

**CO-LOCATION OPPORTUNITIES FOR RENEWABLE ENERGIES AND AQUACULTURE
FACILITIES, DECISION SUPPORT FOR OPERATIONAL MULTI-USE PLATFORM ACTIVITIES AT
COASTAL AREAS”**

(RENAQUA Decision Support System)



User Requirements of the RENAQUA Service
15th January 2020

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List of Acronyms

DIAS	Data Information Access Service
DSS	Decision Support System
HSOM	Health - Safety and Operational Maintenance
IH-MSP	IHCantabria's Platform for Marine Spatial Planning
M2M	Machine to machine communication
Meteocean	meteo-oceanographic
MINECO	Spanish Ministry of Economy, Industry and Competitiveness
MITECO	Spanish Ministry for the Ecological Transition
MRE	Marine Renewable Energy
MUP	Multi-Use Platforms
NCEP	National Centers for Environmental Predictions
NCML	NetCDF Markup Language
NGA	National Geospatial Intelligence Agency
NOAA	National Oceanic and Atmospheric Administration
O&M	Operations & Maintenance
OGC	Open Geospatial Consortium
RENAQUA	RENEWable energies and AQUAculture facilities
SDGs	Sustainable Development Goals
TDS	THREDDS Data server
UCLA	University of California, Los Angeles
UI	User Interface
UX	User Experience
WCS	Web Coverage Service
WEkEO	We knowledge Earth Observation
WMS	Web Map Service

1 METHODOLOGY

The RENAQUA Service is a **user driven Service**. The design of the Service was adapted regarding requirements and functionality, including an interactive method to explore needs and requirements from final end users. The following lines describe the methodology undertaken for the development of the RENAQUA Service at the MSP Platform.

The MSP Platform features were implemented under an iterative and incremental development ensuring a greater ability to incorporate changes during the development cycle, see Figure 1. Software development was divided into four phases: (1) Requirement Analysis, (2) Software specifications, (3) Software development and (4) User Feedback. The following lines provide a brief description, reasons why it was necessary, expected results and possible constraints, assumptions or solutions for each of the development phases:

- *Requirement Analysis* or product line analysis was focused on the relationships between the different spatial information collected from the rest of the ST. This stage broke down functional and non-functional requirements to a basic design view to provide a clear software development framework.
- *Software specifications* phase described the essential features that the MSP Platform provides to the end user. The software requirements fully describe what the software does and how it is expected to perform. Specifications help avoid duplication and inconsistencies and act as a reference for software development. Functional Specifications provide the consensus on what the Platform is going to achieve. Software requirements specification permitted a rigorous assessment of requirements before design began and reduced later redesign. It also provided a realistic basis for estimating product costs, risks, and versioning schedules. This Action took into account the results obtained from the Requirement Analysis phase. Software specifications were created every iterative loop for the software development phase.
- *Software development* phase was based on Software specifications. The MSP Platform System Architecture design was described, which provided the definition of the architecture, components and modules to satisfy all the specifications stated at the Requirement analysis phase.
- Testing and *user feedback* provided significant inputs for the improvement of the final user experiences. Feedback and bugs were included at every iterative loop in order to adapt the RENAQUA Service according to user requirements.

