# FAIRSEA (ID 10046951)

"Fisheries in the AdriatIc Region - a Shared Ecosystem Approach"

# D.4.8.2 Integrated platform and key elements

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| **Work Package:** | WP4 - Implementation of a shared and integrated platform<br><br>Activity: Act.4.8.2 - Integrated platform and key elements |
| **Type of Document** | A database with results from the spatially explicit platform integrating HYDRO, BGC, FSTAT, BSTAT, BIOECO, FWM and EFFORT calibrated and definition of key elements (gear, port, species or area) relevant for management is compiled. |
| **Use** | Public |
| **Responsible PP** | PP3-CNR-IRBIM, PP1-OGS |
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# D.4.8.2 Integrated platform and key elements

**FAIRSEA – Fisheries in the Adriatic Region – a shared Ecosystem Approach**

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*Start date: 01 January 2019*

*End date: 31 August 2021*

# Contents

# Acronyms used

| | |
|---|---|
| **AIS** | Automatic Informative System |
| **BEMTOOL** | Bio-Economic Model TOOLs |
| **CMEMS** | Copernicus Marine Environment Monitoring Service |
| **CFP** | Common Fisheries Policy |
| **DCF** | Data Collection Framework |
| **DCR** | Data Collection Regulation |
| **EAF** | Ecosystem Approach to Fisheries |
| **EU** | European Union |
| **FAIRSEA** | Fisheries in the AdrIatic Region – a Shared Ecosystem Approach |
| **FAO** | Food and Agriculture Organisation |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **GIS** | Geographic Information System |
| **GSA** | Geographical Sub Areas |
| **GT** | Gross tonnellate |
| **IP** | Integrated Platform |
| **LFD** | Length Frequency Distribution |
| **LOA** | Length Over All |
| **MCDA** | Multicriteria Decision Analysis |
| **MEDITS** | International Bottom Trawl Survey in the Mediterranean |
| **RCP** | Representative Concentration Pathway |
| **SOLEMON** | Rapido trawl surveys in the Northern Adriatic Sea |
| **VMS** | Vessel Monitoring System |
| **WP** | Work package |

# FAIRSEA

## About FAIRSEA Project

The FAIRSEA project aims at enhancing transnational capacity and cooperation in the field of an ecosystem approach to fisheries in the Adriatic region by exchanging knowledge and sharing good practices among partners. The complementary expertise of the partners is shared, interlinked and integrated, considering also challenges and opportunities identified by stakeholders. These efforts are embedded in a spatially explicit management platform that will allow to share expertise, create a common pool of knowledge, boost the operational application of the ecosystem approach to fisheries, enhance the competence in complex system dynamics, foster a consensus on the state of the environment and fisheries in the region.

## Project specific objectives

The overall objective of FAIRSEA is to enhance the conditions for implementing innovative approaches in the sector of sustainable fisheries management in the Adriatic Sea considered as the FAO geographical sub-areas (GSA) 17, 18 and 19. This is done through the development of a shared conceptual and operational framework for an Ecosystem approach to fisheries (EAF). It will be achieved through the implementation of a spatially explicit and territorially integrated tool that considers water mass circulation, physical-chemical properties, plankton productivity, dynamics of resources including their interactions, fisheries displacement and bio-economic drivers. The technical integration is adapted to address stakeholders' and policy makers' issues and is used for increasing awareness, for understanding EAF, for increasing technical skills and capacities in the region also through demonstrative applications. The platform result in a high technological and innovative tool for EAF to be useful for policy makers, institutions and organizations and might require patent.

Overall objective will be achieved through three specific objectives:

- Enhance transboundary integrated competence in the field of ecosystem approach to fisheries;
- Implement a shared "state of the art" integrated platform for the region;
- Share benefits and challenges of ecosystem approach to facilitate the achievement of the Common Fisheries Policy (CFP) objectives.

## WP4 - Implementation of a shared and integrated platform

Working Package number 4 (WP4) is dedicated to the development of an integrated platform (IP) for a quantitative ecosystem approach to fisheries that goes across territorial boundaries and across several disciplines. The platform will integrate datasets from physics to bioeconomy of fisheries as a state of the art and decision support tool.

The platform cornerstone elements are:

i) water masses circulation and connectivity (module HYDRO);

ii) biogeochemical planktonic processes and productions (module BGC);

iii) distribution of main resources using scientific surveys (module BSTAT);

iv) disaggregated catches and fleet capacity changes over time (module FSTAT);

v) spatial distribution of effort using scientific VMS/AIS data (module EFFORT);

vi) bioeconomic responses (BIOECO);

vii) food web dynamics (FWM);

viii) preference modelling (trough MCDA – Multicriteria Decision Analysis - methods).

These informative layers are analysed considering spatial limits of management unit areas in order to highlight possible critical overlap or separation. The integrated platform will be developed by the technical partners also considering issues, criteria, and management actions that are foreseen in the region as emerging from technical meetings (WP3) and stakeholder engagement (WP5). The platform is then used as a demonstrative and applied tool to highlight potentialities of the EAF at different target groups. A simplified version containing some scenarios will be used as a demo for dissemination (WP2). Some of its results and controlled simulations will be used for an efficient communication with stakeholders of the Adriatic Region and simulation of alternative local management actions will result in pilot applications (WP5). Application of different broad management measures will provide the basis for informing policy makers of best practices and guidelines also transferable beyond the project area (again in WP5).

## Activity 4.8 - Development of an integrated platform for an Ecosystem Approach to Fisheries

A spatially explicit modelling using Ecospace of the Ecopath with Ecosim software will be used to integrate outputs from activities HYDRO, BGC, BSTAT, FSTAT, EFFORT. HYDRO and BGC spatial results in terms of monthly average currents and production pattern will be interlinked with FWM. BSTAT will be used to calibrate the model outputs. Fisheries dynamics based on FSTAT results will be validated using EFFORT results. Whenever possible, a two-ways coupling will be implemented. Predation mortalities produced by FWM can be an input to BIOECO (natural mortality fluctuations) and BIOECO can, in turn, feed the integrated platform with changes in fleets' behaviour (fishing mortality). The socio-economic components will highlight impacts of cross-interactions among ecosystem processes (including fleets). MCDA will provide the weighing factors for management scenarios, ranking different strategies. At least one future climatic scenario will be applied. Open access to IP and data sharing will allow different stakeholders to model current and future scenarios by improving transparency in decision making process.

### D.4.8.2 Integrated platform and key elements

The present deliverable will describe the general structure of the Integrated Platform with specific focus on modules development. All information uploaded in the platform can be visualized and downloaded in the form of NetCDF, shapefile or zipped folders according to the module of interest. Key elements such as environmental drivers, target species and relevant fleet segment represented and selected in the first four modules of the platform (HYDRO, BGC, BSTAT, FSTAT, EFFORT) are used for bioeconomic and ecosystem modelling in the last two modules (BIOECO and FWM). Results and details for all the modules described can be found in the specific Deliverables produce during the project.

### The FAIRSEA Integrated Platform structure and software

The software development of the IP is being entrusted to the external software development company INKODE (https://inkode.it/).
FAIRSEA IP is a web-GIS application based on open source software. All services are deployed by Docker containers, main services are:

- Backend: based REST API developed in Python with on Django, Django Rest Framework and GeoDjango

- Frontend: a Single Page Application based on AngularJS with Angular Material framework
- Database: PostgreSQL with PostGIS
- GIS software: Geoserver
- Charts and dashboards: Plotly and Grafana

Other used libraries and services: GDAL, scipy, Shapely, netCDF4, Pandas, MapProxy, Pillow

## Test environment

Alpha/testing version of the IP running at https://fairsea.inkode.it/#/login
View only testing credentials: username "***viewer***", password "***fairsea2020***".

