FINAL MEETING OF MPA PROJECTS *PROTOMEDEA*, *MANTIS* AND *SAFENET*

DG MARE, Brussels September 17th 2019

MANTIS: MARINE PROTECTED AREAS NETWORK TOWARDS SUSTAINABLE FISHERIES IN THE CENTRAL MEDITERRANEAN

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http://jadran.izor.hr/mantis

Background

- An overall status of overfishing is reported for most of the demersal resources in the Mediterranean Sea (FAO, 2018)
- Several studies documented the poor exploitation patterns of trawl fisheries characterized by high juvenile fishing mortality and high production of discards
- EU Common Fishery Policy and GFCM forced to reduce the fleet capacity and to increase gears selectivity
- A possible management option is prohibiting trawling when and where recruits and juveniles aggregate.

The new Common Fisheries Policy: sustainability in depth

- Total Allowable Catches
- Fishing licenses
- Boat capacity management
- Reducing environmental impact
- Minimum fish and mesh sizes
- Design and use of gears
- Closed areas or seasons

https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/2015-cfp-management_en.pdf

The main objectives of the MANTIS project are:

i) to review and integrate the knowledge of previous national and EU project on the space-time dynamics of fisheries resources and on Ecosystem Approach to Fishery Management (EAFM) in the Central Mediterranean and

ii) to investigate how a network of Marine Managed Areas (MMAs) can contribute to improve sustainable fisheries and to reach MSY target of CFP in the Central Mediterranean.

The Mantis Partnership

Consiglio Nazionale delle Ricerche

WWF

OGS

CoNISMa
Consorzio Nazionale Interuniversitario per le Scienze del Mare

INSTITUTE OF OCEANOGRAPHY AND FISHERIES SPLIT 1930.

NISEA
Fisheries and Aquaculture Economic Research

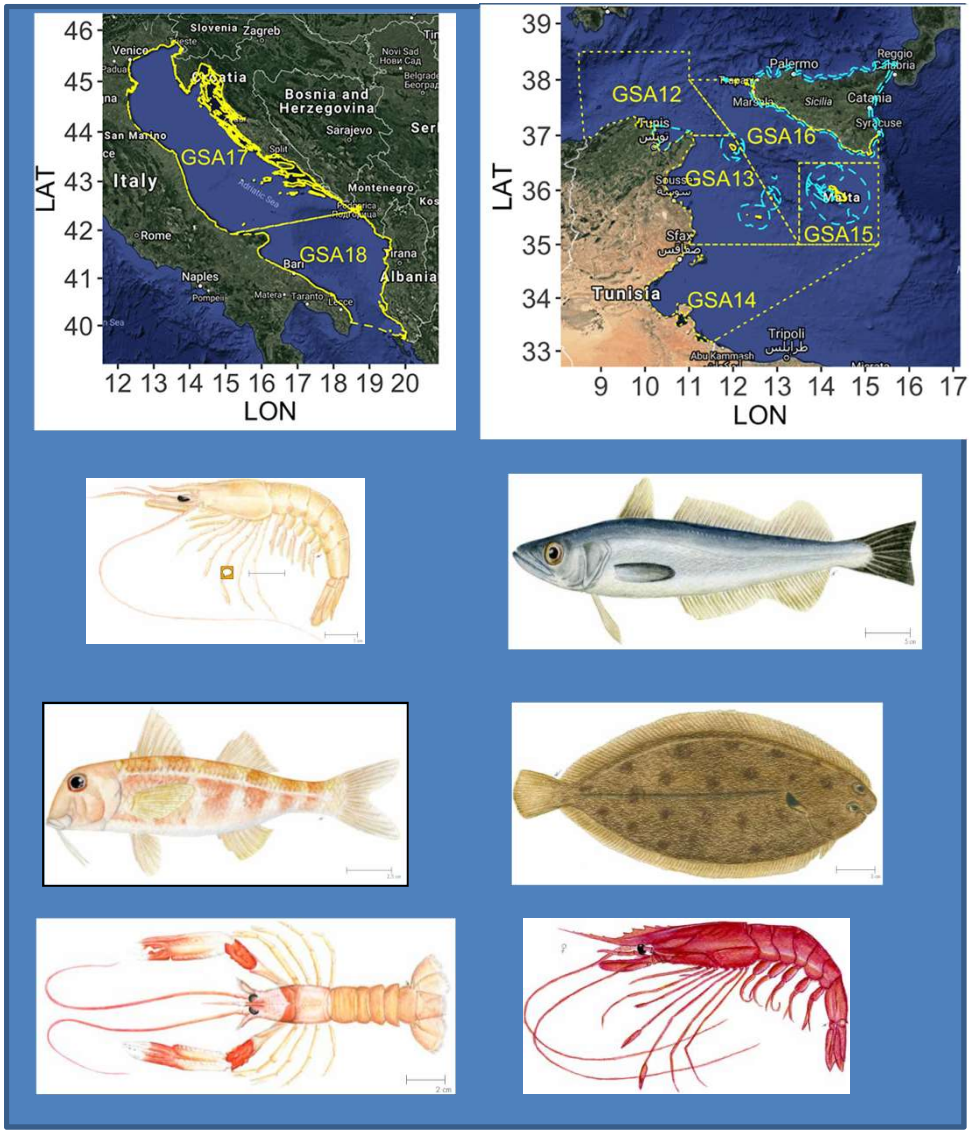
OCEANA

MINISTRY FOR SUSTAINABLE DEVELOPMENT, THE ENVIRONMENT AND CLIMATE CHANGE

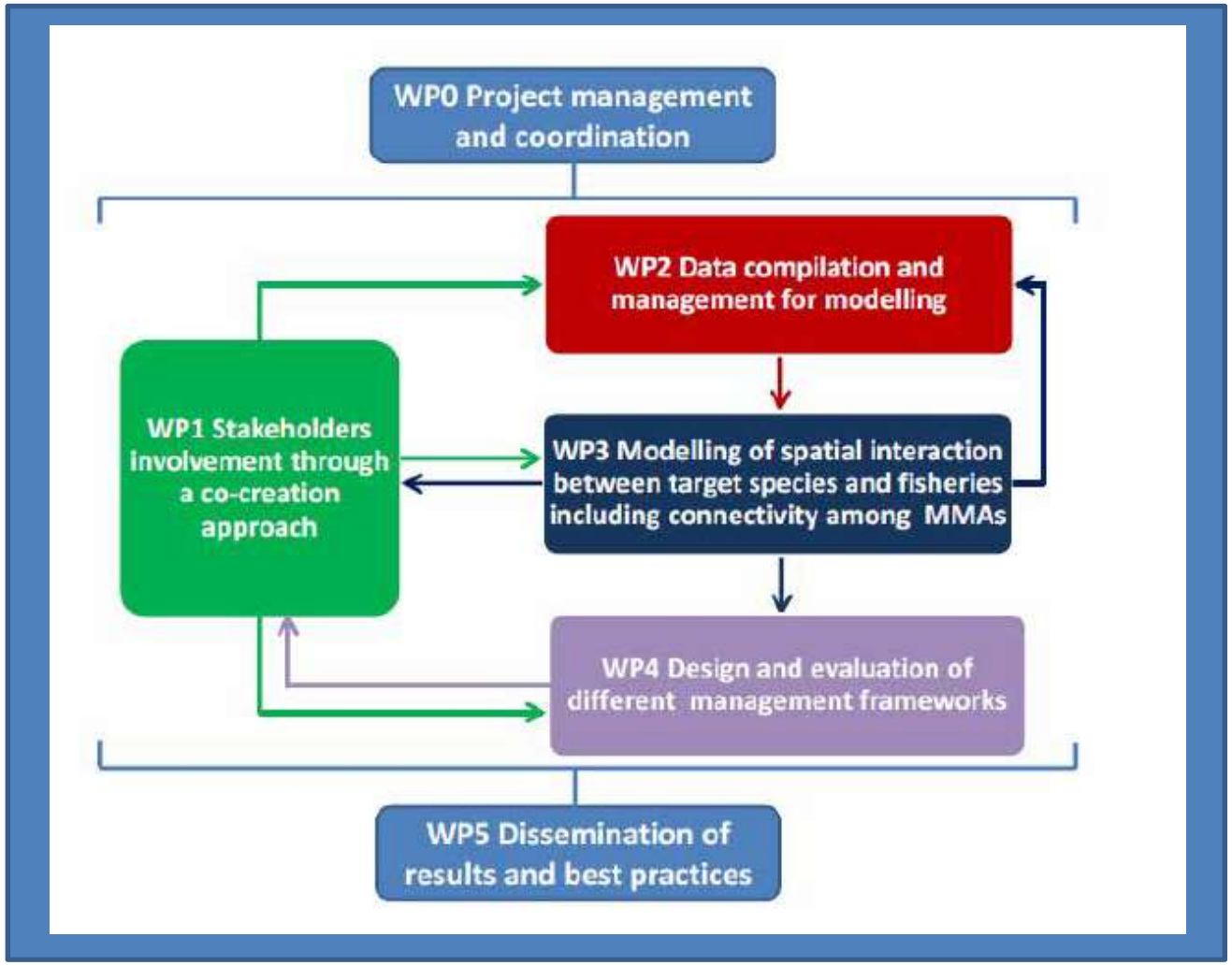
<u>Two case studies</u> and <u>Four target species</u> for each case study were considered:

- **The Strait of Sicily (*Parapenaeus longirostris*, *Merluccius merluccius*, *Mullus barbatus*, *Aristaeomorpha foliacea*)**

- **The North and Central Adriatic (*Solea solea*, *Merluccius merluccius*, *Mullus barbatus*, *Nephrops norvegicus*).**

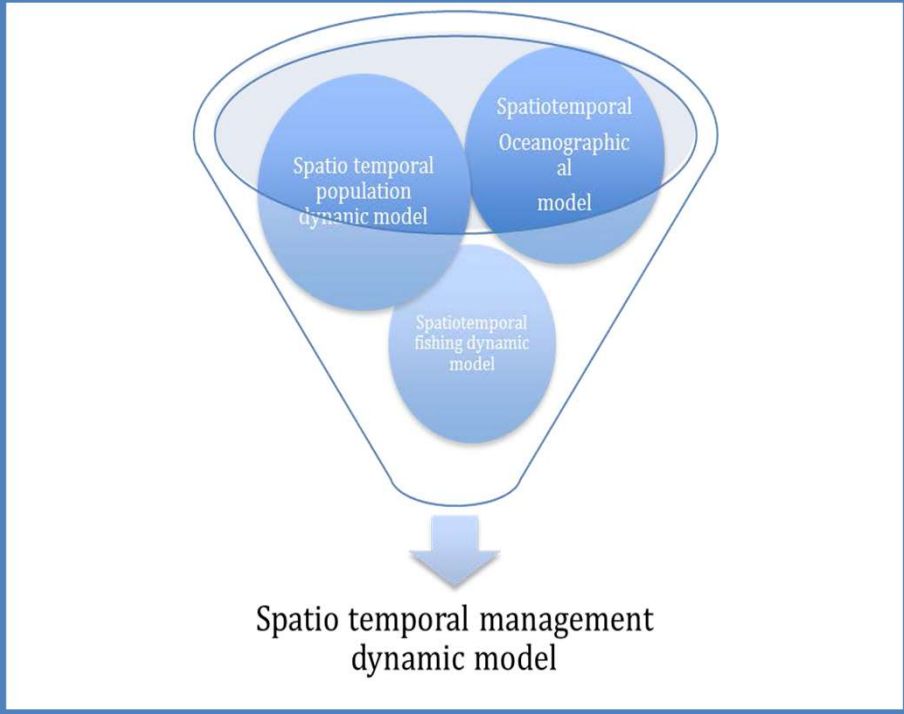


The MANTIS' activities were organized into 5 Work Packages (WP).



The MANTIS approach to assess the effects of MPAs on stock and fisheries

The analytical framework was based on the logical approach used by the SMART (Russo et al., 2014) models to obtain responses of fish stocks (SSB, R, F) and fisheries performance (Y, Economic Gains) under different management scenarios, including spatial based measures



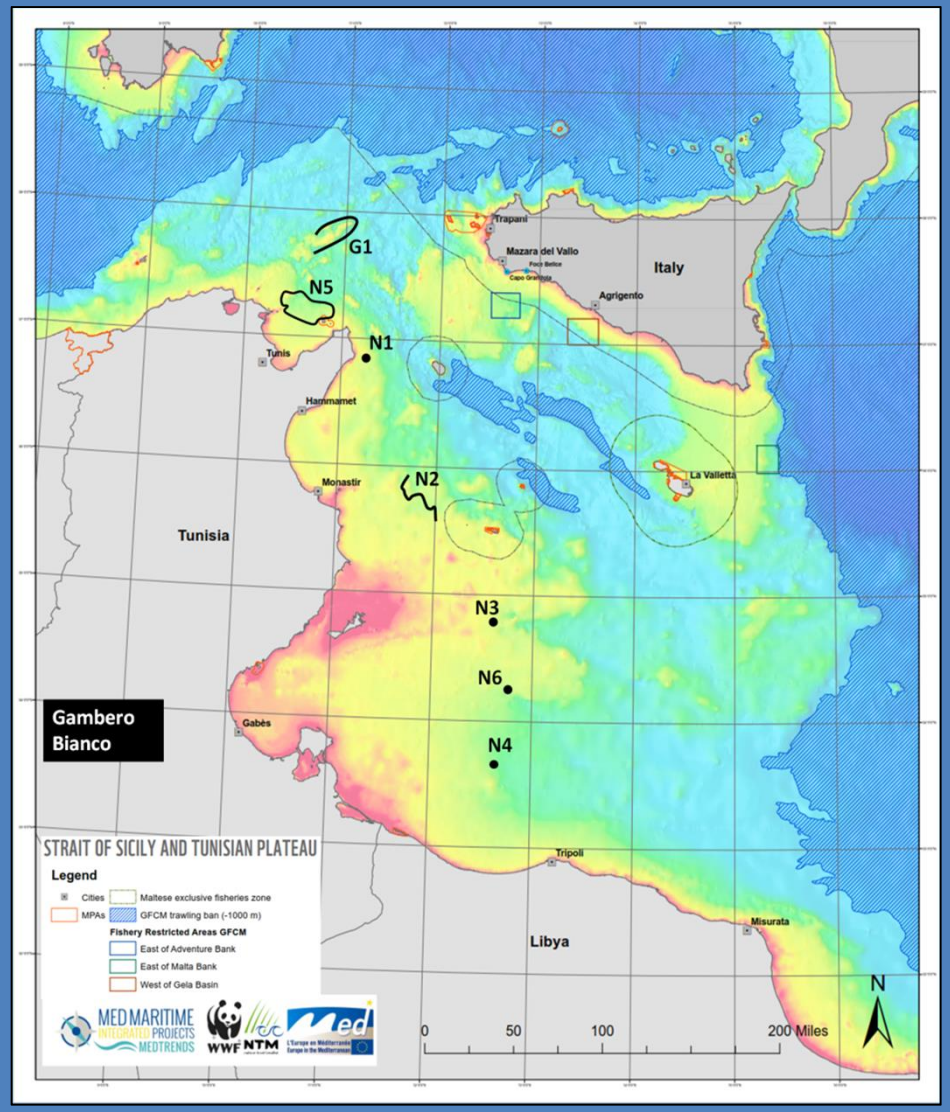
From Mahevas & Pelletier, 2004

WP1 involved **stakeholders in a participatory approach** to:

a) setting scenarios;
b) giving managements inputs;
c) evaluating results of simulations and giving feedback for potential improvements

Sharing information with distant fishers allowed to improve knowledge on EFH of main commercial species off the African coasts.

