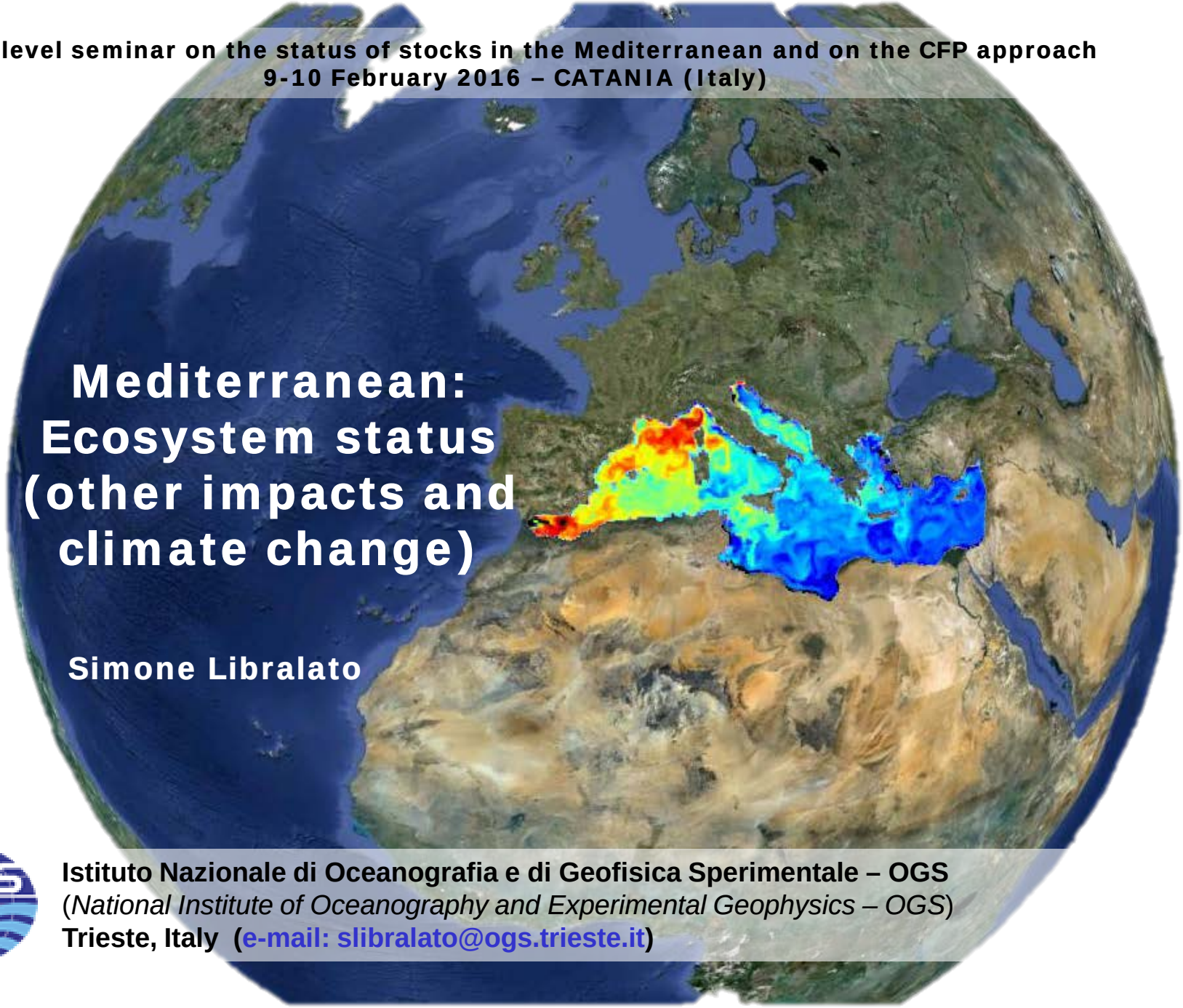
High level seminar on the status of stocks in the Mediterranean and on the CFP approach
9-10 February 2016 – CATANIA (Italy)



Mediterranean: Ecosystem status (other impacts and climate change)

