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

D 2.2.4 – Simplified integrated tool

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Simplified integrated tool

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

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Acronyms used

CFP	Common Fisheries Policy
EAF	Ecosystem Approach to Fisheries
EAFM	Ecosystem Approach to Fisheries Management
EwE	Ecopath with Ecosim
FAIRSEA	Fisheries in the AdrIatic Region – a Shared Ecosystem Approach
FG	Functional Group
FWM	Food Web Model
GSA	Geographical Sub Areas
LP	Lead Partner
MSFD	Marine Strategy Framework Directive
NGO	Non Governamental Organization
PP	Project Partner
SS	Sum of Squares
SSB	Spawning Stock Biomass
WP	Work packages

INTRODUCTION

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. The best way to reach sustainability, in fact, is to ensure stakeholders' participation in the process that requires time, trust, transparency and efficient steering. The 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, and foster a consensus on the state of the environment and fisheries in the region.

Project specific objective 1: **Enhance transboundary integrated competence in the field of ecosystem approach to fisheries**

Enhance the transnational competencies and skills in the field of EAF in all network's members, by crossing and pooling resources and complementary expertise, exchanging and integrating knowledge and sharing the results. The goal is to develop a territorially integrated conceptualization of the EAF beyond existing differences and boundaries, and to strengthen and structure a network for future transnational plans, useful in the framework of the Common Fisheries Policy (CFP). This will result in reinforcing cohesion and encourage identification and adoption of economic optimal strategies.

Project specific objective 2: **Implement a shared "state of the art" integrated platform for the region**

Develop an operational spatially explicit platform that integrates the dynamics of water masses and primary production patterns, main components of the ecosystem in terms of target species and their food, main fisheries spatio-temporal dynamics, also accounting for socio-economic impacts. The tool will result from a novel integration of existing information and numerical approaches applied in the Adriatic basin (GSA17 and GSA18). The FAIRSEA integrated platform will permit testing different exemplificative policies that will be analysed and presented to stakeholders and policy makers for a joint discussion.

Project specific objective 3: **Share benefits and challenges of ecosystem approach to facilitate the achievement of CFP objectives**

Implement participatory processes for sharing the integrated conceptualization of the ecosystem approach to fisheries and the insights obtained from pilot applications. Project process enhances collaborative and participated definition of policies to be tested, also through the involvement of a wide range of key stakeholders. The production of guidelines and best practices for transnational integrated frameworks useful for an ecosystem approach to fisheries is another aim of FAIRSEA. Another objective is transferring at different levels and to different groups the potentialities and the difficulties of the approach, in order to increase its further development in the region and outside the region.

The Integrated platform

The project objectives are going to be met through an Integrated Platform. The collective development of the integrated platform will enhance partners' expertise on an approach seldom carried out in the Mediterranean Sea. The integrated platform results in a spatially explicit dynamic tool, integrating cornerstone elements for an ecosystem approach to fisheries that are: water masses circulation and connectivity (module HYDRO), biogeochemical planktonic processes (BGC), distribution of resources (BSTAT), catch and fleet statistics (FSTAT), effort distribution (EFFORT), bioeconomic responses (BIOECO) and food web dynamics (FWM). The attention to the spatial components in the distribution of the resources, the variability of the oceanographic condition, the management policies and the socio-economic impact is a particularly innovative and extremely valuable aspect. The shared integrated platform will be used as a planning tool to implement demonstrative testing of applicable fisheries policies both at local (subareas) and whole Adriatic scales. Especially, it will provide a scientific basis to formulate and evaluate shared management advice in the local and international participatory processes, answering to the need of reference points knowledge for the optimisation between ecological and socio-economical sustainability. The process developed in FAIRSEA will provide an opportunity to describe best practices and define guidelines for a sustainable fishery management. The integrated platform will result in a product that constitutes the basis for a science-based decision support tool and a preliminary step towards the future development of multiannual fishery management plans.

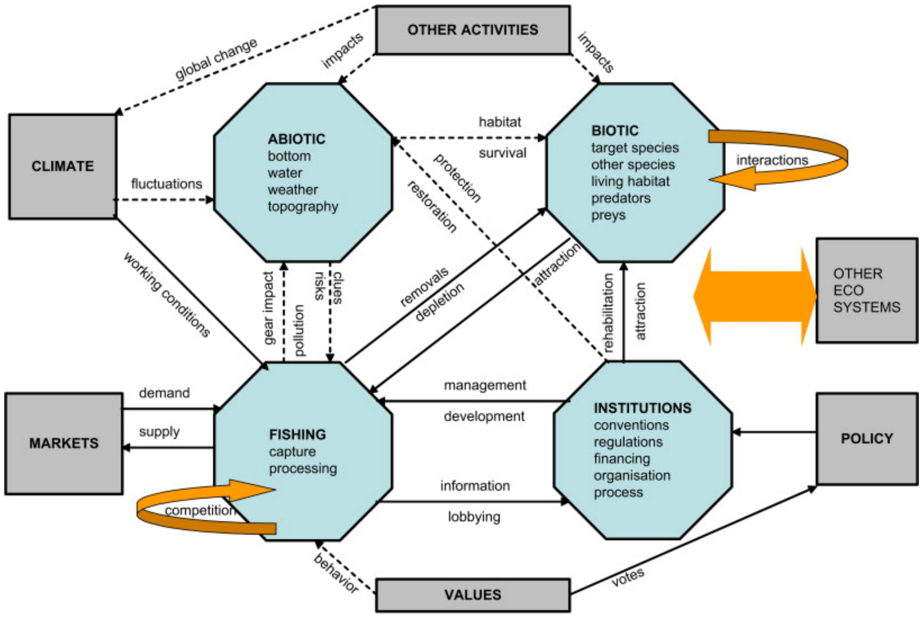


Figure 1. Ecosystem approach to fisheries: pressures, interactions and factors involved.