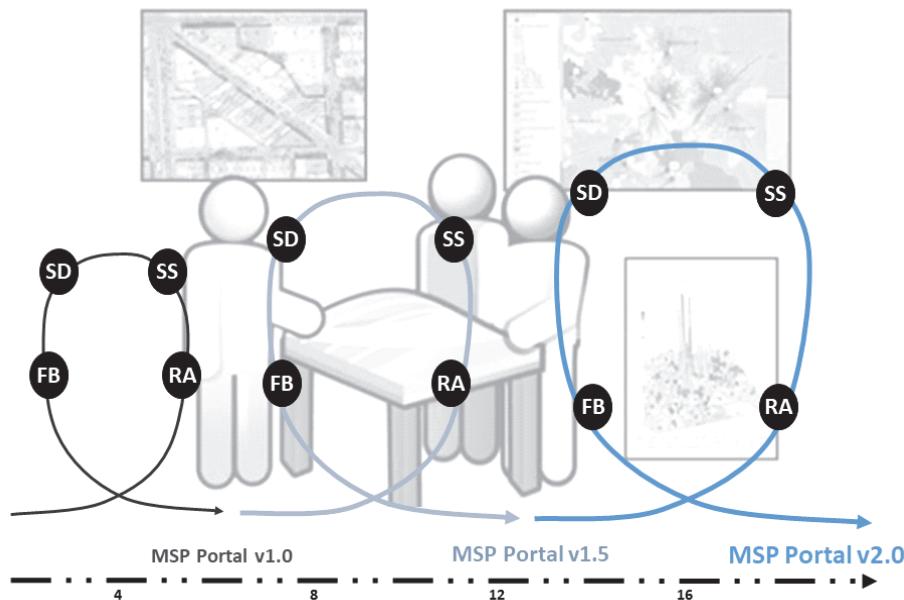


Figure 1. MSP Platform - Iterative and incremental development. [RA- Requirement Analysis, SS- Software Specifications, SD-Software Development, FB- Feedback]

In order to accomplish the previously listed milestones, Local downstream services (TRL Plus and PIAGUA) allowed us to interact with the Aquaculture and MRE sectors. Therefore, the RENAQUA Project was organised in four stages, see Figure 2.

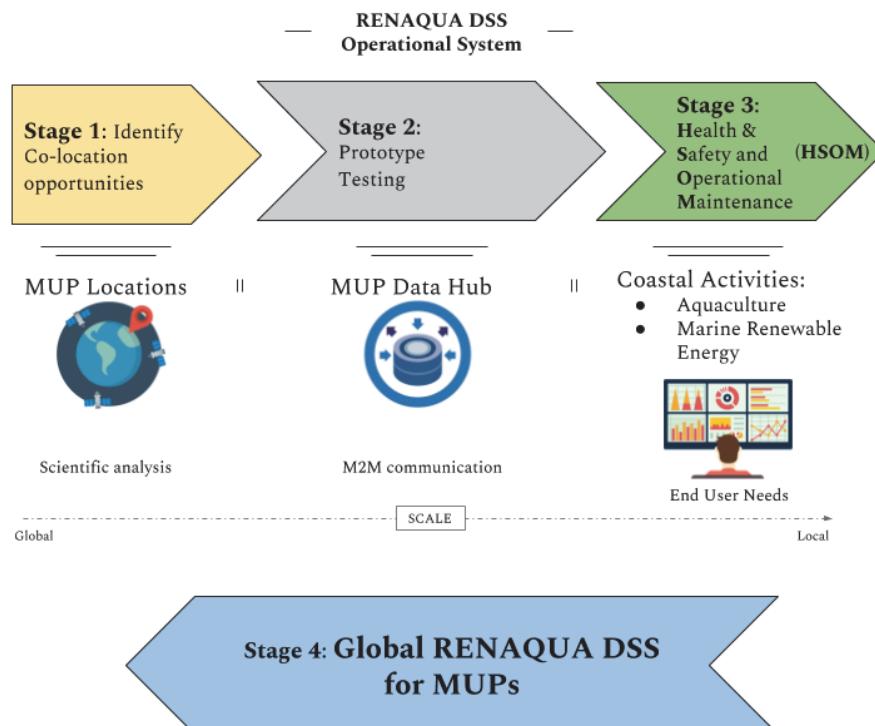


Figure 2. Development stages of RENAQUA DSS Operational System

First stage focused on the identification of co-location in a global scale. The second stage was devoted to build the system architecture and interoperability protocols required for the DatHub. The third stage analyse user requirements at local scale making use of available CMEMS downscaled products. Finally, the forth stage makes use of Global Copernicus Marine Operational products to provide Health-Safety and Operational Maintenance (HSOM) service for MUPs worldwide.

Therefore, under a user driven approach, through iterative and incremental cycles, global and local scale downstream services were designed and developed. The following sections show the different use cases and the architecture built to host and provide the Services.