Simone Libralato

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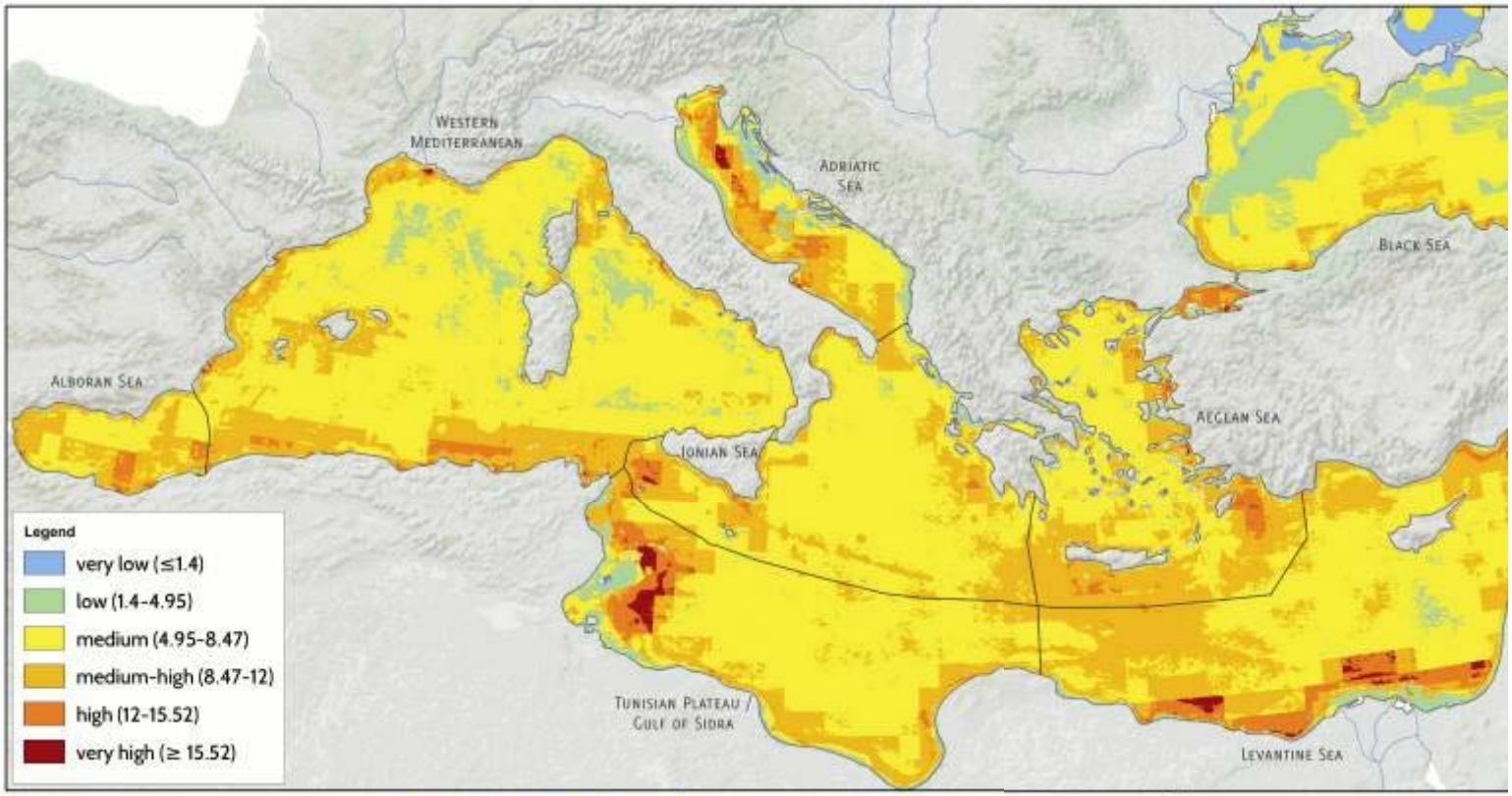
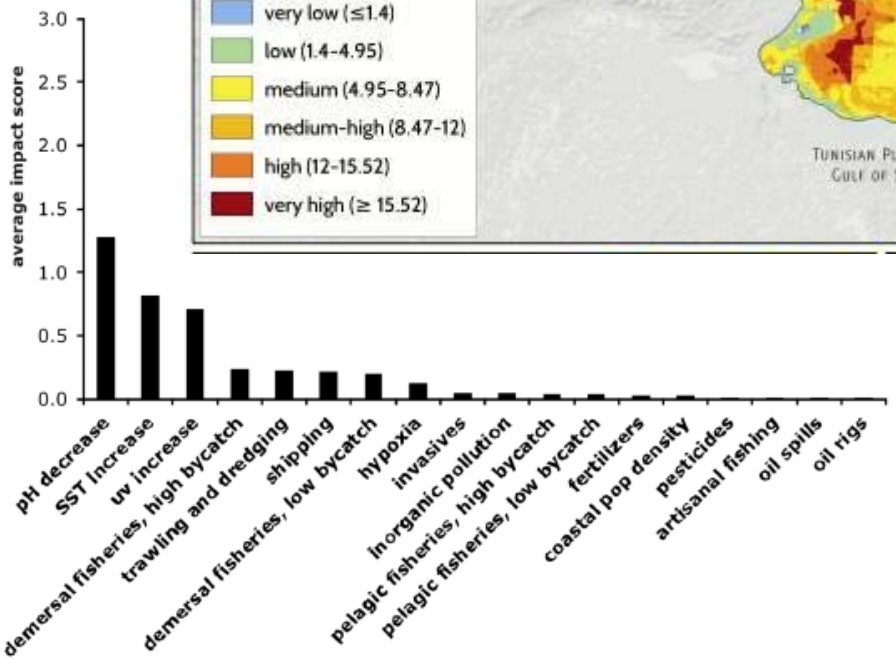
Cumulative human impacts on Mediterranean ecosystem

