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Managing the small pelagics fisheries in a changing Adriatic Sea

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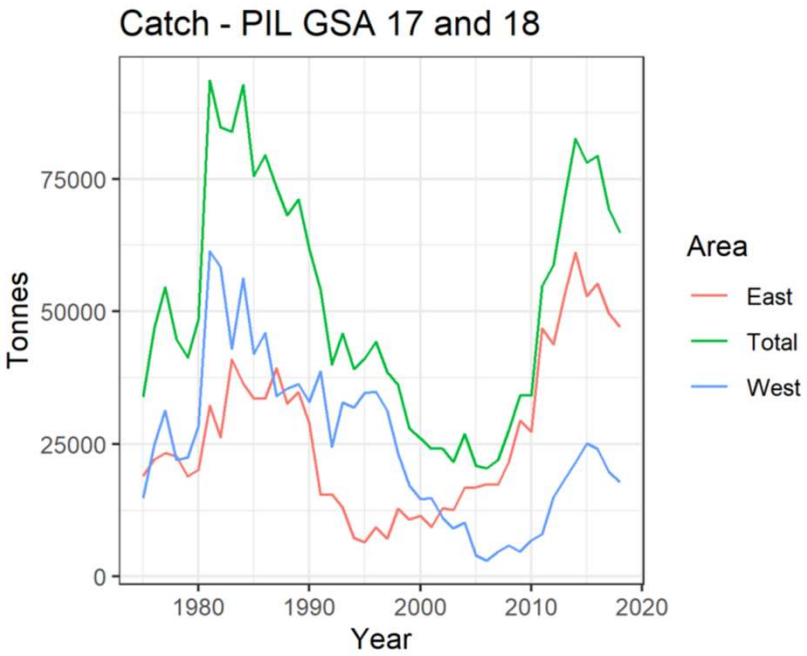
Main goals of the presentation

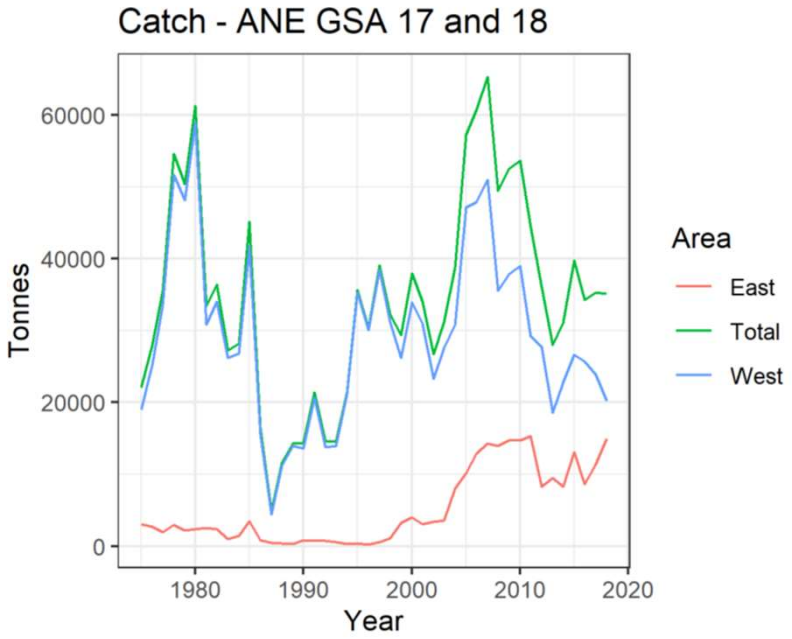
- Summarize main information on **dynamics of the fisheries resources and their major drivers within the context of climate change**;
- Set this information within **a conceptual framework for sustainable management** of fishery activities **in a changing sea**;
- Suggest **how to improve the assessment and the management** of the small pelagics fisheries in the Adriatic Sea from a fishery biologist perspective.

What we know about small pelagics catch in the Adriatic…

Catch of *Sardina pilchardus* in the Adriatic sea. A recovery of the catch from 2005 to 2014 is evident although with a different pattern between western and eastern sector. In the last years the catch is decreasing in the whole basin.

