Deliverable D1.2-C:

Requirements Baseline – Use Case 3: Optimizing Location of Sustainable Shellfish Farming and Tourism in Galicia, Spain

by

Victor Martinez Vicente (PML)

Xose Anton Alvarez Salgado (CSIC)

An ESA funded project implemented by
Nansen Environmental and Remote Sensing Center, Norway and
Plymouth Marine Laboratory, UK

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0.1	20.02.2025	Structure	LHP, VMV + all	ToC structure
0.9	07.04.2025	To NERSC/PM	VMV	Spanish EA survey and analysis
1.0	10.04.2025	To ESA PO	VMV and LHP	Formatted and edited
2.0	26.06.2025	Comments from ESA	MHR and JC	Comments to be addressed
3.0	16.07.2025	Addressed	VMV, XAAS	Comments addressed.

2 Table of Contents

Preface (common to the four Use cases)

The **Earth Observations for Sustainable Aquaculture (EO4SA)** project is funded by the European Space Agency (ESA) in their EO for Sustainable Blue Economy project under the ESA PEOPLE-program. The project is implemented by the Nansen Environmental and Remote Sensing Center (project contractor and manager) in Bergen, Norway and Plymouth Marine Laboratory, UK.

The main objective of EO4SA is to consolidate the requirements and demonstrate the information opportunities, needed by the aquaculture industry and monitoring agencies using EO and other data sources. For selected Early Adopters (EA) the project implements four Use Cases, at several locations in Norway, Spain and the Philippines, related to:

1. Predicting risks of salmon lice infestation in Norway.
2. Forecasting toxic algal blooms (HABs) impacting shellfish farming in Norway.
3. Optimising location of sustainable shellfish farming and tourism in Galicia, Spain.
4. Mapping aquaculture structures and use of marine resources in Palawan, Philippines.

This report is the project deliverable Requirement Baseline (D1.2) includes a detailed analysis of relevant policy aspects to each use case. Further a characterisation of the target user groups, and their information needs are assessed with focus on how EO data can be beneficial. Direct meetings and a questionnaire survey is used to obtain the needed information from the Early Adopters. A further analysis identifies the technical requirements for the innovative EO-based solution to be developed and validated in each of the Use Cases.

This Deliverable is organized in four report documents addressing each of the Use Cases separately, denoted D.1.2.A-D. The first report (D.1.2.A) also includes a common introduction to all use cases (Sections 1-2). From Section 3 the reports are specific to each use case, first describing each Use case as proposed by the Contractors (3). Section 4 addresses the State-of-the-art activities and Section 5 the relevant regulatory (policy) and operational framework for each Use case. Section 6 summarizes the specific requirements for each Early adopter related to their use cases. The requirements are based on direct meetings with and their responses to the EO4SA questionnaire survey (attached in Appendix 1). The EA organisations are further described in D1.1. In Section 7 the project Team presents the baseline and innovative algorithms to be used and in Section 8 the available data sets to be used. The potential limitations of the approaches proposed is summarized in Section 9 and concluding statements in Section 10 for each of the four Use Cases.

In separate Deliverable D1.2-documents (A-D) the four EO4SA Use Cases are addressed in:

- Deliverable D1.2-A: Baseline Requirements – Introduction and Use Case 1: Predicting risks of salmon lice infestation in Norway.
- Deliverable D1.2-B: Baseline Requirements – Use Case 2: Forecasting toxic algal blooms (HABs) impacting shellfish farming in Norway.
- Deliverable D1.2-C: Baseline Requirements – Use Case 3: Optimizing the location of sustainable shellfish farming and tourism in Galicia, Spain.
- Deliverable D1.2-D: Baseline Requirements – Use Case 4: Mapping aquaculture structures and use of marine resources in Palawan, Philippines

3 The EO4SA Use Cases (common to the four Use cases)

On this background, the EO4SA project will implement four use cases that will contribute to the enhancing the future operations of aquaculture management authorities, stakeholders and industry, by taking up new information based on satellite Earth observations data. In brief, these are entitled:

- Predicting risks of salmon lice infestation in Norway.
- Forecasting toxic algal blooms (HABs) impacting shellfish farming in Norway.
- Optimising the location of sustainable shellfish farming and tourism in Galicia, Spain.
- Mapping aquaculture structures and use of marine resources in Palawan, Philippines.

For each of these use cases the EO4SA team has established contacts with Early adopters (EA). These EA´s will contribute with their input to the development and assessment of each of the proposed Use cases (Table 1). The EA´s will contribute to ensure relevance for further use and possible up-scaling of each Use case.

Table 1. The description of the Use Cases and their pilot geographical locations and early adopters. (the Use Case addressed in this report is in bold).

Use Case	***Pilot site locations***	***Early adopters (sector)***
i. Predicting risks of salmon lice infestation in Norway	Norwegian coastal and offshore waters	• Norwegian Directorate of Fisheries (governmental agency) • Lerøy Aurora AS (private company) • Grieg Seafood ASA (private company) • Sparebank 1 Sør Norge ASA (financial institution)
ii. Forecasting toxic algal blooms (HABs) impacting shellfish farming in Norway	Helgeland Fosen Namsen fjord Lyngen fjord	• Norgeskjell AS (private company) • Lyngsskjellan ENK (private company) • Norwegian Directorate of Fisheries (governmental agency) • Norwegian Institute of Marine Research (research institute) • Sparebank 1 Sør Norge ASA (financial institution)
iii. Optimising multi-use of marine areas for shellfish farming and tourism in Galicia, Spain.	**Galician rias of NW Spain**	• FEMEX (Federación de Mejilloneros) and Angulas Aguinaga (Cambados: depuración y transformación de mejillón) (industry) • INTECMAR: Technological Institute for the Monitoring of the Marine Environment in Galicia (monitoring) • CETMAR, Centro Tecnologico del Mar, Galicia, Spain (transfer of technology) • CSIC-IIM: Institute of Marine Research (science) • National Park "Illas Atlánticas de Galicia" (national park)
iv. Mapping aquaculture structures and use of marine resources in Palawan, Philippines.	Puerto Princesa Bay, Palawan, Philippines	• Palawan Aqua-Agri Venture Agriculture Cooperative: 22 registered fish cage operators • Bureau of Fisheries and Aquatic Resources (BFAR)-Province and MIMAROPA Region: responsible for the development, improvement, management, and conservation of the Philippines' fishery and aquatic resources

In preparing this Requirements document (D1.2-A to D), the Early Adopters have been approached directly through individual consultation meetings, phone calls, participation in thematic fora, and written documentation presenting the objectives of the project and the initial plans for each EO4SA Use Case. These direct contacts were used to get the EA´s feedback on each Use Case. Further a Google questionnaire online was distributed to be filled out by each Early adopter (the questionnaire is in Appendix 1). The questionnaire was adapted for all four Use Case studies.

In the following, this report addresses the baseline requirements to meet the information needs as put forward by the Early adopters for all four Use Cases and focusing on the third of the four use cases: ***Deliverable D1.2-C: Baseline Requirements – Use Case 3: Optimizing location of sustainable shellfish farming and tourism in Galicia, Spain.***

4 Use Case 3: Optimising the location of sustainable shellfish farming and tourism in Galicia, Spain

Coastal areas are encompassed by several interests, such as in the Galicia rias (Northwest Spain), where intense maritime traffic, recreation, tourism, and nature conservation (e.g. National Park "Illas Atlánticas") compete for space with small-scale fisheries, shellfish extraction from shellfish grounds and massive mussel aquaculture, with the last representing 40% of the European production (Labarta and Fernández-Reiriz, 2019). Such conflicts can be mitigated by optimizing shellfish operations, such as employing farming activities where mussels can better grow while regulating the maximum farming an area can sustain in terms of carrying capacity, eventually based on natural primary production (PP). Therefore, the aim of this use case is to develop and use different satellite products to guide the sustainable distribution of the space among different users.

5 State-of-the-art and background Rias Baixas, Spain

The Rias Baixas are a set of large coastal inlets of contrasting size, morphology, topography and barriers to water exchange with the shelf (Alvarez-Salgado et al., 2010), ranging from free connection (e.g., Ría de Muros), small islands (e.g., Salvora, Ria de Arousa) to large islands (e.g., Ons, Ría de Pontevedra; Cies, Ria de Vigo). Furthermore, the presence of these islands disturbs the coupling between the zonal circulation of the rias with the meridional circulation of the shelf (Gilcoto et al., 2007; Piedracoba et al., 2016). Circulation in the shelf and the rias is driven by coastal upwelling. During the upwelling season, from May to September in the North-West Spain (Arístegui et al., 2009), it is estimated that about 60% of the shelf surface water consist of recently upwelled Eastern North Atlantic Central Water (ENACW), while the remaining 40% is upwelled ENACW that previously entered the Rias Baixas and it is subsequently outwelled after thermohaline and biogeochemical modification (Álvarez-Salgado et al., 2000).

This large exchange of nutrient rich water fuels the strong phytoplankton PP and increase the phytoplankton biomass in the area. The growth of shellfish depends on the natural food availability and quality, such as the amount of net phytoplankton PP (NPP) and suspended particulate matter (SPM). While phytoplankton NPP can make the shellfish develop well, high concentrations of inedible SPM reduce their growth. Therefore, food availability and food quality are key inputs for the Dynamic Energy Budget (DEB) models used for modelling mussel growth. Mapping regions where mussels can grow better is of extreme relevance for choosing farming locations. In addition, knowing the timing of primary production seems important to predict the spawn and faster growth periods of the mussels. Chl-a concentration and the ratio of particulate organic carbon (POC) to SPM have been revealed as suitable proxies for food availability and quality, respectively (Fuentes-Santos et al., 2019). High-resolution satellite-derived Chl-a and POC/SPM data, together with SST and solar irradiation (used to compute NPP estimates), can allow the modelling of the mussel growth and its use to test strategies (seed size, seeding time, target size, target flesh yield, etc.) to optimize aquaculture production.

