

# FORCOAST



Earth Observation Services For Wild Fisheries, Oystergrounds  
Restoration And Bivalve Mariculture Along European Coasts

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## Executive Summary

This report provides a guide for users to use the marine information service platform, developed in the FORCOAST project. The service can be accessed from <https://forcoast.netlify.app>. The user manual first introduces how to use the general data viewer tool, which is a common function for all service modules. This is followed by a guide on how to use the specific functions for using the service bulletins in the seven service modules. Finally, data products used as inputs of the platform are introduced.

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# 1 Introduction and platform general manual

## 1.1 Introduction

In FORCOAST project, partners have developed real time forecast and hindcast models and algorithms to derive tailored products for seven service modules. The production of the dataflow includes ready-for-use tailored products which are based on both historic data and also future forecast data. They have been integrated into a service platform, providing real time service for both mobile and fixed location terminals. This deliverable produces a user manual for the operational system and product generation as well as for the use of the platform. Chapter 1 gives an overview of the web platform and an introduction to the data viewer. Chapter 2 covers the use of the platform from a user perspective, step by step of the functionalities and services. Chapter 3 focuses on each specific service: set-up, input data, specifics, outcome, description of the information product.

## 1.2 FORCOAST web-platform

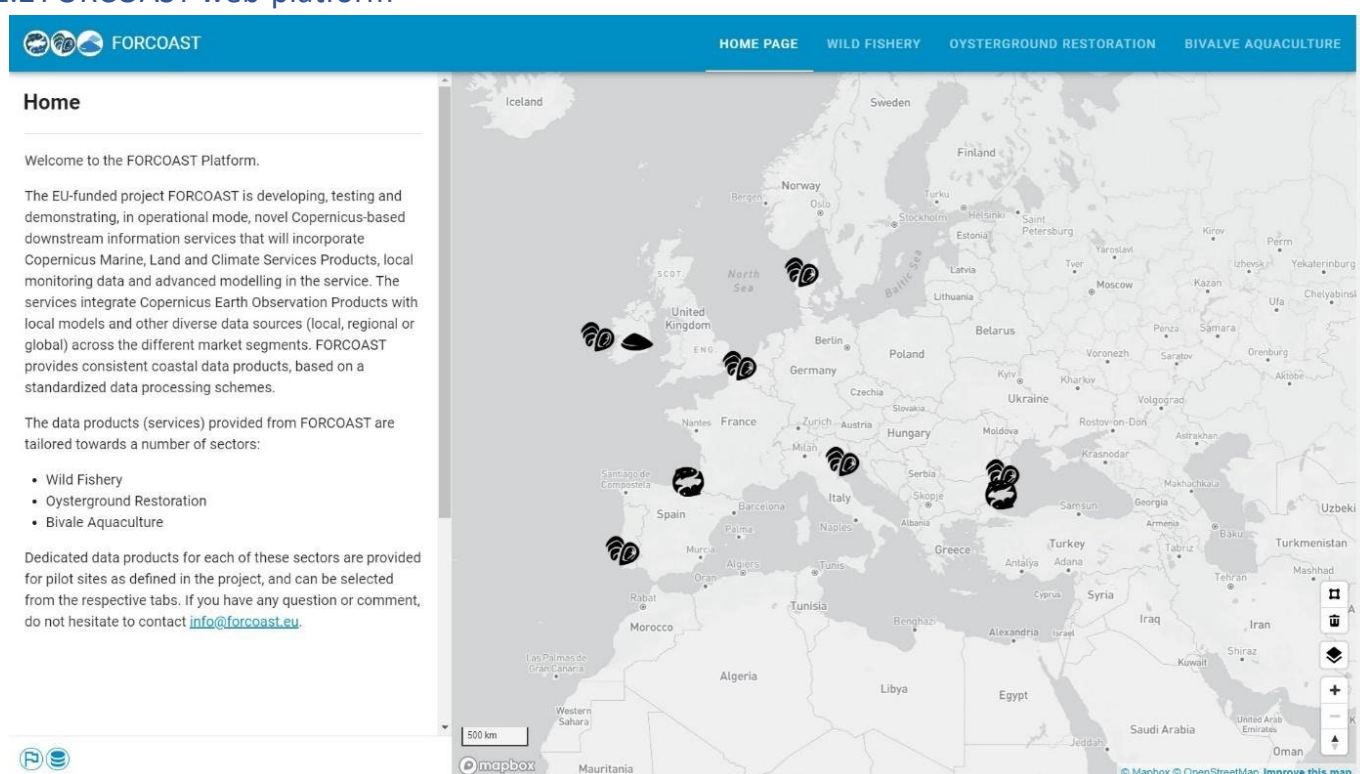


Figure 1: Homepage

Once the user enters the platform the homepage is displayed. On the left of the screen there is a short introduction to the project and the three main sectors, namely *Wild Fishery*, *Oysterground Restoration* and *Bivalve Aquaculture*. On the top of the screen the user can navigate to the homepage of the project for more information and the different sectors and services by clicking on the selected drop-down tab. Clicking on a sector will pop up the areas of interest and the available services for each pilot area as shown in Figure 2.

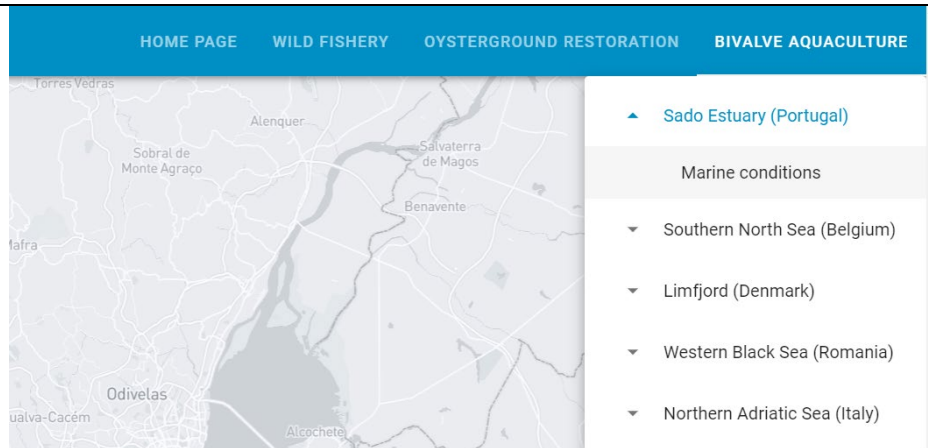


Figure 2: Sector bar and pilot areas

The interactive map display shows the different pilot areas and the provided services. The user can move, zoom in and out, alter the map's background and generate polygons over areas of choice using the bar on the right lower corner as shown in Figure 3.



Figure 3: Map bar

### 1.3 Exploring the data viewer

By selecting a sector and a pilot area from the top bar of the screen, the user will directly navigate to the selected area. Figure 4 shows an example case for using the data viewer.

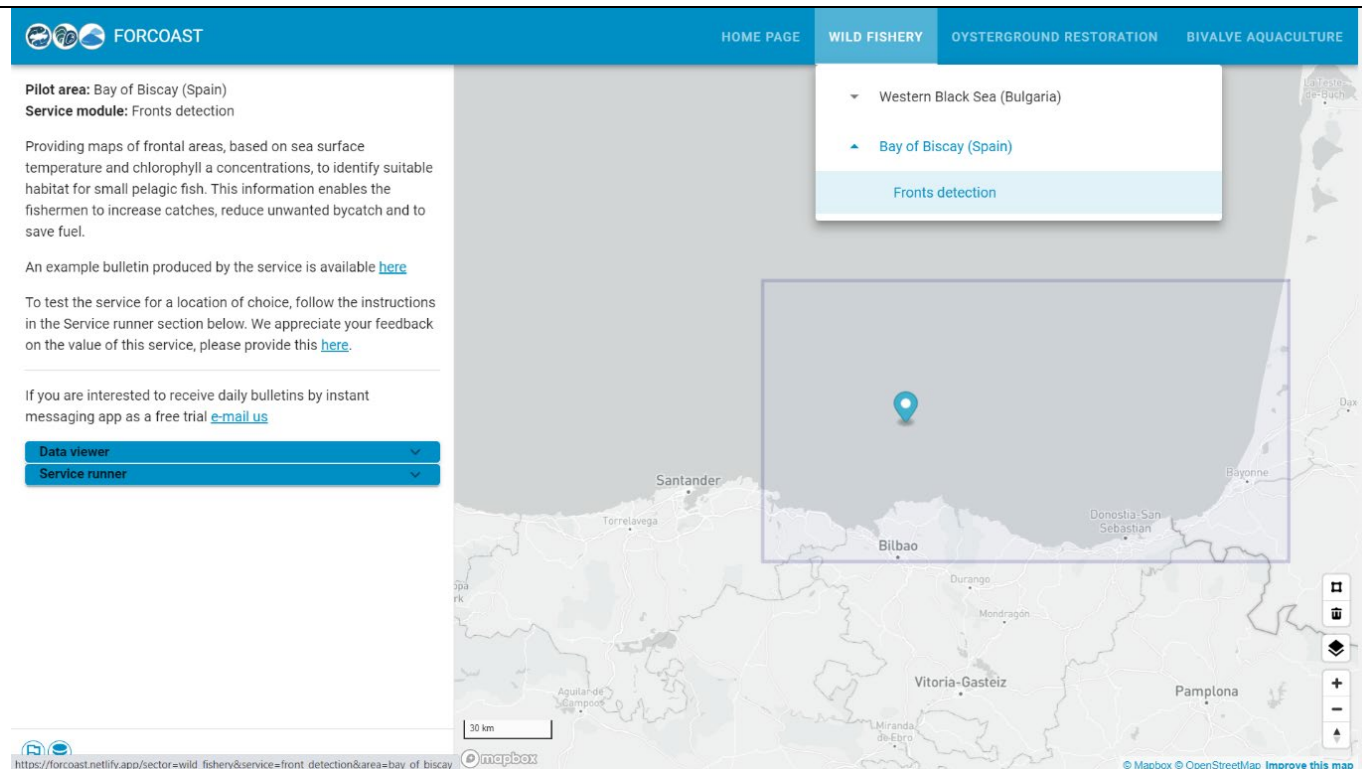


Figure 4: Example display of a pilot area and service selection

On the left of the screen, a short description is provided for the selected service, together with a service output example. From here, the user can open an example bulletin as created by this service, can access a feedback form through which feedback on FORCOAST platform can be provided (Figure 5), and can get in touch by e-mail (Figure 6).

### FORCOAST - Service Feedback

Your feedback after using the FORCOAST Services is of great value since it helps us to improve the service, offering you a better product in return. Please consider answering the questions below:

daniel.twigt@gmail.com
Switch account

\* Required

Email \*
  
Your email

Which Service would you like to evaluate? \*
  
☐ Fronts Detection
  
☐ Suitable Fishing Areas
  
☐ Contaminants Source Retrieval
  
☐ Marine Conditions
  
☐ Land Pollution
  
☐ Site Prospection
  
☐ Spat Capture Assistance

What is your impression of the use service via the platform of the following aspects from 10 (highest) to 1 (lowest)? \*
  
10 9 8 7 6 5 4 3 2

Figure 5: Digital feedback form which can be accessed from the User Interface

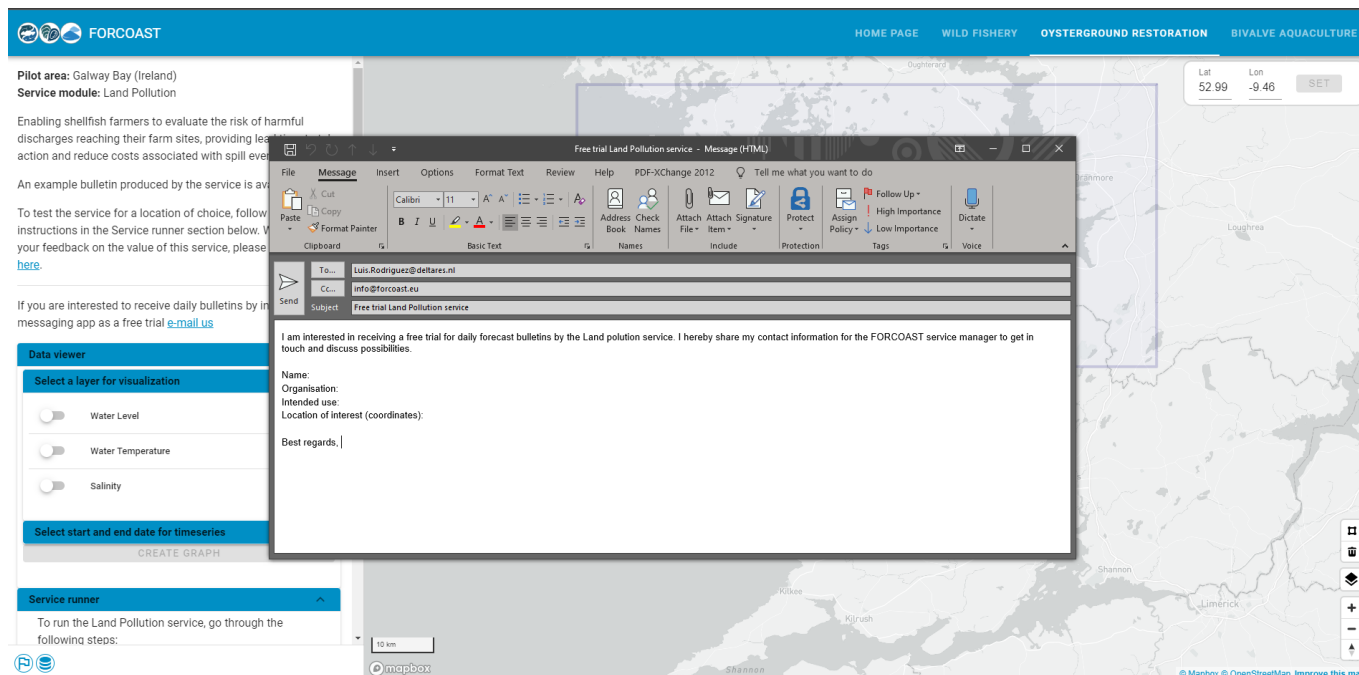


Figure 6: E-mail template to register for automated service

Bellow the description, the Data viewer and “Service Runner” drop-down bars are displayed (Figure 7).



Figure 7: Data-viewer and service runner drop-down bars

The data viewer has the same functionality for all pilot areas and service modules, namely it allows users to visualize data, directly on the web-map viewer. Figure 8 provides an example of the toggable units included in the Data viewer for the above example. Each layer displays the latest data available. An example of a visualized layer can be seen in Figure 9.