2 USER REQUIREMENTS AND USE CASES

In a user driven software development, end users and their needs are the central pillar. Depending on the type of users, their needs and requirements may be different. Subsequently, targeted users were identified and classified, see Figure 3:

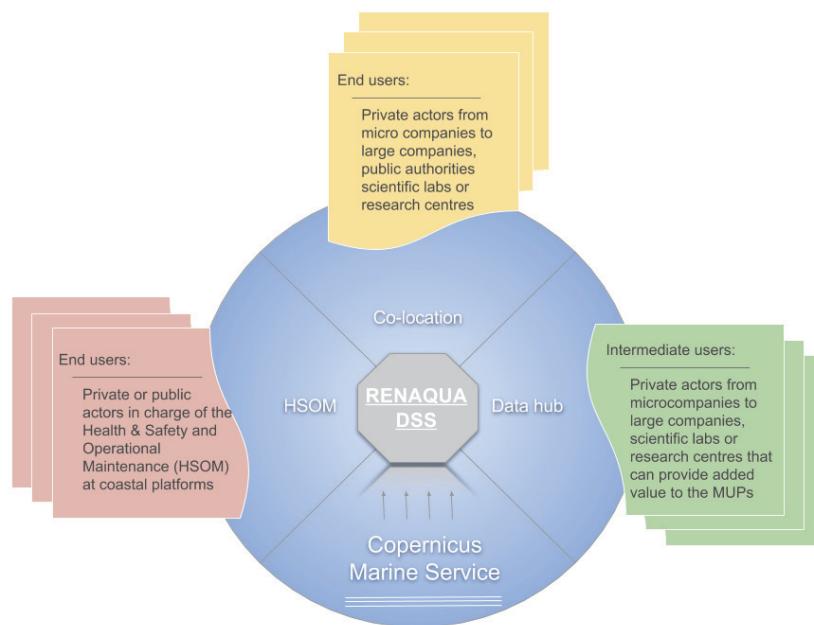


Figure 3. Type of end users of the RENAQUA DSS

End users of the RENAQUA Service are mainly three:

- private actors from microcompanies to large companies,
- public authorities or
- scientific staff from research centres or academia.

It is important to highlight that the interests and needs from companies, the public authorities and researchers are different. In addition, their knowledge and skills to deal with metocean information differs notably. Consequently, to make the most of the RENAQUA Service the access and the information analysed should be provided as tailored information products for each type of user.

In order to have a clear view about what the RENAQUA Service could offer to the identified end users, Table 1 matches three main aspects: (1) the leading thematic fields of the RENAQUA Service, (2) end users needs, and (3) end user solutions for each type of user.

	Needs	End user – Solution
Co-location analysis	A systematic approach towards spatial planning that identifies opportunities for the co-location of activities is essential to minimize conflicts, optimize the use of space, and reduce operation costs.	Analytical capabilities for private companies, public authorities or scientific actors for marine spatial planning (co-location of aquaculture and MRE activities).
Data Hub	support the pathway from the MUP concept to the market, the Copernicus Marine Service provides relevant information to establish decision support for operational activities	MUP designers and engineers will be able to have access to relevant data to test any model or device for aquaculture or MRE activities.
Health & Safety	Jobs in aquaculture are the second most hazardous in Norway, beaten only by fisheries. Therefore, a DSS for operational activities at MUPs is needed in order to reduce the probability and consequences of operational and human errors.	Platform managers require Health-Safety indicators from metocean conditions (real time & forecasting), which can provide warning criteria that indicate the necessity of halting or continuing operations and recommended measures to reduce possible risks
Operational Maintenance	increase the efficiency of operational activities	The System will provide relevant metocean information for the day to day activities undertaken by private or public actors in charge of the MUPs operational maintenance (aquaculture and MRE farms).

Table 1. Needs and targeted users of the RENAQUA project

The RENAQUA downstream service demonstrates: firstly, the capabilities to identify opportunities for the co-location of these activities globally, secondly, the development of the MUP Data Hub to centralize and access relevant MetOcean data sets, and thirdly the use of Global Copernicus Marine Operational products to provide Health-Safety and Operational Maintenance (HSOM) service for MUPs worldwide. However, it is important to highlight that Health-Safety and Operational Maintenance (HSOM) are activities that require spatial and

temporal accuracy. The importance of downscaling techniques to be able to obtain accurate results for the application of decision support for Health - Safety and Operational Maintenance activities (HSOM) is mandatory.

