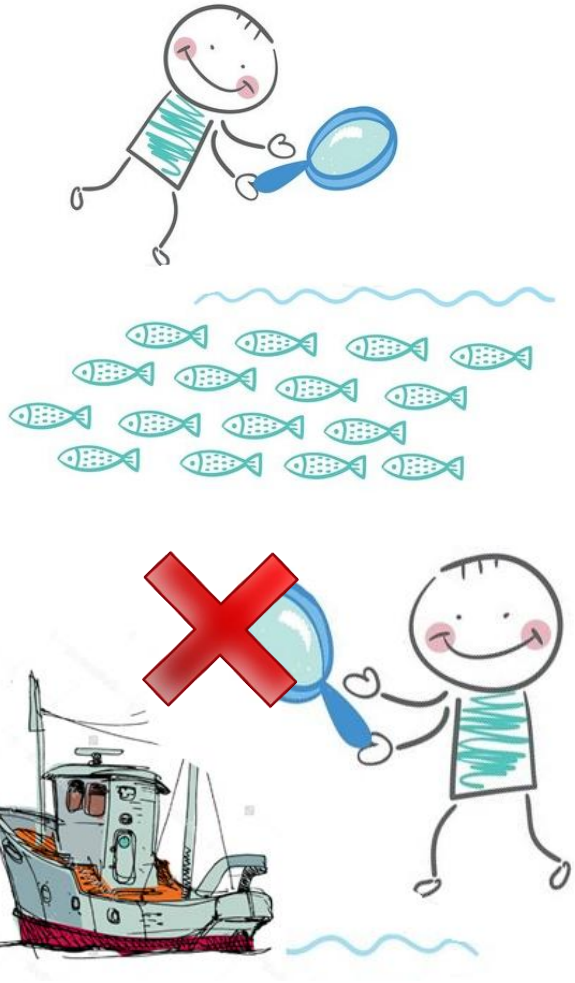
Spatial planning: towards a new approach in fisheries management

Tommaso Russo, University of Tor Vergata, Rome

High-Level Seminar on the State of Stocks in the Mediterranean - Catania, Italy – 9 & 10 February 2016

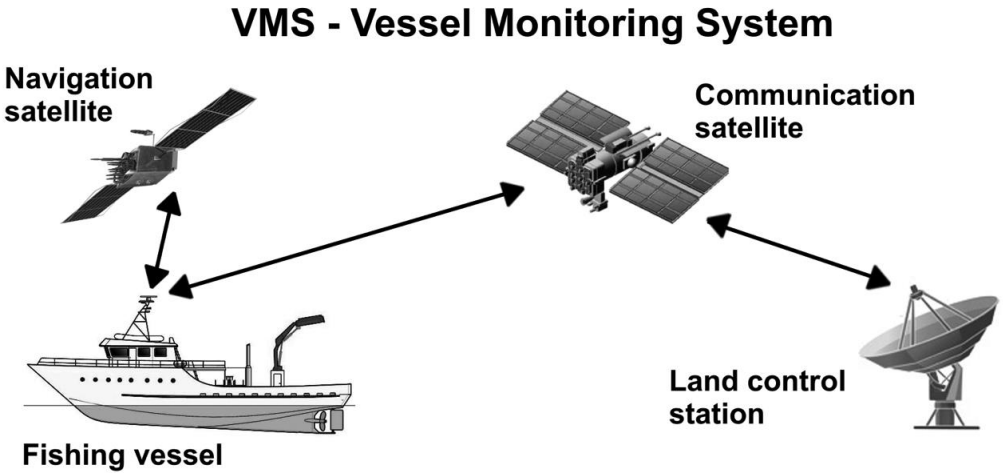
Why spatial planning?

- The exploitation of living resources by fisheries is a complex activity played by different actors (**resources**, **environment** and **human beings**), each one having distinct dynamics and patterns in space and time.
- Spatio/temporal fluctuations of resources and environment are classic objects of ecological investigation and modeling **whereas** the corresponding analysis of fishing effort has been historically hampered by the lack of tools for the survey of fishing fleet activities in space and time.

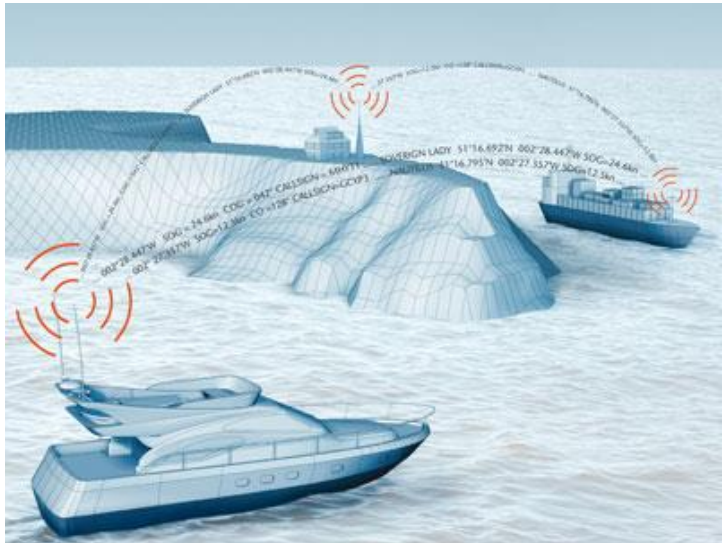


VMS (and the other tracking devices): a revolution in fisheries sciences

- This situation changed (middle 2000's) by the introduction of the **Vessel Monitoring System (VMS)** and of the **Automatic Identification System (AIS).**
- These devices allow <u>tracking fishing activity in space and time by satellite data (position, speed and heading of fishing vessels)</u>

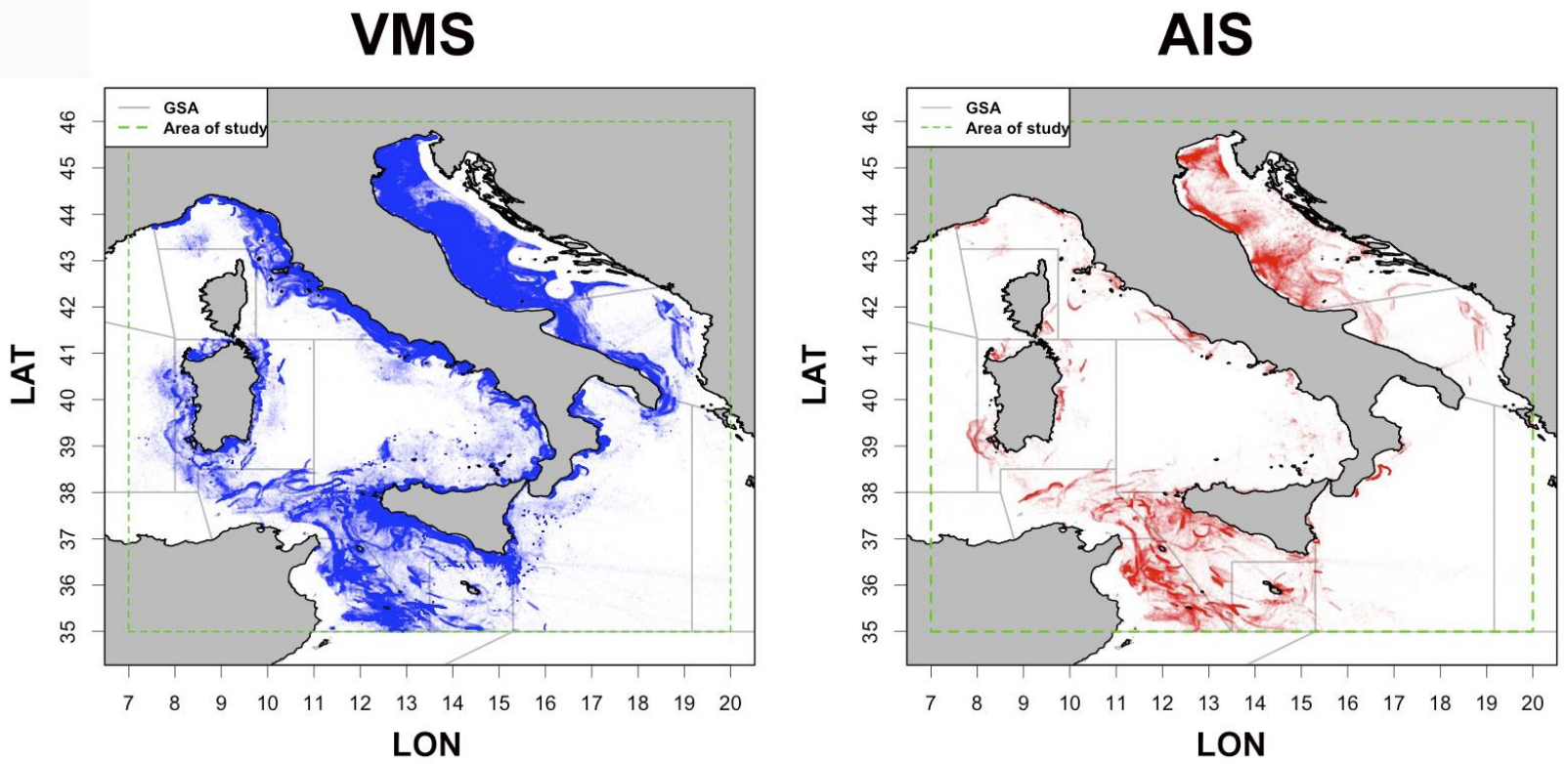


AIS – Automatic Information System



VMS (and the other tracking devices): a revolution in fisheries sciences

- Up to now VMS still represents the best tracking device in terms of spatial coverage



Work in progress

- Fisheries resources need to be properly managed for sustainable exploitation of the world's living aquatic resources
- It has been realized that the traditional fisheries management, which considers the target species as independent, self-sustaining populations not related to spatial and ecological contest, is insufficient
- **EAF: Ecosystem Management for Sustainable Marine Fisheries** has been becoming popular
- However, it has been realized that, a working ecosystem approach management depends on a boarding of data and information on environmental, biological and social aspects, analysis and modeling technologies.

