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EU4 Ocean obs

Earth Observation value chain case study

Sargassum

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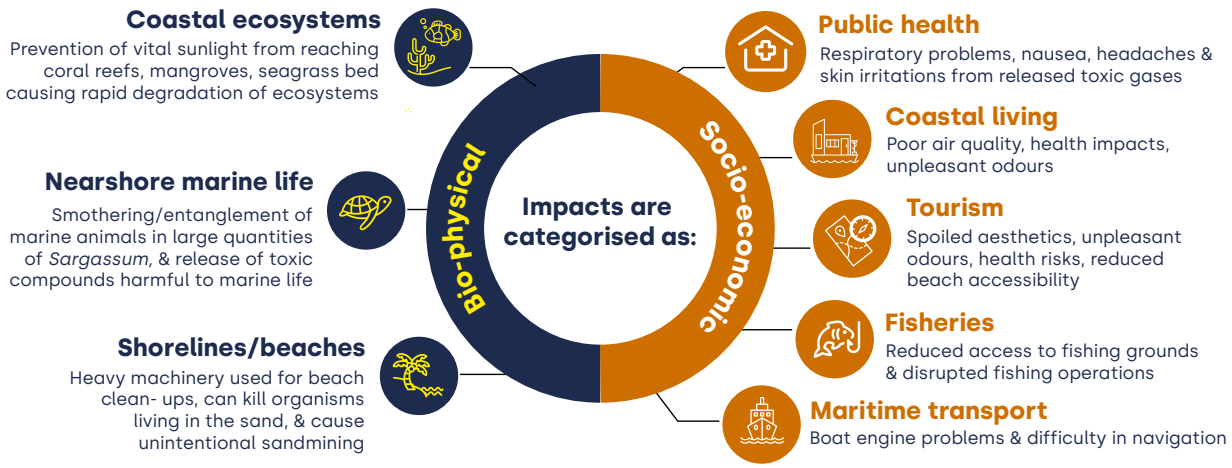
Since 2011, unprecedented massive, episodic strandings of floating holopelagic *Sargassum*, a genus of large brown floating algae, have been observed along the shorelines of the Gulf of Mexico, the Caribbean Sea and the tropical Atlantic. The extension of this phenomenon from West Africa to the Gulf of Mexico is known as the Great Atlantic *Sargassum* Belt (GASB). Around 20M tons of *Sargassum* was recorded in June 2018, 10M tons in June 2019, and 12.7M tons in June 2020. The year 2022 is the worst ever observed with around 24.2 M tons of *Sargassum* recorded in June 2022, thus setting a new historical record high. The large influxes of *Sargassum* on beaches and in coastal areas have become a new norm, increasingly harming marine ecosystems, disrupting coastal activities and impacting local communities.

This case study presents how the European Union is contributing to the detection, monitoring and forecasting of global *Sargassum* influxes, and providing free and open access to data and information needed to understand the *Sargassum* basin-wide spread, its impacts and inform mitigation and adaptation strategies.

Description & impact

Sargassum is a genus of large brown algae that includes over 300 species, some of which are prevalent in the Atlantic Ocean. This floating habitat provides food and protection for marine life and serves as a critical habitat for threatened loggerhead sea turtles and as a nursery area for a variety of commercially important fish. Once confined to the Sargasso Sea, a recent study suggests that anomalous winds during the extreme negative phase of the winter 2009–2010 North Atlantic Oscillation (NAO) could have been a "tipping point" by transporting *Sargassum* from the Sargasso Sea toward the central Tropical North Atlantic, where it now proliferates and seasonally end up on beaches in the Caribbean, Americas and West Africa. Large influxes of floating *Sargassum* in nearshore coastal areas and beaches can cause tremendous harm to marine life and coastal ecosystems, negatively impact public health and disrupt coastal activities, from tourism to fisheries, costing local communities millions of dollars.

Figure 1: Sectors Impacted by Sargassum



Despite these negative and harmful impacts, harvested *Sargassum* may also provide raw materials for commercial use and presents opportunities for economic development. Potential uses include agriculture, bioenergy, bioplastics, construction and cosmetics among others. *Sargassum* can be harvested on land after it has reached the coast or at sea. Both options require sufficient manpower, costly equipment and reliable *Sargassum* drift forecasts to determine where to install harvesting machinery in a timely manner. **Without an effective management and exploitation strategy in place, benefits are mostly likely lost with large quantities of *Sargassum* repeatedly overwhelming coastal areas and are often offset by major negative impacts depending on the resources available and coastal activities.**