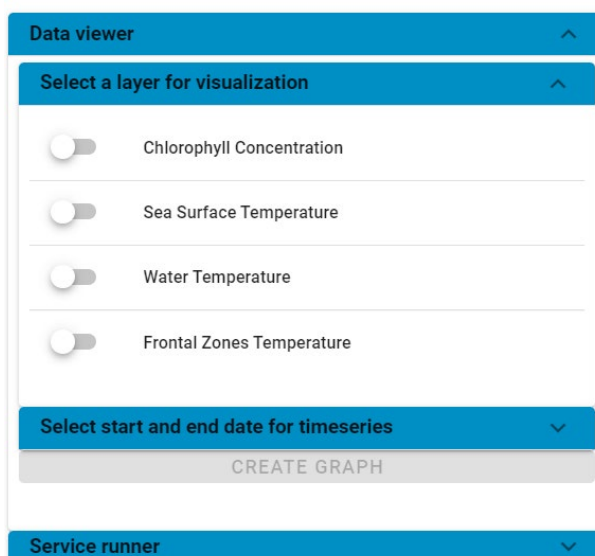


Figure 8: Data viewer toggable units and timeline selection

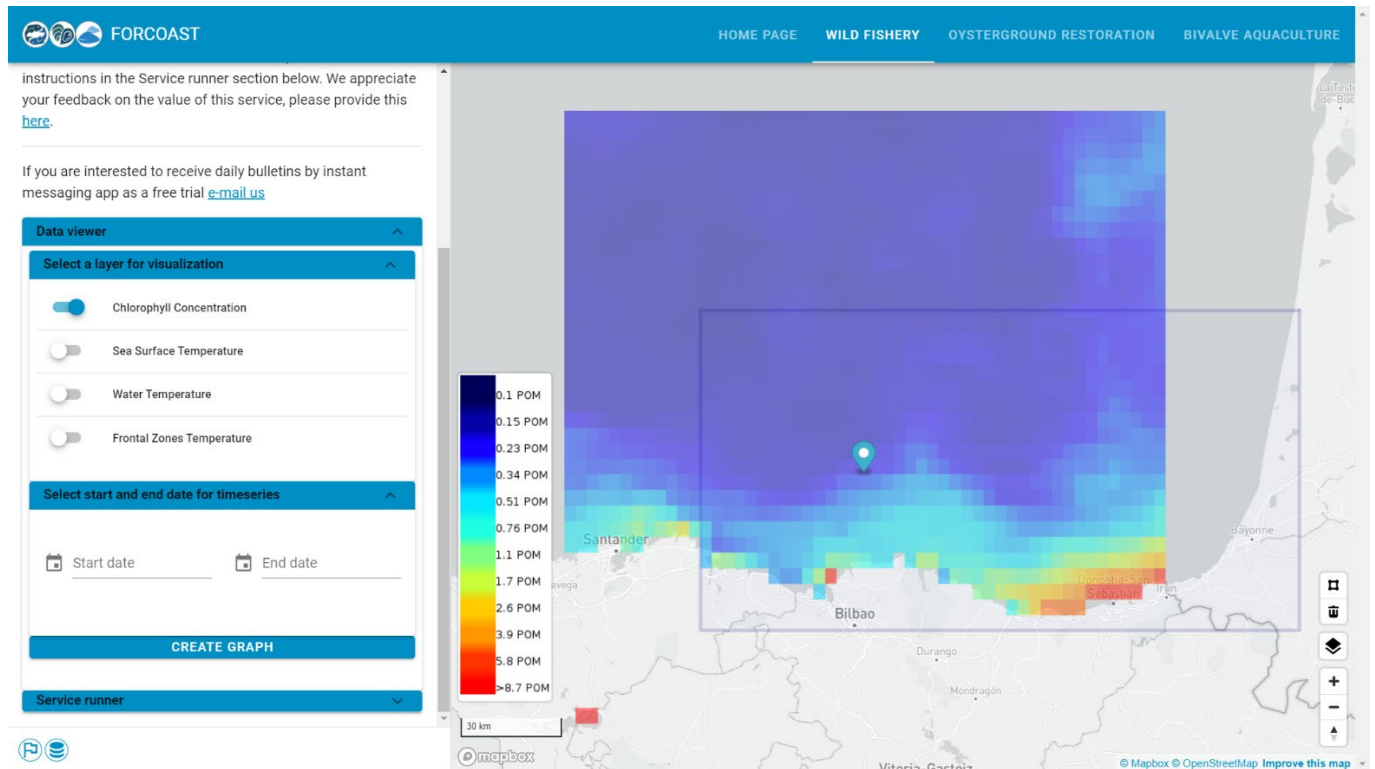


Figure 9: Data-viewer, Visualizing a layer without a timestamp.

Some data can be viewed on a specific date and time as shown in Figure 10. The user can use the top-left panel on the web-map display to select a certain date or (in some cases) a specific time of the day for the layer to be visualized.

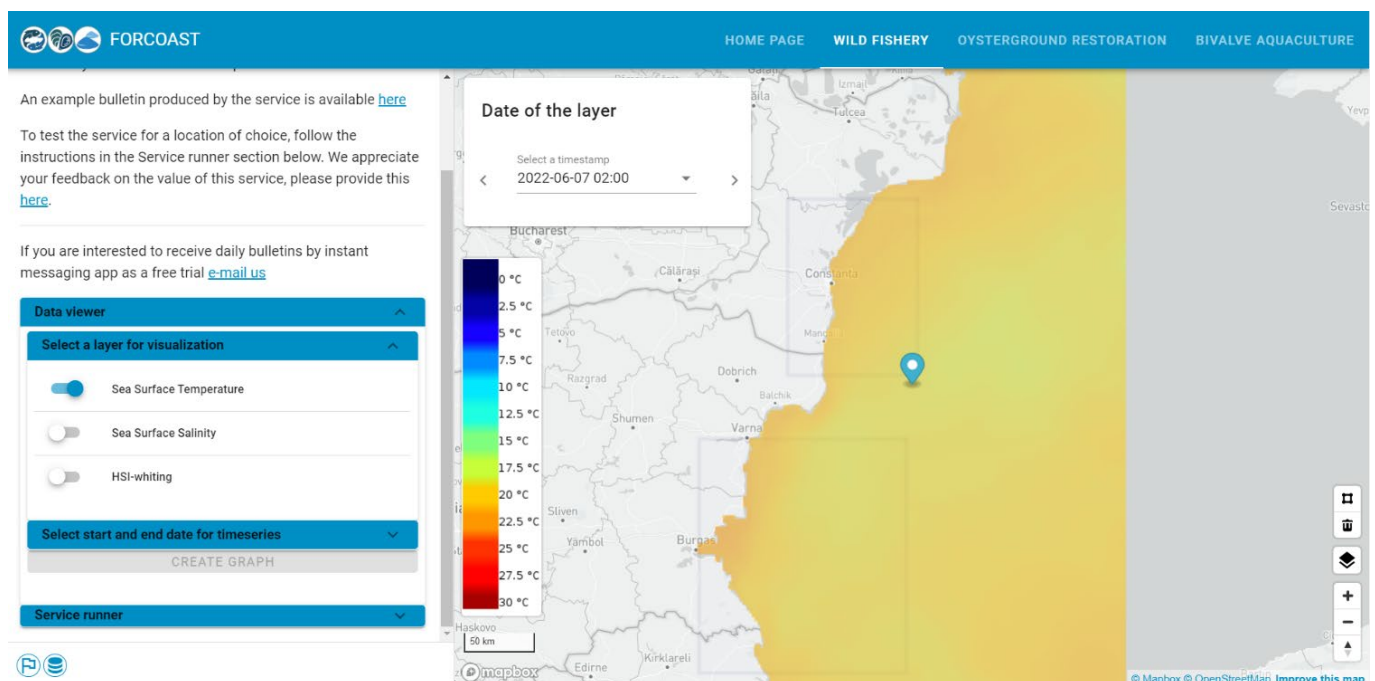




Figure 10: Data-viewer, visualizing a layer with a selected timestamp

## 2. Service specific manual

In this section, the user can find information on how to use the different services provided in the platform for each pilot area. Before diving further into details, a general notice is that some of the services require some input or certain actions from the user, such as declaring a threshold value, setting a date or indicate coordinates. On the other hand, there are certain services, which run as scheduled tasks and the user is only asked to indicate a time range and a certain location. The following chapters will explain how to utilize each service using the FORCOAST platform. Some services may apply to multiple pilot areas. this manual will provide one representative example for each individual service.

### 2.1. Service module: F1 - Suitable Fishing Areas

The presence of areas with high concentrations of fish resources in Bulgarian and Romanian coastal waters (Pilot where the SM has been initially developed) is highly influenced by seasonal variations. In addition, spatial distribution of zones with high fish resources could represent an issue – large distances between fishing areas and collecting centers. The aim of the Fishing Suitability Index developed within this service module is to address these specific stakeholder needs by offering information regarding the localization of optimal conditions for fishing activities in the area of interest. The index has values ranging from 0.1 (less suitable) and 1.0 (best condition).

As shown in Figure 11, this service runs as a scheduled task. To make use of the service, there are two options. First, the user can simply visualize the HSI (Habitat Suitability Index) layer by toggling the layer on. Selecting different timestamps from the time panel on the top-left of the web-map display allows the user to historically explore the data and have a visual inspection.

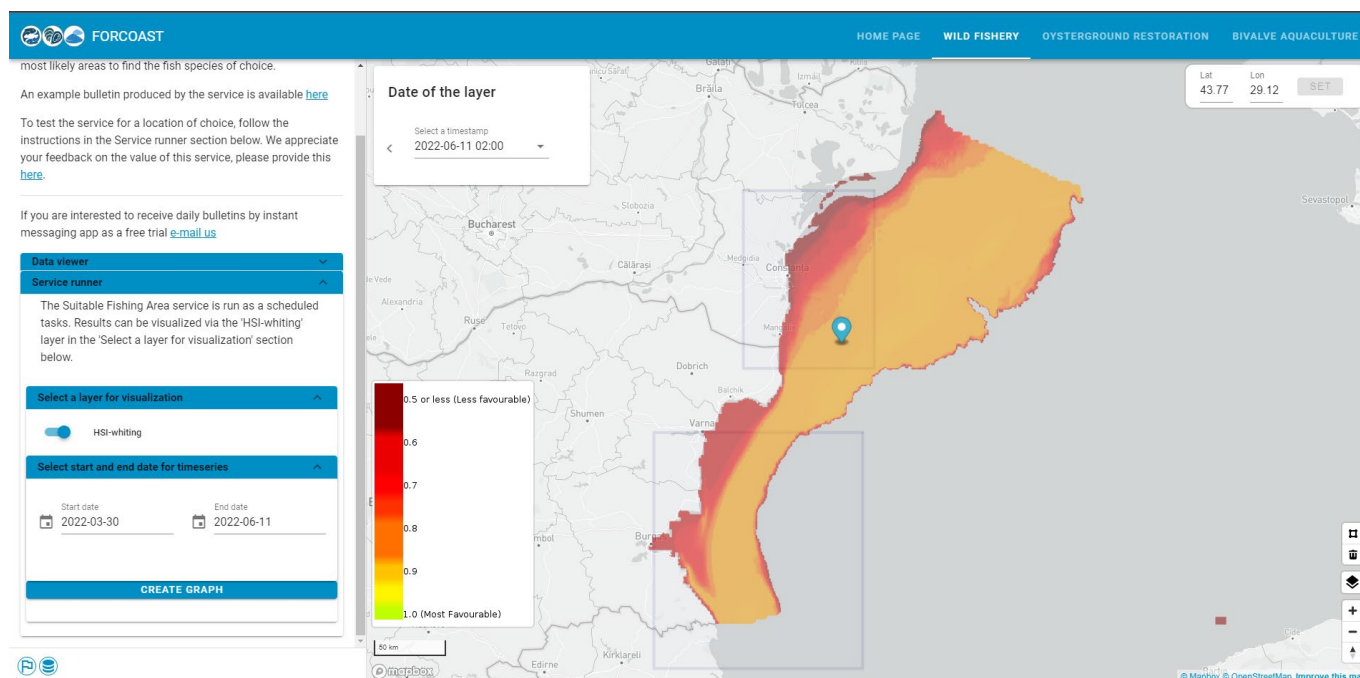


Figure 11: F1-Suitable Fishing Areas, visualizing the HSI-whiting layer and generating a graphical representation of a selected time range.

In addition, the user can select a time range from the panel on the left of the screen below the layers for visualization. After defining a time range, the user can specify the selected area of interest by placing the blue marker on top of it, inside the indicated purple box or by specifying the selected coordinates manually from the top-right panel on the web map-display. Finally, the user needs to lock the coordinates given, by clicking on the “SET” tab. Once these two

steps are fulfilled, the user can click on the “Create Graph” tab on the left side of the screen to run the service and produce a graphical representation of the HSI-layer over a selected time range. An example of the final output can be viewed in Figure 12. Once the graph is generated, a pop-up window appears on the screen displaying the data graphically. This window provides the user with certain options, such as zooming in, viewing the data series, changing the graph to bar or line chart, and downloading the file into a local directory in a .PNG format. This process can be executed for all the layers included in this pilot area.



Figure 12: Example output graph for the HSI-whiting at defined time range on a specified location.

## 2.2. Service Module: F2 - Front detection

Frontal areas are those where there is a sharp gradient in certain properties of seawater, such as temperature or chlorophyll-a concentration. These areas are characterized by a higher-than-normal biological activity, and therefore can be used as an indicator of the presence of certain commercial fish species, helping the user identify potential fishing grounds.

Sea fronts can be identified using both remote sensing imagery (real-time) and model data (forecast of fronts' positions and intensities). The fishing sector needs easy to understand and highly processed data to make fast decisions on where to go for optimizing routes, in combination with the user's knowledge and experience. This service module has been designed with both qualities in mind, which allows identifying the areas of interest immediately, with the subsequent reduction in the time spent at sea and fueling usage.

The F2-Front detection service runs as a scheduled task. Figure 13 shows a visual output of the “Frontal Zones Temperature” layer for a specified date and time. The user is required to toggle the switch under “Data viewer”, “Select a layer for visualization” and “Layers produced by FORCOAST” to activate the layer. Then, select from the top-left panel of the web-map display, the selected timestamp.

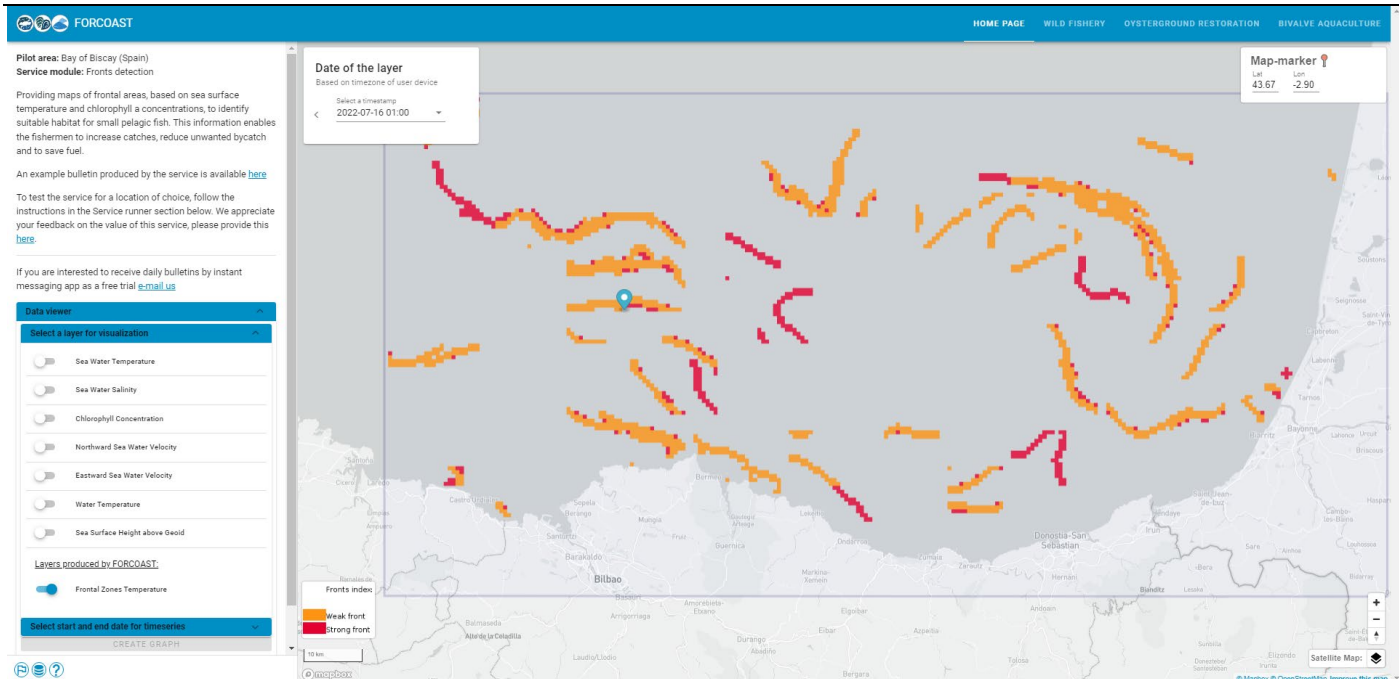


Figure 13: Example of the Front detection service module

This way, the user can see the areas where there are weak or strong fronts (orange and red, respectively) and assess their permanence at a glance.

In addition, the user can select a time range from the panel on the left of the screen, below the layers for visualization, under “Select start and end date for timeseries”. After defining a time range (Start and End date), the user is required to indicate a selected area of interest by placing the blue marker on top of it, inside the indicated purple bounding box or by specifying the selected coordinates manually from the top-right panel on the web map-display. Finally, the user needs to lock the coordinates given, by clicking the “SET” tab (Figure 14). Once these two steps are fulfilled, the user can click on the “Create Graph” tab on the left side of the screen to run the service and produce a graphical representation of the Front Zones Temperature layer over a selected time range. Once the graph is generated, a pop-up window appears on the screen displaying the data graphically. This window provides the user with certain options, such as zooming in, viewing the data series, changing the graph to bar or line chart, and downloading the file into a local directory in a .PNG format (Figure 15). This process can be executed for all the layers included in this pilot area. This is another way to assess the permanence or appearance of the fronts in the desired area.



