ABIOMMED

SUPPORT COHERENT AND COORDINATED ASSESSMENT OF BIODIVERSITY AND MEASURES ACROSS MEDITERRANEAN FOR THE NEXT 6-YEAR CYCLE OF MSFD IMPLEMENTATION

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MEDAC
MEDITERRANEAN ADVISORY COUNCIL

Co-founded by the European Union

Testing spatial management scenarios to reduce the impact of fishing on the benthic habitats in the Mediterranean Sea. An introduction to ABIOMMED methodology

MEDAC meeting, 22-23 Nov 2022

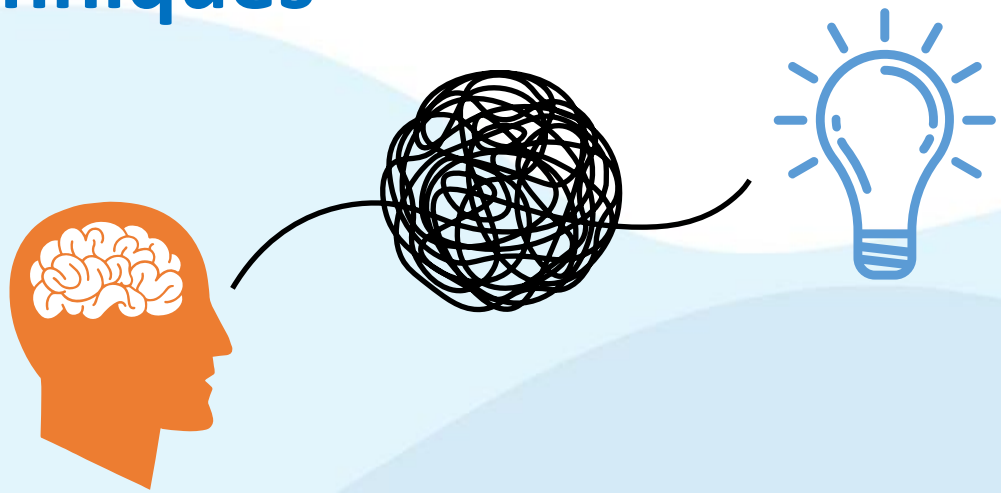
www.abiommed.eu

Scope & Aims

- This task will explore, by using **modelling** tools and literature sources, the expected effects of alternative management options for fisheries and other key pressures (identified within Task 3.2) under different **scenarios**

- The framework of this task is coherent and aligned with the activity of working groups such as WKTRADE3, WGFBIT, Biodiversity Strategy 2030)

Methods & Analysis techniques



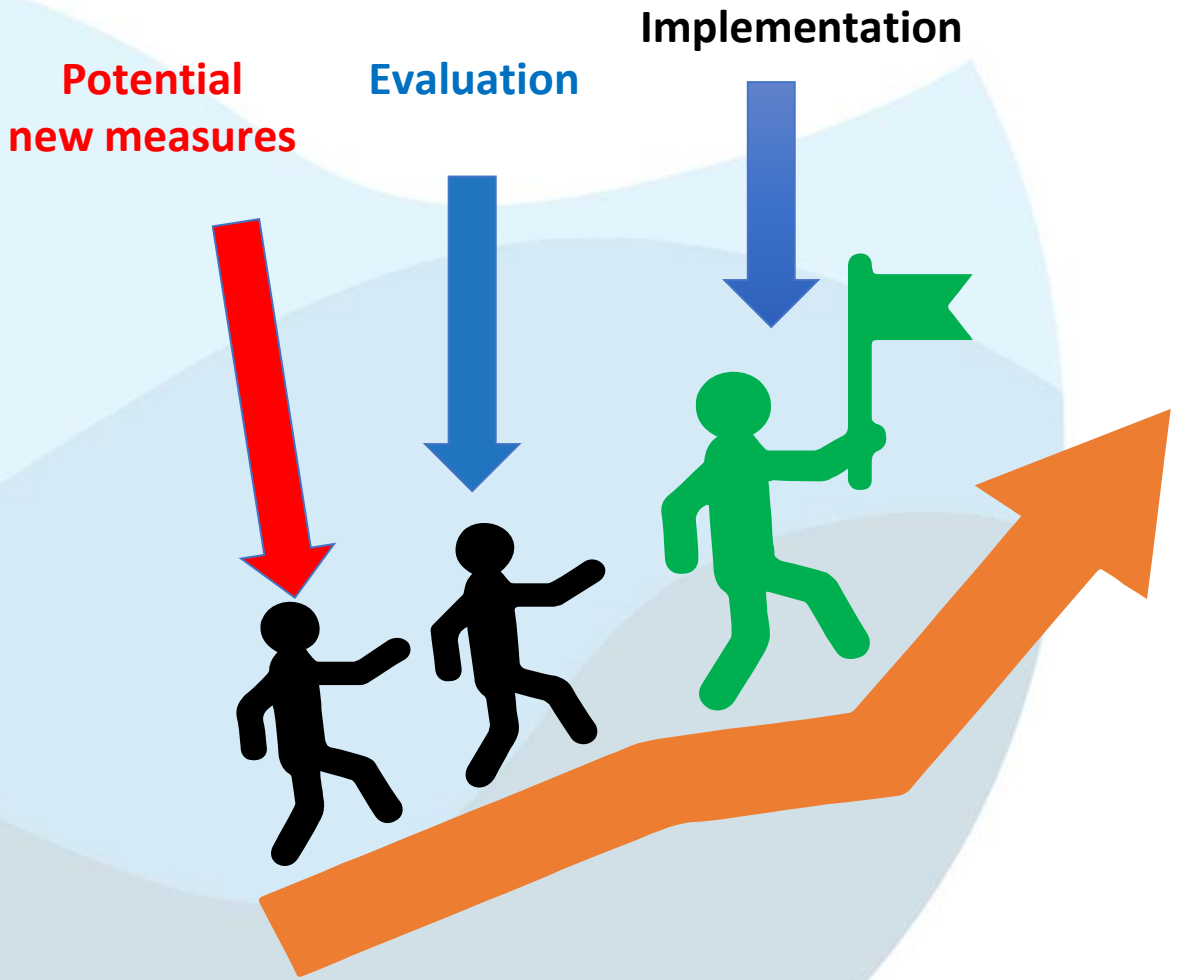
Individual-based models will be applied to simulate and forecast the potential consequences of different management measures on:

- **Fishers and their activity (including the economical dimension)**
- **Resources (in terms of stocks conditions)**
- **Seabed**

Methods & Analysis techniques

The task will also consider expecially the scenarios and approaches applied by the WKTRADE3 and will contribute to its activities. In particular:

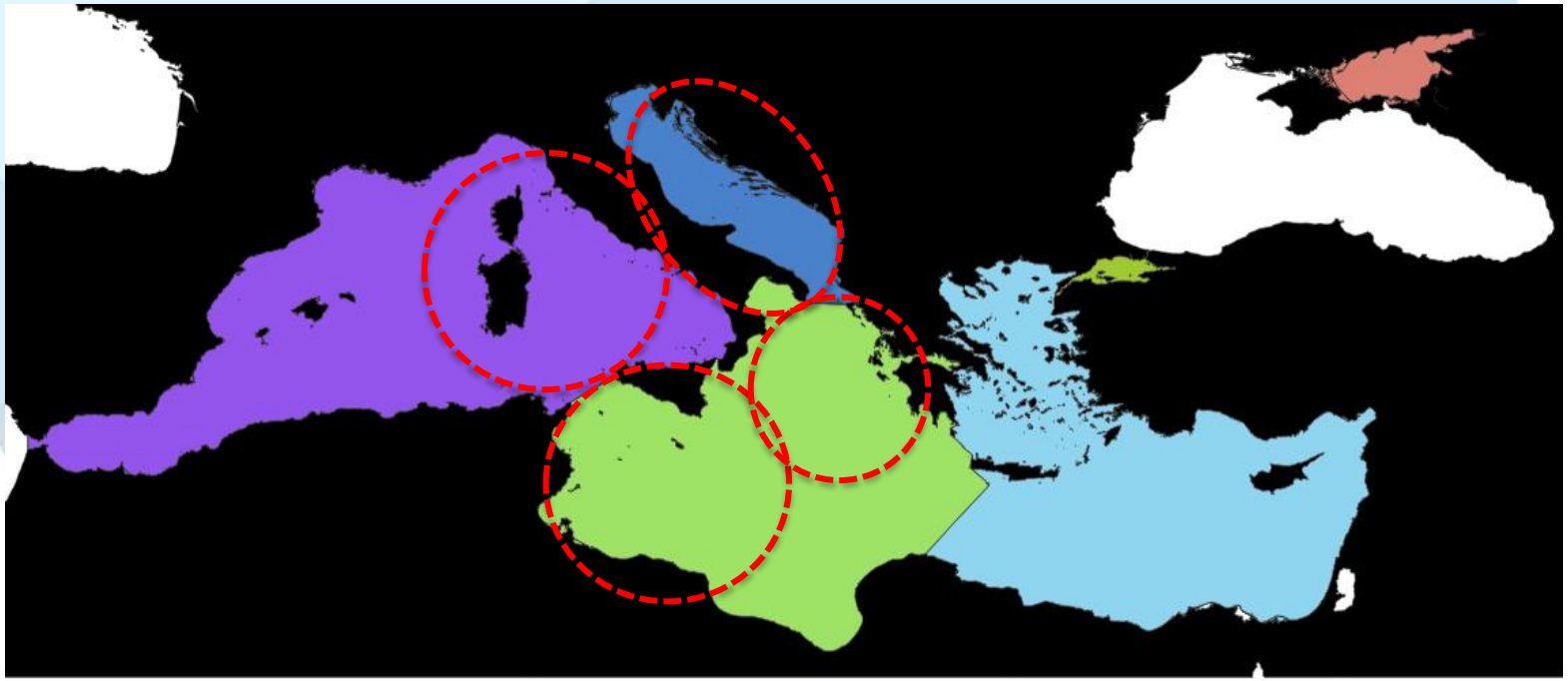
- the optimization approach described in Ban and Vincent (2019) will be considered to identify the set of management options (based on the reduction of fished area) to be evaluated;
- a set of metrics (according to e.g. the work done in the WKTRADE3) characterizing both population and community status and longevity rate will be used to assess the fishing pressure on seabed habitats.
- Attempt to integrate costs into economic modelling of fishing grounds exploitation



Case studies

Four case studies in different Mediterranean subregions:

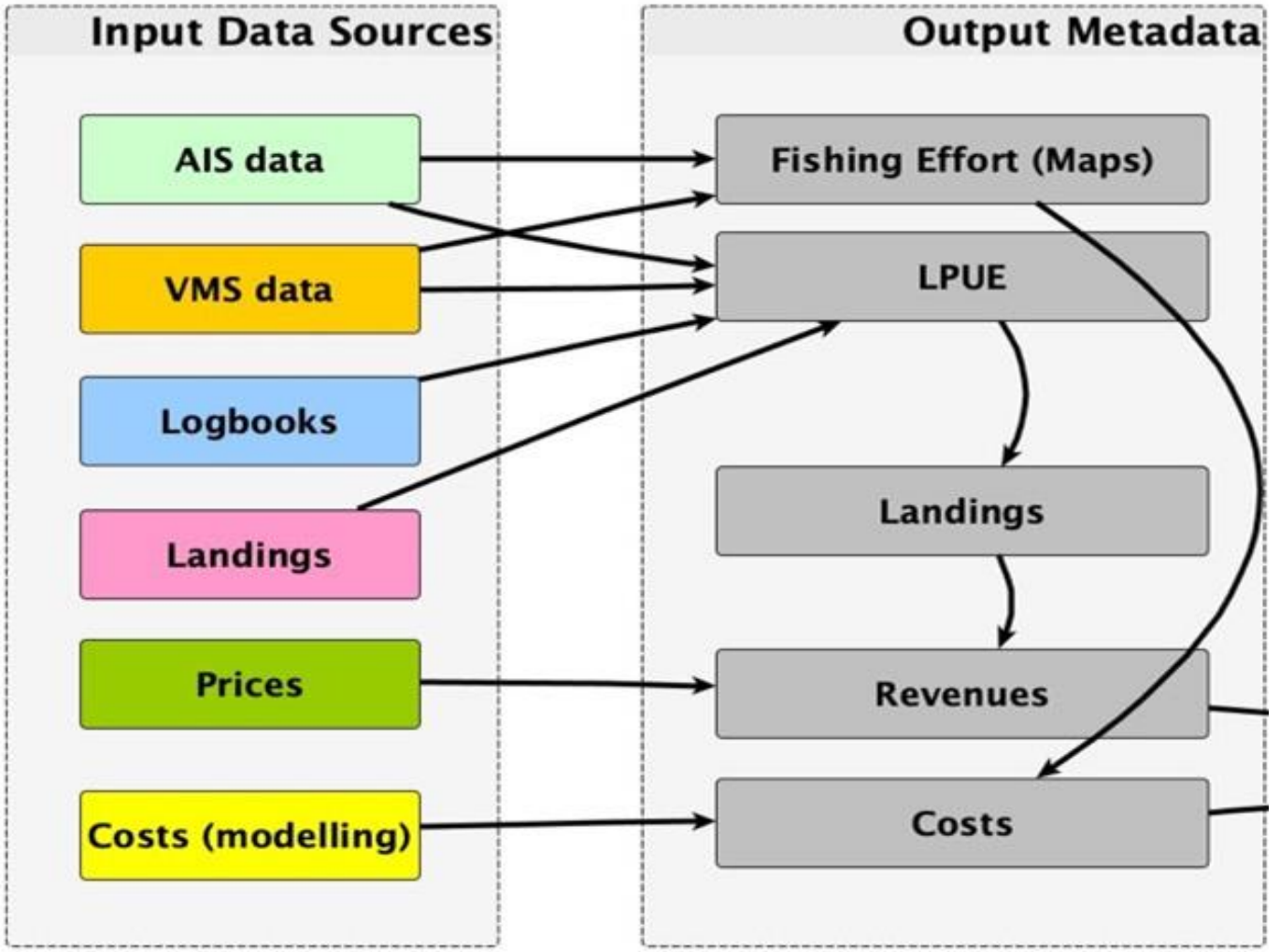
- **The Western Mediterranean (GSAs 9, 10 and 11)**
- **The Strait of Sicily (GSAs 12-16)**
- **The Adriatic Sea (GSAs 17 and 18)**
- **The Ionian Sea (GSA19)**



Modelling approach

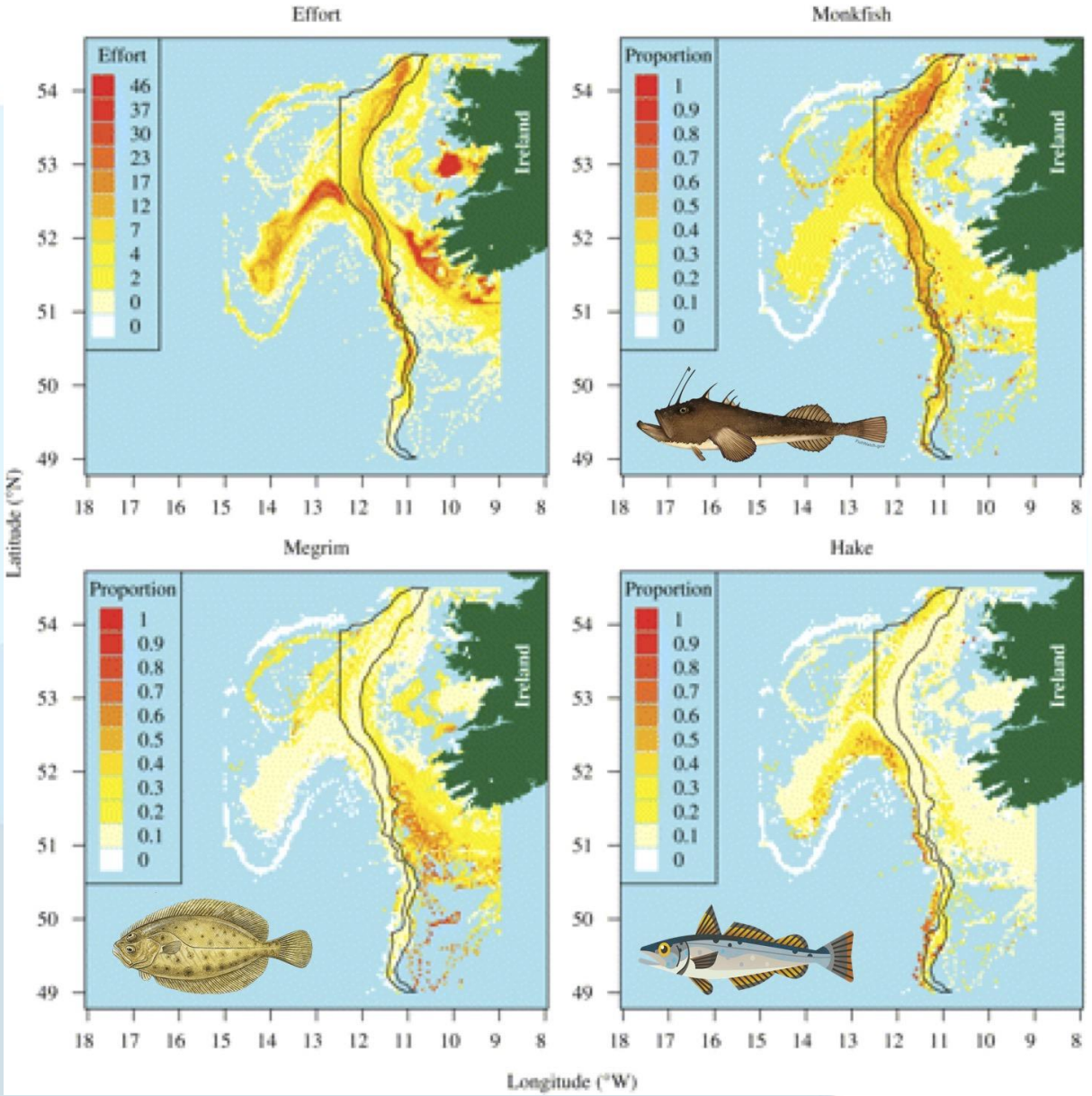
We are using the following input sources:

- VMS and AIS data to map fishing effort and related spatial costs
- Logbook and Logbook-like data to reconstruct catches and spatial LPUE
- Prices at market of the most important species



Modelling approach

- In general, according to the seminal work of Hans Gerritsen and Colm Lordan (2010), it is possible to link fishing effort with catch to reconstruct spatial origin of landings and spatial LPUE)



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Modelling approach

Why this important?