The RENAQUA DSS provides indicators at global scale. However, these indicators are based on the development of Decision Support Systems implemented at local scale. The following lines describe the downscaling approaches that were undertaken for both sectors, aquaculture and marine renewable energies.

Decision support for Health - Safety and Operational Maintenance (HSOM) activities at local scale require User Interfaces (UIs) specifically designed for each end user requirement, which need specific User experiences (UXs). Therefore, two main Web based applications were designed to answer the needs and interact with the aquaculture and MRE sectors.

Interactions with the MRE and aquaculture sectors were the foundations of software design, three use cases have been designed, one for each of the downstream services. A use case is a description of tasks that end users can perform on the System. The use cases of the downstream services outline, from a user's point of view, the system's behaviour as a sequence of simple actions that they can undertake with the System. The following subsections describe the use cases of the TRL Plus DSS, PIAGUA DSS and MSP Platform.

2.1 MARINE RENEWABLE ENERGY (MRE) - TRL PLUS DSS

The current environmental context, both for the dynamics of the planet itself and for the influence of the human being on it, raises real environmental challenges. Obtaining energy from renewable sources could be considered one of the main challenges facing humanity. Marine renewable energy, and especially offshore wind, have the potential to become one of the biggest contributors to Global energy demand according to the latest report of the International Energy Agency (IEA 2019).

The design of new prototypes to obtain energy from marine renewable energy sources requires testing the new devices for validation purposes. In this sense, the TRL Plus research project <http://trlplus.com> (RTC-2015-3836-3), funded by the Ministry of Economy and Competitiveness (MINECO), facilitates three “test environments” for validation:

- (1) *Lab.* Devices can be tested at the Cantabria Coastal and Ocean Basin (CCOB, <https://ccob.ihcantabria.com/>), singular scientific and technical infrastructures (ICTS) that allows to simulate offshore conditions of waves, wind, currents, in a Lab environment.

- (2) *In situ*. Devices can be tested at the BiMEP Platform <https://bimep.com>. BiMEP is an infrastructure operating in real marine conditions for the research, demonstration and operation of marine energy collector devices.
- (3) *On-line*. Information Technologies (IT) allow real or fictitious environmental phenomena to be transferred to a digital environment through an abstract representation.

Unlike the *In situ* or Lab, the On-line or virtual environment allows, through numerical simulation techniques, to carry out a digital representation of the past “hindcast”, of the present “nowcast” and the future “forecast” events of specific locations. Therefore, a Decision Support System called “TRL Plus DSS” was designed with a double objective:

- (i) facilitate decision making in Operation and Maintenance (O&M) tasks of the BiMEP Platform and
- (ii) facilitate access to designer that need to validate their prototypes by means of metocean information of the past, present and/or future.

As a user driven software development, the analysis of type of end users was key, two type of users were identified: managers of the BiMEP Platform and designers of MRE devices. Subsequently, the requirement analysis, under an iterative and incremental approach, concluded with three use cases: operational processes, human interaction and machine interaction.

Firstly, see Figure 4, the system itself must independently obtain metocean information operationally from external data providers, both from *in situ* sensors and numerical models. The information obtained from numerical models must be “downscaled”, that is, the spatial resolution of the dynamics (currents, waves and wind) must be improved. Once the high spatial resolution prediction of environmental phenomena is obtained, it is possible to carry out analyses derived from metocean information, such as the accessibility or device modelling in a virtual way. All the information generated will compose a daily report that will be sent daily to registered users.