Partecipatory Mapping of DPS Nursery and spawing areas off the African Coasts

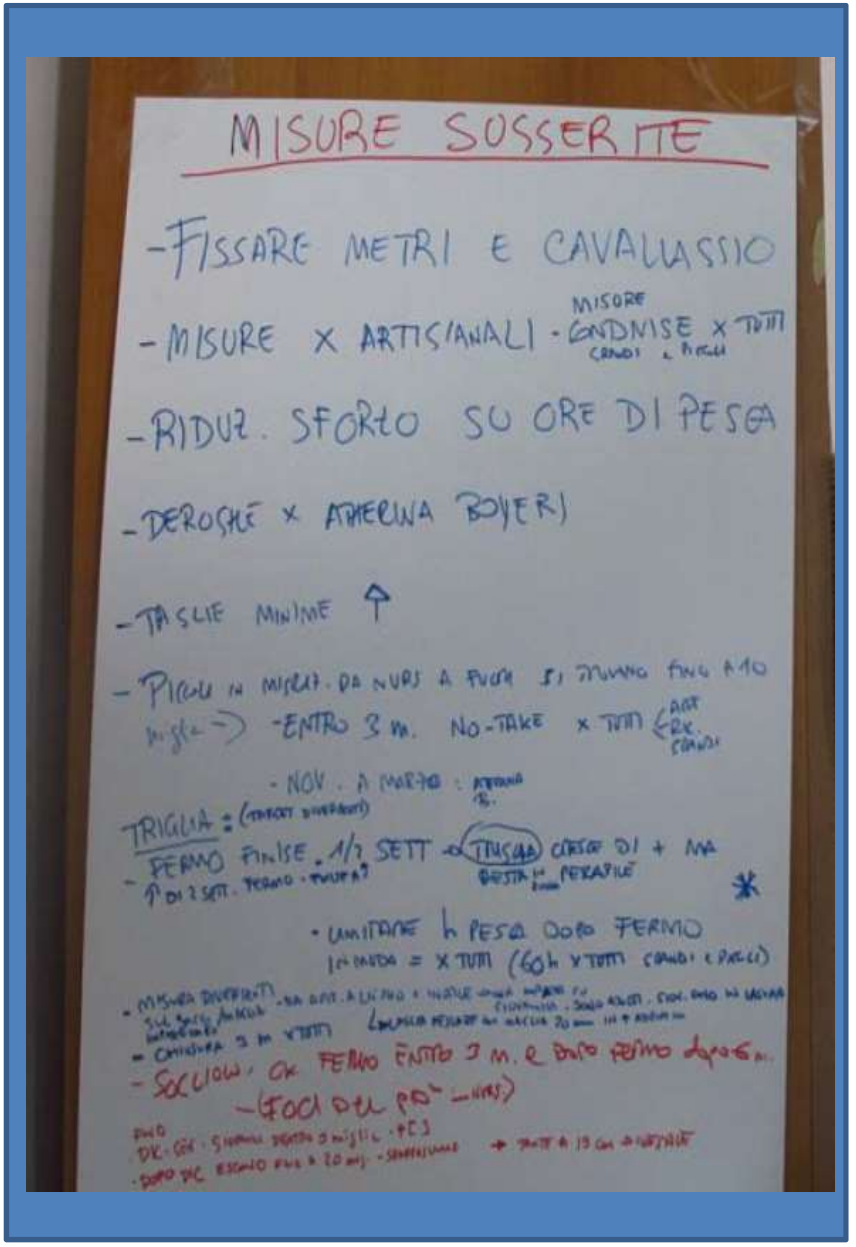


Main results of WP1 – Stakeholders' opinion on fisheries

- A worse perception on the state of fisheries in the SoS compared to the Adriatic.
- Authorities, researchers and MPA staff perceive a worse condition of the state of fisheries than the fishers
- All stakeholders agree in stating a degradation of fisheries in the last ten years.

Main results of WP1 – Stakeholders' opinion on fisheries

- Main threats
  - bad fisheries management and excessive fishing effort
  - pollution (mainly in the SoS)
  - climate (mainly in the Adriatic)
  - Illegal fishing
- Main conflicts
  - artisanal fishers and divers both in the Adriatic (especially Croatia) and in the SoS
  - professional fishers and recreational ones and shipping in Malta.



Main Results of WP1 – MPAs as management tool

- Fishers consider MPAs as a useful tool to protect biodiversity and fish stocks but they can attract illegal fishing
- Improved monitoring and control measures were considered necessary not only by researchers, but by most fishers too
- The general perception is also that MPAs don't help reducing conflicts among users since they cause overcrowding
- The introduction of seasonal fisheries closures was considered the best approach both in the Adriatic and in the SoS
- The enforcement of current fisheries management measures was recommended in both areas (in particular stopping illegal fishing and introducing controls and bans on recreational fishing)

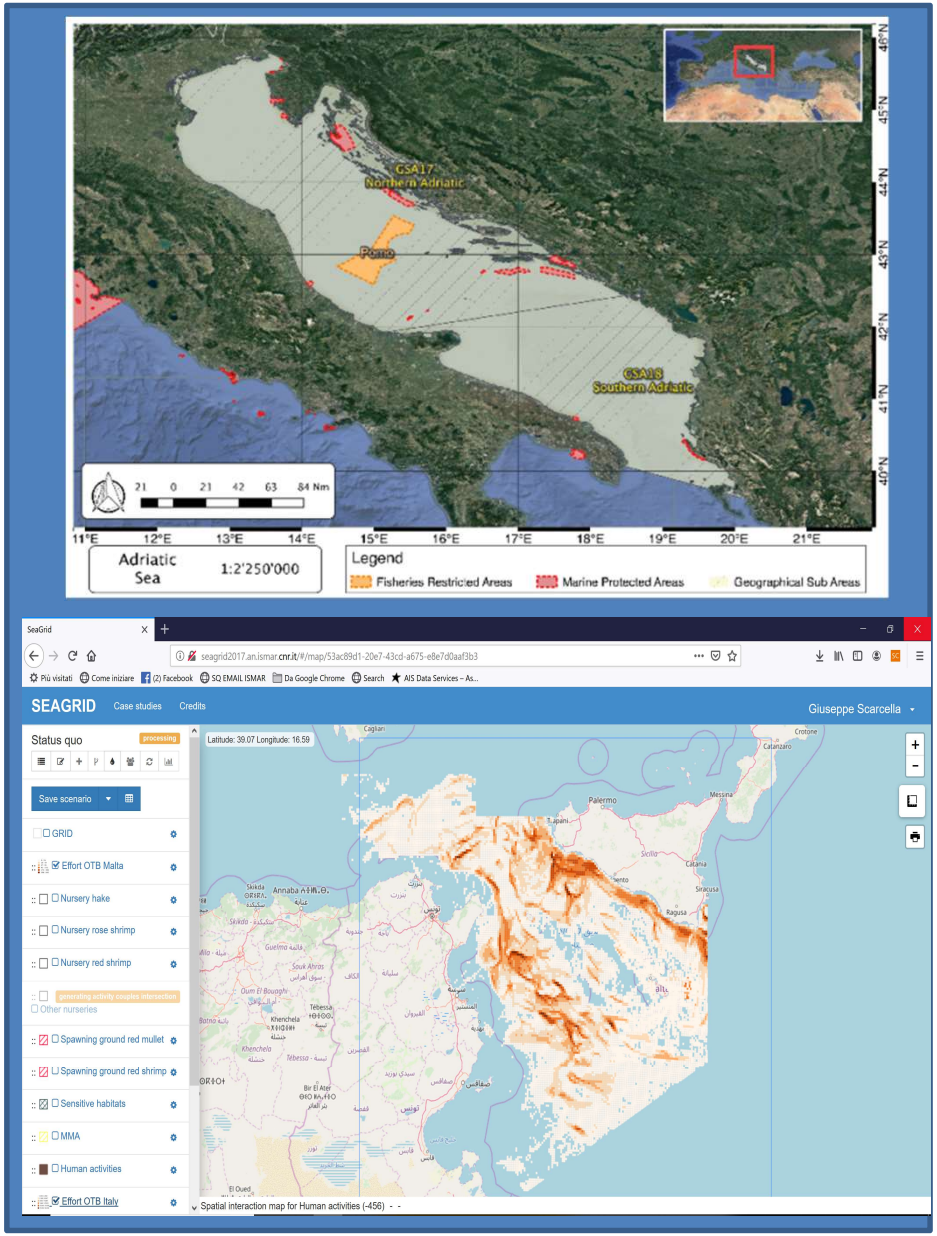
Main Results of WP1 – Fishers' opinion on co-management

- Adriatic fishers were not very responsive to the issue of involvement in co-management
- In the SoS the majority of fishers stated not having being involved in co-management initiatives
- About half of Sicilian fishers believed it is not important to be involved in co-management
- Fishers from Malta wished for more involvement of their sector by the Department of Fisheries and Aquaculture in the definition of management measures

Main Results of WP2

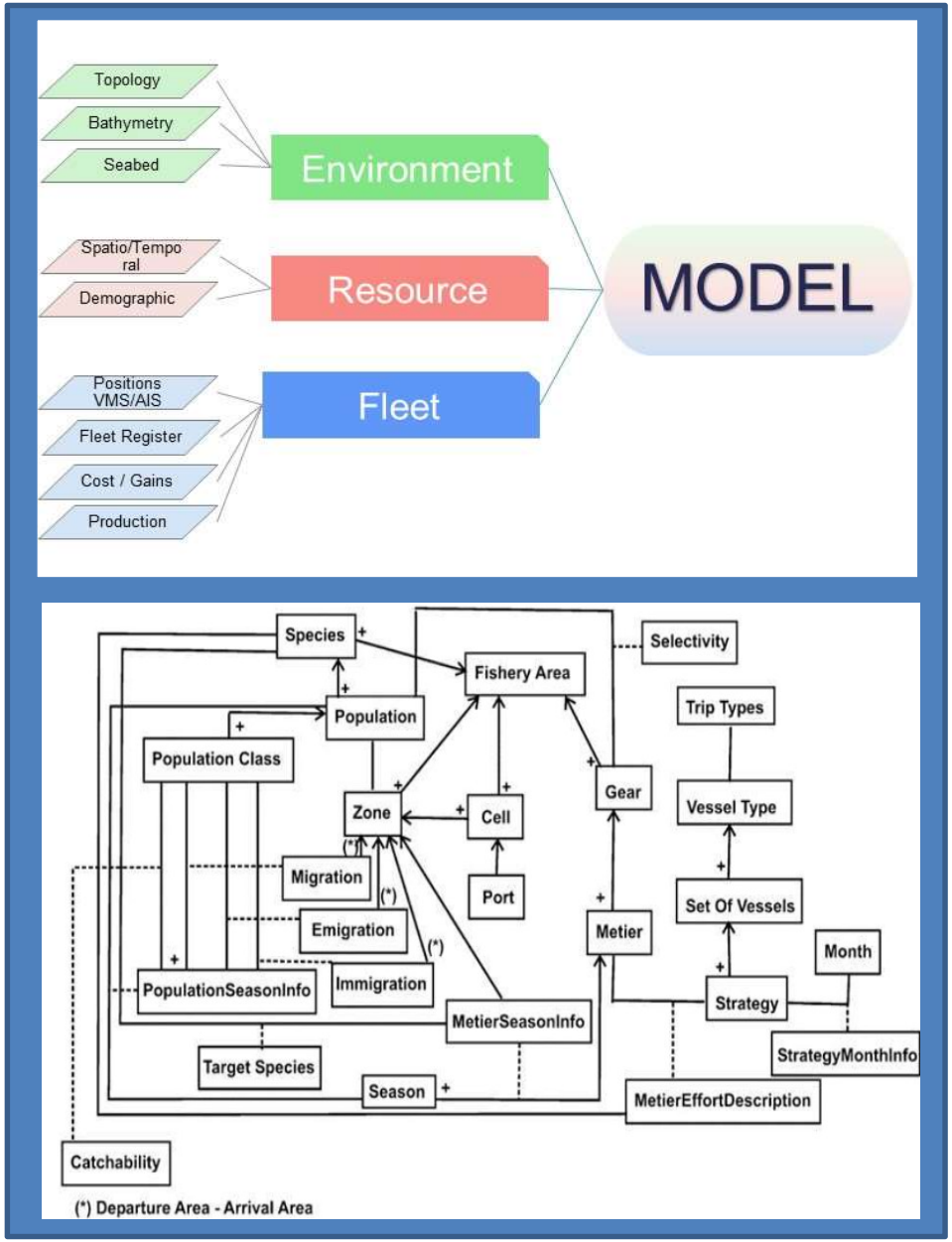
Within the framework of WP2, spatial data relevant for the MANTIS project, were identified and gathered from several projects (MEDISEH, STOCKMED, COCONET, ADRIAMED, MEDSUDMED, etc.).

Information on Marine Managed Areas, Essential Fish Habitats, fishing effort, Sensitive Habitats, main current patterns and anthropic activities in each case study area as shape files were uploaded in each case study in the GRID database. In 2017, a new version of GRID software, SEAGRID, developed within the Aqua Accept project, was adopted

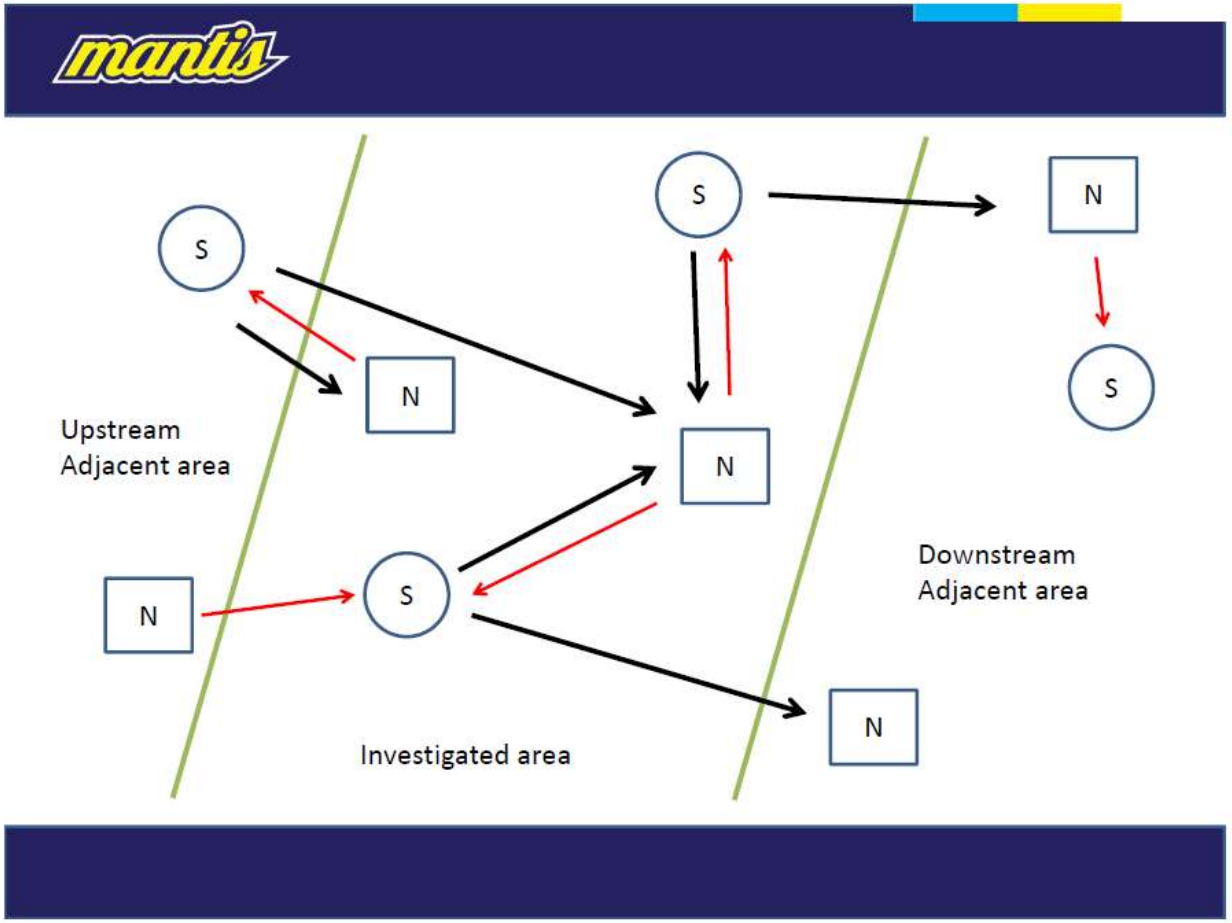


WP3 modelled **the dynamics of target stocks** in terms of abundance, fishing mortality and yield, including larval drift and spawning migration between EFHs.