- CPUE or LPUE time-series can be provided by taking into account changes in fishing locations for fleets that may switch between target species
- The intended target species of each trip may be identified by comparing the spatial distribution of effort and cpue data, allowing trips to be characterized into métiers more accurately
- Distribution maps of catches of vulnerable species can be used to identify areas for potential fisheries closure and to monitor their effectiveness
- Having spatial LPUE means that we can assign a value (expected revenues) to each spatial unit as a function of LPUE by species/time and effort

Modelling approach

BUT.... Logbook data are collected on a different temporal scale from VMS data, which creates a problem for linking the two datasets

- In general, spatial and temporal resolution of Logbook data are much lower than those of the VMS
- Logbooks generally refer to large areas (ICES rectangles or Geographic Sub areas)
- From a time perspective, the logbook data may correspond to the activities conducted during the fishing day (but very unlikely to individual hauls)
- It has been shown (Sampson, 2011) that accuracy and completeness of logbook data are inversely correlated (fishermen may be reluctant to give all the information about their activity)

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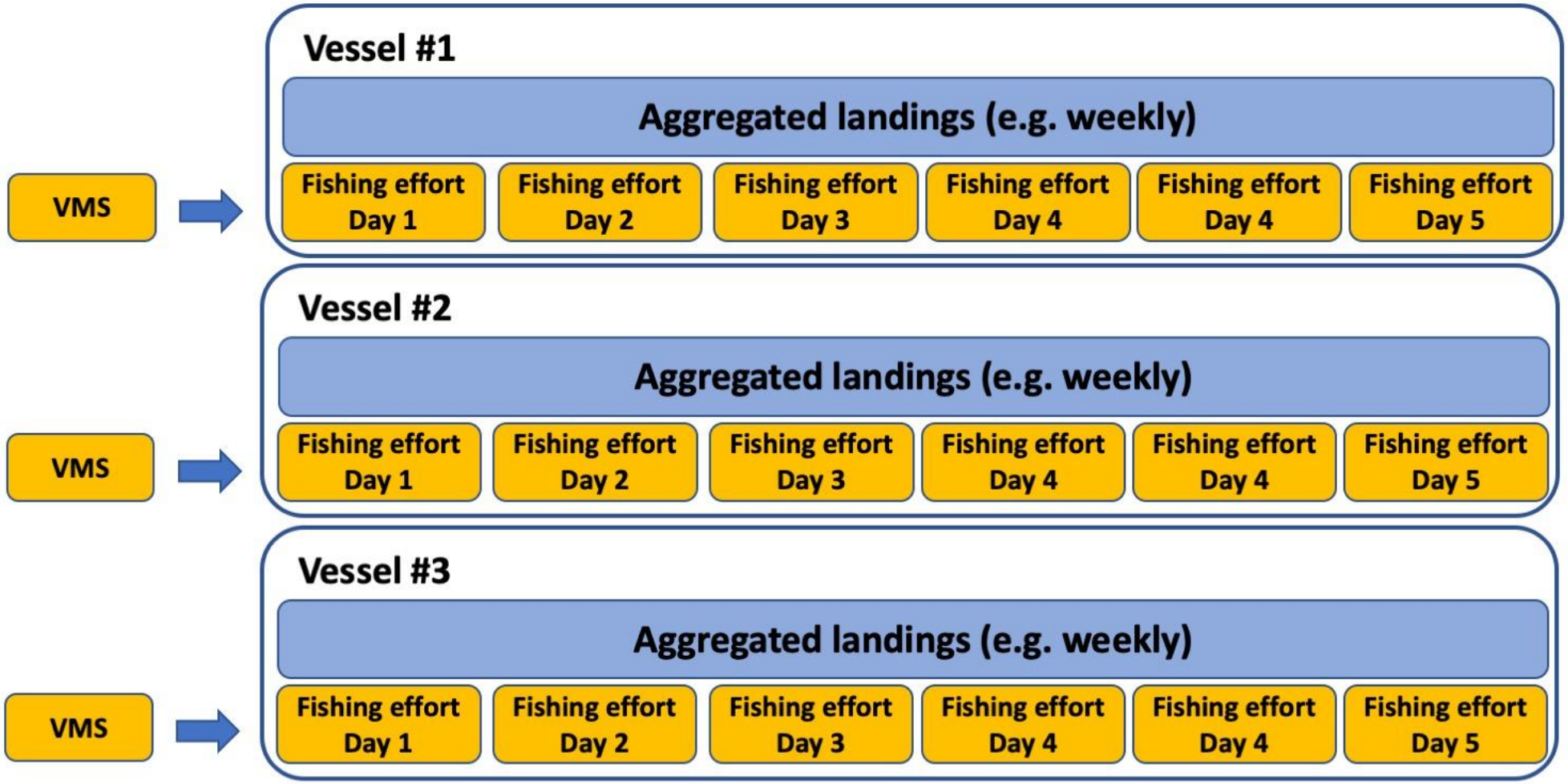
Modelling approach



Modelling approach

We developed a statistical procedure to merge VMS and Logbook data to infer:

- **The spatial origin of catches or landings, even if at a lower time scale (i.e. monthly)**
- **The productivity of different fishing grounds (as. CPUE or LPUE)**

Fisheries Research 199 (2018) 218–230

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Research Paper

A model combining landings and VMS data to estimate landings by fishing ground and harbor

T. Russo[a,*,1], E.B. Morello[b,1], A. Parisi[c], G. Scarcella[b], S Angelini[b], L. Labanchi[d], M. Martinelli[b], L. D'Andrea[a], A Santojanni[b], E. Arneri[b,e], S. Cataudella[a]

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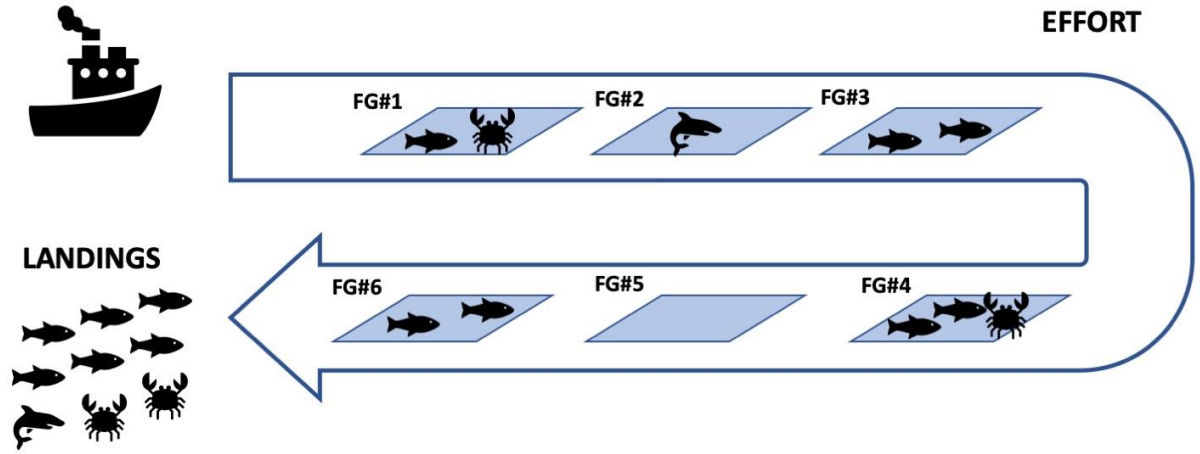
[b] CNR – Italian National Research Council, ISMAR – Institute of Marine Sciences, Largo Fiera della pesca 2, Ancona, 60125, Italy
[c] Department of Economics and Finance, Faculty of Economics, University of Rome Tor Vergata, via Columbia, 00133, Rome, Italy



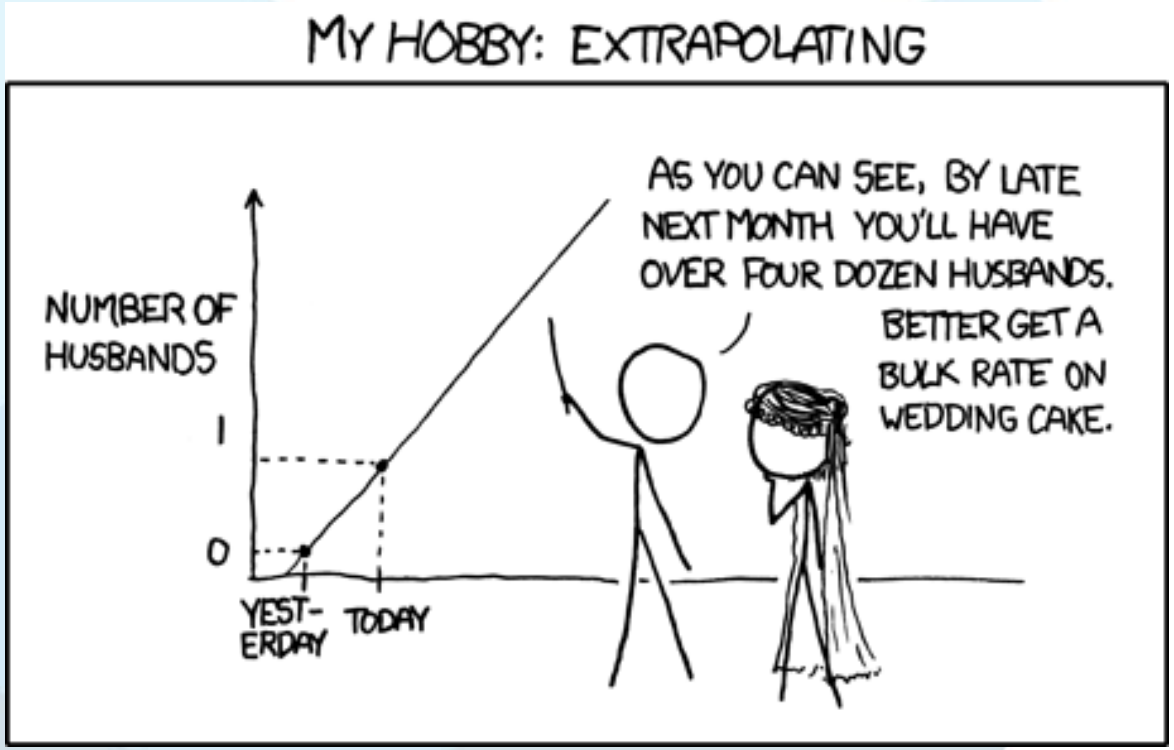
Essentially, total landings are the sum of the products of fishing effort times the productivity of different areas

$$Landings = prod_{FG1} * effort_{FG1} + prod_{FG2} * effort_{FG2} + ...prod_{FGn} * effort_{FGn}$$

Modelling approach

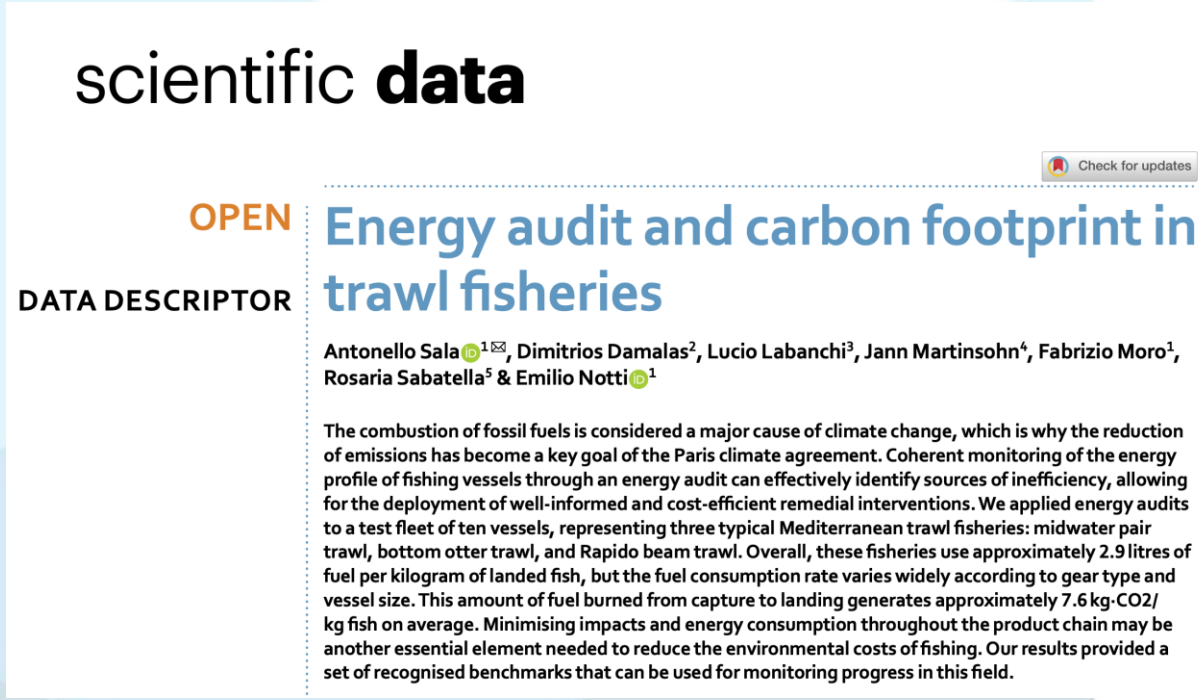
Caveats

- A linear relationship between effort and landings (or catches) is a rigid model
- But it's hard to estimate more complex relationships from data
- Even if available, the interpretability of spatial LPUE or CPUE would be lost
- The coefficients of a linear model are very easy to use
- The size of a vessels generally represents of the main aspects affecting its fishing power



Modelling approach

- Spatial costs can be estimated using some up-to-date relationship between fuel consumption and vessel speed
- Having VMS and AIS data is possible to reconstruct the whole path of a fishing vessel
- It is possible to estimate the spatial costs for a fishing fleet by combining the fishing footprint with the topology (distribution of the harbours with respect to the fishing grounds)



scientific data

Check for updates

OPEN

DATA DESCRIPTOR

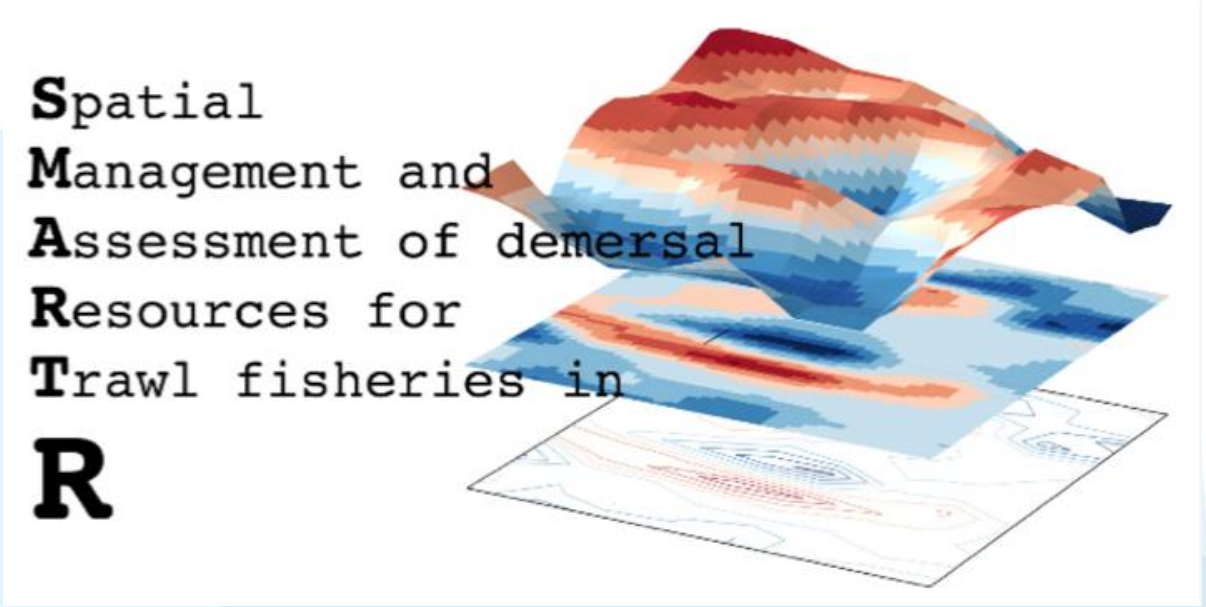
Energy audit and carbon footprint in trawl fisheries

Antonello Sala[1]✉, Dimitrios Damalas[2], Lucio Labanchi[3], Jann Martinsohn[4], Fabrizio Moro[1], Rosaria Sabatella[5] & Emilio Notti[1]

The combustion of fossil fuels is considered a major cause of climate change, which is why the reduction of emissions has become a key goal of the Paris climate agreement. Coherent monitoring of the energy profile of fishing vessels through an energy audit can effectively identify sources of inefficiency, allowing for the deployment of well-informed and cost-efficient remedial interventions. We applied energy audits to a test fleet of ten vessels, representing three typical Mediterranean trawl fisheries: midwater pair trawl, bottom otter trawl, and Rapido beam trawl. Overall, these fisheries use approximately 2.9 litres of fuel per kilogram of landed fish, but the fuel consumption rate varies widely according to gear type and vessel size. This amount of fuel burned from capture to landing generates approximately 7.6 kg·CO2/kg fish on average. Minimising impacts and energy consumption throughout the product chain may be another essential element needed to reduce the environmental costs of fishing. Our results provided a set of recognised benchmarks that can be used for monitoring progress in this field.