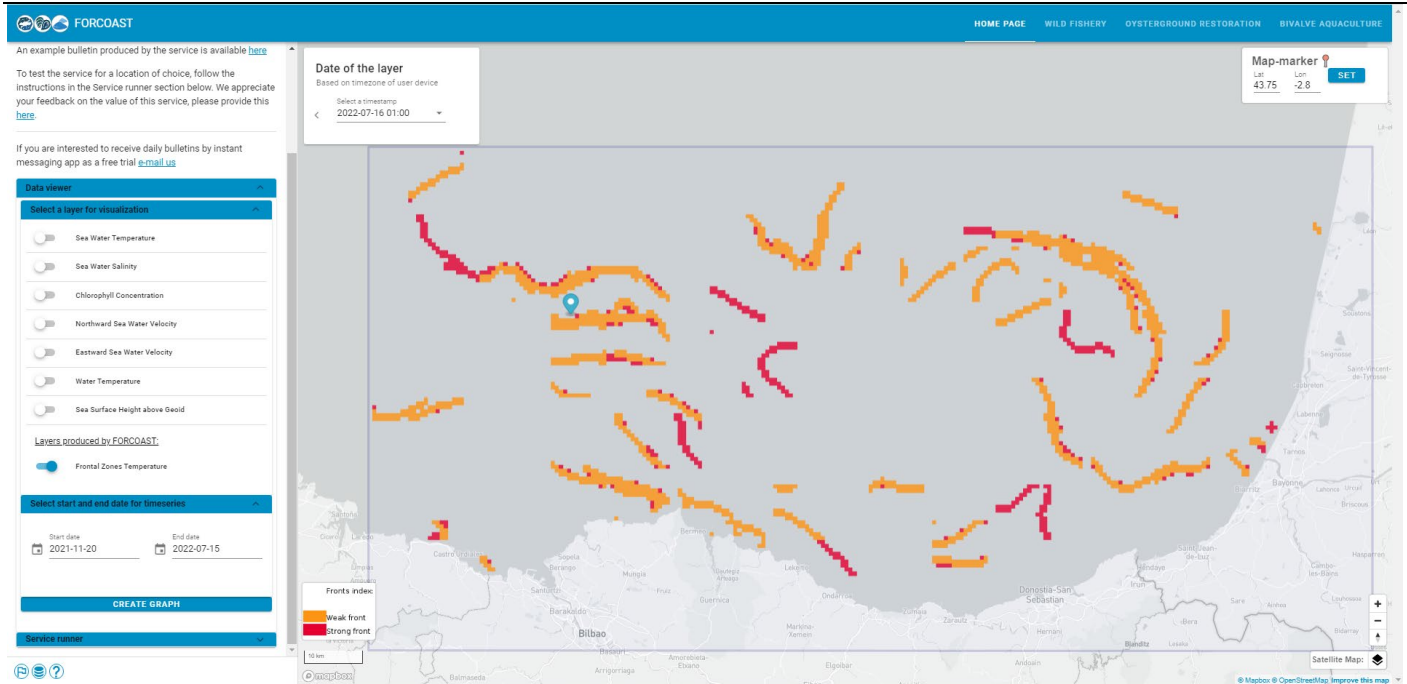


Figure 14: Front detection service - setting up the graphical representation

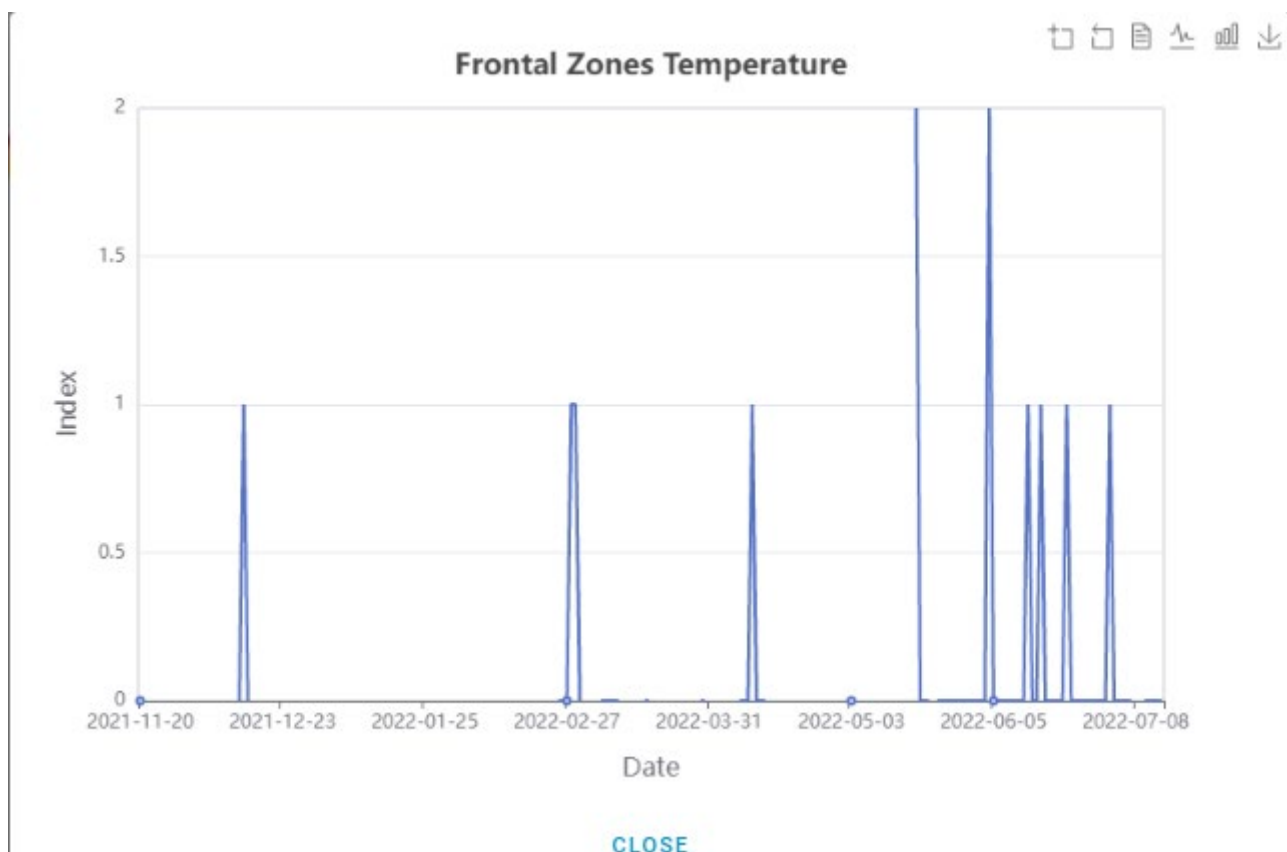


Figure 15: Example output graph for the Front Zones Temperature at defined time range on a specified location

## 2.3. Service Module: A1 - Marine conditions at farming site/alarm system and scheduler

To run the Service runner in the Marine Conditions service the user must follow certain steps, which are also displayed on the left of the screen (Figure 16).

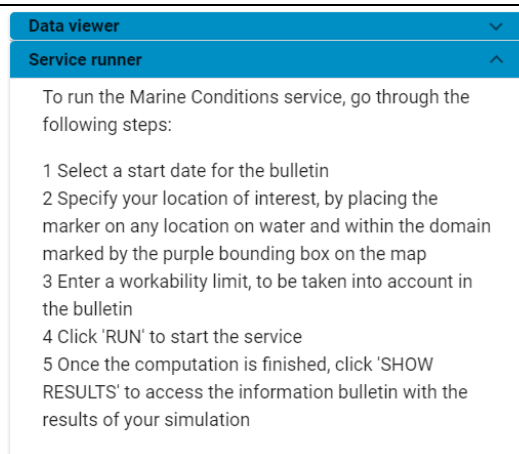


Figure 16: Service runner description for the A-Marine Conditions and scheduler

The first step is to indicate a specific day for the service to start the simulation. To select a starting date for the service run, click on corresponding tab and select an appropriate day for running the service, click “OK”. Once this step is fulfilled, the user must specify the location. There are two ways to do this: one is to place the marker on the web-map display on the location of interest, and the other is to directly type latitude and longitude of the service location in the upright location bar, as shown in Figure 17, and lock the selected coordinates by clicking on the “SET” tab on the top right of the web-map display. The next step asks the user to enter a workability limit for the selected variables. Currently only water level is implemented, and the workability limit of water level must be in range of 0-2 meters.

Notice: The marker, must be placed inside the purple bounding box on top of water locations only

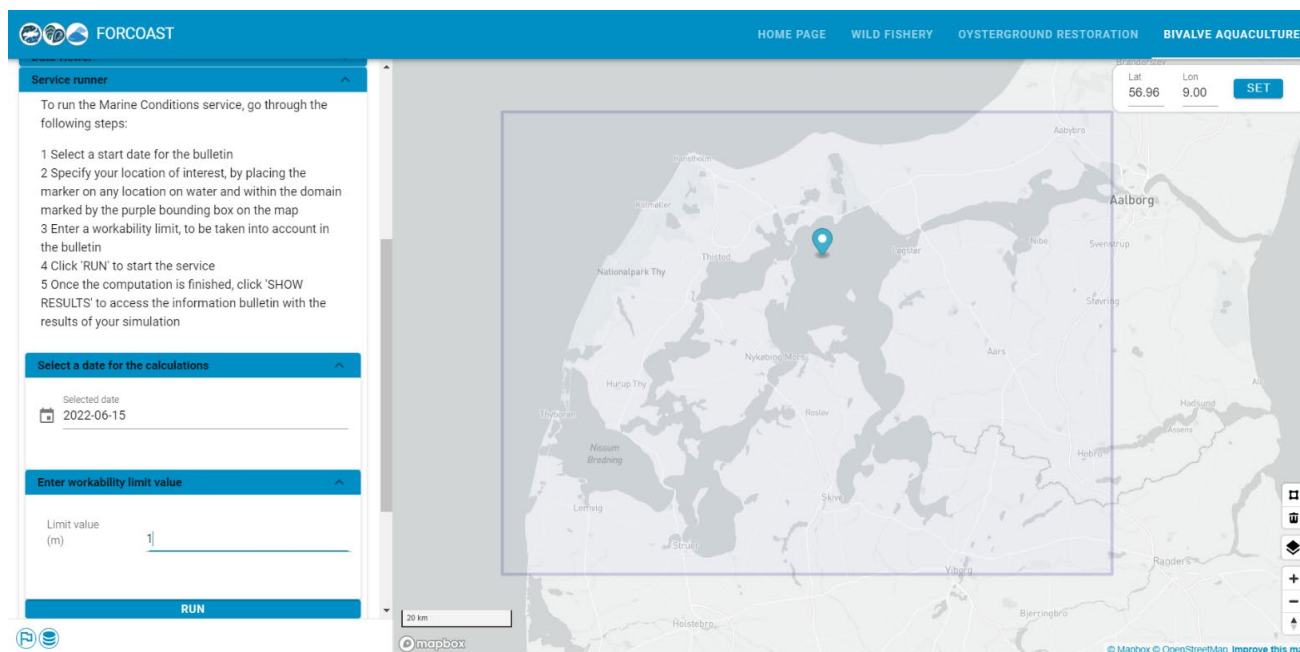


Figure 17: Setting up the date and the location of interest for the service by using the marker

Completing the before-mentioned steps will allow the user to run the service clicking on the “RUN” tab. Figure 18 shows an example run of this service module.

Select a date for the calculations

Selected date

2022-06-15

Enter workability limit value

Limit value (m)

1

RUN

Process status: accepted

Figure 18: Running the A1-Marine Conditions and Scheduler service

Once the run process is completed successfully a new tab will appear below the “RUN” tab called “GET RESULTS” (Figure 19). The user must click on this tab to display the bulletin result of the service.

RUN

Process status: successful

GET RESULTS

Figure 19: Get results tab

Finally, the bulletin results are displayed on the screen (Figure 20). The bulletin can be downloaded by right-clicking on the screen and saving the image locally. Since this bulletin focuses on water level related working environment, the results show 48-hour forecasts of the weather (winds and precipitation) and water level, together with high tide and low tide information, including the times when the water level is lower than the user-specified threshold to perform the desired field operations. It should be noted that currently wind speed has a unit of km/h:  $1 \text{ m/s} = 3.6 \text{ km/h}$ . Information on sunrise and sunset times are also present in the bulletin.



Nearshore farming infrastructures are exposed to land discharges, which in some cases carry harmful substances (e.g. E. coli, pollutants). High-resolution circulation forecasts can be used to assess the likelihood of a farm being affected by material released from potentially harmful sources. This service aims to support quality control, by providing a measure of the probability for farming sites to be affected by harmful land discharge.

Data viewer

Service runner

To run the Land Pollution service, go through the following steps:

- 1 Select a start date for the simulation
- 2 Specify the pollution discharge location, by placing the marker on any location on water and within the domain marked purple on the map
- 3 Draw a rectangle in the map where the area you want to evaluate is (e.g. farm location) by using the drawing tool in the top left part of the map. This should be done on water and within the domain marked by the purple bounding box on the map
- 4 Click 'RUN' to start the service
- 5 Once the computation is finished, click 'SHOW RESULTS' to access the information bulletin with the results of your simulation

Select a date for the calculations

Specify bounding box for target location

RUN

Overview of jobs

Figure 21: Service runner description for the A2-Land Pollution service module

The first step is to indicate a specific day for the service to start the simulation. To select a starting date for the service run, click on corresponding tab and select an appropriate day for running the service. Once this step is fulfilled, the user must place the marker on the web-map display on the potential discharge location as shown in Figure 22 and lock the selected coordinates by clicking on the “SET” tab on the top right of the web-map display. The next step asks from the user to use the polygon tool from the bar on the right-bottom side of the web-map display and draw a polygon around the location of interest (e.g. fish farm) as shown in Figure 16. To draw a polygon, the user must select the polygon tool, then click once on the selected location and move the cursor to generate the polygon around the specified area. In case the user needs to find another location or change the given one, it is first required to select the delete tool from the web-map display bar on the right, delete the former generated polygon and by following the above steps create a new one.

Notice: Both the marker and the polygon, must be placed inside the purple bounding box on top of water locations only.

