Earth Observations for Sustainable Aquaculture

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Introduction

The Earth Observations for Sustainable Aquaculture (EO4SA) project aims to advance the use of EO for promoting the sustainability of aquaculture by developing and employing high level indicators and services.

The project will focus on four Use Cases, which cover: outbreaks of salmon lice infestation, the forecasting of toxic Harmful Algae Blooms (HABs) on shellfish farming, multi-use of coastal areas, and the mapping of aquaculture activities. These factors or the environmental conditions associated with them, are possible to monitor by EO, and therefore EO4SA plans to develop innovative EO high-level indicators and products for supporting the sustainable development and management of aquaculture.

Each Use Case has their Early Adopters (EA), who are key stakeholders in each area. The project interacts closely with the EAs to define and develop the EO indicators and products. EO4SA will work with a range of relevant users, from both large and small seafood companies, aquaculture research organisations, banks that finance aquaculture, to local governments; these organisations can be found on the Partners page of our website. The EAs will test and evaluate the project outputs and give feedback throughout the lifetime of the project.

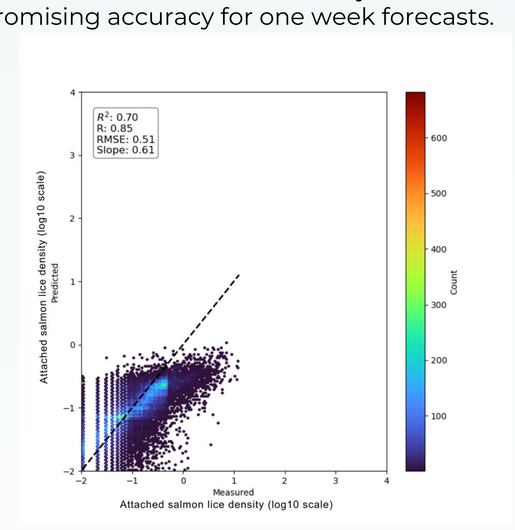
Participative engagement of both the researchers and the main stakeholders in the aquaculture industry is essential to shape the development of products and services, such as establishing the standards for data format, spatial resolution, and temporal frequency, considering their information needs but also the EO limitations. The project started at the beginning of 2025 and will run for two years.

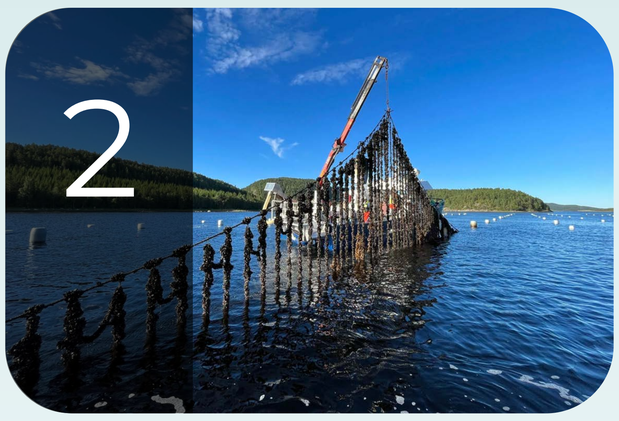
The Use Cases

Predicting Risks of Salmon Lice Infestation in Norway

Salmon lice are crustaceans that infest salmon and facilitate the spread of diseases and the death of fish. Lice are the main challenge in the Norwegian fish farming industry as they can cause the loss of farmed fish and spread to wild salmon. Forecasting lice infestations can provide farmers with an early warning to guide them through mitigation measurements, such as early harvesting or the use of preventative delouse methods.

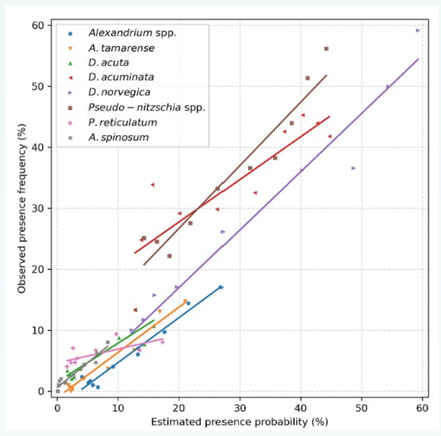
Salmon lice infestations are impacted by environmental conditions, such as ocean temperatures, salinity, and currents. These environmental conditions are observed by satellites and could therefore be used in forecast models of lice density in fish farms. Combining the big data generated by the Norwegian lice monitoring with satellite observations, we can explore machine learning methods to develop forecast models. Preliminary results show promising accuracy for one week forecasts.





Forecasting Harmful Algal Blooms (HABs) Impacting Shellfish Farming in Norway

HABs contaminate shellfish with toxins and pose a threat for humans and wildlife. Besides, shellfish farms can remain contaminated for prolonged periods and incur in high revenue losses, which risks bankrupting farmers. Such losses could be mitigated if farmers are warned about upcoming HABs, so they could harvest the shellfish before being contaminated.



The risk of HABs are tightly related to ocean conditions, such as temperature, salinity, winds, and water stratification. Such conditions can be estimated via remote sensing observations, and thus they can be used as input in forecast models. Two studies in Norway already demonstrate this applicability (Silva et al., 2023; Silva et al., 2024) with good accuracy. The models can now be used to warn the farms of increased risk of HABs and allow them to make decisions on possible mitigation strategies.