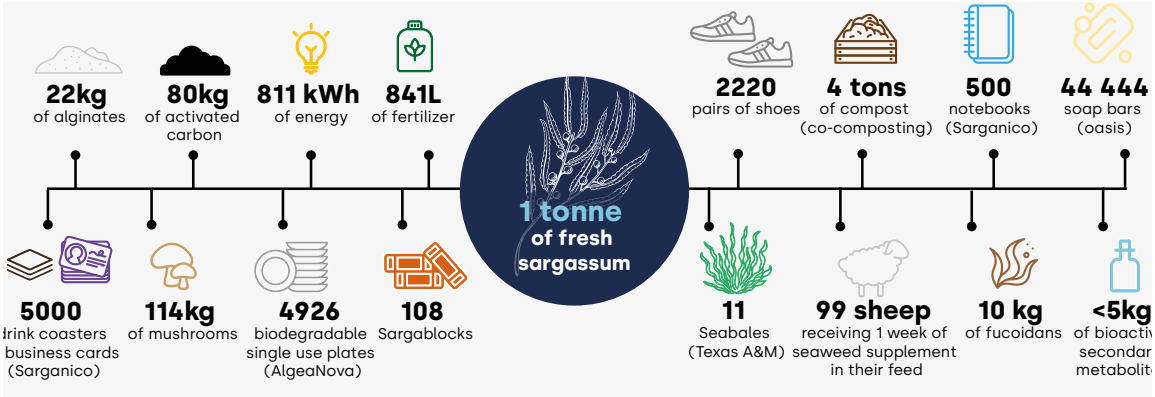


Figure 2: Relative product yields that could potentially be produced from 1000 kg of fresh Sargassum. Adapted from Desrochers et al. 2020.

Earth observation data to address challenges of Sargassum inundations

Detection, monitoring and forecasting of Sargassum

Detecting, modelling and forecasting of floating *Sargassum* are essential for designing effective integrated risk management, mitigation and adaptation strategies. Thanks to the US and **European Copernicus** Earth Observation programmes, there has been significant progress in global remote detection of floating *Sargassum*. Satellite detection of floating *Sargassum* relies on specific algorithms, which capture wavelengths of reflected light associated with the presence of *Sargassum* in the signal received by the on-board sensor.

Today, the following instruments provide ocean colour products and other data products that allow detection, quantification and tracking of *Sargassum* mats over large regions:

- **MODIS (Moderate Resolution Imaging Spectroradiometer)**, onboard the Aqua & Terra satellites,
- **OLCI (Ocean and Land Colour Instrument),** onboard the Copernicus **Sentinel-3 (A & B) satellites**,
- **MSI (MultiSpectral Instrument),** onboard the Copernicus **Sentinel-2 (A & B) satellites,**
- **ABI (Advanced Baseline Imager)**, onboard the GOES-16 satellite,
- **OLI (Operational Land Imager)** onboard the Landsat-8 satellite and
- **VIIRS (Visible Infrared Imaging Radiometer Suite),** onboard the Suomi NPP and NOAA-20 satellite

At the same time, these observations contribute to better understanding of transport, growth and decay properties of the mats, and provide long time series to investigate trends and variability patterns.

Modelling of *Sargassum* transport and physiology helps clarify the link between *Sargassum* distribution and environmental conditions, and provides the groundwork for short-term and seasonal forecasting at the scale of the tropical Atlantic basin. Once a *Sargassum* mat is detected by satellite, its latitude and longitude combined with a drift model can be used to forecast the movement of the mat and possible beaching time - in essence, the basis for an early warning system. The drift model combines meteorological modelling (wind forecasts), hydrodynamic modelling of ocean currents, and can include a growth-decay model of the *Sargassum* biomass in particular for seasonal applications. The model is fed with past and current satellite observations of *Sargassum* combined with in-situ information on previous *Sargassum* inundation events for validation.

Observations and short-term modelling are essential for early warning systems and mitigation guidance, whereas long-term monitoring and forecasting of *Sargassum* (seasonal to interannual) is vital for coastal planning and management, and investment decisions regarding clean-up strategies, harvesting technologies and the development of value-added commercial products.

Access to Sargassum data and information

The European Union (EU) contributes to various monitoring and forecasting platforms, services and tools that provide access to data products and information on *Sargassum*. Data and information, from monitoring of *Sargassum* mats and short-term forecasts of *Sargassum* influxes to outlook bulletins, provide wider access to specifically tailored early warning information. These services, tools and information portals are crucial for decision-making in key sectors (fisheries, tourism, transport, etc.) and by local authorities and government departments.