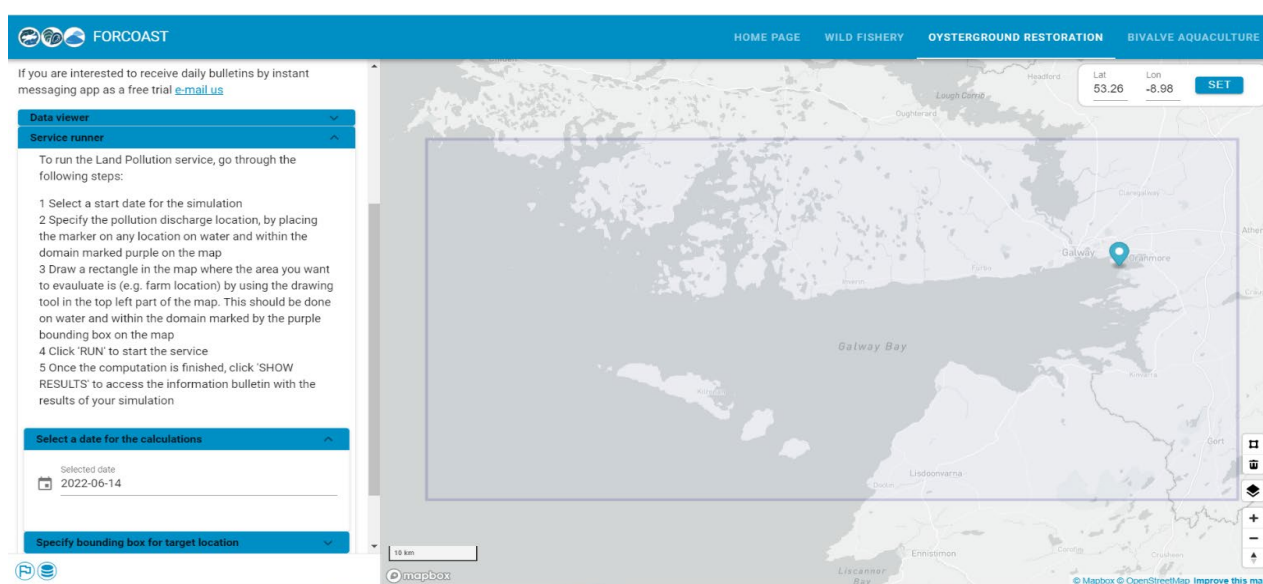


Figure 22: Setting up the date and the specified pollution discharge location by using the marker

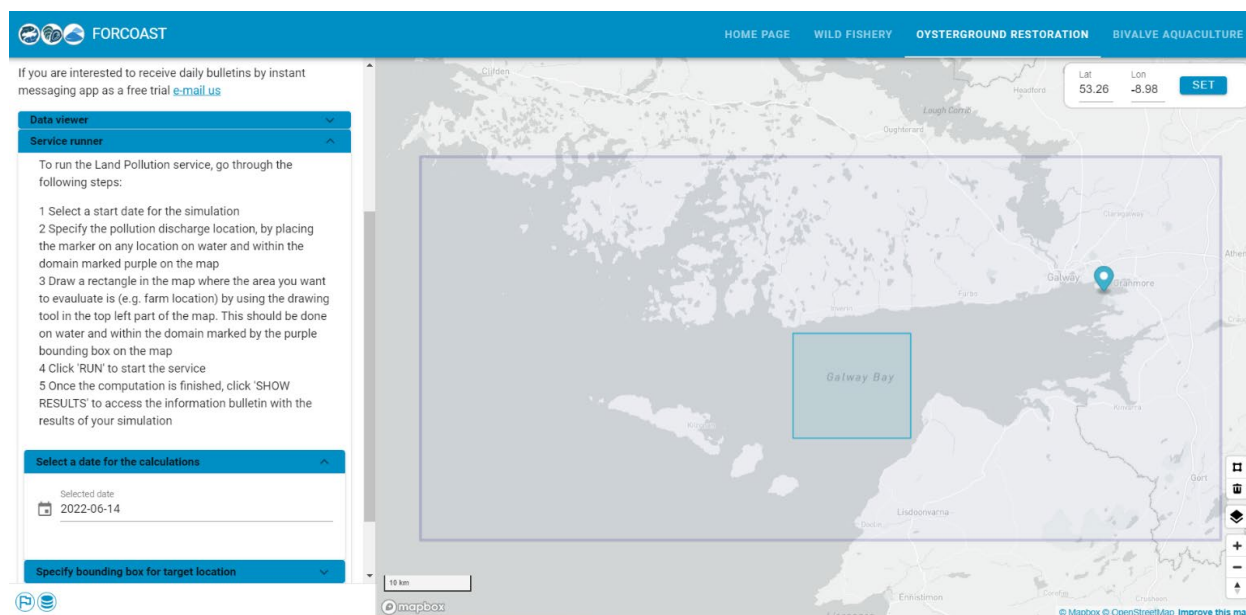


Figure 23: Generation of polygon around the area of interest



Completing the aforementioned steps will allow the user to select the “RUN” tab to start running the service. Figure 24 shows an example run of this service module.

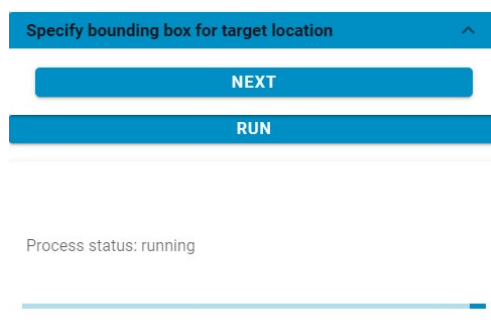


Figure 24: Running the A2-Land Pollution service

Note: due to the significant runtimes of this Service Module, this is preferably run as a scheduled, automated task, in which case the user will receive results when available, rather than needing to wait for this after dispatching a manual run.

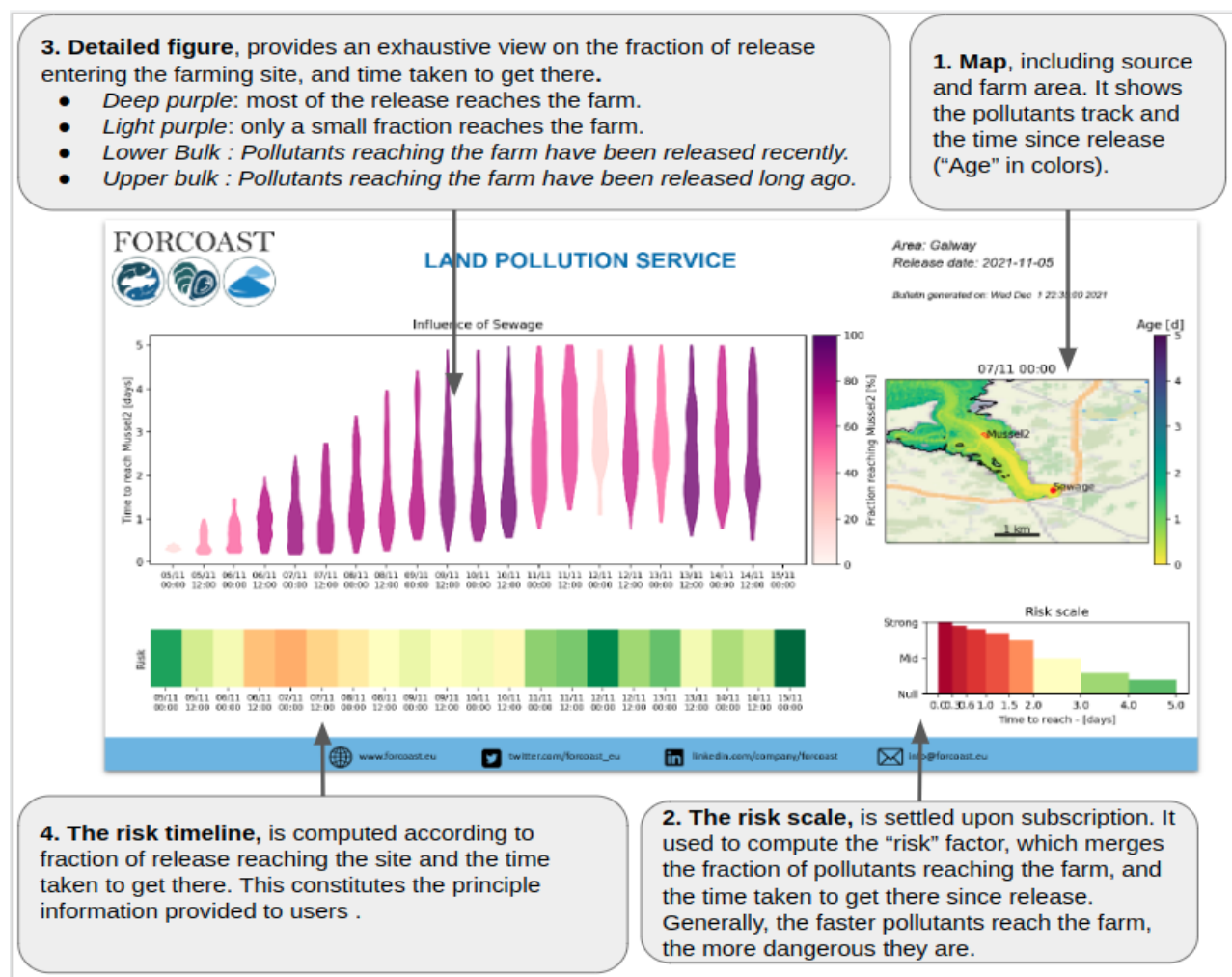


Figure 25: Results of the A2-Land Pollution service

A completed execution of A2, be it triggered manually on the platform or automatically in the case of scheduled executions, ends with the compilation of a synthetic bulletin reporting the results (Fig. 25). Note that an animated

version of the bulletin is also provided. The bulletin contains all the elements intervening in the service's computation :

1. The **map** highlights the pollution source and target farming site defined by the user. In addition, it displays a selected snapshot of the simulation with tracks of the advected particles (i.e., the pollution tracer) and their age (i.e., time elapsed since release). The date of the selected snapshot is that of the 'worst' situation for that run.
2. The **risk scale** is a user-defined relative risk metric, scaling the dangerousness of the pollution for different values of age. For instance, a substance may carry a strong risk if it reaches the farm in less than 6 hours, but only a moderate risk if it has circulated more than two days before reaching the farm.
3. The **detailed figure** provides additional information for the insightful user. In particular, it indicates for each time step (typically, from 5 days before to five days after present-time) what is the fraction of release that reaches the farm (purple color bar), and what is the age distribution for those particles reaching the farm. It may help to decide whether a high-risk index results from a lot of particles reaching the farm, or because of a small amount reaching the farm very quickly.
4. The **risk timeline** is the principal component of the bulletin. It provides a time series of the risk-index, computed based on the user-defined risk scale and the result of the simulated circulation.

It should be stressed that in its present form, the service does not consider real-time discharge data for the pollutant source, nor does it resolve the dynamics of the pollutant itself (i.e., decay of the pollutants, bacterial growth). Those are pieces of information that are difficult to gather automatically. Also, our sole risk assessment is based on 'time since release' which is the best information that can be derived without requesting user knowledge of the pollution's exact nature and discharge rate.

## 2.5. Service Module: A3 – Site Prospection

The purpose of the service module is to identify areas with highest growth potential and lowest mortality for flat oysters, *Ostrea edulis*, and thereby increase harvest and restoration potential. The oyster farmers tend to face challenges with high spat mortality and variable growth depending on environmental conditions. The service module can also be applied to other species, i.e., blue mussels, if the user has knowledge of the species' characteristics.

To run the A3-Site Prospection service the user must follow certain steps, which are also displayed on the left of the screen (Figure 26). In the data viewer, the user can see the background data for a selected period and extract time-series from a chosen location.

Data viewer

Service runner

To run the Site Prospection service, go through the following steps:

- 1 "Basic parameters": enter the year and months of interest, as well as salinity and temperature thresholds
- 2 "Optional parameters": extra variables in case you can provide extra information (the default values are tuned for flat oysters)
- 3 "Area": specify your area of interest using the polygon tool in the lower right of the map. This should be done within the area marked by the purple bounding box

Enter the parameters

Optional parameters

Specify bounding box for target location

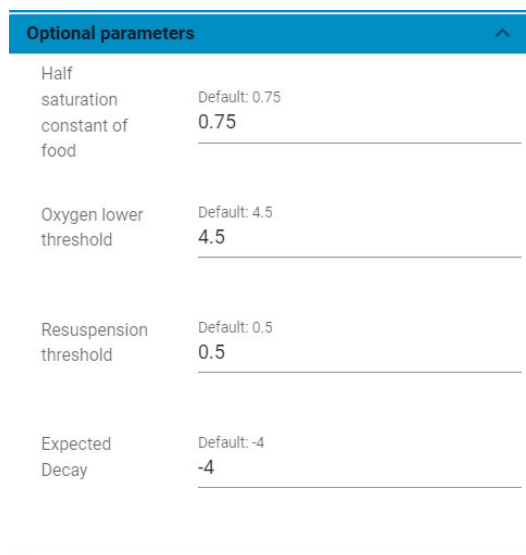
Figure 26: Service runner description for the A3-Site Prospection service

In the service runner, there are two parameter settings tabs. The first one is required to be filled by the user as it refers to the basic input parameters for the service to run (Figure 27). The basic input is the considered months for culturing that can be calculated for different years. Further, the user can define the lower and upper thresholds for salinity and temperature dependencies of the species based on local knowledge or literature data. The second one (Figure 28) refers to optional or advanced parameters in case the user wants to provide more information in relation to the food response, sensitivity to low oxygen levels and the resuspension of sediment that increase the risk for burial.



Enter the parameters		
Enter a start date	February	2010
Enter an end date	March	2012
Salinity thresholds	Lower	Upper
	8	15
Temperature thresholds	Lower	Upper
	8	12

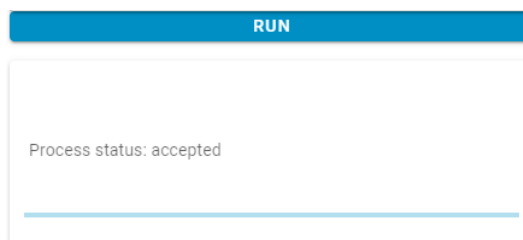
Figure 27: Basic parameters settings tab



Optional parameters	
Half saturation constant of food	Default: 0.75 0.75
Oxygen lower threshold	Default: 4.5 4.5
Resuspension threshold	Default: 0.5 0.5
Expected Decay	Default: -4 -4

Figure 28: Optional/Advanced parameter settings tab

After providing the relevant input, the user can press “RUN” tab to dispatch the job to the FORCOAST back-end.



**RUN**

Process status: accepted



Figure 29: Running the A3-Land Pollution service

The bulletins created show the spatial habitat suitability index (HSI) of flat oysters (or other considered species), indicating the most optimal locations for bottom aquaculture and restoration. The HSI is informed by user-specific provided knowledge of the considered species (e.g. salinity tolerance), DEB modeling (Stechele et al. 2022), and the literature. The obtained HSI is based on the integration of the scoring indices (0 to 1) for each environmental variable for the chosen period by the user. A value of 1 is the best suitable location and value of 0 means not suited

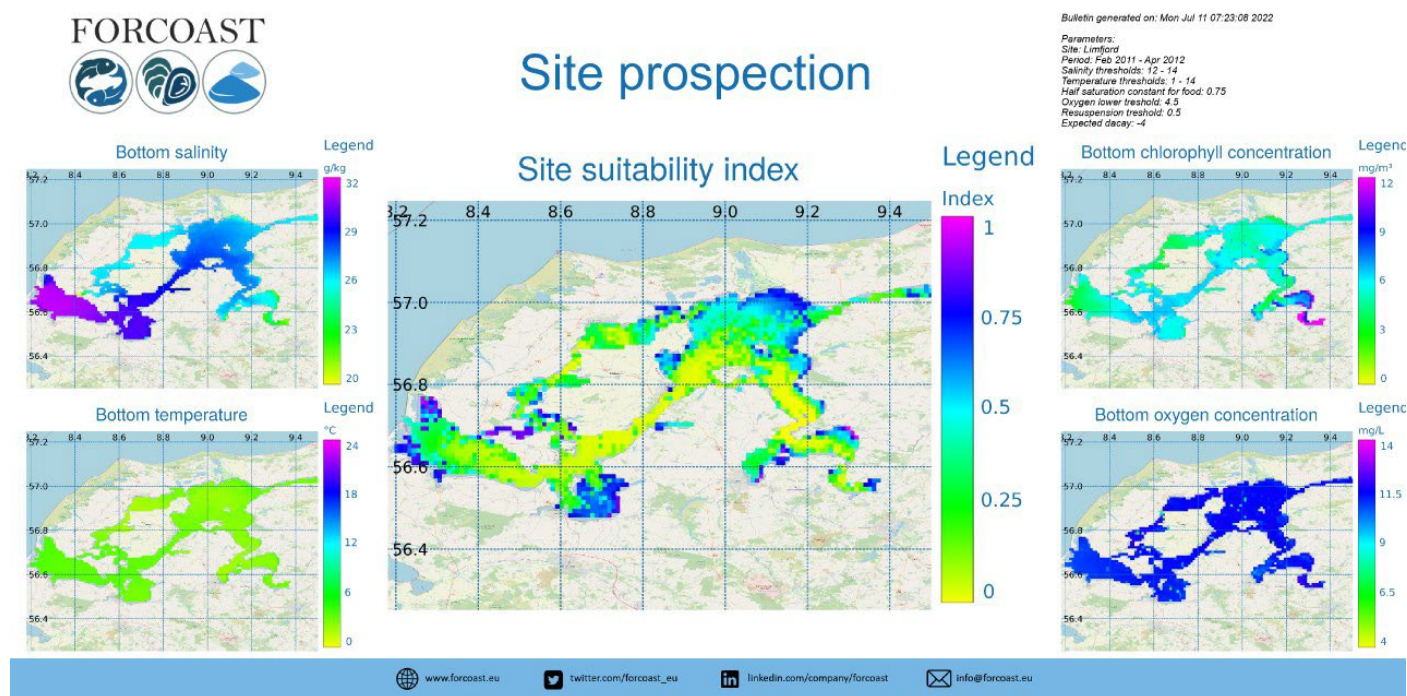


Figure 30: Results of the A3-Site prospection service

## 2.6. Service Module: A4 – Spat Capture Assistance

To run the Spat Capture Assistance service the user must follow certain steps, which are also displayed on the left of the screen (Figure 31)

Data viewer

Service runner

To run the Assistance for Spat Capture service module go through the following steps:

- 1 Select a method to be used: 'Temperature treshold' or 'Cumulative temperature'
- 2 The temperature treshold method requires a temperature treshold for spat spawning
- 3 The cumulative temperature method requires to give a treshold for gonade development and a treshold of cumulative temperature. The cumulative temperature value is the sum of water temperatures since the beginning of the year.
- 4 Select the palegic larval duration. This is time it will take for the spats to drift to the farming location
- 5 Select the duration of the spawning period of the spats

Enter the parameters

Figure 31: Service runner description for the A4-Spat Capture Assistance service module

Note: selection of area or coordinates is not required

The first step is to choose the parameters asked, which includes the method to use for the spawning/release triggering (either based on a temperature threshold or on a cumulative temperature threshold), the temperature threshold or the cumulative temperature threshold of releasing (based on gonad development), and finally the pelagic larval duration. Those parameters will automatically be filled, when the user selects either Oysters or Mussels, but can also be modified manually from the user (Figure 30). When the parameters are filled successfully, the user must click on the “RUN” tab to run the service.