Since the shellfish growing in farms depends on natural NPP, overexploited areas can reduce NPP available to the local ecosystem. The monitoring of Chl-a concentration can provide this information and be used for estimating the NPP and the regional carrying capacity. Satellites can cover vast areas for prolonged periods and provide consistent Chl-a measurements for estimating NPP. In the *PRIMUS - Primary Productivity in Upwelling Systems* project (ESA supported), PML and CSIC used Sentinel-3 OLCI to estimate NPP in the Galician rias and estimated reduction rates from 8.6 to 44.4% for Chl-a and from 4.5 to 23.8% for NPP in several major regions (Álvarez-Salgado et al., in prep.). However, a strong limitation for this application has arisen as Sentinel-3 OLCI has a 300m spatial resolution and cannot differentiate the impact on individual rafts that are approximately 20 x 25 m and 100 m apart from each other. Therefore, changes in NPP cannot be attributed to specific farms. Such high-resolution requirements have been a demand from stakeholders in the region, including farmer associations and representatives from local monitoring bodies. Sentinel-2 MSI observes ocean spectral reflectance at spatial resolutions between 10m and 60m and can serve this purpose. Although it was not initially designed for ocean applications, studies have demonstrated its use in inland and coastal waters where spatial resolution becomes a more important factor (Cairo et al., 2020). Hence, Sentinel-2 MSI can allow observations between individual rafts and further investigate their impact on the ambient phytoplankton and provide the information needed from stakeholders.

Following a preliminary analysis of options PML in consultation with Early Adopter CSIC, formulated the initial characteristics of the EO4SA products, in line with the proposal and negotiation documents (Table 2). These preliminary requirements were refined through the Early Adopters consultation process.

Table 2: Initial parameters, pre-user consultation

Parameters	Initial characteristics
Spatial resolution	300 m for POC; 60 m for PP
Spatial extent	Ria Arousa
Temporal frequency	Monthly
Temporal coverage	2016-2026

6 Current relevant regulatory (policy) and operational framework

Water framework Directive is the EU policy more relevant to the monitoring of the environmental quality of waters in the first 2 miles from shoreline and thus are the overarching legislation relevant to the Rias.

In addition to this, there is the Natural parks directives from the Spanish government, on which we will get more information from the Early Adopters during the project. Finally, there is the Spanish strategy for the Biodiversity (https://www.miteco.gob.es/es/biodiversidad/planes-y-estrategias/index_estrategia_espaniola.html) which is aligned to the Convention for the Biodiversity, and the EU biodiversity Strategy for 2030.

7 Early adopters and their specific requirements

In the preparation of the Requirements documenta virtual meeting was organized on the 27-Feb-2025 to present the objectives of the project and provide initial plans for EO4SA Early adopters of the research to be carried during the project and get initial feedback on these ideas. After the meeting a Google questionnaire online was distributed to be filled by Early adopters (the questionnaire is in Appendix 1). The questionnaire was adapted for the other EO4SA case studies.

The meeting was attended by representatives of four out of the five organisations as Early Adopters (only the FEMEX representative was missing from the meeting) (see Sections 6.1 to 6.5). The feedback received confirmed the suitability of the approach proposed. The questionnaire was presented during the meeting and translated to Spanish. There were N=7 responses recorded, with representatives from all organisations responding to the questionnaire. There were two responses from CETMAR and two responses from the National Park. There were no responses from the CSIC representative in terms of product requirements to avoid biasing the results of the survey. Text in *italics* are the own words of the Early Adopters.

In version 3.0 of this document, the answers from National Park "Illas Atlánticas" (N=2) were added by two different users in the organisation: the director of the National Park and a Technical officer with experience in use of remote sensing.

A summary of the questionnaires is presented in Figure 1, Figure 2 and Figure 3.

Figure 1 is concerned with the level of interest (maximum priority scored 5, minimum scored 1) on satellite products that have been considered by the EO4SA project as a whole (across the different areas of study). Physical parameters (sea surface temperature and salinity) were considered the most priority by most of users (83%, N=6), whereas chlorophyll concentration and harmful algal species were also considered high priority (67%). POC was considered by most Early adopters as an intermediate priority product (scored 3 out of 5 in terms of priority for 67 % of users). Note that Particulate Organic Carbon concentration refers to input to the model of organic mass of mussels, that will be ultimately the product of EO4SA. This was explained to the users during the meeting.

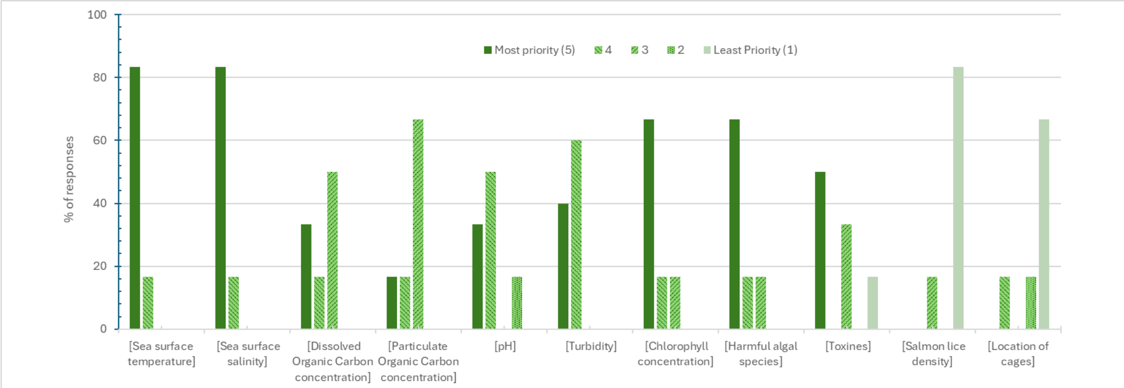


Figure 1: Percentage of responses with a score 1 to 5 (1 is lowest priority and 5 is highest priority) to the question: Which satellite products would you be interested in? Can you assign a priority on them, please?

The responses by Early adopters with respect to the wider EO4SA products are detailed individually per respondent in Table 3. SST and Chlorophyll-a (essential variables for the computation of primary production) seem highly priority for most Early adpopters in the area. POC is more important for users from the Illas Atlanticas National park. This is related to their interest on water transparency (see below).

Table 3: Individual responses to Question 1: What satellite products would you be interested in? Can you assign a priority on them, please? 1 is low priority and 5 is high priority.

		Femex (Federación de Mejilloneros) Angulas Aguinaga	INTECMAR	CETMAR	CETMAR	National Park "Illas Atlánticas de Galicia"	National Park "Illas Atlánticas de Galicia"
What satellite products would you be interested in? Can you assign a priority on them, please? 1 is low priority and 5 is high priority	[Sea surface temperature]	5	5	4	5	5	5
	[Sea surface salinity]	5	5	4	5	5	5
	[Dissolved Organic Carbon concentration]	5	3	3	3	5	4
	[Particulate Organic Carbon concentration]	3	3	3	3	5	4
	[pH]	5	4	2	4	5	4
	[Turbidity]	4	5	4		5	4
	[Chlorophyll concentration]	5	3	4	5	5	5
	[Harmful algal species]	5	3	4	5	5	5
	[Toxines]	5	3	1	3	5	5
	[Salmon lice density]	1	1	1	3	1	1
	[Location of cages]	1	1	2	4	1	1

In terms of the characteristics of the products, POC requirements are presented in Figure 2 Percentage of responses for the question: Particulate Organic Carbon for mussel growth adequacy (in Spanish: Concentracion de Carbono Organico Particulado y biomasa del mejillon) of the initial proposed product in EO4SA for POC for mussel growth adequacy (or in Spanish: Concentración de Carbono Orgánico Particulado y biomasa del mejillón) in terms of spatial resolution proposed (300m), and extent (Ria Arousa) are considered ideal, preferred or minimum by all users consulted. However, although the temporal coverage seems ideal or preferred for most users (aggregated 83% of responses), some (17 %) find it insufficient. Temporal frequency of a month is considered insufficient by most. During the meeting it was explained that, in practice there will be two products from the project: POC and mussel biomass, output of a model. Responding to the users' requirements, monthly predictions of mussel biomass will be computed from daily POC concentrations from satellite, which will be made available for interested Early adopters, as has been required. Model outputs are mussel biomass (size and condition[1]) and culture time from seeding (15 mm) to commercial size (50 to 75 mm) and will be reported at monthly frequency.

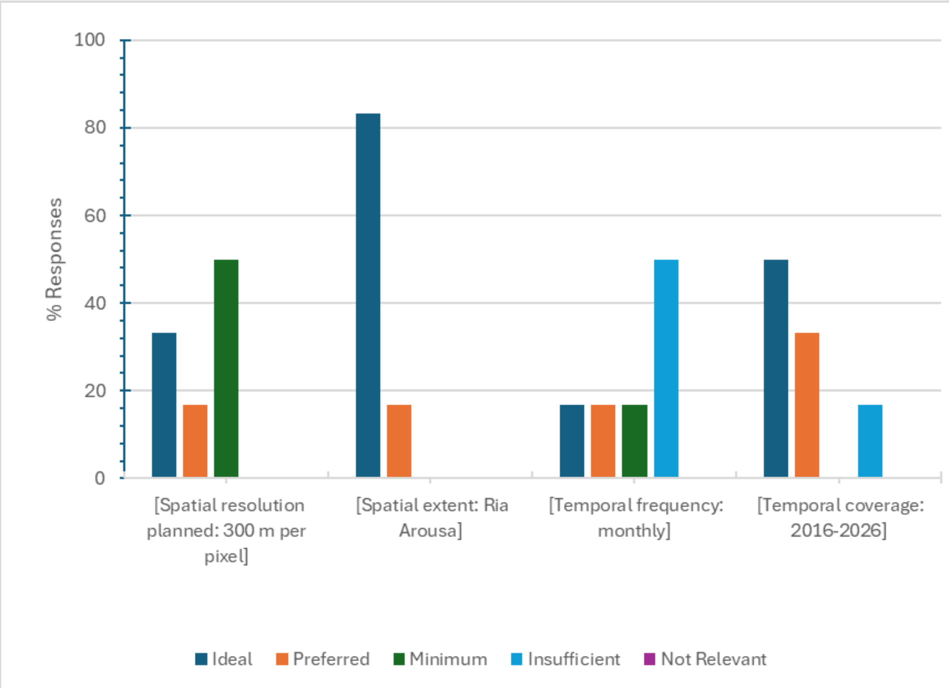


Figure 2 Percentage of responses for the question: Particulate Organic Carbon for mussel growth adequacy (in Spanish: Concentracion de Carbono Organico Particulado y biomasa del mejillon) of the initial proposed product in EO4SA.

[1] Condition index is meat yield (= g of meat / total weight of the mussel)

Table 4 Individual responses to Question 2 on required resolution and coverage.