Modelling approach

- Spatial costs can be estimated using some up-to-date relationship between fuel consumption and vessel speed
- Having VMS and AIS data is possible to reconstruct the whole path of a fishing vessel
- It is possible to estimate the spatial costs for a fishing fleet by combining the fishing footprint with the topology (distribution of the harbours with respect to the fishing grounds)



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APPLICATION

Methods in Ecology and Evolution BRITISH ECOLOGICAL SOCIETY

smart R: An r package for spatial modelling of fisheries and scenario simulation of management strategies

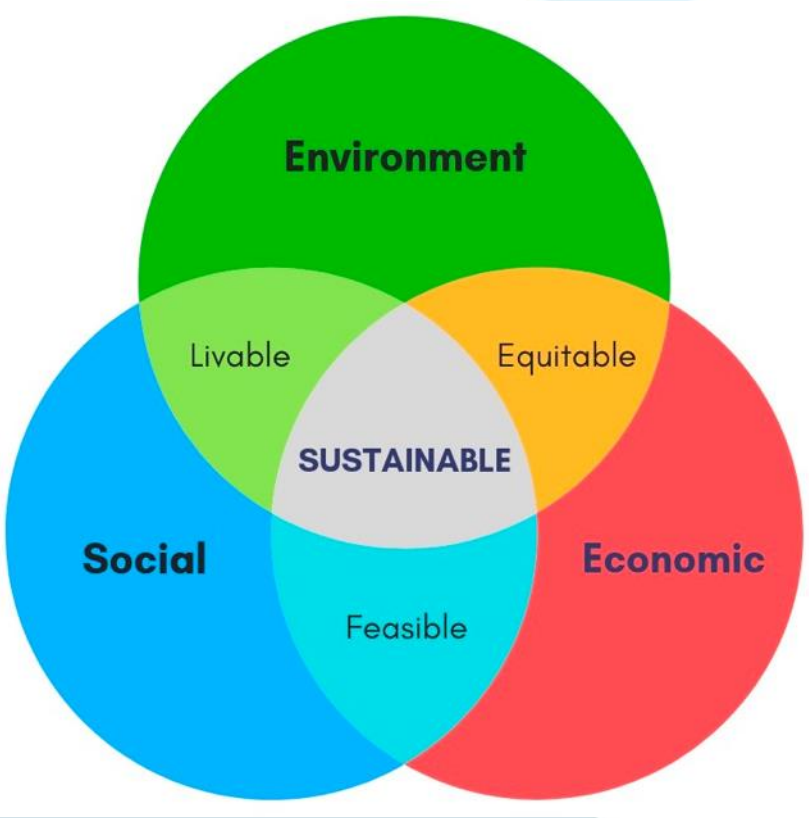
Lorenzo D'Andrea[1] | Antonio Parisi[2] | Fabio Fiorentino[3] | Germana Garofalo[3] | Michele Gristina[4] | Stefano Cataudella[1] | Tommaso Russo[1]

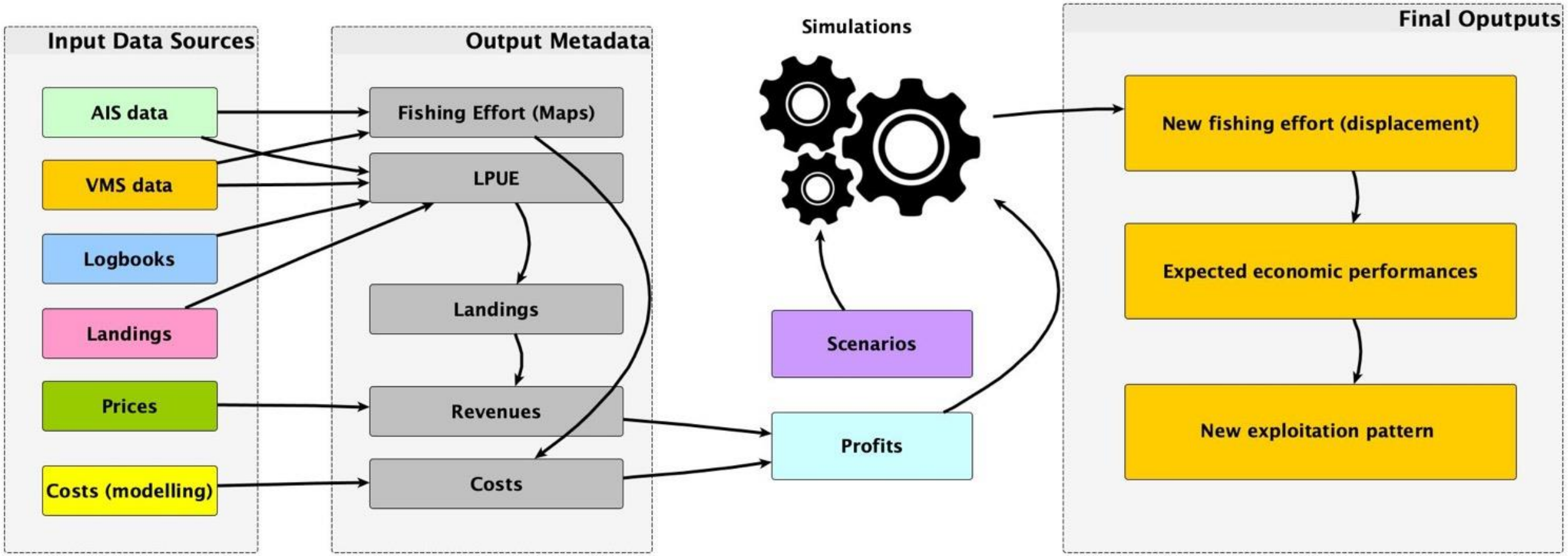
Challenges

- Most management measures determine fishing effort displacement (spatial reallocation of fishing activities)

- The question is whether the reallocated fishing effort reduces the sustainability of remaining fishing grounds, and whether the (ecological) costs and benefits would be balanced

- Models that predict the expected reallocation of fishing activities can assist managerial decisions and the potential need of complementary management measures in the surrounding areas

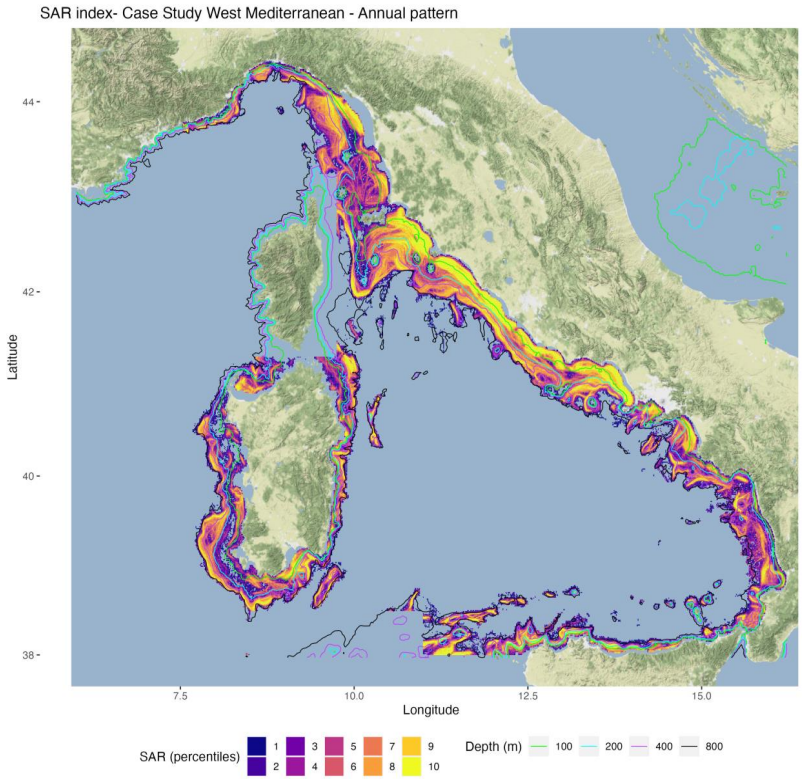


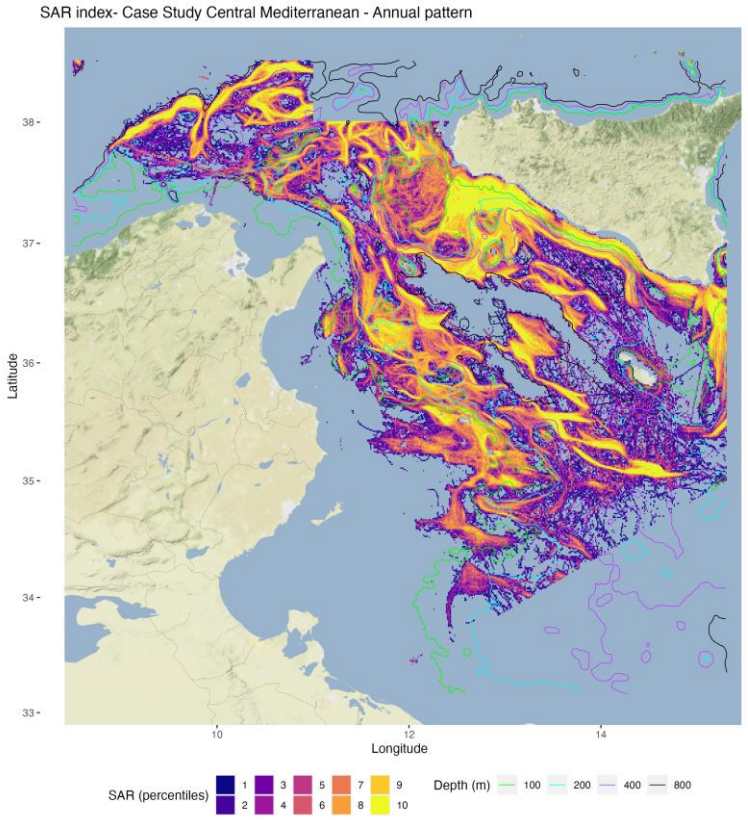

Input Data Sources
AIS data
VMS data
Logbooks
Landings
Prices
Costs (modelling)
Output Metadata
Fishing Effort (Maps)
LPUE
Landings
Revenues
Costs
Simulations
Scenarios
Profits
Final Oputputs
New fishing effort (displacement)
Expected economic performances
New exploitation pattern

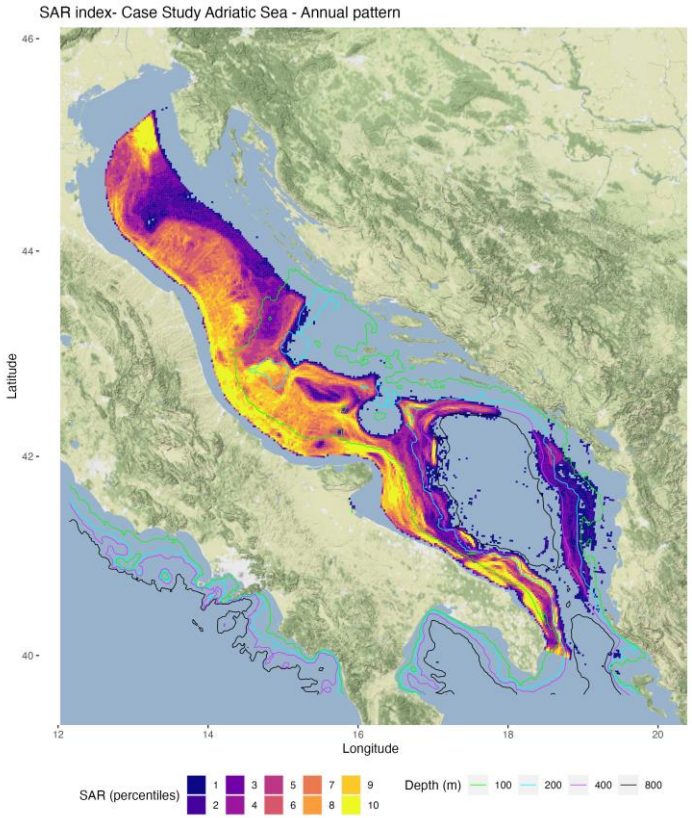
Work in progress: status of the activity

1. Data Collection (effort, landings, etc): **completed**
2. Analysis of the fishing effort: **completed**
3. Extimation of annual and seasonal LPUE: **completed**
4. Scenario analysis: **in progress (preliminary results without displacement)**

Examples: Fishing effort - Swept Area Ratio





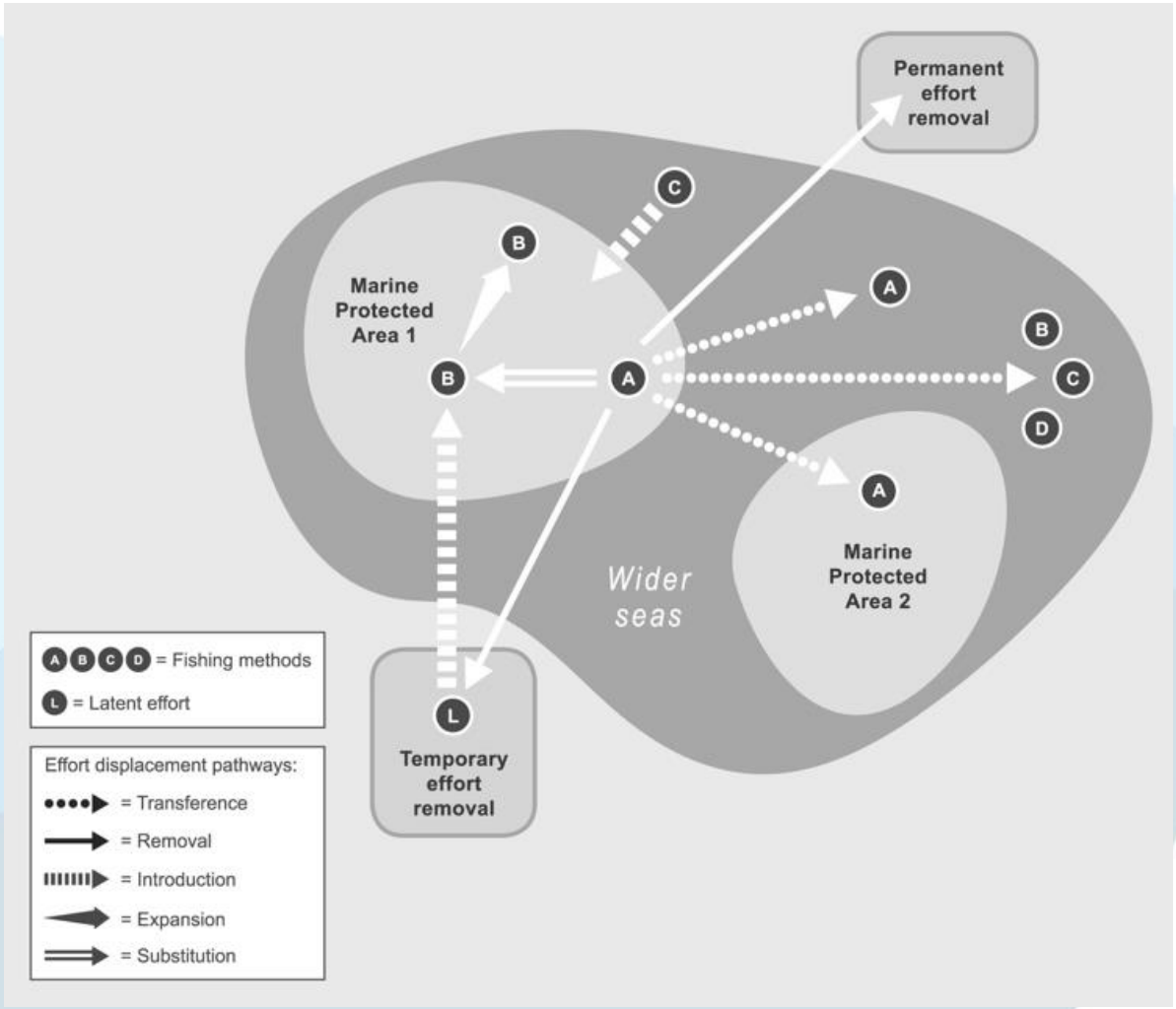


A step beyond

- **Displacement** is re-allocation of effort removed from marine protected areas

- Displacement of fishing effort due to implementing marine protected areas is expected and will be estimated

- Displacement can determine different patterns of economic indicators (with respect to the «frozen» approach



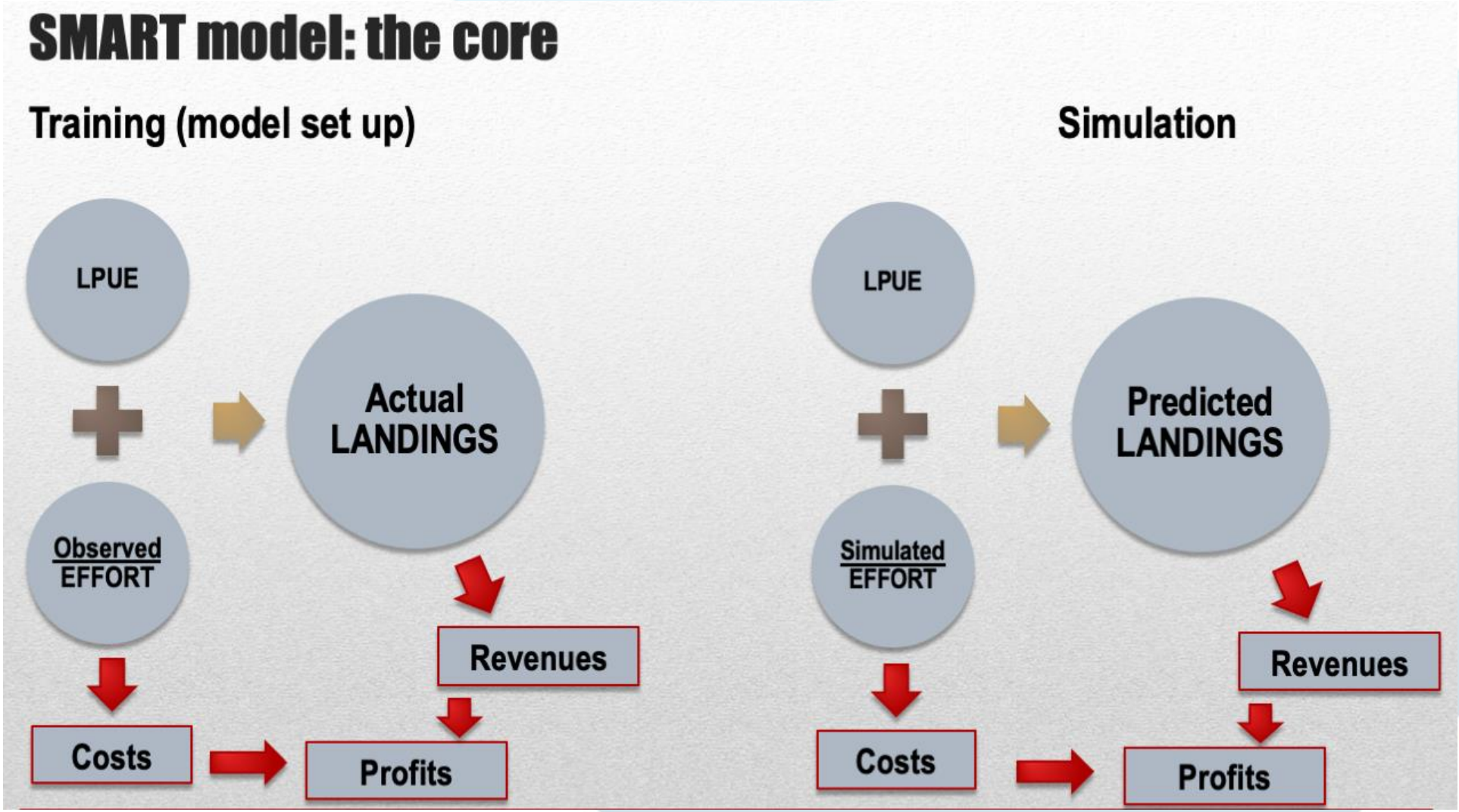
Source: https://www.sciencedirect.com/science/article/pii/S0308597X16307588#f0005

Next steps

How we can eventually predict the displacement determined by a new Fishery-Restricted area?

- **•We can assume that fishers will re-allocate their effort in other areas…. but which areas?**
- **We can reasonably assume that they will use their knowledge and experience (i.e. the way they ”see” the fishing grounds in terms of costs/benefits)**
- **We can randomly explore new potential vessel- and time- specific patterns of fishing effort and score them according to some economic criteria**
- **We can assume that each fisher is always aimed at maximizing its profits over a given time frame (e.g. total revenues - total costs = Gross Profit Margin at a daily, monthly or yearly scale)**

Rationale


SMART model: the core
Training (model set up)
LPUE
Observed EFFORT
Actual LANDINGS
Revenues
Costs
Profits
Simulation
LPUE
Simulated EFFORT
Predicted LANDINGS
Revenues
Costs
Profits

Scenario Analysis

1. **Fisheries-Restricted Areas already defined**
2. **Raising the bathymetric limit from 1000 to 800m**
3. **Band closure up to 6 miles from the coast**
4. **Closure of cells up to 50% of the overall trawled area**
5. **Additional analysis using the WKTRADE3 approach**

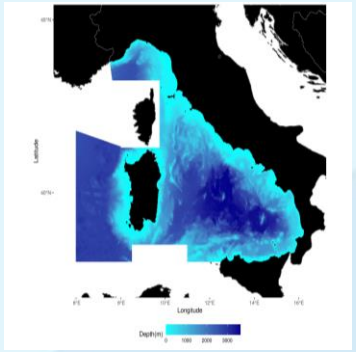
Preliminary results & management scenarios

- We will present in detail the case studies, the species considered, and the outputs of the modeling framework produced within our subtask.