## Modules details

In this chapter is reported a summary of the main characteristics of the FAIRSEA IP. Each individual module and sub-module will be briefly described in detail.

| **Modules (Sub-modules) name** | **Modules description** |
|---|---|
| 4.1 HYDRO – Hydrodynamic circulation and connectivity<br><br>*- Connectivity and main circulation patterns in the Adriatic Sea* | Results on the space-time distribution of temperature, salinity and current velocity at different vertical layers for the past 20 years. |
| 4.2 BGC – Biogeochemical processes and dynamics<br><br>*- Production patterns in the Adriatic Sea* | Results on the space-time distribution of nitrogen, chlorophyll, primary production, plankton biomass and oxygen indicators for the past 20 years. |

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|---|---|
| 4.3 BSTAT – Spatial distribution of marine resources<br><br>- *GSA17*<br><br>- *GSA18*<br><br>- *GSA19* | Results of the application of spatio-temporal analyses, through BioIndex and BioStand routine (https://www.coispa.it), to fishery independent survey (MEDITS, SOLEMON) data of GSA17, GSA18 and GSA19 for the time series 1994-2018. |
| 4.4 FSTAT – Fisheries production and capacity | Information from time series of catches (i.e. landings and discards), fleet consistency and economic data (e.g. costs, revenues) by fleet segment. |
| 4.5 EFFORT – Effort distribution and fleet displacement | Results of assessment of the fishing effort distribution for both fishing vessels equipped with tracking devices (i.e. VMS or AIS) and non-equipped vessels (typically the fishing vessel smaller than 12 m) |
| 4.6 BIOECO – A multi- fleet and multi-stock platform for mixed fisheries | Results of different alternative management scenarios in the Adriatic-Ionian region obtained using BEMTOOL. |
| 4.7 FWM – Food web modeling | Results from Ecopath approach applied to 3 food web models describing the trophic structure of the Adriatic and Ionian Sea. |
| Summary Module | Interaction workspace between module layers. |

## 4.1 HYDRO – Hydrodynamic circulation and connectivity

*Connectivity and main circulation patterns in the Adriatic Sea*

This sub-module contains the description of the physical properties of the Adriatic and Ionian basins provided by a multidecadal reanalysis of the Mediterranean Sea (CMEMS data, http://marine.copernicus.eu/). The physical variables selected are temperature (T), bottom temperature, salinity and the meridional (V) and zonal (U) component of the currents (these two variables can be used as a proxy of the connectivity) for the period 1999-2018. All the details about this sub-module can be found in the Deliverable 4.1.1 (*Connectivity and main circulation patterns in the Adriatic Sea*). Within the platform the outputs can be easily mapped through different layers that can be activated or not thanks to an interactive legend. Through a drop-down menu you can choose to view different vertical end temporal levels (Fig. 1). The winter seasons is defined as the period encompassing January-February-March (JFM), spring as the period encompassing April-May-June (AMJ), summer as the period encompassing July-August-September (JAS), fall as the period encompassing October-November-December (OND). The temporal averages have been computed considering the following vertical averaged levels: 0-50 m, 50-100 m, 100-200 m, 200-500 m and 500-800 m. Each variable, excluding those of bottom, is presented as annually (mean) and seasonally (mean_JFM, mean_AMJ, mean_JAS and mean_OND) averages between 0-50 m (for example mean_0m_50m), between 50-100 m (for example mean_JFM_50m_100m), between 100-200 m (for example mean_AMJ_100m_200m) between 200-500 m (for example mean_AMJ_200m_500m) and between 500-800 m (for example mean_AMJ_500m_800m).

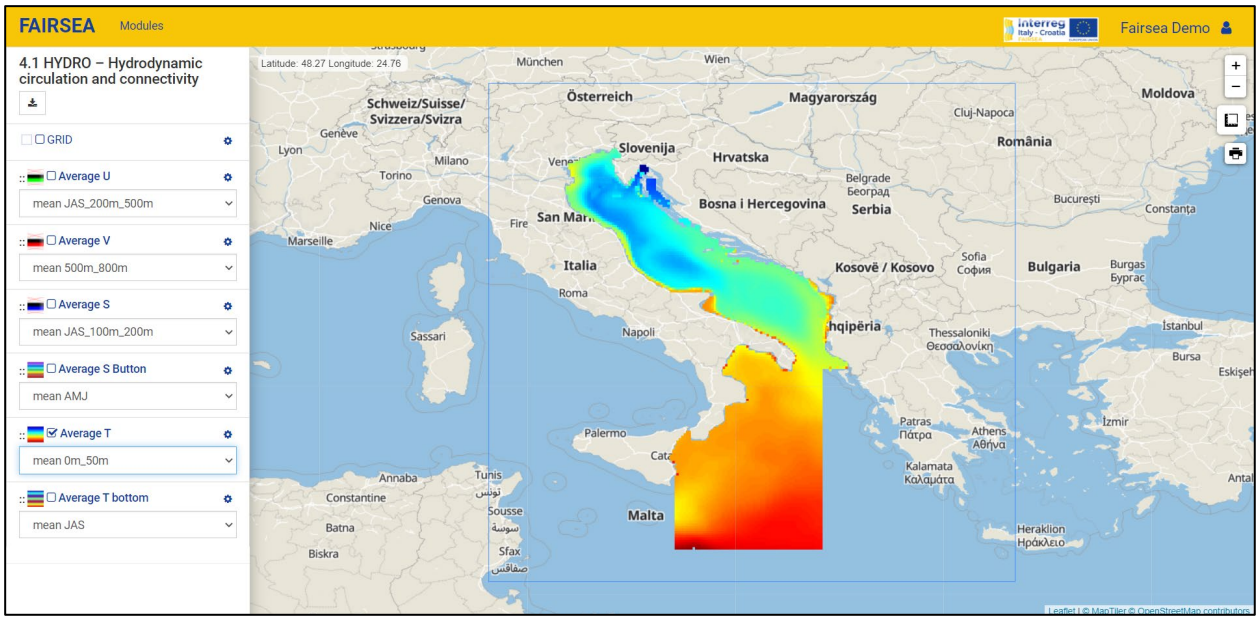



***Figure 1.*** HYDRO output layout for "Connectivity and main circulation patterns in the Adriatic Sea" within FAIRSEA IP. This example displays the annual average of temperature values (T) in the project study area at 0-50 m depth (0m-50m).

## 4.2 BGC – Biogeochemical processes and dynamics

*Production patterns in the Adriatic Sea*

This sub-module contains the description of the biogeochemical properties of the Adriatic and Ionian basins provided by a multidecadal reanalysis of the Mediterranean Sea (CMEMS data, http://marine.copernicus.eu/). The biogeochemical variables selected are chlorophyll-a, dissolved nitrogen (DIN), phosphate (N1p), dissolved oxygen (both in water column and on bottom), phytoplankton carbon biomass (PC), zooplankton carbon biomass (ZC), particulate organic carbon or POC, pH and net primary production (ppn) for the period 1999-2018. All the details about this sub-module can be found in the Deliverable 4.2.1 (*Production patterns in the Adriatic Sea*). Within the platform the outputs can be easily mapped through different layers that can be activated or not thanks to an interactive legend. Through a drop-down menu you can choose to view different vertical end temporal levels (Fig. 3). The winter seasons is defined as the period encompassing January-February-March (JFM), spring as the period encompassing April-May-June (AMJ), summer as the period encompassing July-August-September (JAS), fall as the period encompassing October-November-December (OND). The temporal averages have been computed considering the following vertical averaged levels: 0-50 m, 50-100 m, 100-200 m, 200-500 m and 500-800 m.

Each variable, excluding those of bottom, is presented as annually (mean) and seasonally (mean_JFM, mean_AMJ, mean_JAS and mean_OND) averages between 0-50 m (for example mean_0m_50m), between 50-100 m (for example mean_JFM_50m_100m), between 100-200 m (for example mean_AMJ_100m_200m), between 200-500 m (for example mean_AMJ_200m_500m) and between 500-800 m (for example mean_AMJ_500m_800m).

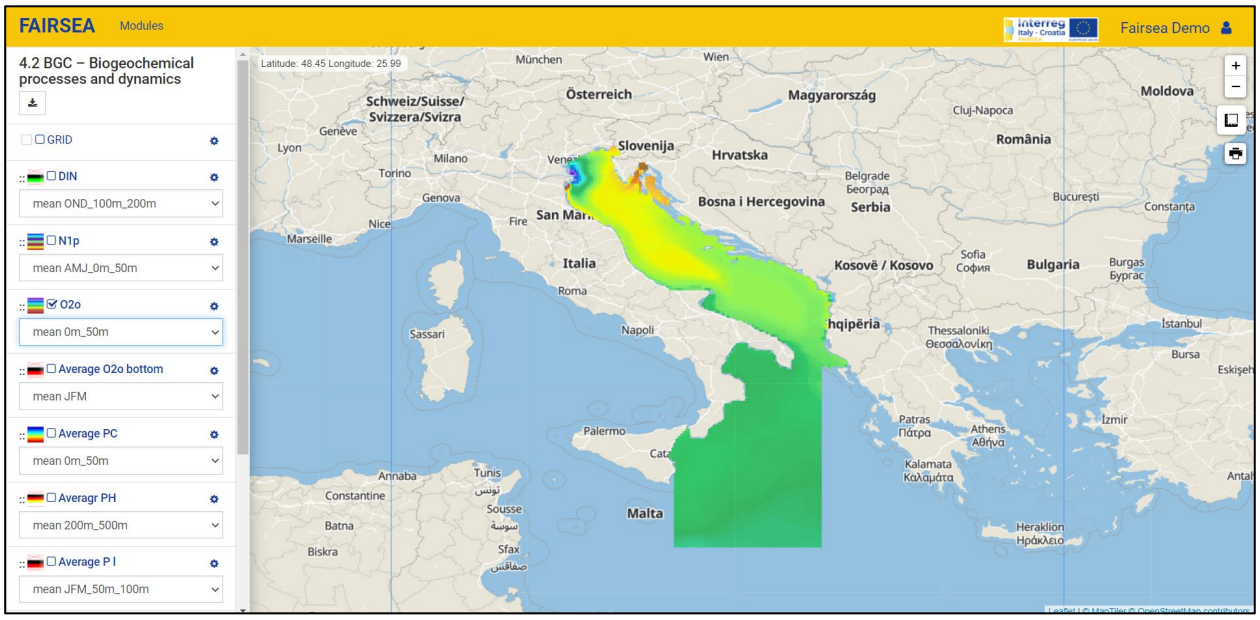



***Figure 3.*** BGC output layout for "Production patterns in the Adriatic Sea" within FAIRSEA IP. This example displays the annual average of dissolved oxygen values in the project study area at 0-50 m depth (0m-50m).