		Femex (Federación de Mejilloneros) Angulas Aguinaga (Cambados: depuración y transformación de mejillón) Productor de mejillón	INTECMAR	CETMAR	CETMAR	National Park "Illas Atlánticas de Galicia"	National Park "Illas Atlánticas de Galicia"
Particulate Organic Carbon for mussel growth	[Spatial resolution planned: 300 m per pixel]	Ideal	Minimum	Minimum	Ideal	Preferred	Minimum
	[Spatial extent: Ria Arousa]	Ideal	Ideal	Ideal	Ideal	Ideal	Preferred
	[Temporal frequency: monthly]	Insufficient	Insufficient	Insufficient	Ideal	Minimum	Preferred
	[Temporal coverage: 2016-2026]	Insufficient	Ideal	Ideal	Ideal	Preferred	Preferred

The primary production requirements (Figure 3 and

Table 5) were similar to POC and mussel biomass prediction requirements. Users were satisfied by a higher spatial resolution (60 m). However, the temporal frequency was still insufficient for most, in particular it was more critical for the National Park. Given the native frequency of the input of data for primary production at the 60 m spatial resolution (i.e. every 2-3 days for Chlorophyll a from Sentinel-2 MSI) and the frequent cloud cover in the area, it will be difficult to achieve a greater temporal resolution.

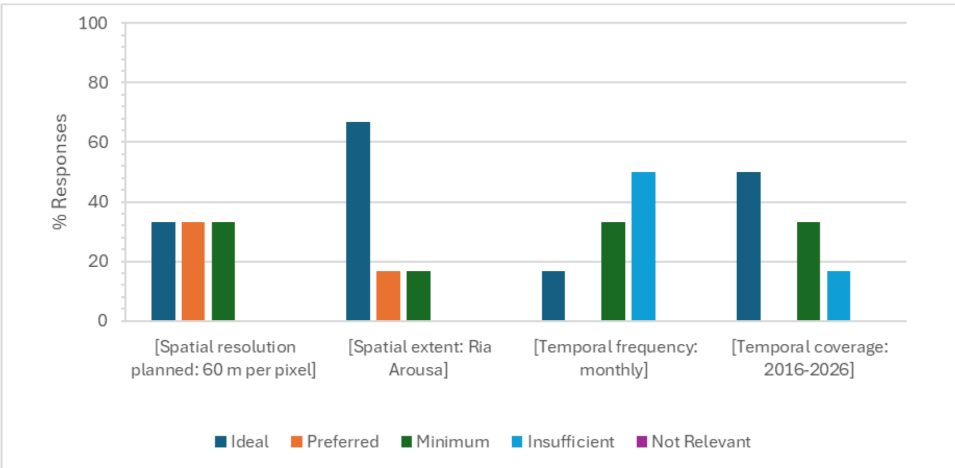


Figure 3: Percentage of responses for the question: Primary production initial proposed product in EO4SA.

In order to address the Early adopters requirements, we will produce primary production estimates at the frequency of Sentinel-2 MSI overpasses and make them available.

Table 5 Individual responses to Question 3.

		Femex (Federación de Mejilloneros) Angulas Aguinaga	INTECMAR	CETMAR	CETMAR	National Park "Illas Atlánticas de Galicia"	National Park "Illas Atlánticas de Galicia"
Primary Production for Aquaculture and Tourism planning	[Spatial resolution planned: 60 m per pixel]	Preferred	Preferred	Ideal	Ideal	Minimum	Minimum
	[Spatial extent: Ria Arousa]	Preferred	Ideal	Ideal	Ideal	Ideal	Minimum
	[Temporal frequency: monthly]	Insufficient	Insufficient	Insufficient	Ideal	Minimum	Minimum
	[Temporal coverage: 2016-2026]	Insufficient	Ideal	Ideal	Ideal	Minimum	Minimum

In terms of data access, we asked: "*Is data access through a Web portal useful to you*?", to which all users responded positively.

Some detailed answers, about additional data access ways included (in their own words):

- *Data Portal and some OGC formats, as WMS, WFS or NetCDF*
- *It would be perfect if this web page allows the download of data through a M2M interaction*
- *It is perfect to have access through a data/web portal. In fact I have used PRIMUS data.*
- *I believe that web portals are a very useful tool for accessing data, especially for data that is updated in real-time or at a high frequency. Regarding access methods, I think platforms that combine data viewers for manual downloads with an automatic download system through programs like Python or R are the most effective*.
- *It is more comfortable to access through the website also quickly*
- *It is more practical*

7.1 FEMEX (Federación de Mejilloneros) and Angulas Aguinaga (Cambados: depuración y transformación de mejillón)

The same representative acts for both institutions as Early Adopter. The Federación de Asociacións de Mexilloeiros (FEMEX) is a federation of mussel producers' associations based in Rianxo, La Coruña, Spain. Established in 2013, FEMEX represents approximately 400 mussel rafts (bateas) from the Ria de Arousa and Northern Ria de Vigo (Morrazo region). (ChatGPT search on 04-2025, ChatGPT-4-turbo).

FEMEX actively participates in the Mesa do Mexillón, an advisory body that consults with the Consellería do Mar (Galician Ministry of the Sea) on mussel aquaculture-related matters. The organization has advocated for the enforcement of anti-late payment laws, urging authorities to withhold subsidies from processing companies that are indebted to producers**.** FEMEX also collaborates with other industry organizations, such as the Federación de Asociaciones de Mejilloneros de Arosa y Norte (FARN), to promote the interests and safety of mussel producers and ensure the quality of their products and farming operations.

Angulas Aguinaga, a Spanish seafood company, operates a state-of-the-art mussel purification and processing facility in Cambados, Galicia. Specializing in the depuration, cleaning, packaging, and commercialization of mussels, the company processes over 10,000 tons annually, serving both European and Asian markets.

In collaboration with ANFACO-CECOPESCA and supported by the Xunta de Galicia, Angulas Aguinaga launched the PROMOGAL Mixed Research Unit. This initiative focuses on enhancing sustainable mussel farming through innovative practices such as developing seed cultivation processes to reduce reliance on wild seed, improving the sanitary and nutritional quality of mussels, and integrating artificial intelligence tools to optimize production efficiency.

This user does not use environmental observations to comply with environmental legislation and does not currently use Earth Observation products.

In addition to the requirements highlighted above, this user noted, with respect to POC:

Apart from the direct impact on mussel growth, there is also a relationship with the proliferation of microalgae. Additionally, it is essential to understand the variations in POC caused by rainfall, considering that several rivers flow into the Ría de Arousa. During the rainy season (mainly autumn and winter), the decrease in salinity in the estuary is significant. This justifies the requirement of this user for EO products at a frequency higher than 1 month (likely sub-weekly, to match rain events).

And with respect to the PP:

Mussel farming is an extensive form of aquaculture where feeding does not require any additional nutrients, relying solely on those available in the natural environment. Having the most accurate possible knowledge of the availability of these nutrients throughout the year can lead to more efficient farming. This would allow for better use of spawning periods to collect more seed on collectors and reduce dependence on coastal harvesting, take advantage of periods with higher meat yield, and adjust farming densities according to food availability.

In addition, this user has a monitoring facility, which makes them a proactive potential Early Adopter of EO4SA products:

We are starting continuous monitoring on a mussel raft, and satellite data is of great interest to us for establishing correlations and developing models for growth, fattening, spawning, etc. This will lead to better resource utilization and improved quality. These objectives are shared by mussel producers, as well as by companies involved in purification and commercialization, and those dedicated to processing (canning, freezing, pasteurization). These data will be available to the project, but not to public in their native form due to their commercially sensitive nature. During the project we will aim to negotiate the publication of the data in aggregate form.

The environmental variables that the user measures are sea surface temperature, salinity, Chla-fluorescence, turbidity, weight of mussel ropes from a mussel raft, that will be used:

- *To predict the occurrence of harmful algal blooms (HABs).*
- *To determine the best harvest time based on the size of the mussel.*
- *To establish a relationship between chlorophyll abundance and mussel fattening.*
- *To predict spawning events to prevent the commercialization of low-quality products and to identify the optimal time for seed collection using collectors.*

From these responses, it seems that **timing** is a really important indicator for this Early Adopter, both in terms of seasonality of food availability (autumn-winter rainy season and land influence), as in terms of the PP connection to the mussels spawning and mussel growth. Hence our analysis will focus on the timing of events as a priority to provide EO products (POC and PP) at higher frequency than 1 month (sub-weekly) to capture rain events.

7.2 INTECMAR: Technological Institute for the Monitoring of the Marine Environment in Galicia, Vilagarcía de Arousa, Spain

The Technological Institute for the Control of the Marine Environment of Galicia (INTECMAR), located in Vilagarcía de Arousa, Spain, is a public institution established in 2004. It serves as the official body of Galicia's autonomous administration, tasked with monitoring the quality of the marine environment and enforcing regulations related to the technical and health control of seafood products. (ChatGPT search on 04-2025, ChatGPT-4-turbo)

INTECMAR's primary mission is to ensure the safety and quality of marine organisms, particularly molluscs, while contributing to the protection and improvement of Galicia's coastal waters. The institute focuses on monitoring oceanographic conditions, detecting marine biotoxins, assessing chemical pollution—including heavy metals, organochlorides, and hydrocarbons—and conducting microbiological and pathological analyses.

INTECMAR plays a crucial role in managing Galicia's shellfish production areas by determining their opening and closing based on safety assessments. As the Reference Laboratory for marine biotoxins for the Public Administration of Galicia, the institute specializes in controlling and monitoring biotoxins in bivalve molluscs and other marine organisms.

Collaborating with entities like CETMAR and MeteoGalicia, INTECMAR has been instrumental in establishing the Integral Coastal Observatory of Galicia. This initiative aims to support coordinated marine environment management, preserve ecosystem services, and facilitate the sustainable development of blue economy sectors.

This user is dedicated to the monitoring of the coastal environment to support management. In this context is an Early Adopter closer to research which has extensive monitoring and modelling network.

This user represents an environmental data provider to other organisations and does currently use Earth Observation products, in particular Copernicus SST.

The current uses of the monitoring are:

- *To predict HABs occurrences,*
- *To support scientific studies,*
- *To fulfill obligations with environmental policies,*

- *To fulfill obligations with Food Standards policies,*
- *Oil spill contingency plans*

An important request for this user is the availability of satellite data at a higher frequency than the one initially proposed by EO4SA (i.e. monthly), to combine with their in situ observations. As an additional requirement, this user mentioned that *training* would be beneficial.