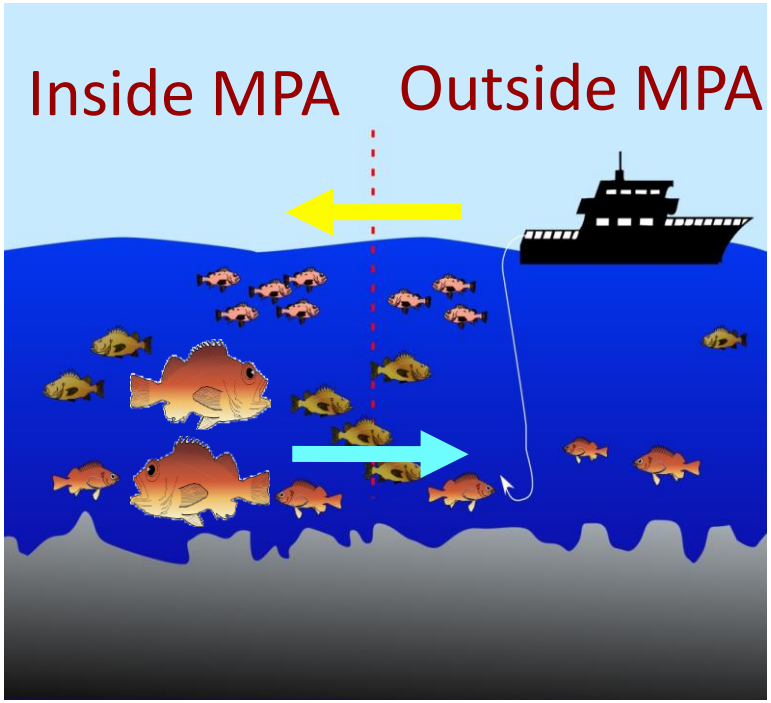
Work in progress

- A large community of Italian researches, including public and private companies, has been involved in the development of spatially-explicit approaches

- The **ITAFISHNET** and the **Data Colletion** groups includes:
  - S. Cataudella (Scientific Head of the Research Group - GFCM President – Full prof. of Ecology), M. Scardi
  - F. Fiorentino, G. Garofalo, M. Gristina (National Research Council – IAMC);
  - E. Morello, G. Scarcella, A. Santojanni, A. Sala, A. Lucchetti, M. Martinelli, P. Carpi, A. Belardinelli, S. Angelini (National Research Council – ISMAR);
  - M.T. Spedicato, G. Lembo, P. Carbonara, M.T. Facchini, I. Bitetto (COISPA);
  - A. Tursi, R. Carlucci, L. Maiorano, G. D'Onghia, L. Sion (UNIBARI);
  - C. Solidoro, S. Libralato (OGS)
  - L. Labachi, E. Sabatella, R. Sabatella. D. Pinello, P. Accadia (NISEA/ITAFISHSTAT)
  - S. Raicevich (ISPRA);

The trends and the challenges

- Fisheries collapsing due to open access;
- Marine protected areas for conservation and sustainable exploitation;
- Moving towards property-based;
- Traditionally: Fish win/Fishermen lose
- Emerging Science:
  - Enhance productivity
  - "Spillover"
  - Connectivity
  - Couple with fisheries management
  - Requires careful design



The toolbox

- **Remote Sensing Technology** has gained increasing importance in studies of marine systems, for extracting oceanographic information, and monitoring the dynamics of oceanic environment;
- **GIS Technology** has proven to be an indispensable tool for integrating, managing and visualising spatially distributed data, discovering hidden patterns that other numerical methods could not find, and providing maps;
- **Statistical technology and geo-statistical analyses and modelling** have been widely used to provide quantitative description and predictions about living marine resources

The toolbox

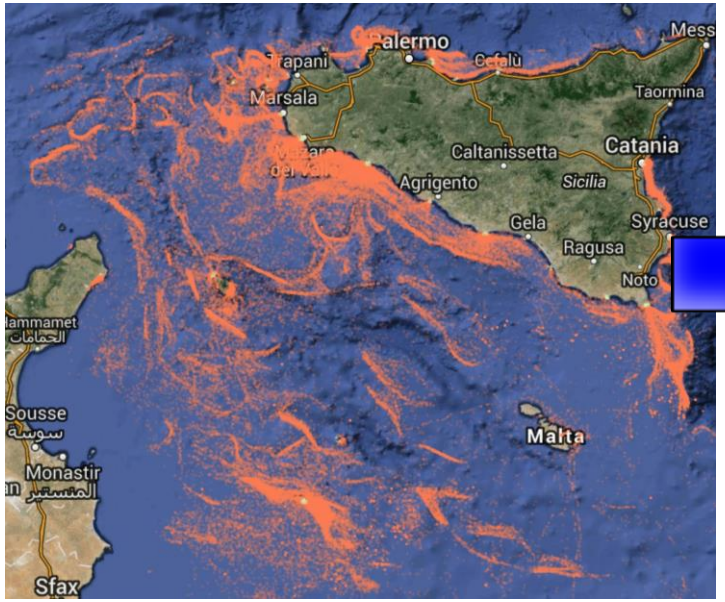
- Fisheries sciences are moving toward spatially explicit approaches in which:
  1. both the impact of fishing activities and the response of resources in space are modeled, and
  2. management measures are evaluated on the basis of fishing impacts observed or hypothesized in space.
  - The first step: filling the toolbox:
  - VMS/AIS data need appropriate protocol to be integrated in fisheries models

Tools for VMS/AIS data

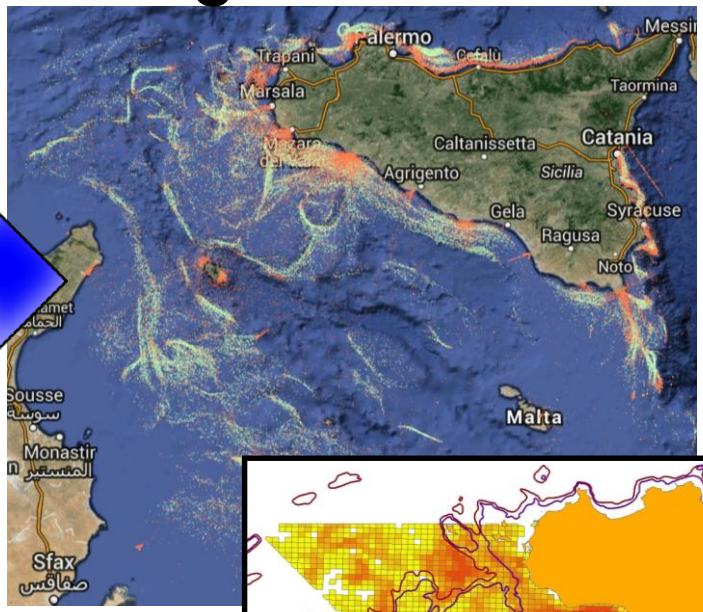
- The Tor Vergata Team is actually composed by:
  - **S. Cataudella** (Prof.)
  - **T. Russo** (Researcher in Ecology);
  - **L. D'Andrea** (PhD student)
  - **A. Parisi** (Researcher in Economic Statistics)
- Within the **Data Collection Framework**, we contributed by developing the VMSbase platform as a R-package
- **VMSbase allows combining, standardizing and integrating VMS and AIS data**

VMS+AIS Integrated maps

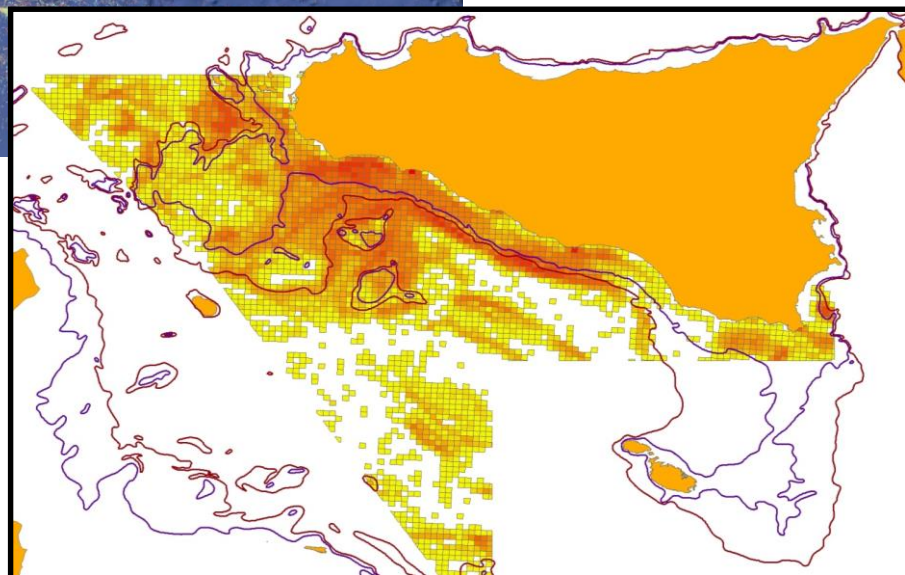
Raw Data (VMS+AIS)



Fishing Set Positions



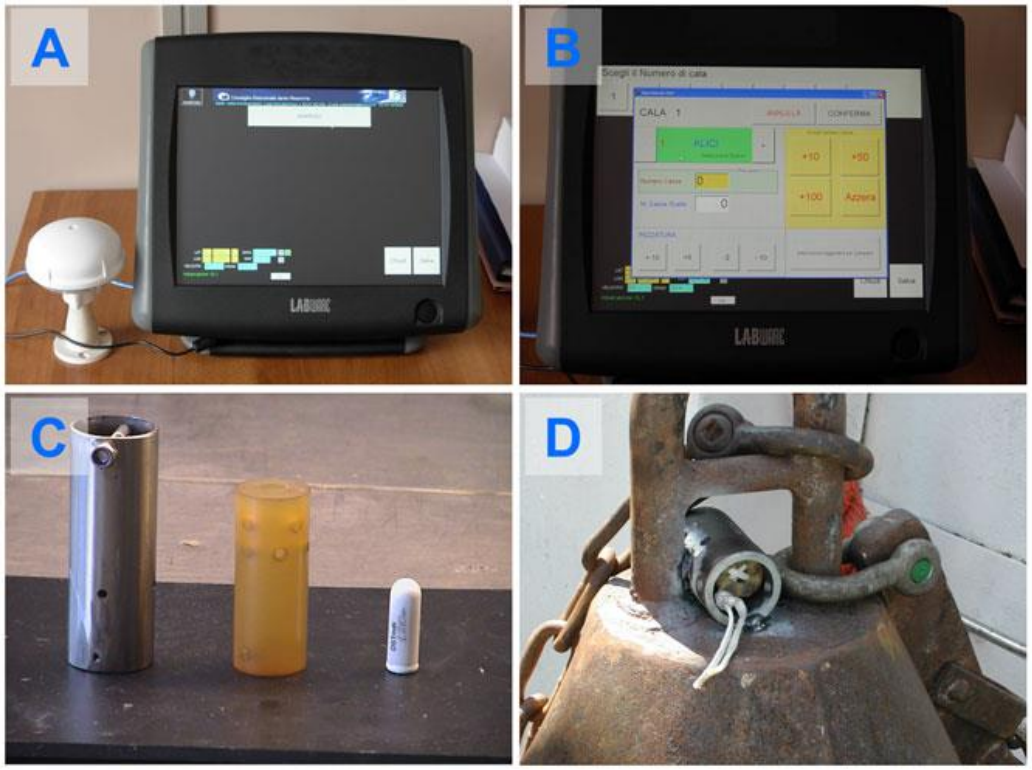
Effort maps



Beyond VMS and AIS: the FOS experience

This Fishery Observing System (FOS), is basically composed by 3 main components:

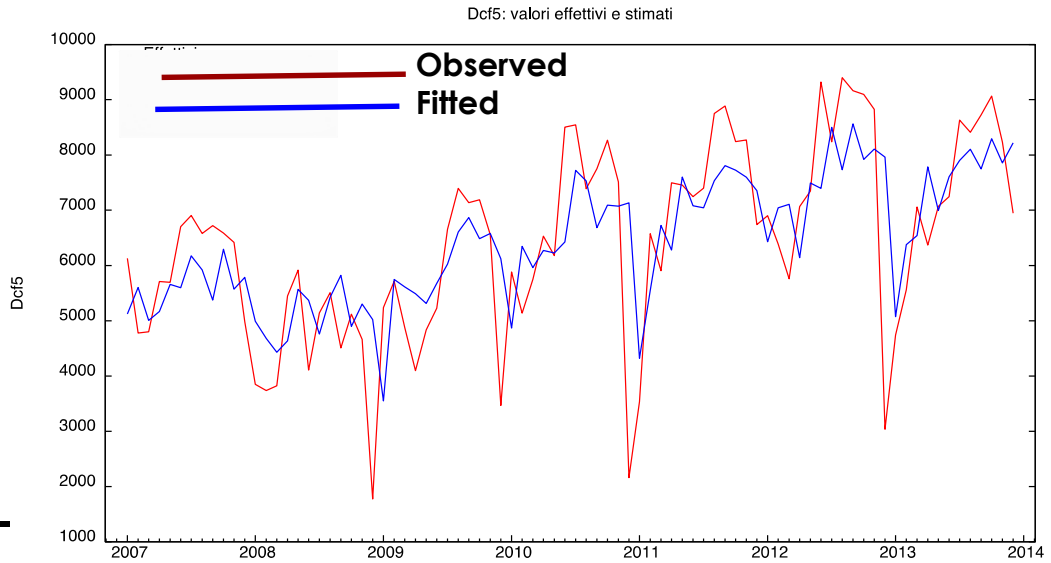
1) an electronic touch screen logbook that allows the captain to record haul by haul data concerning catch amount, species caught, bycacth and target species sizes (A+B);
2) a GPS antenna connected to the logbook in order to obtain the position of the hauls;
3) an oceanographic sensor attached to the fishing equipment (C+D)



What tracking devices tell us about fishing effort?

Indicator	Name	Description
DCF5	Extention of fishing activity	Total sea area interested by fishing effort

Despite fleets reduction, area exploited by trawlers is still increasing



Contents lists available at SciVerse ScienceDirect

Ecological Indicators

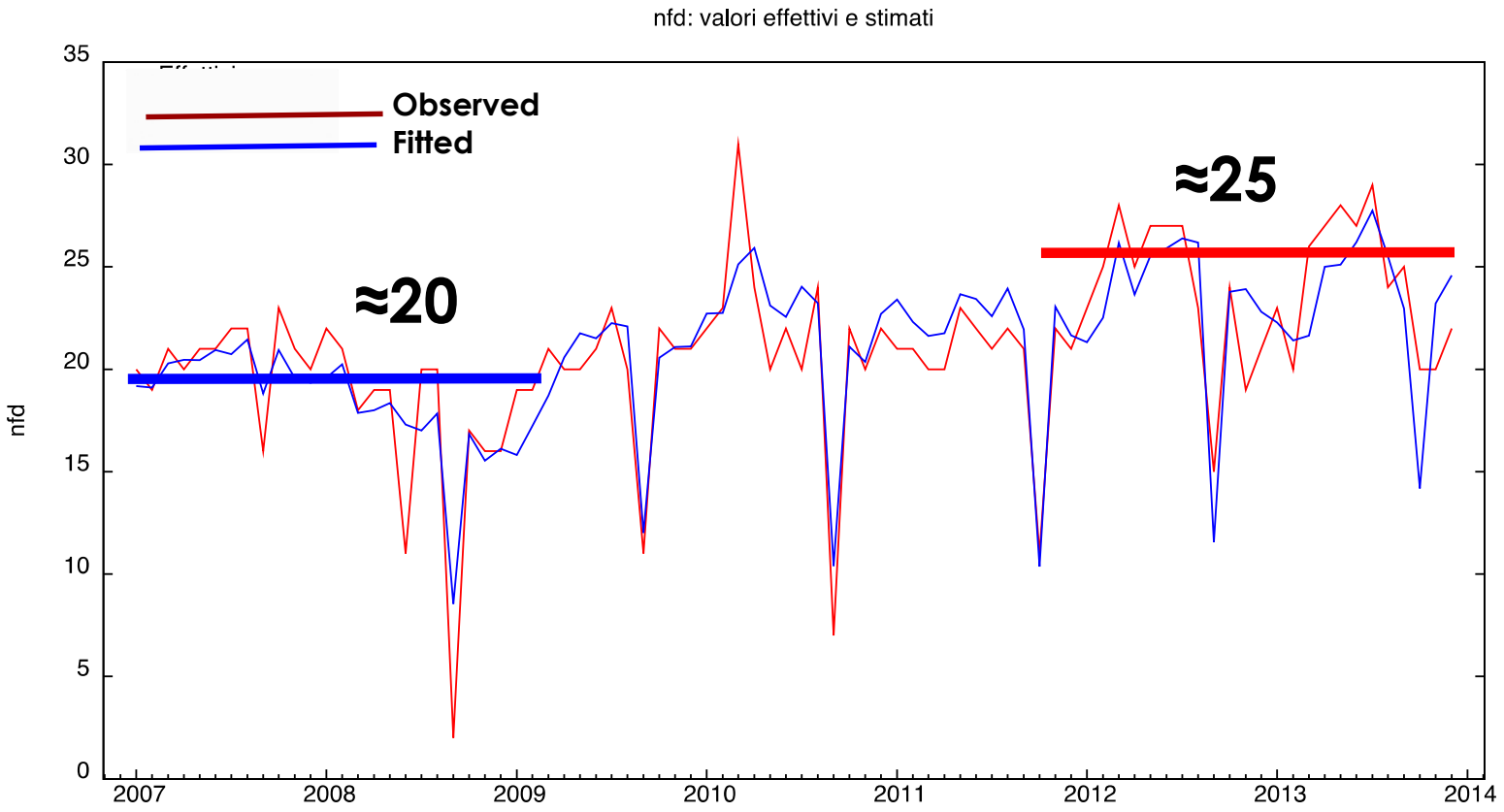
journal homepage: www.elsevier.com/locate/ecolind

Spatial indicators of fishing pressure: Preliminary analyses and possible developments

T. Russo[a,*], A. Parisi[b], S. Cataudella[a]

What (an why) tracking devices tell us about fishing effort?

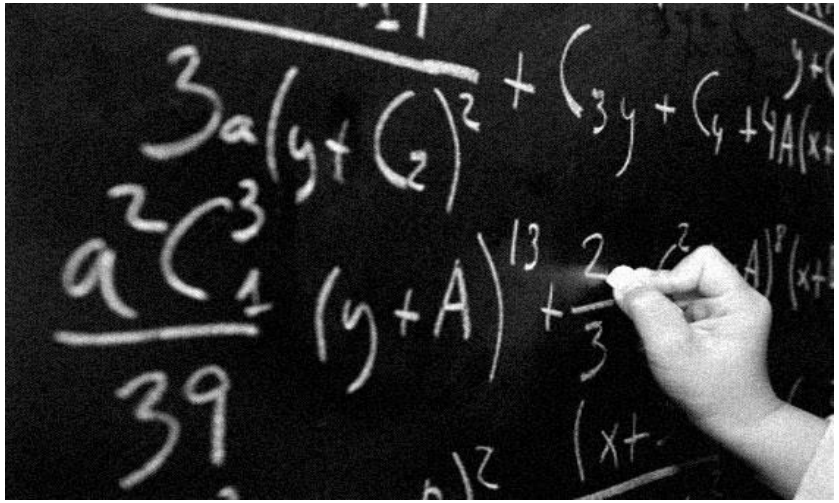
Are the fishing days increasing?



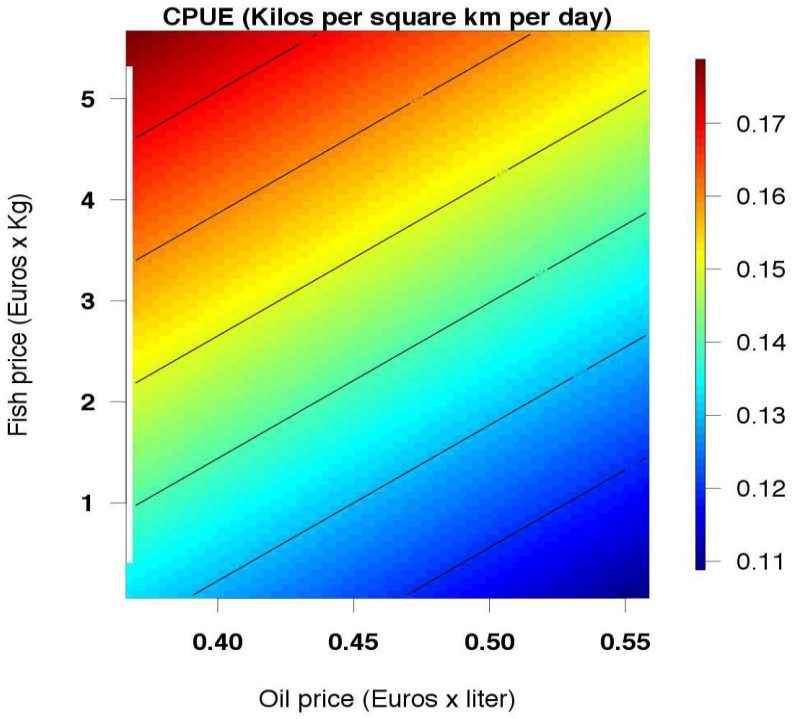
Bioeconomic models for conservation and economics

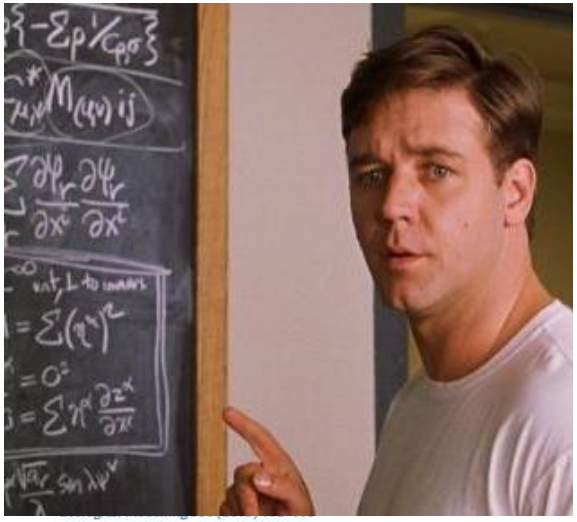
What we ultimately need (and expect):