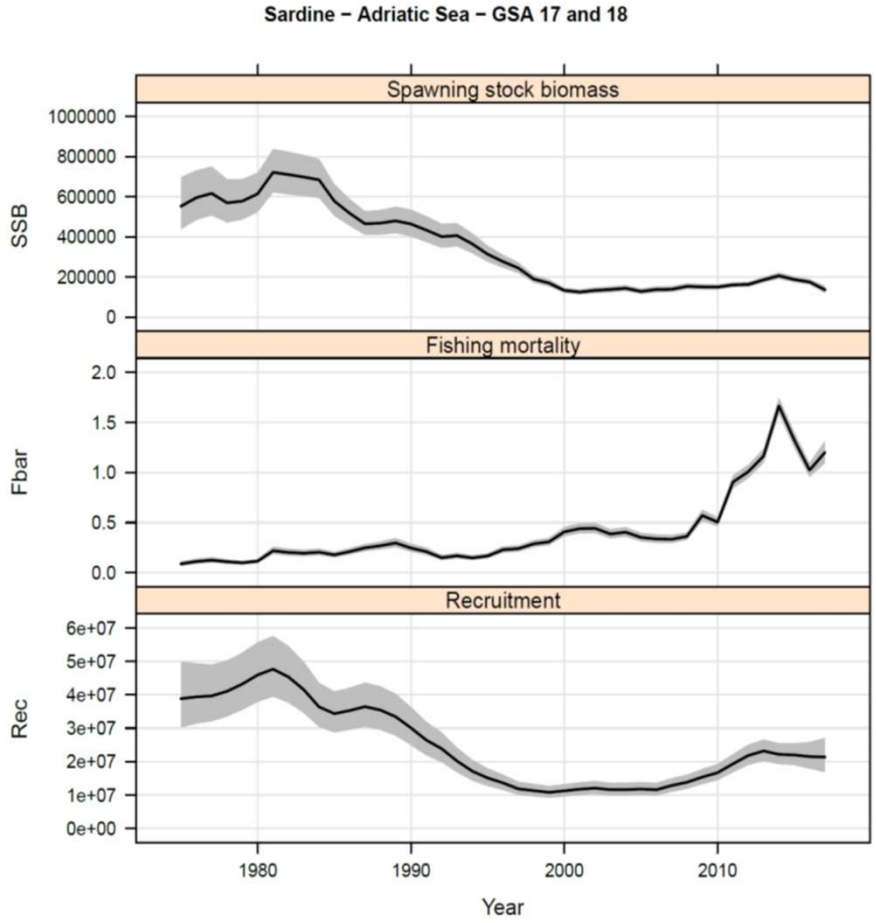


Catch of *Engraulis enchrasicolus* in the Adriatic sea. A recovery of the catch from early 1990s to late 2000s is evident, followed by a decrease of catch mainly occurring in the western sector.



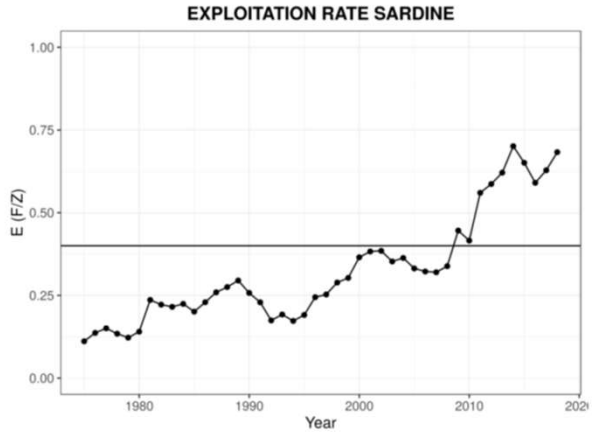
The status of sardine stock in the Adriatic according to the last SAC Assessment by Angelini et al., 2019

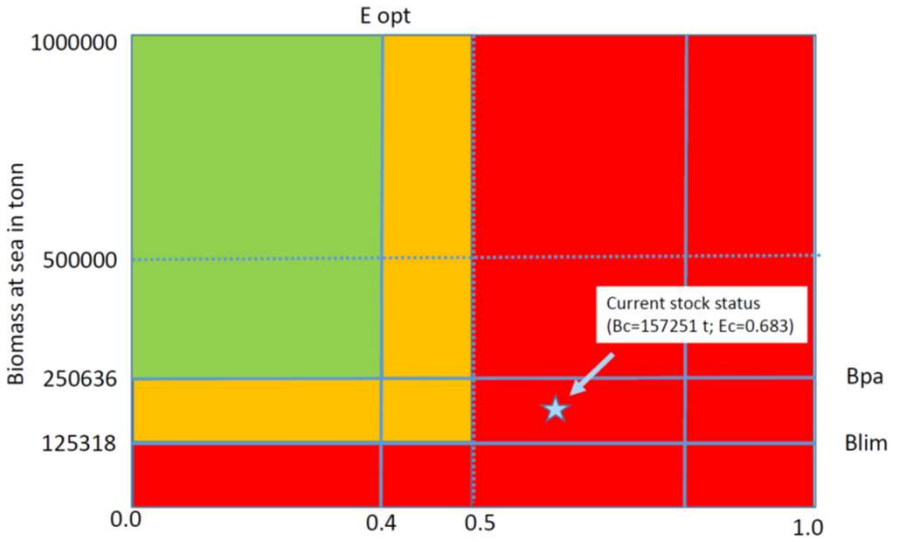
Trends in Recruitment, Fishing mortality, and Spawning Stock Biomass according to the State-space Assessment Model (SAM)



In overfishing with biomass higher the Blim

Trend in Exploitation rate (E=F/Z) (top) and Kobe plot summarizing the state of Sardine stock (bottom)