Stock status and fishery performances were modelled by the th **SMART platform** (Russo et al., 2014), allowing to assess effect of spatial based measures for fishery manangement.



Assessing how much the benefits of closing a area to fisheries are reflected outside the protected area is crucial



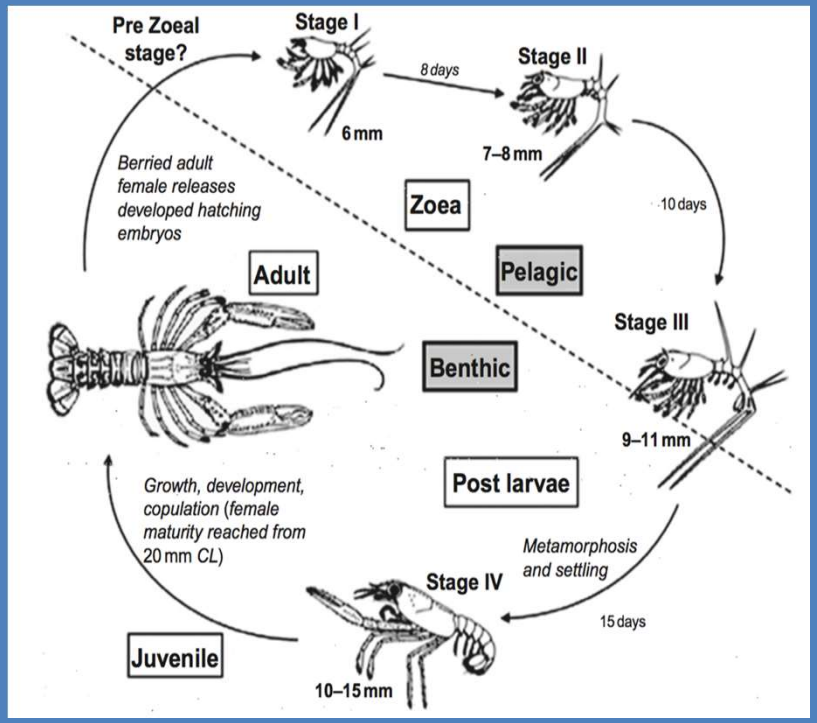
Integration of Connectivity in stock assessment and simulation in MANTIS

Two aspects of connectivity were considered:

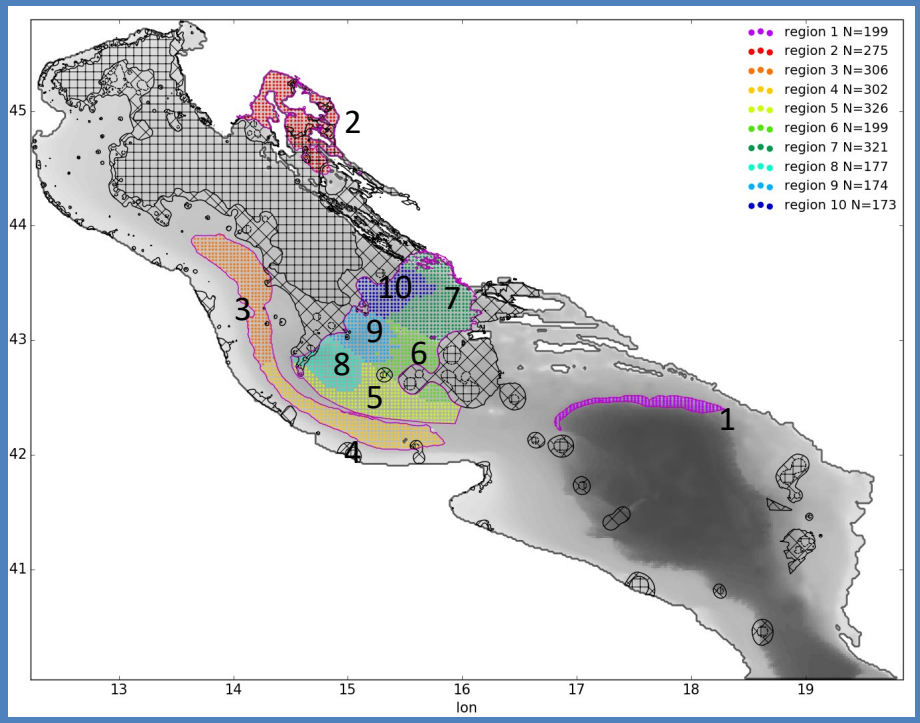
- the connectivity due to larval dispersal from spawning to nursery areas
- reproductive migration from nursery/feeding grounds to spawning areas.

Numerical modelling - Off-line larvae transport Lagrangian model that runs with stored ocean model hindcasts

The case of *N. norvegicus* in the Adriatic Sea

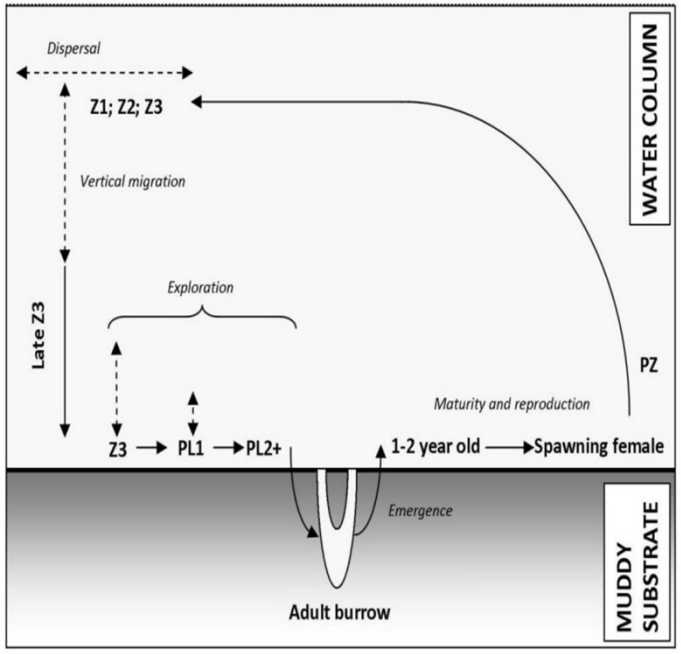


The *N. norvegicus* life cycle



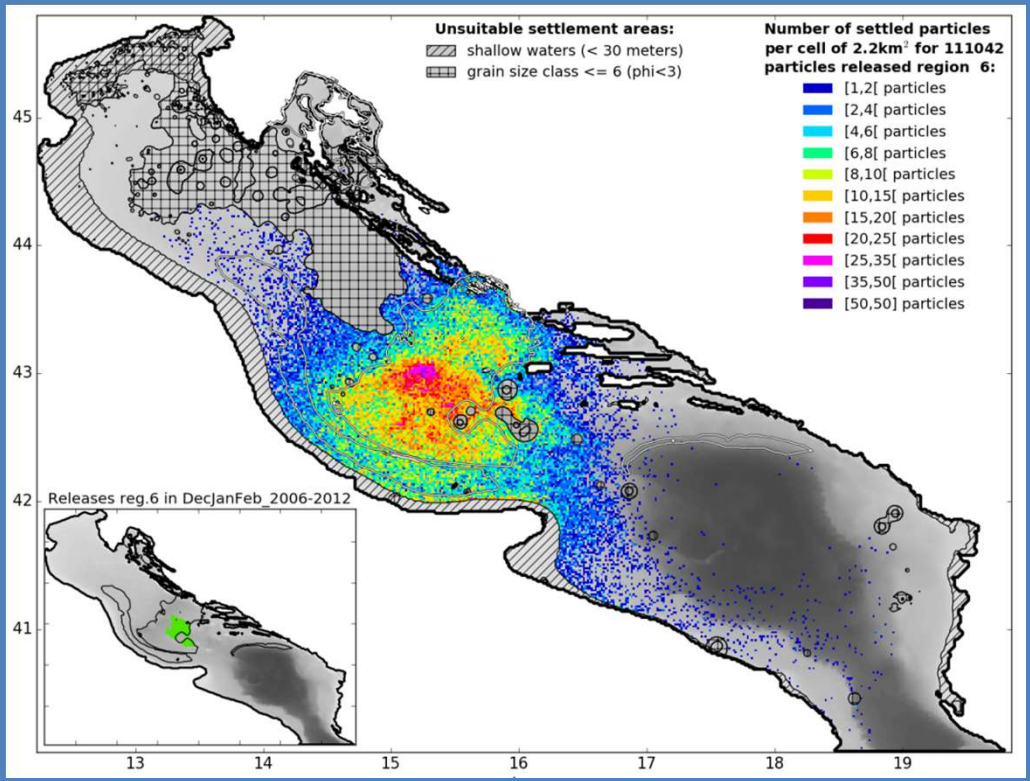
10 spawning areas from MEDISEH Project

- Release in dec, jan, feb, from Spawning areas
- Ascending phase 25 mm/sec
- Larvae Growth rate temperature dependent
- Planktonic phase up to 14 mm size
- Descendent phase 25 mm/sec
- Sediment selection for settling (grain >=7). Searching up to 3 days.

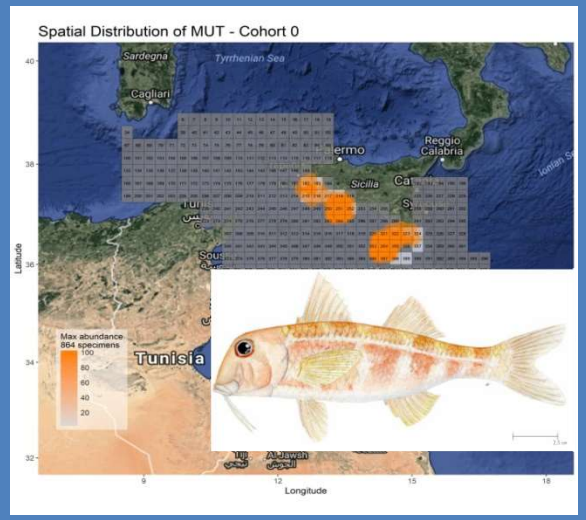


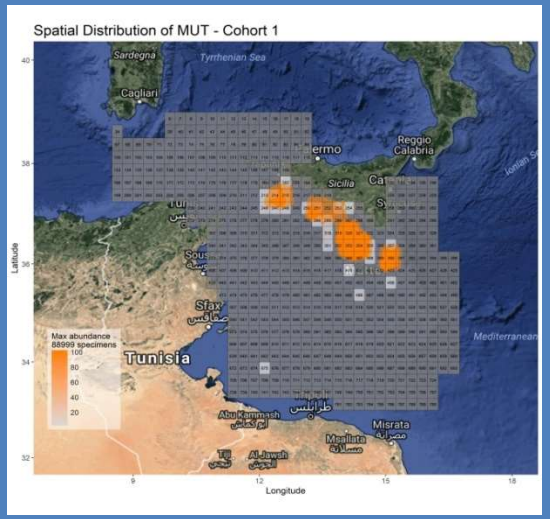
The case of *N. norvegicus* in the Adriatic Sea

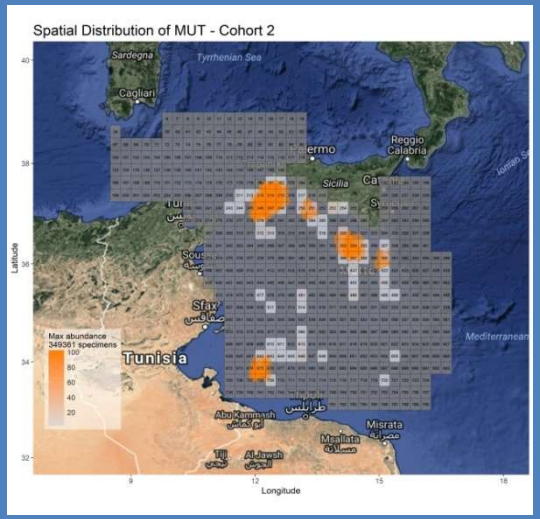
- Adult inhabiting burrows in muddy sediments.
- Eggs and larvae transported by current for 1-3 weeks

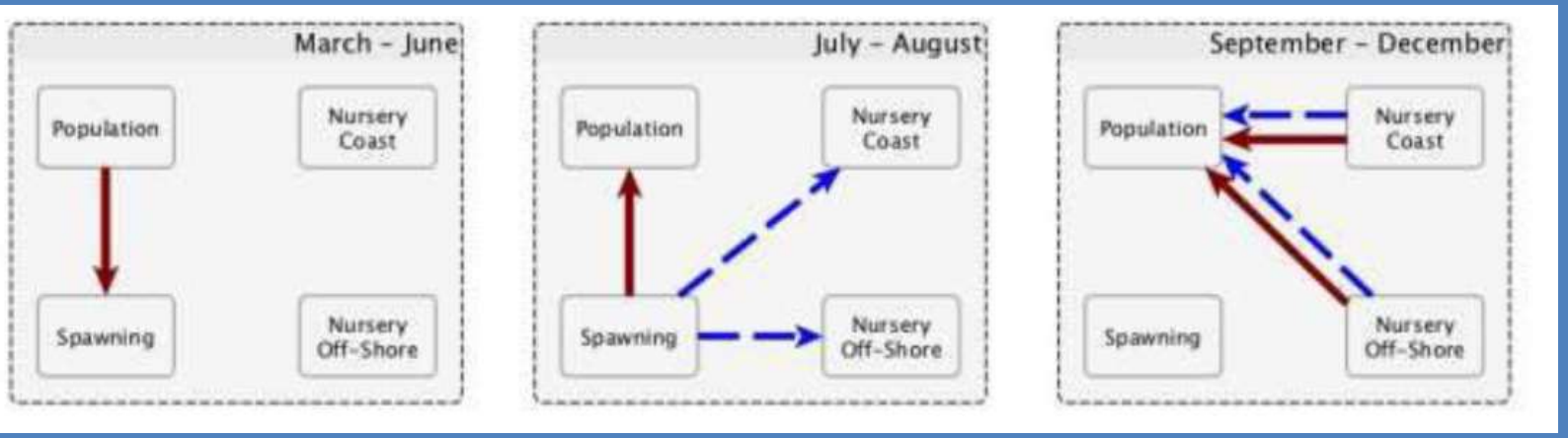


An Empirical approach - The migration pattern of the adult component of the stock is derived by the variation of the spatial distribution of age classes at different time.