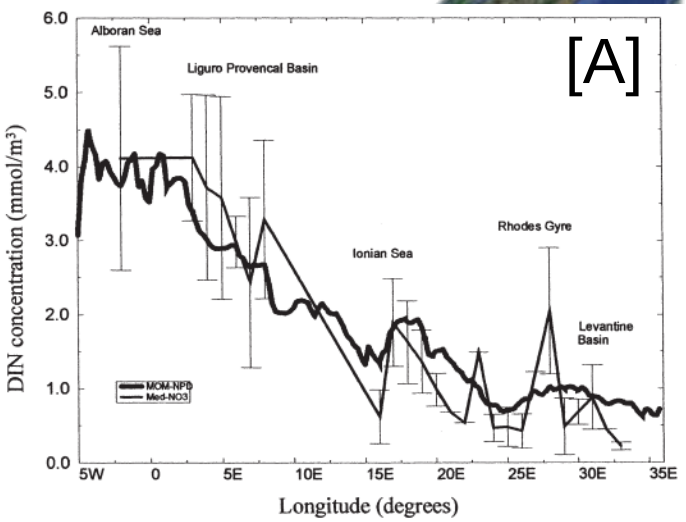


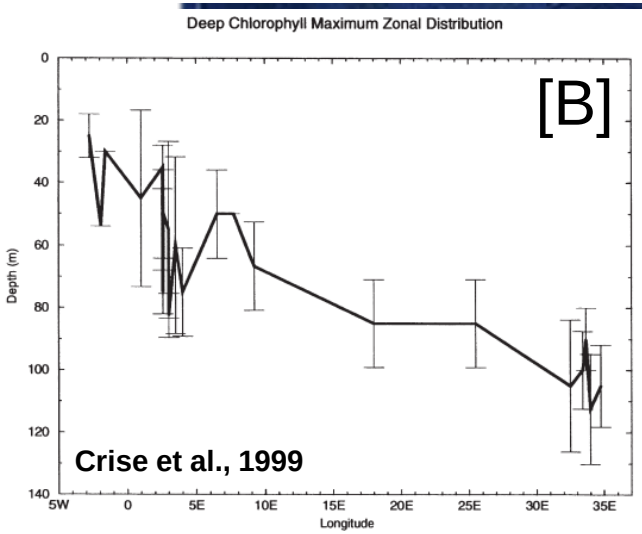


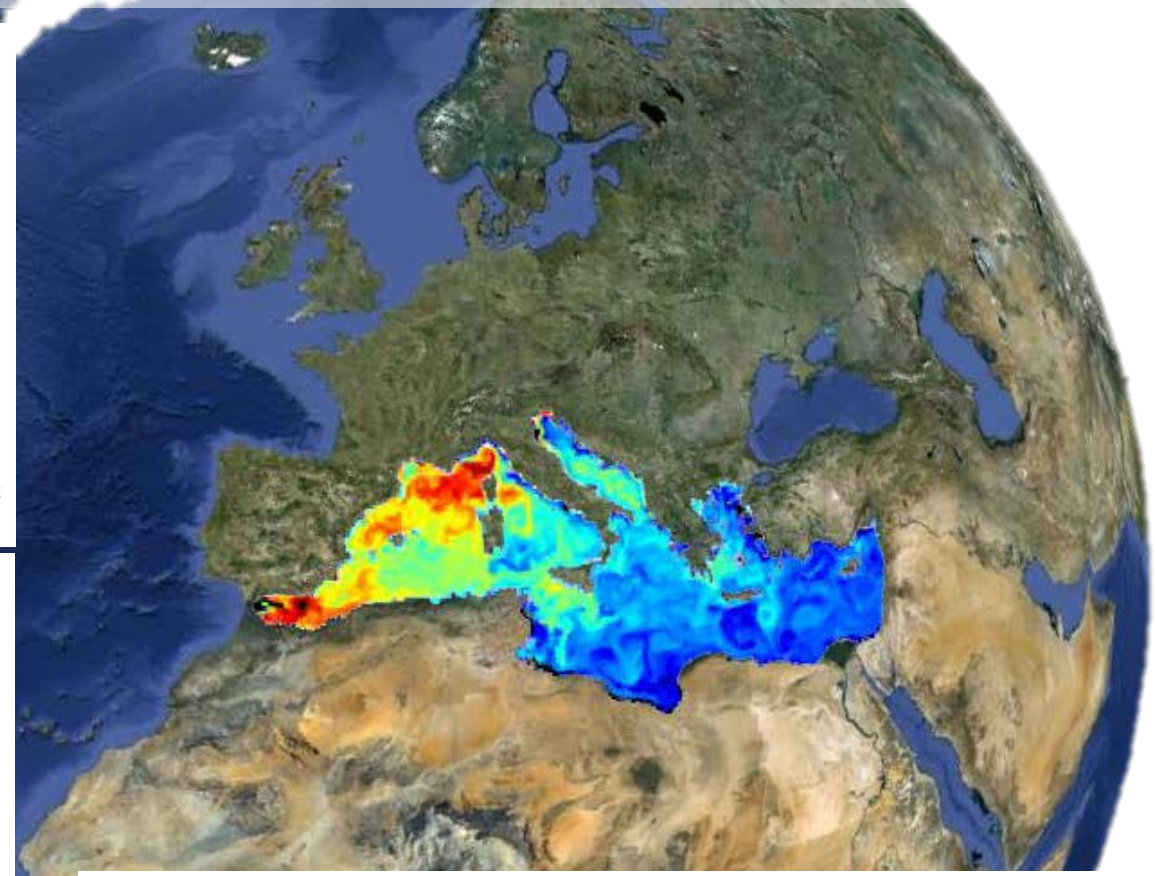
18 impacts were categorized and identified a weighting score as a basis for defining cumulative impacts at a fine scale

Micheli et al., 2013

The Mediterranean: an oligotrophic sea





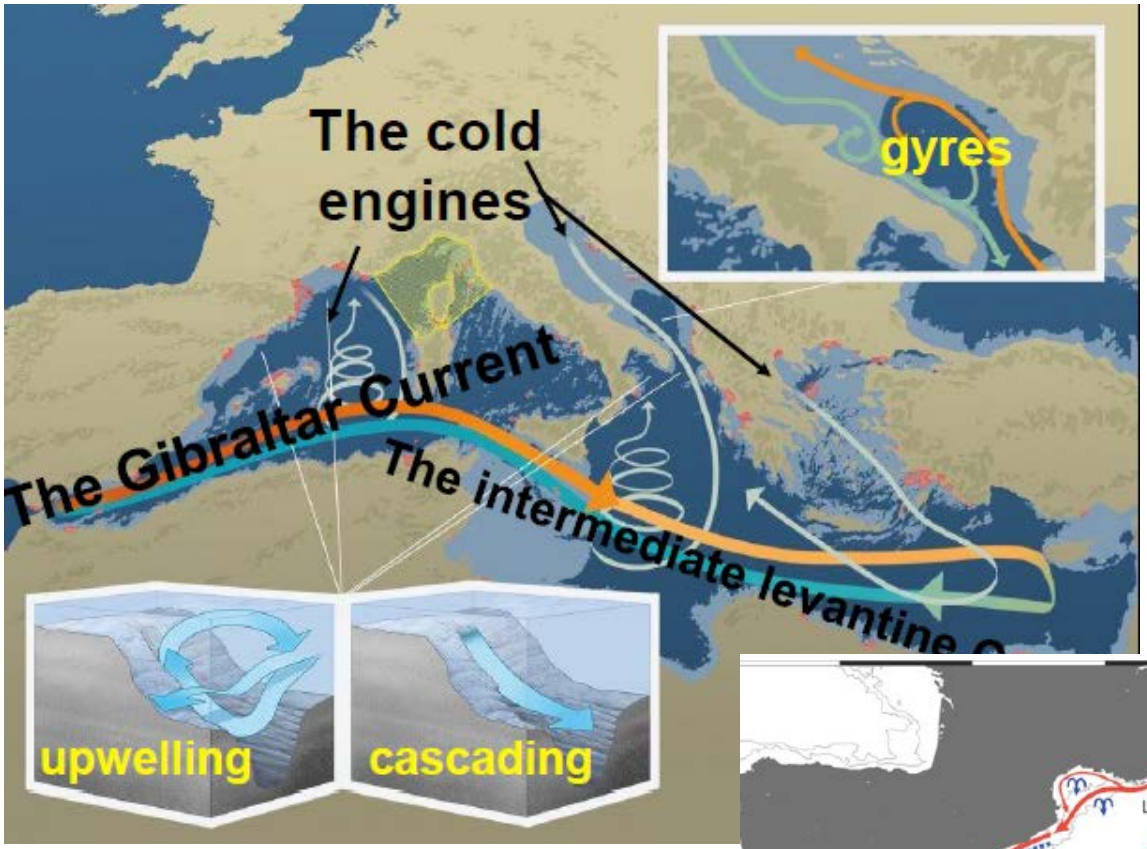


The Mediterranean is a “blue sea” (oligotrophic) with a great difference in primary productivity from west to east as well as other biogeochemical properties (nutrient concentration [A], deep chlorophyll maximum [B]