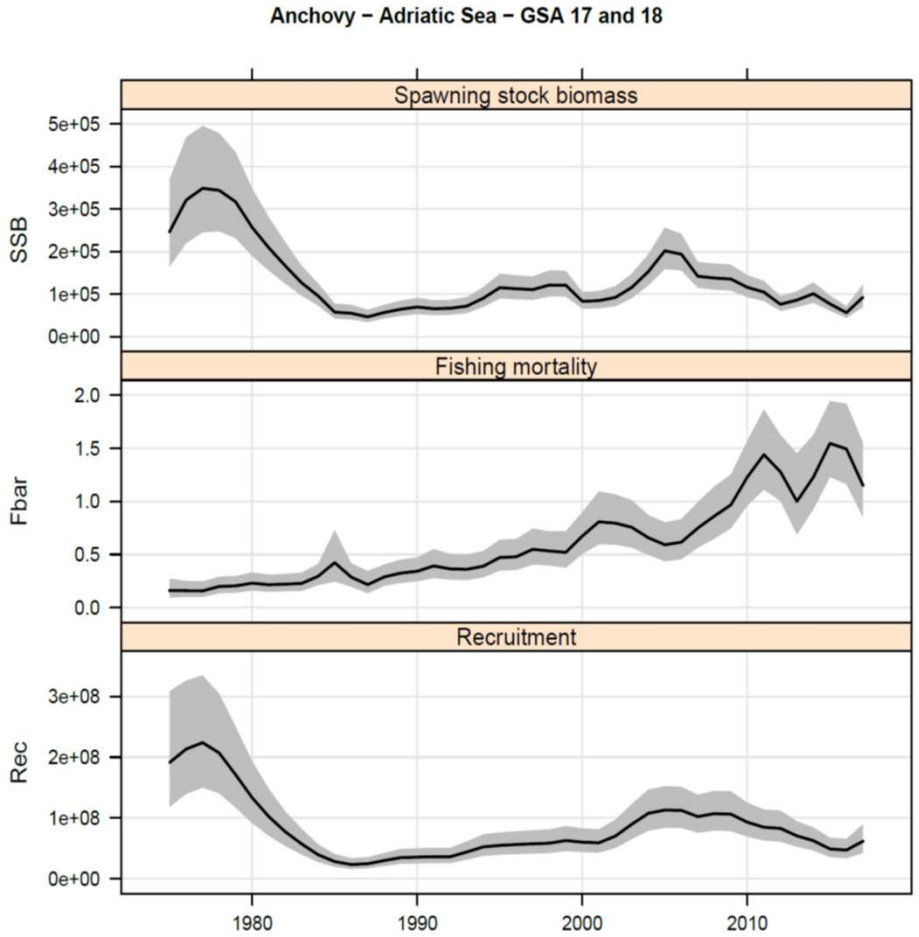




<u>The management measures taken so far have not been able to remedy the increasing overfishing</u>

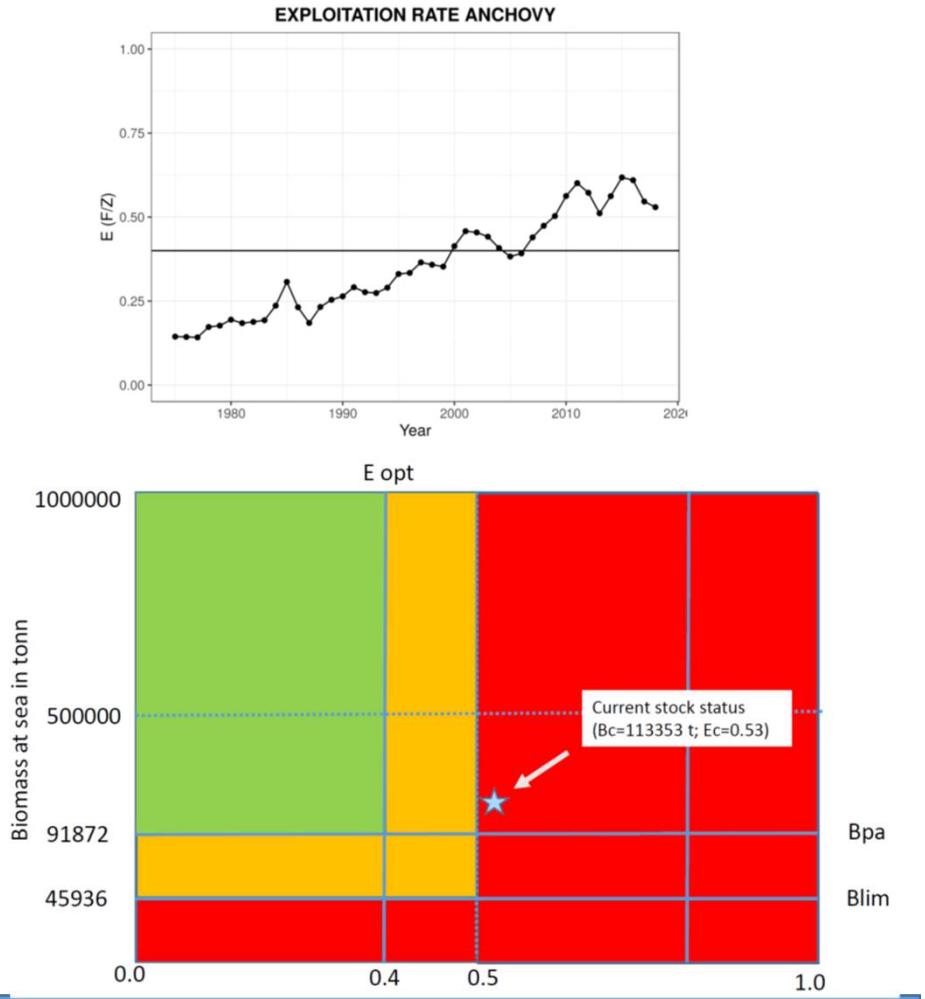
The status of anchovy stock in the Adriatic according to the last SAC Assessment by Angelini et al., 2019

Trends in Spawning Stock Biomass, Fishing mortality, and Recruitment according to the State-space Assessment Model (SAM)



In overfishing with biomass higher than B_{Pa}

Trend in Exploitation rate (E=F/Z) (top) and Kobe plot summarizing the state of Sardine stock (bottom)



<u>The management measures taken so far have not been able to remedy the increasing overfishing</u>

The GFCM recommendations on MAP for management of fisheries exploiting the small pelagics in the Adriatic Sea (GSA 17 & 18)

- Recommendation GFCM/37/2013/1 on a multiannual management plan for fisheries exploiting small pelagic stocks in geographical subarea 17 (northern Adriatic Sea) and on transitional conservation measures for fisheries exploiting small pelagic stocks in geographical subarea 18 (southern Adriatic Sea);
- Recommendation GFCM/38/2014/1 on precautionary and emergency measures for 2015 on small pelagic stocks in geographical subarea 17 and amending Recommendation GFCM/37/2013/1
- Recommendation GFCM/39/2015/1 establishing further precautionary and emergency measures in 2016 for small pelagic stocks in the Adriatic Sea (geographical subareas 17 and 18);
- Recommendation GFCM/40/2016/3 establishing further emergency measures in 2017 and 2018 for small pelagic stocks in the Adriatic Sea (geographical subareas 17 and 18);
- Recommendation GFCM/42/2018/8 on further emergency measures in 2019-2021 for small pelagic stocks in the Adriatic Sea (geographical subareas 17 and 18).