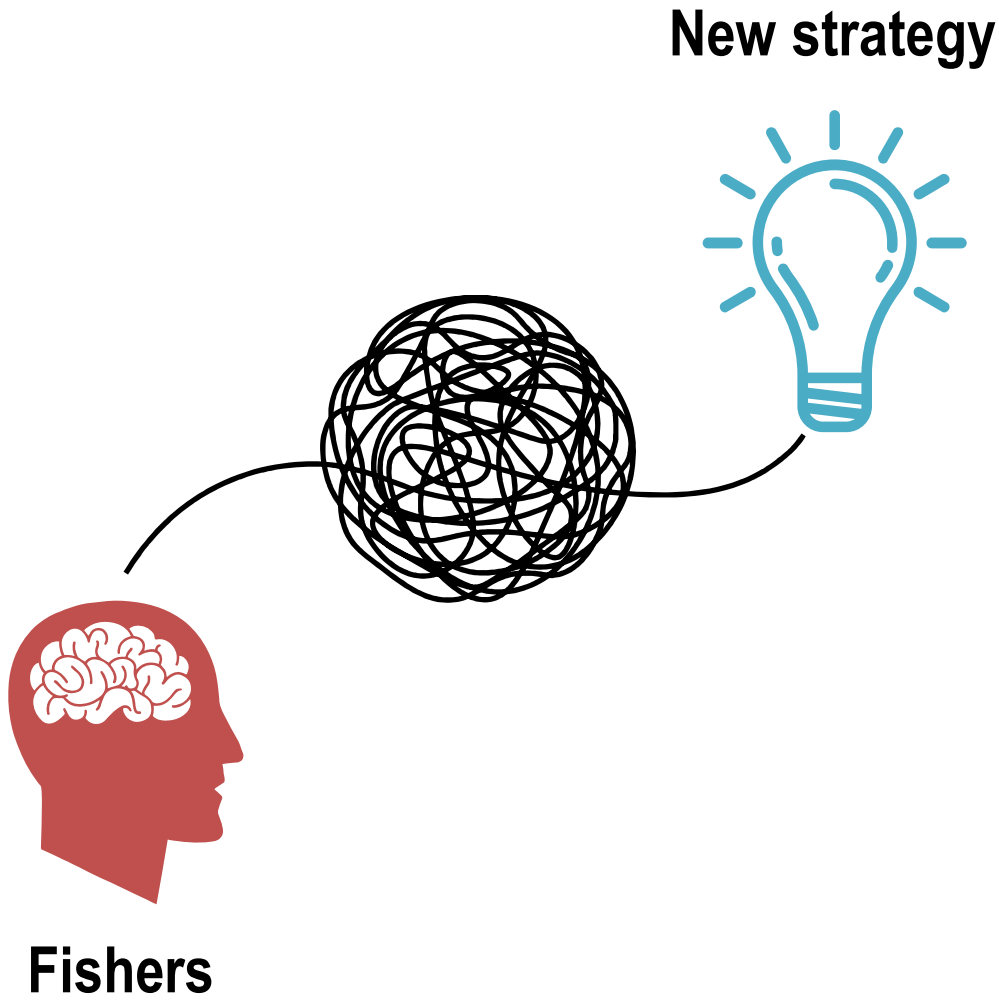






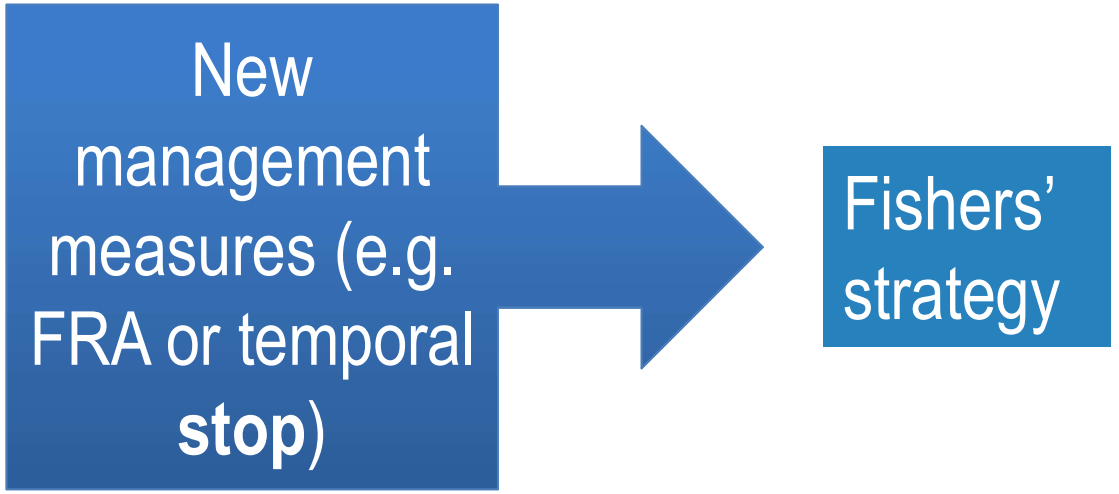


Several studies have underlined the effects of the adaptation of fishers, in terms of redistribution of fishing effort, as consequence of the spatial based fishing regulation



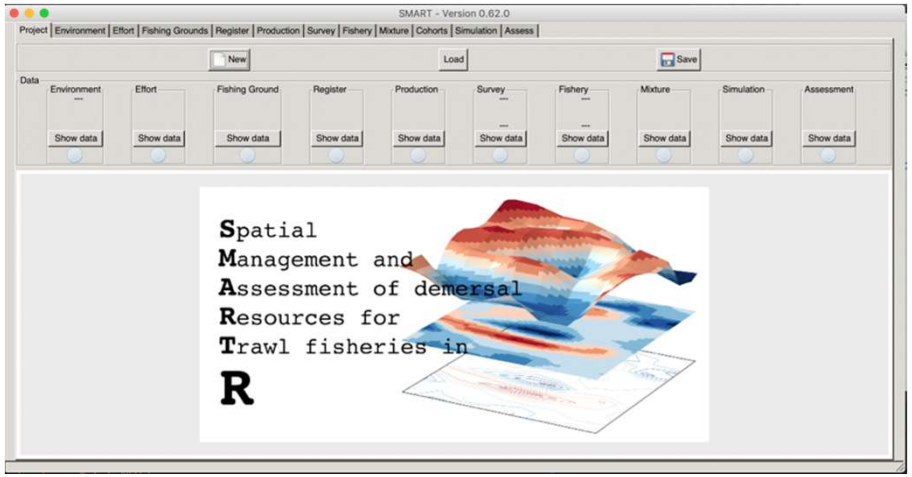
Predicting fishing effort displacement

SMART includes an individual-based model (IBM) predicting the allocation of the fishing effort (by vessel) according to different scenarios (spatial closures, temporal stops, etc.).



The workflow of the SMART platform

- Subdivide area under investigation into functional fishing areas (Fishing Grounds);
- Detect the spatial origin of the landings/catches and estimate the Landings/Catches per Unit of Effort (Lander);
- Determine the growth parameters and subdivide the studied stock(s) into cohorts (Growth);
- Estimate costs and revenues associated to a given fishing effort pattern (Performance);
- Simulate different management scenarios (Simulation);
- Assess the status of the studied stock(s) (Assessment).



smartR: Spatial Management and Assessment of Demersal Resources for Trawl Fisheries

A tool for assessing bio-economic feedback in different management scenarios. 'smartR' (Spatial Management and Assessment of demersal Resources for Trawl fisheries) combines information from different tasks gathered within the European Data Collection Framework for the fishery sector. The 'smartR' package implements the SMART model (Russo et al., 2014 <doi:10.1371/journal.pone.0086222>), through the object-oriented programming paradigm, and within this package it is possible to achieve the complete set of analyses required by the SMART approach: from the editing and formatting of the raw data; the construction and maintenance of coherent datasets; the numerical and visual inspection of the generated metadata; to the final simulation of management scenarios and the forecast of their effects. The interaction between the user and the application could take place through invocation of methods via the command line or could be entirely committed to the graphical user interfaces (GUI).

Version:	0.62.0
Depends:	R6, rjags, maptools, mapdata
Imports:	PBSmapping, gWidgets2, gWidgets2RGtk2, gstat, lattice, plyr, sp, maps, clues, cluster, spdep, marmap, shape, jpeg, grid, ggplot2, sqldf, gsubfn, chron, reshape2, foreign, ROCR, caret, nnls, mtsdi, grodExtra, rgeos, scales, grDevices, ggthemes, vegan, rpart, ggrepel, rgdal, RColorBrewer, jsonlite, igraph, mapproj
Published:	2018-11-30
Author:	Lorenzo D'Andrea, Tommaso Russo, Antonio Parisi, Stefano Cataudella
Maintainer:	Lorenzo D'Andrea <dandrea.lorenz at gmail.com>
License:	GPL-2 | GPL-3 [expanded from: GPL (≥ 2)]
NeedsCompilation:	no
CRAN checks:	smartR results

Downloads:

Reference manual:	smartR.pdf
Package source:	smartR_0.62.0.tar.gz
Windows binaries:	r-devel: smartR_0.62.0.zip, r-release: smartR_0.62.0.zip, r-oldrel: smartR_0.62.0.zip
OS X binaries:	r-release: not available, r-oldrel: not available

https://cran.r-project.org/web/packages/smartR/index.html

SMART model: typical architecture of a case study

- Spatial domain defined as a grid of cells or a set (either regular or irregular) polygons;

- Estimation of the spatial/temporal productivity (standardized LPUE or CPUE) by species, age, area, and time using:

  - VMS;
  - Logbook data or Landing data (often aggregated at weekly or monthly level);
  - Biological sampling of catches: age/length structure of catches by area and time

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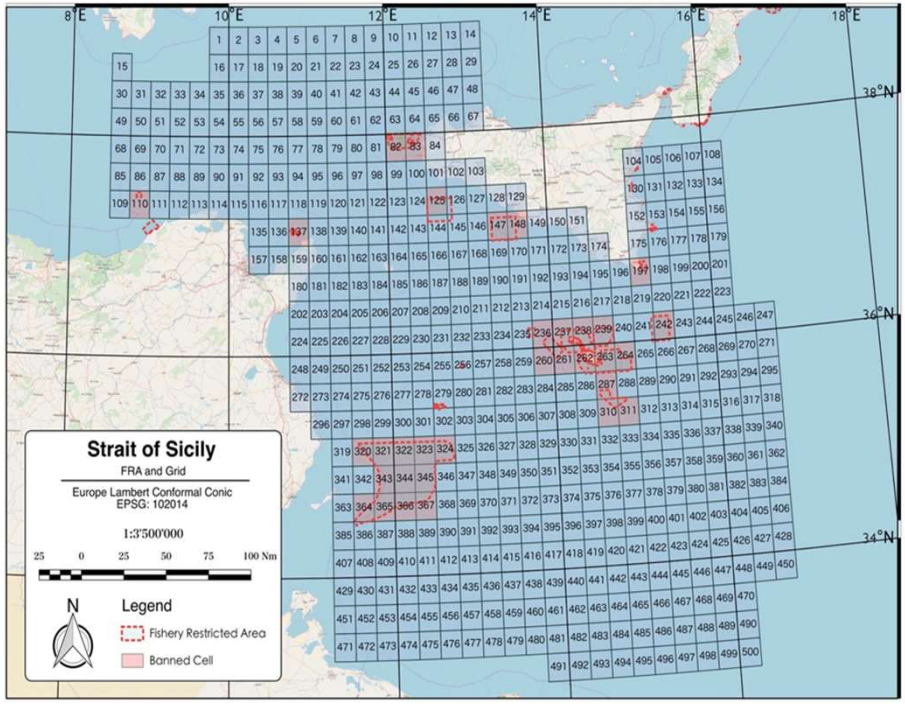
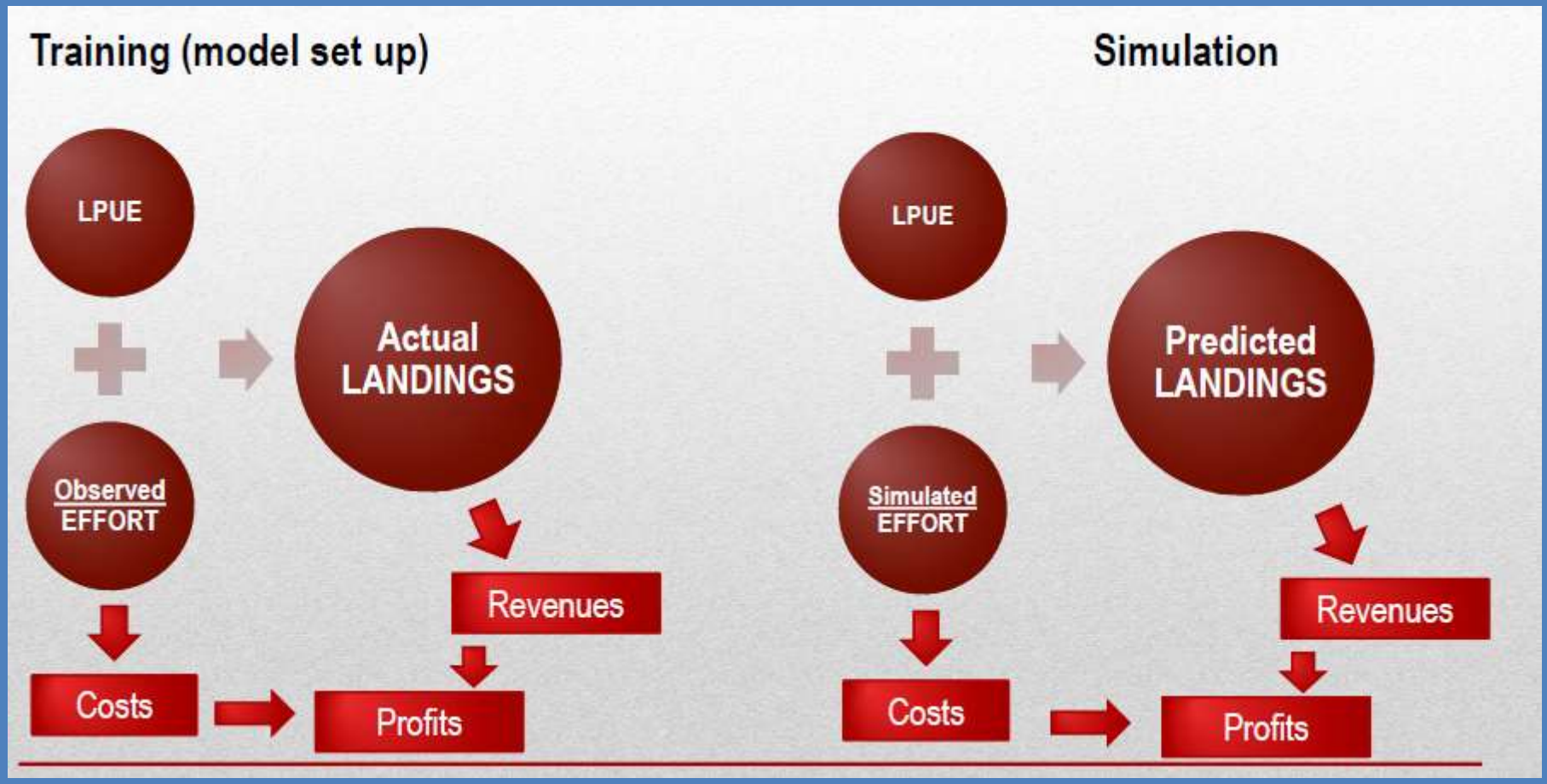
LPUE (Kg/m of LOA/hour fishing)