Copernicus
Europe's eyes on Earth

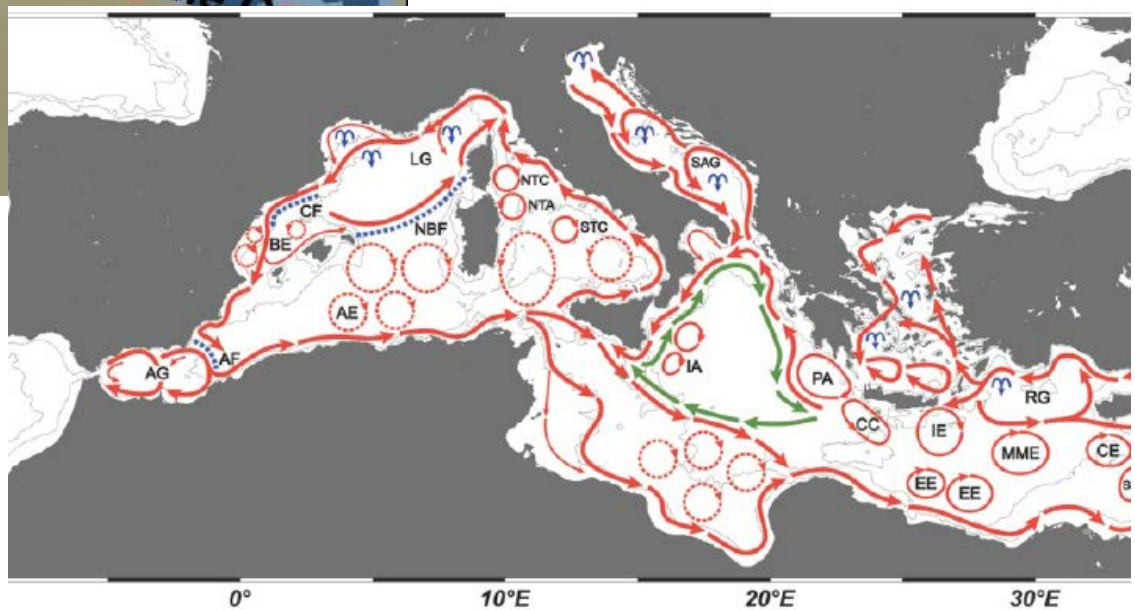
OPATM-BFM 3D model

Circulation drives patterns and connectivity



The circulation is driven by the Atlantic waters flowing eastward on the surface (Gibraltar current) becoming less rich in nutrient and oxygen while going east, compensated by deeper waters less rich. But dense water formation in north areas contribute to this circulation.

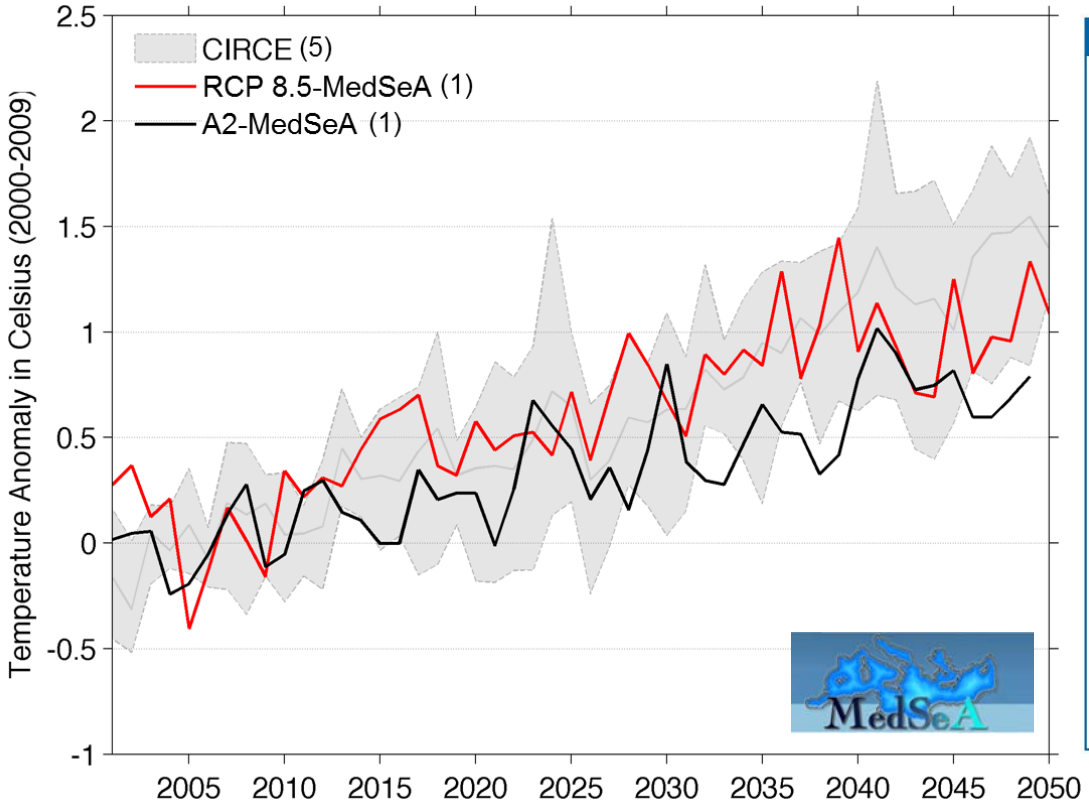
Gyres and other structures define areas (VOLUME) more connected internally than with the other areas

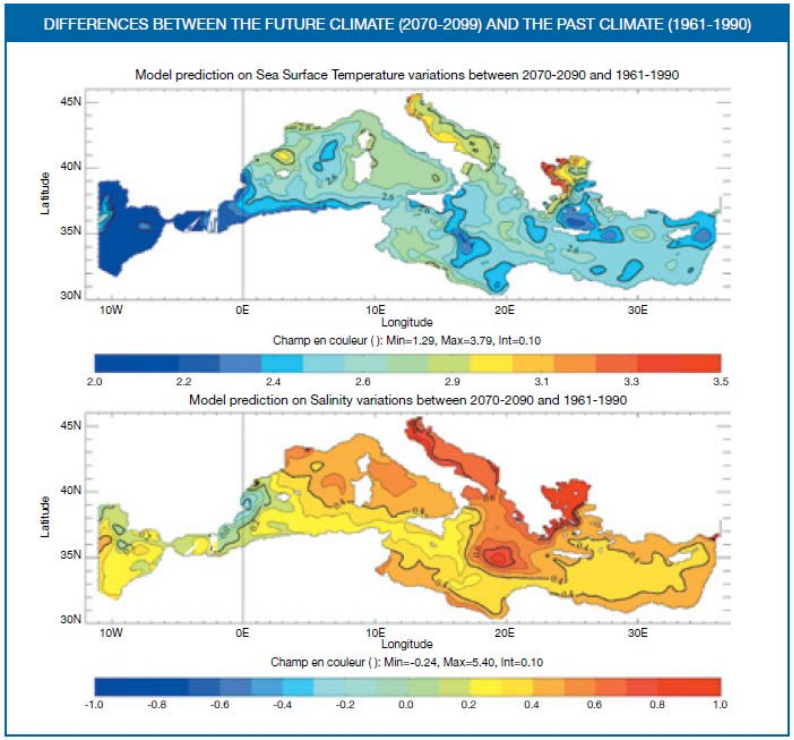


Courtesy F. Boero

Climate change: increase of sea surface temperature (SST)