The main content of the MAP and management measures:

A Reference Point framework based on:

- Exploitation Rate (E=F/Z= 0.4);
- SSB Precautional (SSBpa) being 250000 tonnes for Anchovy and 109200 tonnes for Sardine;
- SSB limit (SSBlim) being 179000 tonnes for Anchovy and 78000 for Sardine

A pre-determined rules that control fishing activities (fishing effort and catch) according to the biological state of the stock based on results of stock assessment models.

A suite of emergency measures based on the bad state of the stocks has been adopted from 2014 to 2018 introducing fishing effort limits (both in terms of capacity and activity), spatial & temporal closures, and catch limits

Some main pattern about the changing Adriatic sea…

Long-term ecological studies reported significant modifications of the environmental conditions in the Adriatic, due to climatic fluctuations and changes of the anthropogenic pressure, as:

- a warming of surface waters at basin level;
- a marked decrease of the freshwater outflow due to reduction of precipitations, that, together with increasing flow of the Eastern Adriatic Current, caused a rise of surface salinity more marked in the western area;
- an increased river loads of N coupled to decreased P loads, due to enforcements of environmental law;
- an acidification of waters due to the increase of atmospheric CO2;

These environmental changes had relevant consequences for the ecosystem, which responses were:

- a reduction of the phytoplankton biomass and the intensity /frequency of late winter diatom blooms due to a decrease of TP concentrations, particularly in the western North Adriatic;
- a general trend toward small size species, which can explain the decrease of chlorophyll a concentration;
- a mesozooplankton increase both in number of individuals and in biomass;
- a macrobenthos recovery in areas previously impacted by eutrophication;
- an increase in the abundance of thermo-philic and thermo-tolerant species and the disappearance or rarefaction of 'cold' steno-thermal species;
- a decreasing trend in total biomass of target demersal fishes;
- a decreasing trend in small pelagic fish catches;
- a reduction of the average trophic level of fish community;

from Coll et al., 2009; Giani et al. 2012

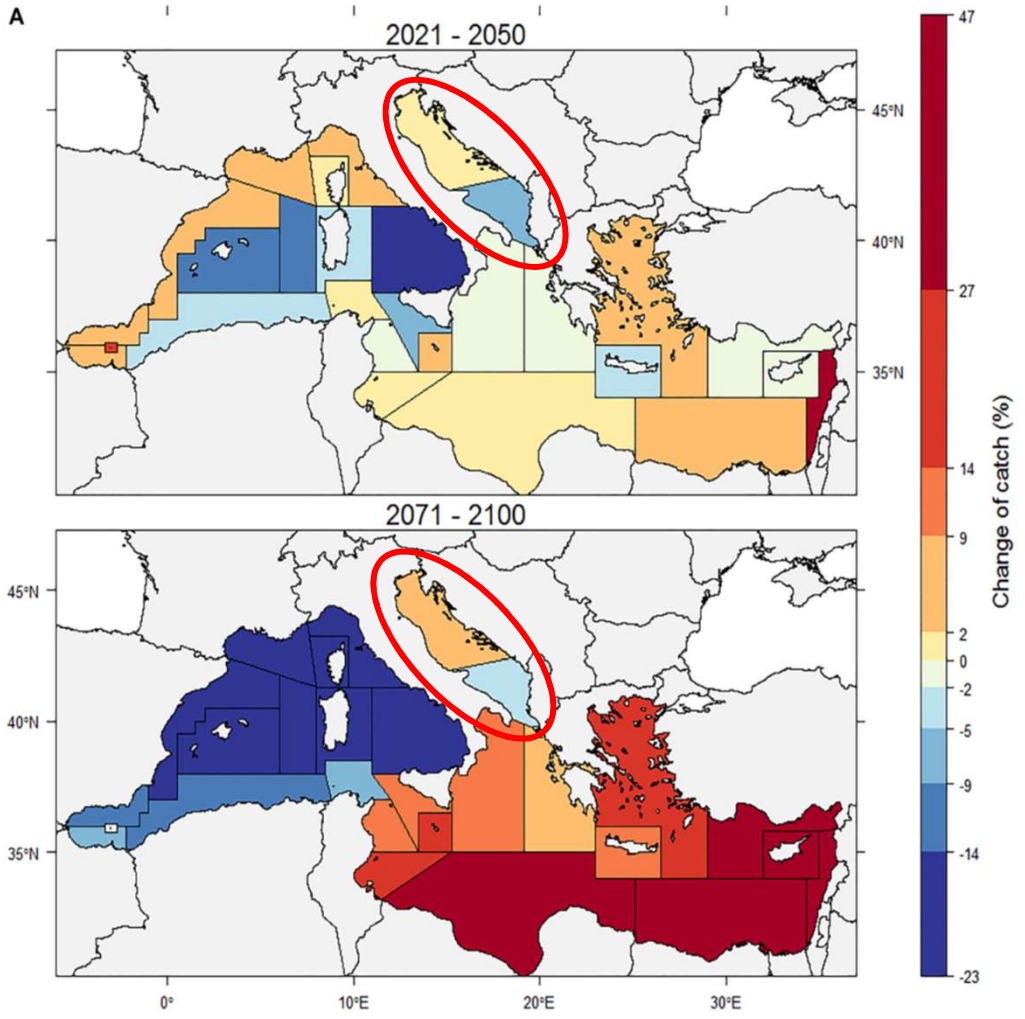
Some simulation of multispecies spatial dynamics under the current emission and fishing mortality scenarios using Eco3M-S coupled with OSMOSE models

The total catch of the Mediterranean is expected to increase by 0.3 and 7% by the first and second half of the XXI century, respectively.