The regular grid in the Strait of Sicily

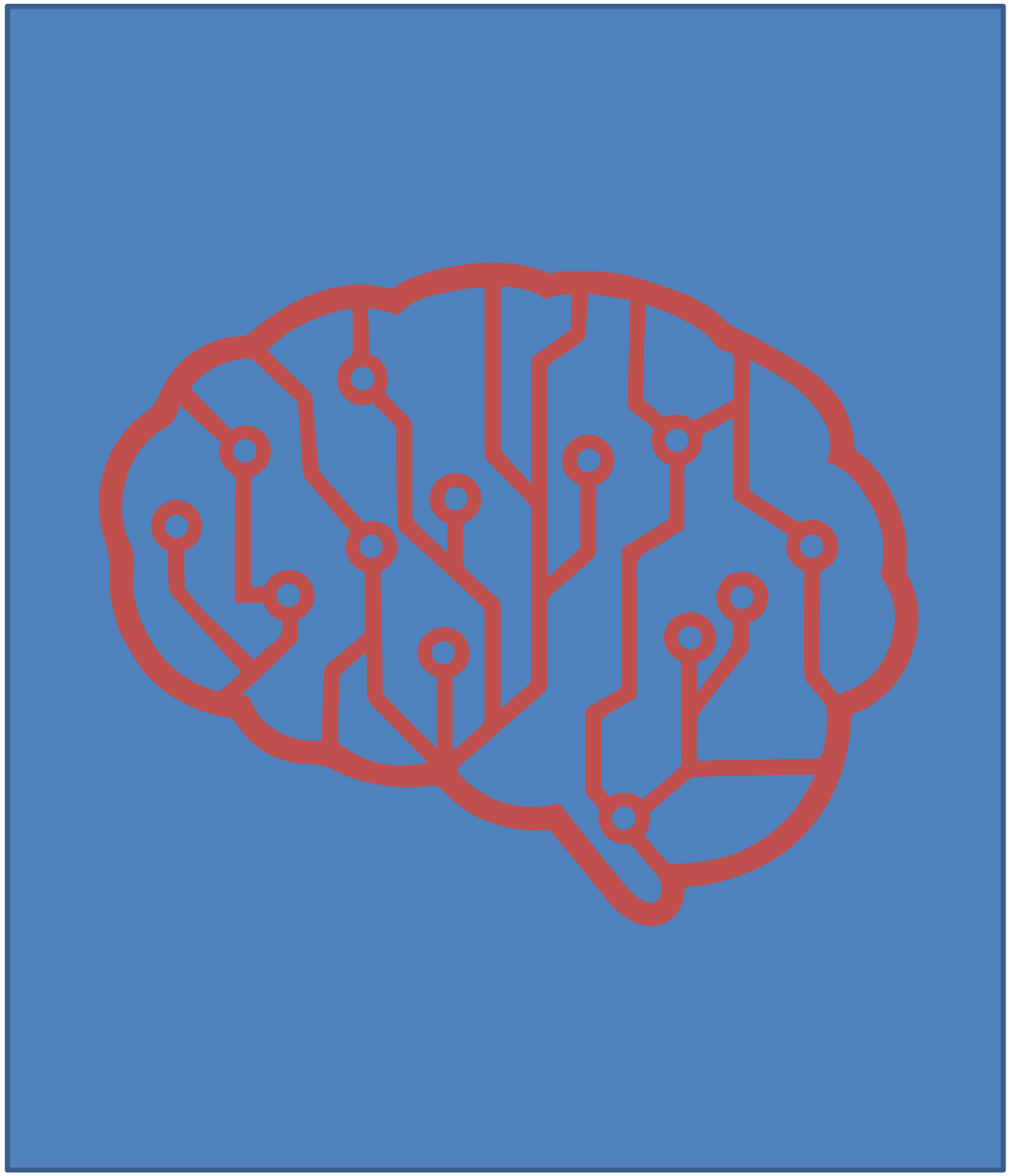


The core of the SMART model



How modelling connectivity

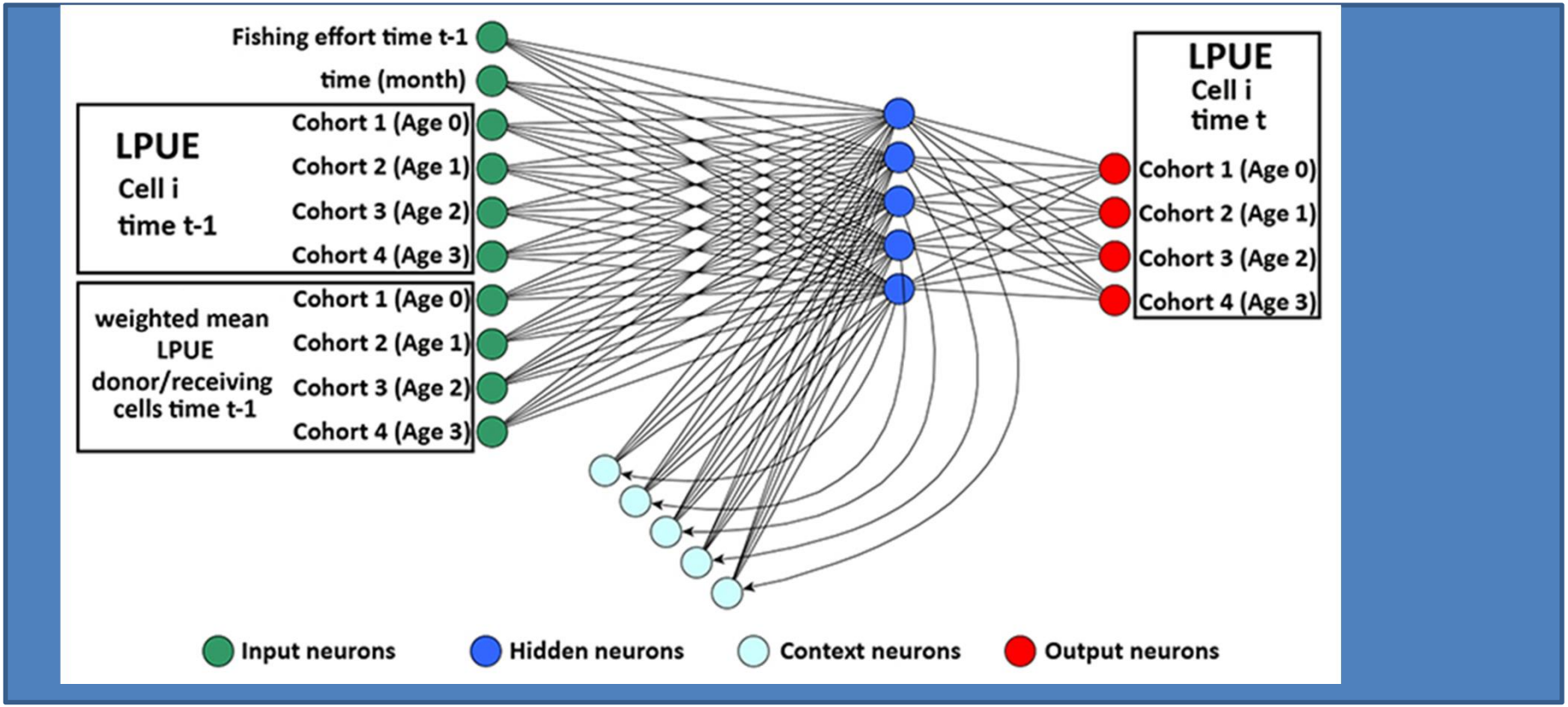
The Elman Network is a recurrent neural network, that is a class of artificial neural networks where connections between nodes form a directed graph along a temporal sequence. This allows it to exhibit temporal dynamic behavior.

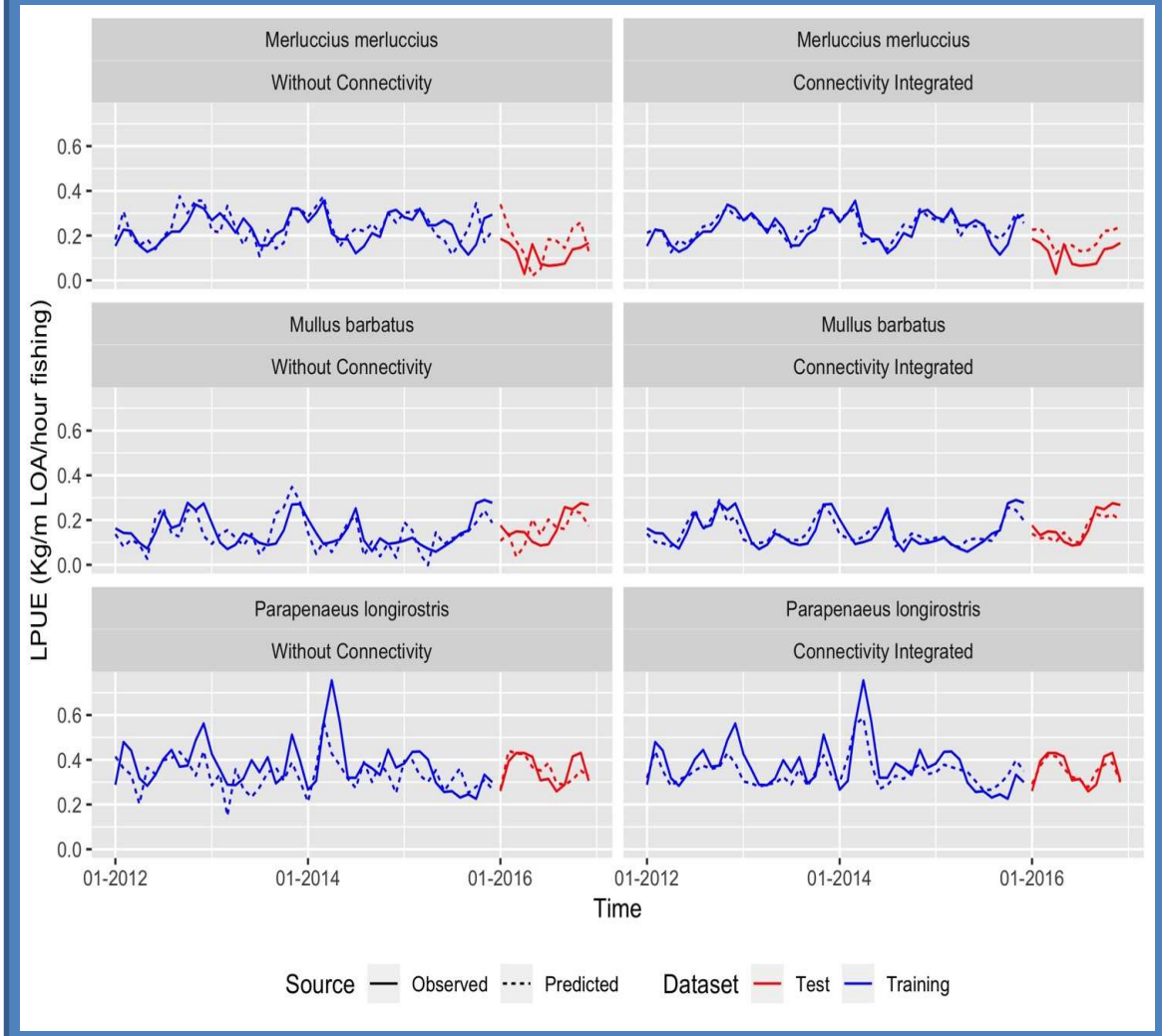


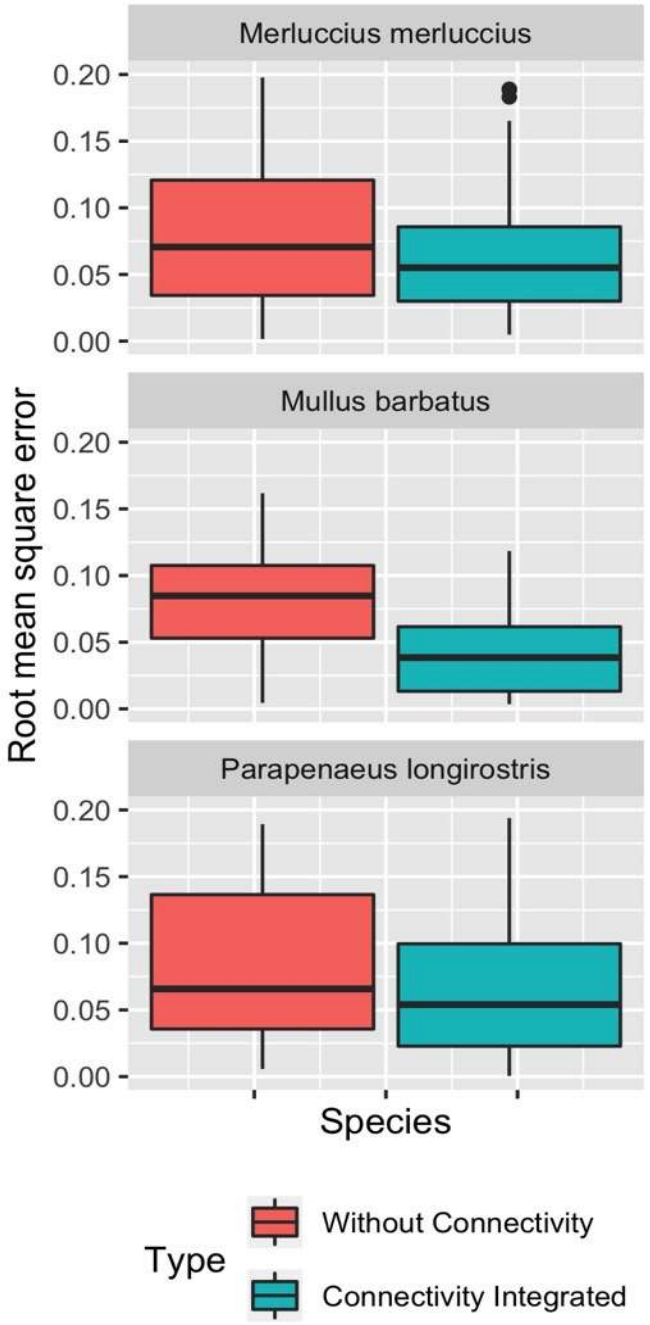
How modelling connectivity

LPUE (by age/species/cell/time) are expected to depend upon:

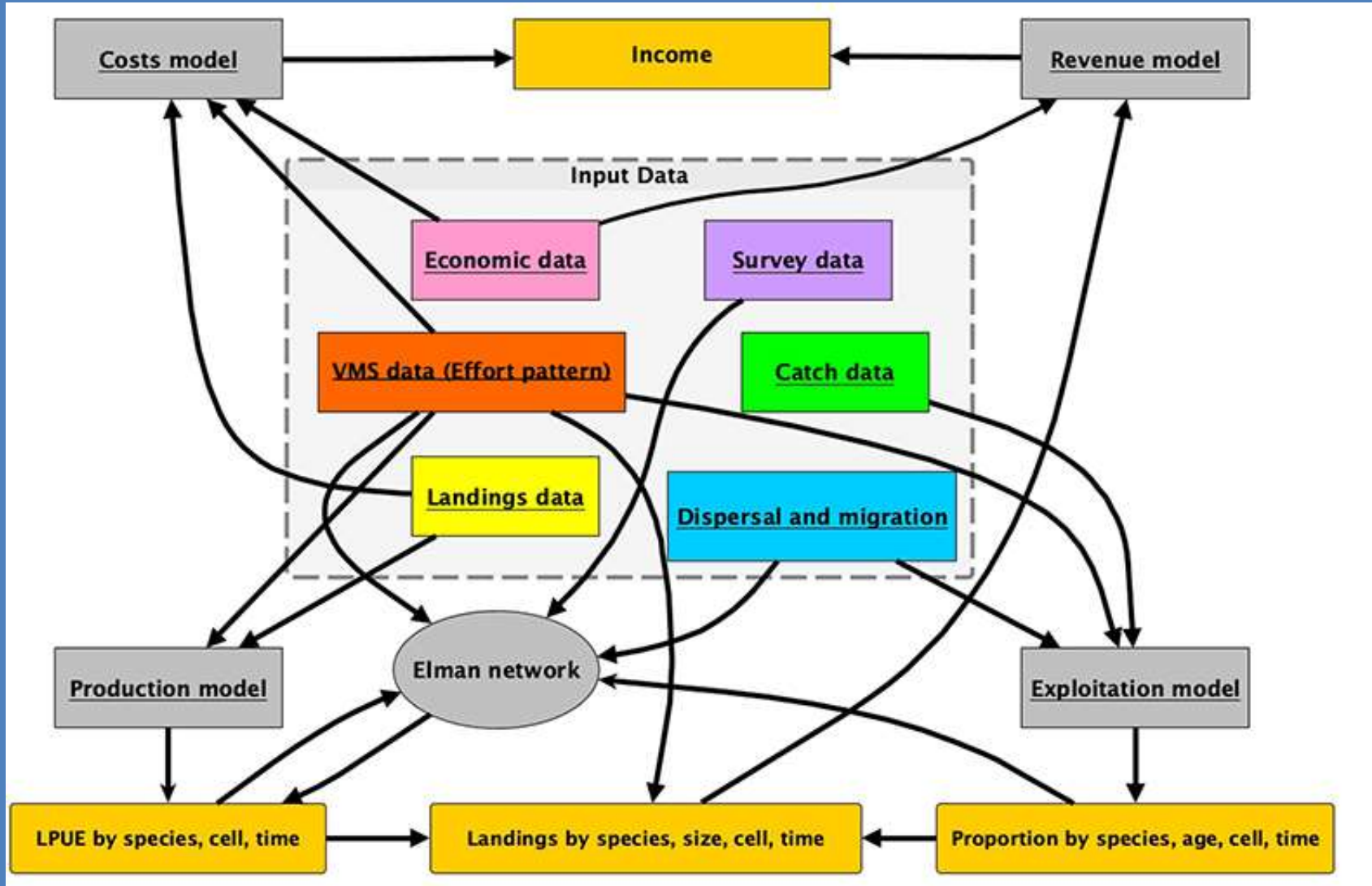
1) **Previous Fishing effort pattern in cell c;**
2) **Previous values of $LPUE_{a,s,c,t}$ (the "inertia" of the system);**
3) **Mean previous values of $LPUE_{a,s,t}$ in the donor/receiving cells**