Figure 32: A4-Spat Capture Assistance parameter settings & Run

After “RUN” is pressed. The process status will turn to “accepted” once the back-end accepted the job request. Subsequently, the status will change to “running” one the job is running in the back-end. If the job is unsuccessful, the status will be set to “failed”. Upon successful completion, the job status will be set to “successful” (See Figure 33 for example). Note that it might take a couple of minutes for a run to complete.

Once the service run is completed successfully, the “GET RESULTS” tab will appear, which allows users to display the bulletin result on their screen (Figure 33, Figure 34).

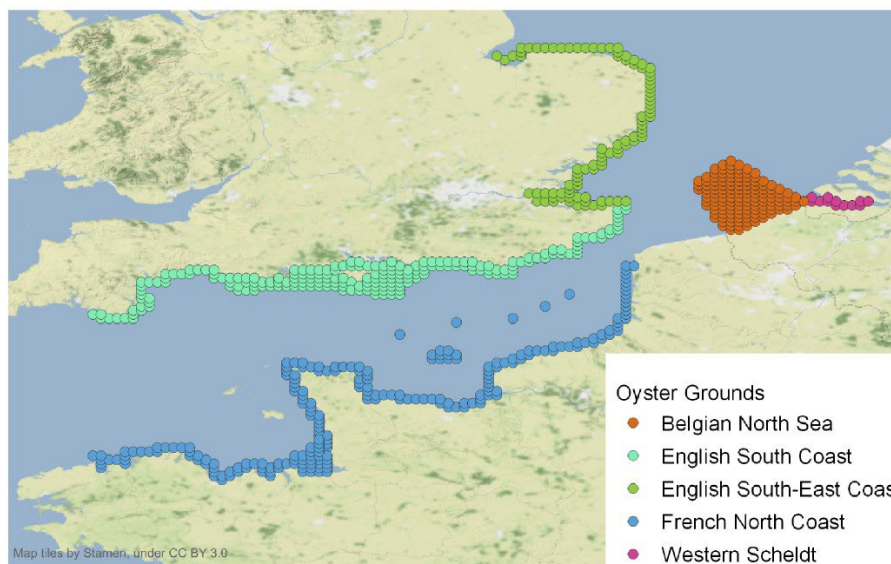
Figure 33: Get results tab after successful run



## Spat Capture Assistance

Bulletin generated on: Mon Jun 20 08:54:20 2022

Parameters:  
 -Site: North-Sea  
 -Method: Temperature threshold  
 -Threshold temperature: 15 °C  
 -Threshold of temperature for gonade development: 7 °C  
 -Threshold of cumulative temperature: 576 °C  
 -Minimal pelagic larval duration of the selected species: 20 days  
 -Maximal pelagic larval duration of the selected species parameter: 30 days  
 -Spawning duration: 30 days



First and last arrivals per Oysterground

Spawning ground	First arrival	Last arrival
Western Scheldt	28-06-22	07-08-22
Belgian North Sea	05-07-22	14-08-22
French North Coast	30-06-22	09-08-22
English South Coast	28-06-22	07-08-22
English South-East Coast	07-07-22	16-08-22

Figure 34: Bulletin result example of the A4-Spat Capture Assistance service module.

The Service Module-A4 indicates the likely period of spat arrival in the collect location and indicates the best period to install collectors. The date of arrival (beginning and end) from each of the source locations are provided as output.

On the Bulletin (Figure 34), the map shows the potential spawning grounds for which each estimated spawning period is specified. The table in the bulletin presents for each of the spawning grounds the period when the spats are likely to arrive at the farm from the beginning of the spat arrival period (first arrival) until the end of spat arrival period (last arrival).

The mention “No spawning event” instead of a date means that there is no foreseen spawning event in the considered spawning ground with the selected parameterization for the rest of the year.

## 2.7. Service Module: R1 - Contaminants Source Retrieval

To run the Contaminants Source Retrieval service the user must follow certain steps, which are also displayed on the left of the screen (Figure 35).

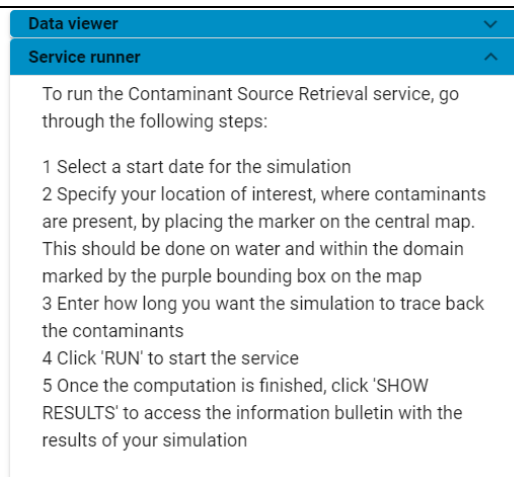


Figure 35: Service runner description for the R1 - Contaminants Source Retrieval

The first step is to indicate a specific day for the service to start the simulation. To select a starting date for the service run, click on corresponding tab and select an appropriate day for running the service. Once this step is fulfilled, the user must place the marker on the web-map display on the potential location, where contaminants are present, as shown in Figure 36 and lock the selected coordinates by clicking on the “SET” tab on the top right of the web-map display. The next step asks from the user to enter a time period for the simulation (1-48 hours).

Notice: The marker, must be placed inside the purple bounding box on top of water locations only.

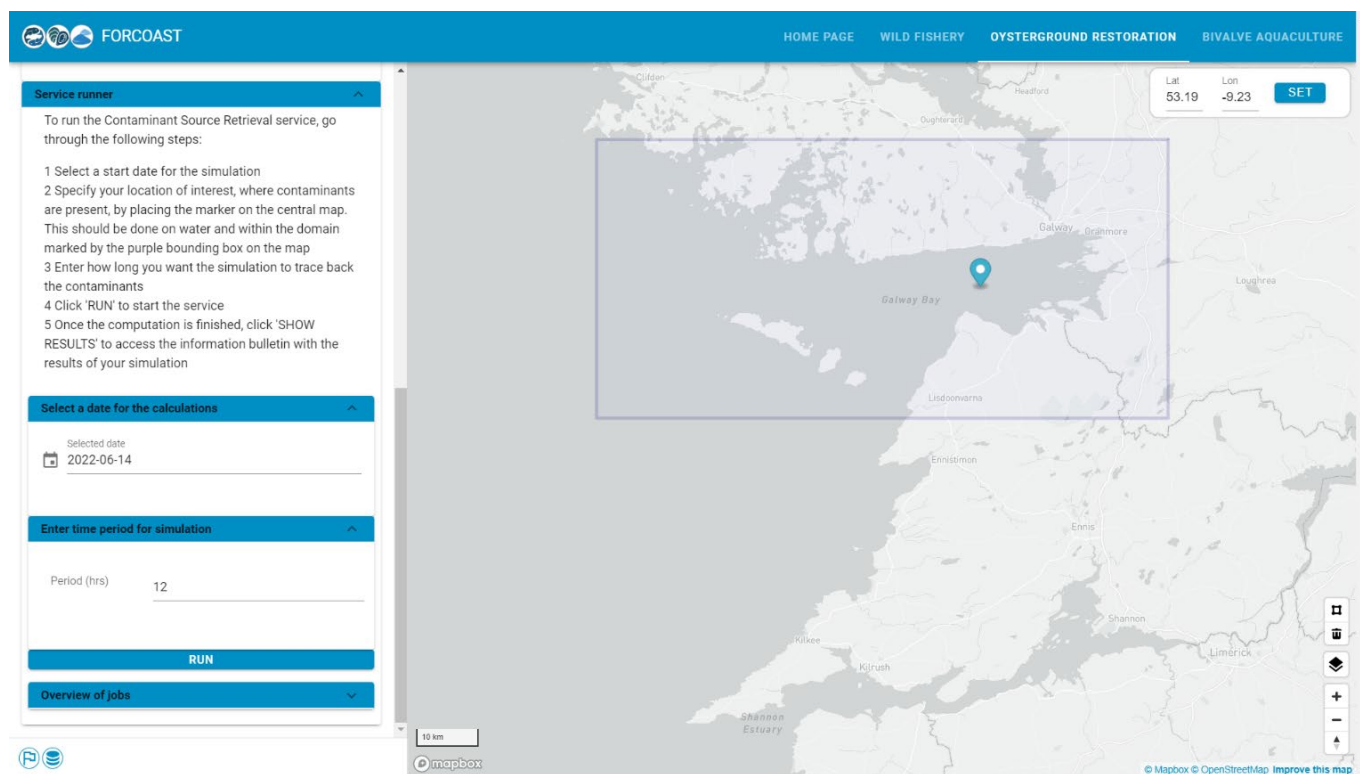


Figure 36: Setting up the date and potential contaminant location by using the marker.

Completing the aforementioned steps will allow the user to run the service clicking on the “RUN” tab. Figure 37 shows an example run of this service module. During the service run, the user can have an overview of the tasks executed in the back end below the tab “Overview of jobs”.



Selected date  
2022-06-14

Enter time period for simulation

Period (hrs) 12

RUN

Process status: running

Figure 37: Running the R1-Contaminants Source Retrieval service

The bulletin generated provides the user with maps showing:

(a) The location of the contamination plume (shown as red bubbles) at the time indicated at the top of the map.

(b) At each site, and at the time indicated at the top of the map, the probability that contaminants can be found at that site. The probability is shown as a color scale, with light yellow colors indicating a lower probability, while dark red colors showing a higher probability. Where no color is shown (i.e., the background map can be seen), it means that the model has determined that that area would not be impacted by the contamination at the indicated time.

(c) A map highlighting the areas where the contaminants would stay for longer periods of time. These regions would typically be semi-enclosed, near-coastal areas with stagnant waters. However, quite often such regions cannot be identified, and thus the corresponding map will not display any meaningful information. This map has the label “Areas where Local Exposure Time longer than [...]”. The Local Exposure Time is the time that, on average, the contaminants spend at each site. The overall maximum Local Exposure Time is then determined across the whole region, and the map in the bulletin will highlight only those areas where the Local Exposure Time is 75% above that maximum.

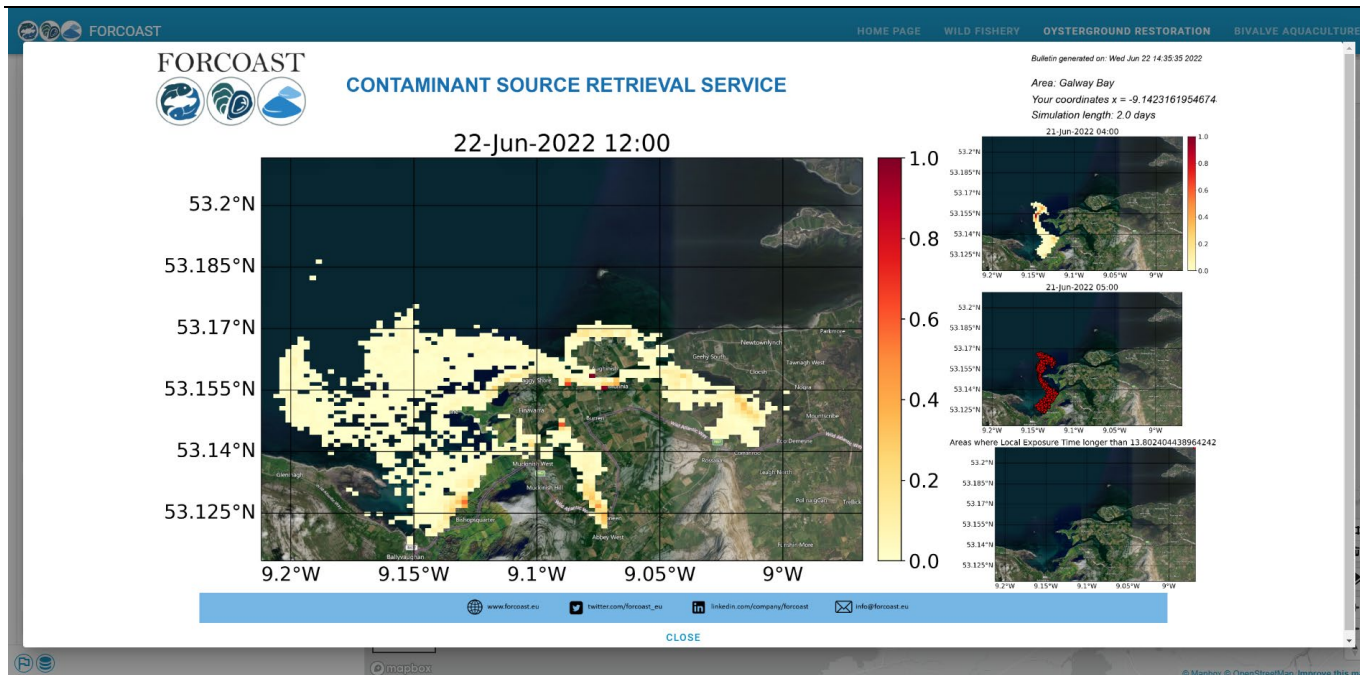


Figure 38: Results of the R1-Contaminants Source Retrieval service

### 3 Data availability and data product description

The FORCOAST service modules are dependent on input data generated by the FORCOAST pilots (users of the system at pilot level) and open data provided from CMEMS. To check whether relevant data sources are up-to-date, data monitoring bulletins are created. These can be accessed from the database icon in the lower left (Figure 39).



Figure 39: access data monitoring bulletin

The bulletin accessed this way is presently updated every 12 hours and shows whether the data sources listed are up-to-date or delayed (Figure 40).