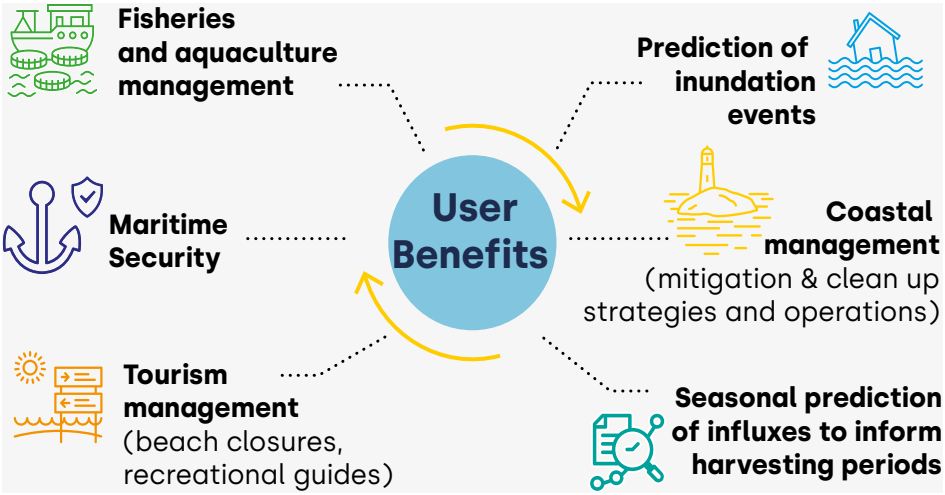


Figure 3: User benefits and decision points from access to Sargassum monitoring and forecasting tools, and services

The EU supports the following projects, services and initiatives providing monitoring and forecasting services, and access to data and information on *Sargassum* in the tropical Atlantic:

The **Sargassum Information Hub** (sargassumhub.org) centralises access to information and tools for the monitoring and management of *Sargassum* blooms in different regions for all stakeholders, from local fishers to scientists. Users can explore available observations, forecast reports, ongoing research and development efforts, and the latest technologies and applications used to detect and predict the movements of *Sargassum*. The Hub is a joint collaboration between GEO Blue Planet, IOCARIBE of IOC-UNESCO, AtlantOS, the Atlantic International Research (AIR) Centre and other partners, with funding support from the EU.

The **European Copernicus Marine Service** (marine.copernicus.eu) provides free and open access to satellite, in situ and modelled data products that can be used to monitor, model and forecast *Sargassum*. Under the Copernicus 2 programme, Copernicus Marine will work to enhance and improve *Sargassum* detection and forecasting techniques through the combination of existing sensors and the use of non-conventional sensors. This work will be carried out between 2022 and 2024 as part of the Copernicus Marine Service evolution programme.

The "**FOREcasting seasonal *Sargassum* Events in the Atlantic - FORESEA**" (sargassum-foresea.cnrs.fr) project is designed to improve understanding of *Sargassum* blooms and drift in the open and coastal sea and to develop a skillful seasonal forecast of the quantity of *Sargassum* in key regions of the Tropical Atlantic Ocean. Led by the Institut de Recherche et de Dévelopment (IRD), this 3-year project was funded by the French National Research Agency (ANR), the Regional Council of Guadeloupe and the Territorial Collectivity of Martinique. The project will end in 2023 but these actions could be continued in the scope of the MOSAIC project submitted to a joint call launched in 2021 funded by the ANR, Brazil, and the Netherlands "**Understanding and predicting *Sargassum* Blooms**".

The **SAMtool** (datastore.cls.fr/products/samtool-sargassum-detection) is a key operational web-based service to detect and monitor *Sargassum* in the wider Tropical Atlantic region, including Carribean and African coasts, responding to the needs of scientific, institutional and private users. The service provides real-time detection of *Sargassum* using satellite imagery provided by a combination of Earth Observation ocean colour instruments onboard Copernicus Sentinel satellites among others. The tool also runs a drift model to estimate *Sargassum* trajectories and probably of landing on the coasts. The SAMtool is implemented by Collecte Localisation Satellite (CLS), with funding from the European Space Agency (ESA).

Sargassum Forecast Bulletins for the French Antilles (meteofrance.gp/fr/sargasses, meteofrance.mq/fr/sargasse), French Guiana (meteofrance.gf/fr/sargasses), provide *Sargassum* surveillance updates twice a week for local authorities in Guadeloupe and other islands in the French Antilles and French Guiana to predict the risk of upcoming landings of *Sargassum* mats and help organise timely clean-up crews. The bulletins present a simple cartography of the coasts concerned, with a risk index and a 4-day forecast, together with a 2-week trend of Sargassum inundation. These bulletins are produced using the high-resolution drift model MOTHY of the French Meteorological Service (Meteo-France) fed by Copernicus and NASA/NOAA satellite observation data, and Mercator Ocean International Ocean forecasting models.