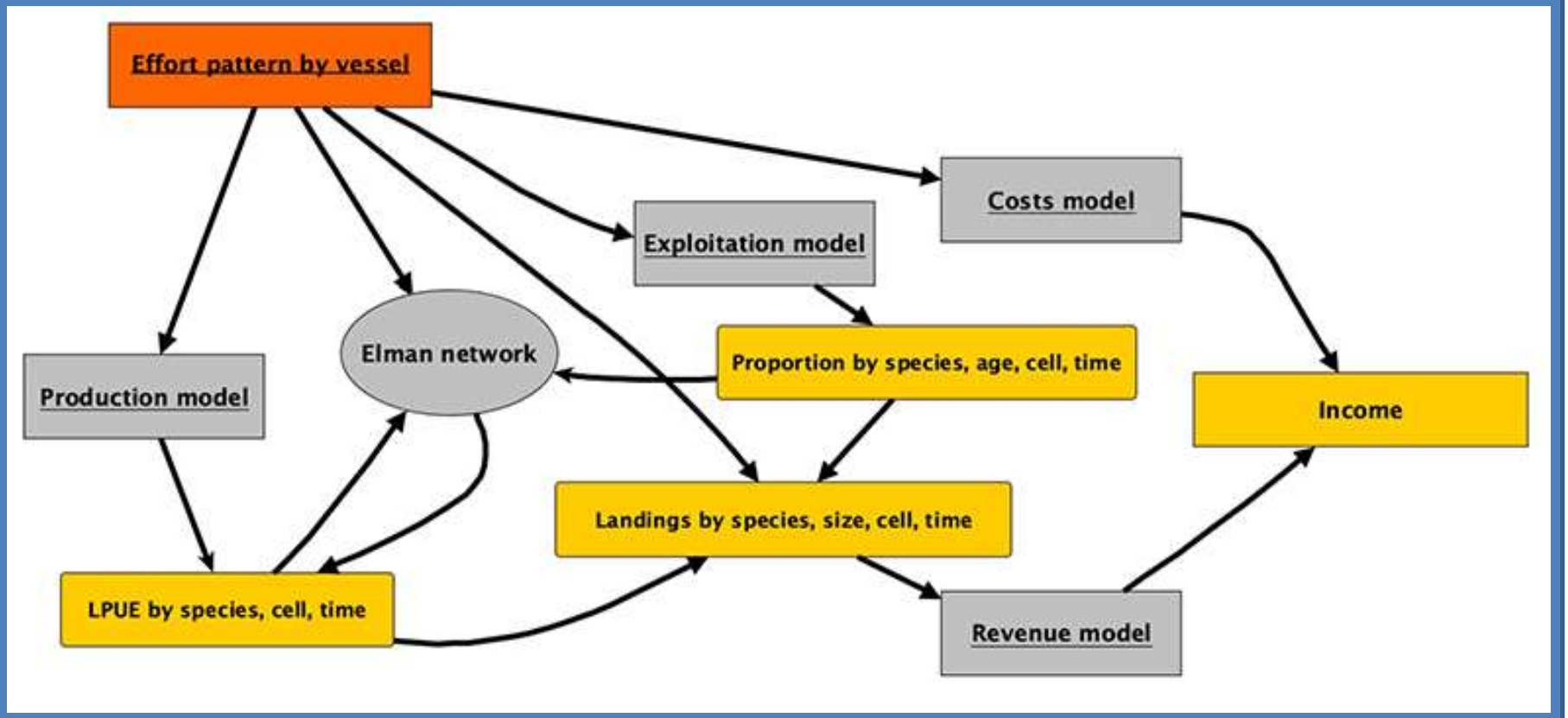

Merluccius merluccius
Without Connectivity
Merluccius merluccius
Connectivity Integrated
Mullus barbatus
Without Connectivity
Mullus barbatus
Connectivity Integrated
Parapenaeus longirostris
Without Connectivity
Parapenaeus longirostris
Connectivity Integrated
LPUE (Kg/m LOA/hour fishing)
0.0
0.2
0.4
0.6
01-2012
01-2014
01-2016
Time
Source
Observed
Predicted
Dataset
Test
Training


Merluccius merluccius
Mullus barbatus
Parapenaeus longirostris
Root mean square error
0.00
0.05
0.10
0.15
0.20
Species
Type
Without Connectivity
Connectivity Integrated

Work flow of SMART in MANTIS – Input data and output information



Work flow of SMART in MANTIS – effort data and bioeconomic variables

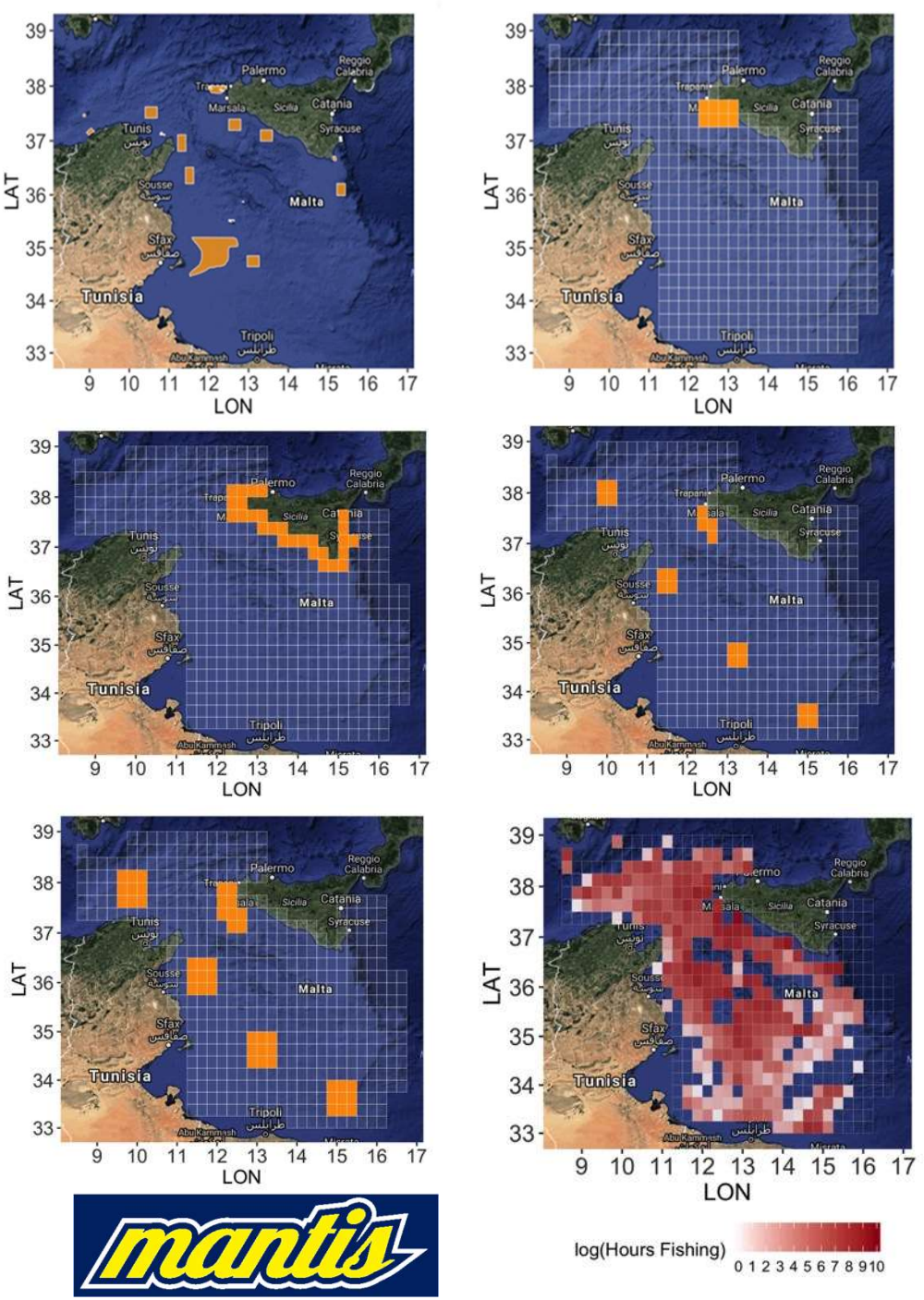


Predicted landings by species/age (or size) are passed to a MICE (Model of Intermediate Complexity) to assess the biological consequences of the selected scenario.

Economic and biological outcomes for the selected scenarios are compared in a Management Scenario Evaluation (MSE).

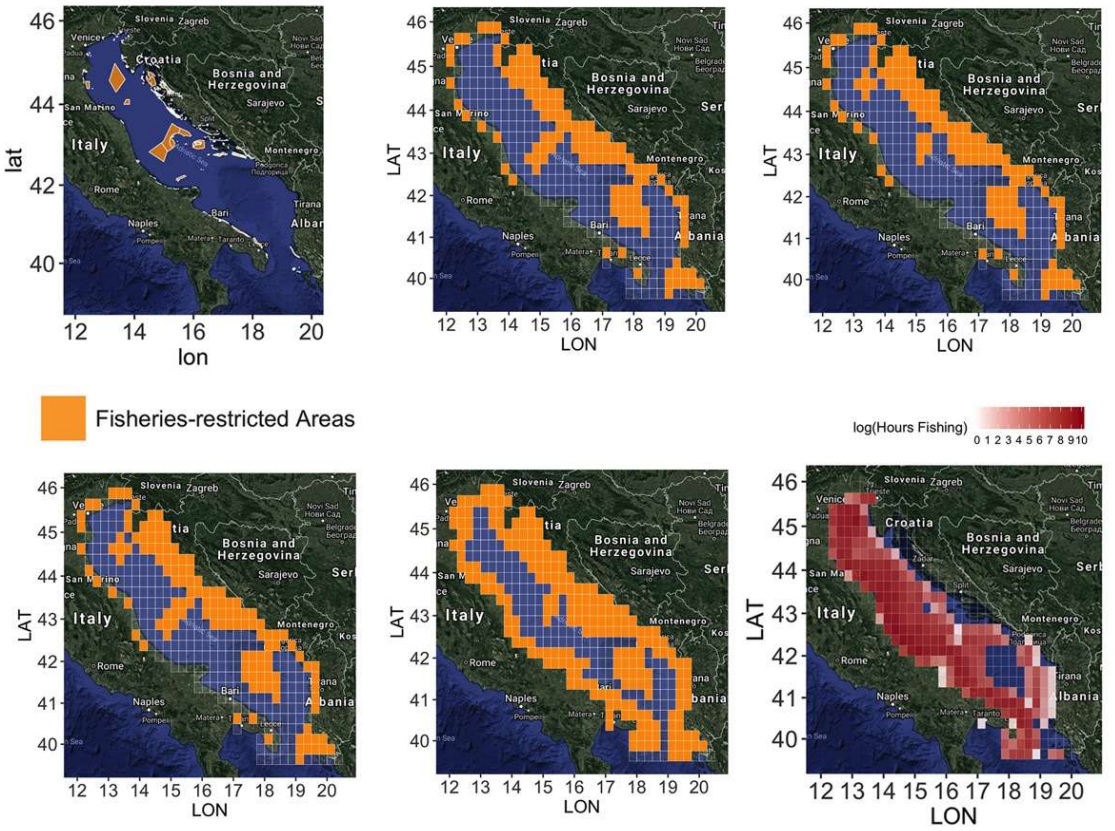
Simulated scenarios in the SoS

Name	Type
Status quo	Capacity/Effort-based
Effort Regime	Capacity/Effort-based
GFCM FRA	Spatial-based
FRA Network	Spatial-based
Adventure Bank	Spatial-based
Coastal closure	Spatial-based
Network 2×2	Spatial-based
Network 3×3	Spatial-based
Short Winter stop	Temporal-based
Short Summer stop	Temporal-based
Extended Winter stop	Temporal-based
Extended Summer stop	Temporal-based
GFCM FRA – 4 Effort	Combined
GFCM FRA – 8 Effort	Combined



Simulated scenarios in the Adriatic Sea

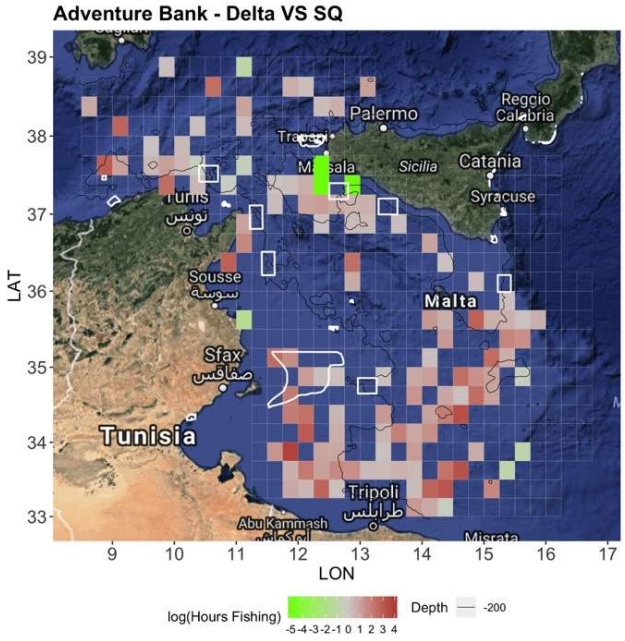
Name	Type
Status quo	Capacity/Effort-based
Effort Regime	Capacity/Effort-based
Coastal closure	Spatial-based
Pomo Pit FRA	Spatial-based
Sole's Sanctuary	Spatial-based
Pomo Pit + Sole's Sanctuary	Spatial-based