- **Inputs:** Habitat, species, ocean currents, management, MPAs, fisherman behavior
- **Outputs:** Spatial distribution of fish, fisheries performances, profit



The case of small pelagics in the Adriatic Sea





Game theory tell us that:

- suboptimal exploitation patterns occur when fishermen compete for shared resources
- Economic drivers are crucial in determining the faith of stocks

Contents lists available at ScienceDirect

Ecological Modelling

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

Modelling the strategy of mid-water trawlers targeting small pelagic fish in the Adriatic Sea and its drivers

Tommaso Russo[a,*], Jacopo Pulcinella[a], Antonio Parisi[b], Michela Martinelli[c], Andrea Belardinelli[c], Alberto Santojanni[c], Stefano Cataudella[a], Sabrina Colella[c], Luca Anderlini[d]

[a] Laboratory of Experimental Ecology and Aquaculture, Department of Biology, University of Rome Tor Vergata, Rome, Italy
[b] Department of Economics and Finance, Faculty of Economics, University of Rome Tor Vergata, Rome, Italy
[c] CNR, National Research Council of Italy, ISMAR, Marine Sciences Institute in Ancona, Italy
[d] Department of Economics, Georgetown University, Washington, DC, USA

SMART: A Spatially Explicit Bio-Economic Model for Assessing and Managing Demersal Fisheries

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PLOS ONE

SMART: A Spatially Explicit Bio-Economic Model for Assessing and Managing Demersal Fisheries, with an Application to Italian Trawlers in the Strait of Sicily

Tommaso Russo[1]*, Antonio Parisi[2], Germana Garofalo[3], Michele Gristina[3], Stefano Cataudella[1], Fabio Fiorentino[3]

1 Laboratory of Experimental Ecology and Aquaculture, Department of Biology, "Tor Vergata" University of Rome, via della Ricerca Scientifica s.n.c., Rome, Italy, **2** Department of Economics and Finance, Faculty of Economics, "Tor Vergata" University of Rome, Rome, Italy, **3** National Research Council (CNR), Institute for Coastal Marine Environment (IAMC), Mazara del Vallo, Italy

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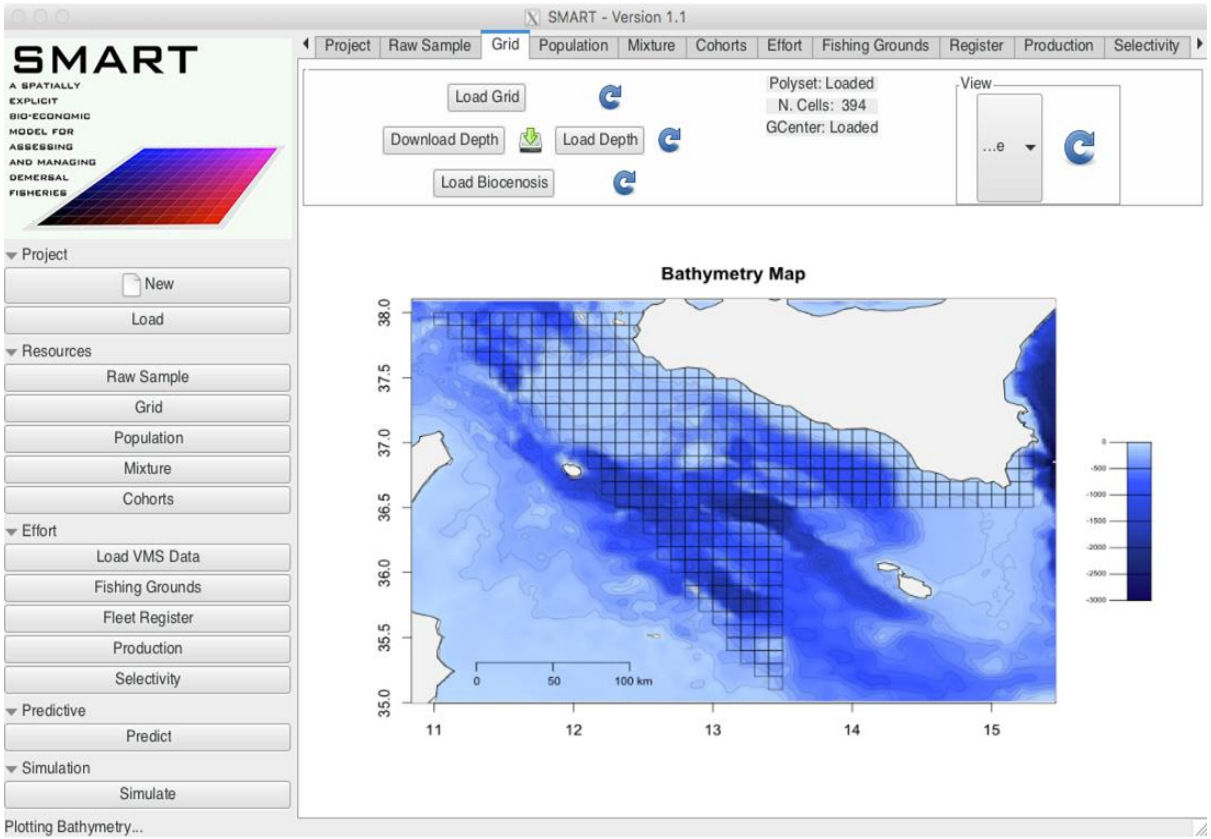


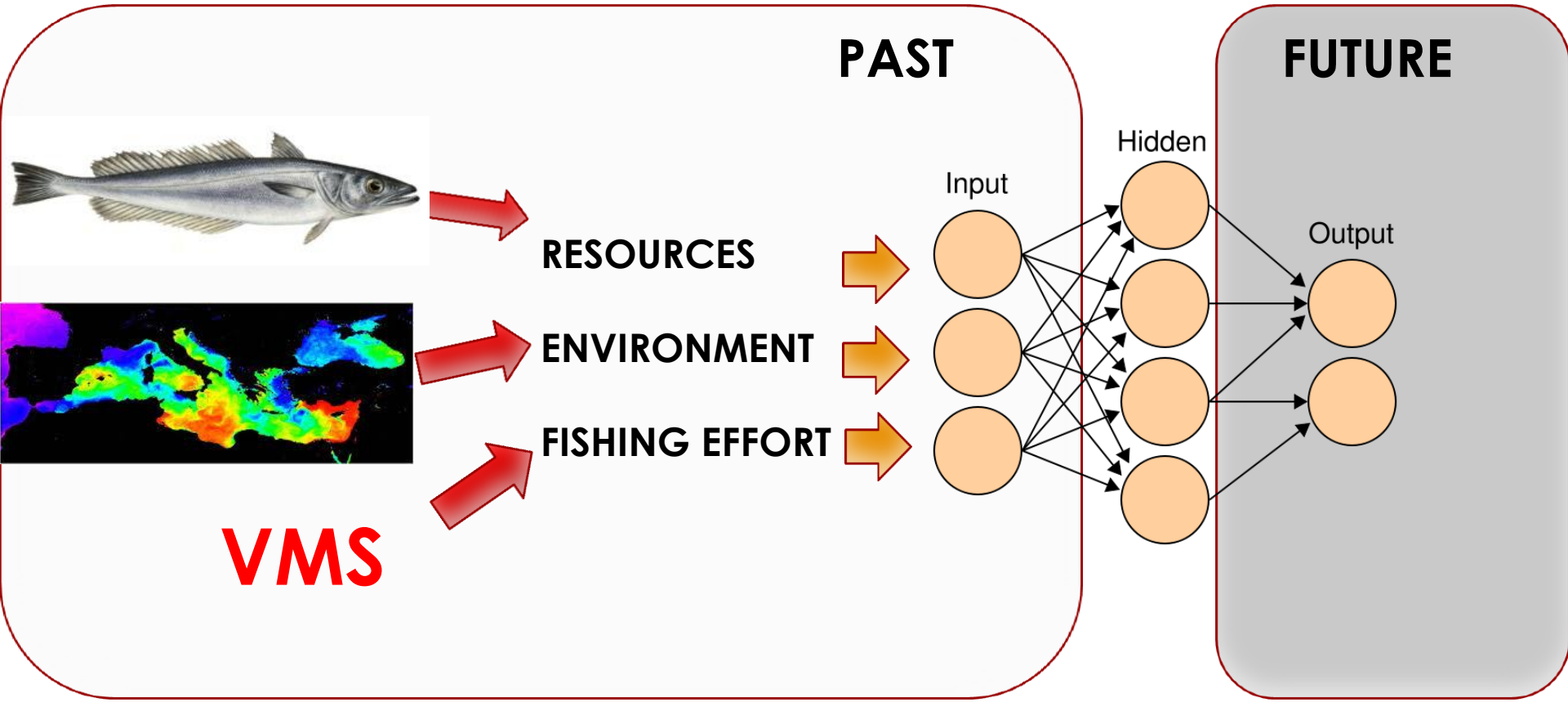
Developing SMART: rationale of the workflow

SMART is composed by 4 modules:

1. **Analysis of spatial patterns for resources, fishing effort and environmental variables (depth, SST, etc.)**
2. **Artificial neural network**
3. **Deterministic module for catches, revenues, costs and gains**
4. **Simulation approach to evaluate effort scenarios**