Pilot	Source	Layers	TinyURL	Response code	Last available date	Date status	Status
1. Sado Estuary	MARETEC THREDDS	(YYYYmdd)00_Surface.nc:ssh	tinyurl.com/2tft8eje	Success (200)	22-06-21:02:00:00	Up-to-date < 96h	✓
1. Sado Estuary	MARETEC THREDDS	(YYYYmdd)00.nc:wind_speed	tinyurl.com/29pvpb5x	Success (200)	22-06-21:02:00:00	Up-to-date < 96h	✓
2. Bay of Biscay	EuskOOS THREDDS	(YYYYmdd)_fronts_exp.nc:sst	tinyurl.com/SenJ2szh	Success (200)	22-06-23:02:00:00	Up-to-date < 96h	✓
2. Bay of Biscay	Geoserver	forcoast:biscay_sst	tinyurl.com/FORCOAST	Success (200)	22-06-21:23:00:00	Up-to-date < 96h	✓
2. Bay of Biscay	Geoserver	forcoast:biscay_fronts_sst	tinyurl.com/FORCOAST	Success (200)	22-06-21:23:00:00	Up-to-date < 96h	✓
3. Black Sea BG	Geoserver	forcoast:pilot_3_CMEMS_sst	tinyurl.com/FORCOAST	Success (200)	22-06-30:00:00:00	Up-to-date < 96h	✓
3. Black Sea BG	Geoserver	forcoast:HSI_whiting	tinyurl.com/FORCOAST	Success (200)	22-06-11:00:00:00	Outdated > 96h	⊘
4. North Sea	RBINS ERDDAP	NOS_HydroState_V1.nc:sst	tinyurl.com/3hfeuj2n	Success (200)	22-06-24:02:00:00	Up-to-date < 96h	✓
5. Galway Bay	Marine Institute THREDDS	galway_bay_(YYYYmdd)HHI_AN.nc:?	tinyurl.com/22e8936j	Success (200)	22-06-13:02:00:00	Outdated > 96h	⊘
5. Galway Bay	Marine Institute THREDDS	IMI_ROMS_HYDRO/GALWAY_BAY_NATIVE_70M_8L_1H_forecast	null	Success (200)	22-06-22:02:00:00	Up-to-date < 96h	✓
6. Limfjord	DMI FTP via Geoserver	forcoast:dk_elev	tinyurl.com/FORCOAST	Success (200)	22-06-26:00:00:00	Up-to-date < 24h	✓
6. Limfjord	DMI FTP via Geoserver	forcoast:dk_salt	tinyurl.com/FORCOAST	Success (200)	22-06-26:00:00:00	Up-to-date < 24h	✓
6. Limfjord	DMI FTP via Geoserver	forcoast:dk_temp	tinyurl.com/FORCOAST	Success (200)	22-06-26:00:00:00	Up-to-date < 24h	✓
6. Limfjord	DMI FTP via Geoserver	forcoast:dk_currentspeed	tinyurl.com/FORCOAST	Success (200)	22-06-26:00:00:00	Up-to-date < 24h	✓
6. Limfjord	DMI FTP via Geoserver	forcoast:dk_windspeed	tinyurl.com/FORCOAST	Success (200)	22-06-26:00:00:00	Up-to-date < 24h	✓
7. Black Sea RO	SEAMOD THREDDS	2_EFORIE_grid_T	null	Success (200)	22-06-24:02:00:00	Up-to-date < 96h	✓
7. Black Sea RO	SEAMOD THREDDS	1_NWS_grid_T	null	Success (200)	22-06-24:02:00:00	Up-to-date < 96h	✓
7. Black Sea RO	SEAMOD THREDDS	BS_1h_grid_T	null	Success (200)	22-06-24:02:00:00	Up-to-date < 96h	✓
8. Northern Adriatic	Geoserver via OGS	forcoast:northernadriatic_thetao	tinyurl.com/FORCOAST	Success (200)	13-01-01:00:00:00	Up-to-date < 96h	✓
8. Northern Adriatic	Geoserver	forcoast:northernadriatic_fronts_sst	tinyurl.com/FORCOAST	Success (200)	22-06-21:23:00:00	Up-to-date < 96h	✓
8. Northern Adriatic	OGS THREDDS	chl	null	Success (200)	22-06-23:23:00:00	Up-to-date < 96h	✓
8. Northern Adriatic	OGS THREDDS	o2	null	Success (200)	22-06-23:23:00:00	Up-to-date < 96h	✓
Multiple pilots	CMEMS THREDDS	CHL	null	Success (200)	22-06-20:00:00:00	Up-to-date < 96h	✓
Multiple pilots	CMEMS THREDDS	analysed_sst	null	Success (200)	22-01-01:00:00:00	Outdated > 96h	⊘

Figure 40: data monitoring bulletin, showing whether relevant input datasets are up to date

All products provided by the SMs are described by “FORCOAST Technical Specifications V1.0” accessible from [https://docs.google.com/spreadsheets/d/16nEHZE52fcszCqJHlo2PIDAXZwqo4BtzxJ1\\_rCIHvw/edit#gid=462035942](https://docs.google.com/spreadsheets/d/16nEHZE52fcszCqJHlo2PIDAXZwqo4BtzxJ1_rCIHvw/edit#gid=462035942)

#### 3.1 SM-F1 Suitable fishing areas

The input data for this service module are obtained from CMEMS for a period of 3 years. The variables, spatial and temporal resolutions are given in Table 1. One can find more information from CMEMS website <https://resources.marine.copernicus.eu/products>. The remote sensing products are generated by CMEMS SST TAC and OC TAC while the model products are generated by BS MFC (Table 1). These data are used to calculate fishery resource index HSI.

Table 1 Data products used in SM-F1

Data type	Input variable (use nc standard names)	Hindcast Period	Timestep	Spatial resolution
Model	sea_water_salinity	3 years	1 d	3km

Remote Sensing	mass_concentration_of_chlorophyll_a_in_sea_water	3 years	1 d	1km
Remote Sensing	sea_surface_temperature	3 years	1 d	0.05degree
Model	sea_surface_wave_height	3 yesrs	1h	3km
Model	sea_surface_wave_mean_period	3 years	1h	3km
Model	Wave drift East	3 years	1h	3km
Model	Wave drift north	3 years	1h	3km
Model	sea_water_temperature	3 years	1 d	3km
Model	Sea_surface_height_above geoid	3 years	1 d	3km
Model	eastward_sea_water_velocity	3 years	1 d	3km
Model	northward_sea_water_velocity	3 years	1 d	3km

### 3.2 SM-F2 Front detection

The objective of the Front detection service module is to provide information about the location and extension of the main temperature fronts within the sea surface. Frontal areas are those where there is a sharp gradient in the properties of the seawater and since there is a high biological activity in such areas, as commercial fish species, front detection together with other ocean information is useful in fisheries to search fishing grounds. Sea fronts can be identified from remote sensing and or model imagery, since the fishing sector needs more processed data to make fast decisions, this Service Module has been designed for a fast identification of frontal areas. Thus, this service module provides information about areas that could be useful for locating fishing grounds, in a user-friendly way.

This service was developed for Pilot 2 and for being applied to the outputs of the CROCO (Coastal and Regional Ocean Community model, <https://www.croco-ocean.org>) the numerical modelling tool. This model is based on a new non-hydrostatic and non-Boussinesq solver, developed within the former ROMS kernel. CROCO is an extension of ROMS from which it inherited the robustness and efficiency of its time-splitting implementation, the accuracy of high-order methods, including its pressure gradient scheme for terrain-following coordinates, and computing performances. The CROCO domain used in EusKOOS covers the southeastern Bay of Biscay, extending from 43.24° N to 44° N and from 3.4° W to 1.3° W, with a mean horizontal resolution of approximately 670 m. Vertically, the water column is divided into 32 sigma-coordinate levels. These levels are more concentrated within the surface waters, where most of the ocean variability occurs. The present CROCO configuration provides 96-hour forecasts of the sea conditions (i.e. temperature, salinity, sea surface height and ocean currents).

Nevertheless, this service module could be applied to the other wild fisheries pilot within the FORCOAT consortium, i.e. the Bulgarian Pilot, together with other marine sectors. The front detection algorithm is applied usually to sea surface temperature and sea surface chlorophyll concentration maps (remote sensing or model data), but it could be applied to other variables (e.g., salinity).

General information on the input data for service module F2 is displayed in Table 2. The remote sensing data are obtained from CMEMS SST TAC and OC TAC. The spatiotemporal resolution of the remote sensing data is the same as used in SM-F1 (Table 1).



Table 2 Data products used in SM-F2

Data type	Input variable (use nc standard names)
Model	sea_water_temperature
Model	sea_water_temperature_fronts
Model	sea_surface_height_above_geoid
Model	sea_water_salinity
Model	northward_sea_water_velocity
Model	eastward_sea_water_velocity
Remote sensing	mass_concentration_of_chlorophyll_a_in_sea_water
Remote sensing	Sea surface temperature

### 3.3 SM-A1 Marine conditions

This service module provides service for two areas: Limfjorden in Denmark and Portugal coast.

#### 3.3.1 Products in Limfjord

The product used in Limfjord is produced by the Danish Meteorological Institute (DMI). The product is the physical forecast for the Limfjorden using the hydrodynamic model HIROMB-BOOS model (HBM). The product variables are hourly and include sea surface height, water salinity, water temperature and horizontal current components. The geographical coverage of the data is 8.13°E - 10.32 °E ; 56.46°N - 57.11 °N. 8.13°E - 10.32 °E ; 56.46°N - 57.11 °N. The data archive holds 7 days of data in the past and 5 days for forecast, with hourly instantaneous values. The forecast is updated twice a day at 01:00 and 13:00 (UTC). The horizontal resolution is about 185 m, on a regular latitudinal-longitudinal grid, with 22 vertical layers. The data are delivered in the format of Netcdf CF4.0.

The circulation model used is HBM, a two-way nested operational hydrodynamic model used at DMI (Danish Meteorological Institute) since 2000 (She et al., 2007; Berg and Poulsen, 2012; Murawski et al., 2021; Frishfeld et al. 2021).

The HBM model has a single domain that covers Limfjord: longitude 8.13-10.32 °E, 56.46-57.11 °N in the regular longitude and latitude grid. Wet boundary conditions at west are derived from CMEMS product NORTHWESTSHELF\_ANALYSIS\_FORECAST\_PHY\_004\_013 (updated once daily) with hourly instantaneous values for salinity and temperature, and 15 min. data for sea surface height. Wet boundary conditions at east are derived from CMEMS product BALTICSEA\_ANALYSISFORECAST\_PHY\_003\_006 (updated twice daily) with hourly instantaneous temperature and salinity and 15 minute data for sea surface height. Meteorological forcing is provided by the DMI HARMONIE model with approximately 2.5 km horizontal resolution. It is updated 4 times per day. The forecast cycle starts either from 0 or 12 hour (UTC) of the day. Model run starts from time ~1.5 days back taking into account updates of CMEMS boundary forecasts. Each forecast is 132 hours long.

The horizontal grid step is regular in latitude and longitude and the resolution is about 1/10 nautical miles (lat: 1/600 degrees; lon: 1/360 degrees). The grid is a staggered Arakawa C-grid. The dataset of the scalar variables are centered in the T point of the grid; at the grid cell node. The velocity components in the corresponding physical reanalysis are located half-way between adjacent grid cell nodes on the face of the grid cell in the respective direction. That is, the components of the velocity vector (u, v) have spatially staggered locations.

### 3.3.1 Products for Portugal coast

The products in Portugal coast are delivered 2019 onwards from a local hydrodynamic model. The data interval is 3 hour and spatial resolution is 200 m. The parameters used in the service module include sea level, wind velocity, air temperature at mean sea level and precipitation.

### 3.4 SM-A2 Land pollution

The data products used in SM-A2 include water level, water temperature and salinity, sea water velocity, both horizontal and vertical, ocean vertical heat diffusivity, significant wave height, mean wave period, and sea surface wave Stokes drift velocity. In Bay of Galway, the data consist of a 3 day forecast and 10 day hindcast. The hydrodynamic data are produced by using a ROMS ocean model, with a horizontal resolution of 200 m.

### 3.5 SM-A3 Prospection for new sites

The purpose of the service module is to identify areas with highest growth potential and lowest mortality for flat oysters, *Ostrea edulis*, and thereby increase harvest and restoration potential. The oyster farmers tend to face challenges with high spat mortality and variable growth depending on environmental conditions. The service module provides a spatial habitat suitability index (HSI) of flat oysters based on user-specific information for the considered species, literature values, and spatial environmental data. This information can be used in the future planning of new sites for aquaculture for farmers and managers. The module can be extended to include other commercial benthic species, e.g. blue mussels, and other areas with similar data and needs.

#### 3.5.1 Set-up requirements

The service module contains maps of monthly means and variability (Standard deviations) of selected environmental variables important for oyster growth and survival (temperature, salinity, chl a, hypoxia, resuspension of particulate organic matter (POM)). These variables were identified by potential end-users as the most important factors for oyster growth. The environmental variables are obtained mostly from hind-casts of ecological model data, but some (e.g. temperature, POM) can be provided by remote sensing data. The data is used to create a spatial habitat suitability index (HSI) of flat oysters based on user-specific information for the considered species. The user can change the default values based on their local knowledge of the considered species. Data layers and algorithms can be improved with updates and new years can be added over time.

The environmental data behind the service module for the Limfjord case is generated by the 3D FlexSem model consisting of a hydrodynamic model coupled to the biogeochemical model ERGOM (Larsen et al. 2020, Maar et al. 2020, Pastor et al. 2021). The model receives open initial and boundary conditions from the regional HBM model (Murawski et al. 2021). Data is provided as monthly means from 2009 to 2017 on an unstructured grid with a resolution from 145 m to 1 km (Schourup-Kristensen et al. 2021). However, the data is interpolated to raster data with 200 m resolution because the Forcoast platform can only handle structured data. The products are stored using the NetCDF format. The validation of the physical model has been published (Schourup-Kristensen et al. 2021) and the ERGOM model is validated in D5.4 and a submitted manuscript.

#### 3.5.2 Description of the bulletin

Firstly, the user must provide some information about the environmental thresholds of the considered species. The thresholds are used to calculate scoring indices from 0 to 1 for each environmental variable.

Table 3 Overview of the needed user defined inputs, suggested ranges and default values

Variables	User inputs	Range	Default values

<b>Species name</b>	Latin name	<i>Ostrea edulis</i>	<i>Ostrea edulis</i>
<b>Period</b>	Months, years	Months 1-12, years 2009 to 2017	Months 5 to 9 2009
<b>Temperature tolerance</b>	Lower temp Upper temp	0°C to 10°C 10°C to 35°C	5°C 26°C
<b>Salinity tolerance</b>	Lower threshold Upper threshold	8 psu 36 psu	16 psu 28 psu
<b>Food requirements</b>	Half-saturation coefficient	0 to 100 µg-C/l	30 µg-C/l
<b>Hypoxia tolerance</b>	Critical oxygen threshold	From 0 to 10 mg-O <sub>2</sub> /l	4.5 mg-O <sub>2</sub> /l
<b>Resuspension of sediments</b>	Critical bottom stress threshold	0-2 g-POM/m <sup>2</sup> /d	0.50 g-POM/m <sup>2</sup> /d

#### Input required from users:

When starting the service module, the user is prompted for several questions (Q) related to the species, period and knowledge of the species environmental tolerances and preferences.

**Species:** Name of the species? (drop-down menu). Used to set the default values for each species. Currently, only *Ostrea edulis* is considered.

**Months:** choose the months to be used in the calculations (drop-down menu). Oyster growth is mainly occurring from May to September. Default values are months 5 to 9.

**Temperature tolerance:** Oyster growth increases with temperature, but too high temperatures (heat waves) may hamper growth. The user must define the temperature thresholds for growth based on the known physiology of the species. Default settings can be applied.

Q1: What is the temperature lower threshold (°C) for growth? Default value is 5°C.

Q2: What is the temperature upper threshold (°C) for growth? Default value is 28°C.