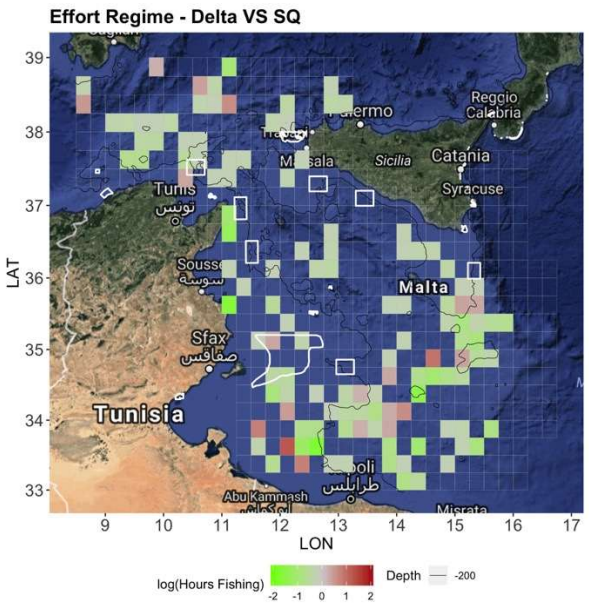


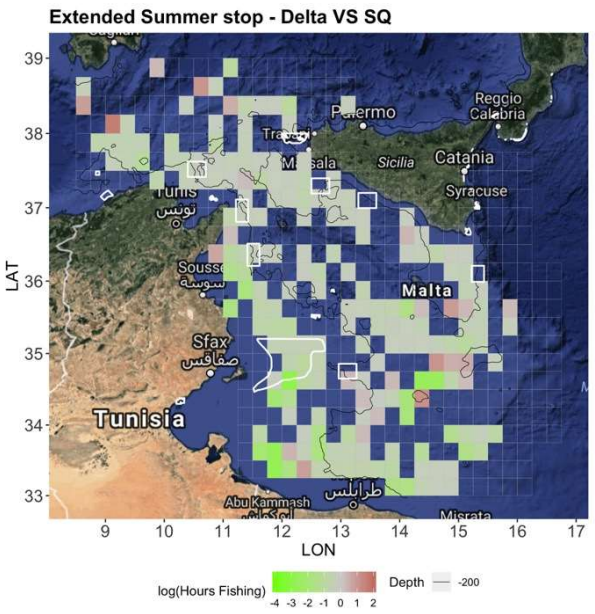
Main results

http://jadran.izor.hr/mantis

Some examples of effort displacement in the SoS



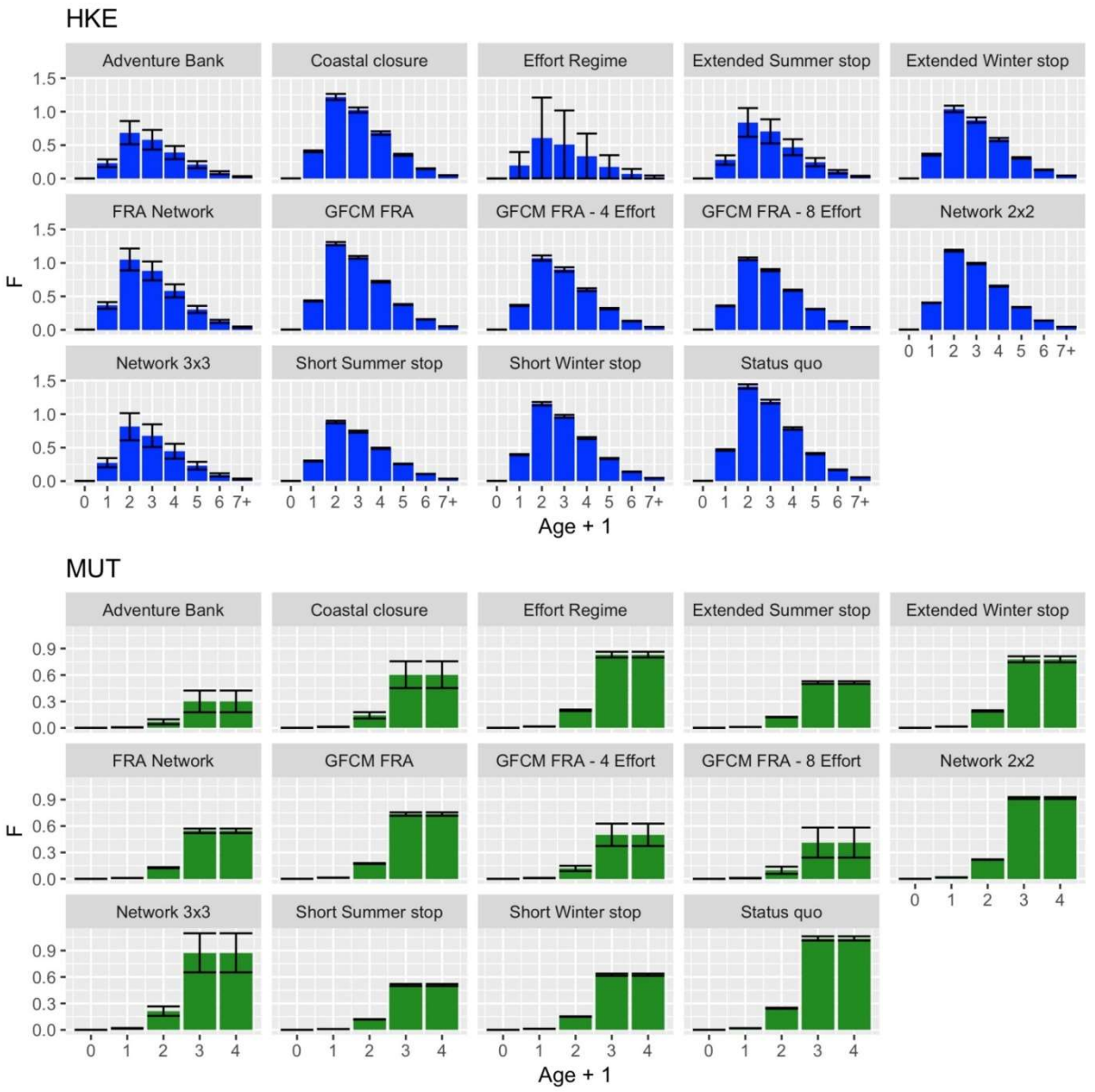




Main results

http://jadran.izor.hr/mantis

Some examples of fishing mortality according the different scenarios in the SoS



Main results

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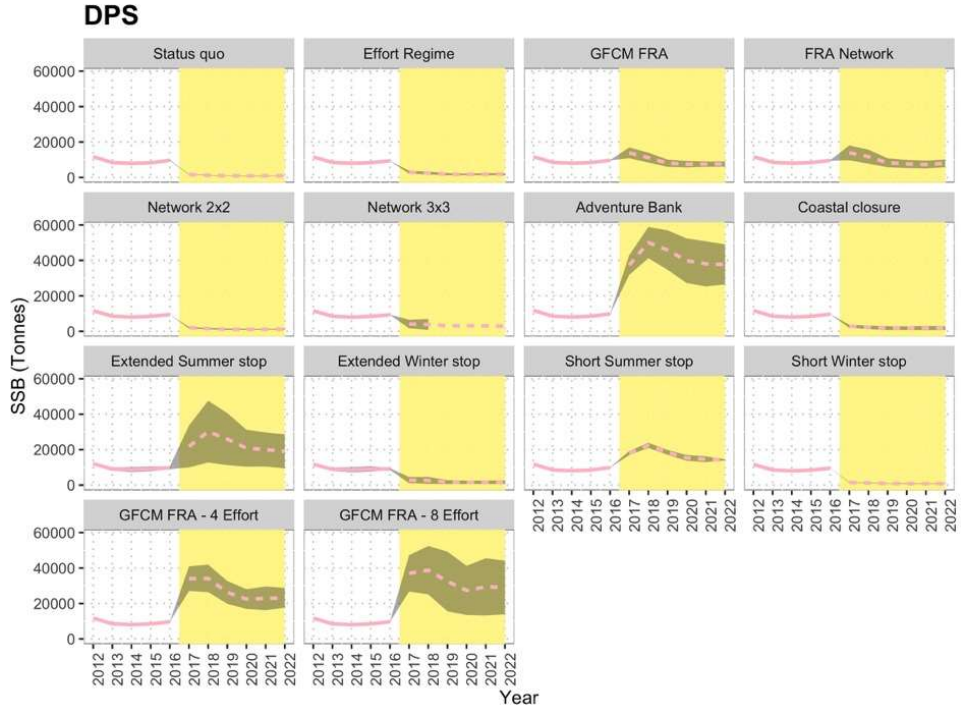
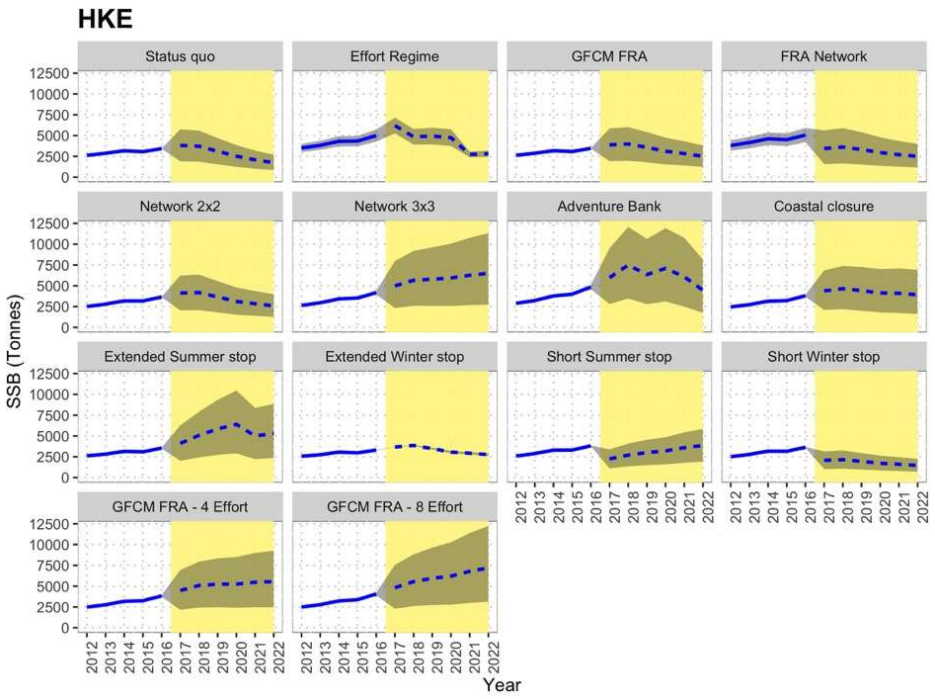
Some examples of effects on the stocks in the SoS





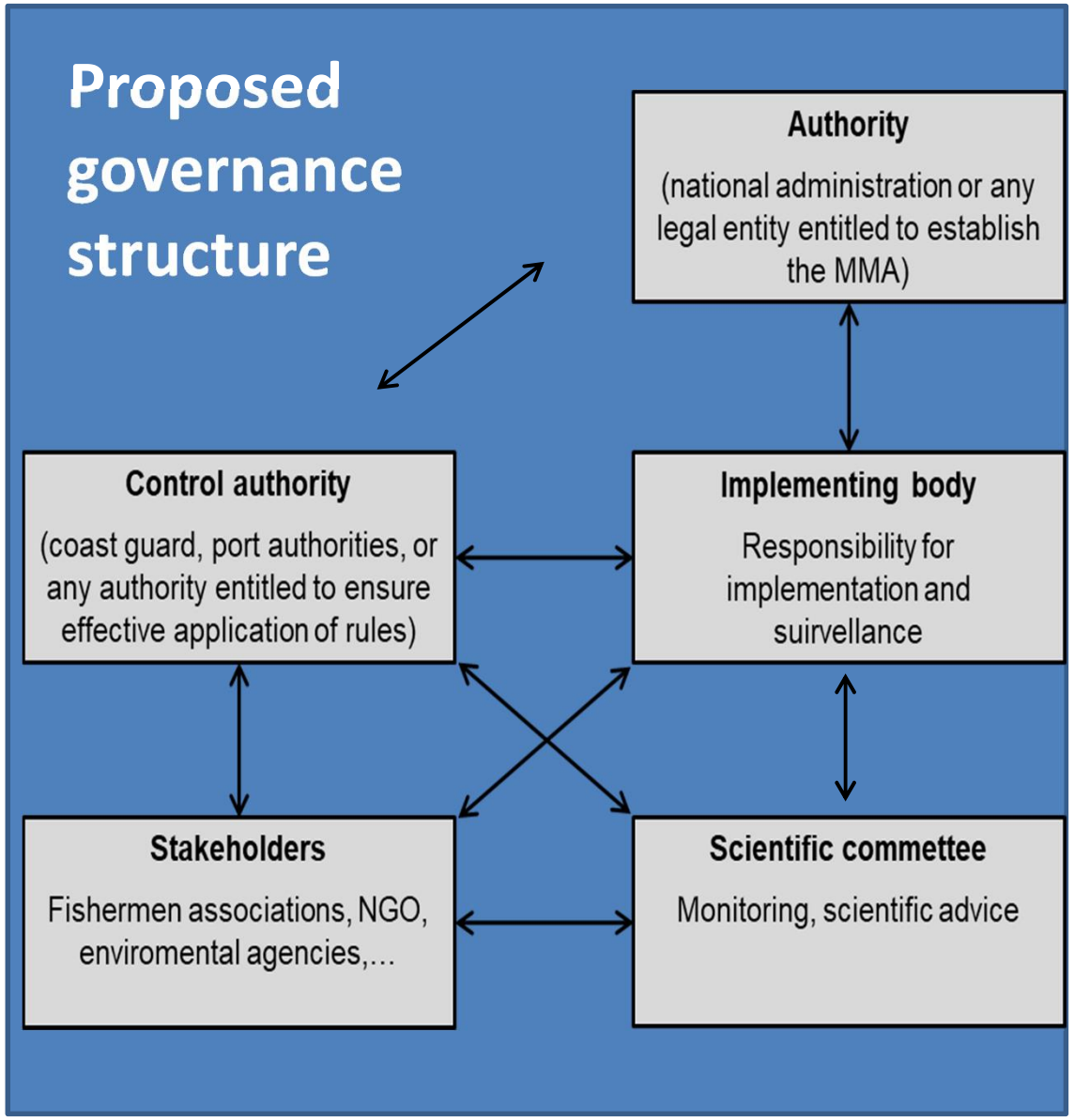
- **WP4 reviewed and designed a management framework of the MMA network** including the establishment, maintenance, monitoring and governance

- This framework considered the involvement of the stakeholders (Fishers, NGOs, Public Administrations) following the **Responsive Fisheries Management System** Approach

Responsive Fisheries Management System (RFMS) (EU FP7 project ECOFISHMAN)