Models projections indicate a +**0.02° C/y** trend in MedSea Surface Temperature





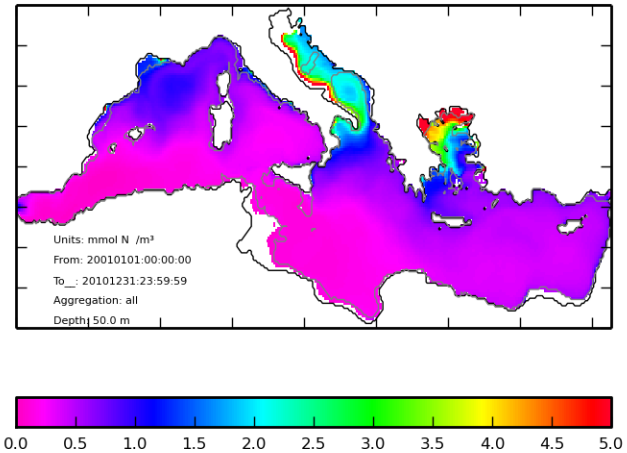
IUCN/Piero Lionello

Increase of SST has several effects, including impact on the primary production: Increase stratification of waters, nutrients tend to be trapped in the deeper NON euphotic layers

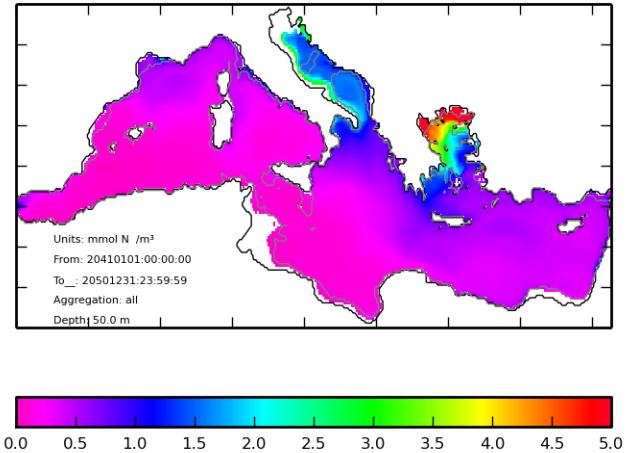
Climate change: increase SST and effects on biogeochemical cycles

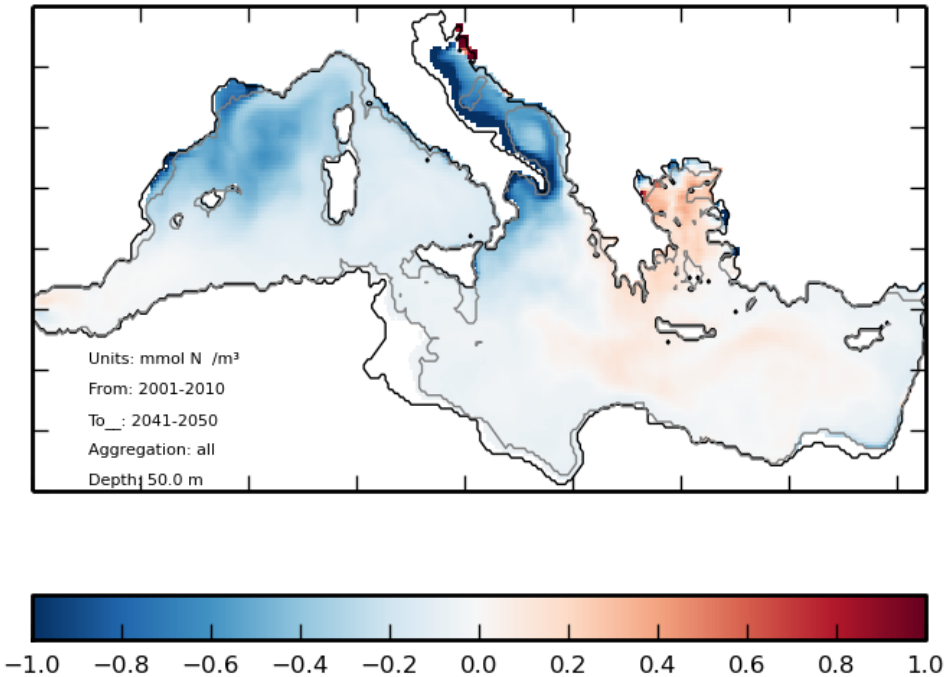
Increase of SST result in he decrease of nitrates on surface (euphotic) layers, with a reduction of nutrient available to producers especially in central western part….

2001-2010



2041-2050



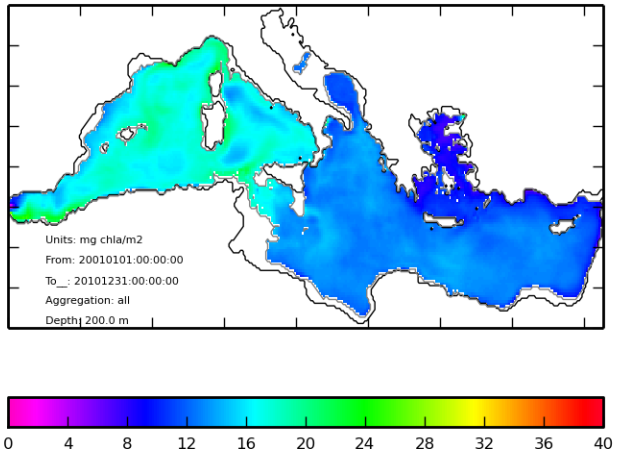


Nitrates 0-50 average mmol N/m3

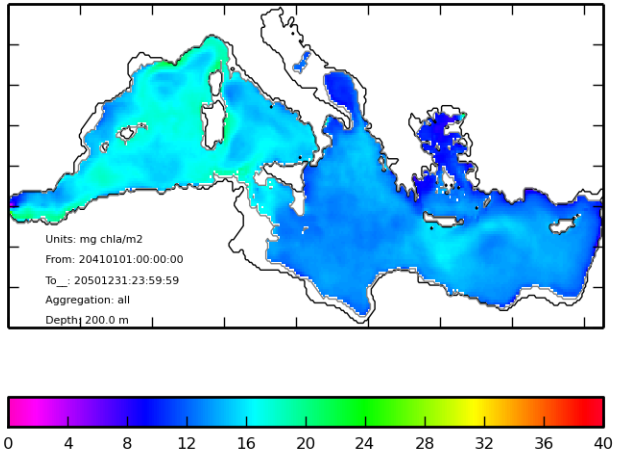
Climate change: ultimately will affect productivity