## 4.3 BSTAT – Spatial distribution of marine resources (GSA17, GSA18, GSA19)

These sub-modules (BSTAT GSA17, BSTAT GSA18, BSTAT GSA19) contain database of standardised indices and maps of commercial species distribution based on the knowledge from the past 20 years divided by GSAs. Data are gathered from the main bottom trawl surveys conducted in the Adriatic Sea and in the Western Ionian Sea by several FAIRSEA partners: MEDITS (Anonymous, 2017), SOLEMON (Anonymous, 2019). Where the information is available from the fishery-independent survey, the identification of main areas of aggregation, including areas of persistent presence of critical life stages, such as nursery and spawning area, is another objective. Outputs from trawl surveys are provided thanks to specifically designed open source tools, as Rroutine BioIndex and BioStand (available at: https://www.coispa.it). The ranking of the species for the objectives of the BSTAT module was done according to the following criteria: an inverse ranking of biomass-weighted log abundance, fixing a cut-off at 90th percentile.
On the on-line platform, outputs from BSTAT are divided in Bioindex and BioStand outputs: 1) BioIndex folders contains plots and data table of biomass and abundance index together with exploratory analyses (9 key population state-indicators) providing comparable information among the various GSAs (Fig. 5); 2) BioStand folder contains plots and data table outputs from the standardization procedure using Generalized Additive Models (Fig. 6). Moreover, spatial distribution of of interesting species in the GSA17 can be easily mapped through different layers that can be activated or not thanks to an interactive legend. Through a drop-down menu the user can choose to view different species (Fig. 7).
All the details about BSTAT module can be found in the Deliverable 4.3.1 (*Spatio-temporal distribution of marine species*)

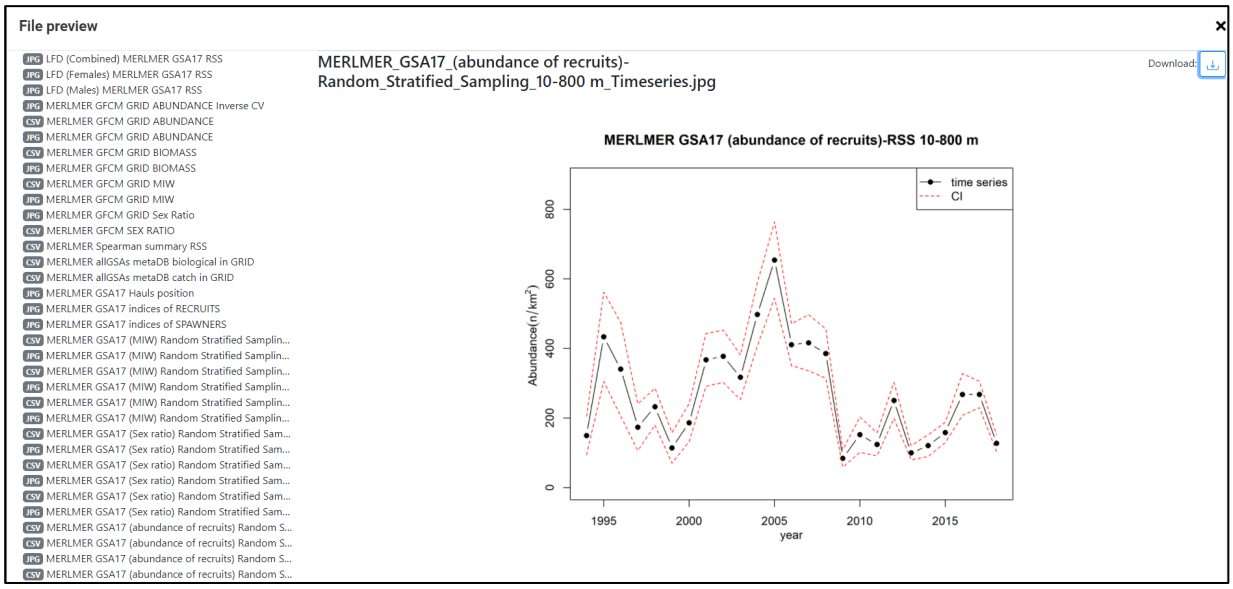



***Figure 5.*** Overview of BioIndex output layout for within FAIRSEA IP. This example displays the recruits abundance index for hake in GSA17 from MEDITS survey.

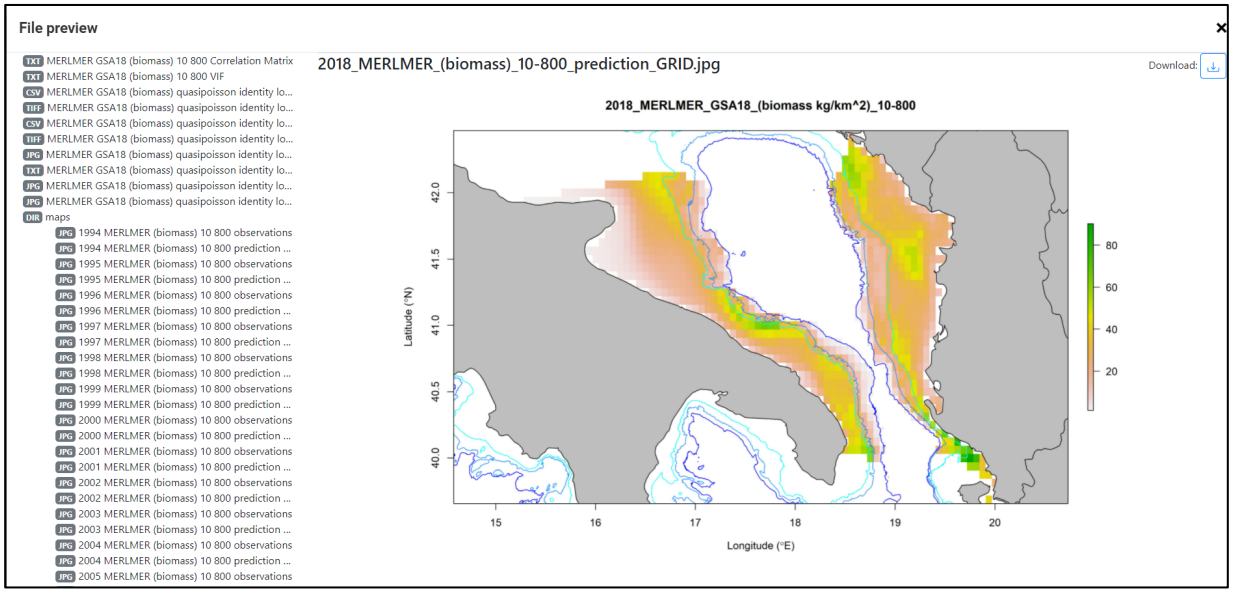



***Figure 6.*** Overview of BioStand output layout for within FAIRSEA IP. This example displays the predicted spatial distribution (kg/km2) of hake in GSA18 using GAMs.