Communication strategy

Stakeholder and public engagement is central to the success of FAIRSEA, which aims at broadening stakeholder participation in fisheries management and at disseminating ecosystem views and concepts beyond partnership. Innovative communication strategies will be adopted to ensure large engagement and will include visual instruments, gaming approaches and storytelling. These components are integrated into the Communication Plan, jointly prepared by the WP2 leader and the Communication Managers (CM) of each Project partner.

Communication and awareness raising are essential and pervasive activities throughout the project's life and integrated within all WPs. This interconnection aims at bringing closer scientists, policy makers and end-user communities while making them work together on sustainable management of Adriatic fisheries.

The project would also use innovative tools for sharing the information on activities implemented during the project. While communication items such as press releases, policy papers, fact sheets, conference presentations and digital materials are developed aimed at broad set of stakeholders, a simplified version of the decision support tool will be used to interact with stakeholders, institutional bodies and with students.

Figure 2. The 5 areas of use of the Integrated platform developed in FAIRSEA for an Ecosystem approach to fisheries

The development of new tools is essential considering the objectives of the project and the complexity of the platform. The different uses of the platform spam from support to policy makers, to increase capacity in the area, to share results and information to stakeholders to support understanding of the complexity of the ecological-human interaction that is pervasive in the fisheries system. The simplified integrated tool is thus conceived as a mean for facilitating the transferring of knowledge, capability to use, awareness increase.

Communication objectives of the simplified integrated tool

According to the AF, the FAIRSEA project has three main communication objectives each with specific targets. A simplified version of the decision support tool will be used to interact with stakeholders, institutional bodies and with students.

This activity has the role to contribute to the **"Communication objective 1: Informing about possible tools to tackle ecosystem complexity".** The EAF moves fisheries management from the single-species models used in stock assessments, to more complex models that include species interactions, environmental drivers and human consequences. Different models and tools have been developed to tackle this complexity. However, difficulties in understanding the models and related uncertainties by those who make the decisions result in hesitation to use EAF approaches. Explaining how EAF tools work is essential to predicting the effects of fisheries and other drivers. Complexity makes communicating new research about these ecosystems a challenge. Too much complexity can confuse the audience, even one that is scientifically literate. The role of communication is to translate such complexity in a language understandable to non-technical audience and policy-makers involved in fisheries management. This requires the development of tools to effectively disseminate knowledge and inform management in a simple and effective way.

Target groups: Local, regional and national authorities; universities and research institutions; NGOs; education and training organisations.

Tactics/approach: Two approaches will be used. On one side, increasing the literacy of Adriatic community on EAF quantitative tools. Summer schools on advanced methods for an EAF will allow for a deep understanding of principles and scientific capabilities to tackle ecosystem complexity, thus enhancing technical skills of students, researchers and policymakers. A second approach is based on the use of a simplified version of the integrated decision support tool developed in WP4 that will be used in the framework of WP2 as a demonstrative and applied tool for highlighting potentialities of EAF at different target groups during public and networking events. The simplified tool will include a comprehensible and detailed user manual and an interactive and attractive user interface. Stakeholders are expected to be directly involved in the model use since part of the purpose is capacitybuilding and training in the understanding of scientific modelling. The aim is to introduce the use of ecosystem models in fisheries management by translating complexity into a language understandable to the non-technical audience.

Specific objectives of the Simplified Integrated Tool

A simplified version of the integrated decision support tool is developed to allow implementing a participatory activity for the definition of management/policy scenarios to test and illustrate basic principles of EAF. 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. Thus, other than the scientific development of a shared conceptual and operational framework for an Ecosystem Approach to Fisheries (EAF), adapted to address stakeholders' and policy makers' issues, **the integrated efforts of the project are used for increasing capacities in the field of EAF,** for improving technical skills and capacities in the region also through demonstrative applications.

In order to create an impact that will last beyond the end of the project, targeted and innovative instruments will be prepared and disseminated during the communication events. These instruments include the **Simplified Integrated tool** (Activity 2.2.4; this deliverable) reproducing the Adriatic/Mediterranean marine food web and fisheries complexity, considering most of the details included in the integrated platform (see WP4 deliverables), aggregated and compacted in a single approach.

Development of the Simplified Integrated tool

The approach chosen is the Ecopath with Ecosim and Ecospace modelling that allows for

- Develop a tool strongly based on the results from the module food web modelling (FWM);
- Including information on the biogeochemistry and primary production as coming from HYDRO & BGC modelling;
- Talking into account all the information coming from trawl survey (independent fisheries data) as analysed in BSTAT module;
- Considering all the catches and fishing capacity data acquired in the FSTAT module;
- Including also some information on costs and revenues as included in the module BIOECO;
- Evaluating the results of fisheries displacements as produced by module EFFORT;

The simplified integrated tool structure, therefore, is conceptually similar to the integrated platform to be developed in WP4 with its complexity in species, fisheries, environmental variabilities and socio-economic pressures.