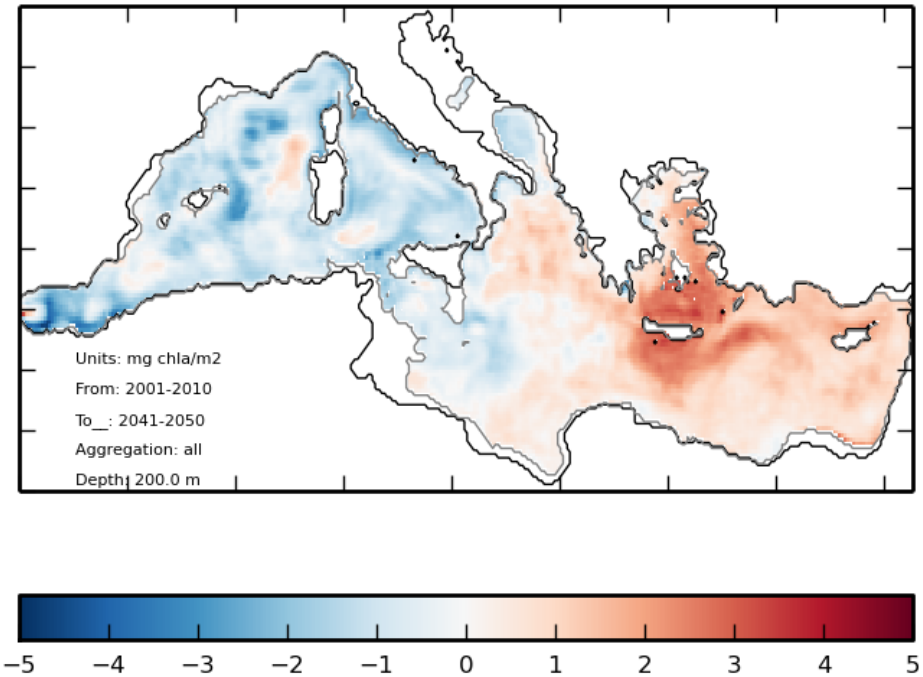
…as a result chlorophyll concentration is expected to decrease in western part of the basin and increase in the eastern (order 10%)