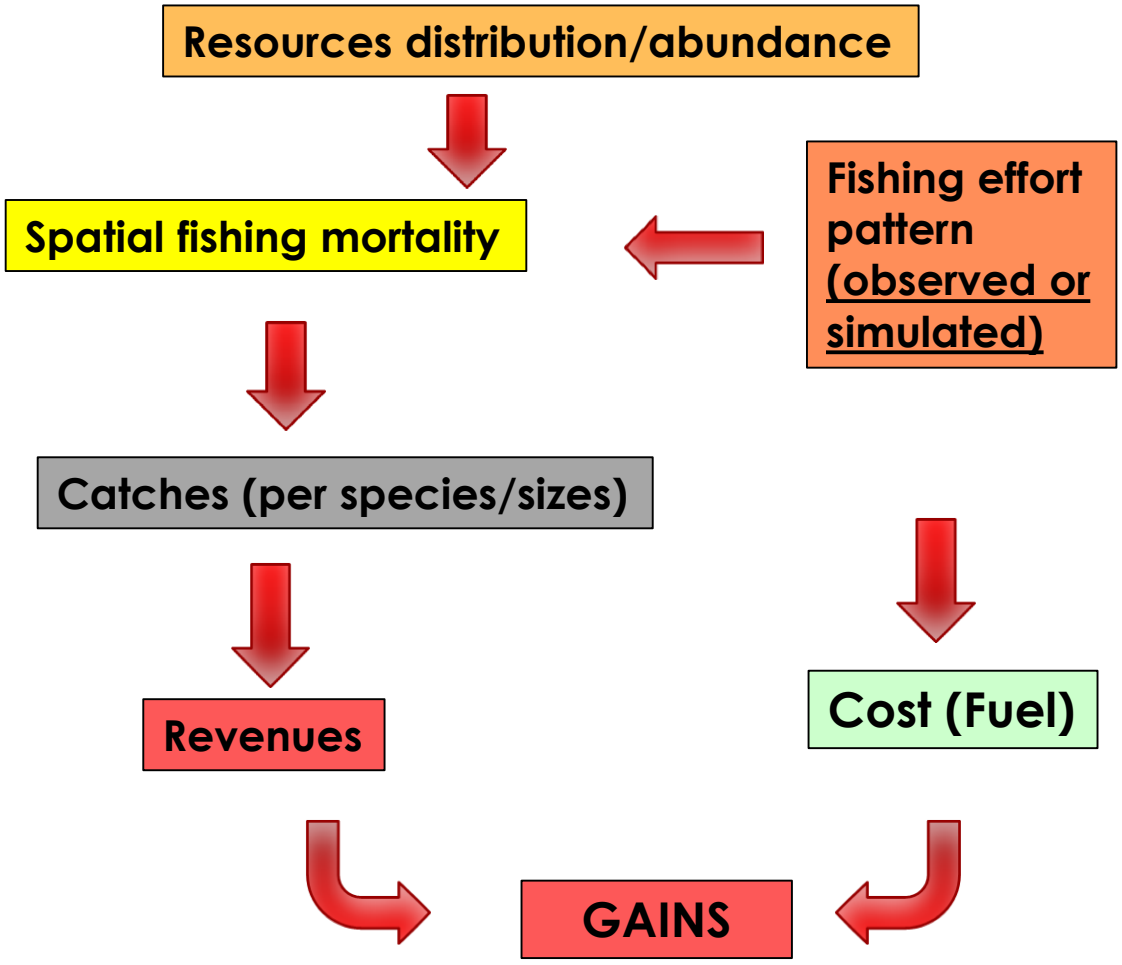
Developing SMART: rationale of the workflow

A model that allows predicting the short term effects of fishing effort management on exploited species and fishery performances

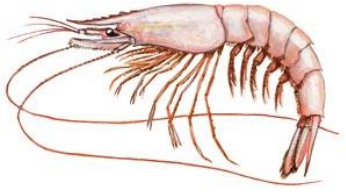


SMART: computation of catches, costs, revenues and GAINS

The ANN fed a deterministic model that computes the specific **size structure of catches** corresponding to a given combination of **resources distribution** and **fishing effort** using classic fishery science equations. These **catches** are then converted into **revenues** on the basis of market **prices** by species/size, while a simple model is used to compute the **fuel costs** associated to the **fishing effort pattern**. Finally, **revenues** and **costs** are combined to obtain **gains**.

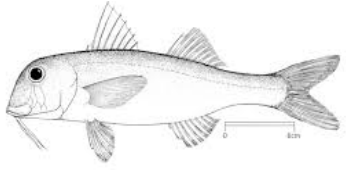


Case study: the trawlers operating in the Strait of Sicily (GSA16) and the three main exploited species



P. Longirostris

M. Merluccius



M. barbatus

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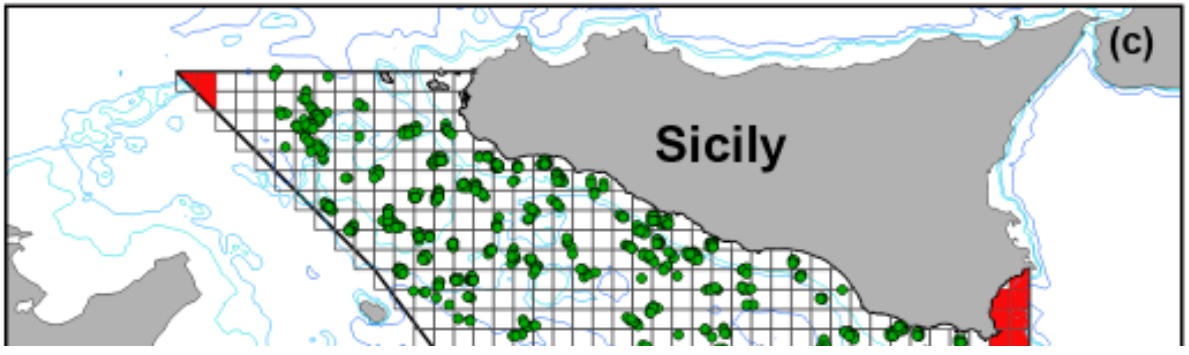
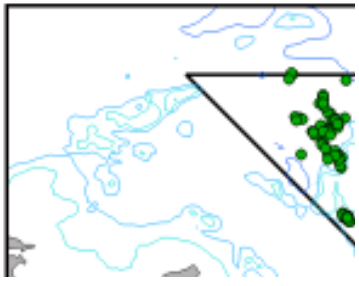
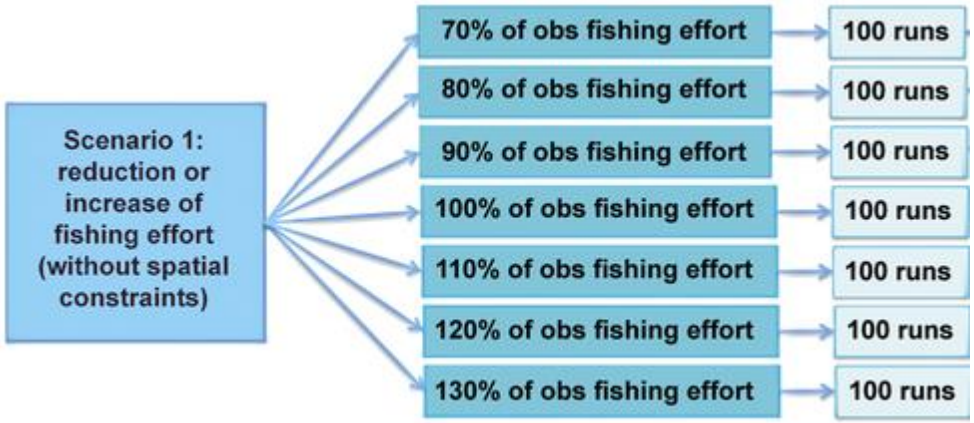


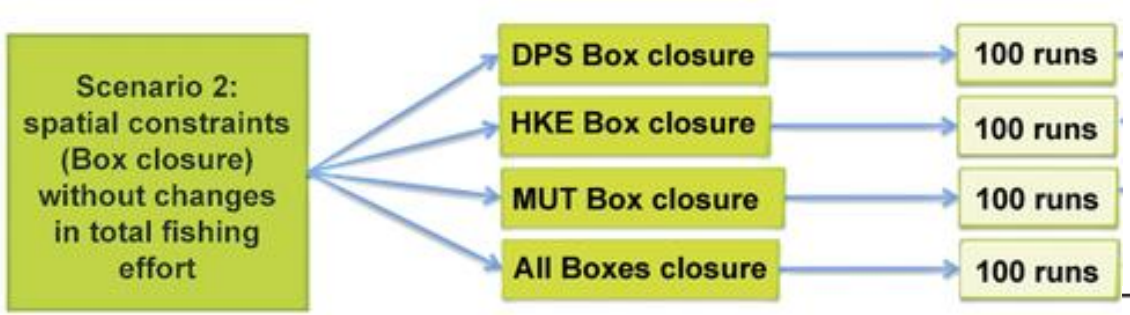
Modelling the distribution of demersal resources, fishing effort and abiotic factors for the years **2006–2010**;

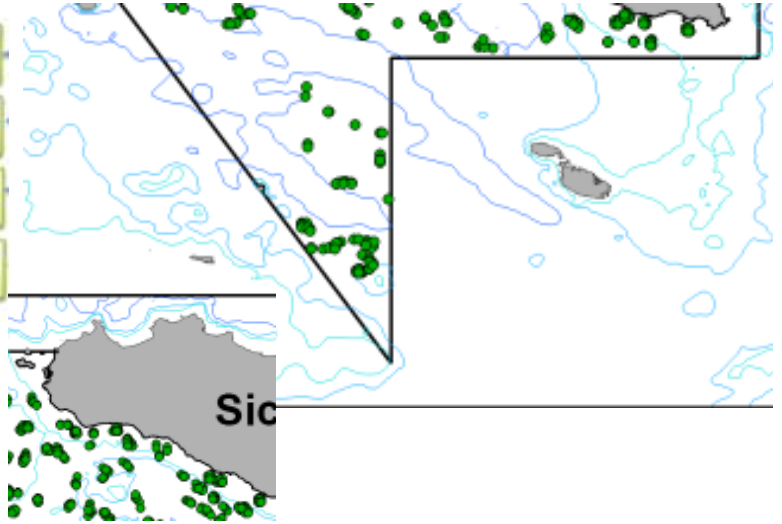


SMART simulations: reduction or increase of fishing effort (without spatial constrains)