The simplified integrated tool will be used during the project and after it to increase capacities in the field of EAF and to increase the awareness of the general public and especially the younger generations on what is fishing and the large complexity of species targeted by exploitations. Moreover, the simplified integrated tool will allow grasping what is the impact on marine ecosystem processes induced by fishing and what is the complexity of fisheries techniques.

The simplified integrated tool allows obtaining more quickly the scenarios representing environmental and anthropogenic factors (climate, etc.) including fisheries management options. Results will be simplified but accurate.

The tool developed can be used in in group activities to perform in technical and scientific events in collaboration with other projects and entities. Given its nature the simplified integrated tool do not need to be updated and could be useful also beyond the project thus increasing the durability of the EAF framework.

Structure

The simplified integrated tool was developed using the software package Ecopath with Ecosim (www.ecopath.org; Christensen et al., 2008) which is a flexible tool largely used wordwide and that embeds a series of approaches and diagnostics that facilitate its application (Heymans et al., 2014). The food web model can be forced by environmental and anthropogenic drivers, which are tipically the primary production and the fishing effort, respectively. Thus the “food web” model can be refer more comprehensively and accurately as an “ecosystem food web model” and it is used as a simplified and portable integrated tool.

Compared to the model developed in “D4.7.1 – Calibrated Ecopath with Ecosim model for the Adriatic and Ionian region”, the simplified IP is developed by aggregating functional groups of the model for the GSA17-18 into approximately 40 functional groups. The approach was to consider the structure used for the Fish N’ Ships card game (see “D.2.3.5 Food web card game”).

Thus the Simplified IP had the following 43 functional groups resulting from aggregation of species and groups from the FWM of the GSA17-18.

Table 1: Functional groups of the Simplified Integrated tool and their relation with the groups of the FWM developed in Activity 4.7.

Functional Group name Simplified IP	Functional Group name FWM	Short name FWM
G01_Seabirds	Seabirds	G01_SBR
G02_Turtles	Marine turtles	G02_TTL
G03_Dolphins and other mammals	Mid-large odontocets	G03_ODO
	Common Bottlenose Dolphin	G04_DBO
	Striped Dolphin	G05_DST
	Fin whale	G06_FIW
G04_Rays	Rays skates (Slope)	G07_BATs
	Rays skates (Shelf)	G08_BATh
G05_Sharks	Sharks (Slope)	G09_SELs
	Sharks (Shelf)	G10_SELh
	Blackmouth catshark	G11_SHO
G06_Large Pelagics	Large pelagics fish	G12_PLS
G07_Medium pelagics	Medium pelagics fish	G13_PMS
G08_Demersal piscivorous	Demersal piscivorous fish (Slope)	G14_DPSs
	Demersal piscivorous fish (Shelf)	G15_DPSh
G09_Epipelagic fish	Epipelagic fish	G16_EPI
	Mesopelagic crustacean feeding fish	G17_MCF
	Zooplancton jellyfish feeding fish	G18_ZJF
G10_Demersal	Demersal fish (Slope)	G19_DEMs
	Demersal fish (Shelf)	G20_DEMh
	Gurnads	G23_GUR
G11_Turbot and Brill	Turbot and brill	G22_FTB
G12_Other gadids	Other gadids	G24_GDX
G13_Other small pelagics	Other small pelagics	G25_SPX
G14_Mackerels	Mackarels	G26_MCK
G15_Anglerfish	Anglers	G27_LOP
G16_Sardine	Sardine (age 0)	G28_PIL0
	Sardine (age 1+)	G29_PIL1
G17_Anchovy	Anchovy (age 0)	G30_ANE0
	Anchovy (age 1+)	G31_ANE1

Functional Group name Simplified IP	Functional Group name FWM	Short name FWM
G18_Common sole	Other flatfishes	G21_FLX
	Solea (age 0)	G32_SOL0
	Solea (age 1)	G33_SOL1
	Solea (age 2+)	G34_SOL2
G19_Red mullet	Red mullet (age 0)	G35_MUT0
	Red mullet (age 1+)	G36_MUT1
G20_European hake	Hake (age 0)	G37_HKE0
	Hake (age 1)	G38_HKE1
	Hake (age 2+)	G39_HKE2
G21_Squids	Other cephalopods (Slope)	G40_CPXs
	Squids	G42_SQD
G22_Common cuttlefish	Other cephalopods (Shelf)	G41_CPXh
	Common cuttlefish	G43_CTC
G23_Musky octopus	Musky-Horned octopus	G44_OCM
G24_Mantis shrimp	Mantis shrimp (age 0)	G45_MTS0
	Mantis shrimp (age 1+)	G46_MTS1
G25_Norway lobster	Norway lobster (age 0)	G47_NEP0
	Norway lobster (age 1+)	G48_NEP1
G26_Shrimps	Blue and Red Shrimp	G49_ARA
	Red Giant Shrimp	G50_ARS
	Deep-water Rose Shrimp (age 0)	G51_DPS0
	Deep-water Rose Shrimp (age 1+)	G52_DPS1
	Caramote prawn	G53_TGS
G27_Other crustaceans	Decapods_Reptantia (Slope)	G54_REPs
	Decapods_Reptantia (Shelf)	G55_REPh
	Decapods_Natantia (Slope)	G56_NATs
	Decapods_Natantia (Shelf)	G57_NATh
G28_Suprabenthos	Peracarida (suprabenthos)	G58_PER
G29_Clams	Clams	G59_CLM
G30_Scallops	Scallops	G60_SCL
G31_Benthic macroinvertebrates	Other Benthic invertebrates	G61_BIX
G32_Seagrasses	Seagrasses	G62_SGR
G33_Seaweed	Seaweeds	G63_SWD
G34_Jellyfish	Jellyfish	G64_JLY
G35_Macrozooplankton and Euphasiid	Macrozooplankton &Euphasiacea	G65_ZMA