2001-2010



2041-2050

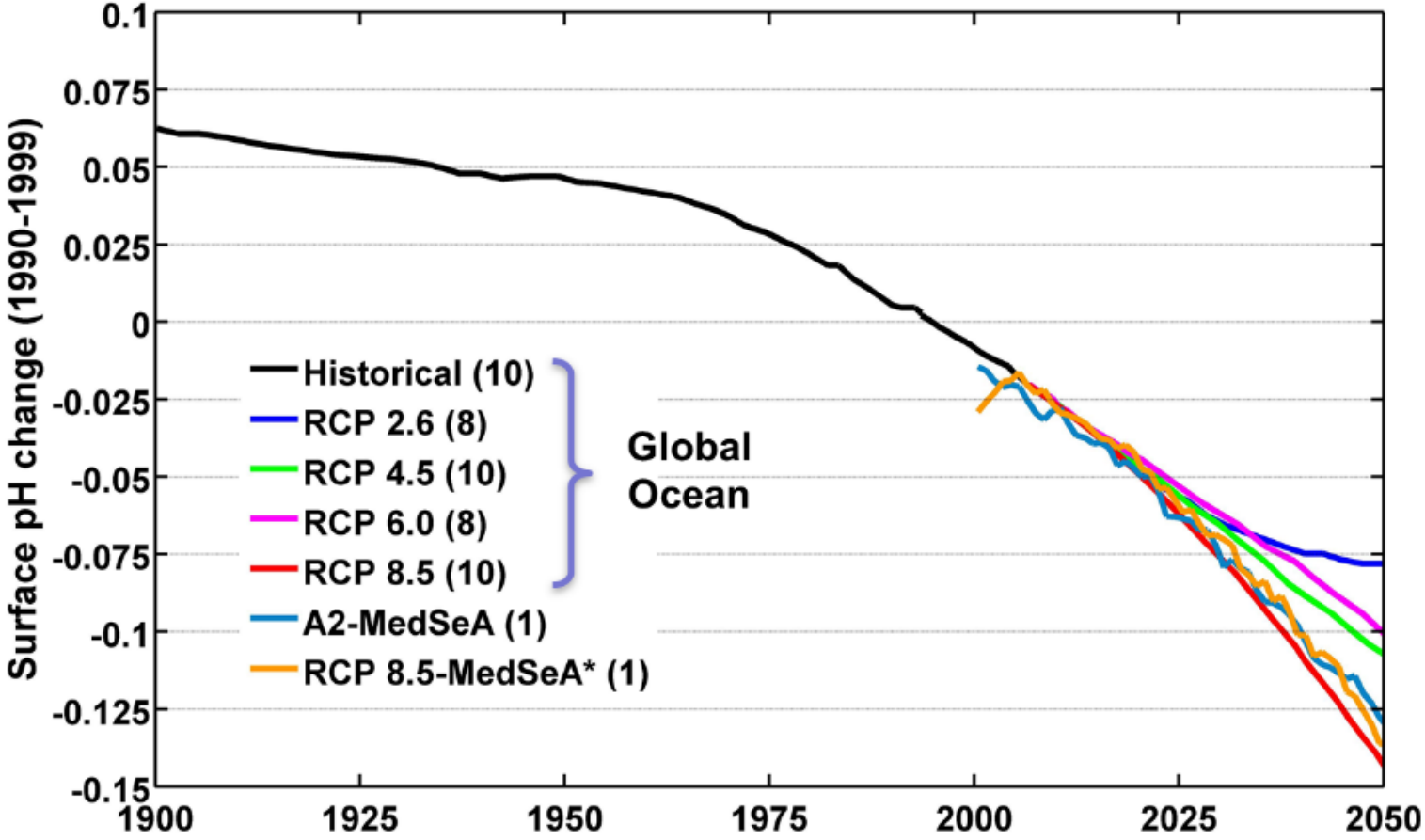




Chlorophyll 0-200 integral mg chla/m2

Ocean acidification

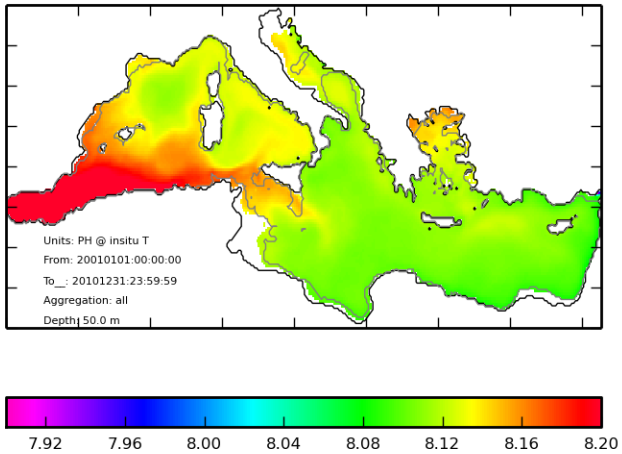
The change in surface pH of the MedSea is consistent with the global ocean mean projections (Bopp et al., 2013)



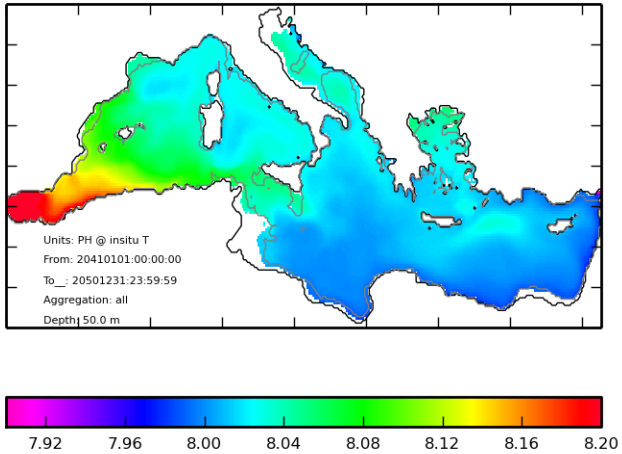
Ocean acidification is critical for many species that are not tolerant to low pH