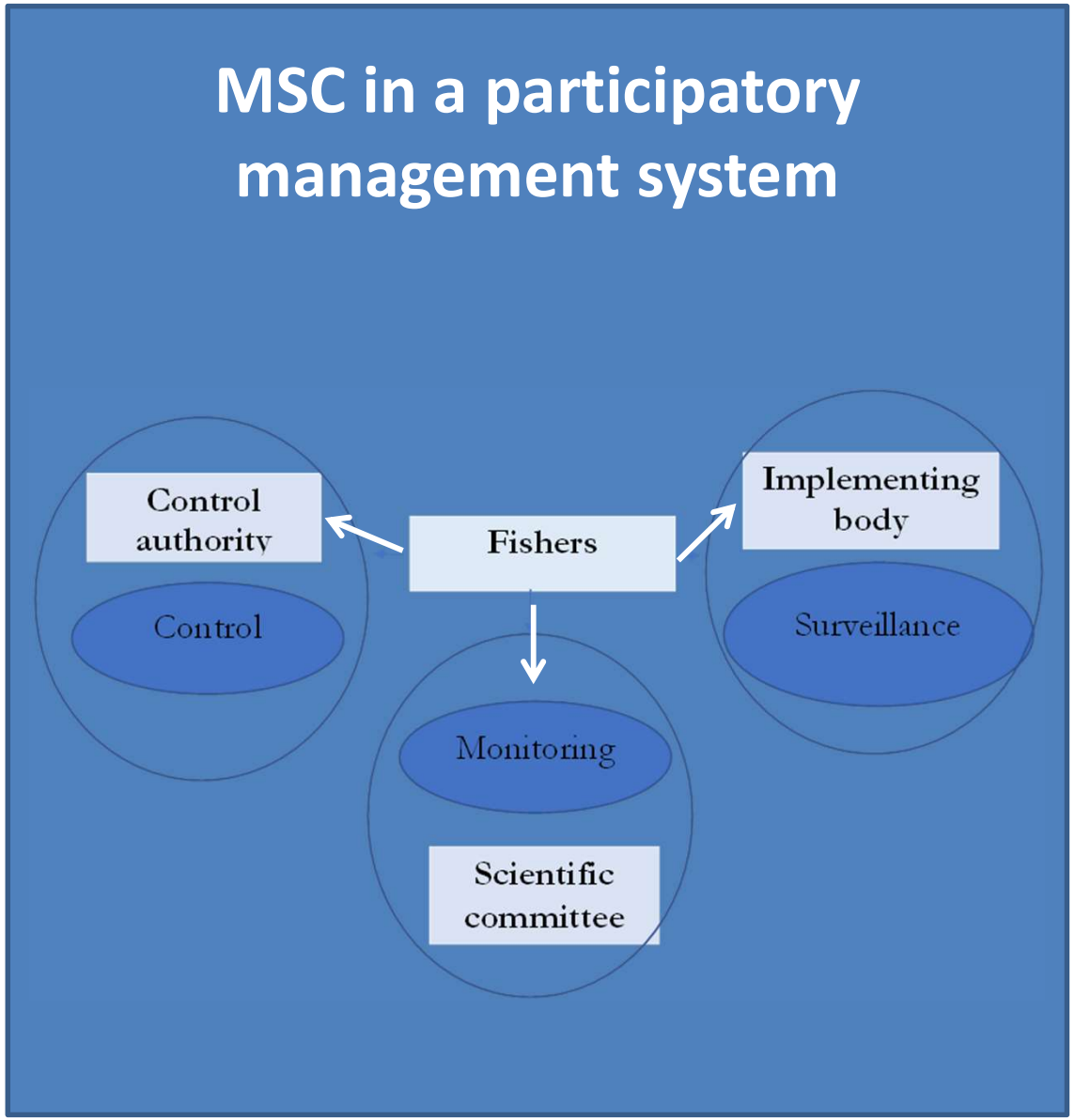
Three main actors are identified:

- authority, with the final responsibility for resource management;
- operators, organised group of resource users (e.g. association of fishermen with fishing rights in a given fishery);
- auditor, evaluating whether the outcome targets listed in the management plan have been achieved



Main aspect to be considered in MCS approach in MPAs:

- **spatial and/or temporal constraints;**
- **the types of fleets/fisheries involved;**
- **the regulatory requirements of the measures being enforced;**
- **a stakeholder participatory approach defined;**
- **the types of "entry conditions";**
- **the types of surveillance actions to be implemented to maintain compliance with the regulatory controls imposed on fishing activities.**



The main aspects to be monitored for assessing effects of MPA:

- **the degree of fish movement across closed-area boundaries (larval drifting and spillover effect),**
- **the spatial distribution and quantity of displaced fishing effort,**
- **the relative catchability (cpue) of the target stock(s) outside the closures,**
- **the level of protection afforded to undersized animals taken by the fishery,**
- **the effect on the overall sustainability of commercial stocks,**
- **the impact on the ecosystem,**
- **the socio-economic implications.**

Objectives, indicators and data of a MMAs network monitoring program. Data are provided at different time scales: m: one month, q:quarter, y: year. In bold the frequency of calculation of indicators. See the D 4.4 for a complete list of Indicators

Monitoring objectives	Indicators	Data				
		Survey CPUE by age/size	Commercial CPUE by age/size by fleet segment	VMS/AIS	Catch of commercial fleets	Socio economic and governance variables
1. Spillover from MMAs	Temporal trend in cpue of target stocks by size/age class	***y***	***q***			
2. Fishing effort trend	Spatial trend			***m***		
3. Level of protection afforded to undersized specimens	Proportion of juveniles protected by the MMA network	***y***		***m***		
4. Fisheries sustainability	Indicator 3.1.1 MSFD: F/Fmsy of commercial stocks	***y***	***y***		***q***	
5. Ecosystem impact	Proportion of seabed significantly affected by trawling (Indicator 6.1.2 MSFD)			***q***		
6. Socio-economic sustainability	Indices of profitability (ROFTA)					***y***
7. Governance	Amount of illegal fishing within the MMA			***q***		

Skills, human power and source of raw data for calculating monitoring descriptor

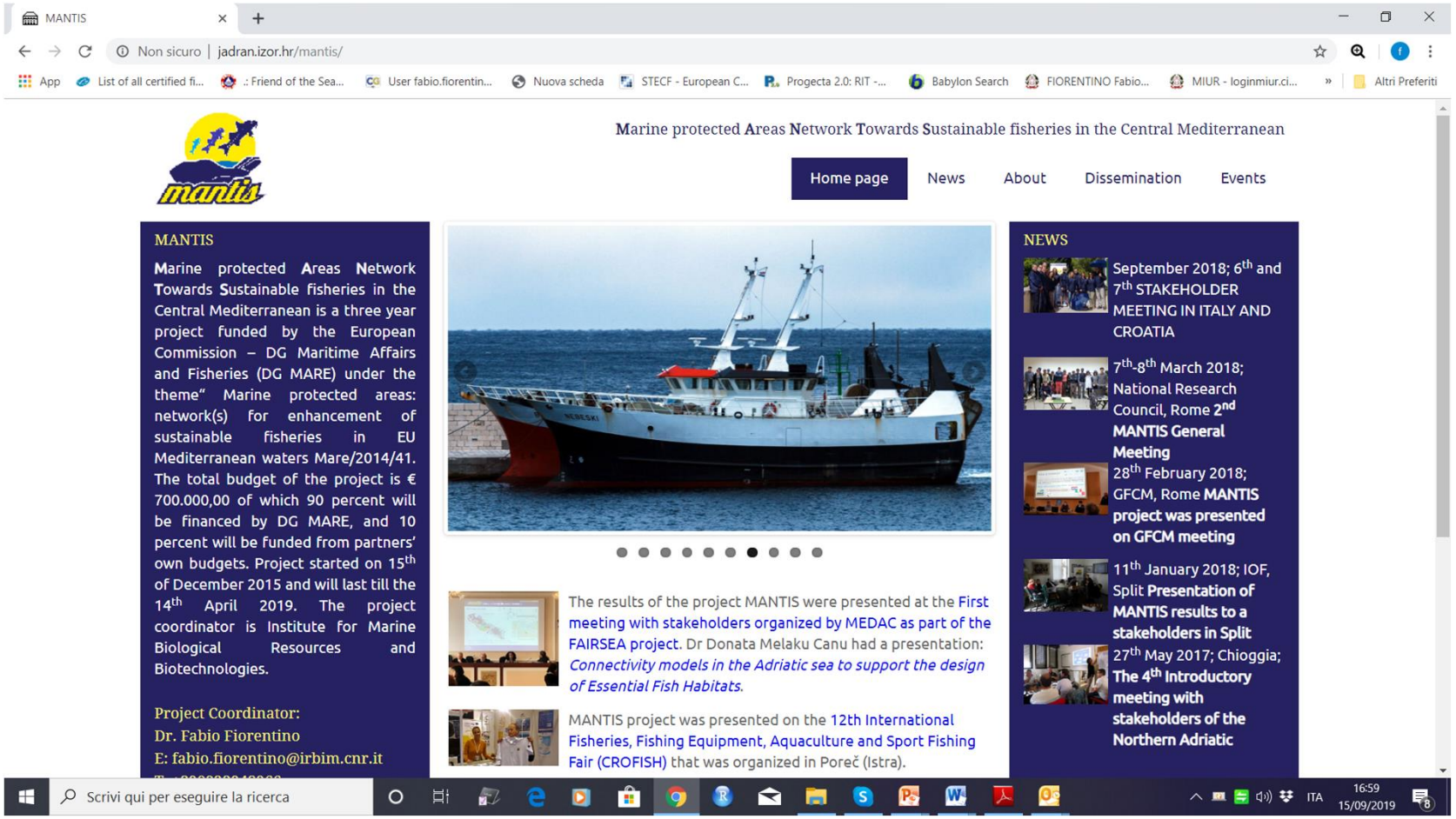
Monitoring objectives	Indicators	Skills and human power		Source of data
		Skills	Man / months	
1. Spillover from MMAs	Temporal trend in cpue of target stocks by size/age class	Time series analysis	2	MEDITS / SOLEMON
2. Track fishing effort displacement	Spatial trend	VMS data analysis	3	DG PESCA - MIPAAF
	Temporal trend			
3. Level of protection afforded to undersized specimens	Proportion of juveniles protected by the MMA network	Spatial analysis	3	MEDITS / SOLEMON
4. Fisheries sustainability	Indicator 3.1.1 MSFD: F/Fmsy of commercial stocks	Stock assessment	2	DCF
	Cpue of commercial by-catch species	Time series analysis	1	MEDITS / SOLEMON & DCF
	Cpue of non commercial species			
5. Ecosystem impact	Proportion of seabed significantly affected by trawling (Indicator 6.1.2 MSFD)	VMS data analysis	3	DG PESCA - MIPAAF
	Proportion of selected species at the top of the food web (Criterion 4.2 MFSD)	Time series analysis	3	MEDITS / SOLEMON /DCF
	Selaceans abundance (Criterion 4.3 MSFD: Abundance / distribution of key trophic groups/species)			
6. Socio-economic sustainability	ROFTA	Socio-economic data analysis	3	DCF
	GAV			
	NEP			
	Net Profit per vessel			
	CR/BER			
	Landing (total and by vessel/day)			
	Landing value (total and by vessel/day)			
	Revenue (total and by vessel/day)			
	Revenue per day			
	Average market price of landings			
	Fuel cost by vessel/day			
	Employment			
	Gross value added per FTEs			
	Gross value added per vessel			
	Average wages			
7. Fishers commitment	Amount of illegal fishing within the MMA	VMS data analysis	1	DG PESCA - MIPAAF
	Violation of regulations (n. and types of infringments)		1	NATIONAL AUTHORITIES
	Management costs and enforcement costs		2	

Technological tools for control and surveillance of MMAs

Geo-referenced information on Effort and Catch are essential for assessing and managing fisheries by temporal and spatial measures for massive demersal fisheries.
Amongst them should be considered:

- Electronic Logbook (EL)
- Vessel Monitoring System (VMS)
- Automatic Identification System (AIS)
- Global Positioning Services (GPS)
- Copernicus Maritime Surveillance (CMS)
- Remote Electronic Monitoring (REM)
- Fishery and Oceanography Observing System (FOOS)

WP5 disseminated and will continue to disseminate through web site http://jadran.izor.hr/mantis results obtained and **best practices** experienced during the MANTIS project.



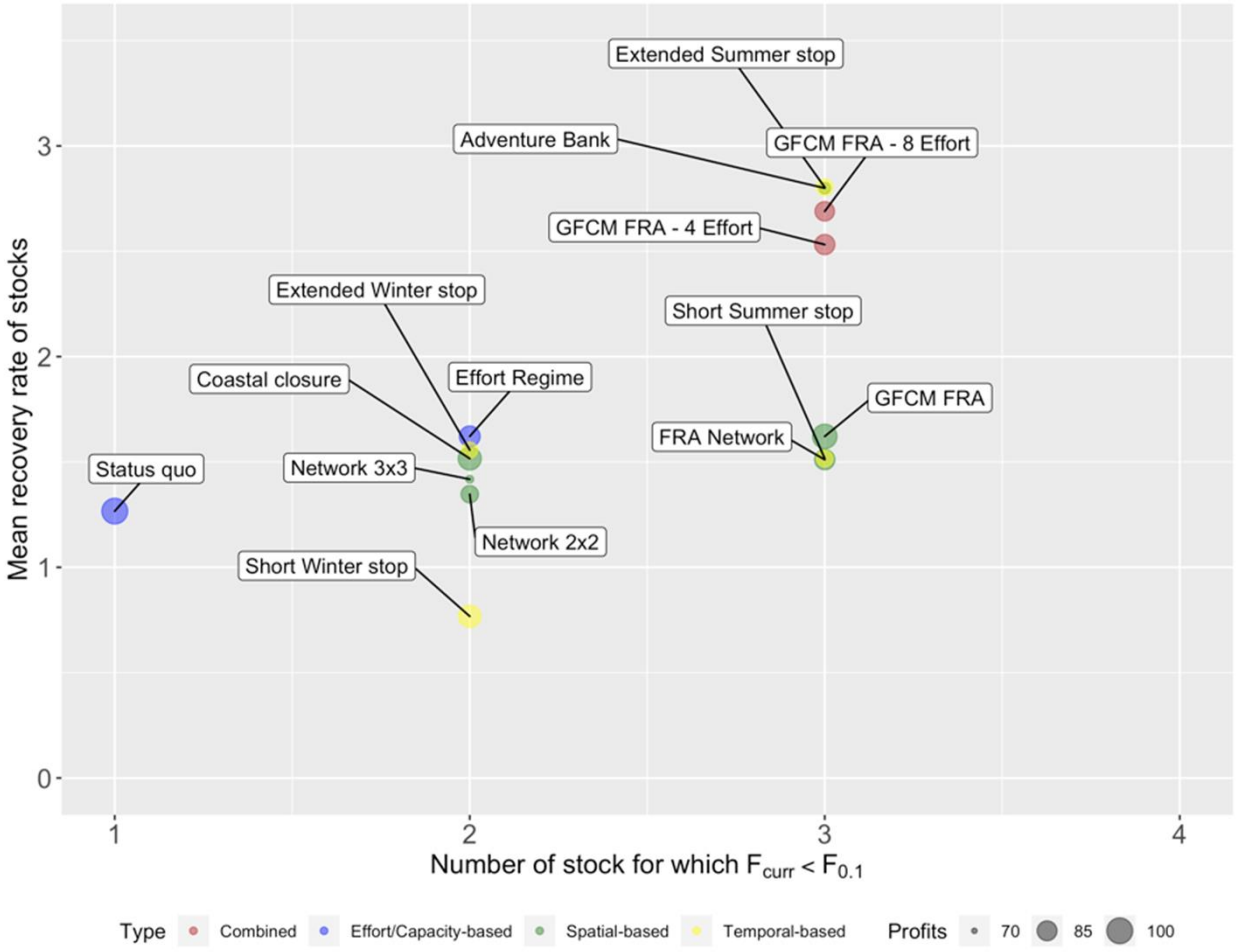
The main contribution of Mantis to the achievement of the CFP objectives

i) the closure of the three established GFCM FRA are likely to allow reaching $F_{0.1}$ for three stocks considered with exclusion of Hake

ii) an Extended Summer stop, that is the full temporal ban of trawling for 2 months followed by other two months of reduced activity, represents another potentially effective approach (but costly)

iii) all the management scenarios are always associated, at least in their first phase of entry into force, to a decrease of the profit for the fleet with respect to the *status quo*

The demersal resources of the Strait of Sicily



The main contribution of Mantis to the achievement of the CFP objectives

i) the FRA for the Sole Sanctuary seems to be effective for sole, while the Pomo Pit FRA is likely to determine positive consequences for the Norway lobster

ii) the reduction of trawl effort seems not enough to recover the SSB for the four target species,

iii) the most effective measure seems to be the closure all the year around of a large coastal area (within 6 nautical miles from the coast), although its economic effects could be negative for the fleet in the short term,

iv) the Extended Summer stop scenario does not seem a promising approach in the Adriatic Sea

The demersal resources of the Adriatic Sea