7.3 CETMAR, Centro Tecnologico del Mar, Galicia, Spain

The Centro Tecnológico del Mar – Fundación CETMAR is a marine research and innovation center based in Galicia, Spain. Established in 2001, it operates under the regional government of Galicia (Xunta de Galicia) in collaboration with the Spanish Ministry of Science, Innovation and Universities. CETMAR plays a key role in promoting sustainable development in the marine, fisheries, and aquaculture sectors by fostering innovation, scientific research, and international cooperation. (ChatGPT search on 04-2025, ChatGPT-4-turbo)

CETMAR's primary mission is to enhance the sustainability, competitiveness, and technological advancement of maritime industries while promoting the protection and responsible management of marine resources.

This user maintains environmental observations to comply with environmental legislation (e.g. HF radar and meteorological-oceanographic buoys). Currently use Earth Observation products, in particular Copernicus Sentinel-3 SST and Chlorophyll a concentration at 300m. Previously used the PRIMUS project data and portal.

CETMAR is involved in various marine and maritime sectors, including:

- Fisheries and Aquaculture: Improving sustainable fishing practices, seafood quality, and aquaculture development.
- Marine Environment & Biodiversity: Research on ocean health, climate change impacts, and ecosystem conservation.
- Ocean Observation & Satellite Data: Using Earth observation technologies for marine monitoring.
- Maritime Industries & Blue Economy: Supporting innovation in shipbuilding, renewable marine energy, and coastal development.
- Food Safety & Marine Biotechnology: Enhancing seafood processing, traceability, and biotechnology applications.

In addition to the requirements above, this user highlights their intention to develop new products:

- *Metabolic Rates or Meat Yield rates. Maybe it's useful to combine several to suit better results.*
- *I think this use is very interesting to support the aquaculture sector and improve its resilience.*

As an additional requirement:

- *It would be very interesting to follow the advances of this project. I would also be very grateful if you could share with us any issues with the product, including its disadvantages.*

7.4 CSIC-IIM: Institute of Marine Research, Vigo, Spain

CSIC (Spanish National Research Council) is the largest public research institution in Spain and the third largest in Europe. CSIC covers all fields of knowledge. The scientific activity of its 69 fully own institutes/centres, 50 joint units with universities or other research institutions and 2 associates is organised around three global areas: society, materials and life. The Institute of Marine Research (IIM), develops research in the three global areas, particularly on marine environment, fisheries, aquaculture and food science & technology and its socioeconomic implications. The overall aim of CSIC-IIM is contributing to the sustainable development of the extensive fisheries and aquaculture activities off the NW Iberian upwelling system (Galicia, Spain) and its associated transformation industry. Among the interests of the Organic Geochemistry Lab (OGL), Department of Oceanography of CSIC-IIM, is the study of the highly productive large inlets of the Galician coast, collectively known as "rías", and adjacent continental shelf with focus on the assessment of the ecosystem services provided by the rias, as well as the evaluation of the impact of global and climate change on these services, and the implementation of mitigation and adaption measures to secure the services in the forthcoming decades.

They are the main EO4SA collaborators to combine the mussel model with the satellite algorithm of POC (see description in Section 8).

7.5 National Park "Illas Atlánticas de Galicia"

The National Park "Illas Atlánticas de Galicia" is a group of islands located mostly at the entrance of the Rias Baixas, hosting a variety of biodiversity rich ecosystems and the surrounding waters, enjoy the maximum level of protected status which favours eco-sustainable tourism. Indeed, the park attracts a large and increasing number of tourists attracted by the sustainability aspect. Between 15 May and 15 September of 2024, a total of 451000 visitors visited the National Park, which is a 5% increase over the previous year. Visitors support the activities of 26 private companies operating in the National Park, which follow the European Charter of Sustainable Tourism. Currently, the National Park marine area is forbidden for aquaculture exploitation. However, given the increasing number of visitors, there could be a case for potential for extension identification of surrounding areas for touristic use or even for consideration of extension of the protected areas.

This Early Adopter currently uses Earth Observation data, either from Copernicus directly or through data providers (INTECMAR or National Organisation of Natural Parks – Organismos Autonomos de Parques Nacionales). Real time data have been used in the framework of projects such as TIAMAT (https://www.observatoriotiamat.es/). The objective of TIAMAT was to monitor the marine environment and to provide alerts of extreme events (marine heat waves and turbidity). This project produced 1Km resolution of Chla and 10m Chlorophyll, Suspended particulate matter and turbidity data from Copernicus. Therefore, there is a familiarity of the Early Adopter with satellite data, which is processed by other organisations.

These variables are used for biodiversity conservation, to provide monitoring support to the Habitat Directive, the Birds directive and the OSPAR convention. In particular, this user is interested on access to primary production estimates as an additional variable to monitor the health of the ecosystem in the park and also to complement the current primary production estimates over the land part of the park.

In addition to the satellite, this Early Adopter measures the public usage of the reserve, the birds census, tourism use, meteorology and light pollution in the area.

In addition to the uses above, the Early adopter proposes additional uses for satellite data, such as **diving,** where additional information such as **bathymetry from satellite** would be useful to inform tourism and facilitate monitoring in situ**.**

7.6 Summary of requirements by Early adopters

From the consultations above, we have distinguished different types of users:

- High expertise in data handling (scientific data providers): INTECMAR, CETMAR
- Lower expertise in data handling (public and commercial users): National park and FEMEX-Angulas Aguinaga.

From the discussions during the virtual meeting and the feedback in the questionnaire, it has emerged that we need to revise the characteristics of the products to match the Early adopters requirements for POC and mussel products and primary production (Table 6 and Table 7).

For POC and mussel products, we shall address the requirement for higher temporal frequency of POC from satellite by providing data at the maximum available frequency (POC). The satellite data will be produced as spatial maps. Satellite POC will be then aggregated spatially using the polygons from the mussel farms and protected areas (current and hypothetical) and fed into the mussel model. Mussel model outputs will be computed daily and made available monthly, although they can be shared at a daily frequency if requested to Early Adopters.

Table 6: Initial parameters, and revised parameters for POC and mussel products after consultation

Parameters	Initial characteristics	Revised characteristics (satellite products)	Revised characteristics mussel model products
Spatial resolution	300 m for POC	300 m for POC	Mussel farm polygon
Spatial extent	Ria Arousa	Ria Arousa	Ria Arousa
Temporal frequency	Monthly	Daily	Computed daily, but distributed monthly
Temporal coverage	2016-2026	2016-2026	1) Culture time from seeding to harvesting 2) Mussel biomass and condition (Meat Yield rates)

Table 7: Initial parameters, and revised parameters for primary production after consultation

Parameters	Initial characteristics	Revised parameters

Spatial resolution	60 m for PP	60 m for PP
Spatial extent	Ria Arousa	Ria Arousa
Temporal frequency	Monthly	Daily
Temporal coverage	2016-2026	2016-2026

In addition, interaction with Early adopters will be sought to get in situ observations (a formal request already ongoing from CSIC to INTECMAR). The portal proposed seems satisfactory for the users as a means to reach the data. Additional requirements are that the users are provided with training with respect to the interpretation and analysis of the satellite data.

8 Approach

Following the consultation with the early Adopters, we will focus on Ria de Arousa and will compare the outer part with the inner part of this embayment (Figure 4). The approximate location of the protected Natural Park areas is given in Figure 5. The approach will be:

- To compute monthly POC and PP maps of this area from the native frequency of the sensors (S3 OLCI and S2MSI).
- To use monthly POC and PP to compute integrated values around the areas of the mussel rafts and around the current areas protected by the Natural Park.
- To use monthly POC spatially integrated values (and Chl-a and SPM) to input into the mussel biomass model to produce time series of mussels biomass (connected to the Early Adopter 1 requirements).
- To use monthly PP spatially integrated to produce time series in areas around the mussel rafts, the protected areas of the natural parks and (in consultation with the Early adopters) additional areas where extensions of rafts and protected areas could be placed, and what are the PP levels there (if equivalent to those sustaining mussel rafts).
- An additional comparison is planned between the areas within (around the mussel rafts) and areas outside the mussel rafts to see whether there is a potential clearance effect by mussels on the ecosystem (or an effect on primary production), in particular around those areas close to the Natural Park boundary.