Functional Group name Simplified IP	Functional Group name FWM	Short name FWM
G36_Mesozooplankton	Mesozooplankton	G66_ZME
G37_Microzooplankton	Microzooplankton	G67_ZMI
G38_Bacterioplankton	Bacterioplankton	G68_BPL
G39_Diatoms	Phytoplankton - diatoms	G69_PDM
G40_Picophytoplankton	Phytoplankton - dinoflagellates	G70_PDF
G41_Discards	Discards, carrion	G71_DSC
G42_Particulate organic matter	Suspended detritus	G72_POM
G43_Benthic detritus	Bottom detritus	G73_BTD

Fleets represented in the simplified IP avoided all the stratification of fleets by size and implemented a simple representation by country of main gears, i.e., dredges (DRB), otter trawl (OTB), beam trawl (TBB), purse seine (PS), pelagic trawlers (PTM), longlines (LLX), gillnets (GNX) and mixed small scale fisheries (MIX). The resulting structure of fleets is reported in Table.2

Table 2: Fishing fleets represented in the Simplified Integrated tool

Fleet name	Fleet code
HRV_Rampon	HRV_DTX
HRV_Gillnets	HRV_GNX
HRV_Longlines	HRV_LLX
HRV_Small scale fisheries	HRV_MIX
HRV_Otter trawl	HRV_OTB
HRV_Purse seine	HRV_PS
HRV_Dredges	ITA_DRB
ITA_Gillnets	ITA_GNX
ITA_Longlines	ITA_LLX
ITA_Small scale fisheries	ITA_MIX
ITA_Otter trawl	ITA_OTB
ITA_Purse seine	ITA_PS
ITA_Pelagic trawlers	ITA_PTM
ITA_Rapido	ITA_TBB
Albania Montenegro	OTH_MIX
SLO_Small scale fisheries	SLO_MIX
SLO_Otter trawl	SLO_OTB
SLO_Small pelagic fisheries	SLO_SMP

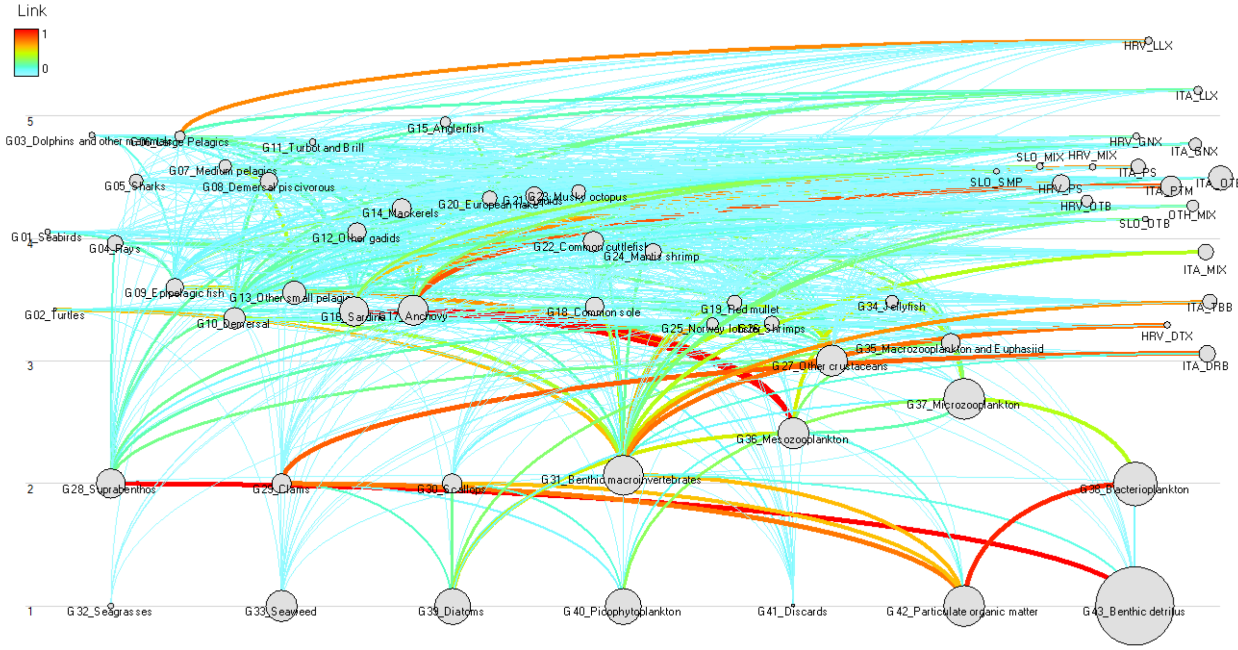


Figure 3. Flow diagram of the FGs of the simplified Integrated tool. On the right all the fleets represented in the model. Circles are proportional to square root of FG biomass (or catches). Connecting arcs are proportional to flows and colored considering its quantities.