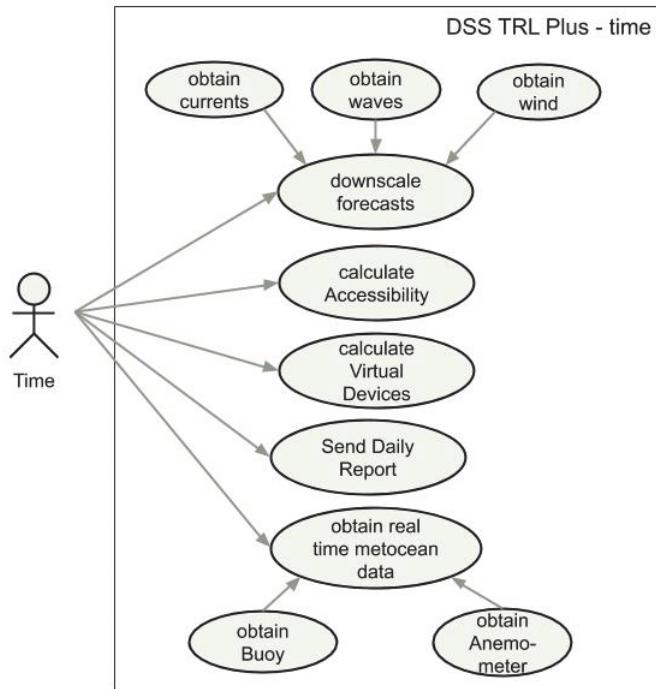


Figure 4. TRL Plus - Operational and autonomous processes

Secondly, see Figure 5, device designers or BiMEP managers, must be able to access the information generated by the System in a clear and friendly way, without the need to install specific software. In this sense, Web technologies offer an effective communication channel that allows the visualization of metocean information (past, present and future), enable the configuration / simulation of devices, allow the subscription to the daily report and display additional information of the test area: location of buoys, cables, mooring areas, bathymetries, bottom type, etc.

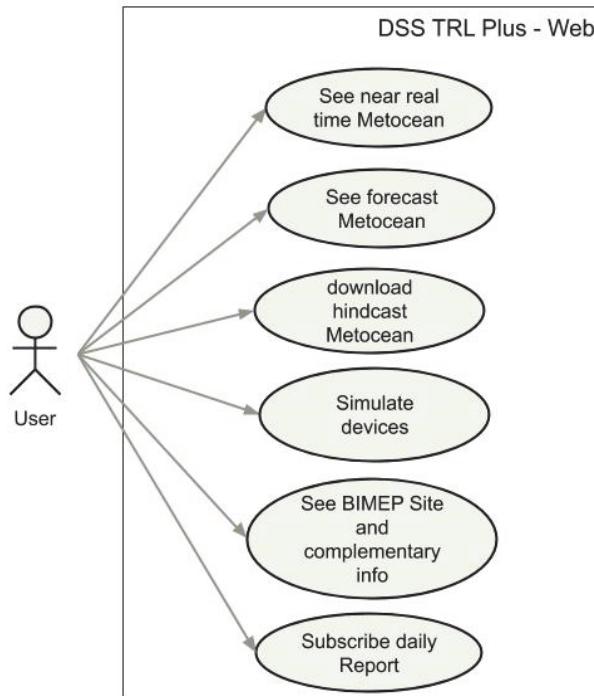


Figure 5. TRL Plus - User interaction

Thirdly, see Figure 6, users with programming capabilities, such as device engineers, must be able to develop software by establishing a machine-machine (M2M) communication with the DSS TRL Plus System. The interoperability of the TRL Plus System allows access to metocean information (past, present and future), as well as the simulation or processing service of virtual devices and the calculation of accessibility.

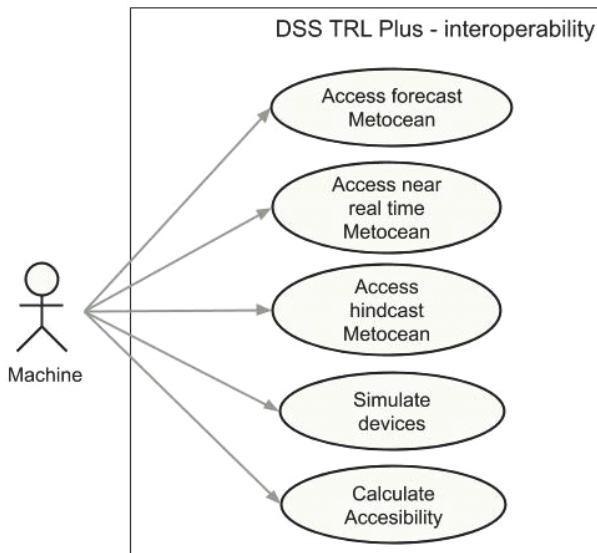


Figure 6. TRL Plus - Machine interaction

The TRL PLUS requirement analysis, showed as use cases, allowed having a consensus about functional specifications and what the TRL Plus DSS was going to provide to end users.