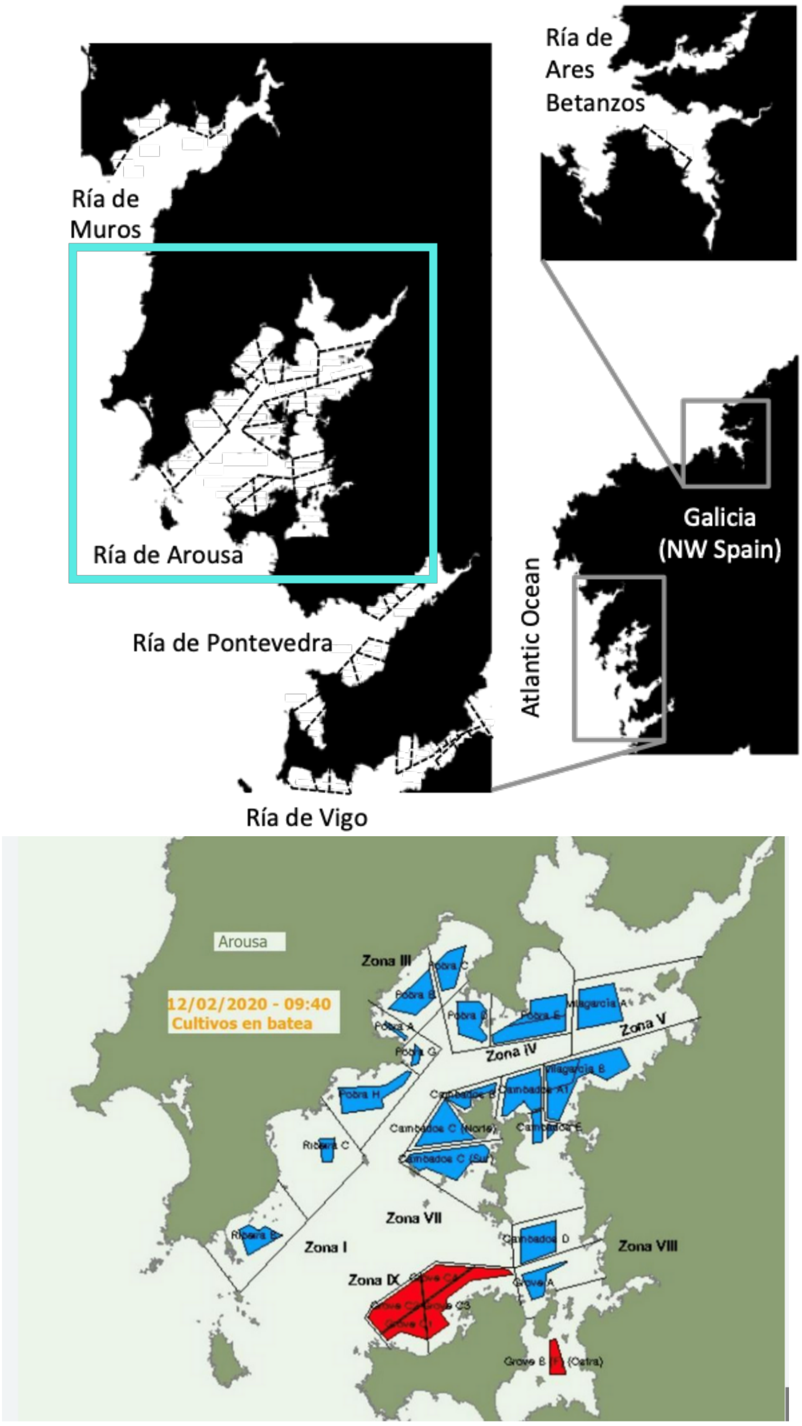


Figure 4. Case study 3 area in Galician rias. Location of the mussel farming polygons, delimited with dotted lines. Top: In clear blue the ria de Arousa, where the study will be centred. Bottom: Specific areas of the mussel farming. In this project we will focus preliminary on Villagarcía A (following PRIMUS), el Pobra E (coinciding with instrumented Aguinaga mussel raft), el Cambados C, el Ribeira B y el Grove (following PRIMUS).

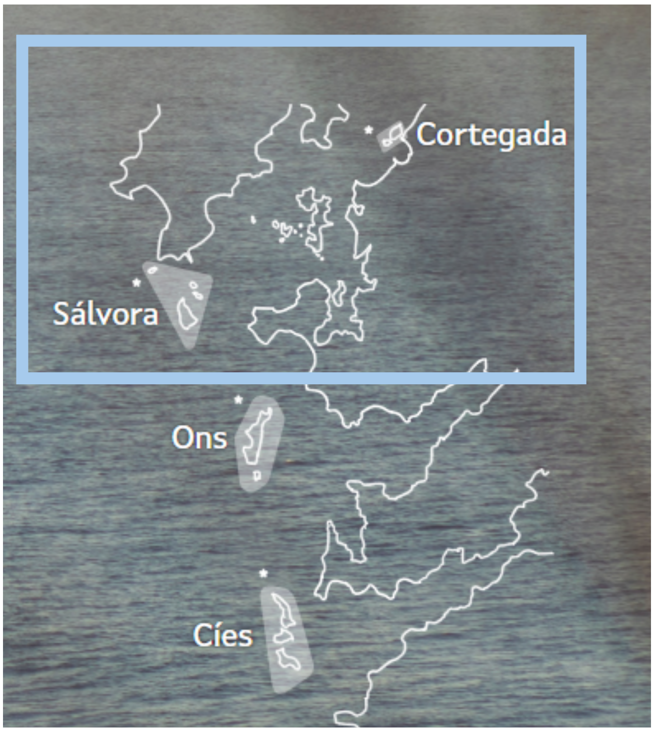


Figure 5. Approximate location of the Marine protected areas. We will obtain exact locations of the protected areas from the Park Authorities. Salvora and Cortegada are Islands around which the protected areas of the park are located. Clear blue is Ria de Arousa, where the EO4SA study will be centred.

In terms of the methods used for this study, EO data is a key input variables for a Mussel Biomass model used for modelling mussel growth. The model to be used is from Fuentes-Santos et al (2019), the description of the original implementation therein (Figure 6).

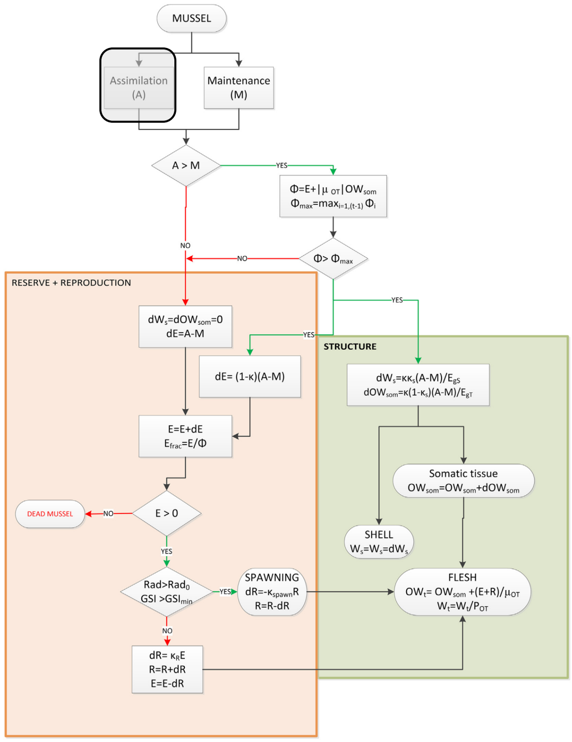


Figure 6: Diagram showing the implementation of the Fuentes-Santos et al. (2019) algorithm, highlighting with a square the point of entry of POC from satellite.

In EO4SA the following satellite data will be used: high resolution satellite-derived Chl-a, POC and POC/SPM data will allow modelling the mussel growth in all the polygons of the rias.

Specifically, the DEB will use satellite derived POC and SPM will be used in the following equations:

1) IR = CR × POM; where IR is ingestion rate, which is the product of the clearance rate (CR) by the particulate organic matter (POM), which in this case we will estimate from POC (Kong et al., 2024), derived through the ESA BICEP project, led by PML (Brewin et al., 2023) and applied to Sentinel-3 data for the Galician rias, by exploring existing datasets (e.g. Reynolds et al., 2016) or recently collected by HyperBOOST in coastal European waters through an ESA-funded project.
2) From the equation:

$$A = \mu_{POM} IR \times AE = \mu_{POM} IR \left(a_{AE} - \frac{b_{AE}}{f} \right)$$

Several terms for the computation of A (Assimilation Rate), of which f is the ratio POM/SPM. POM will be derived as above, and SPM are derived from the processor developed in the EC H2020 CERTO project led by PML. We will also use Chl-a (from the same processor) as a secondary way to verify the particle assemblage composition (Martinez-Vicente et al., 2010).

9 Algorithms available – Baseline and innovative

9.1 Particulate Organic Carbon

Particulate Organic Carbon (POC) is a heterogeneous pool of carbon that includes living organisms that range from viruses to bacteria, phytoplankton and zooplankton, and non-living material such as detritus. The global POC pool is around 2.3-4.0 Gt C in magnitude (Galí et al., 2022; Stramski et al., 2008). Over the last several years, various methods have been proposed to estimate POC from satellite-based observations. The variables that have been used in POC algorithms include remote sensing reflectance (Rrs) values, particle back-scattering coefficients, the diffuse attenuation coefficient and the concentration of chlorophyll-a. An assessment (Evers-King et al., 2017) produced in ESA-POCO and updated in ESA-BICEP (Kong et al., 2024) led to consistent results. One of the best-performing algorithms has been used to generate time series of POC for the entire OC-CCI period along with uncertainty estimates, and the product has been made available through CEDA, as part of the BICEP project. These products are currently being updated to 4 km spatial resolution, based on the OC-CCI time series, in the ongoing SCOPE project. However, in coastal waters the detection of POC is more challenging than in the open ocean, because particles producing an optical backscattering signal can have a significant contribution from mineral particles in these environments (Martinez-Vicente et al., 2010; Neukermans et al., 2012, 2016). Indeed, this interference by different types of particles is expected to completely mask another important particulate organic carbon pool constituted by phytoplankton Carbon.

In EO4SA we initially planned to use (Kong et al., 2024) algorithm to compute POC, adapting it to Sentinel-3 OLCI at 300 m. The coefficients from Kong et al algorithm are shown in Table 8. However, during the requirements review process we acknowledge that there would be a need to perform a band shift to make this algorithm work for Sentinel-3 OLCI.

Table 8: From Kong et al 2024, global relationships for POC algorithms.

Tuned POC band ratio algorithms (S1, S2, S3, and S4) and associated parameter values that can be directly applied to the OC-CCI version 5 products. The a_0 and a_1 indicate the parameters values of the POC algorithms (mg m^{-3}): $\hat{C_p} = a_0(\frac{X}{Y})^{a_1}$. The coefficient of determination (r^2) and Pearson's parametric correlation coefficient (r) for relationship between the *in situ* POC and satellite-derived POC matchup data ($N = 3287$) are shown.

Algorithm(s)	a_0	a_1	X	Y	r^2	r
S1	221	-1.02	$R_{rs}(443)$	$R_{rs}(560)$	0.83	0.91
S2	292	-1.49	$R_{rs}(490)$	$R_{rs}(560)$	0.84	0.92
S3	466	-2.67	$R_{rs}(510)$	$R_{rs}(560)$	0.82	0.91
S4	209	-0.86	$R_{rs}(443, 490, 510)$	$R_{rs}(560)$	0.83	0.91

In addition, the (Kong et al., 2024) algorithm is fitted to global waters, dominated by open ocean datasets. Therefore, we will incorporate information from Chl-a and SPM from existing products. This approach is drawn from a recently published algorithm for POC/SPM detection in coastal waters Stramski et al. (2023), which incorporates information on SPM and POC (Figure 7), was developed for coastal applications and included model coefficients appropriated for the OLCI spectral bands.