Data Input to the Simplified Integrated tool

The simplified IP initial conditions and parameters (Ecopath module) were obtained by:

- aggregating parameters and biomasses of the model developed in the module FWM ("*D 4.7.1 Calibrated Ecopath with Ecosim model for the Adriatic region*") by using the weighted average of initial parameters on the basis of biomasses of the FGs to aggregate (see Libralato et al., 2010).
- Aggregating the diet matrix of the model developed in the module FWM ("*D 4.7.1 Calibrated Ecopath with Ecosim model for the Adriatic region*") by weighting the elements with the consumption of the FGs to aggregate (see Libralato et al., 2010).

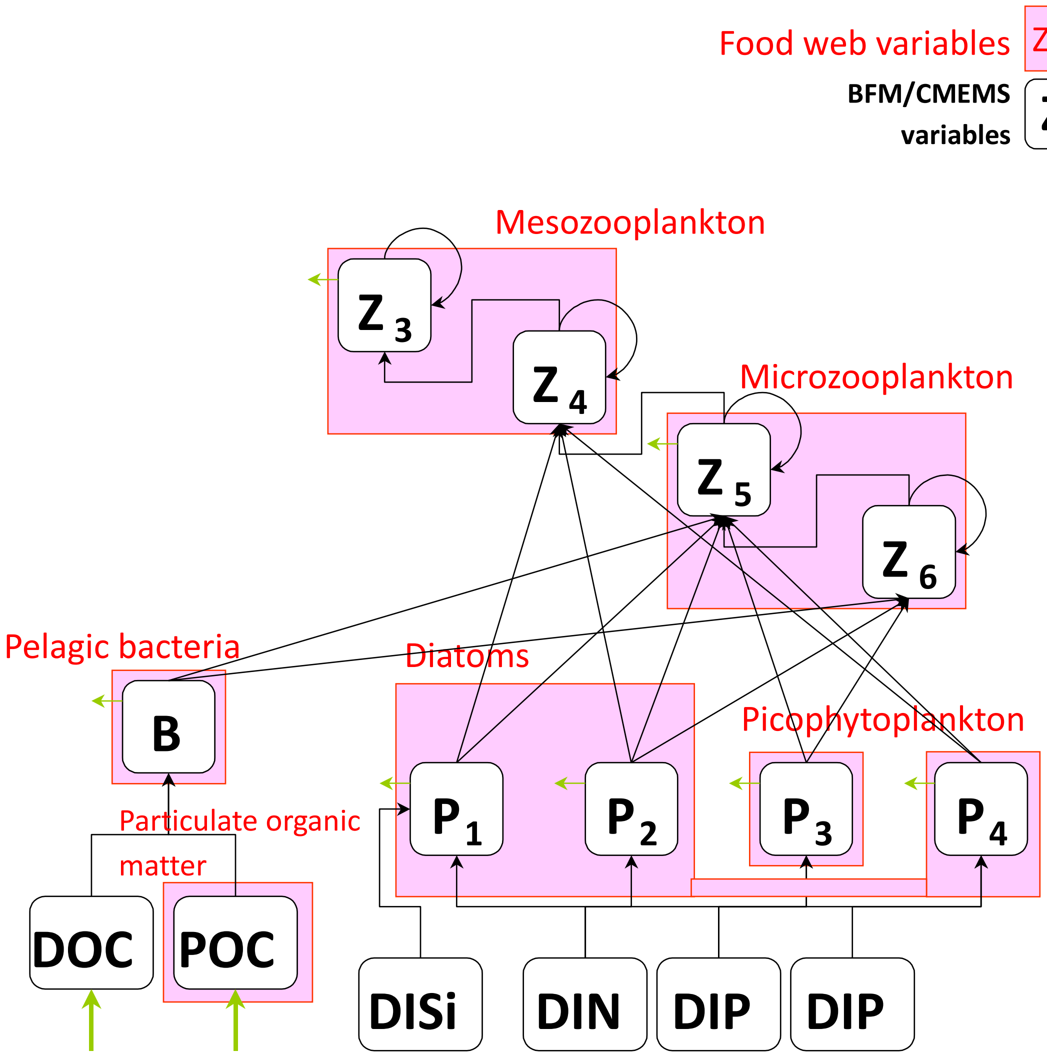
- Aggregating initial conditions of catches for FGs by summing together initial catches by gear and by species from module FSTAT (see "*D4.4.1 Catches and fishing capacity by fleet segment and port*").

The simplified IP forcings and parameters of the time dynamic module (Ecosim module) were obtained as in the following.