2.2 AQUACULTURE – PIAGUA DSS

Fish convert feed into body protein more efficiently than cattle or chicken production. Fish farming aquaculture involves the selective breeding of fish with the purpose of producing a food source for consumption. It requires food and proper water conditions as well temperatures. Aquaculture plays a key role in many emerging economies, by virtue of its potential to contribute to increased food production while helping reduce pressure on fish resources (OECD 2019).

Grupo Culmarex is an international aquaculture company <http://www.culmarex.com/> with several farms in the mediterranean coasts, Spain, see Figure 5.



Figure 7. Grupo Culmarex Aquaculture Farms

In order to identify and collect the needs and requirements for offshore aquaculture farming, several meetings took place with *Grupo Culmarex* staff. The main outputs from the meetings were two: the selection of the PIAGUA offshore farm as the pilot site to design and develop the PIAGUA DSS and information required to provide a Health & Safety and Operational Maintenance Decision Support System for Offshore Aquaculture facilities. The PIAGUA farm (Almeria) hosts 36 cages for fattening seabream and seabass and a feeding platform.

Therefore, a Decision Support System called “PIAGUA DSS” was designed with a double objective:

- (i) facilitate decision making in Operation and Maintenance (O&M) tasks for the PIAGUA farm and
- (ii) facilitate the access to metocean data related with aquaculture activities.

As a user driven software development, the analysis of type of end users was undertaken, two type of users were identified: managers of the PIAGUA Platform and Aquaculture researchers. Subsequently, the requirement analysis, under an iterative and incremental approach, concluded with three use cases: operational processes, human interaction and machine interaction.

Firstly, see Figure 8, the system itself must independently obtain meteocean information operationally. Outputs from downscaling numerical models provided by external data sources are collected: waves, temperatures, currents and winds.

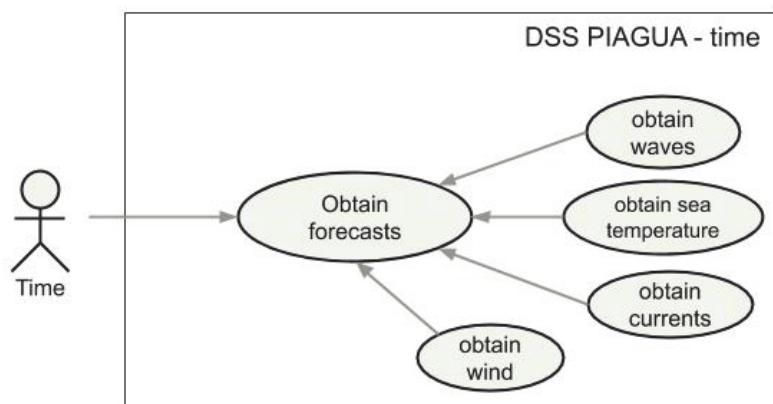


Figure 8. PIAGUA - Operational and autonomous processes

Secondly, see Figure 9, PIAGUA managers must be able to access the information generated by the System in a clear and friendly way. In this sense, Web technologies offer an effective communication channel that allows the visualization of metocean information and display the Suggested Feeding Rate (SFR) and operability.

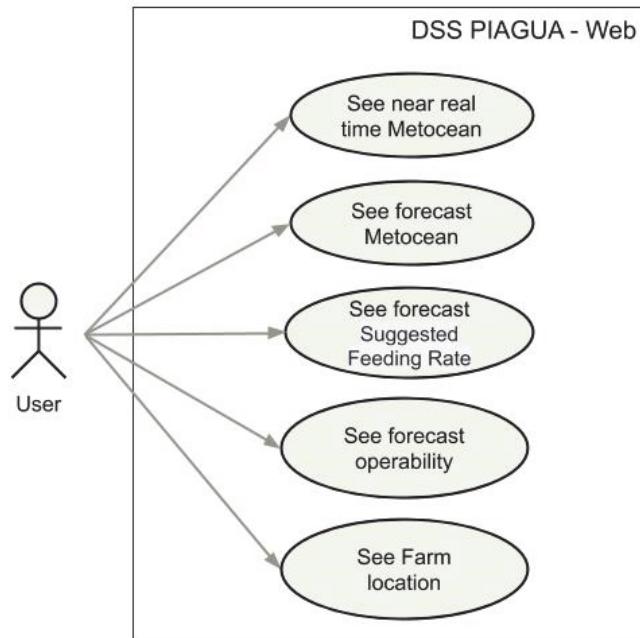


Figure 9. PIAGUA - User interaction

Thirdly, see Figure 10, users with programming capabilities, such as Aquaculture researchers, must be able to develop analytical scripting software by establishing a machine-machine (M2M) communication with the DSS PIAGUA System. The interoperability of the PIAGUA System allows access to the forecasting metocean information of waves, wind and currents.