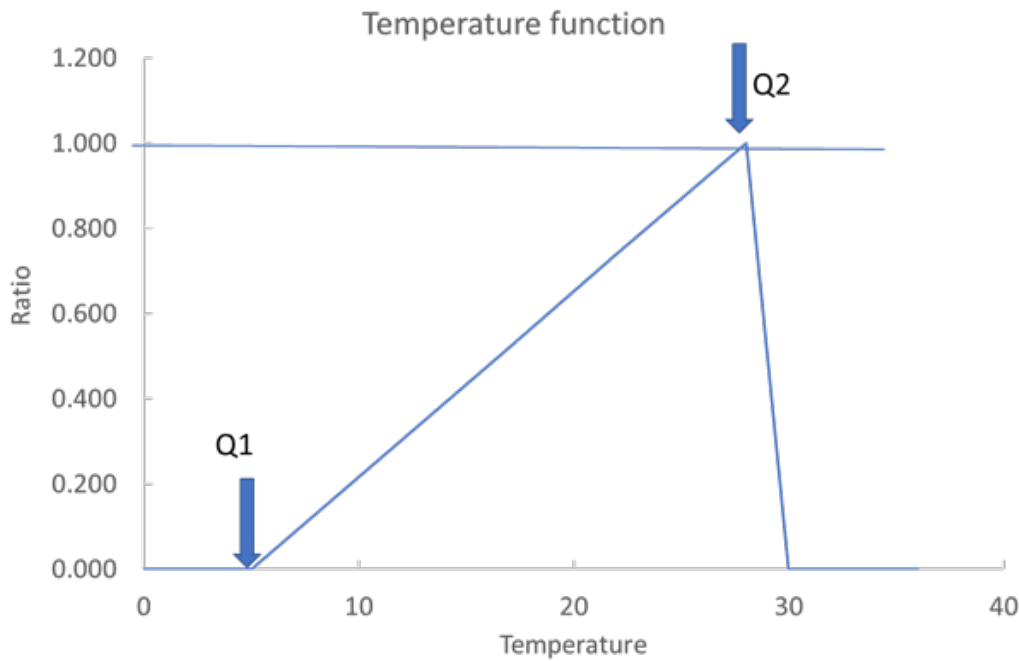


Figure 41 Temperature index function with lower and upper thresholds (see Q1 and Q2)

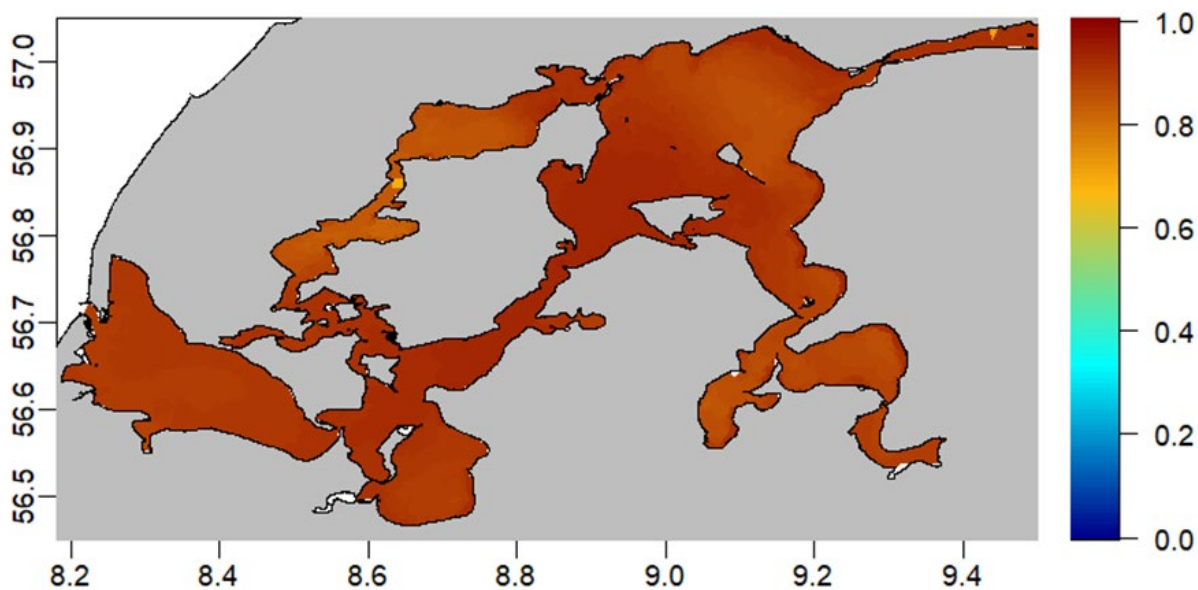


Figure 42 Temperature scoring index from May to September

**Salinity tolerance:** Many species are sensitive to changes in salinity that can affect growth rates and mortality. The user must define the salinity thresholds for growth based on the known physiology of the species (Hutchinson et al. 1992). Default settings can be applied.

Q3: What is the lower salinity threshold from where the species starts to grow and survive? Default value is 15 psu.

Q4: What is the upper salinity threshold (if any) from where growth declines? Default value is 36 psu.

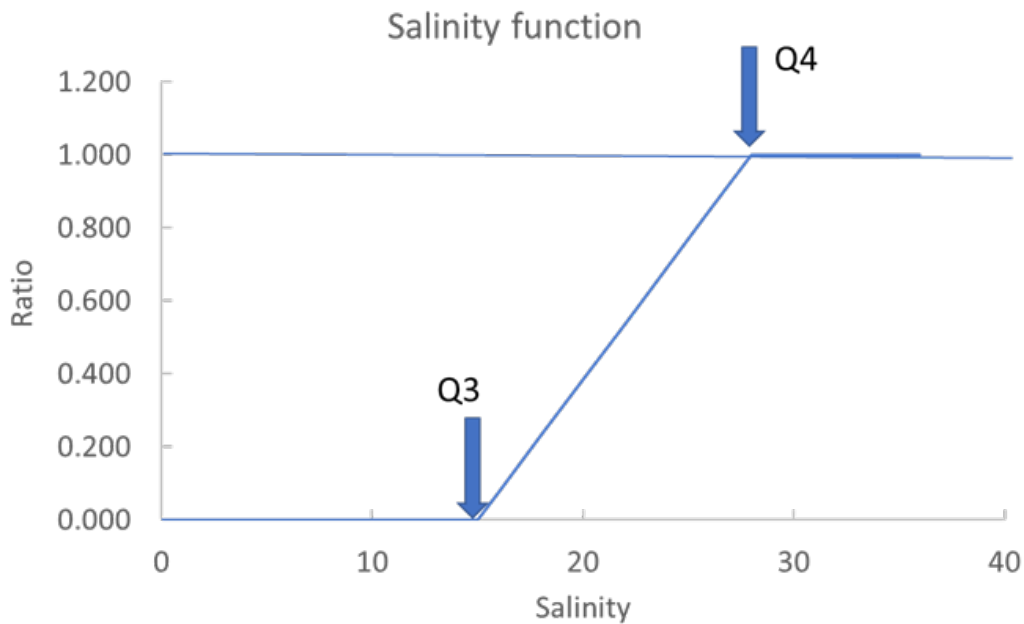


Figure 43 Salinity index function with lower and upper thresholds (see Q3-Q4)

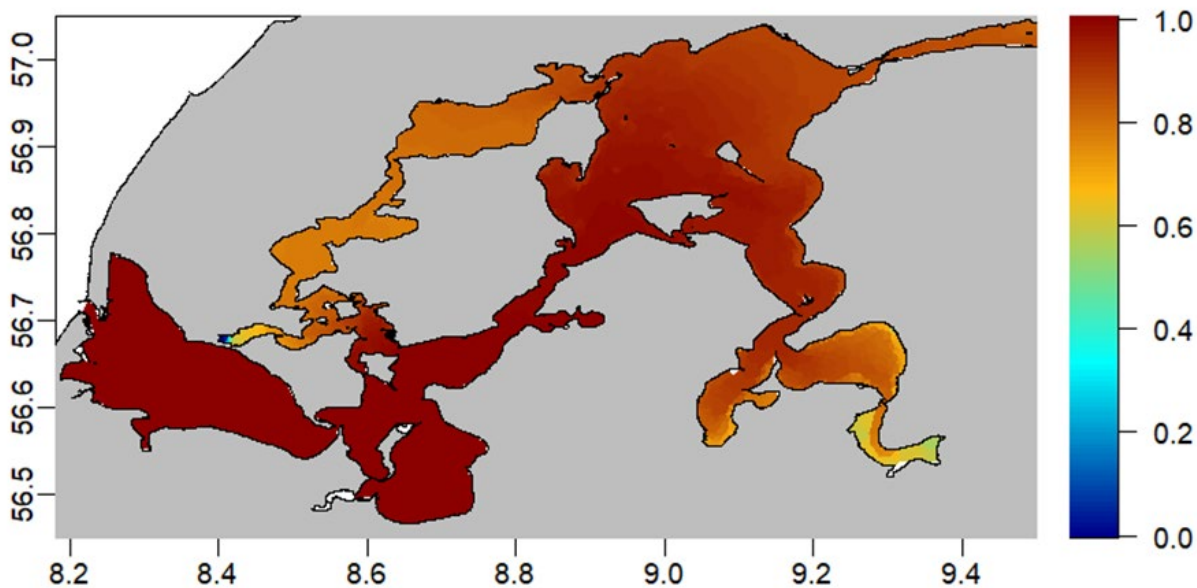


Figure 44 Salinity scoring index from May to September

**Food level index:** High food concentration is important for optimal growth; too low food levels can impose starvation and death. The user can set the half-saturation coefficient of the food response based on the known physiology of the species. Default settings can be applied. Applied conversion factor is 40 mg-C/mg-Chla.

Q5: What is the food half-saturation constant measured as  $\mu\text{g-C/l}$ ? Default value is 30  $\mu\text{g-C/l}$ .

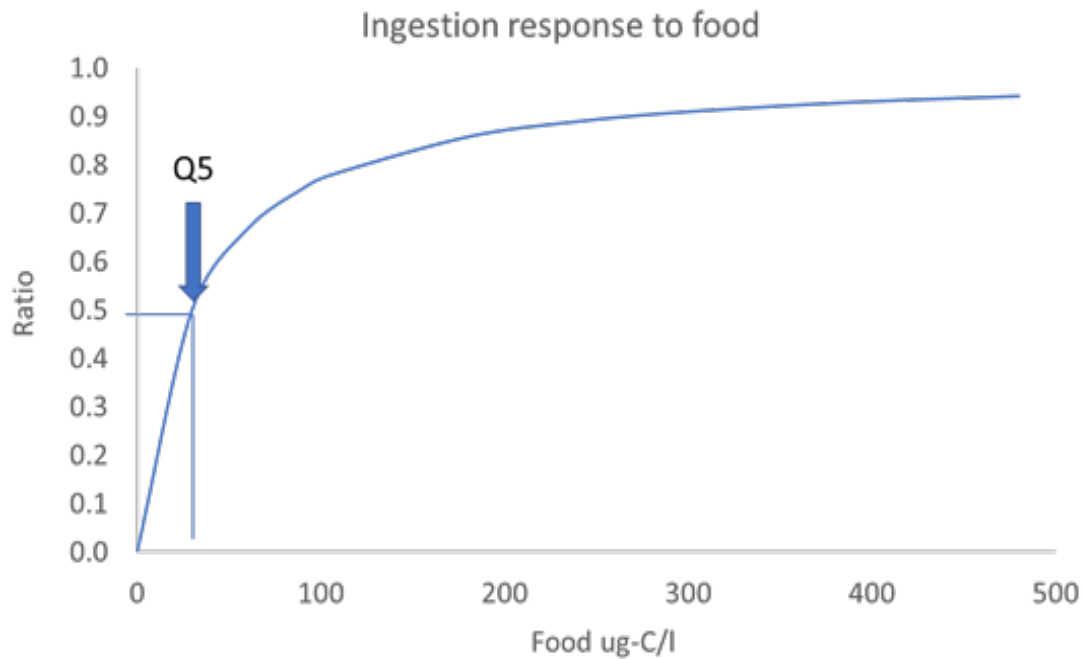


Figure 45 Food function with half-saturation constant (see Q5)

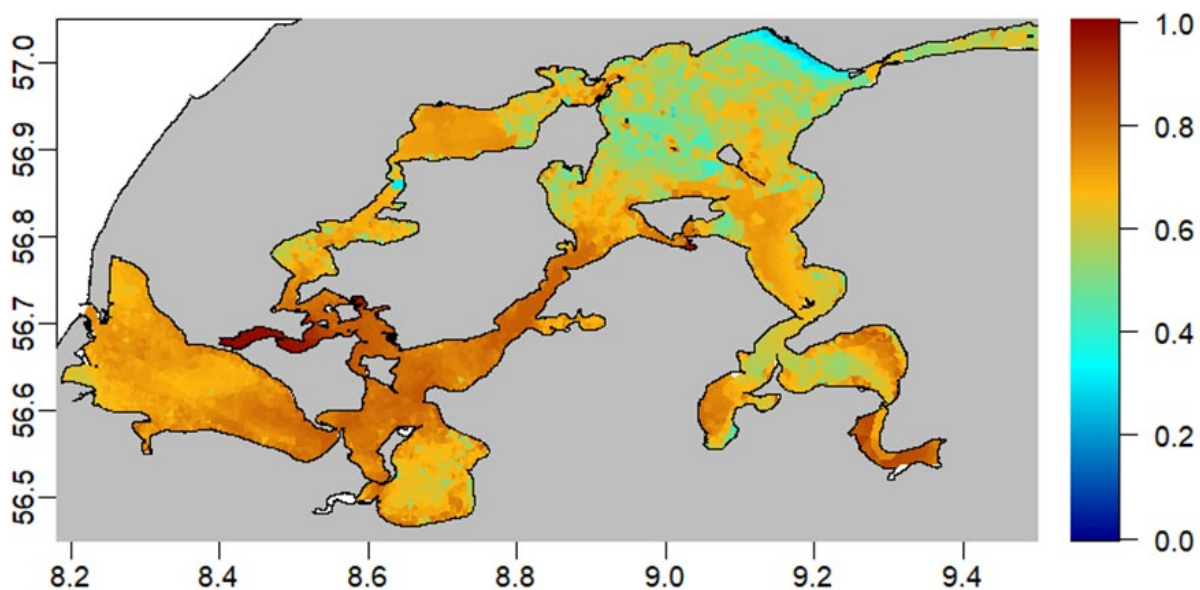


Figure 46 Food function scoring index from May to September

**Hypoxia:** Hypoxia occurs when the bottom oxygen drops to very low values (<4 mg/L). Species have different sensitivity to hypoxia. The oxygen sensitivity threshold can be defined by the user. Default settings can be applied.

Q6: What is the hypoxia critical tolerance threshold (mg/l) for reduced growth and mortality? Default value is 4.5 mg/l.



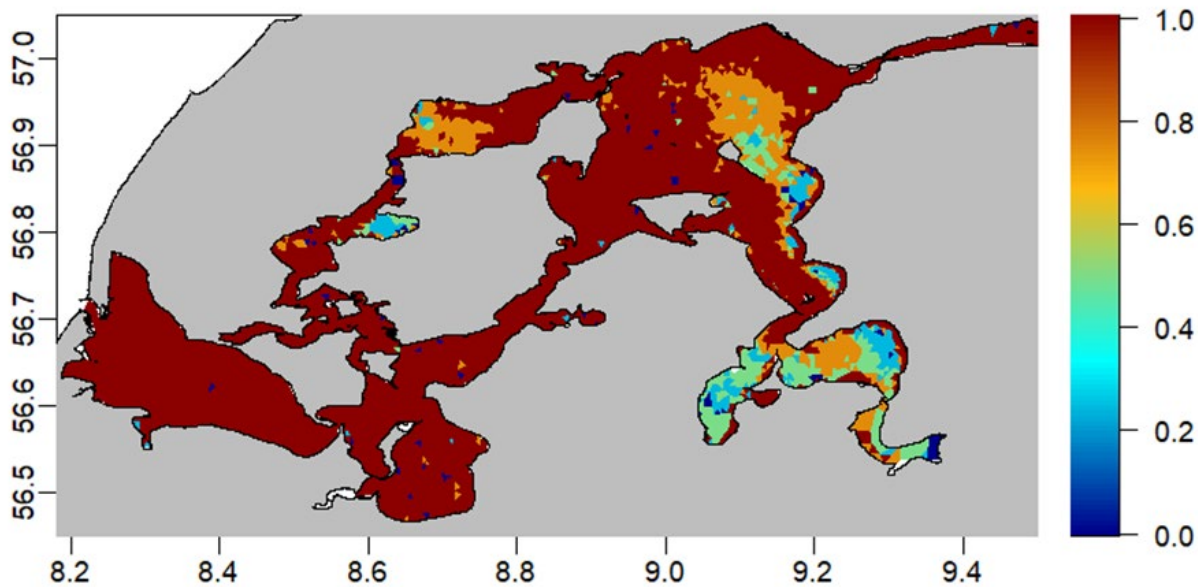


Figure 47 Hypoxia scoring index May to September

**Resuspension:** Turbulent kinetic energy, or bottom stress, is important for the resuspension of sediment POM. High resuspension of POM can cover and bury shellfish in sediment material. The user can define a critical threshold for bottom resuspension from where the oysters are negatively affected. Default settings can be applied.

Q7: What is the resuspension critical threshold for negative effects on shellfish growth? Default value is 0.5 g-POM/m<sup>2</sup>/d.