1) Aggregating time series of catches for FGs by summing together catches from module FSTAT for each year as distinguished by FG (see "*D4.4.1 Catches and fishing capacity by fleet segment and port*").
2) Aggregating time series of biomasses for FGs by summing together biomasses from the module BSTAT analysing trawl survey data (both MEDITS and SOLEMON); spatial data were lumped over space using the Souplet formulation and/or results from application of the tools BioIndex and Biostand (see: *"D4.3.1 Spatio-temporal distribution of marine species").*
3) Results from module BGC for the hindcast biogechemical simulation (D4.2.1 Production patterns in the Adriatic Sea) were aggregated over the water column and over space to obtain time series over time of biomass of G36_Mesozooplankton, G37_Microzooplankton, G38_Bacterioplankton, G39_Diatoms, G40_Picophytoplankton, G42_Particulate organic matter (see also Figure 4).
4) Data on stock assessments regarding Fishing mortality, SSB and catches for assessed species (Anchovy, Sardine, Common sole, red mullet, European hake, Mantis shrimp, Norway lobster) were taken from module BIOECO (*"D4.6.1 Calibrated BEMTOOL applications to the Adriatic Region").*
5) Time series of efforts for the time dynamic module were obtained by combining information contained in modules EFFORT (hours spent fishing by fleet obtained from VMS/AIS analysis; *"D4.5.1 Fishing effort map distribution")* and FSTAT (fishing capacity; *"D4.4.1 Catches and fishing capacity by fleet segment and port")* to have the best estimate of effort applied to fleets over time.

These efforts resulted in a total of 26 time series of biomass, 27 time series of catches and 18 time series of effort were used to calibrate the Ecosim model. The ANNEX 2: "FAIRSEA GSA1718 simplified time series 20220218.csv" contains all the time series used.

Figure 4. Variables of the BFM/CMEMS model used in the module BGC pf FAIRSEA and their aggregation into variables of the simplified integrated tool.



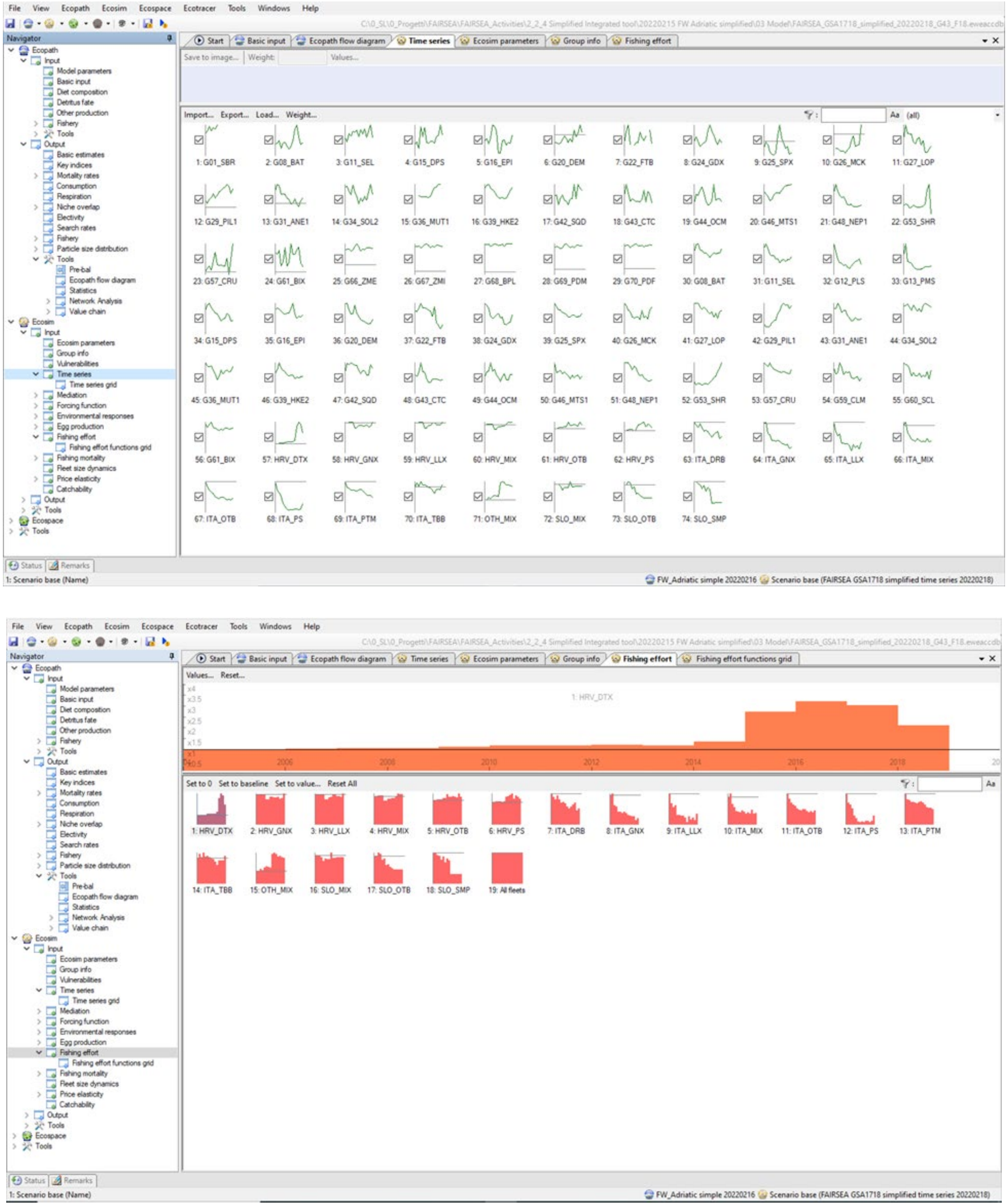


Figure 5. Time series used in the Simplified Integrated tool for the time dynamic simulation. Above: biomasses and catches by FG used for the calibration process. Below: Time series of effort by fleet used as forcings.