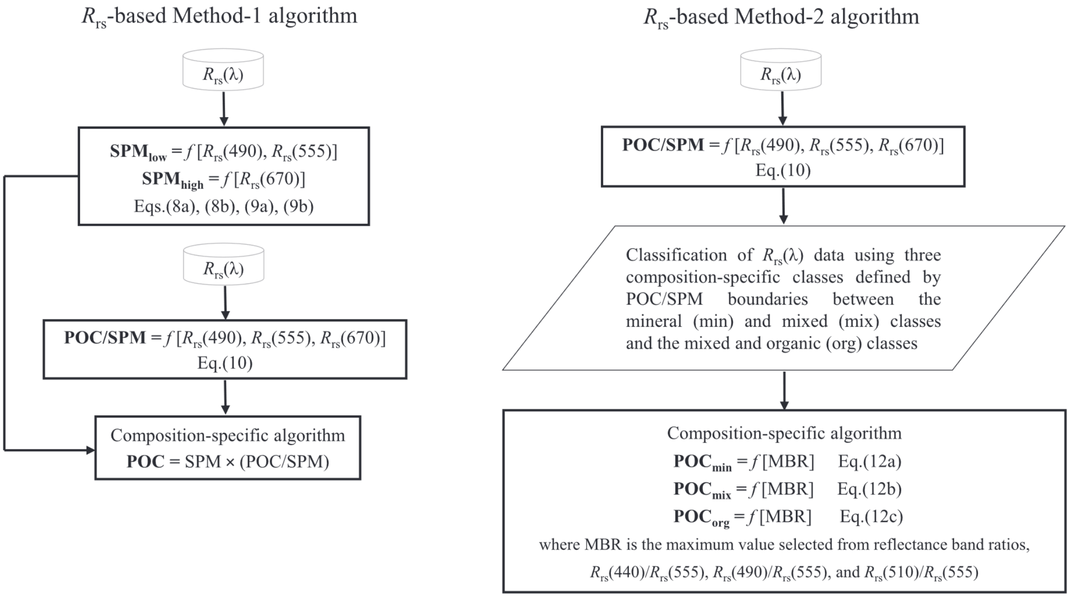


Figure 7 Diagram showing the workflow for the two approaches described in the (Stramski et al., 2023) work.

Therefore, we will use the Stramski et al. (2023) algorithm as our default POC algorithm, and we will test the use of the two methods proposed by the author.

9.2 Primary production

Marine primary production by phytoplankton, estimated to be of the order of 50 Gt C per annum (Kulk et al., 2020; Longhurst, 1995), is one of the largest fluxes of carbon on our planet. By removing CO_2 from the surrounding waters, phytoplankton lower the ambient CO_2 concentrations in surface waters, which can potentially lead to the drawdown of CO_2 from the atmosphere.

In the past few decades, substantial progress has been made in estimating global primary production using ocean-colour remote sensing observations. Most satellite-based primary production models (Friedrichs et al., 2009; Saba et al., 2011; Sathyendranath and Platt, 2007) calculate daily water column production as a function of some measure of phytoplankton biomass and the photosynthetic response of phytoplankton to light. The different models can be categorised as linear or non-linear; spectral or non-spectral; vertically-uniform or vertically-non-uniform; or a combination of these; and as depth-integrated or resolved and as wavelength-integrated or resolved (Friedrichs et al. 2009). While the implementation of these models may differ, satellite-based primary production models have been shown to conform to the same principles with the same set of parameters (Sathyendranath and Platt, 2007). Yet, one of the major challenges in the application of satellite-based primary production models remains the assignment of the appropriate model parameters, which forms the largest source of uncertainty in the computation of satellite-based primary production estimates (Kulk et al. in preparation) and understanding the spatial and temporal variability in these parameters. Recent advancements in the assignment of photosynthetic parameters in the ESA-funded

BICEP and SCOPE projects have shown that machine learning techniques can be used in combination with satellite-in situ match-up datasets to assign model parameters more dynamically (Britten et al. submitted; Rodriguez et al. unpublished). This demonstrates the potential to increase the spatial and temporal resolution of satellite-based primary production models and reduce the uncertainties associated with the model parameterisation.

In the ESA-funded PRIMUS project, the groundwork has been laid for the application of satellite-based primary production models to higher resolution ocean-colour observations. In the Atlantic Eastern Boundary Upwelling Systems (EBUS), two satellite-based primary production models (Platt and Sathyendranath, 1988; Smyth et al., 2005) were applied to data from the Ocean Colour Climate Change Initiative (OC-CCI) at 1 km spatial and daily temporal resolution. This is a significant step-change in the resolution achieved, with estimates of global primary production from these models typically being available at 9 km spatial and monthly temporal resolution (see for example Kulk et al. 2020; refined to 4 km for SCOPE). While both models performed similarly in comparison with in situ primary production data, results from PRIMUS showed that the parameterisation of photosynthetic and chlorophyll-a profile parameters at a seasonal resolution in the model of Platt and Sathyendranath (1988); with updates as in Sathyendranath et al. (2020) and Kulk et al. (2020), led to discrepancies in primary production estimates between days that the season changes, while this was not observed in the model of Smyth et al. (2005). It therefore seems that in this case the model of Smyth et al. (2005) would be better suited for application with high-resolution data. PRIMUS successfully demonstrated the use of 1-km primary production data in the Atlantic EBUS in several science and impact case studies. Moreover, for one of these case studies, the Smyth et al. (2005) model was applied to Sentinel-3 OLCI data at 300 m spatial resolution to study the use of this data to inform aquaculture activities in the Spanish rias. While this demonstrated the use of satellite-based primary production models at high spatial resolution in a specific case study, there is scope to generate such data products for larger regions and study the impact of fine-scale processes associated with upwelling regions on phytoplankton primary production and other carbon pools and fluxes. In the EO4SA we will implement the Smyth et al. (2005) at 60m spatial resolution (using Chlorophyll inputs from Sentinel-2 MSI).

10 Datasets available

10.1 Input datasets

For the POC algorithm, Rrs from OLCI at 300m resolutions will be used. These POC estimates will be spatially averaged over mussel rafts polygons available from: https://mapas.intecmar.gal/plancamgal/ and over the National park water demarcation (https://www.miteco.gob.es/es/parques-nacionales-oapn/red-parques-nacionales/parques-nacionales/islas-atlanticas/ficha-tecnica.html).

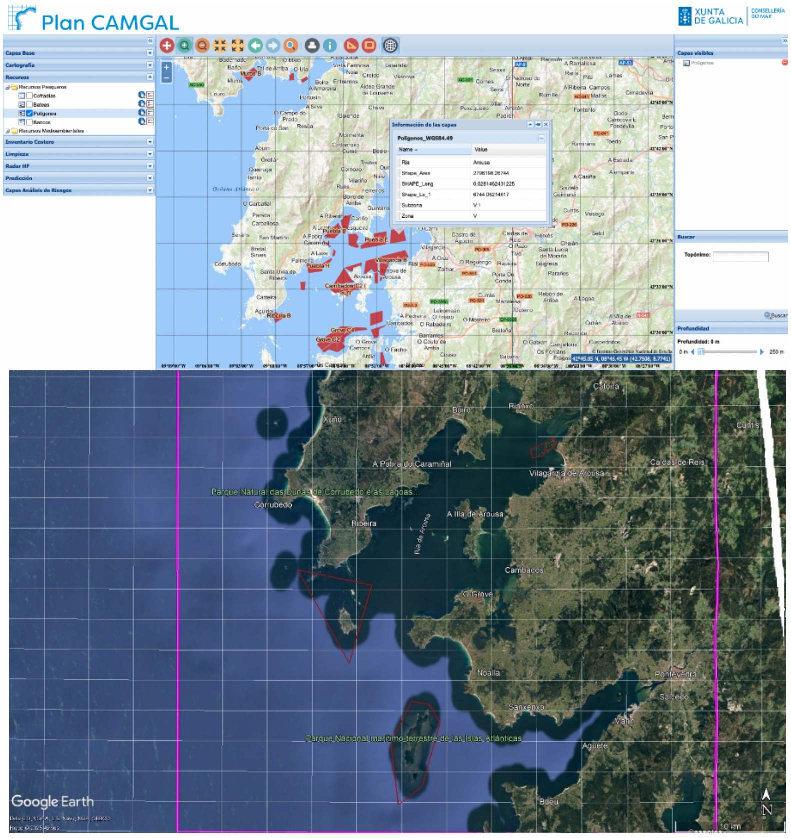


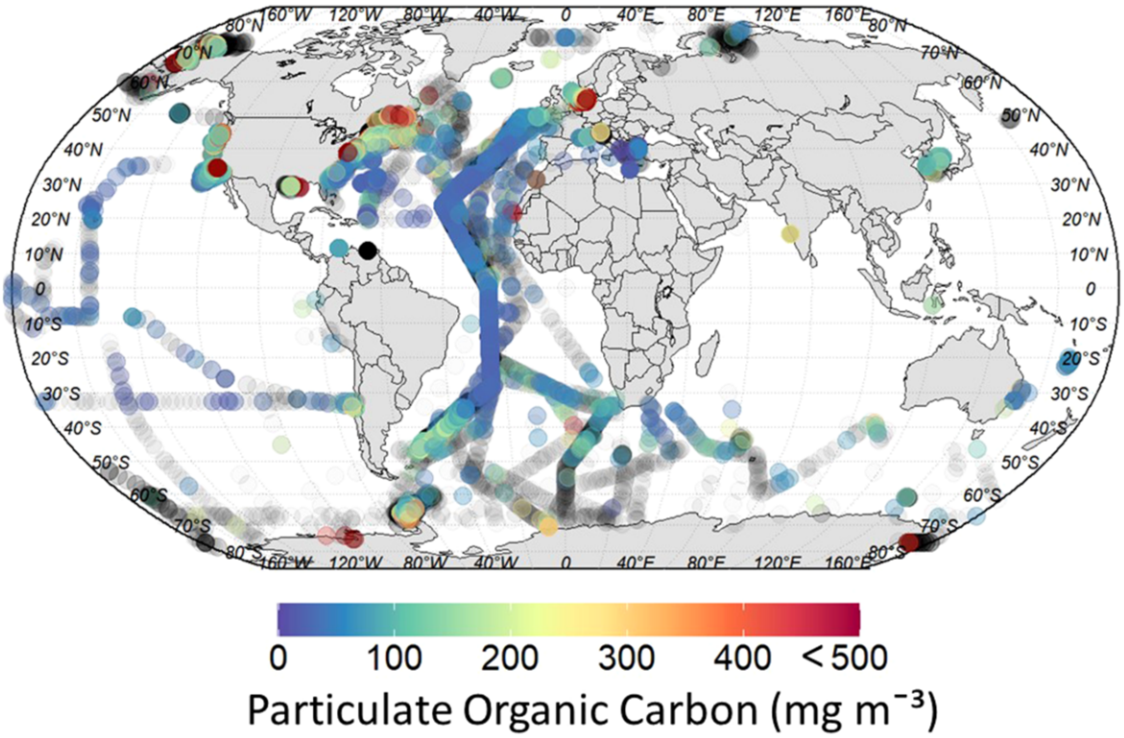
Figure 8 Polygons maps of the location of the mussel rafts and National park areas.