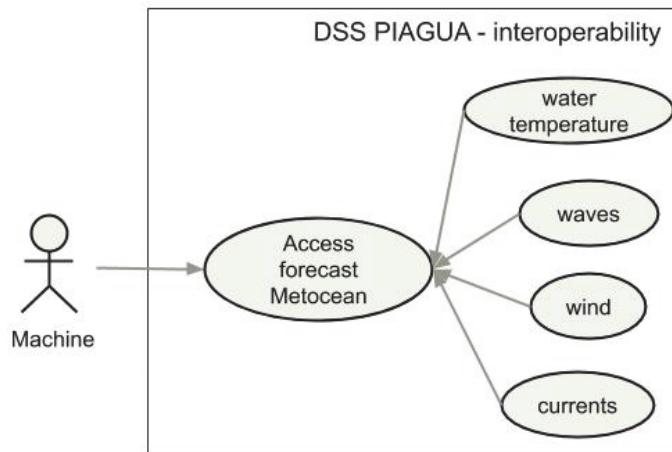


Figure 10. PIAGUA - Machine interaction

The PIAGUA requirement analysis, which have been described as use cases, allowed having a consensus about functional specifications and what the PIAGUA DSS was going to provide to end users.

2.3 MARINE SPATIAL PLANNING (MSP) PLATFORM

Competition over space will become a delicate issue for the sustainable development of the marine environment and will require creative and innovative solutions for co-location of activities (Christie et al., 2014). Marine Spatial Planning (MSP) is a fundamental tool for balancing sector interests and achieving Blue Growth, elucidating trade-offs of individual and combined uses of marine resources (White et al., 2012).

As a user driven software development, the analysis of type of end users was undertaken, three types of users were identified: governments dealing with MSP implementations, MSP researchers and companies. Subsequently, the requirement analysis, under an iterative and incremental approach, concluded with three use cases: operational processes, human interaction and machine interaction.

Firstly, see Figure 11, the system itself must independently obtain metocean information operationally. Outputs from Global numerical models, provided by external data sources, are collected: waves, temperatures, currents, sea level and winds. In the same way, metocean data from in situ sensors, buoys and tidal gauges, is collected operationally.

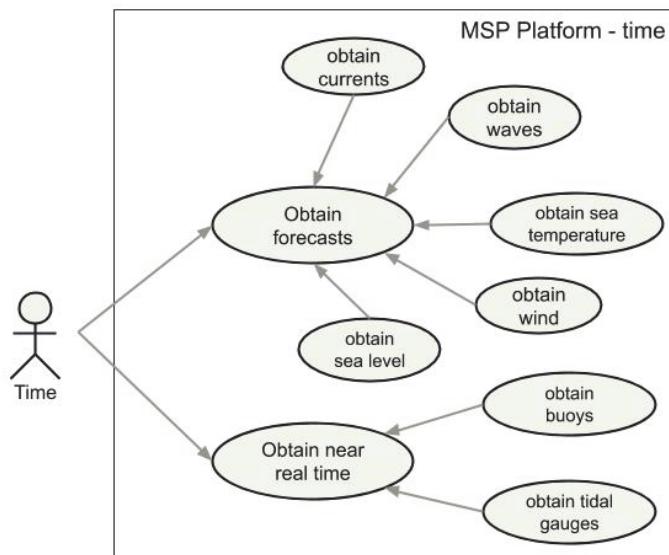


Figure 11. MSP Platform - Operational and autonomous processes

Secondly, see Figure 12, end users must be able to access the information generated by the System in a clear and friendly way. In this sense, Web technologies offer an effective communication channel that allows the visualization of suitability maps for aquaculture and MRE, discover metocean data products, make new queries and calculations with end user defined thresholds for Aquaculture and MRE suitabilities, and see thematic maps

(bathymetry, geology, habitats, etc.). The MSP Platform includes metocean data from the past or “hindcast”, near real time or “nowcast”, short term forecast and climate change scenarios.