Calibrated Simplified Integrated tool

All sets of data obtained from the different modules of the WP4 were thus embedded into the simplified integrated tool to represent time dynamic of the system at best.

To assure that the model developed is accurate in representing time dynamic processes and effects of forcings, the model has been calibrated over time series of data concerning years 2004-2018 (hindcast). Model results in terms of biomasses and catches by FGs were confronted with observations (see Figure 5). The model was forced with primary production affecting G39_Diatoms, G40_Picophytoplankton, and yearly effort changes by fleet (Figure 5 lower panel).

The calibration consisted in minimize the Sum of Squares (SS) of differences between observations and model results in runs with different setting of the prey predator interaction (vulnerability parametrization) . The process was similar to that carried out in the module FWM (see *“D 4.7.1 Calibrated Ecopath with Ecosim model for the Adriatic region*”).

The resulting best model is considered the best hindcast model representing the past observations (see Figure 6) and useful for producing scenario simulations for the future.

Future improvements

Given the simplified approach used, the Simplified Integrated tool might be improved in several aspects in the future, especially regarding the best fitting. In fact, several different fitting approaches might be done for:

- Improving the overall best fit;
- Setting differently several other Ecosim parameters (see *“D 4.7.1 Calibrated Ecopath with Ecosim model for the Adriatic region*” and the citations therein)
- Providing opportune fitting improving some target functional groups or data (for example by weighting time series to fit);
- Developing ensamble of fitting simulations: this approach is time consuming not simple to carry out in controlled manner when simulations are too many but has the advantage of increasing the potential accuracy of “average of the ensamble” and have clear explicit demonstration of model uncertainty.

