larvae are very sensitive to water quality issues.

Attending to user interests and specific needs, the first phase of Service/Tool development and design, must consider the possibility of providing the following:

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IV. Conclusion

Ports and aquaculture are two different worlds which have different objectives and needs. However, in term of environmental monitoring and forecasting their requirements converge in several areas.

First, both need "Water quality monitoring and forecast" information at high spatial resolution and at high frequency. The currently available standard model outputs products provided by Copernicus at high frequency (hourly, 3-hourly …) have a resolution which is too low (1 km or more) and can only provide general information of the quality of the water body around the port or the farm. However, model outputs provide interesting information in terms of forecasting and water column composition. For remote sensing, the medium resolution sensors (MODIS, VIIRS, OLCI …) have a repetitiveness of ~one day at mid latitudes and a spatial resolution from 300 m to 1.2 km. Like Copernicus models, they can provide interesting information around the port or the farm which can help ports managers and farmers to better understand the surrounding events. High resolution satellite images, from Sentinel-2, have a spatial resolution of 10 to 60 m that is suitable to the ports or marine farm extension, but have a low repetitiveness (~5 days). The higher the spatial resolution the lower the repetitiveness or frequency of data collection. Moreover, water quality algorithms are limited in terms of parameters detection (only turbidity, suspended matters and chlorophyll-a) and often need local adjustment. So, the development of local models is critical to obtain high resolution estimation at high frequency. The use of models and satellite imagery in complementary way allows coverage of most parameters needed by port managers and aquaculture famers for water quality monitoring and forecasting.

Weather and sea state monitoring and forecast are also needed by port managers and famers to prevent potential infrastructure damage, storm surge and pollution. Meteorological models and station observations, wind and wave model and observations are currently used in port and farm management. In the framework of HiSea this monitoring and forecasting will cover most of the users' needs.

Both water quality, weather and sea state monitoring and forecasting must trigger alarms based on thresholds and indicators combinations that must be specified in decision trees and displayed on the dashboard to help managers in their decisions and actions.

Oil and floating debris monitoring seem to be more important for ports management than for aquaculture. In that case oil and debris monitoring can be done by satellite detection and trajectory forecast can be done by models. Alerts could be provided on demand in case of propagation risks in or out the port and on the farm location.

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HABs detection and jellyfish presence are specific to aquaculture requirements. These parameters can dramatically affect aquaculture production causing mortality, temporary closure or material damage.

Users' needs and requirements will be updated and finalize during the project by May 2021. However, the work performed up till now already enables HiSea developers to better understand the users and stakeholders' expectations in terms of monitoring, forecasting, alarms and management.

In summary, while Copernicus products and medium resolution satellite imagery provide general information around the farms and the ports, the spatial resolution is too low to serve the needs of these sectors. Therefore, the development of local models in combination with the use of high-resolution satellite images is critical to meet users' expectations in terms of high spatial resolution monitoring and forecasting at high frequency.

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