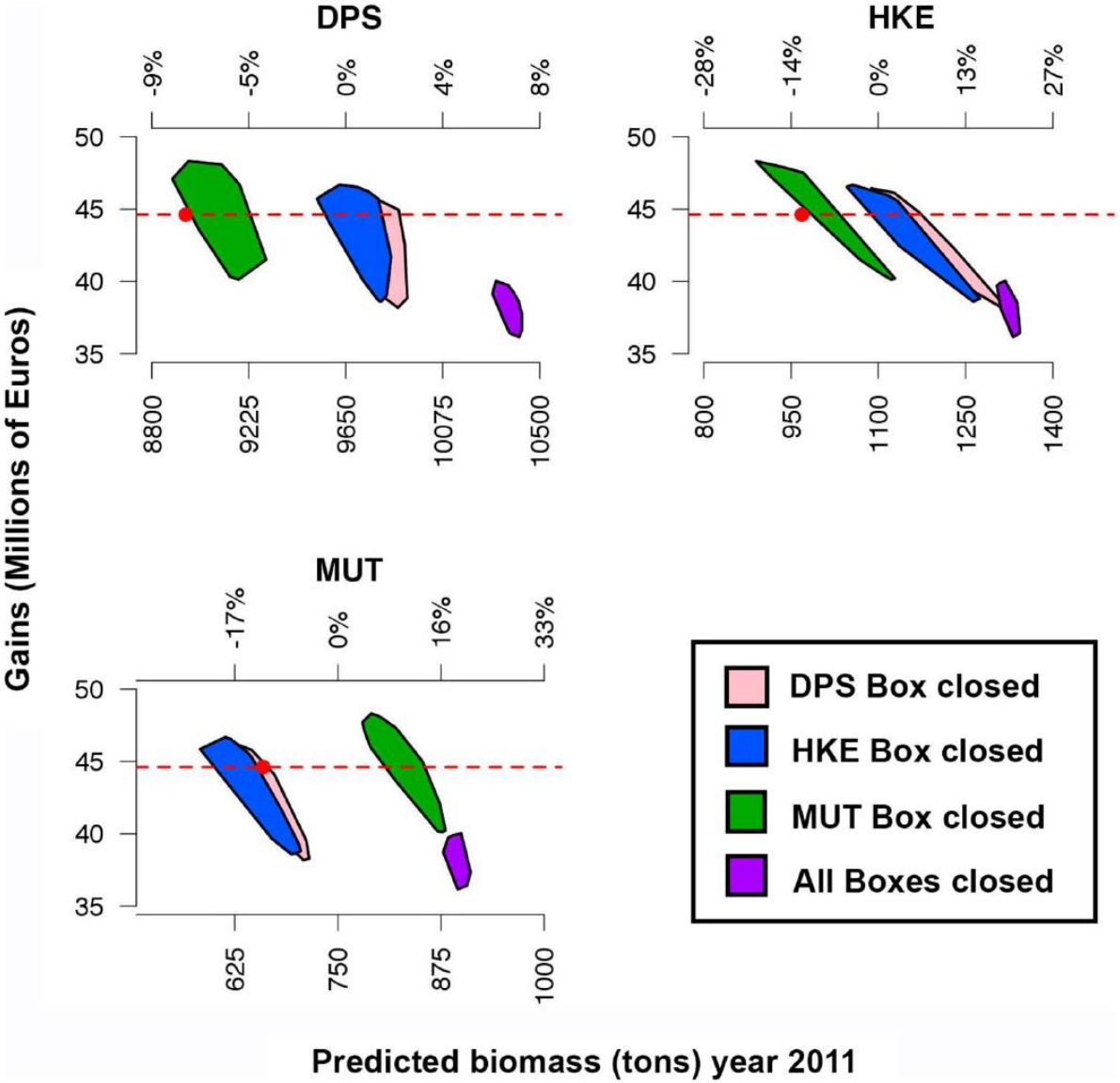


SMART simulations: reduction or increase of fishing effort (without spatial constrains)





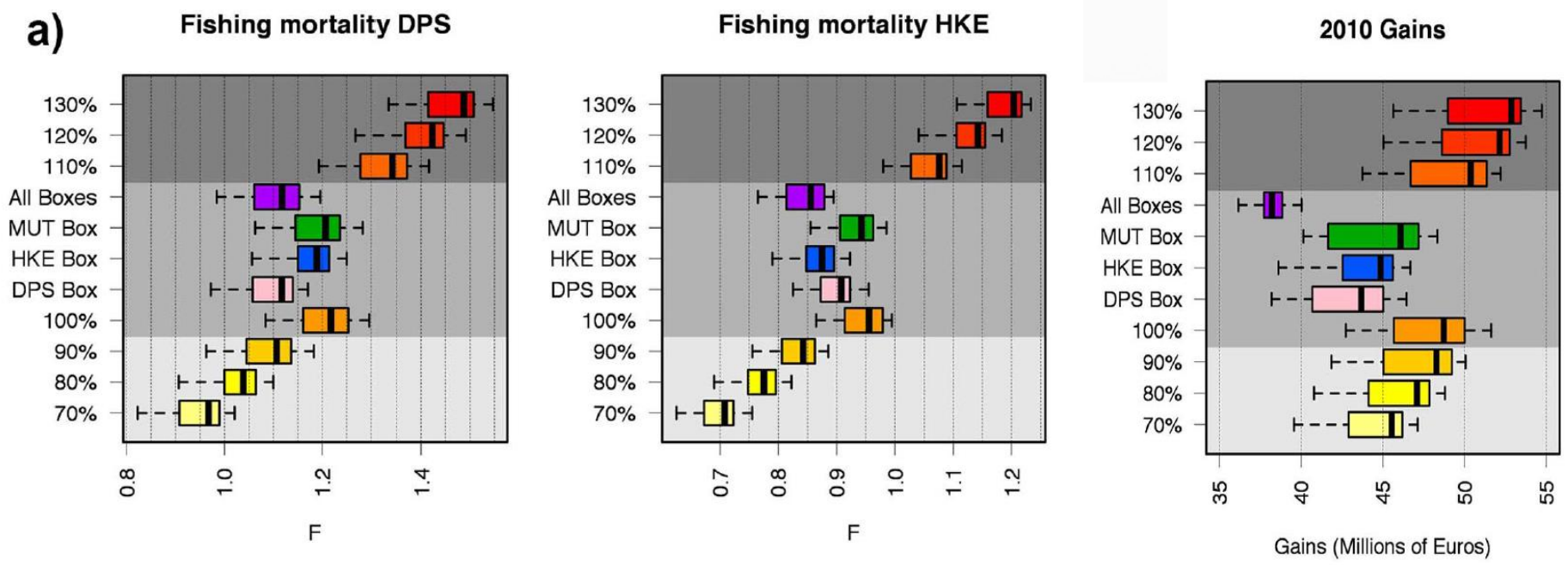
Results



- Reciprocal influence between nurseries: multi-specific effects of spatial management
- Strong effect in case of full ban

Results

- **Changes of the exploitation pattern lead to noticeable improvements of stock conditions but also to socio-economics effects**



SMART will be availlable soon as a free R add-on package via CRAN

VMSbase

Forceful, Friendly, Free

http://www.vmsbase.org/
https://cran.r-project.org/web/packages/vmsbase/index.html

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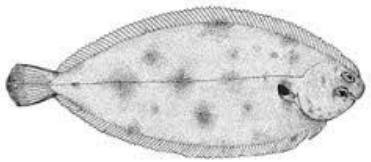
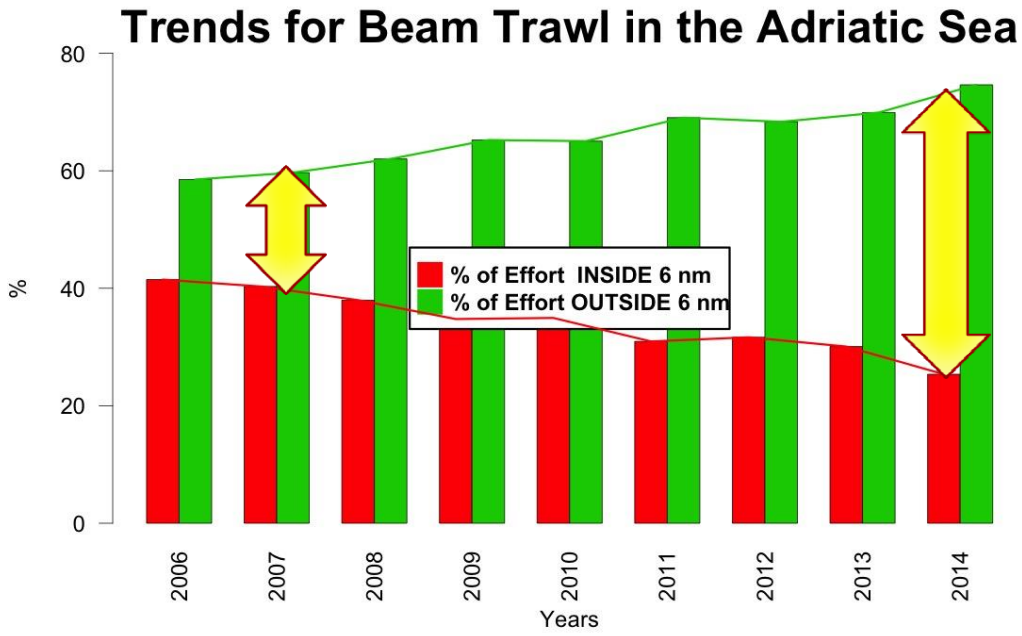
Russo T, Parisi A, Garofalo G, Gristina M, Cataudella S, Fiorentino F (2014) SMART: A Spatially Explicit Bio-Economic Model for Assessing and Managing Demersal Fisheries, with an Application to Italian Trawlers in the Strait of Sicily. PLoS ONE 9(1): e86222.

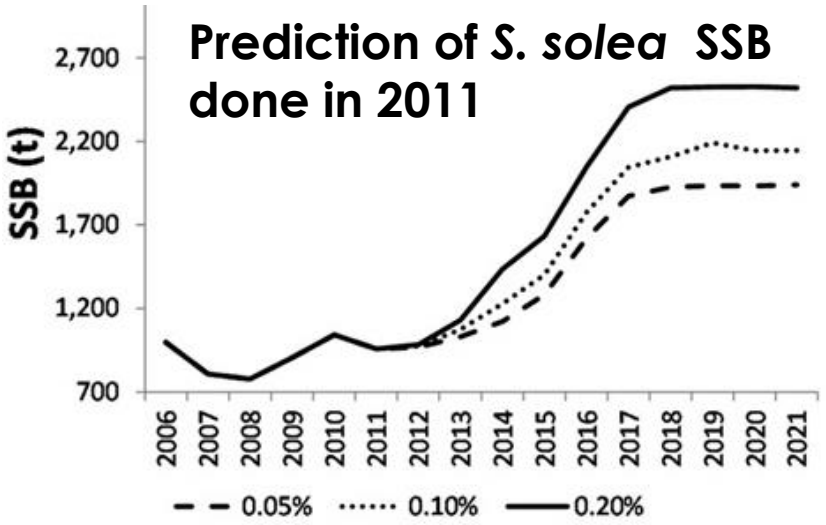
SMART

A SPATIALLY EXPLICIT BIO-ECONOMIC MODEL FOR ASSESSING AND MANAGING DEMERSAL FISHERIES

Emerging patterns and practical actions







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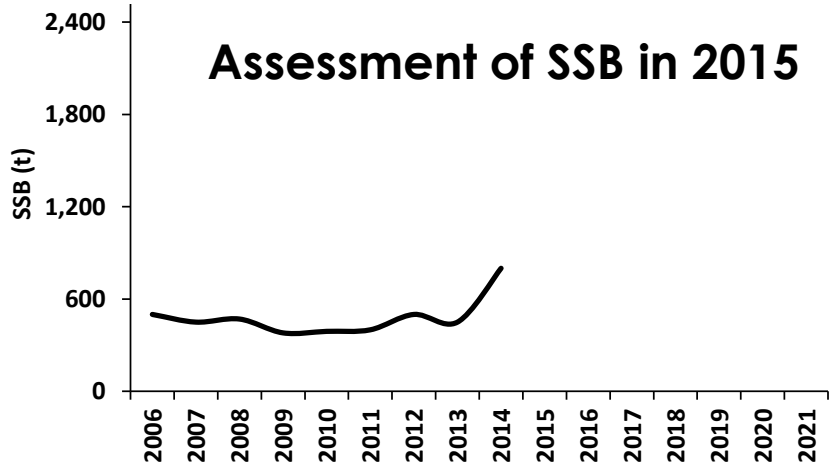
Journal of Sea Research