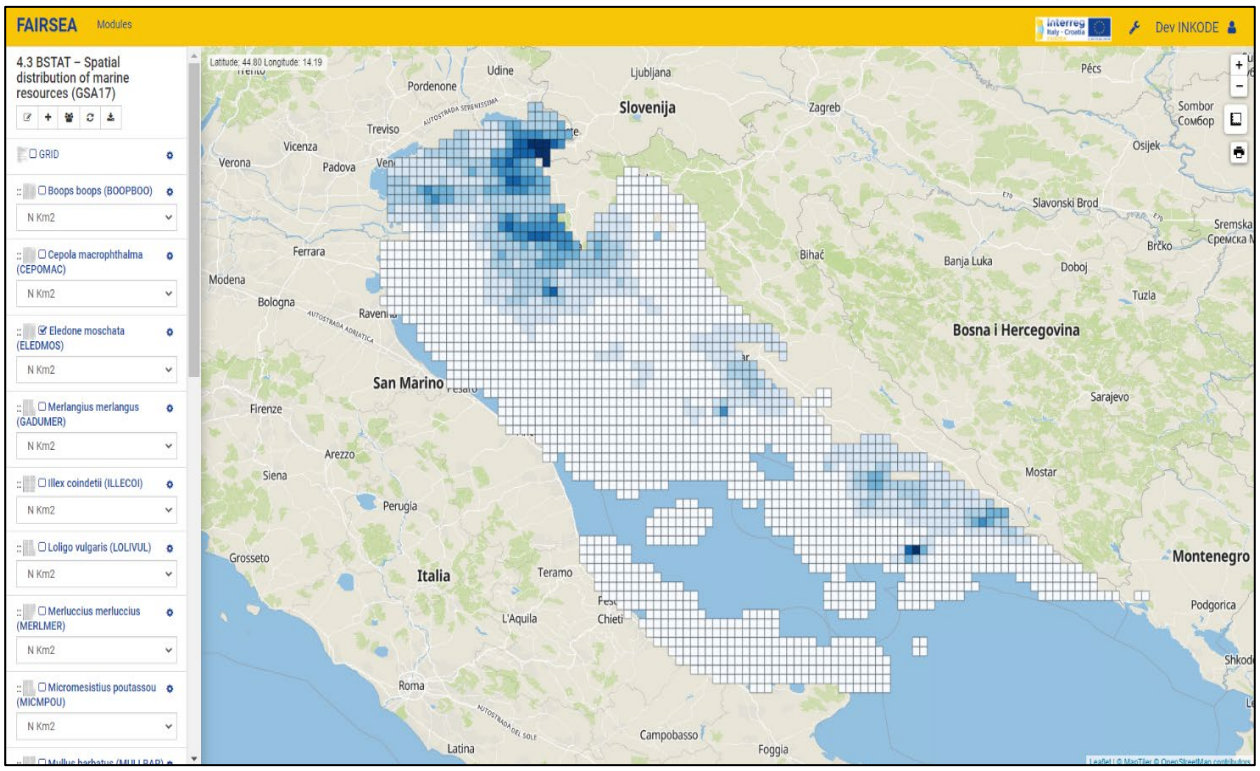



***Figure 7.*** GSA17 mapped layout for BSTAT within FAIRSEA IP. This example displays the spatial distribution of *Eledone moschata* from MEDITS survey.

## 4.4 FSTAT – Catches and fishing capacity by fleet segment

This module contains a dataset of fisheries dependent information including data for the last decade in terms of catches (both quantities and price), length frequency distribution (LFD) and fleet capacity (number, GT, LOA, and fixed and variable costs) by species and fleet segment.
Fisheries dependent information in the Adriatic and Ionian Sea regions has been collected by observers on board commercial vessels under the Data Collection Regulation/Framework (DCR/DCF; EU Regulations No. 1543/2000, No. 199/2008) and other national or international projects and includes total landings by fleet segment, composition of catches (landings and discards) and economic variables.
All the details about FSTAT module can be found in the Deliverable 4.4.1 (*Catches and fishing capacity by fleet segment*).
Within the platform the outputs can be easily view through an interactive dashboard. Through a filter menu the user can choose to view different years, GSAs, species, fleet segment levels (Fig. 8).

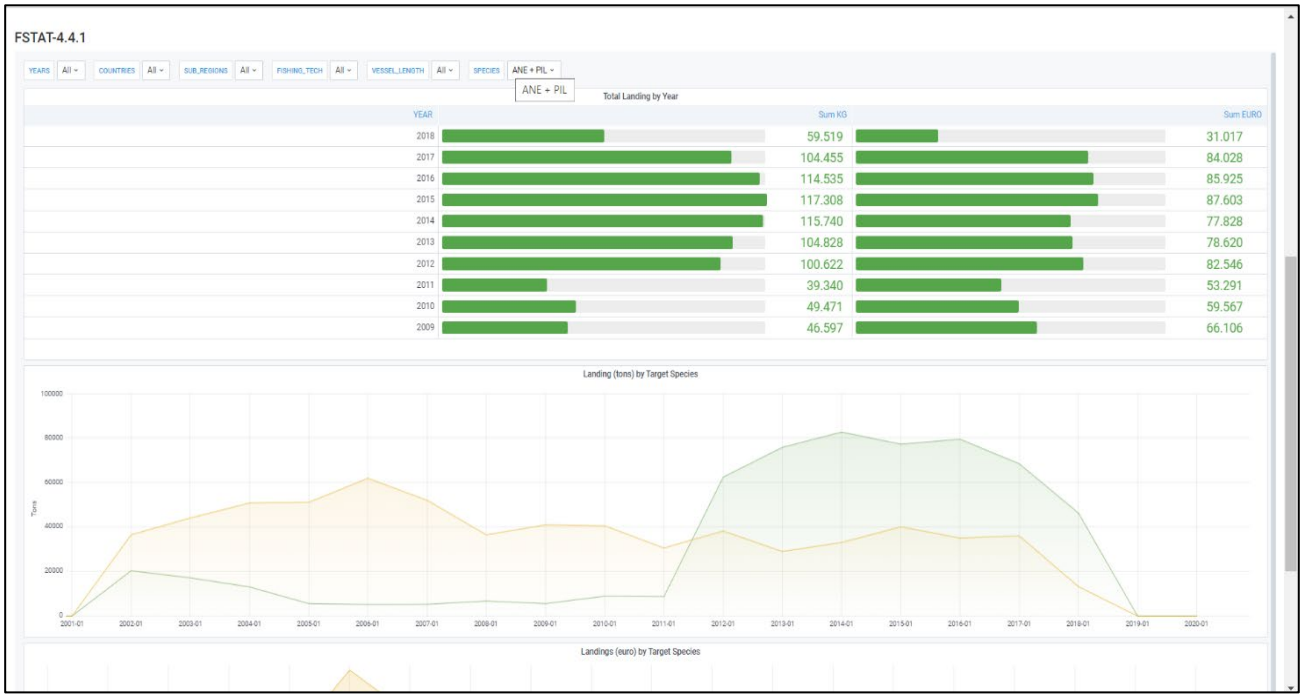



***Figure 8.*** Overview of FSTAT interactive dashboard output within FAIRSEA IP. This example displays the landings in tons and Euro of anchovies and sardines (ANE and PIL).

## 4.5 EFFORT – Effort distribution and fleet displacement

This module contains fishing effort maps distribution by the main fishing segments and small-scale fishing activities obtained by integrating VMS/AIS data on vessel displacement with on-board observations of fishing operations in the Adriatic-Ionian region. Fishing hours per fleet segment in each quadrant for both fishing vessels equipped with tracking devices (i.e. VMS or AIS) and non-equipped vessels (typically the fishing vessel smaller than 12 m) were pursued using a combined approach: (i) VMS/AIS data were analysed using the state-of-the-art VMSbase platform (Russo et al., 2014); (ii) the distribution of the small-scale fishing fleet was obtained through a methodology based on the identification of the most relevant factors which determine the spatial pattern of small-scale fishing. Both Italian and Croatian fleets operating in the Adriatic Sea were considered.

Within the platform the outputs by gears and LOA can be easily mapped through different layers that can be activated or not thanks to an interactive legend. Through a drop-down menu the user can choose to view different years (Fig. 9). The analysys have been computed considering the following gear/LOA levels: OTB (bottom otter trawler) with 3 LOA classes (12-18, 18-24, 24-40); PS (purse-seiner) with 4 LOA classes (12-18, 18-24, 24-40, >40); PTM (mid-water pair trawler) with 3 LOA classes (12-18, 18-24, 24-40); TBB ("rapido" trawler) with 3 LOA classes (12-18, 18-24, 24-40); LL (longliners) with 2 LOA classes (12-18, 18-24).