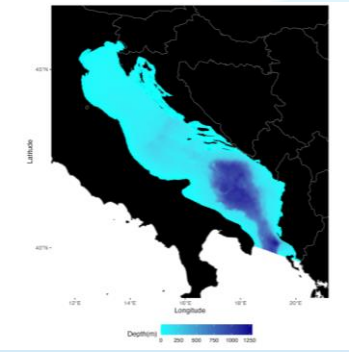
- We will then observe the different management scenarios tested to visualize the types of insight our approach can bring.

Case studies

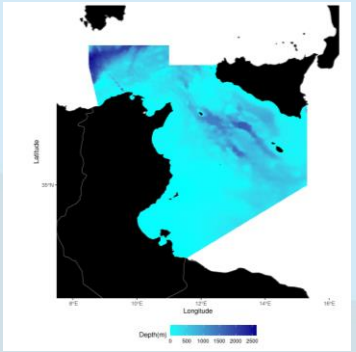
- **Our approach was performed on 4 different case study areas in the Central Mediterranean sea, encompassing the EEZ of Italy, Croatia, Albania, Malta…& international waters.**



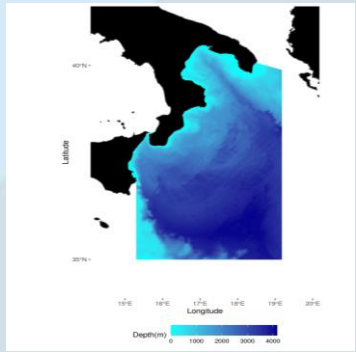
1. West Mediterranean Sea



3. Adriatic Sea



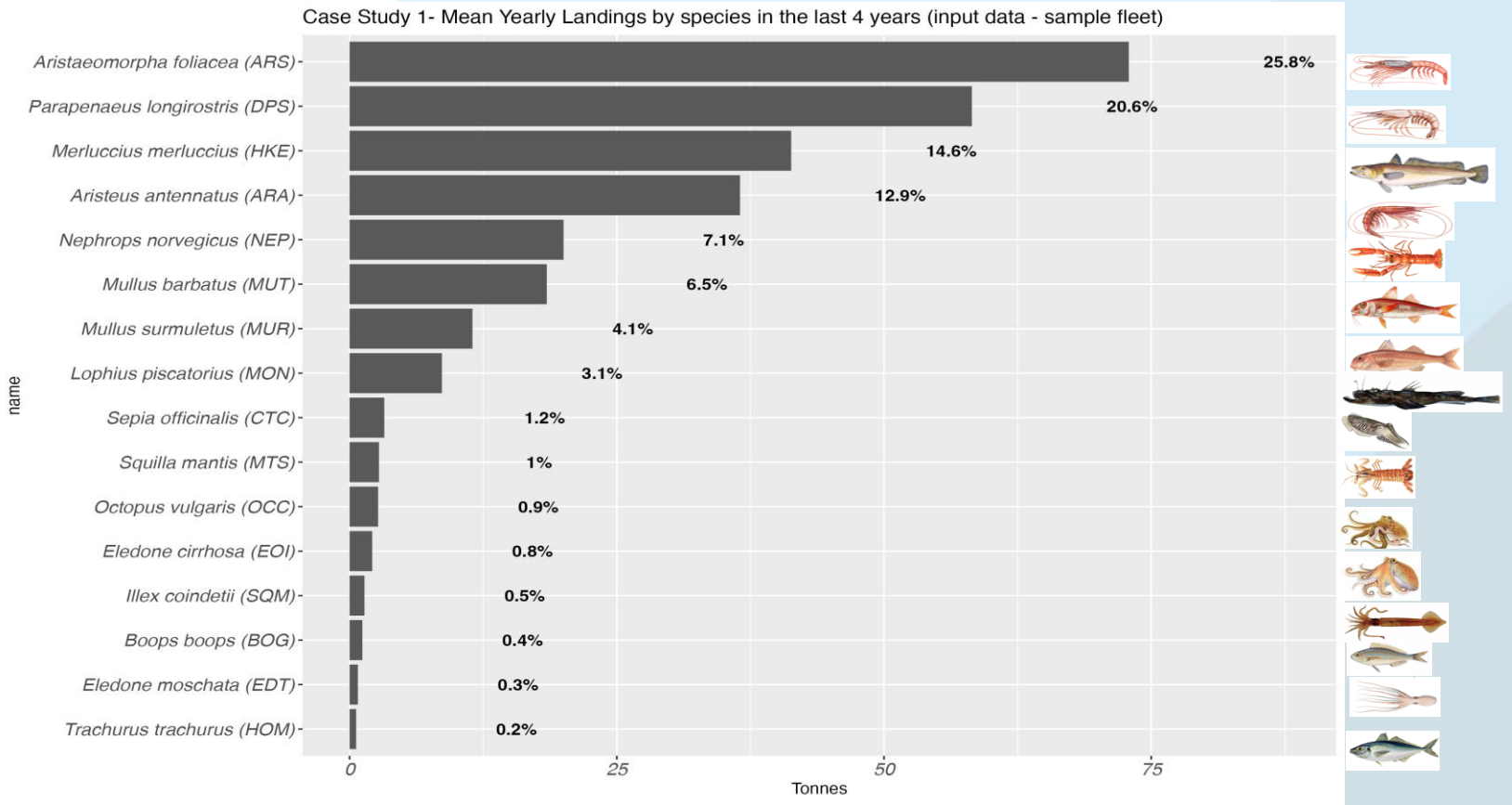
2. Strait of Sicily



4. Ionian sea

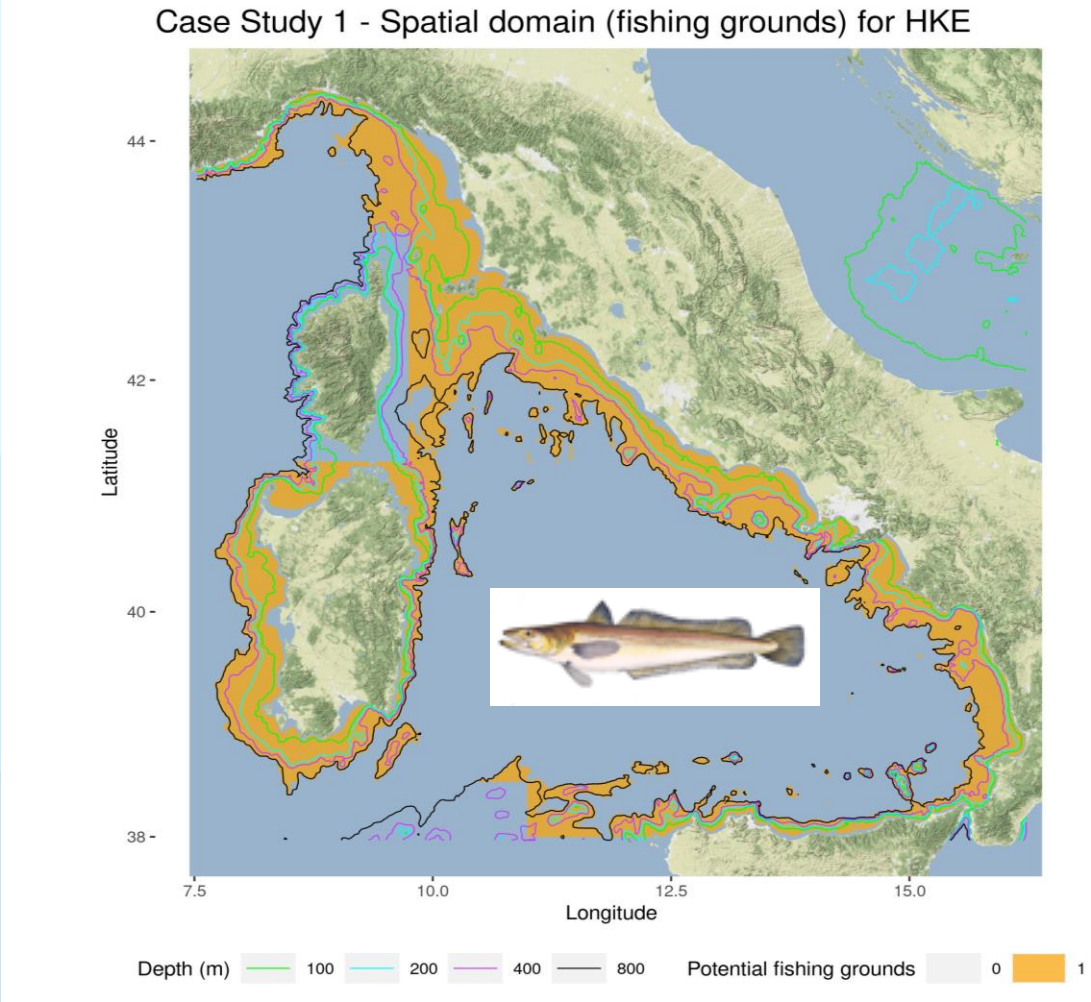
Exploited species considered

- **The 16 species with the highest landing in tonnes by bottom trawlers were selected and used to represent fisheries revenues.**



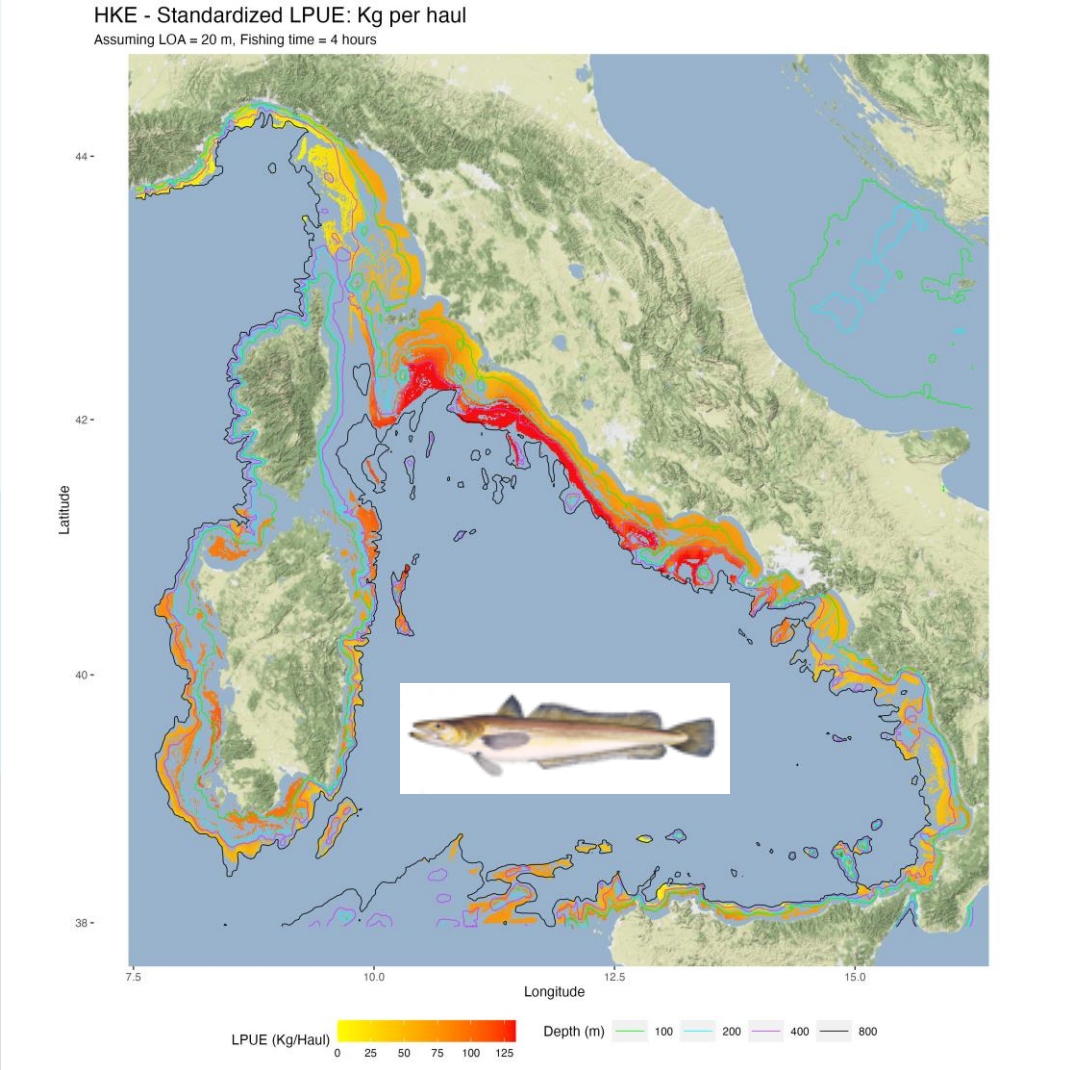
Fishing grounds calculation

- We used the known depth range of each species to infer “Fishing grounds” for each species.
- Example with *Merluccius merluccius* in Case study 1



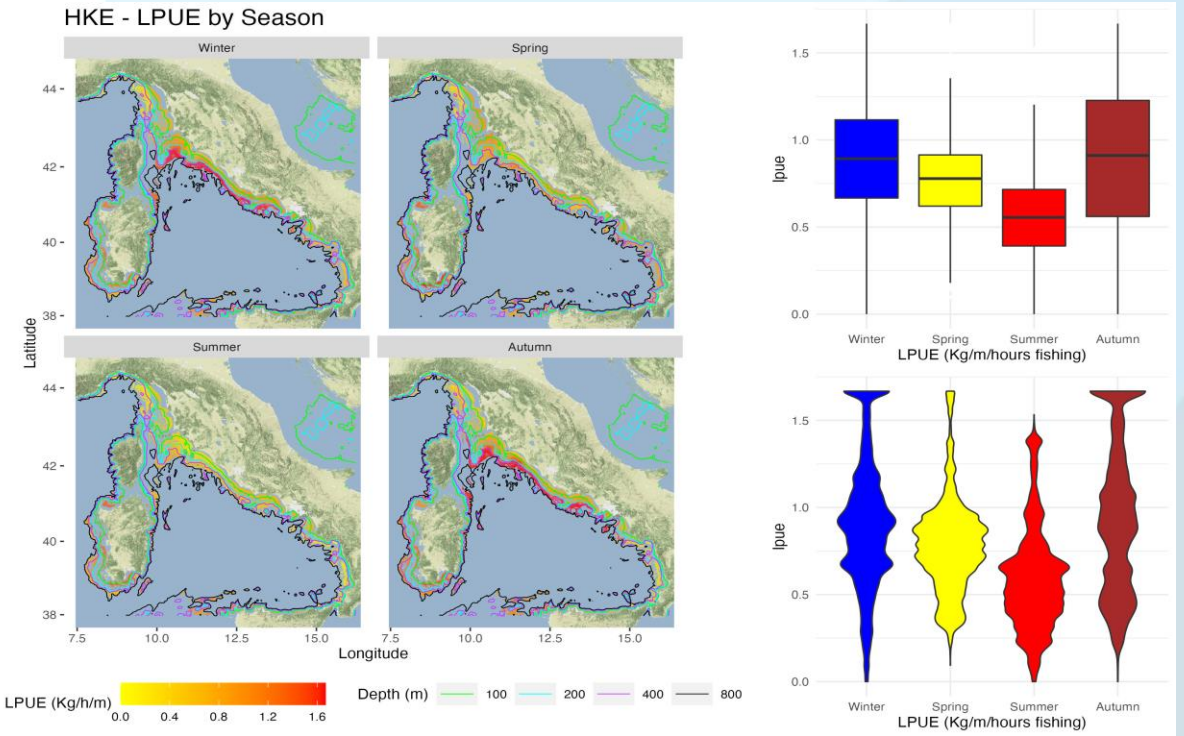
LPUE Interpolation – Yearly

- Using 3D - Nearest neighbor spatial interpolation, we computed for each species and each case study, The landings per unit of effort per year.



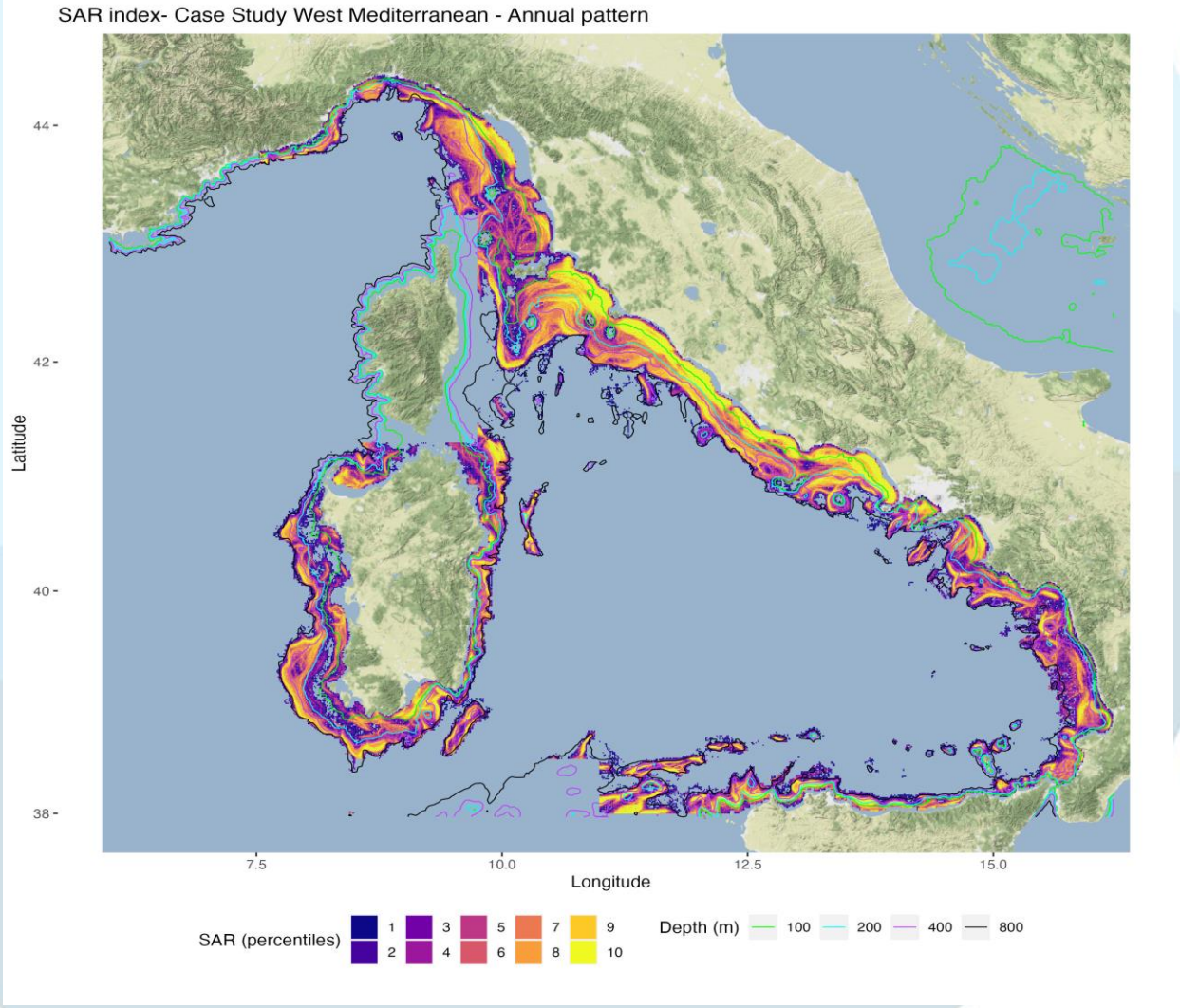
LPUE Interpolation – Seasonal

- **LPUE was also computed seasonally to encompass the temporal variability of fisheries.**