Catch would increase in the south-eastern part of the basin while it could decrease by up to 23% in the Western part.

Winner species would mainly belong to the thermophilic and/or exotic pelagics, with smaller size and low trophic level;

Loser species should be large-sized, some of them of great commercial interest, with a contraction or shift of their geographic range.

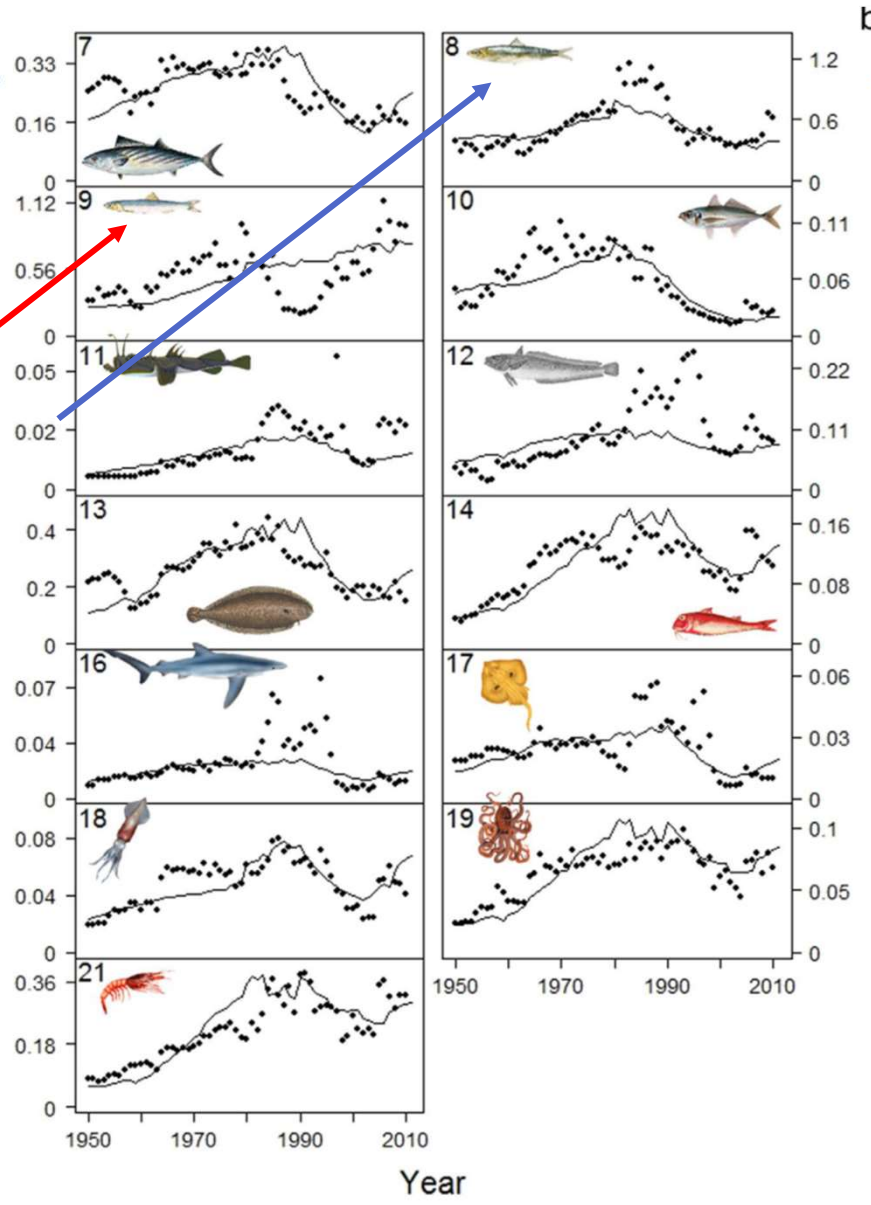


by Moullec et al., 2019

Some simulation of multispecies dynamics in the Adriatic sea using a Ecopath with Ecosim (EwE) food web model

Both changes in Primary Production (PP) and fishing pressure played an important role in driving species Dynamics but, PP was the strongest driver upon the Mediterranean Sea ecosystem.

Ecological indicators, with exception of total catch and biodiversity, show overall Adriatic ecosystem degradation from 1950 to 2011.

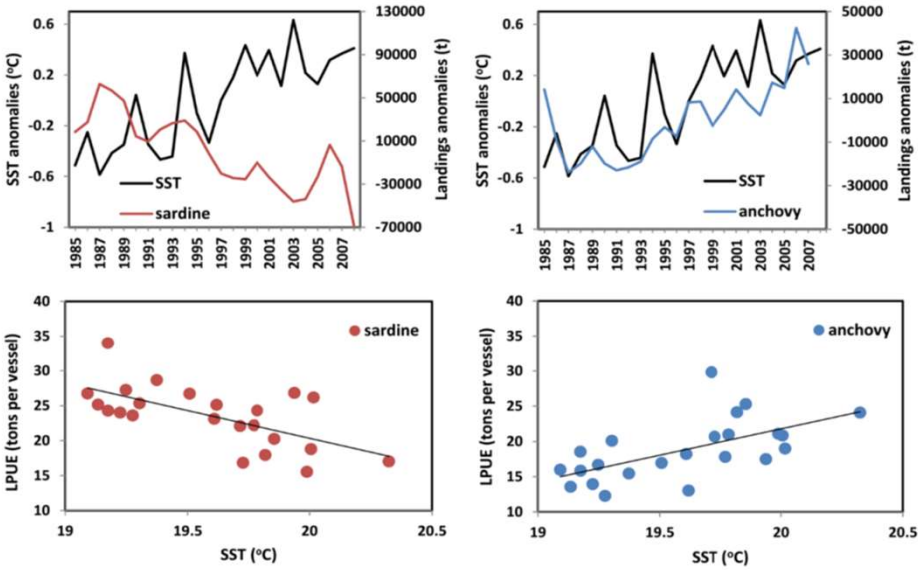


Predicted (solid lines) versus observed (dots) catches (t·km−2·year−1) for main commercially important functional groups of Adriatic ecosystems (1950–2011). **Anchovy** and **sardine** catch are marked.