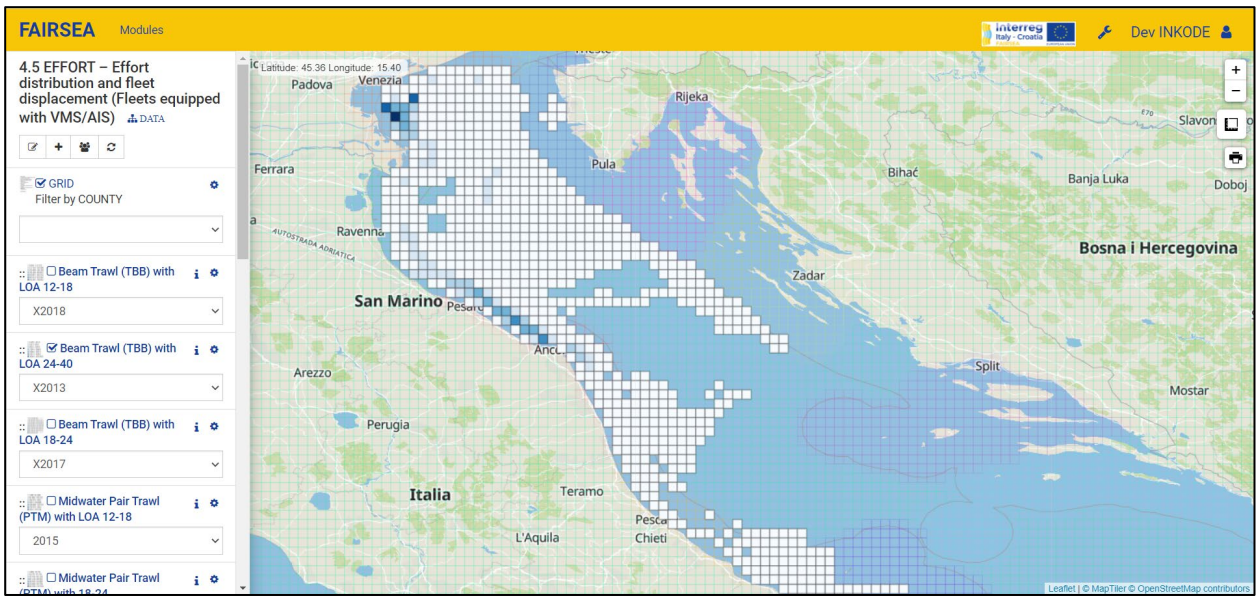



***Figure 9.*** EFFORT output layout within FAIRSEA IP. This example displays the fishing effort map distribution of *rapido* trawlers (TBB) with LOA 24-40 meters in GSA17 in 2013.

## 4.6 BIOECO – A multi-fleet and multi-stock platform for mixed fisheries

This module contains the output of different alternative management scenarios in the Adriatic-Ionian region obtained using BEMTOOL bio-economic model (Spedicato et. al 2016). This tool allows to set scenarios for evaluating how changes/shifts in population traits (e.g. natural mortality, growth), fishery-driven impacts (e.g. fishing mortality, population and gear selectivity) and management or fishing strategies (e.g. closed season, changes in fishing opportunity), affect stock and fisheries dynamics in terms of landings, discards and economic performance. BEMTOOL is a multi-fleet and multiple species bio-economic platform in R language, mimicking the effects of management on stocks and mixed fisheries. BEMTOOL model includes 6 sub-modules: a) biological; b) impact; c) socio-economic; d) policy/harvest rules; e) fleet behaviour; f) MCDA. All the details about BEMTOOL sub-modules and model calibration can be found in the Deliverable 4.6.1 and related Annex (Calibrated BEMTOOL applications to the Adriatic Region).

Results of scenario modelling for the target species, by fleet segment (and fisheries), for the Adriatic basin have been produced, providing outputs in terms of biological, fishing impact and economic indicators. Specifically: three scenarios were implemented within the project:

1. **(S0)** Status quo (no variations compared to 2021).
2. **(S1)** Linear reduction of 40% in fishing days until 2026, for trawlers and rapido, toward the FMSY combined (0.35 value). We used a combined reference point of the target species included in the GFCM Recommendation (GFCM/43/2019/5), instead the one of European hake FMSY (0.18 value), in order to avoid the risk of underutilisation for the less exploited species.
3. **(S2)** A combination of measures selected by stakeholders, based on fleet selectivity improvements + spatial closure areas (within 6 nautical miles, until December), taking into account the presence of nurseries of the main target species in the areas + 2 months of fishing bans for other gears (PGP 17-18 and DFN Croatia fishing ban in Feb and May; HOK GSA 18 March and May) + linear reduction of 25% in fishing days for trawlers and *rapido* fleets.

Within the platform the outputs of the three different scenarios can be visualized selecting the specific scenario name from the drop-down menu (Fig. 10a). Results are divided in three section: State of the stock, Impact/Pressure, State of the fleet. The first section contains plots of stock status indicators from 5 selected species (Fig. 10b: red mullet in GSA17-18, European hake in GSA17-18, Norway lobster in GSA17-18, deep-water rose shrimp in GSA17-18, common sole in GSA17); among these we have SSB (spawning stock biomass), total biomass, mean length of population, total mortality, spawning potential ratio and critical length (Fig. 10c). In section Impact/Pressure time series of catch and fishing mortality by stock are present (Fig. 11). The last section is dedicated to economic indicators by fleet: once selected the

desired fleet segment, the platform shows the user plots for total landing and total revenues, average salary and number of employees, profit salary and capital cost, revenues on break even revenues (R/BER) and net profits (Fig. 12). All plots of these three sections can be easily compared between different scenarios via "*compare scenario*" button.

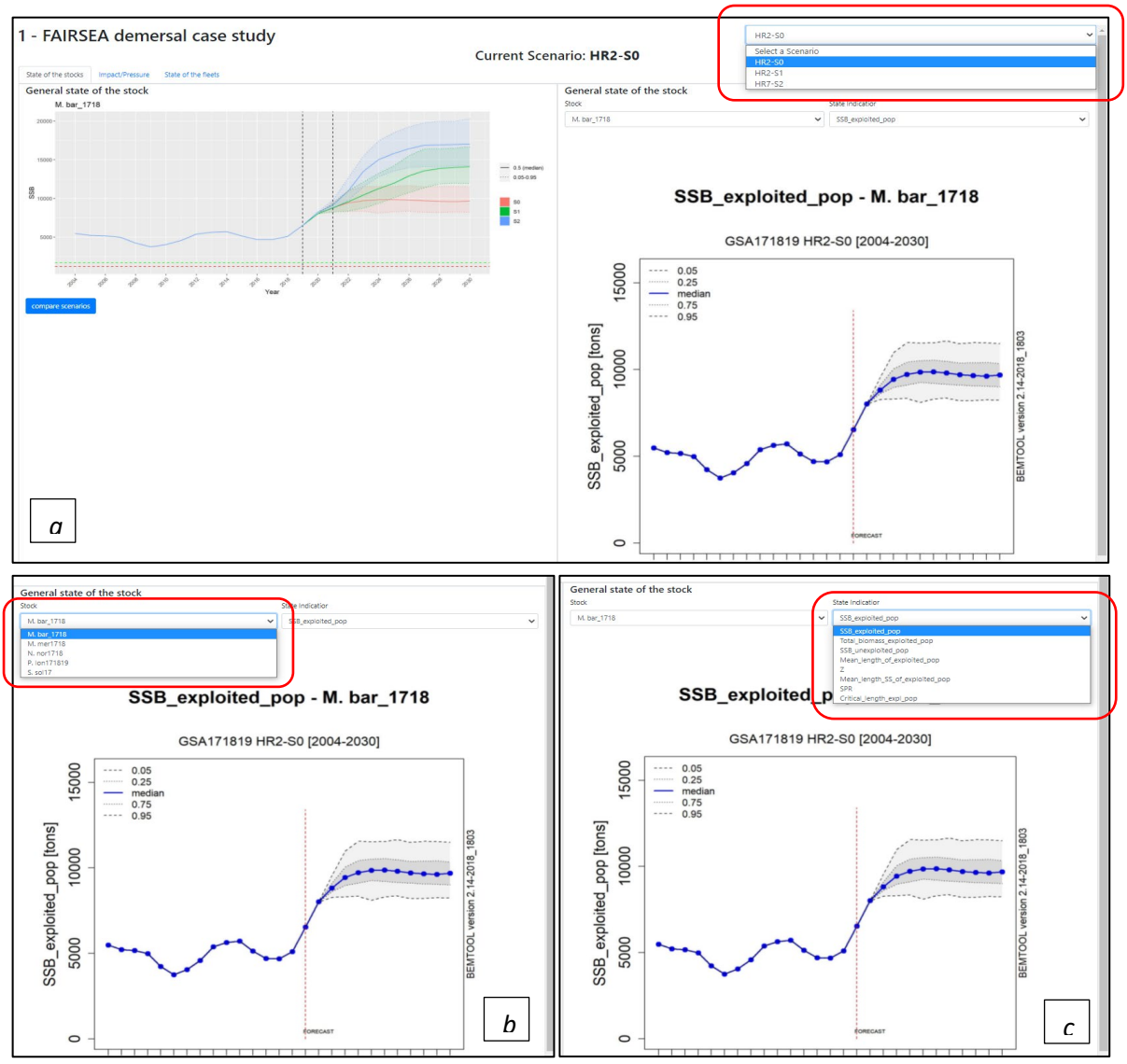



***Figure 10.*** BEMTOOL scenarios output: State of the Stock. Different scenarios can be visualized selecting the specific scenario name from the drop-down menu, in this case S0 (a); results from different species can be visualized, in this case red mullet from GSA17-18 (b); menu of stock status indicators present in the platform, in this case SSB of exploited population (c).