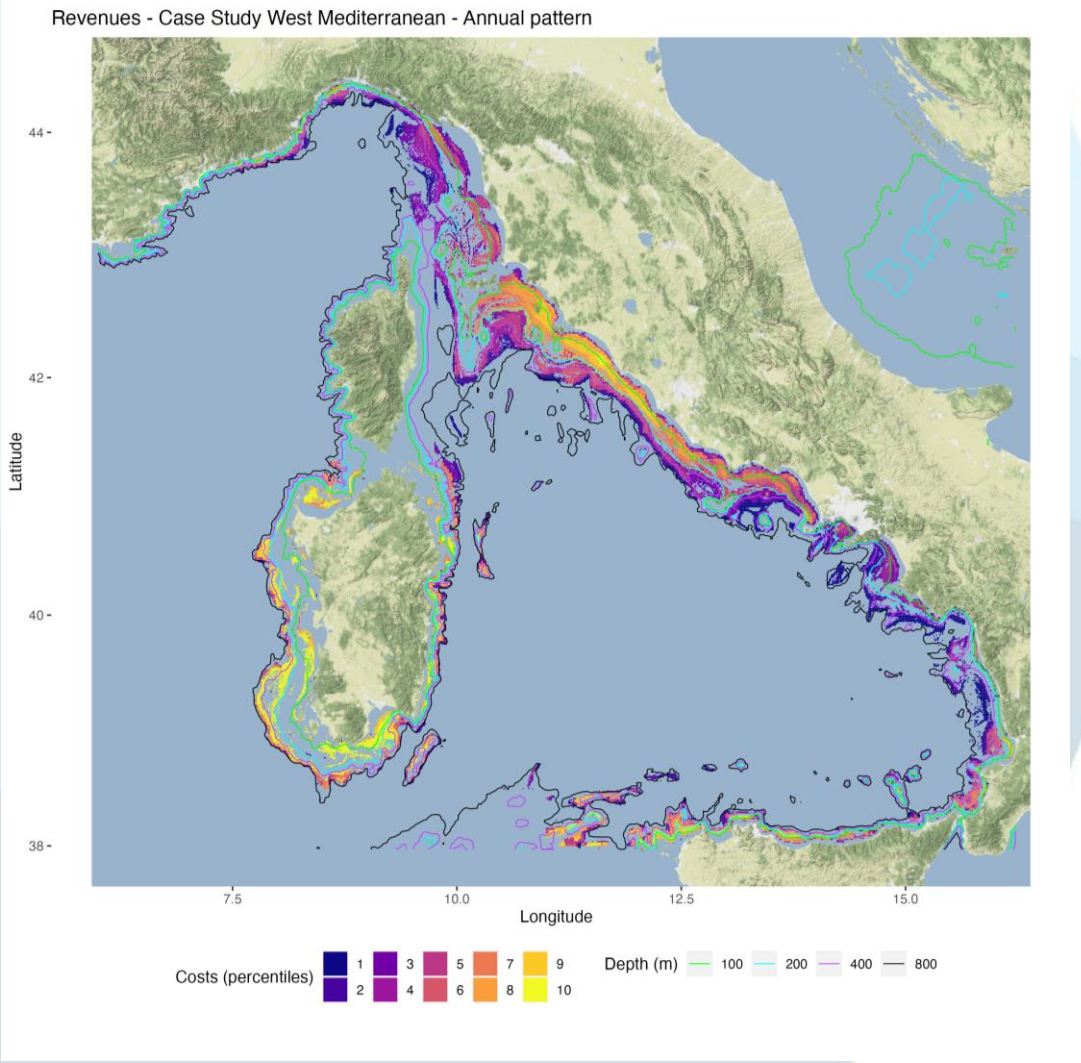
Fishing effort calculation

- We calculated the swept-area-ratio from VMS track data to estimate the intensity of fishing. This process was also done seasonally.



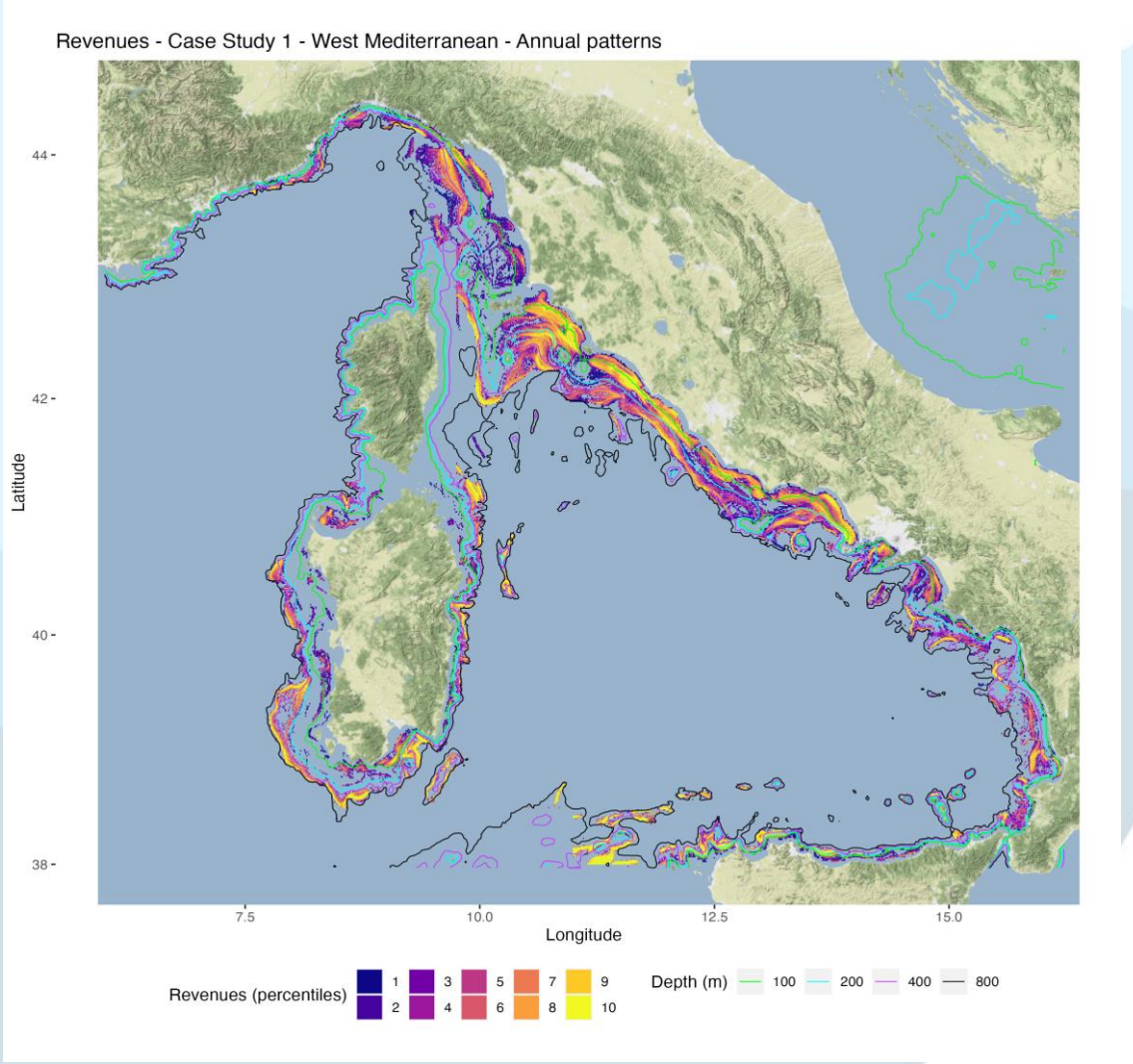
Costs estimation

- We estimated using fuel prices, distance to coast and effort, the cost of each cell's exploitation. This process was also done seasonally.



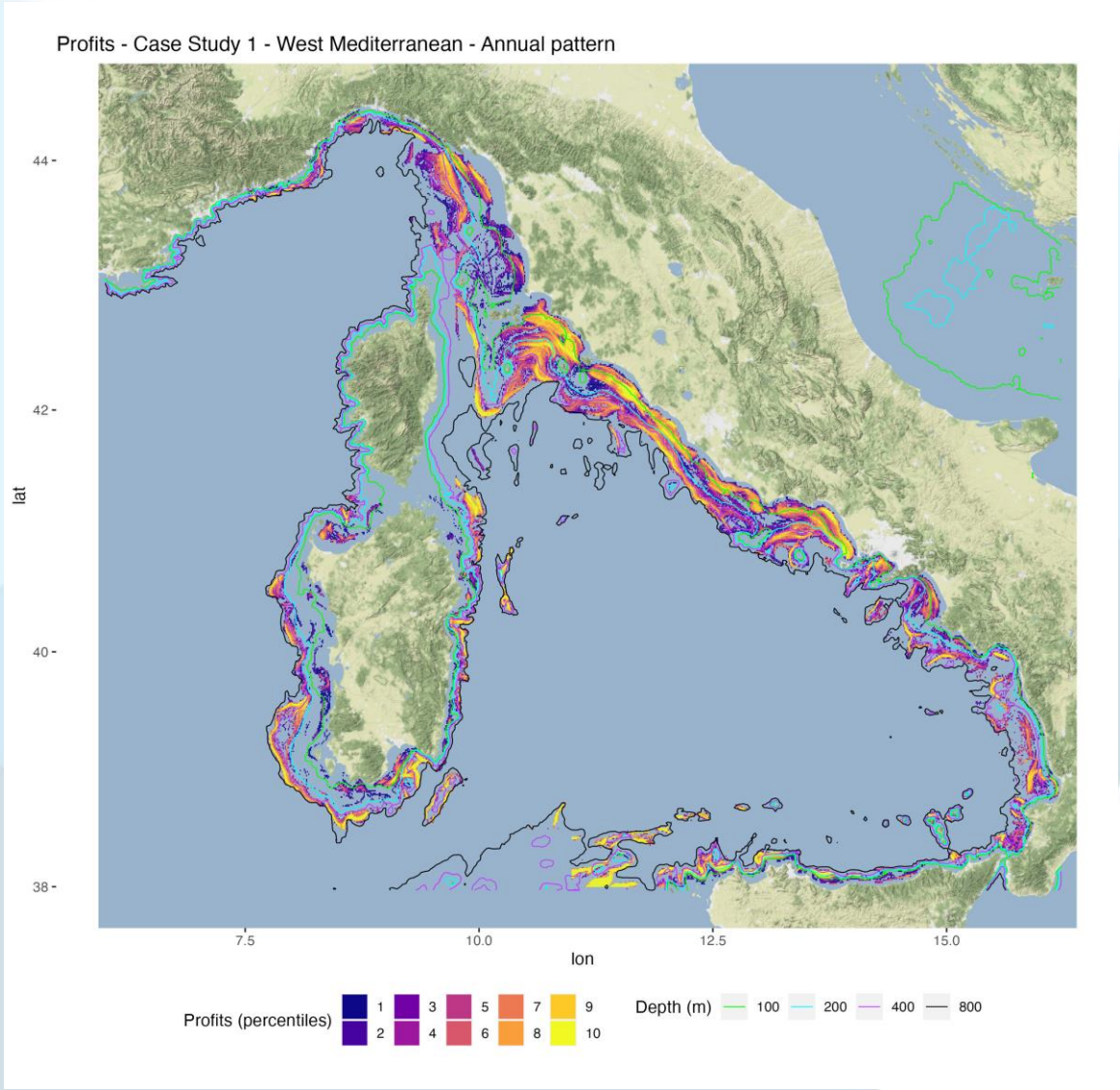
Gross revenue

- We estimated using the market value of all the selected species, the interpolated LPUE and the fishing effort, the revenue from fishing in each cell.



Profitability

- Using the revenue and the cost of each cell's exploitation, we can estimate their profitability, a key parameter in order to compare management scenarios.

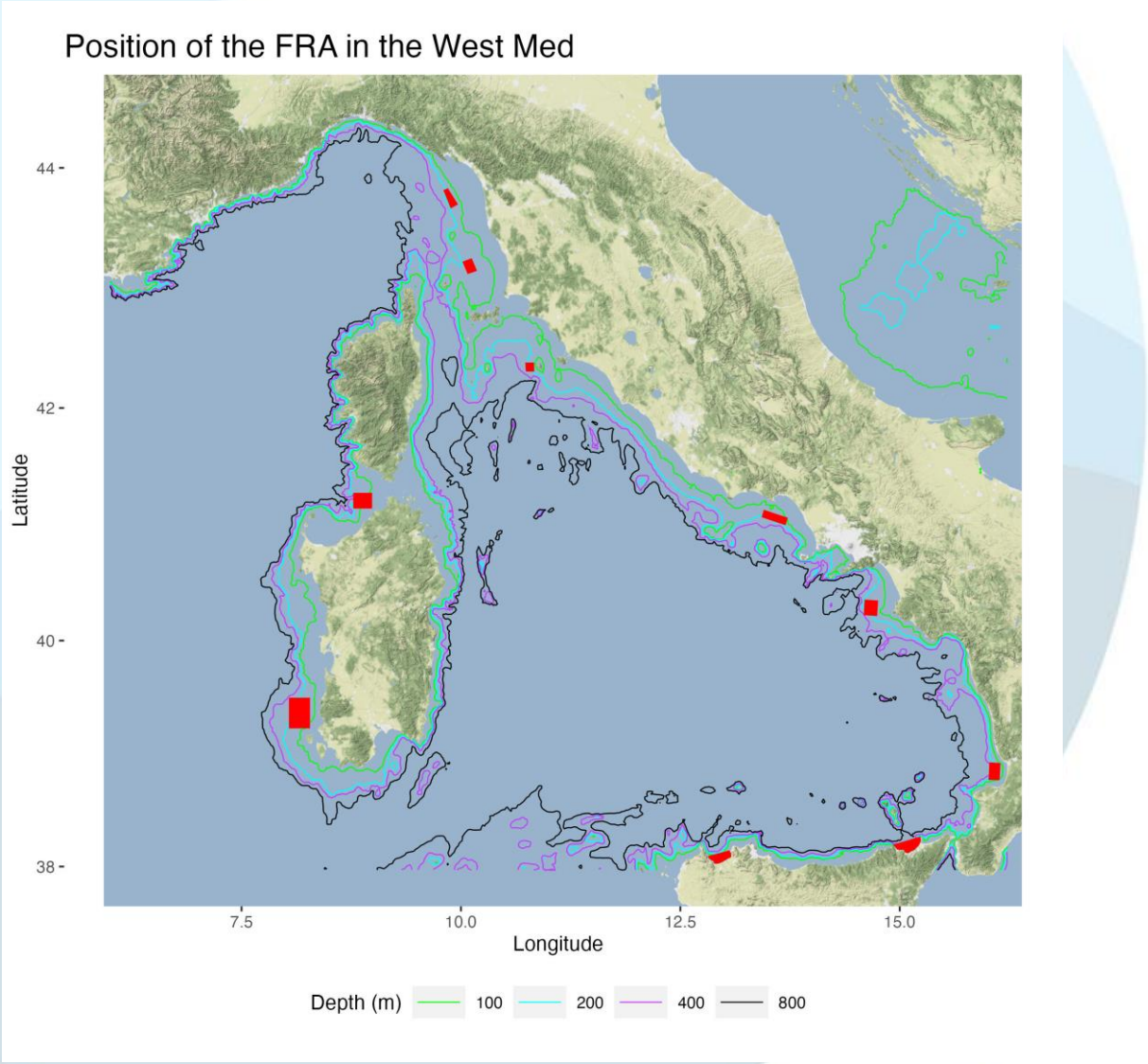


Managment scenarios

- The purpose of the study is to estimate the loss of profit for fishermen when areas are closed.
- Our approach follows WKTRADE3's work, plus the implementation of costs of fishing
- We modeled 3 main scenarios (FRA, ov800, MED600)
- Plus, several additional scenarios based on closing the least profitable cells first

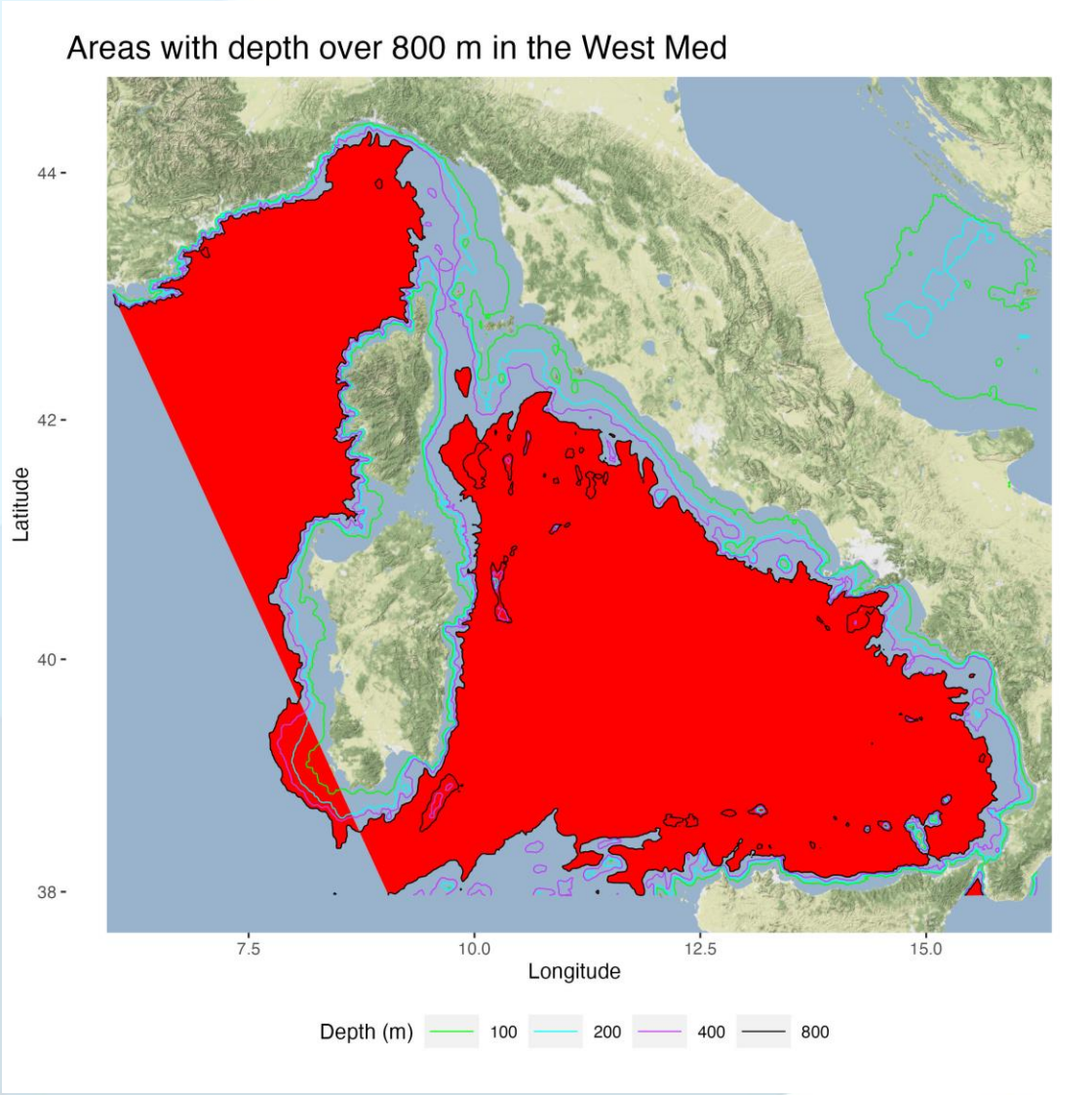
Scenario 1 : Current Fisheries restricted areas (FRA)