by Piroddi et al., 2017

The expected reaction of sardine and anchovy to the sea warming…

The different ecological optimal temperature of sardine (SST range 12 - 14 °C) and anchovy (SST range 17– 19°C) (by Palomera et al., 2007)



Tzanatos et al. 2014; Stergiou et al. 2016

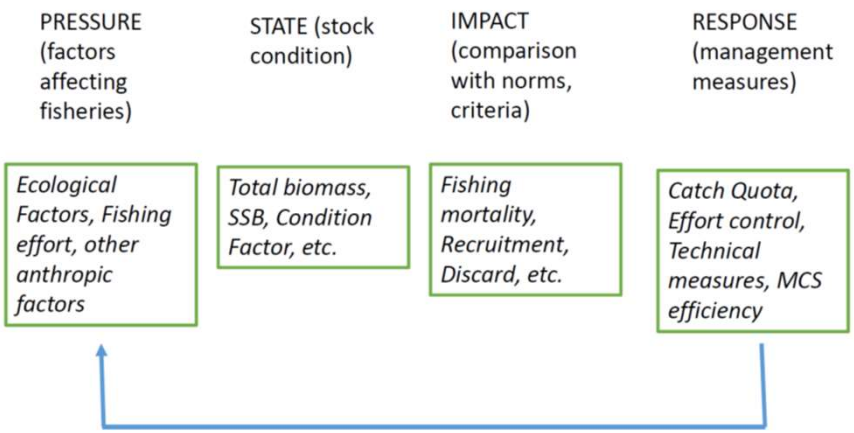
Increasing water temperature, particularly during winter when sardine reproduces, may decrease breeding performance and cause population declines

Warming may have resulted in an improvement of the spawning success or period duration (summer) for anchovy

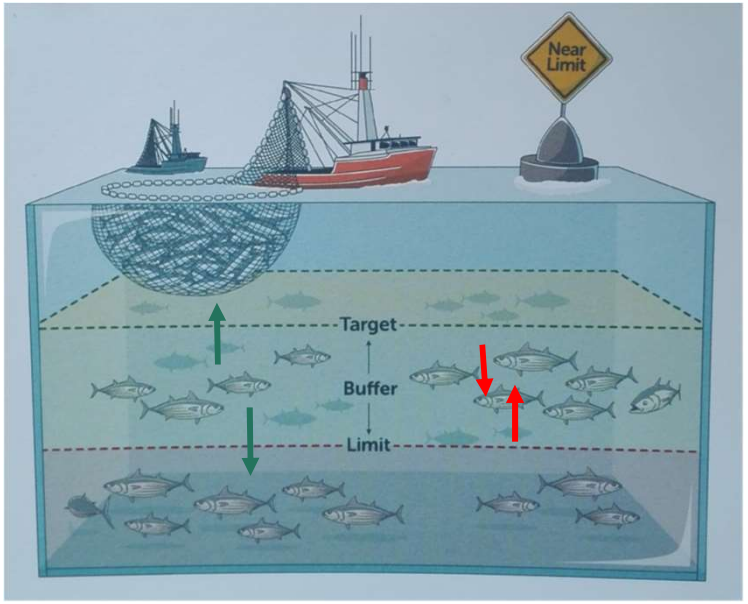
..by the way…the optimal SST for round sardine is > 23°C

by Fortibuoni, 2020

How we can use sets of indicators in the management framework of fisheries according to a Pressure State Impact Response (PSIR) approach…



In medium- long term period MSY should be considered as a 'moving target' in a changing sea