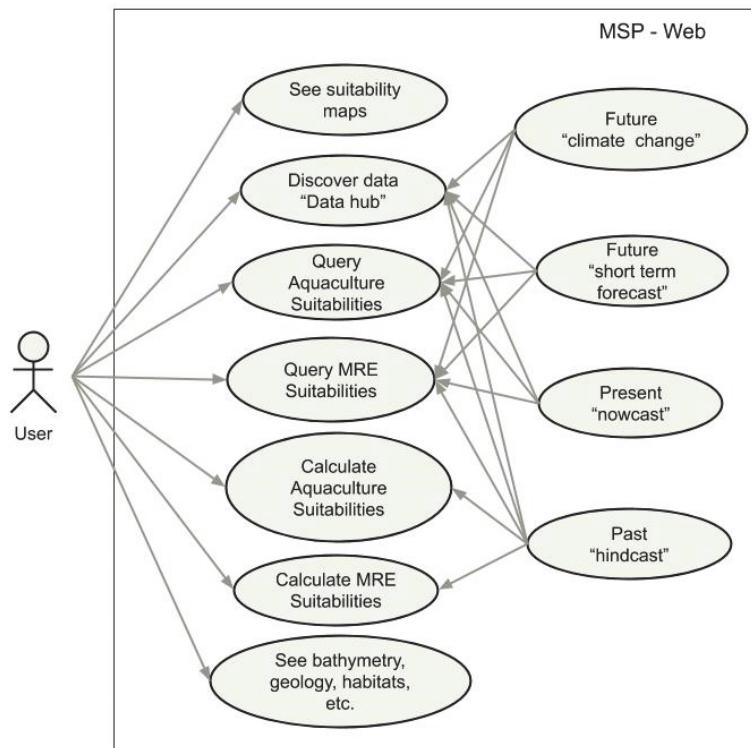


Figure 12. MSP Platform - User interaction

Thirdly, see Figure 13, users with programming capabilities, such as MSP researchers or companies, must be able to develop software by establishing a machine-machine (M2M) communication with the MSP Platform. The interoperability of the MSP Platform allows access to the suitability indicators (MRE and aquaculture), climate change metocean scenarios, short term metocean forecasting, near real time metocean data, hindcasting metocean data and the option to request suitability analysis.

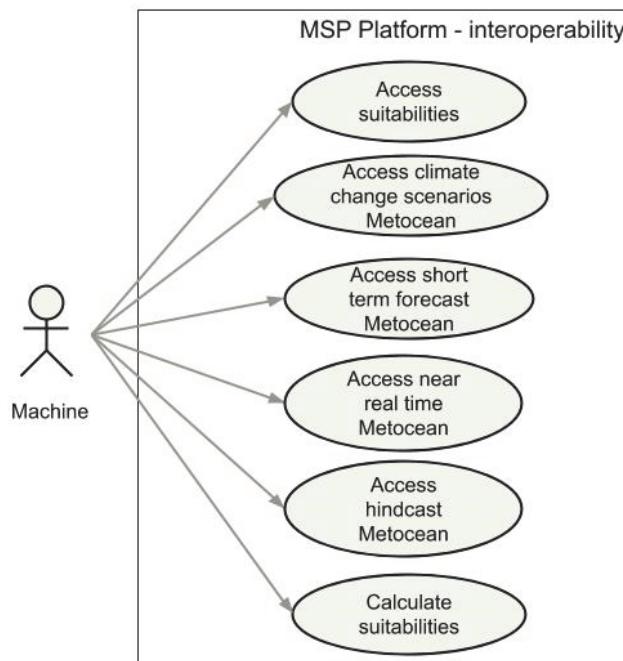


Figure 13. MSP Platform - Machine interaction

The MSP Platform requirement analysis, showed as use cases, allowed having a consensus about functional specifications and what the MSP Platform was going to provide to end users.

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