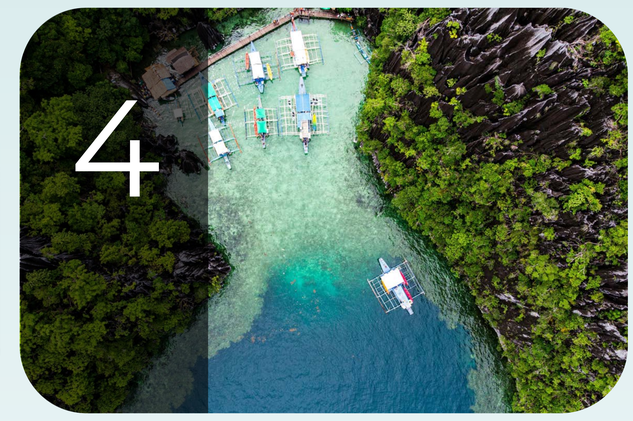
Optimising the Location of Sustainable Shellfish Farming and Tourism in Galicia, Spain

Galician rias. Location of the aquaculture cages. In clear blue the ria de Arousa, where the study is taking place.

The Rías Baixas are a series of large coastal inlets with contrasting sizes, morphologies, topographies, and varying degrees of water exchange with the continental shelf. In this region, maritime traffic, recreation, tourism, and nature conservation compete for space with small-scale fisheries, shellfish harvesting from sandbanks, and extensive mussel aquaculture. These spatial conflicts can be mitigated by optimizing shellfish farming operations.

Shellfish growth depends on the availability and quality of natural food sources, such as net primary production (NPP) and suspended particulate matter (SPM). While high phytoplankton NPP promotes shellfish development, elevated concentrations of inedible SPM hinder growth. Therefore, mapping areas that offer favorable conditions for mussel cultivation is highly relevant when selecting farming locations. This task is approached using Earth Observation (EO) methods. High-resolution NPP estimates will be derived using Sentinel-2 MSI data at a spatial resolution of 60 meters. Previous work under the PRISMA project produced Chl-a estimates for the Galicia region using Sentinel-3 OLCI data. We now plan to extend this approach to higher spatial resolution, which is necessary to capture changes in NPP within mussel raft areas.

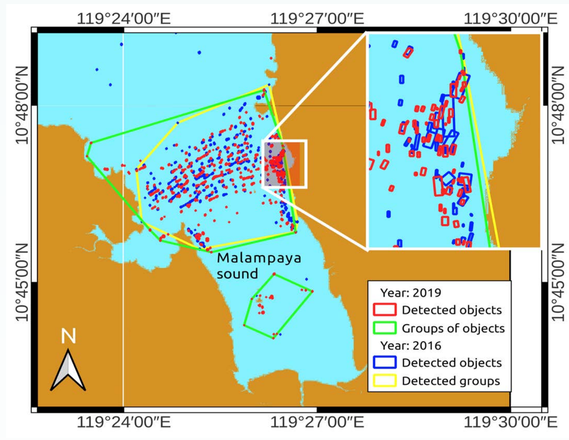
A second innovation in the Galician Rías involves modeling mussel growth using EO data as input variables in a Dynamic Energy Budget (DEB) model. High-resolution satellite-derived Chl-a and POC/SPM data, combined with sea surface temperature (SST) and solar irradiation, will enable accurate modeling of mussel growth in these coastal systems.



Mapping Aquaculture Structures and Use of Marine Resources in Palawan, Philippines

In Palawan, Philippines, coastal aquaculture is gaining momentum as a means to increase fish production. However, this growth also poses challenges to the sustainability of these areas. Puerto Princesa City, known as the "Eco-Tourism Center of the Philippines," features many beach resorts and seafood restaurants. The diversity of activities in the region requires the local government to implement accurate planning and efficient regulation of marine resource use.

Monitoring aquaculture infrastructure is essential for the effective management and control of marine resources, as well as for reducing environmental impacts. For aquaculture mapping, we use satellite remote sensing methods (Kurekin A.A. , et. al., 2022), which are both cost-effective and efficient. Remote sensing allows for automated, regular monitoring over large areas while minimizing additional costs. PML has recently developed an automated approach to mapping aquaculture structures by combining observations from Sentinel-1 SAR and Sentinel-2 MSI. We are planning to extend this method by incorporating AI and applying it to a new study site in Puerto Princesa Bay, Palawan.



Aquaculture farming structures detected using EO method described in Kurekin et al. (2022).

Project Outline

Participative engagement of both the researchers and the main stakeholders in the aquaculture industry and management is key. Each of the four Use Cases will be implemented through the four key activities below, and at end of the project, a roadmap for further development will be made:

Connecting the aquaculture farmers' and public agencies' needs with EO
For tailoring of products required by stakeholders and national guidelines and promoting early adoption of products.

The development of EO based products
Combining EO, models, and in-situ measurements to produce high level EO-based products to support sustainable aquaculture.

User friendly platforms
For making developed EO-based products available on cloud platforms easily accessible by users.

Engaging with the interdisciplinary community
For sharing results and experience with the aquaculture industry and researchers and developing a roadmap for future advancements.

References

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