- **This scenario is quasi-equivalent to a status-quo, with current restricted areas perfectly enforced.**



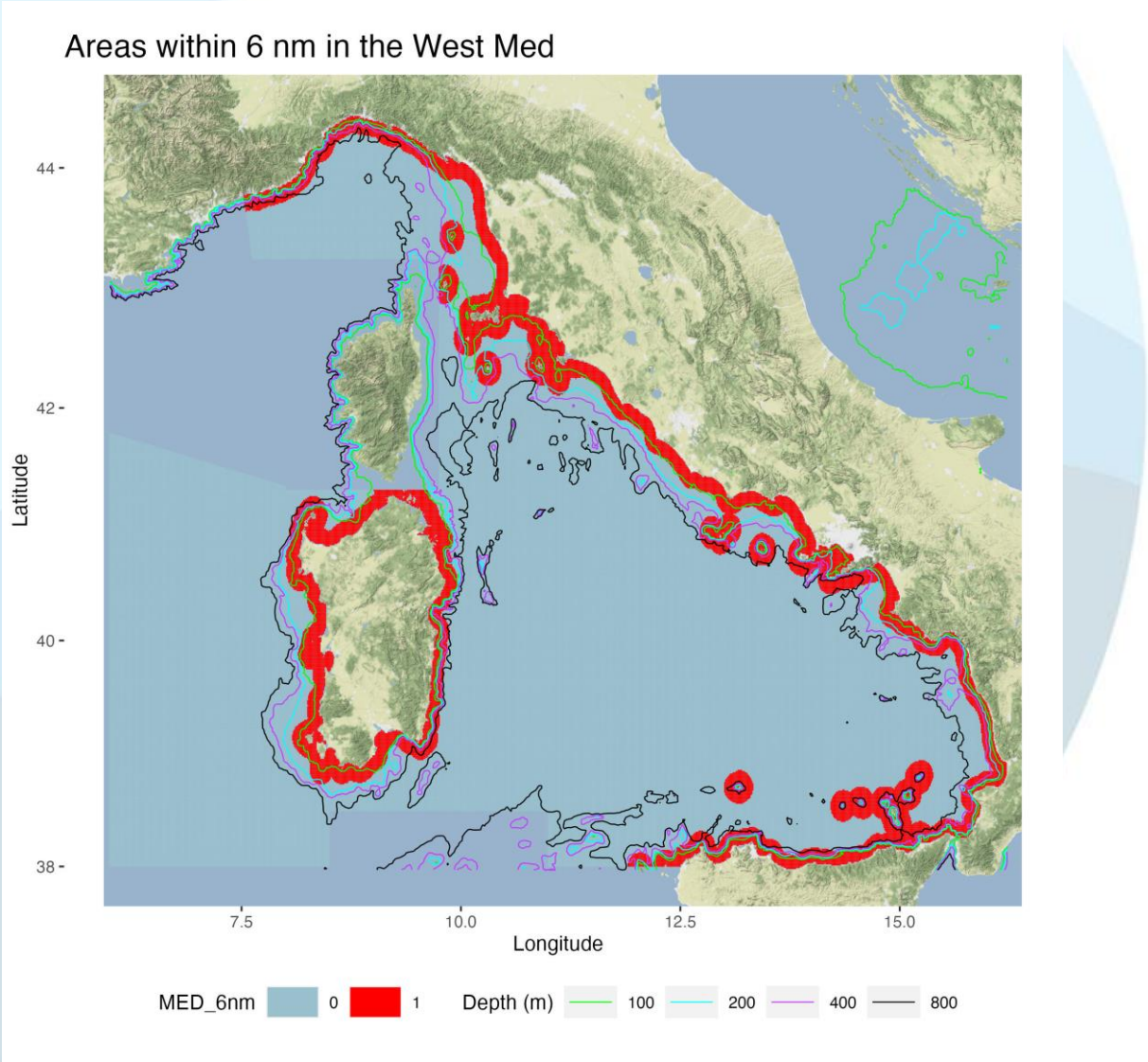
Scenario 2 : Deeper than 800 meters (Ov800)

- This scenario shows the hypothesis of a ban of all bottom fishing in areas deeper than 800 meters.

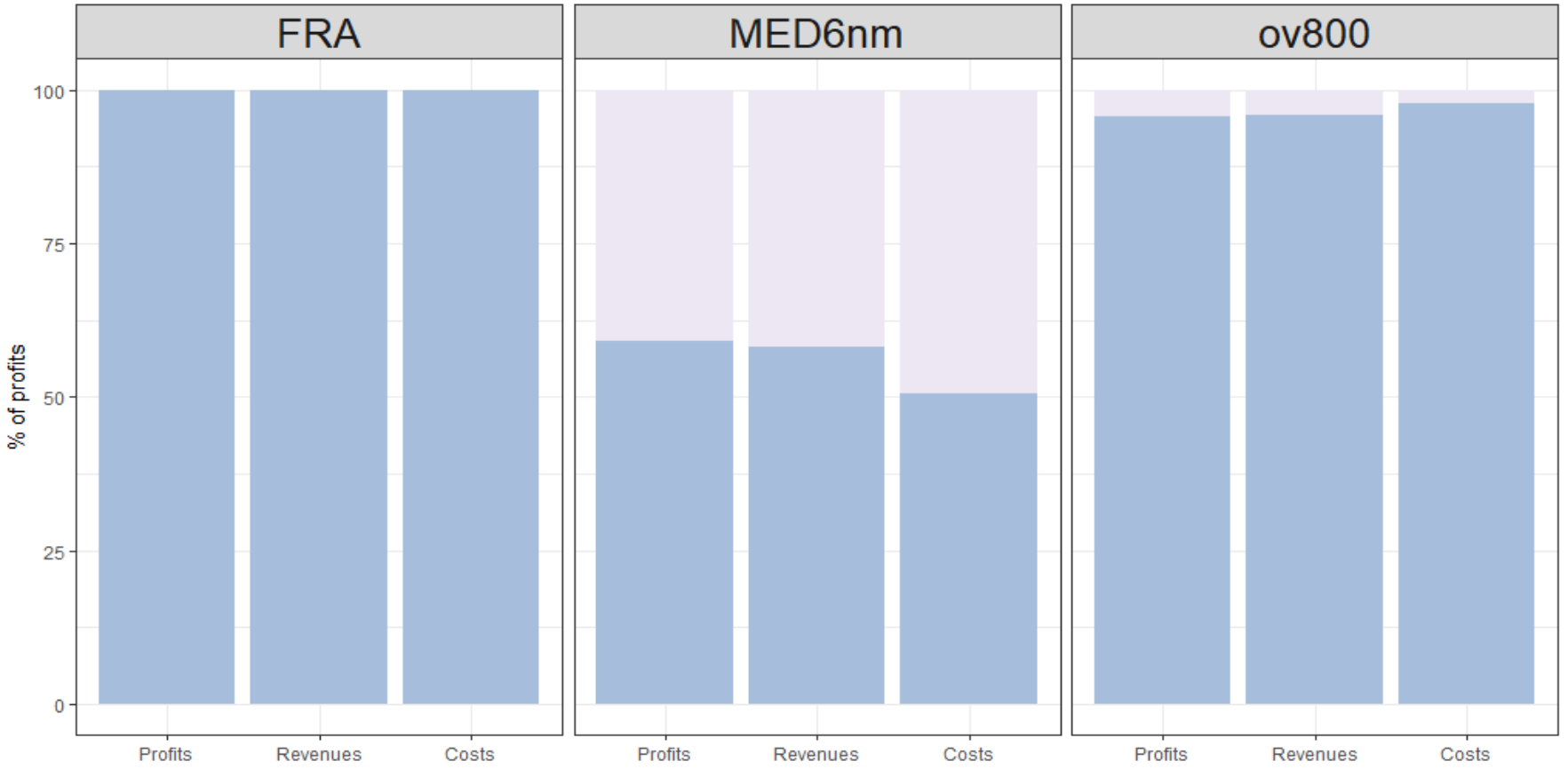


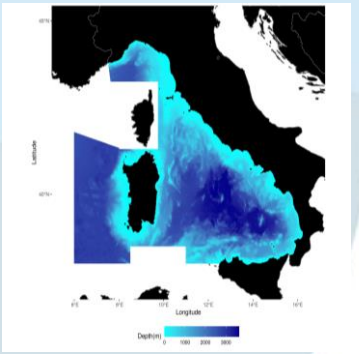
Scenario 3 : 6 nautical miles ban (MED6nm)

- This scenario shows the hypothesis of a ban of all bottom fishing in areas closer than 6 nautical miles to the coast.

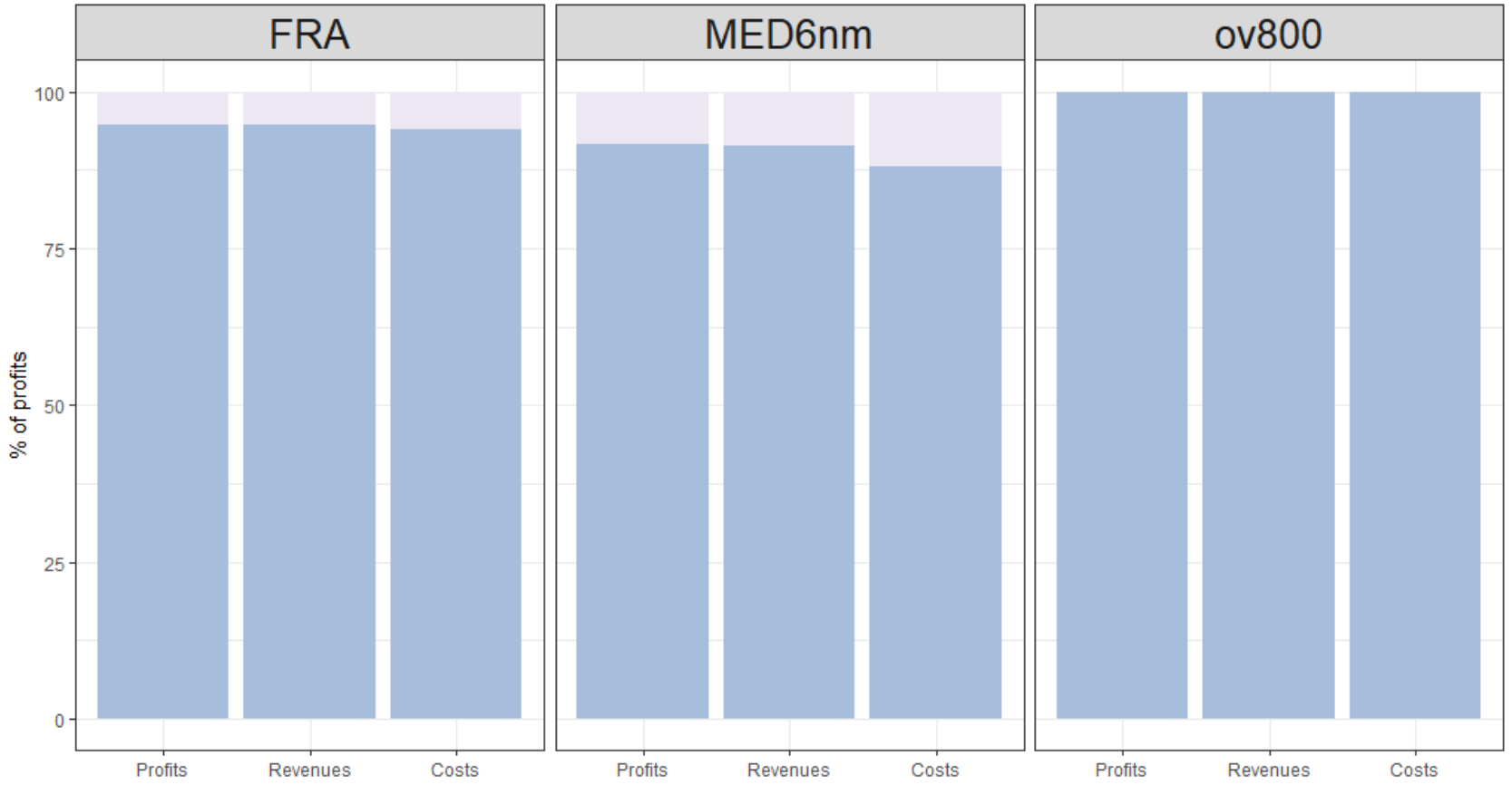


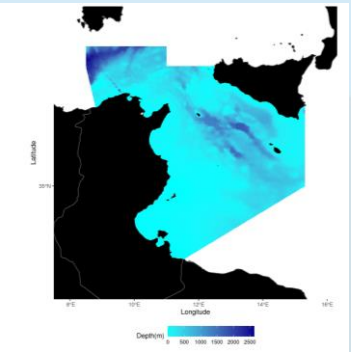
Expected effects of the 3 main scenarios : Case study 1 - Western Mediterranean



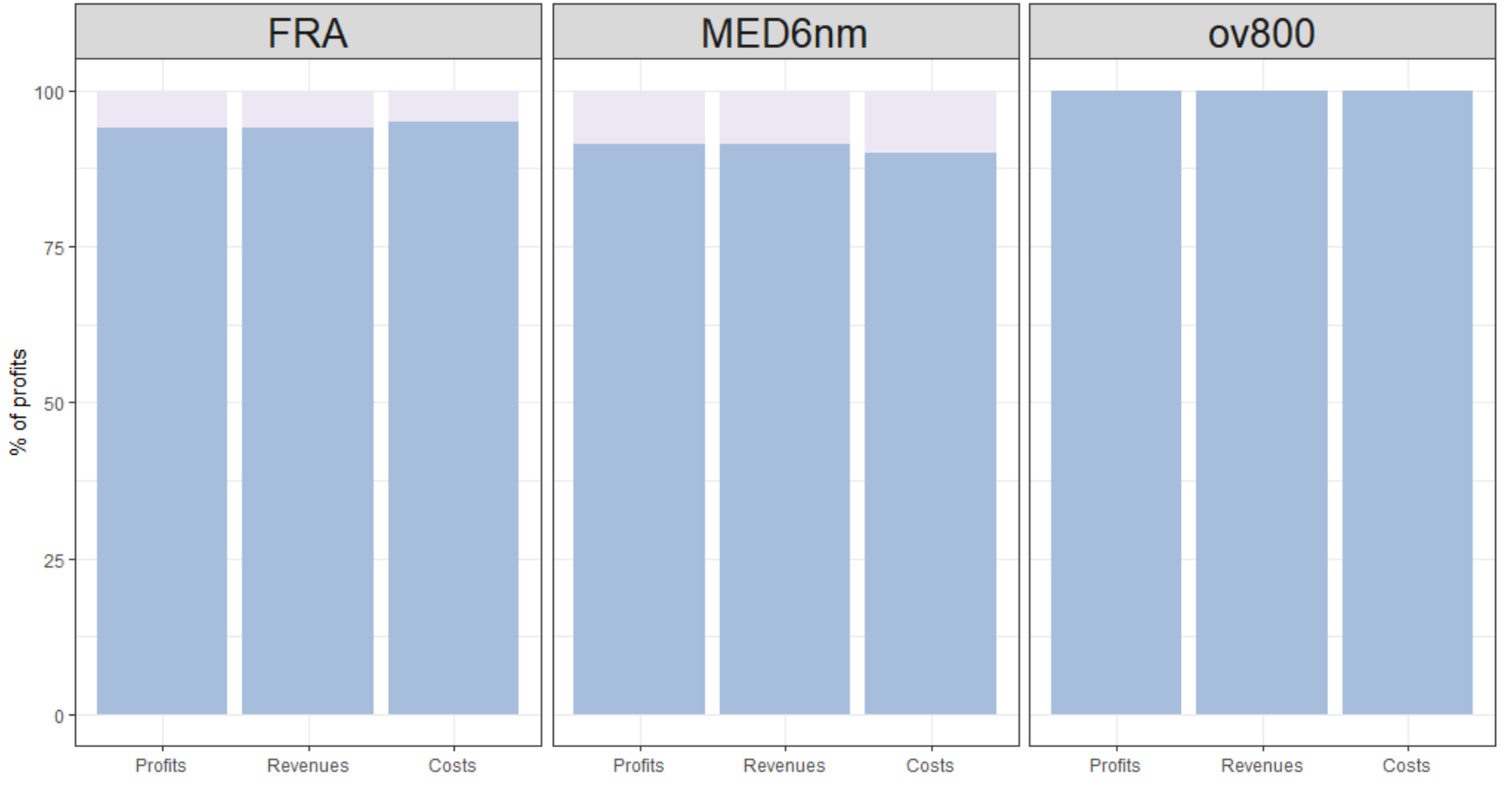


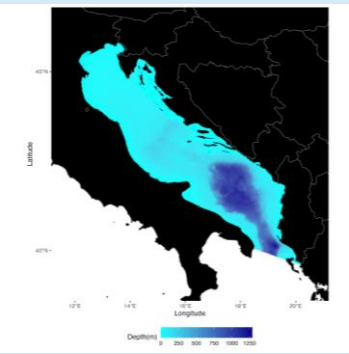
Expected effects of the 3 main scenarios :
Case study 2 – Strait of Sicily