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

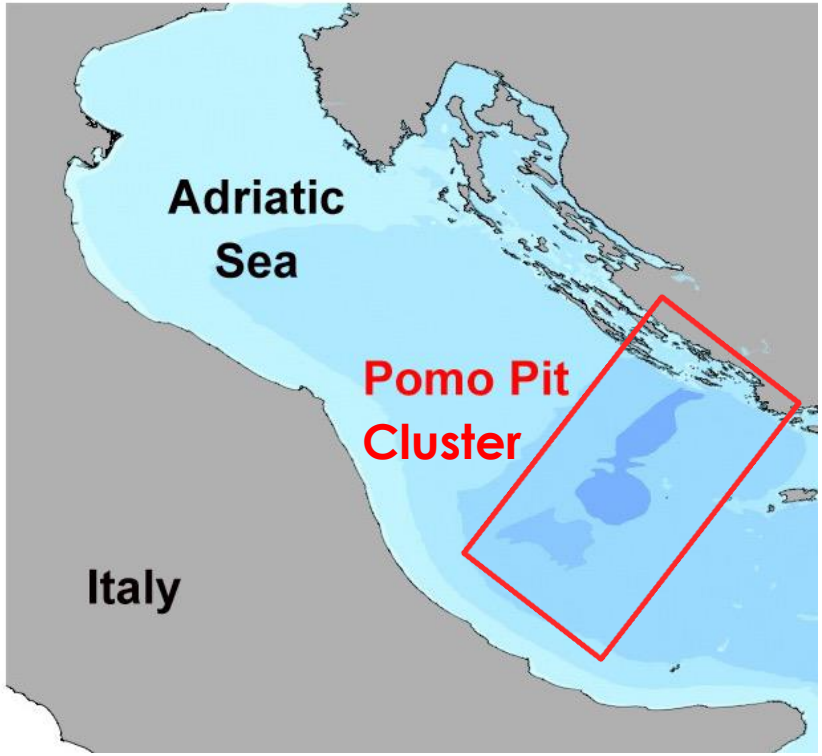
Common sole in the northern and central Adriatic Sea: Spatial management scenarios to rebuild the stock

Giuseppe Scarcella [a,*], Fabio Grati [a], Saša Raicevich [b], Tommaso Russo [c], Roberto Gramolini [d], Robert D. Scott [e], Piero Polidori [a], Filippo Domenichetti [a], Luca Bolognini [a], Otello Giovanardi [b], Igor Celić [b], Laura Sabatini [b], Nedo Vrgoč [f], Igor Isajlović [f], Bojan Marčeta [g], Gianna Fabi [a]

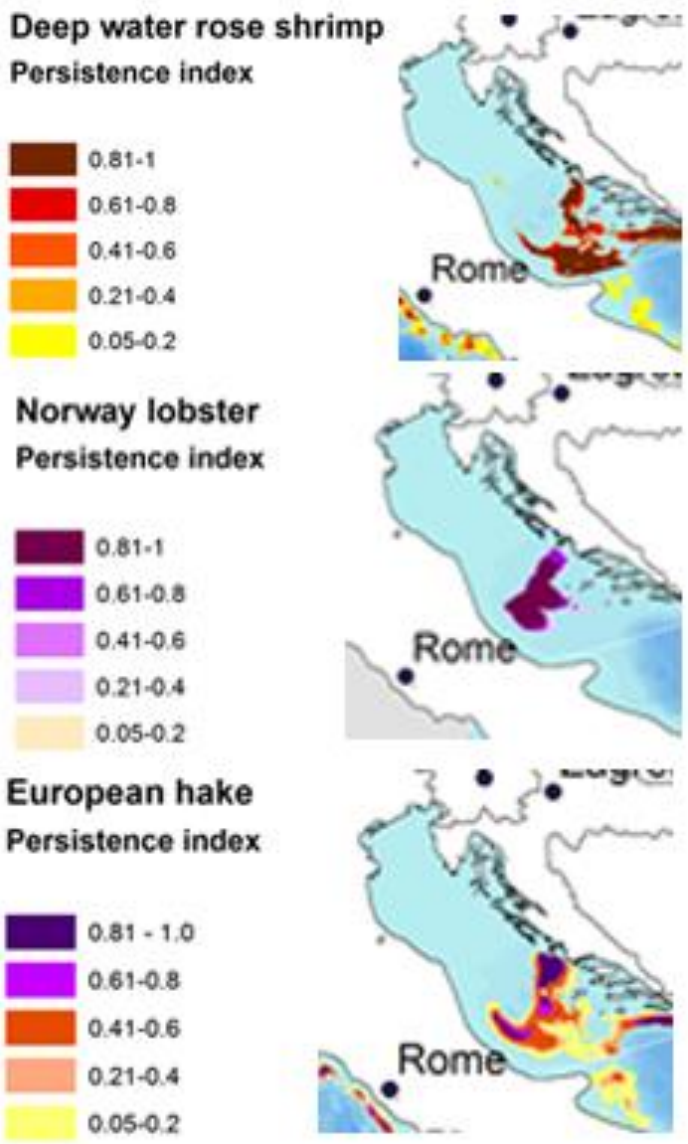


The case of the Pomo pit in the Adriatic Sea

- Jabuka/Pomo Pit is a cluster of of **three depressions** down to 260 m depth situated in the central open Adriatic;
- Up-welling region with the bottom water being cooler and more nutrients than near surface waters. Upwelling currents bring cool water to the surface allowing the production of a rich planktonic community;
- These conditions encourage a **high abundance of fish and shellfish** and the area has long been known as a productive fishing ground.



Colloca et al., (2015) The Seascape of Demersal Fish Nursery Areas in the North Mediterranean Sea, a First Step Towards the Implementation of Spatial Planning for Trawl Fisheries. PLoS ONE 10(3): e0119590.

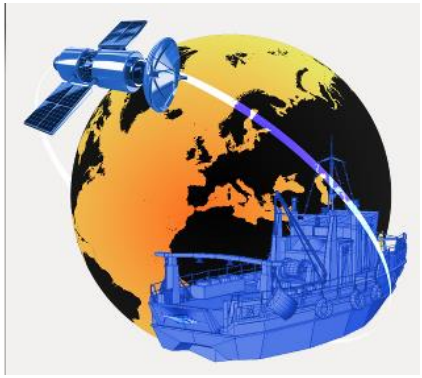


- For European hake17 (*Merluccius merluccius*) **SAC 2015:** SCAA (SS3), Y/R reports overexploitation status with intermediate biomass
- Indication is: **Reduce fishing mortality** without other specific comments on this stock.
- **Angelini et al. 2015 (WG demersal report 2014 involving Croatia)**: Reduction of fishing mortality and improvement in exploitation pattern is advisable, especially for bottom trawlers, which mainly exploit juveniles. **Particular management measure can be considered for the Pomo area since it constitutes a nursery area for hake, supporting the entire Adriatic hake stock, and in the eastern part a persistency area for spawners has been revealed from the MEDISEH project.**

A model for the dynamic of trawl fishing in the Adriatic Sea

- Logbook/independent observers survey

- VMS



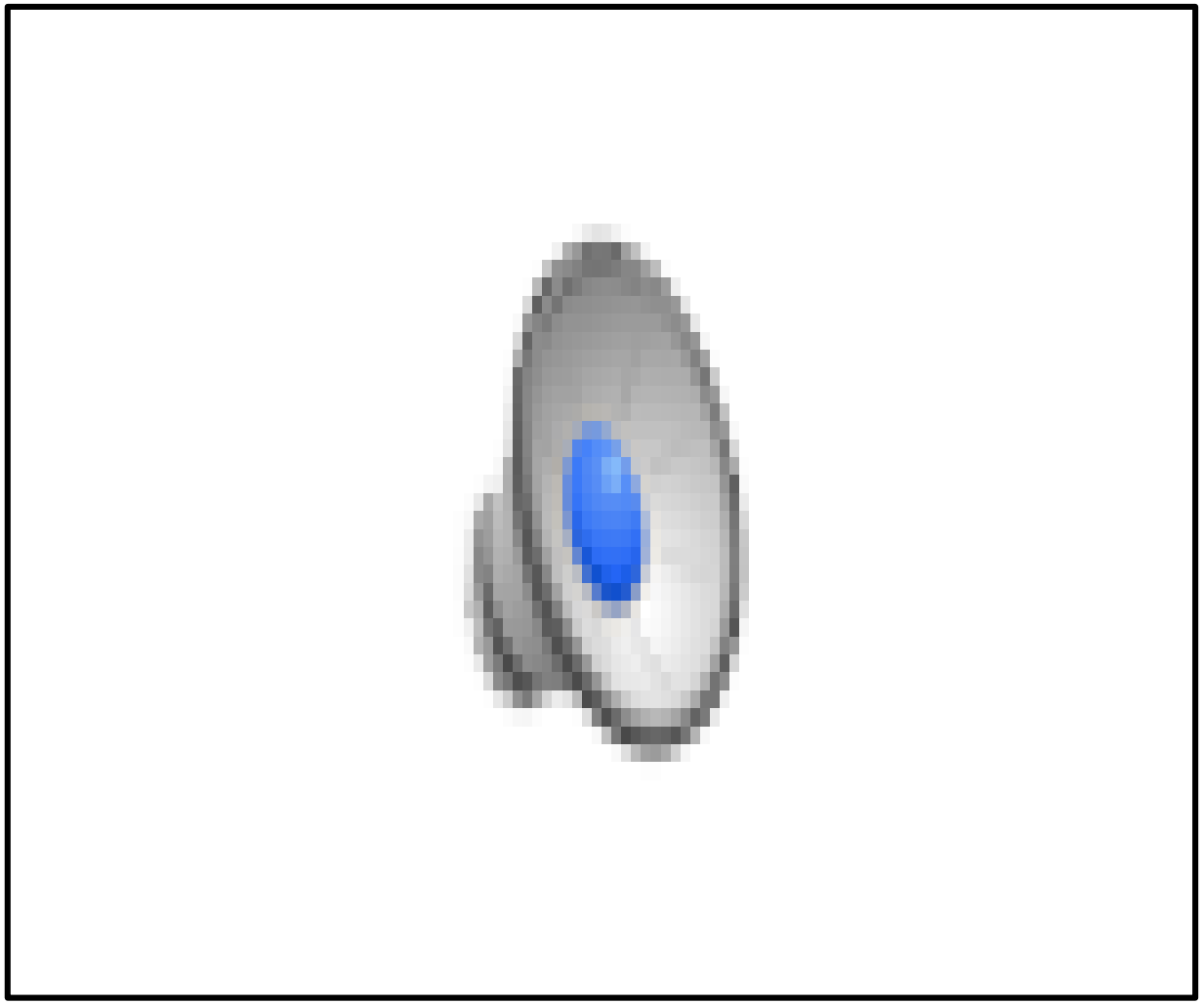
- Characterizing catches for different gears operating in different areas/periods
- Linking fishing effort pattern to quantitative impacts on target and accessory species