The **Caribbean Cooperation Programme Against Sargassum - Sarg'coop** (interreg-caraibes.eu/sargcoop) is an operational *Sargassum* monitoring service and network for the Caribbean region involving St. Lucia, Dominican Republic, Tobago, Cuba and Mexico. The service includes a web-based early warning system, centralised in Guadeloupe, sanitary surveillance and serves as a platform to facilitate the sharing of knowledge and expertise in the management of *Sargassum* at regional scale. With the aim to strengthen the joint preparedness of Caribbean territories and their resilience to the invasion of *Sargassum*, the project is led by the Regional Council of Guadeloupe with funding from the EU.

Figure 4: EO-based Sargassum monitoring & forecasting value chain

EARTH OBSERVATION PLATFORM

EU Copernicus Satellites
Sentinels 1,2 & 3
(Radar, MSI & OLCI)

US Satellites
Aqua, Terra & Landsat-8
(MODIS & OLI)

Copernicus
Europe's eyes on Earth

Improve Calibration

NEED FOR IN SITU OBSERVATIONS

- Information on Sargassum growth and mortality
- Accurate regional wind and ocean current data
- Data on quality and location of Sargassum beaching

DATA

Ocean Data Products

Improve validation & accuracy of models

ANALYSIS

Sargassum Detection algorithm/model

Meteorological forecast (wind models)

Hydrodynamic modelling

Numerical drift & growth/decay models

Detection model > **Predictive model**

INFORMATION

Sargassum presence probability
Sargassum raft shapes and sizes

Sargassum distribution and location

PRODUCTS / SERVICES

Sargassum early warning systems
Sargassum monitoring and detection visualisation platforms & tools
Sargassum outlook bulletins and reports

END USER BENEFITS

Target

Public & local authorities

Coastal communities

Industries (Fisheries, Aquaculture, Tourism, Bioenergy, etc.)

Maritime Transport & Security

Decision points

Daily monitoring & early warning of Sargassum blooms

Informing mitigation & exploitation plans, improving coastal resilience & preparedness

Informing recreational guides (beach closures)

Planning of Sargassum clean-ups & harvesting

Benefits

Reduce environmental and socio-economic impacts by providing at least several months of lead time for coastal communities and local authorities to better prepare for upcoming Sargassum influxes and beaching events

Facilitate timely Sargassum harvesting for commercial opportunities

Reduce disruption of coastal activities with timely and more efficent clean up operations

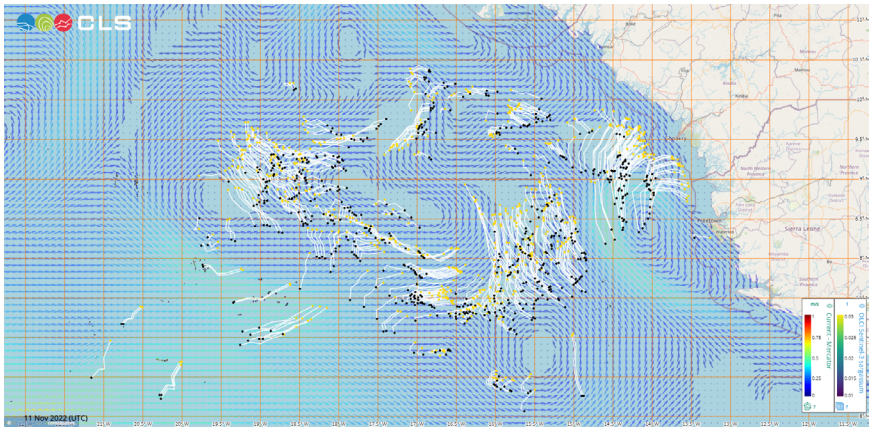


Figure 5: Detection and forecast trajectories of Sargassum mats in the tropical Atlantic, along the coast of West Africa, overlayed on the modelled surface current direction (blue arrows) provided by Mercator Ocean International. The black marks show positions of the Sargassum mats detected by satellite on 6 November 2022. The white lines show the modelled estimated trajectories and the yellow marks the estimated position of the Sargassum mats on 11 November 2022.
SAMtool. Credit CLS.