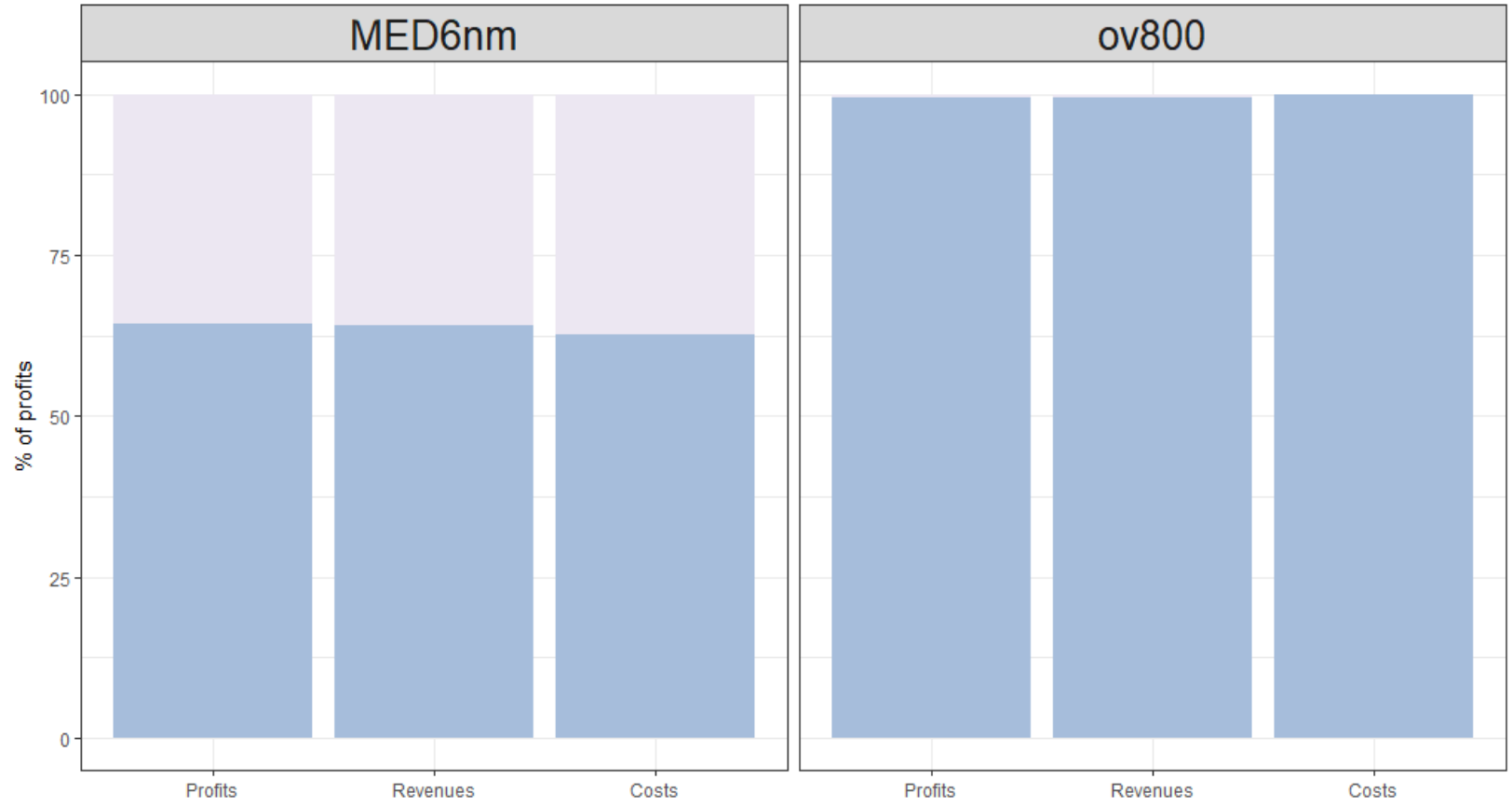


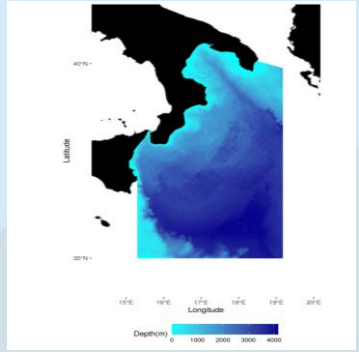
Expected effects of the 3 main scenarios :
Case study 3 - Adriatic Sea





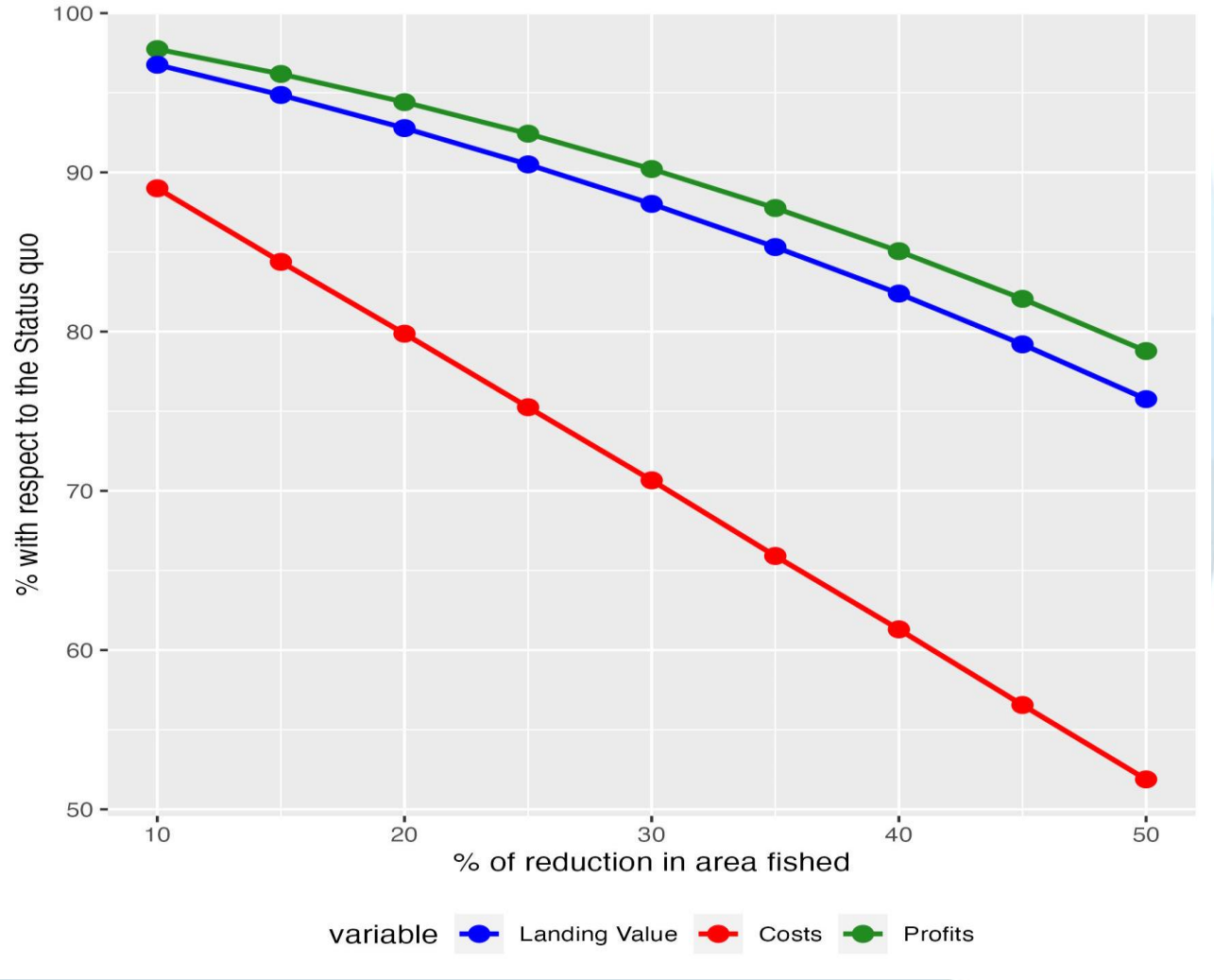
Expected effects of the 3 main scenarios : Case study 4 – Ionian sea



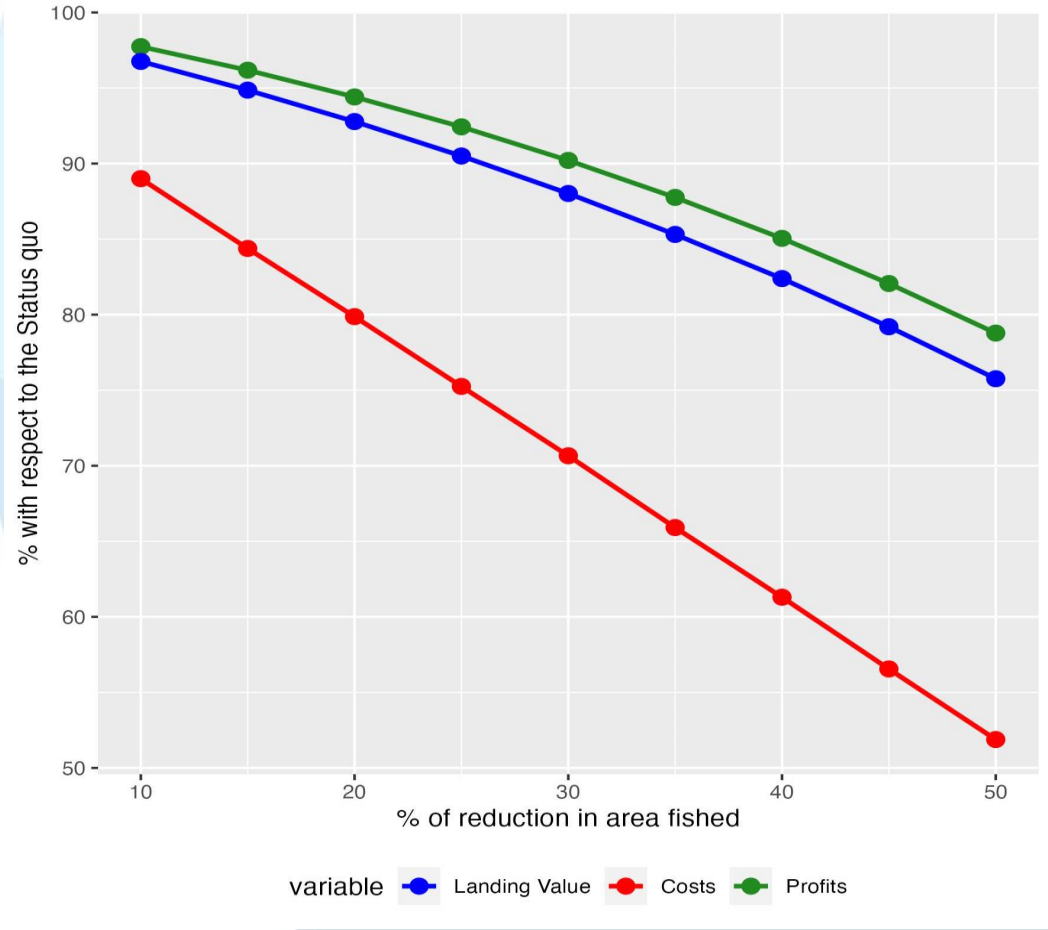


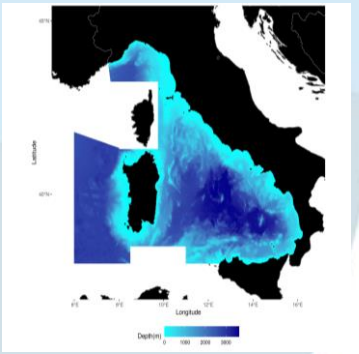
Additional scenarios : Least profit cells approach

- We tested the closing of a % of the least profitable areas (10-15-20… up to 50%).
- We can observe the expected decrease in profits.

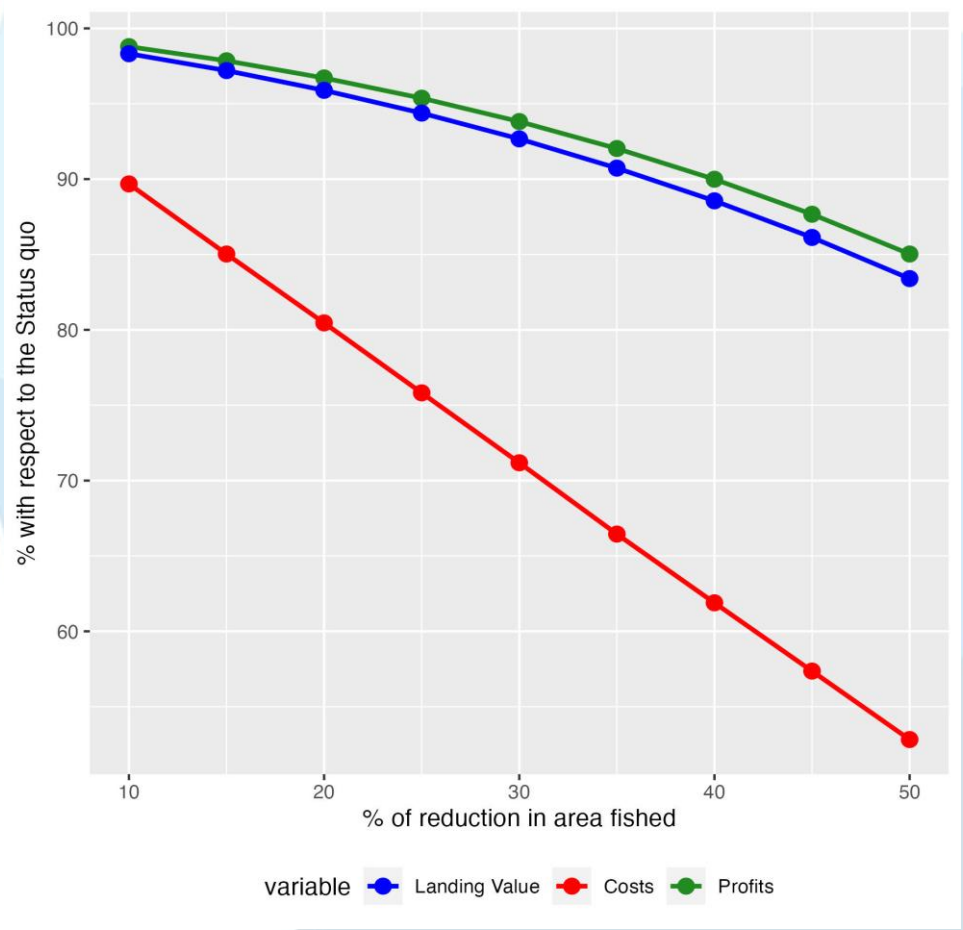


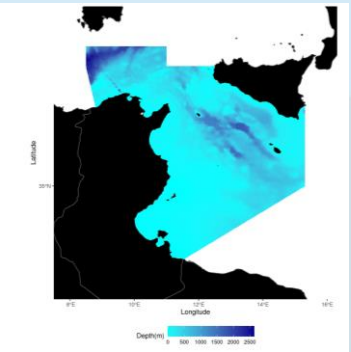
Additional scenarios : Least profit cells approach
Case study 1 - Western Mediterranean



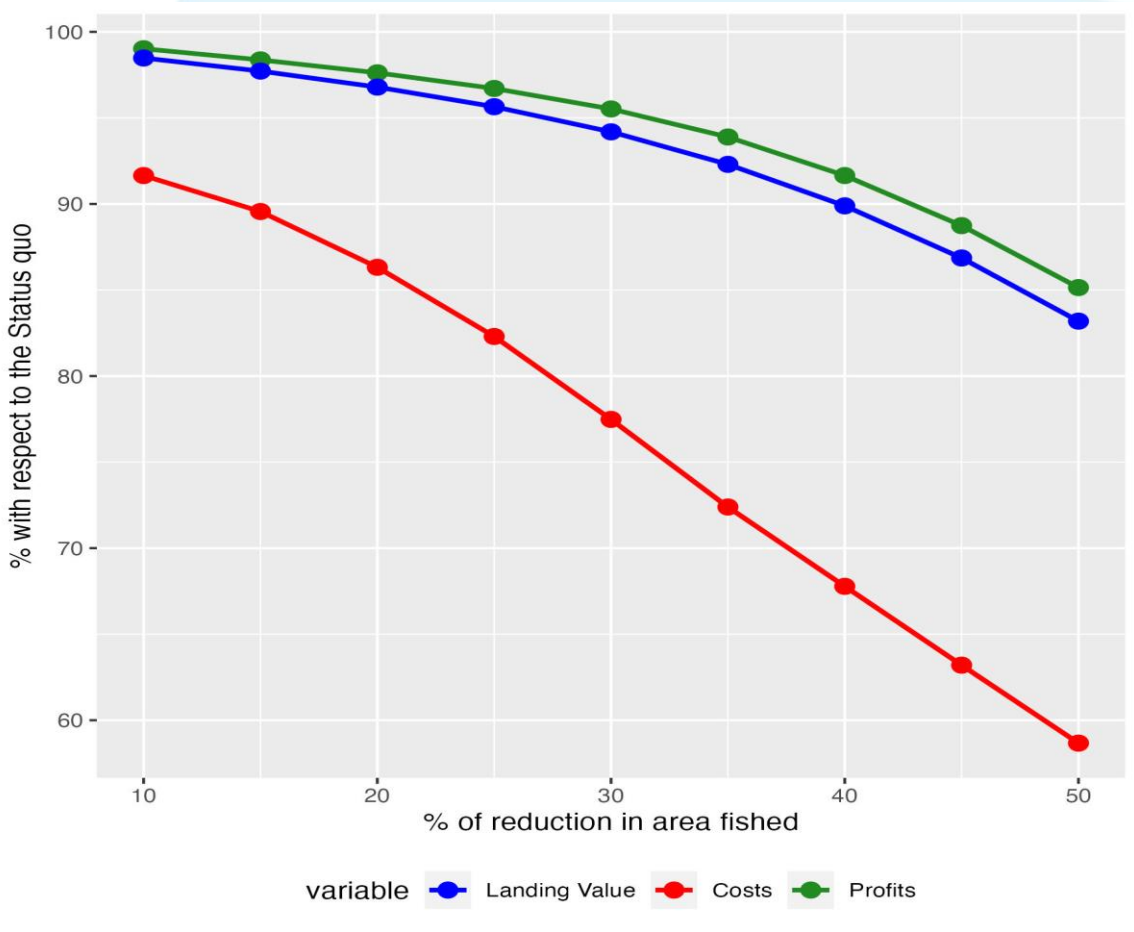


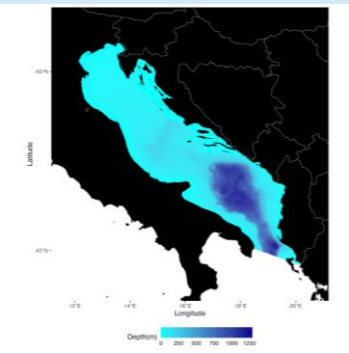
Additional scenarios: Least profit cells approach : Case study 2 – Strait of Sicily