ICES Journal of Marine Science; doi:10.1093/icesjms/fsq137

Integrating vessel monitoring systems (VMS) data with daily catch data from logbooks to explore the spatial distribution of catch and effort at high resolution

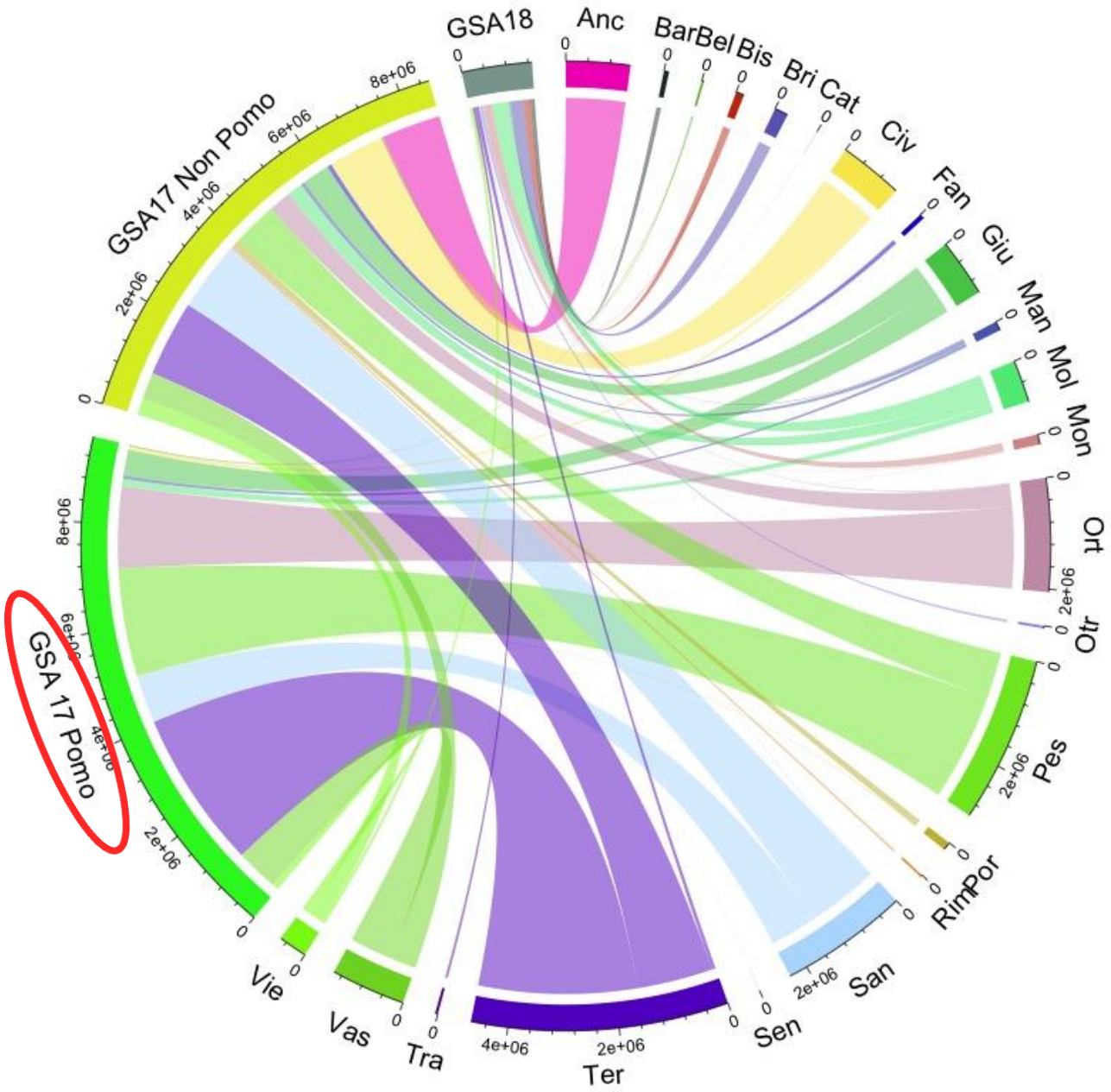
Hans Gerritsen* and Colm Lordan

A model for the dynamic of trawl fishing in the Adriatic Sea



- Modelling of the whole trawling activity and of **biomass fluxes from fishing grounds to harbours**
- Insights for spatial management

https://www.youtube.com/watch?v=6lKoPu6yUSg&feature=youtu.be

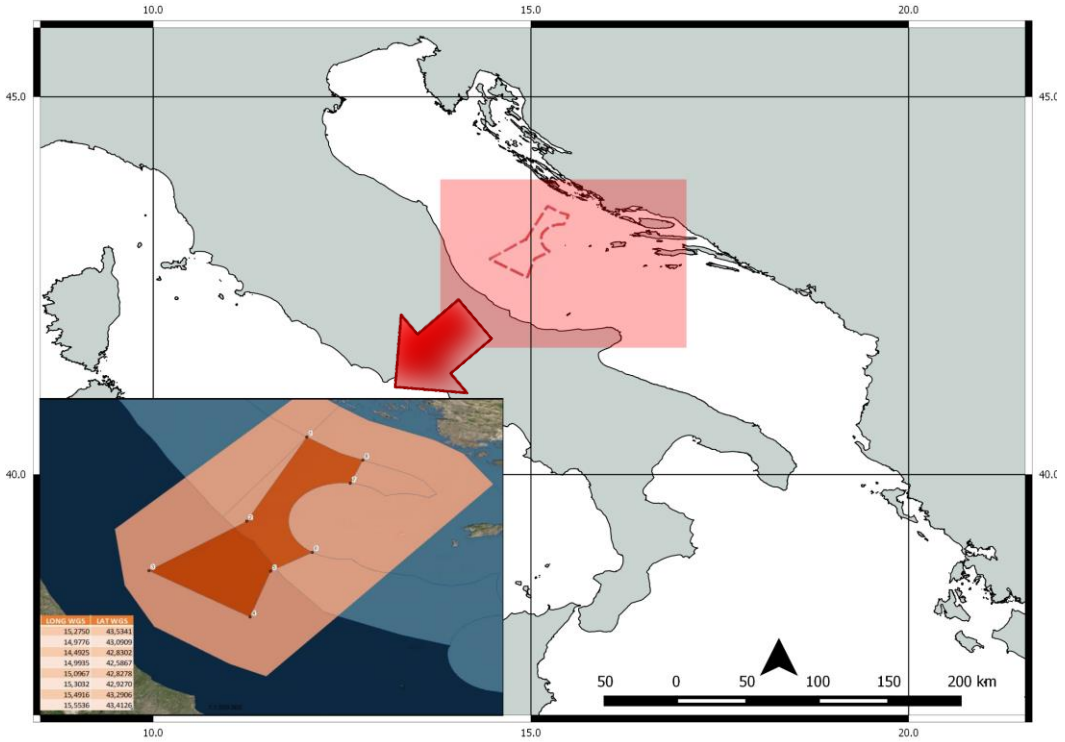


- The Pomo complex is a critical area for all the fleets operating in the Adriatic Sea
- Pomo Complex: 32% of the area in which the species is present
- Above 49% of the total production of Norway lobster

Joint Italian/Croatian actions to preserve stocks

Management objectives

- Improve resource status by spatial managing of fishing effort
- **Ministry of agricultural food and forestry policies:** Since July 2015 the Pomo Pit area is interdicted to trawl fishing for vessels with VMS and interdicted to navigation for vessels without VMS (precautionary approach)



Conclusions

- Several projects and actions contributed to update and inprove our knowledge of resources distribution, comprising some details about critical stages, and of environmental drivers

- Other projects are focused on the effects of fishing disturbance on species , communities and environments

- We must take into account and capitalize on this work concerning area-based management for fisheries and nature conservation

Conclusions

- The Common Fisheries Policy (CFP) is inter alia oriented towards promoting the establishment of biologically sensitive protected areas, including nursery and spawning grounds of exploited stocks in which all or certain fishing activities are temporarily or permanently banned or restricted in order to improve the exploitation and conservation of living aquatic resources and marine ecosystems.
- The Union shall continue to give additional protection to existing biologically sensitive areas.
- Moreover the Marine Strategy Framework Directive (MSFD) requires Member States to identify the measures needed in order to contribute to a coherent and representative network of marine protected areas (MPAs ***sensu latu***) adequately covering the diversity of the constituent marine ecosystems with a view to delivering good environmental status.

Conclusions

- Spatial management could represent an effective approach (in combination with other actions) to improve the **exploitation pattern**
- Spatial management is coherent with the **Ecosystem approach** since it allows addressing **multi-specific targets** and protecting critical environments from highly impacting fishing activity (i.e. trawling), and particularly in complex multi-specific fisheries such as the trawling in the Mediterranean
- The involvement of stakeholders could lead to good spatial and strong compliance and return valuable scientific data (e.g. by FOS)
- Spatial management could support a more effective control (i.e. strong control in critical areas)

Thank you for the attention

- DGMARE: Project MANTIS: Marine protected Areas Network Towards Sustainable fisheries in the Central Mediterranean
- FAO – Adriamed Project / Medsudmed Project
- CNR-IAMC: Mazara del Vallo (Italy)
- CNR-ISMAR: Ancona (Italy)
- Uni BARI: Bari (Italy)
- Hellenic Centre for Marine Research (HCMR): Athens (Greece)
- AZTI-Tecnalia, Centro Tecnológico del Mar y los Alimentos: Pasaia (Spain)
- National Oceanography Centre (NOC): Southampton (UK)

As scientific responsible, S. Cataudella guarantees that all the tools and methods developed in this framework are freely available under request

The hard lesson from the past

- If we look at fisheries that have been successful over the long term, the reason for their success is not to be found in assessment, learning and management models, but in the existence of a spatial accident, something about the spatial structure of population dynamics interacting with regulatory systems, or about the behavior of the species and fishers, that creates a large scale refuge for a substantial segment of the spawning population. (Carl Walters, 1995)
- When such `natural accidents' do not exist, the first priority of any sensible management plan should be to create their equivalents: nurseries and spawning refugia that, through regulation and enforcement, are off limits to fishery operations. (Orensanz, 1998)