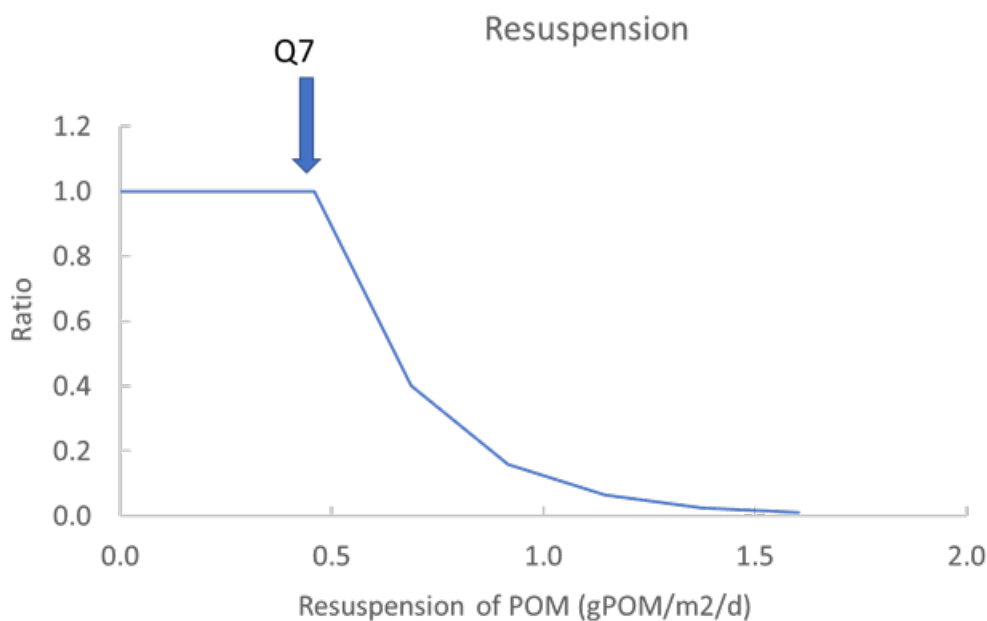


Figure 48 Resuspension function with a critical threshold (see Q7)

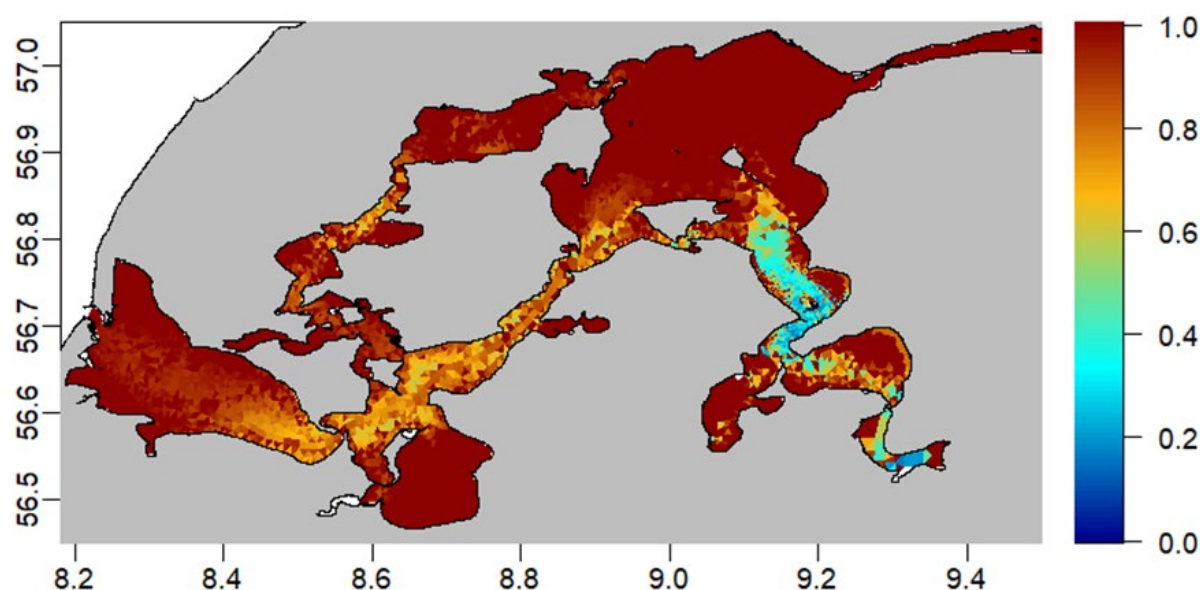


Figure 49 Resuspension scoring index from May to September

The default values for the oyster environmental thresholds in Table 3 are based on an eco-physiological modeling using a Dynamic Energy Budget model with input from literature values and lab measurements (Stechele et al. 2022). These physiological responses were used to define the default values and calculate each scoring index from 0 to 1 (See section 2). However, the user can define other thresholds based on local knowledge. The individual scores are multiplied and thereby combined into an overall scoring. Finally, the scoring is normalized by the maximum value to cover the full range from 0 to 1 in the resultant habitat suitability index.

A value of 0-0.25 means unsuitable for bivalve farming, 0.25-0.50 means less suitable, 0.5-0.75 means medium suitable and 0.75-1 means suitable (Table 4). If an area is not suitable regarding one parameter, the area remains unsuitable regardless of the values of the other parameters within the same month.

Table 4 The overall habitat suitability scores applied from von Thenen et al. (2020)

Combined values	Classification
0 – 0.25	Unsuitable
>0.25-0.5	Less suitable
>0.5-0.75	Medium suitable
>0.75-1	Suitable

The service generates different maps (environmental values and calculated scoring indices) as monthly means or standard deviations for selected months and years. Further, time-series can be extracted from monitoring stations. The HSI is calculated by the service module based on the scoring indices for each variable (Figure 10). The HSI shows the most optimal locations for bottom aquaculture and restoration. A value of 1 is the best location and value of 0



means not suited. There was a good agreement between the HSI and the observed distribution of oysters (Figure 11). The observed distribution was very patchy and varied between years, but oysters were generally found in the suitable areas predicted by the HSI. The HSI showed that oysters should be able to grow in more areas than where they were observed. Hence, there may be other factors limiting their distribution e.g. larvae spreading and successful settling, predation, migratory behavior, and competition for space with Pacific oyster and blue mussels. The variability across years can be used to assess the robustness of local areas to climatic changes.

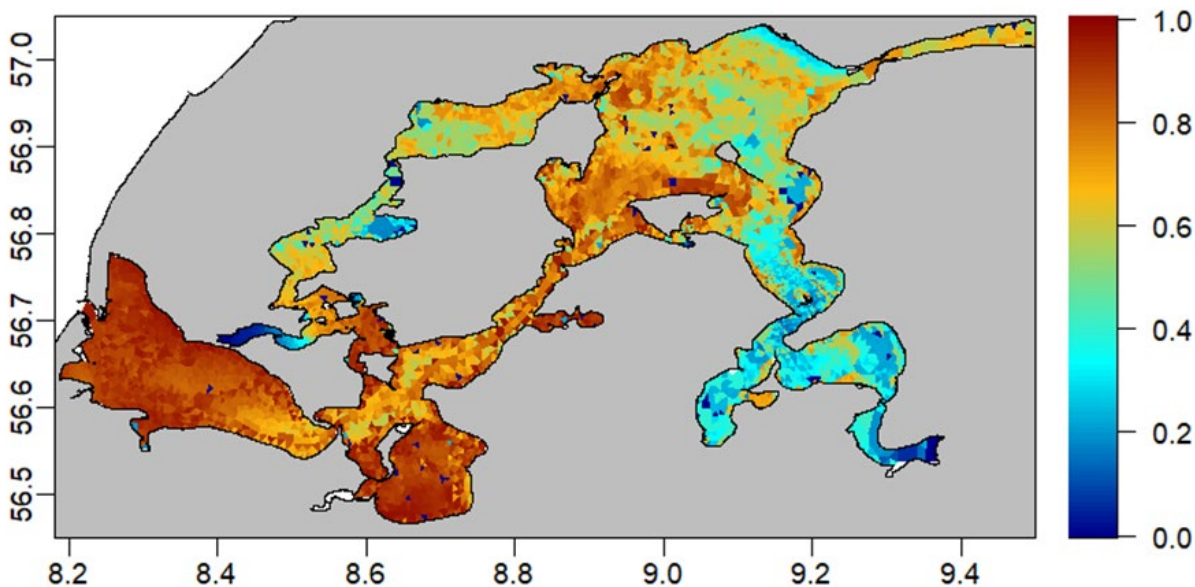


Figure 50 Habitat suitability index from May to September 2009

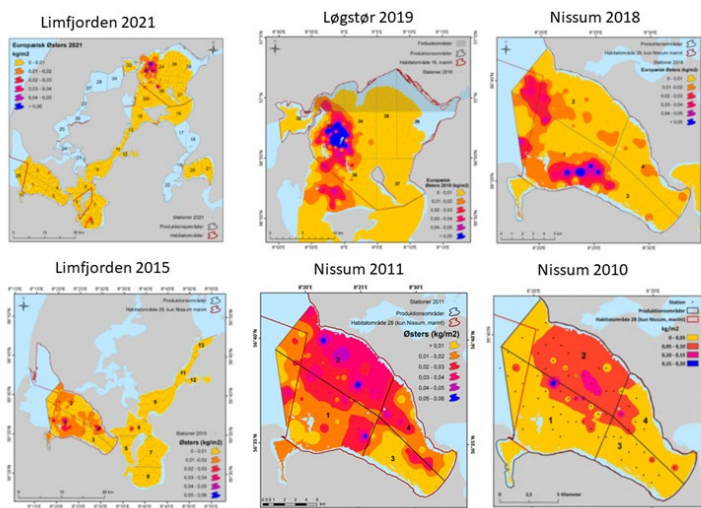


Figure 51 Stock assessment of flat oysters in the Limfjorden conducted by DTU Aqua (Dolmer et al. 2010, Nielsen et al. 2015, 2018)

### 3.6 SM-A4 Assistance for spat capture

The objective of the Assistance for spat capture service module is to provide information about the period where spat of a specific species is likely to arrive in the collecting location(s). Spawning events are related to environmental conditions (such as temperature, chlorophyll concentration, waves....); the services will detect those conditions in source location and warn of the arrival of spat in the collecting location. From the detection of a spawning event, the module computes a spawning period and a delay between spawning and spat settlement to assess the period where

spat could be collected. The service module is designed to be improved by the user by local knowledge but can be used with default value for oyster and mussel based on the literature value.

### 3.6.2 Set-up requirements

For the functioning of services several parameters have to be defined by the user.

**Collecting locations:** Users have to select the place where the collector will be installed.

**Source location:** SM-A4 considers potential source location(s) where the population of the considered species is present (either natural or farmed population) and can provide larvae to the collecting location(s). This information could come from different sources as for example, local expertise and/or from a drift model. In the case of Pilot 4, this information will be provided by a larval transport model. By default, users have to select shellfish farms and coastal areas around collecting locations.

**Forecast days:** The numbers of forecast days for which condition in source location was tested (default value is 3).

**Variable of interest:** Environmental cue responsible for spawning events (Default value is Temperature).

**Methods of assessment:** this switch asks for a threshold responsible for spawning events. Two methods are possible: “value threshold” and “cumulative threshold”. Default is “value threshold” for mussels and oysters, it is also possible to use a “cumulative threshold” for oysters.

#### Value of the threshold:

*Simple threshold:* a single value (default value is 9°C for mussels and 15C for oysters)

*Cumulative threshold:* A value of “gonad development threshold” represent the value where maturation of gonad starts (default is 7°C for oysters) and “threshold for cumulative sum” which represent the value for spawning event (default value for oysters is 576°C) (Maathius et al, 2019)

**Duration of drift:** The drift duration is also specific to a considered species. In addition, this value can also be dependent on environmental conditions and must be locally assessed. An interval of drift duration (PLDmin and PLDmax corresponding to the longer and shorter pelagic duration estimate) could be provided by experts taking into account uncertainties, this interval could be reduced by local expertise and data obtained in the farm. This interval would represent uncertainties in the estimation of PLD coming from 3 main sources: uncertainties of the growth rate and interindividual variability, uncertainties due to different environmental conditions met by larvae of the same cohort (as for example temperature or food availability which could affect the growth rate) and interannual variability. Swarming should be included if needed.

*PLDmin* Default value is for 25 days mussel and for 20 oysters

*PLDmax:* Default value is for 45 days mussel and for 30 oysters

**Duration of release events:** Knowledge about the spawning event duration is needed to determine the potential date of arrival. Usually this period is species specific and fixed. By default the period is 10 days for flat oysters and 90 days for mussels.

### 3.6.2 Description of the bulletin

The SM-A4 indicates the likely period of spat arrival in the collect location. The output will provide the date of arrival (beginning and end) from each of the source locations. In addition to arrival from each source location, the whole period of arrival is also estimated by combining all source locations. A table (Table 5) summarizes the likely arrival period for the species selected and the source location(s) associated with this arrival.

Table 5. Example of user's output. This table summarizes the information from the different source locations as well as the total period of potential arrival. The mention "Not known yet" means that spawning event had not started yet in the considered area.

Table 5 Example of user's output

Source location	Arrival expected from	Arrival expected until
Source area 1	21 October 2020	21 November 2020
Source area 2	Not known yet	Not known yet
Source area ...		
Source area n	15 October 2020	17 November 2020
Total	15 October 2020	21 November 2020

### 3.7 SM-R1 Retrieve sources of contaminants

This service predicts the forward and backward advection of contaminants. Backward tracking allows end users to investigate the source of contamination affecting their farms. The user only has to provide information on the time and location (i.e. latitude and longitude) of the contamination event.

The contaminants are tracked as passive tracers, moving along with the water. Therefore, only the ocean current field is needed to apply this service. The particle-tracking algorithm is based on OpenDrift (Dagestad et al., 2018). The 3day ocean forecast in the Galway Bay is made by the MI-ROMS model, in a spatial resolution of 70 m.

The user is provided with a bulletin displaying the following information (**Fig. 52**):

- A map showing the distribution of contaminants as the individual particles.
- The map (a) referred to above is sometimes not useful to distinguish which areas have a higher concentration of contaminants. For this reason, heat maps showing the probability distribution of contaminants are also provided with the bulletin.
- The Local Exposure Time (Du et al., 2020), a measure of the residence time of contaminants, is provided too.

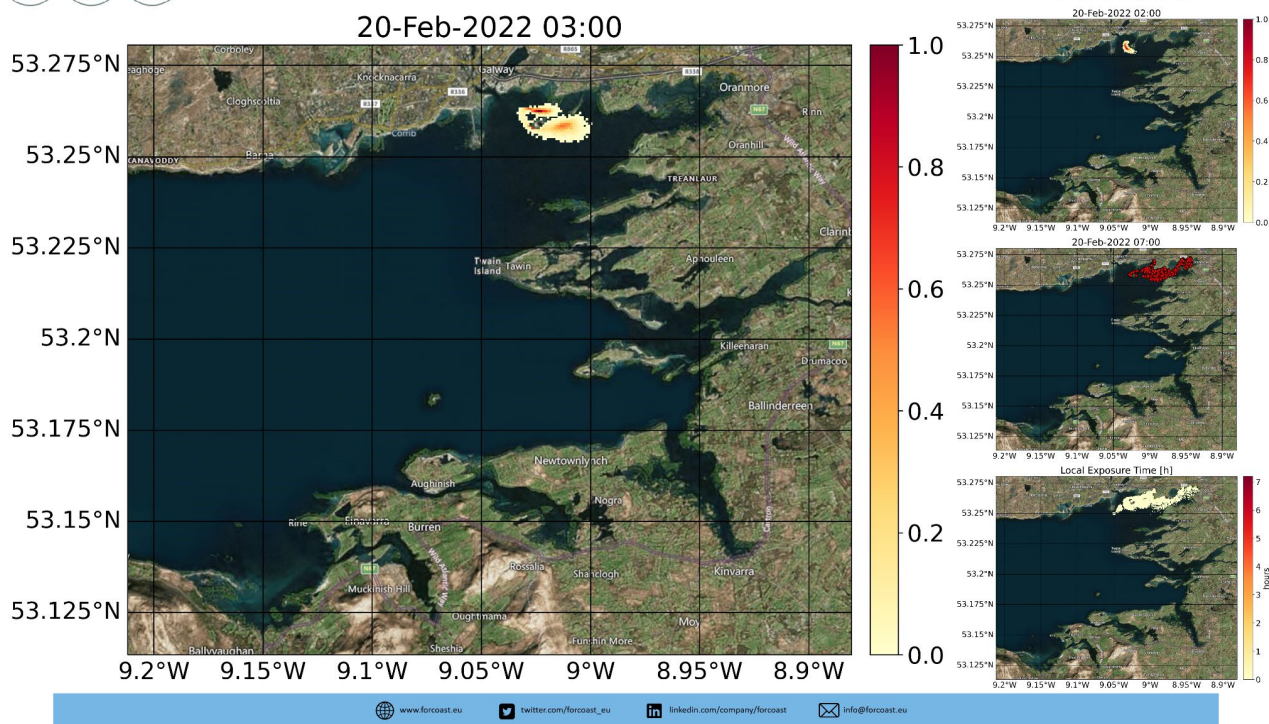


Figure 52 Bulletin from Service Module R1: Retrieve Sources of Contaminants

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