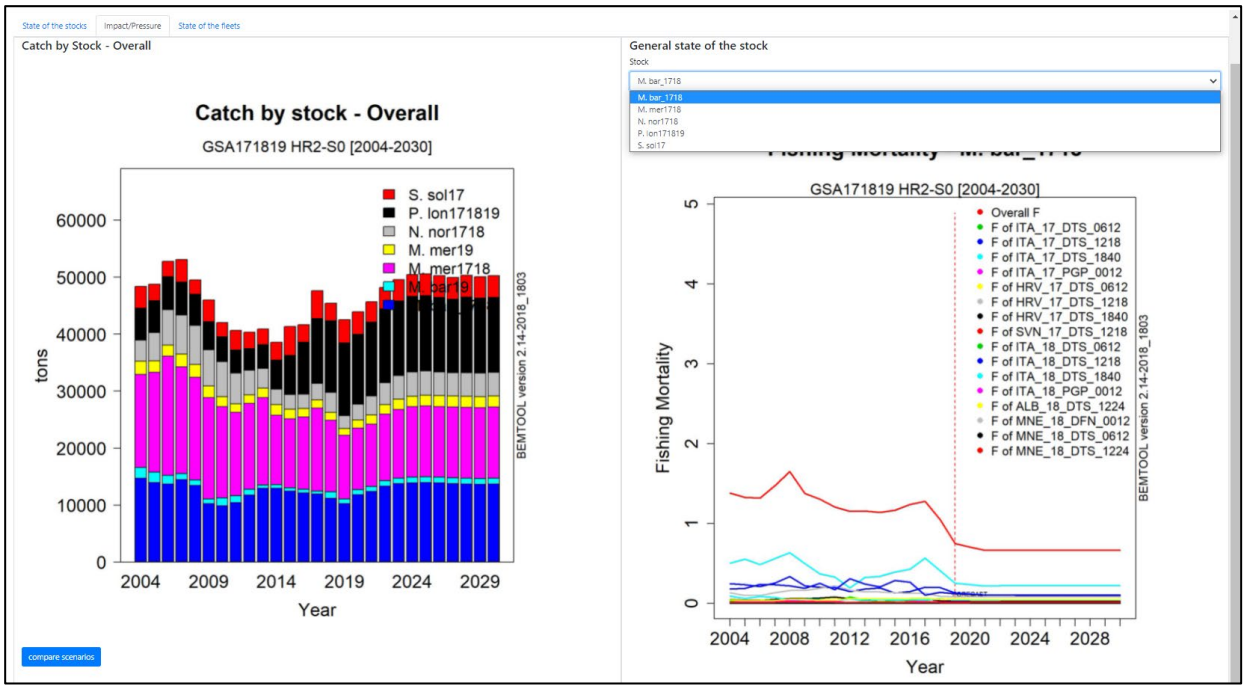



***Figure 11.*** BEMTOOL scenarios output: Impact/Pressure. Pressure time series of catch and fishing mortality by stock are visualized, in this case red mullet in GSA17-18.

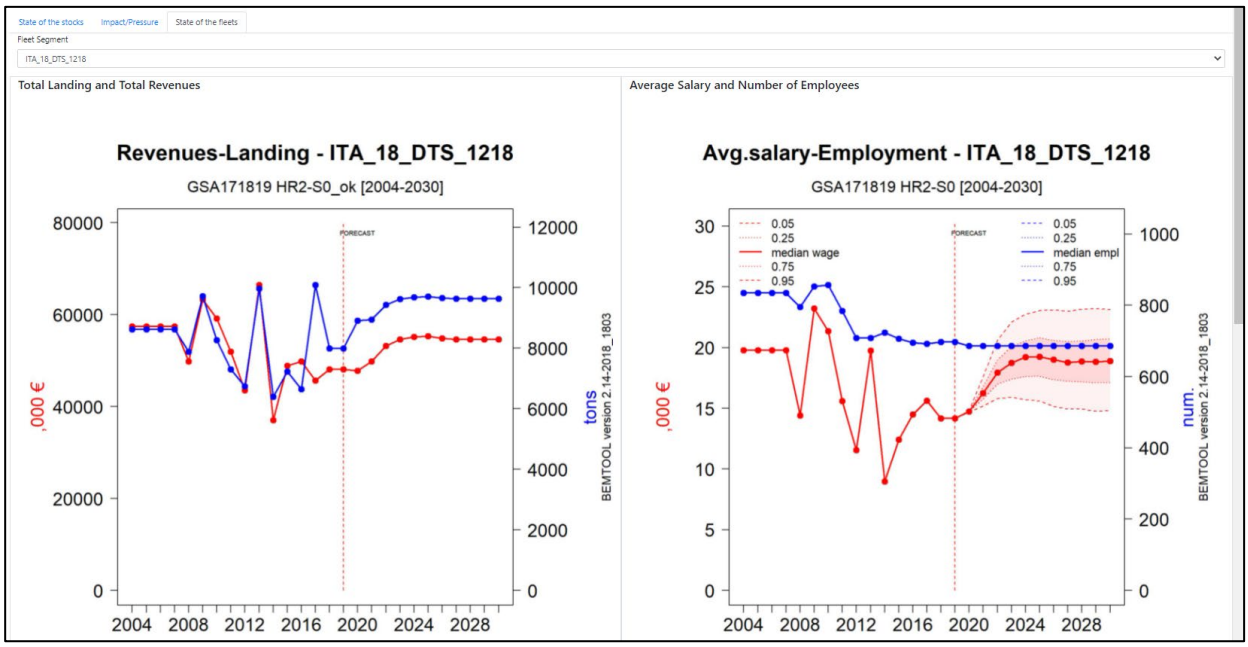



***Figure 12.*** BEMTOOL scenarios output: State of the Fleet. Results from four different economic indicators by fleet. In this example total landing and total revenues (left-side) and average salary and number of employees (right-side) for Italian GSA18 trawlers with LOA between 12-18 meters.

The MCDA (Multiple-criteria decision analysis) part of BIOECO model has been implemented in the on-line platform. The embedded MCDA component allows to include stakeholders preference about management objectives and rank scenarios accordingly. Within the platform, the goal is to allow the dynamic generation of different scenarios results under different management criteria (e.g. socioeconomic vs. biological objectives); variations in the form of vector of weighting in the indicators may result from consultation with stakeholders. Outputs are automatically generated in the form of graphs and tables that can be consulted interactively through different display windows (Fig. 13).