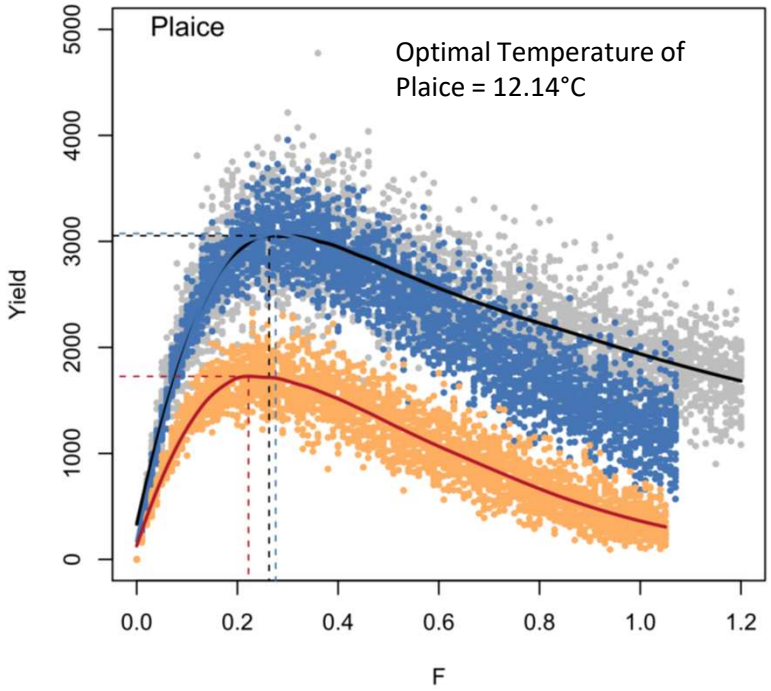


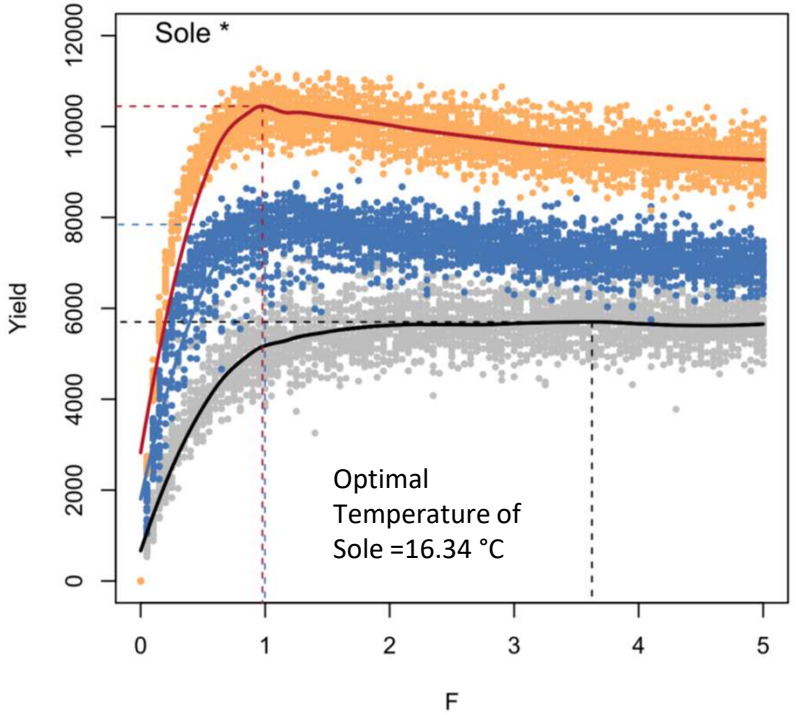
Ecological factors should be included in pressure ones in describing stock dynamics

(by Caddy, 2010)

The variation of fishing reference points under climate change….

Some simulations on Sustainable yield vs. fishing mortality of flat fish in the English Channel





Coming back to the Adriatic Sea, a decreasing the fishing mortalities at level similar to that exerted before 1980s might not produce a corresponding increase of yield, being estimation of MSY based on historic time series too optimistic in the future.

By Travers-Trolet et al., 2020

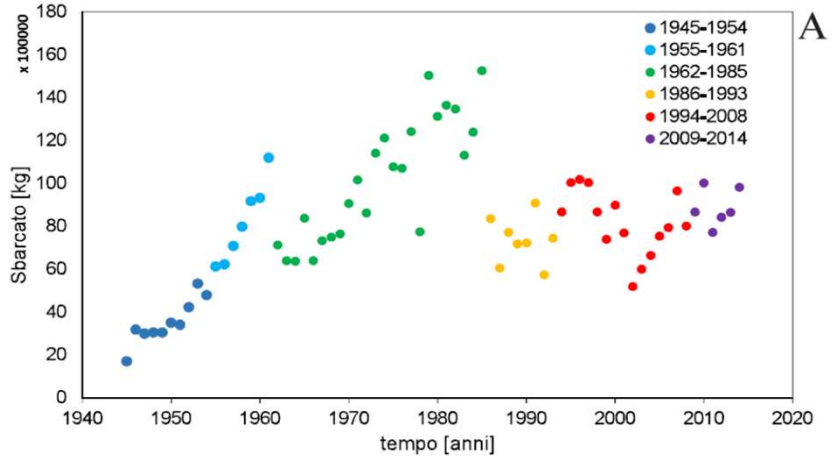
Looking for a set of indicators to manage a fishery subject to environmental impacts showing us what a situation is like…

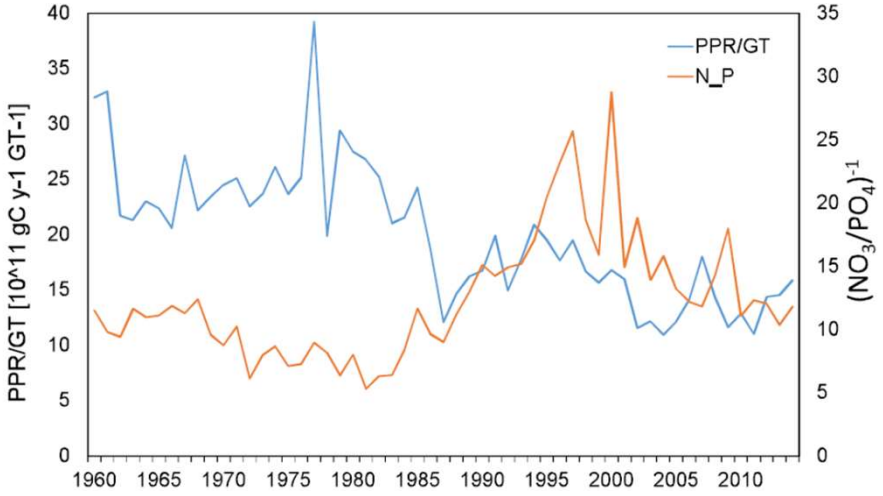
ENVIRONMENTAL DRIVING FUNCTIONS
- *Indicators of:*
  - *River inflow/upwelling*
  - *Seasonality of abiotic/biotic factors*
  - *Shelf anoxia*
  - *Nutrient inputs*
  - *Phytoplankton/zooplankton abundance*
  - *Indicators of eutrophication*
  - *Jelly predators (Mnemiopsis, Beroe etc)*