For the Primary production algorithm, Sea Surface Temperature and PAR 1 Km resolution, and 60m resolution from S2-MSI. Primary production will also be computed in the polygons of the mussel farms and the National Parks, as requested by the Early Adopter from National Parks (see above).

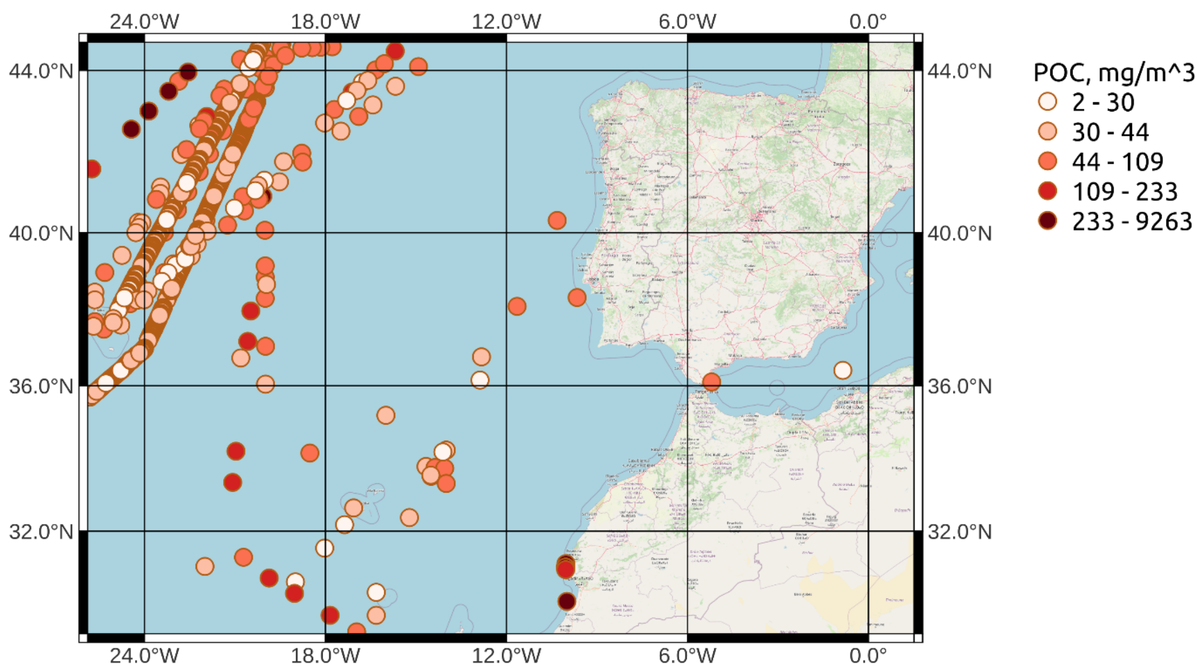
10.2 Validation datasets

The following list of input data are available for this project:

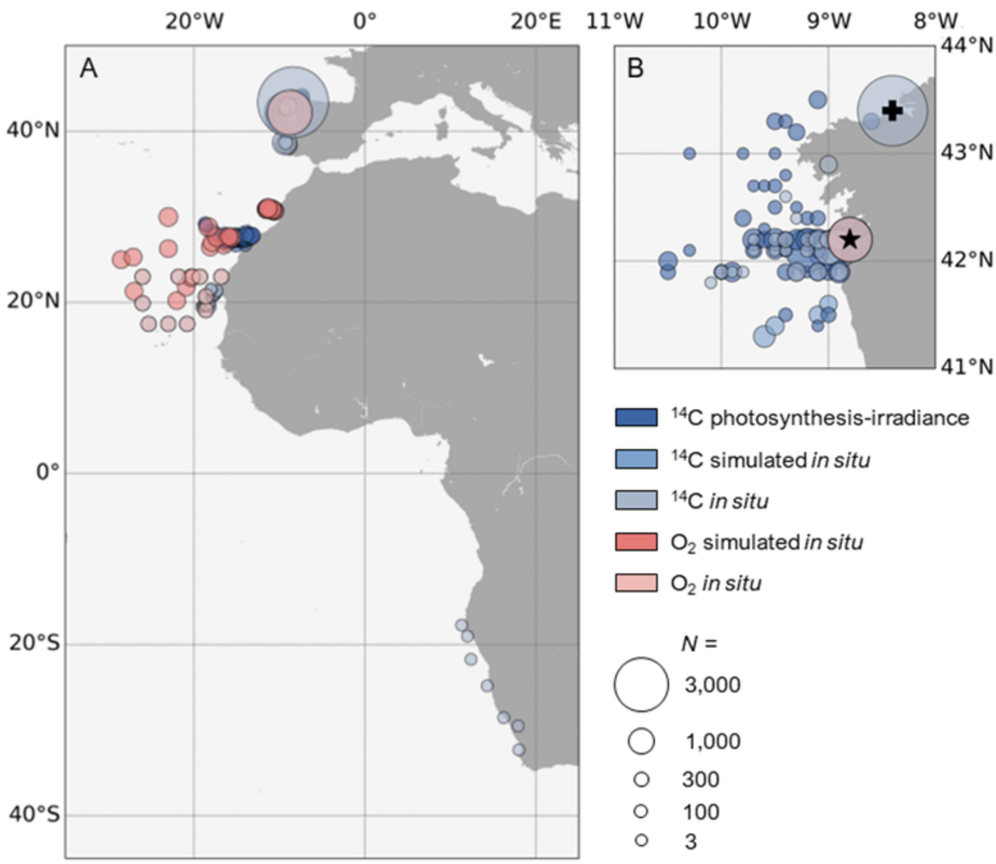
- PRIMUS primary production data: to be published by Kulk et al. (in preparation).
- POC global data: un-published data compilation used by Kong et al. (2024). Figure 9 shows the positions of the in situ samples.


0
100
200
300
400
< 500
Particulate Organic Carbon (mg m⁻³)

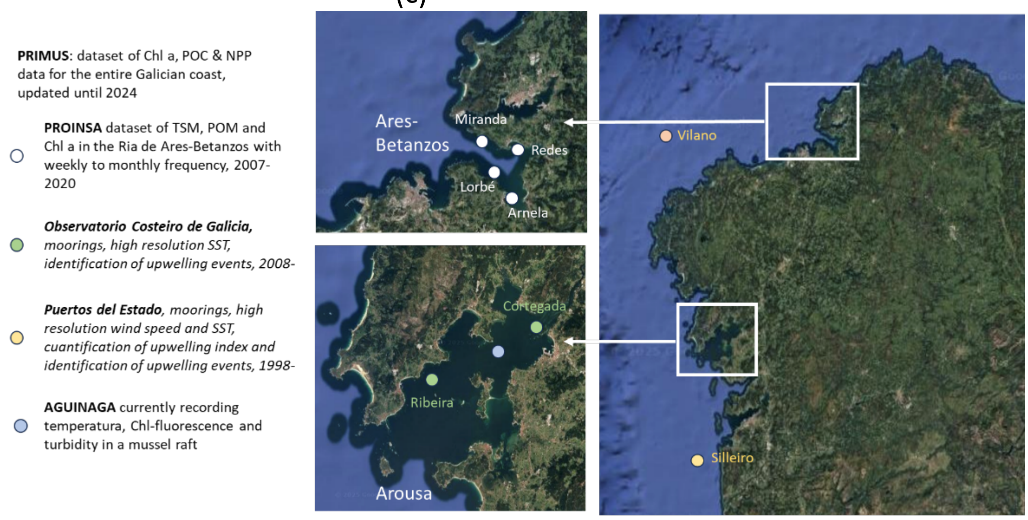
(a)


24.0°W
18.0°W
12.0°W
6.0°W
0.0°
44.0°N
40.0°N
36.0°N
32.0°N
POC, mg/m^3
2 - 30
30 - 44
44 - 109
109 - 233
233 - 9263

(b)



(c)



(d)

Figure 9: Position of POC in situ samples available in EO4SA: from Kong et al. (2024): (a) global map; (b) a zoomed in view on the area of interest,(c) Data set available in the region of interest from ESA-PRIMUS project from Kulk et al. (in preparation) (d) from EO4SA early adopters.

- Hyperboost data: Location of data available are shown in Figure 10
- Additional in situ data from Early Adopters monitoring (Figure 9)Due to the commercially sensitive nature of the in situ data from Early Adopters, the public availability of these data will be subject to negotiation, with a potential solution being the public access to aggregated data.

A more detailed description of the in situ datasets will be provided in Deliverable D2 (Input Data set).

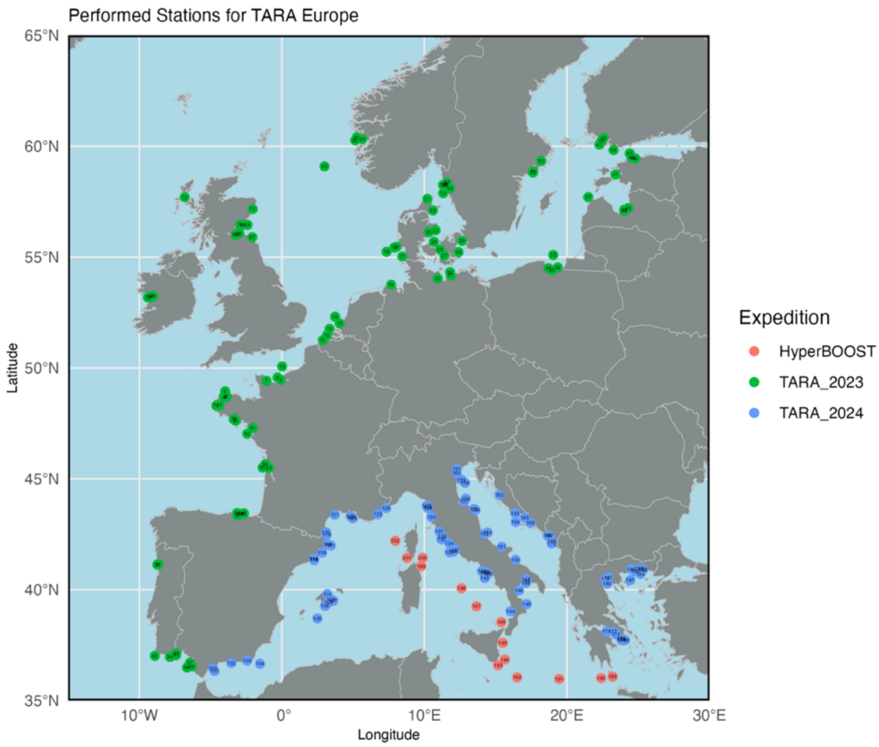


Figure 10: Location of samples from the HyperBoost cruise. Despite not having exact locations around the area of the Galician rias, coastal bio-optical relationships will be explored between in situ data and reflectance to compare with the products developed in EO4SA.