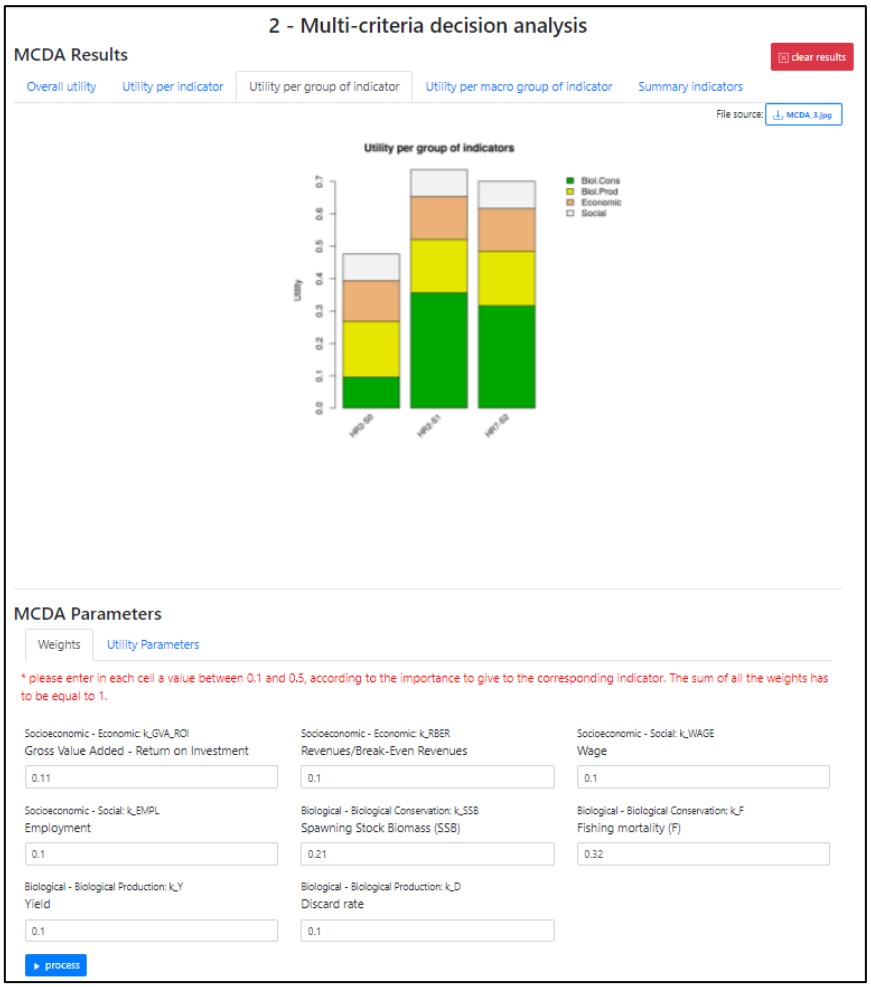



***Figure 13.*** MCDA implementation: comparison of group indicators from an example case study. In this case when asked to compare management criteria at the top-level hierarchy (socioeconomic vs. biological objectives), the experts (economists and biologists) considered biological aspects to be more important than socioeconomic ones in order to maximize society's wellbeing.

## 4.7 FWM – Food web modelling

This module contains the output from food web model approach developed using the Ecopath with Ecosim and Ecospace suite (Pauly et al., 2000). The food web mode is describing the trophic structure of the Adriatic and Ionian Sea as reported in the Deliverable "*D 4.7.1 Calibrated Ecopath with Ecosim model for the Adriatic region*".

The module platform, in particular, contains the output from the Ecopath with Ecosim and Ecospace approach applied to the Adriatic Sea, i.e., the simulations of spatial and temporal scenarios. The Ecospace model performs the simulations guided by the spatial and temporal distribution of the plankton resources from HYDRO and BGC, calibrated over time using BSTAT results as reference and forced using EFFORT and FSTAT results. The application of fishery restricted areas and other management alternatives are done in six different management scenarios that have been included in the platform:

1. S0 – baseline
2. S1 – application of coastal closure areas
3. S2 – fishing effort reduction
4. S3 – fishing effort reduction and application of fishery restricted areas (FRA)
5. S4 – simulation of climate change according to RCP 8.5 scenario
6. S5 – application of fishery restricted areas (FRA)

Detailed explanation of scenarios and main results are reported in the Deliverable "*D5.3.1 Report on the results from the application of scenarios for fisheries management in the Adriatic Region*." Although, the effects of the forcing and management alternative in scenarios were resulting in monthly results for all variables of the model to vary over time and space, in the platform were reported results for the 8 main commercial species for the Adriatic Sea, namely sardine (PIL), European anchovy (ANE), European hake (HKE), red mullet (MUT), common sole (SOL), Norway lobster (NEP), mantis squillid (MTS) and deep-water rose shrimp (DPS).

Results from the 6 scenarios for these 8 specie were summarized into maps of spatial distribution of resources and trends of the total biomass, averaging results into 7 timeframes of 5 years each (2016-20, 2021-25, 2026-2030, 2031-35, 2036-40, 2041-45, 2046-50). Thus a total of 48 GIS maps have been produced and loaded to the platform (8 species x 6 scenarios), allowing the visualization of 7 above mentioned timeframes. An example of spatial map is reported in Figure 14.

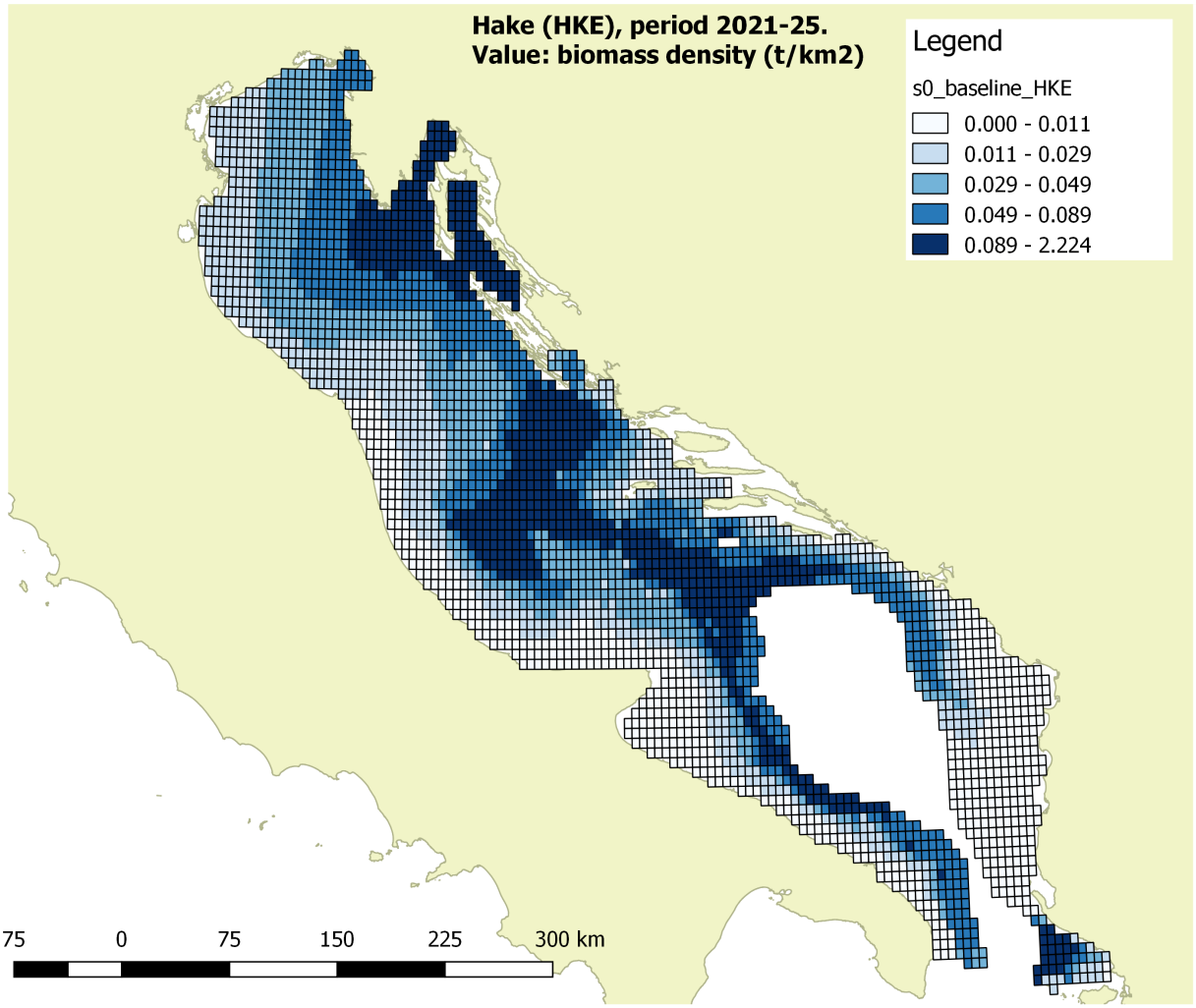



***Figure 14.*** Representation of average spatial distribution of European hake biomass in period 2021-25 in the baseline scenario S0.

Moreover, in order to make the user appreciating the dynamics over time of resources, time evolution graphs are included representing the changes in resource biomass and in catches for each species in each scenario. An example of these graphs is reported in Figure 15.