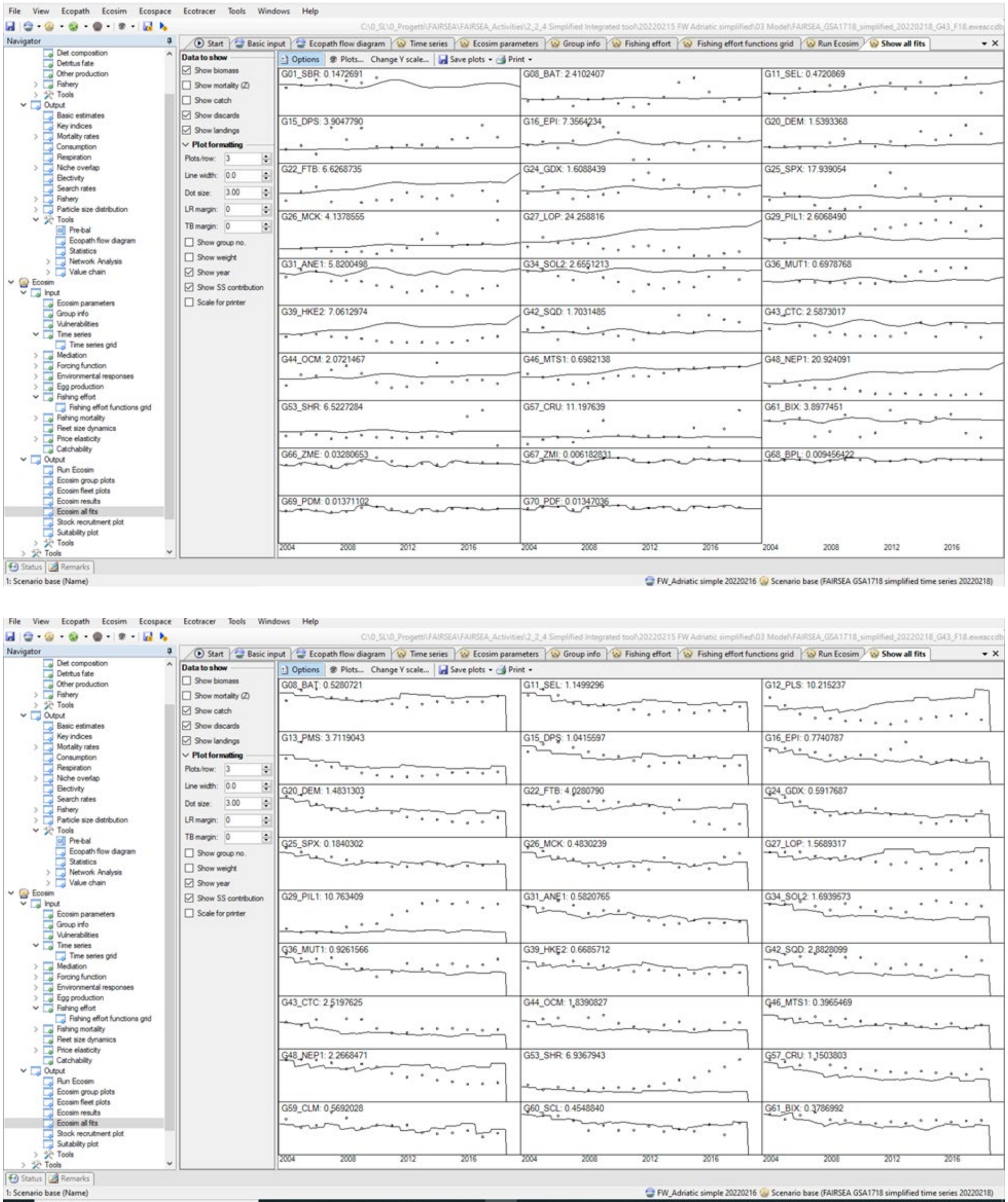


Figure 6. Simplified Integrated tool model calibrated over time series of BGC, BSTAT time series of biomass (upper panel) and FTAT time series of catches. The model is forced with primary production changes over time from BGC results and effort by fleet over time from EFFORT module.

Use of the Simplified Integrated tool

The simplified Integrated tool is developed for making group working and exemplification in dissemination exercises. It is expected that the Simplified integrated tool is used in:

- In **live Demonstrations** of Scientific efforts to wide public (such as Open Days, Science Forums);
- **Lectures** to young broad experts on marine affairs and blue growth: to be used as a demonstrator (e.g., at the Master of the Blue Sustainable Growth);
- In **capacity building events** as a teaching tool to be explored in a few days of analysis (such as the Advanced School AMAREMED);
- **Working groups with technical experts** (from fisheries, policy makers and NGOs) to produce live demonstration of policy and possibly to gain consensus on fisheries policy options;
- In the future it is foreseen to improve the Simplified Integrated tool and permits its development as **TWIN of the OCEAN for the Adriatic Sea**;
- Further developments of the Spatial patterns will allow to use the Simplified Integrated Tool in **Marine Spatial Planning exercises** (e.g., MSP challenge).

Analyses with the Simplified Integrated tool

The accuracy of the hindcast (2004-2018) permits to simulate future scenarios to be tested with the simplified integrated tool. Notably there is virtually no limit to the time simulation or future scenarios but some recommendations are here given for being consistent with assumptions and peculiarities of the Simplified Integrated tool.

Duration of the simulation: no limits, but future simulations shorter than 1 year has no meaning. On the contrary, simulations without future forcings from BGC modelling will go to steady state after 20-30 years from last change in effort. Thus relevant future simulations should go from year 2018 to year 2100 according to BGC scenarios.

Fisheries ecology analyses: the Simplified integrated tool represents a useful tool for conducting sensitivity analyses of any aspect related to fisheries ecology that goes from the analysis of technical interactions among fleets (competition of fishing fleets) to cascading effects of fisheries on the ecosystem (e.g., interactions among fisheries and mammals), to ecological drivers affecting fisheries (e.g., change in nutrient inputs from the watersheds).

Ecological Indicators: the Simplified Integrated tool permits calculating a wide set of ecological significant indicators both directly as outputs (see Christensen et al., 2008; Heymans et al., 2013) and other as elaborations of model outputs. These indicators might be useful for comparisons and for example for MSFD-related analyses.

Fisheries Indicators: the Simplified Integrated tool provides estimates of total mortality by species distinguished into fishing mortality (F), predation mortality and other mortalities. The Simplified Integrated tool can also be used to determine MSY by species in the multispecies context. Yet, it is worth nothing, however, that results in terms of F and MSY might be substantially different in multispecies context than those from stock assessment approaches. This is because of the different parametrization, the simplification of the population dynamics in Simplified IP but also because the multispecies representation. It is therefore suggested to consider analyses always in relative terms, to avoid inconsistent results.

Building scenarios with the Simplified Integrated tool

The Simplified Integrated Tool is developed for building scenarios particular fisheries and climate scenarios . Clearly other forcing or changes over time (pollution, temperature, etc) could be implemented, but these analyses might require identification of functional effects of new forcings on the FGs of the Simplified Integrated Tool using experimental data or analyses.

Fisheries management scenarios: the Simplified integrated tool allows representing scenarios of future changes in fisheries sector. Possible changes regard:

- ***modification of future effort*** of any of the 18 fleets represented; notably the simulated changes should be represented as relative values respective to the year 2004 (effort=1);

- ***seasonal modification of effort***: changes of effort by month in the future is possible, for example for representing temporary fishing bans (“fermo pesca”). Yet the results of these applications should be considered with great care because both for biological resolution (there is no explicit representation of stock-recruitment) and for inherent capabilities of the model, these results are highly imprecise. The approach is mainly useful for strategic analyses.

- ***modification of discards and their fate***: these analyses might be done for simulating scenarios of different destiny of the discards, or scenarios of improved selectivity by gear (fleet in the model).

Climate scenarios: the Simplified integrated tool allows representing scenarios of future changes in climate conditions. These might regard changes in productivity as obtained from biogeochemical models (for example scenarios developed in "*D4.1.2 Scenario analysis of future circulation*" and *"D4.2.2 Future scenario of production patterns"*)

ANNEXES

ANNEX 1: The simplified Integrated tool:
"FAIRSEA_GSA1718_simplified_20220218_G43_F18.eweaccdb"

ANNEX 2: "FAIRSEA GSA1718 simplified time series 20220218.csv"