10.3 Output datasets

Table 9 summarises the characteristics of the products revised to match requirements by Early Adopters in Case study 3.

Table 9. The geographical extension and time period covered by for Galician rias, case study 3.

Product	Geographical extension	Spatial resolution	Period	Update rate
Particulate organic carbon concentration (POC) from satellite	Arousa Ria	300 m	2016 - 2026	Daily Weekly Monthly
Culture time from seeding to harvesting from model	Arousa Ria	Polygons	2016 - 2026	Daily (available) Monthly
Mussel biomass and condition (Meat Yield rates) from model	Arousa Ria	Polygons	2016 - 2026	Daily (available) Monthly

Pelagic Primary production from satellite	Arousa Ria	60 m	2016 - 2026	Daily (as available from S2-MSI) Weekly Monthly

11 Potential limitations of the approach

- Limitations by the POC algorithms not working correctly in coastal waters. This limitation can be addressed by incorporating algorithm advances similar to the ones in (Stramski et al., 2023).
- Limitations of the in-situ data for calibration and validation of the products. This limitation will be addressed by engaging with Early adopters which collect in situ dataset relevant to the study, some of which have already proposed to contribute with their data to the project, and exploring additional datasets such as Hyperboost, for which we have already access.
- Limitations by the primary production algorithms being fed by coarse resolutions input data (e.g. Sea Surface Temperature). Although other satellites exist (LANDSAT/TIRS), the scope of the project does not allow to investigate the effects of improving spatial resolution of SST on primary production estimates.
- Potential effects from the bottom close to the shores – we will discard pixels close to shore.
- Potential effects of HABs on: a)- discolouration of water - affecting algorithm performance and atmospheric corrections b) anomalous relationships between Chla and POC. We will be investigating known HAB events during the Sentinel era and evaluate the changes in the POC and PP.
- Potential effects of the raft structures on the optical signal. We will process Sentinel-2 MSI using atmospheric corrections that take into account high reflectance of floating objects (e.g. Acolite) and compare with Polymer processed imagery.

12 Conclusions

The approach initially written in the proposal has been verified and refined by a consultation with the Early Adopters during a meeting and with quantitative information from a questionnaire. The products will be computed at monthly frequency from daily observations, and both will be made available to Early Adopters following their requests. Some of the users have in situ data available and will be happy to contribute them to the project for validation. The extent of the study will be limited to the Arousa Ria and will investigate the off Rias and in Ria processes and exchanges, in particular related to timings of riverine runoffs which condition production phases of the mussel farms, as noted by Early adopters.

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APPENDIX 1: Questionnaire used for Early Adopters Survey of the Galicia in Spain Use Cases (11 pages)

Added PDF file with 11 pages

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Earth Observations for Sustainable Aquaculture (EO4SA) Early Adopters Requirements

Thank you for being willing to participate as an
Early Adopter to the project Earth Obersvations for Sustainable Aquaculture (EO4SA). In this project the Nansen Center, Plymouth Marine Laboratory, the Institute of marine Research (IIM-CSIC) and he Western Philippines University will implement four use cases related to:

a.Predicting risk of salmon lice infestation in Norway.

b.Forecasting toxic HABs related to shellfish farming in Norway.

c.Optimizing shellfish farming by high resolution NPP and mussel growth maps in Galicia, Spain.

d.Mapping unreported and unregulated aquaculture structures and exploitation of marine resources, in Palavan, Philippines.

In this questionaire is a set of questions to assess your current operations and possible needs for Earth Observation based tools in your operations/responsibilities related to aquaculture. We will use your responses and a direct meeting with you to elaborate further on these issues. during the project , we will discuss with you if the tools we are planning to create and shared with you in EO4SA are useful to you and if you will be likely to use them further. In this process we will identify what changes and improvements will be need to make for the tools to be useful to you.

The questionnaire will **take up to 30 minutes to fill in**. The information you give will be stored under UK/Norwegian General Data Protection Regulation (GDPR) to ensure that all data are secure. Answers that you will give will be shared amongst colleagues within the EO4SA project as well as the European Space Agency. They may also be used in scientific publications, presentations and reports to ESA, however then the respondent will be anonymized. This is solely to advance the usefulness of the EO4SA tools and services to be developed. Please do let me know if this is not ok for you.

Many thanks for your time spent on filling in this questionnaire to help us make the project more useful,

The EO4SA team

* Indicates required question

1. Email *

Information about you

In this section we want to know about who you are , your organisation and your position in it

2. 1. What is your Name? *

3. 2. What is your Surname? *

____

4. 3. In which organisation or company do you work? *

____

5. 4. What is your role or position in your organisation? *

____

6. 5. What type of organisation is it? (Select as many as relevant) *

Tick all that apply.

- [ ] Non-Gubernamental Organisation (NGO)
- [ ] Research institute
- [ ] Park Management
- [ ] Private Company
- [ ] Government Agency
- [ ] Financial institution
- [ ] Other: _______________

Information about your interest on EO4SA

7. 6. In which of the four EO4SA use case are you participating? (Select as many as relevant) *

Tick all that apply.

- [ ] a. Predicting risk of salmon lice infestation in Norway.
- [ ] b. Forecasting toxic HABs related to shellfish farming in Norway.
- [ ] c. Optimizing shellfish farming by high resolution NPP and mussel growth maps in Galicia, Spain.
- [ ] d. Mapping unreported and unregulated aquaculture structures and exploitation of marine resources, in Palavan, Philippines.

8. 7. Briefly describe the relevant responsibilities or activities of your organization in relation to the use case(s). *

_____
_____
_____
_____
_____

9. 8. Do you/your organisation carry out or use any regular environmental monitoring of your area/site? *

Mark only one oval.

- ( ) Yes *Skip to question 10*
- ( ) No *Skip to question 20*

If you carry out environmental monitoring

10. 9. If you answered yes to the previous question, what environmental variables do you monitor? (Please select as many as relevant to you) *

Tick all that apply.

- [ ] physical variables (Temperature, Salinity, currents)
- [ ] chemical variables (Dissolved Organic Carbon , Particulate Organic Carbon, pH, turbidity,..)
- [ ] biological variables (Chla, Harmful Algal Blooms, Primary production, toxines)
- [ ] salmon lice density
- [ ] medication or counteractions actions
- [ ] I don't know
- [ ] Other: _____

11. 10. Why do you measure the environmental variables selected in the previous question? (Choose as many as relevant for your case) *

Tick all that apply.

- [ ] To predict HABs occurrences
- [ ] To predict Lice infestation
- [ ] To predict best harvesting time for the size of the animal
- [ ] To support scientific studies
- [ ] To select new areas to put my cages/aquaculture site
- [ ] To fulfill obligations with environmental policies
- [ ] To fulfill obligations with Food Standards policies
- [ ] To obtain Organic certification for my product
- [ ] Other: ____________

12. If you use satellite monitoring to fulfill obligations with environmental policies or EU directives, can you please specify which ones? *

____

____

____

____

____

13. 11 Do you use satellite remote sensing for any of the above environmental variables? Please select the categories you use satellite remote sensing for. *

Tick all that apply.

- [ ] Physical variables
- [ ] Chemical variables
- [ ] Biological variables
- [ ] Other: ____________

14. 12 If you use any satellite product, can you describe which one briefly? Please include specific information if you know it, for example the spatial resolution (size of one pixel), frequency of the satellite product, variable measured. *

15. What satellite products would you be interested in? Can you assign a priority on them, please? 1 is low priority and 5 is high priority *

Mark only one oval per row.

	1	2	3	4	5
Sea surface temperature	⬭	⬭	⬭	⬭	⬭
Sea surface salinity	⬭	⬭	⬭	⬭	⬭
Dissolved Organic Carbon concentration	⬭	⬭	⬭	⬭	⬭
Particulate Organic Carbon concentration	⬭	⬭	⬭	⬭	⬭
pH	⬭	⬭	⬭	⬭	⬭
Turbidity	⬭	⬭	⬭	⬭	⬭
Chlorophyll concentration	⬭	⬭	⬭	⬭	⬭
Harmful algal species	⬭	⬭	⬭	⬭	⬭
Toxines	⬭	⬭	⬭	⬭	⬭
Salmon lice density	⬭	⬭	⬭	⬭	⬭
Location of cages	⬭	⬭	⬭	⬭	⬭

Initial specifications of the products to be developed for EO4SA

EO4SA is going to be developing some products, with a priory characteristics. Here you have opportunity to provide us feedback on the potential use of these products and how can we shape them better to fit your needs.

16. Particulate Organic Carbon for mussel growth *

Tick all that apply.

	not relevant	Insuficient	Minimum	Preferred	Ideal
Spatial resolution planned: 300 m per pixel	☐	☐	☐	☐	☐
Spatial extent: Ria Arousa	☐	☐	☐	☐	☐
Temporal frequency: monthly	☐	☐	☐	☐	☐
Temporal coverage: 2016-2026	☐	☐	☐	☐	☐

17. POC for mussel growth: Do you have any suggestion for other characteristics that suit your use better? Please list them here and provide a short description of your reasons. *

18. Primary Production for Aquaculture and Turism planning *

Tick all that apply.

	not relevant	Insuficient	Minimum	Preferred	Ideal
Spatial resolution planned: 60 m per pixel	☐	☐	☐	☐	☐
Spatial extent: Ria Arousa	☐	☐	☐	☐	☐
Temporal frequency: monthly	☐	☐	☐	☐	☐
Temporal coverage: 2016-2026	☐	☐	☐	☐	☐

19. NPP for different uses : Do you have any suggestion for other characteristics that suit your use better? Please list them here and provide a short description of your reasons. *

Data access and other suggestions

20. Is data access through a Web portal useful to you? *

Mark only one oval.

- Yes
- No

21. Data portal: Can you please justify your answer? If no suitable, can you please list your preferred way of accepting the data? *

_____
_____
_____
_____
_____

22. Do you have any other requirement that you would like to add, to help us tailor the products better to your needs? *

_____
_____
_____
_____
_____

Many thanks

If you have any follow up questions please contact vmv@pml.ac.uk
Many thansk for your help.
The EO4SA team