Gaps in monitoring and forecasting Sargassum inundations and spread

Despite all the significant progress made, there are gaps in monitoring and forecasting capacity and capabilities, which include:

- Limited optical satellite coverage in cloud covered *Sargassum* source regions
- Lack of knowledge on *Sargassum* physiology (information on growth and mortality rates) as it travels through different environments
- Lack of consistent and operational national and site-level monitoring of *Sargassum* strandings, especially about quantity and location, which constrain the ability to validate forecasting models
- Limited availability and accessibility of *Sargassum* outlook bulletin information in a user-friendly way and at a global scale
- Uncertainties on the nutrient content (analysis and forecast) of the Tropical Atlantic to feed the *Sargassum* growth models

Recommendations

To improve monitoring and forecasting of Sargassum, and enhance our understanding and predictions of *Sargassum* influxes for better evidence-based management and mitigation actions the following recommendations are proposed:

• **Improve accuracy of satellite detection** by developing the capacity of and using relevant radar satellites, with enhanced optical coverage insensitive to cloud covering (cloud shadow, sun glint, etc.), often present in *Sargassum* source regions.

• **Development of higher precision remotely sensed imagery** for better satellite observational data on *Sargassum* movements nearshore. For example, better observational data would reduce uncertainty in the accuracy of open ocean current models over long-distance paths through this complex and dynamic Atlantic Ocean region, and thus improve local prediction of strandings..

• **In situ observation data over the target areas** are required to validate the accuracy and quality of *Sargassum* monitoring and forecasting tools and technologies. It is thus important to establish historical databases containing official information about zones and dates with and without presence of *Sargassum* on coastlines and complete these efforts with continuous and comprehensive in-situ observations initiatives.

• **Improved and public access to data products and services** to monitor and forecast *Sargassum*, will help management decisions and mitigation and adaptation actions and planning. Given the various activities in place, there is need for further integration of information and services through initiatives such as the **Sargassum Information Hub**.

remote sensing and traditional in-situ data sources to improve and fill gaps in the detection and monitoring process. European efforts could integrate and build on existing global citizen science initiatives such as the **Epicollect5 Sargassum Watch**, the **UNEP Sargassum sightings form**, the **NOAA/AOML Atlantic Pelagic Sargassum Survey**, to mention a few, to engage citizens in data collection.

• **Multidisciplinary research collaborations** with marine biologists, meteorologists and radar specialists will significantly improve *Sargassum* forecasting capabilities. For example, to improve our understanding of the growth and mortality of *Sargassum*, further research and development efforts in *Sargassum* biology and ecology are needed.

• **Strengthened and coordinated global efforts** to monitor and forecast *Sargassum*, particularly to develop long- and short-term forecasting for the impacted regions, share best practices for managing *Sargassum*. For example, increased knowledge and information sharing on different regional and national monitoring and forecasting systems, techniques, services, data sources, projects, etc., through international collaborative initiatives such as the **GEO Blue Planet Sargassum working group**.

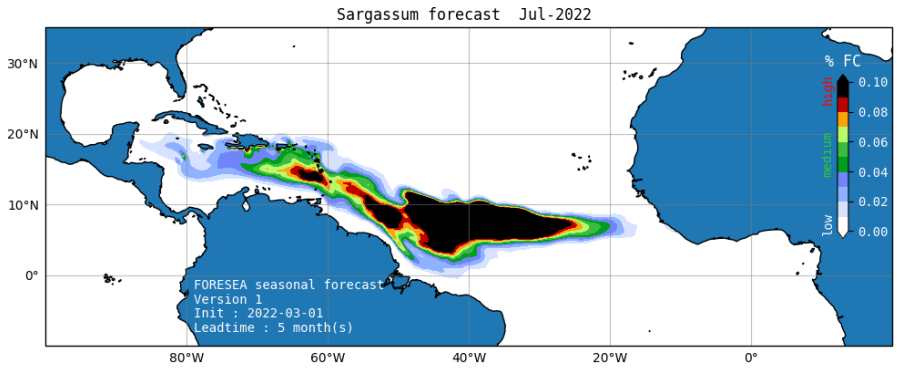


Figure 6: The pre-operational forecasting system developed withing FORESEA project. Sargassum fractional coverage (representative of the fraction of 25km X 25km pixels covered by Sargassum, in percentage) forecast initialised on 1 April 2022, and shown after 4.5 months of integration (July 2022). The forecast is based on an average of an ensemble of 25 simulations. Such ensemblist strategy allows to consider the uncertainties regarding the forecasted surface current, temperature, winds, and Sargassum detections. Credit: FORESEA project.

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