FISHERIES INDICATORS
- *Biological:*
  - *Egg and larval surveys (Anchovy etc)*
  - *Indices ofrecruitment*
  - *Coordinated trawl surveys (finfish biomass)*
  - *Coordinated/calibrated acoustic surveys*
  - *Catch and effort for selected species*
  - *Coordinated log book data collection*
  - *Port sampling (size, age, maturity)*
- *Fleet:*
  - *No./fishing power/gear + vessel type*
  - *Days fished/month (log book/interview)*
  - *No licences issued/species*
  - *Black Sea vessel registry/licence #*

INFORMATION REQUIREMENTS FOR MANAGING A FISHERY SUBJECT TO ENVIRONMENTAL IMPACTS

SOCIO-ECONOMICS /RESEARCH/MCS
- *Employment in the fisheries sector:*
  - *Number of full/part time fishermen*
  - *Self employed/state sector employee*
  - *Cooperatives? NGO's?*
- *Information on processing . marketing?*
- *Community involvement*
- *physical port infrastructure*
- *Management framework*
  - *national legislation/regulations*
  - *possible harmonization over B. Sea?*
  - *facilities for control/surveillance?*
- *Research facilities /research programmes*
  - *Researchers by subject studied*
  - *Fisheries officers /MCS capabilities*





An empirical assessment framework could based on quartile of indicators of state (landing, biomass at sea, recruits, catch) and pressure on stocks (PPR/GT, N/P, zooplankton biomass, others to be investigated)

By Caddy (2010), Libralato et al. (2018)

An empirical approach for small pelagics including indicators of stock abundance and environmental conditions …

Due to high uncertainty in Stock assessment, data-based, rather than model-based, approaches to setting quotas should be preferred (by Hilborn , 2002)…empirical approaches based on indicators trend could improve the stakeholders understanding of stock status …

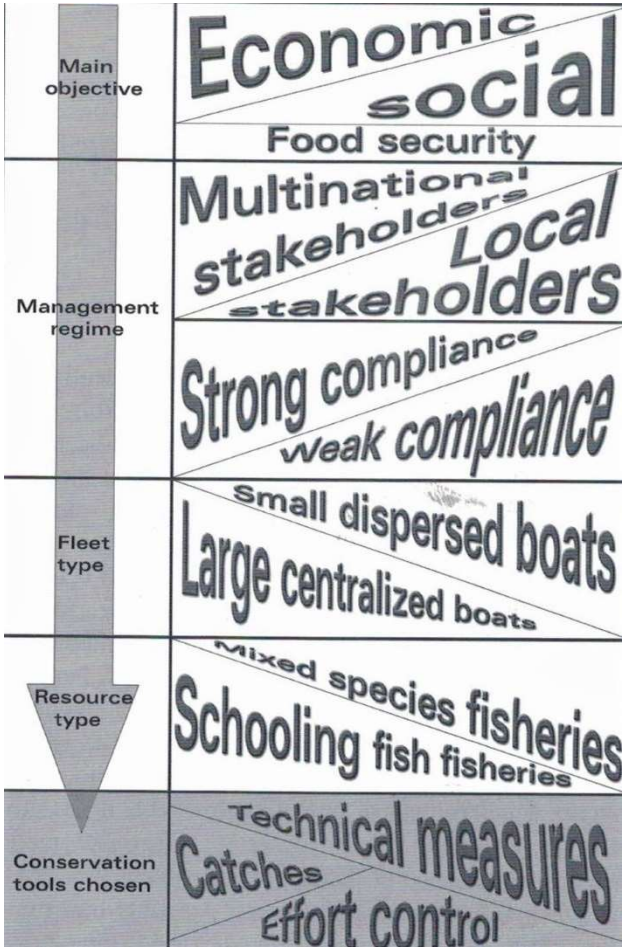
Empirical management tools monitoring multiple indicators within a traffic light framework

INDICATORS OF ENVIRON-MENT AND ECOSYSTEM ↓	STOCK CONDITION (based on annual surveys) →		
	HEALTHY STOCK CONDITION	BIOMASS BELOW Bpr	BIOMASS BELOW Blim
habitat/environ-mental conditions satisfactory	May increase capacity	maintain capacity constant	Close the fishery in this subarea
Evidence of deteriorating productivity	maintain capacity constant	Seek to reduce capacity or days fished	Close the fishery in this subarea
Habitat/ environ-mental conditions unsatisfactory	Seek to reduce capacity or days fished	Close the fishery in this subarea	Close the fishery in this subarea

By Caddy, 2004

Some suggestions for improving assessment and management of small pelagics fisheries in the Adriatic Sea. A fishery biologist perspective…

- It is necessary to obtain information to **evaluate the stock status quickly** but nothing is done to modify the DCF accordingly (**improve monitoring of state of stock at sea, communities and ecosystem, including fishing activities to allow an adaptive management**);
- Climate changes affects the productivity of stocks through changes in recruitment and interactions with trophic web. Therefore **assessment and management should consider effects of climate and sea change on the resources**;
- A **management system based on effort regulation assumes** a strong relationships between fishing effort and catch through fishing mortality. This assumption **is very weak in small pelagics (hyperstability of schooling resources CPUE**);
- Being small pelagics fisheries in the Adriatic based just on two target species and two fishing system, **the adoption of the introduction of a catch quota system could be explored**;
- Since effects of climate change is expected to intensify in the Adriatic Sea, **a quota management system could allow a faster adaptation** of the exploitation **to the effects of the environmental factors** on thre small pelagics standing stocks.



by Pope, 2009

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