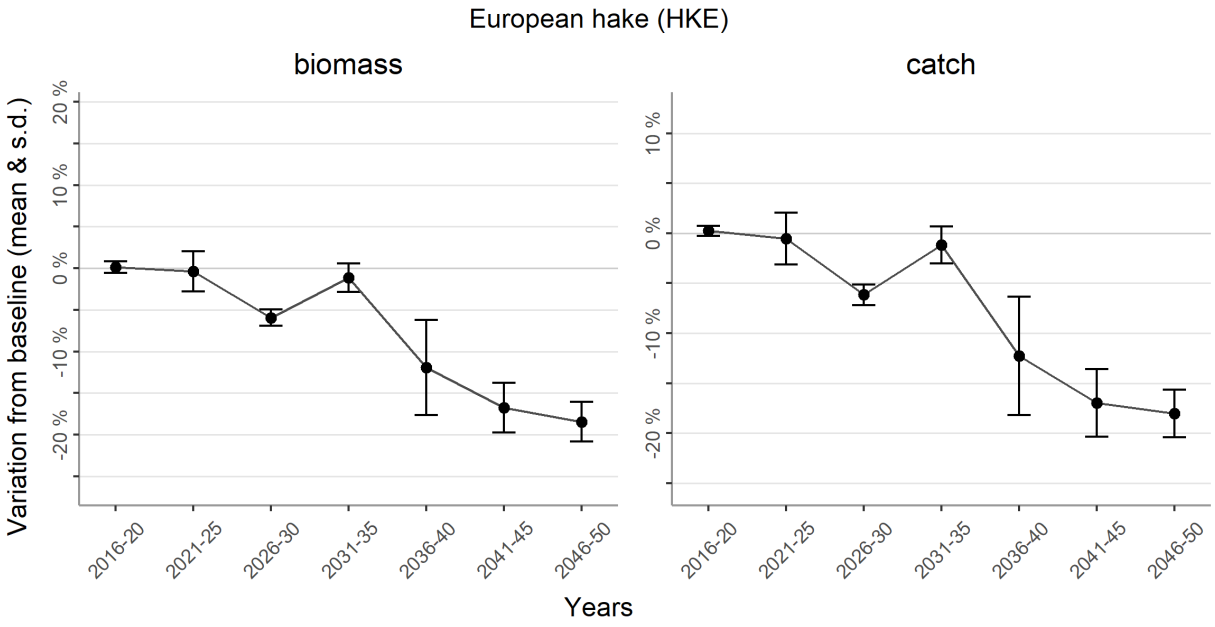



***Figure 15.*** Diagram of European hake's biomass and catch average trend in the climate scenario S4. The dots represent the average value of the 5-year period and the whiskers the standard deviation.

## Summary Module

Ad-hoc interaction workspace between module layers has been implemented. The workspace gives the user the possibility of simple calculations on different layers on a regional/county basis (average, sum, min and max value) (Fig. 16,17).

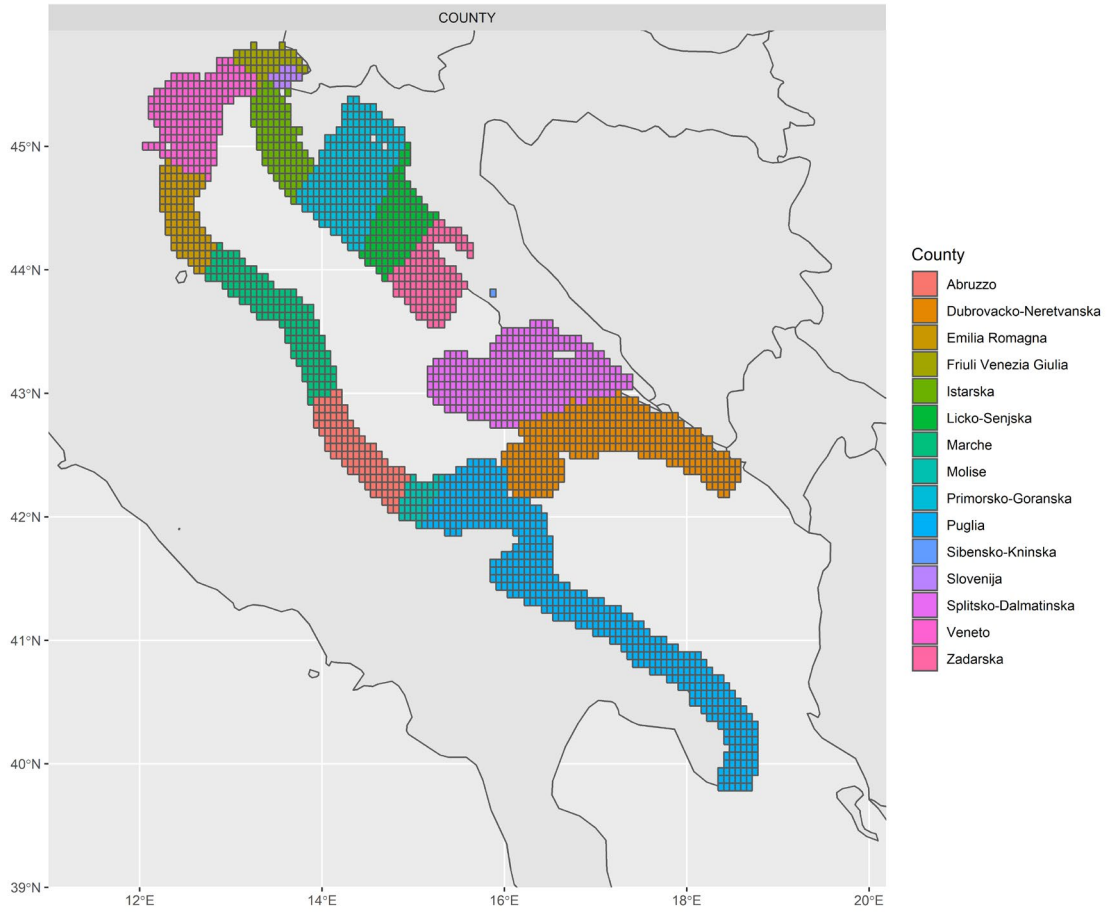
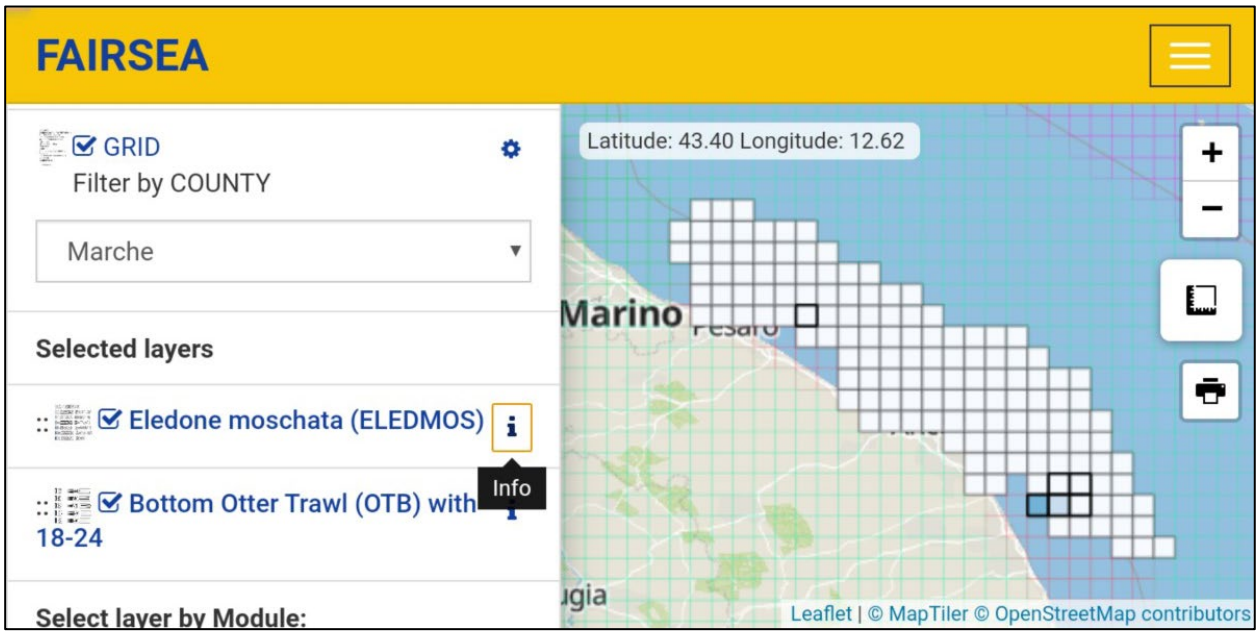



***Figure 16.*** National waters FAIRSEA regional/county Grid.




**Eledone moschata (ELEDMOS)**

Metrics on N_Km2

| |
|---|
| Grid filter: **Marche** |
| Average: **4.004161743697478** |
| Min: **0** |
| Sum: **952.9904949999997** |
| Max: **66.91217** |

**Bottom Otter Trawl (OTB) with 18-24**

Metrics on X2018

| |
|---|
| Grid filter: **Marche** |
| Average: **825.5096899224806** |
| Min: **0** |
| Sum: **141987.66666666666** |
| Max: **8332.66666666667** |

***Figure 17.*** Interaction workspace between module layers in the IP. This example displays the spatial distribution and summary calculation on *Eledone moschata* from MEDITS survey and the fishing effort of bottom trawler in the Marche region waters.

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