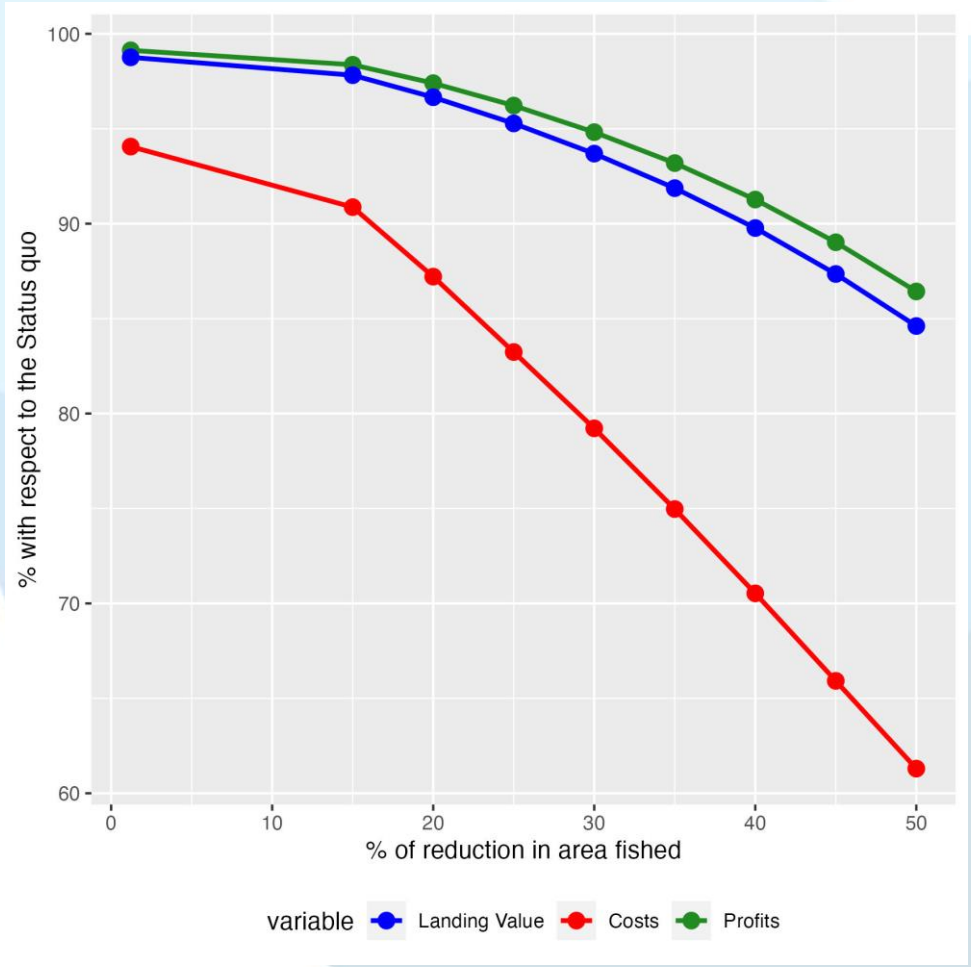


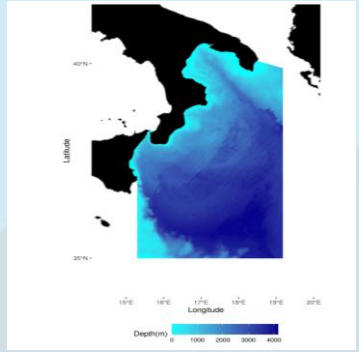
Additional scenarios : Least profit cells approach
Case study 3 - Adriatic Sea





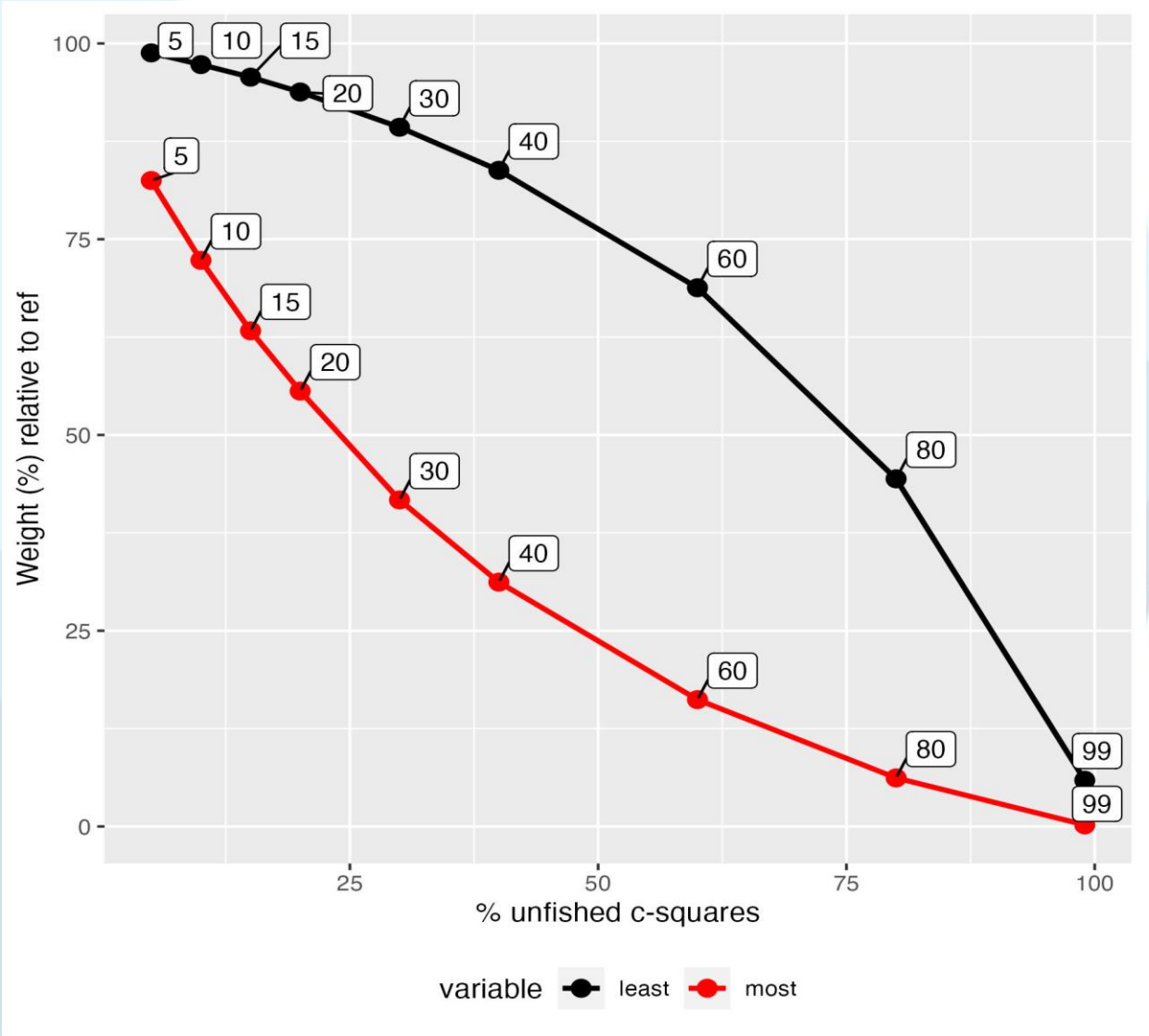
Additional scenarios : Least profit cells approach : Case study 4 – Ionian sea



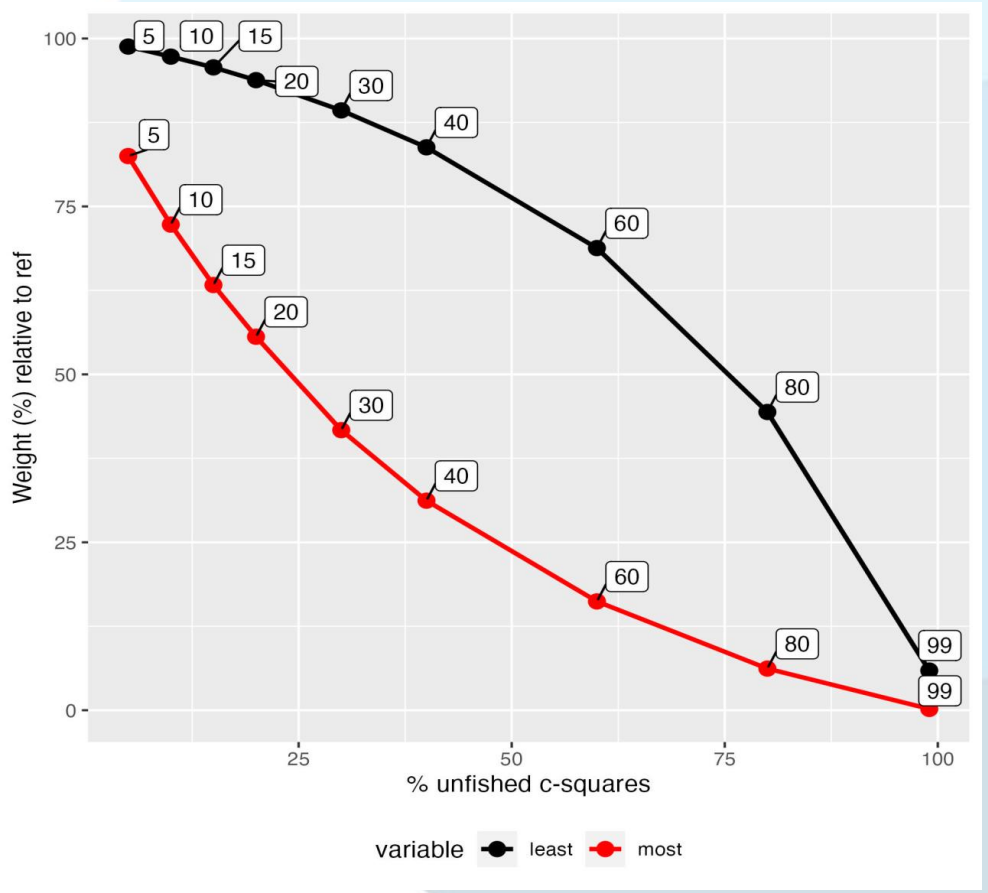


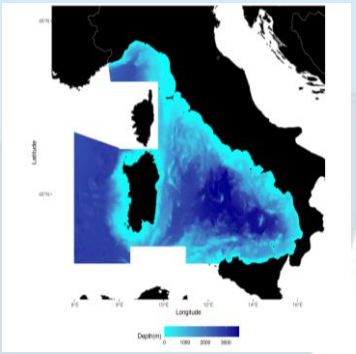
Distribution of effort

- We plotted the relative loss of effort when we close the X% most fished cells (red) & least fished cells (black).
- This profile allows us to see the level of concentration of fishing.

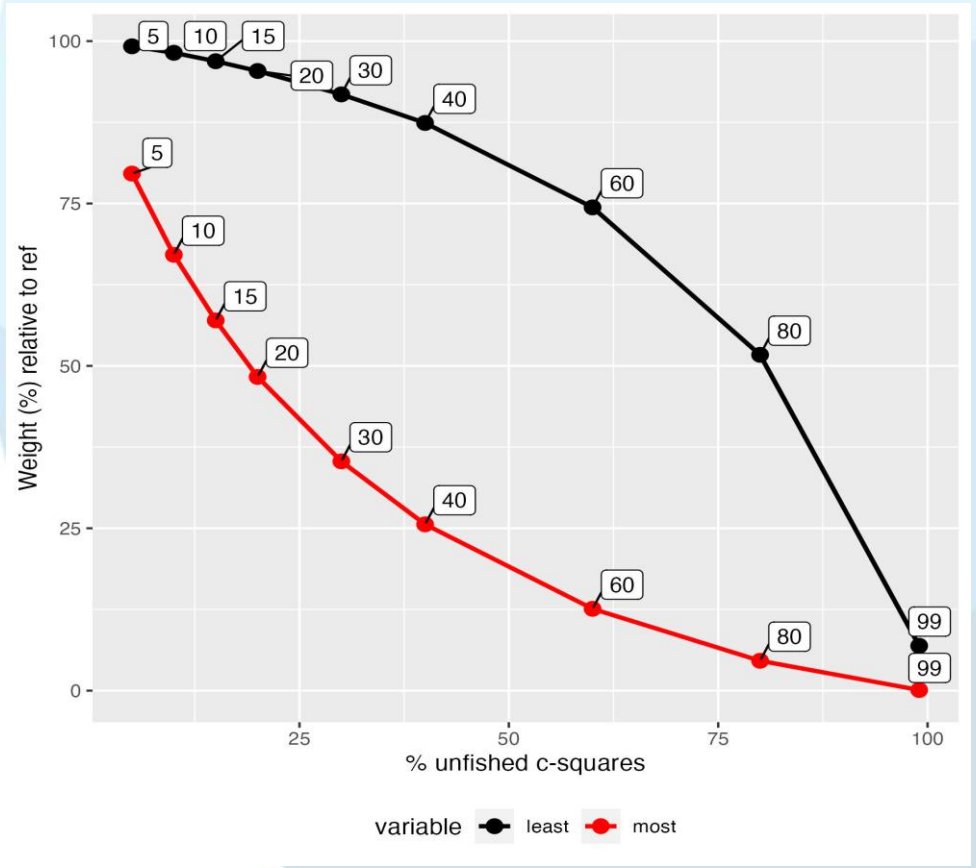


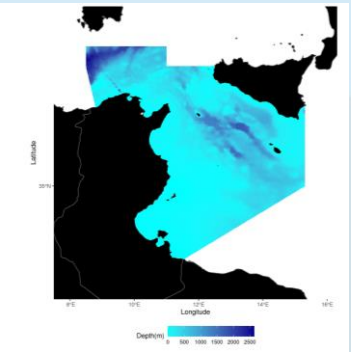
Distribution of effort :
Case study 1 - Western Mediterranean



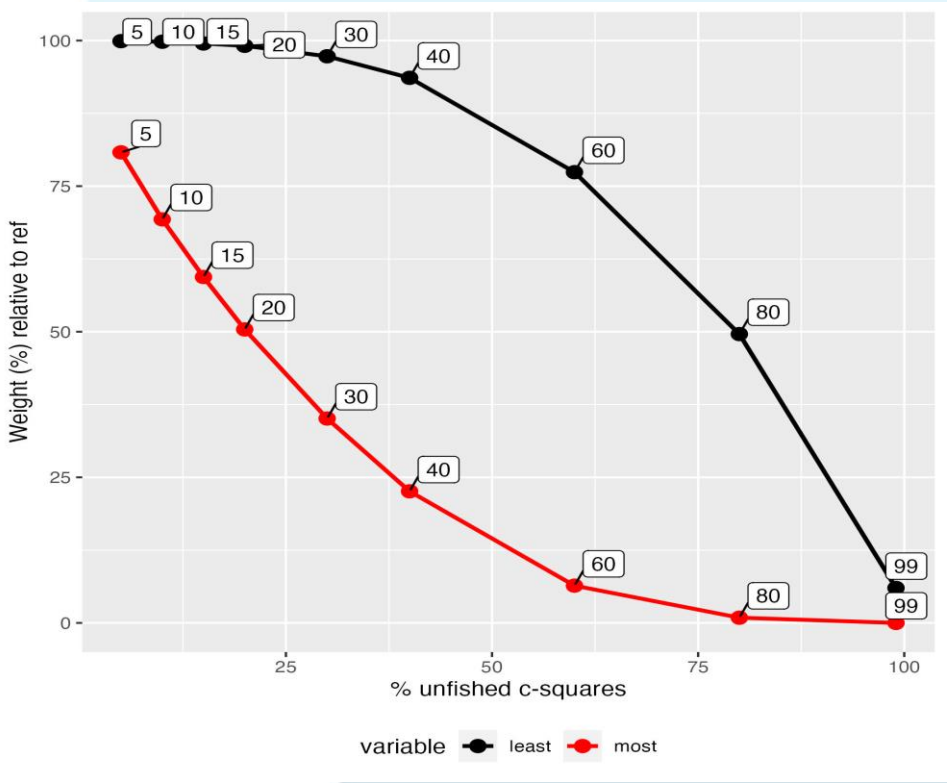


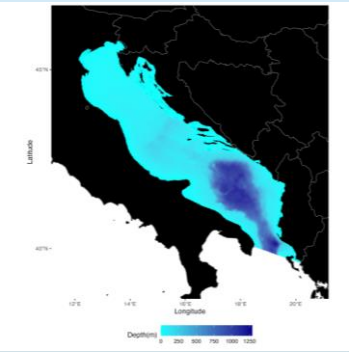
Distribution of effort :
Case study 2 – Strait of Sicily



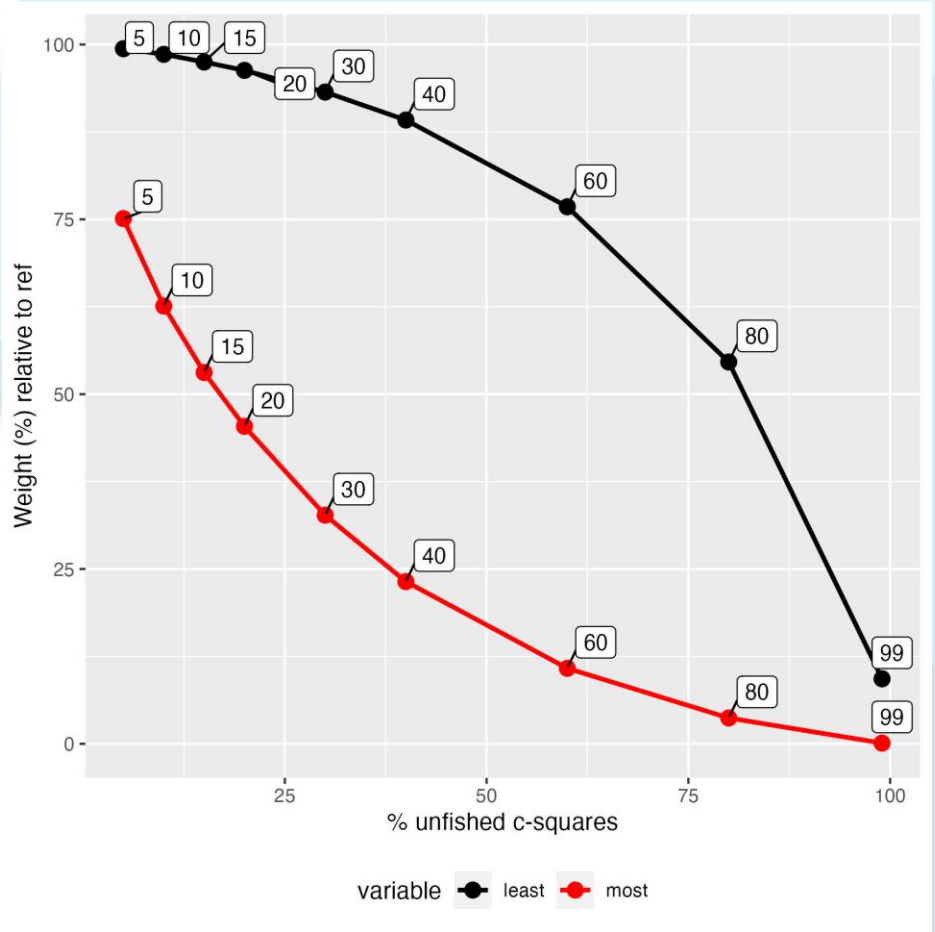


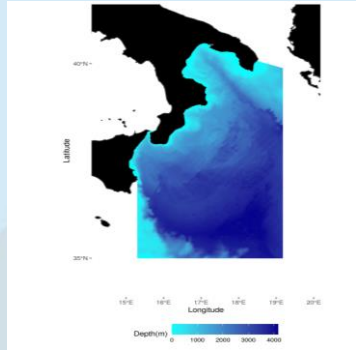
Distribution of effort :
Case study 3 - Adriatic Sea





Distribution of effort :
Case study 4 – Ionian sea





Current status & next steps

- We have produced annual and seasonal results for each case study.
- We designed a framework to test management scenarios.
- We wish to implement seasonally the effect of the scenarios.

- These are still preliminary results – Displacement has yet to be implemented.
- The Adriatic case study interpolation lacks data from the Croatian fleet. [Fixed now ?]

Areas to explore (from colleague's feedback)

- Explore more depth & distance to shore scenarios.
- Find regional compromises accounting for regional specificities
- Take into account the impact on VME & broad habitat types
- If possible, dig deeper into métiers definition to understand fleet compositions.
- Propose at least one scenario with no displacement.

Thank you for your attention

The goal of this presentation is to obtain feedback on our framework for the stakeholder part. It is essential as we intend to accurately model socio-economic factors for pertinent and optimized regulations.

Feedback is very important, please suggest improvement in zoom, in chat, or by email (vincentgeorges75010@gmail.com - tommaso.russo@uniroma2.it)