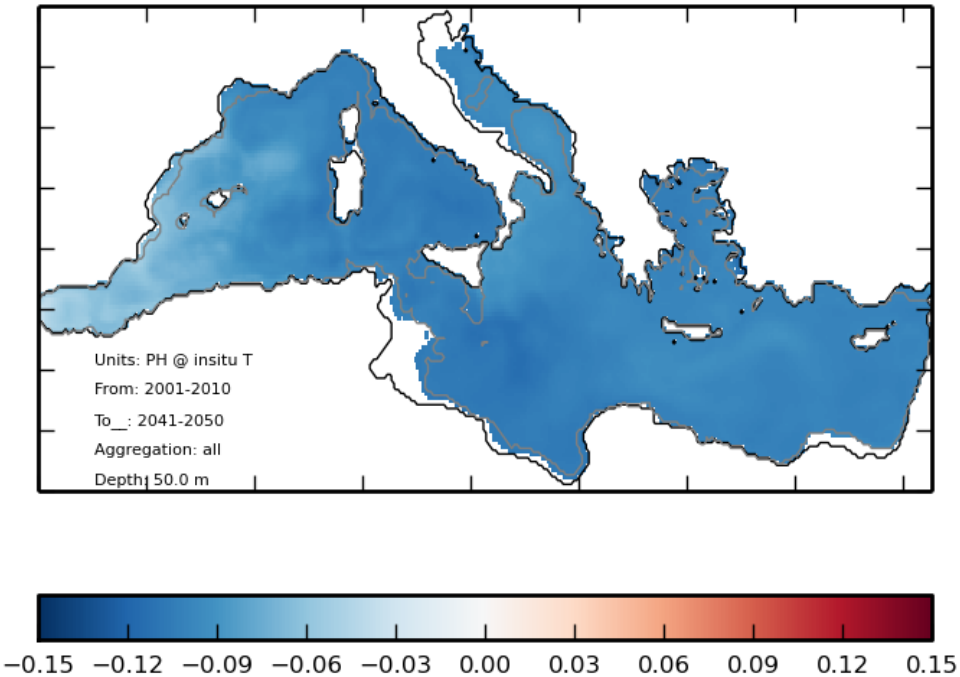
Ocean acidification

2001-2010



2041-2050

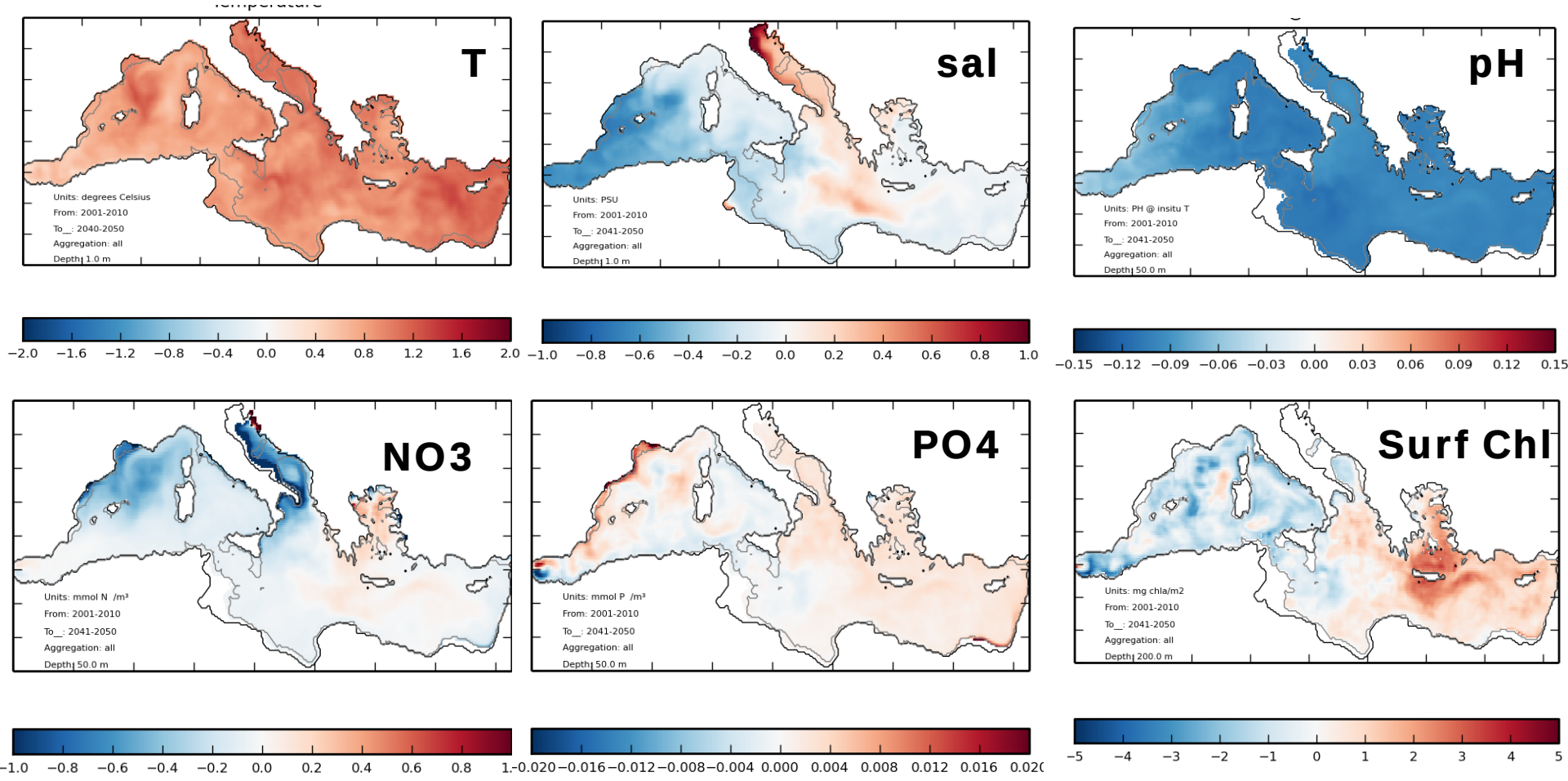




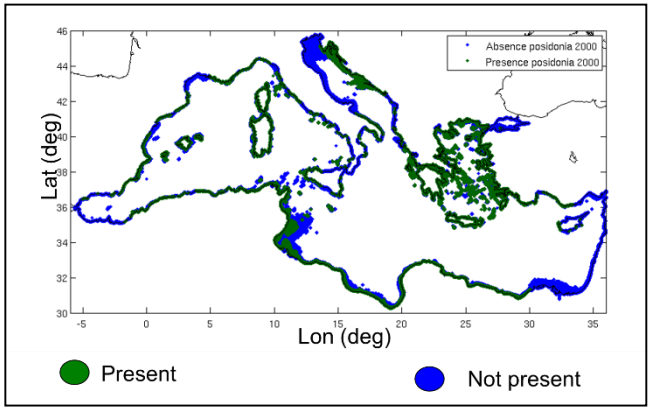
pH @ inSITU temperature

Projections show decrease of pH almost evenly in the whole Mediterranean Sea by the order of -0.1 pH unit

Climate change: direct and indirect changes



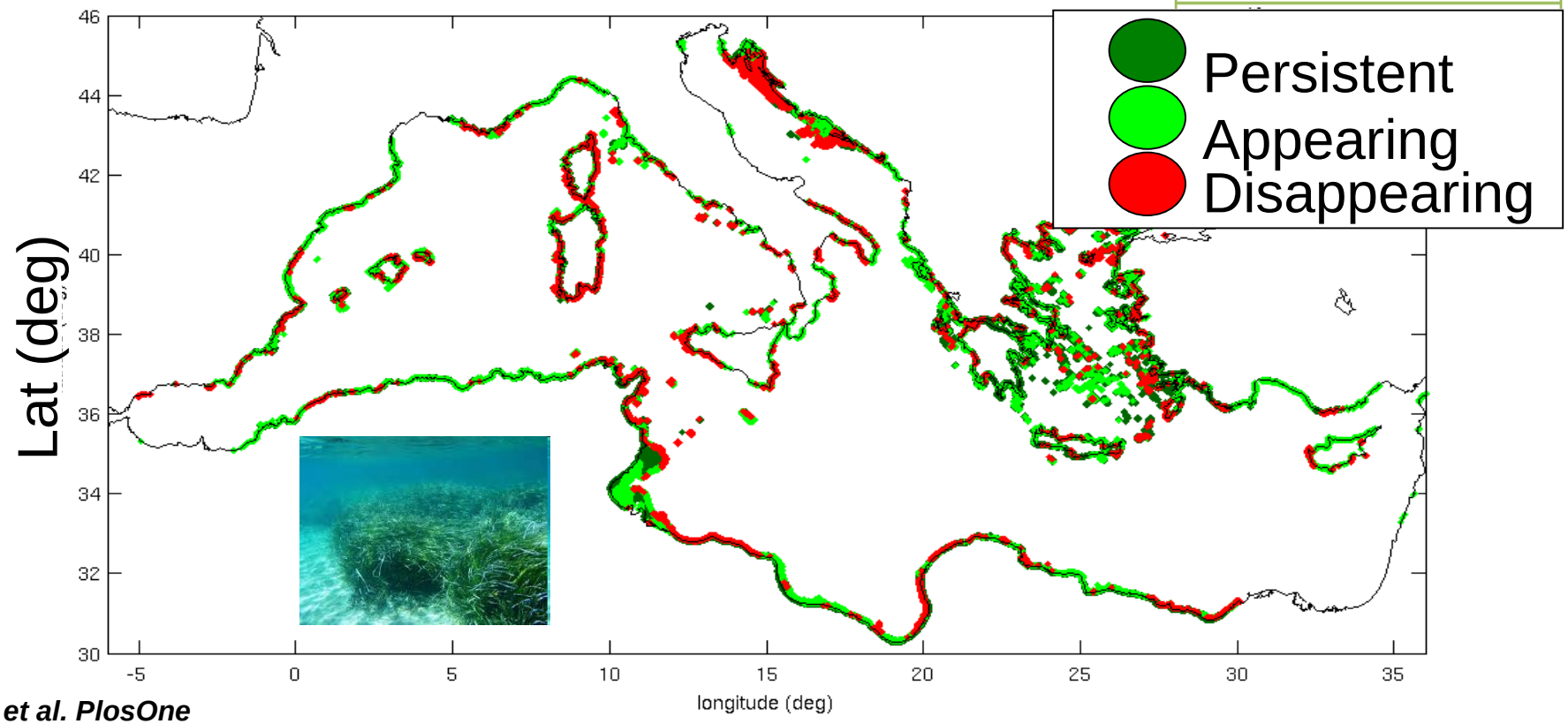
Effects on species: seagrass bed (Posidonia)



Training a model (random forest) on actual presence/absence data and physical biogeochemical data, and then applying to future changes resulted in zones with likely changes in Posidonia beds

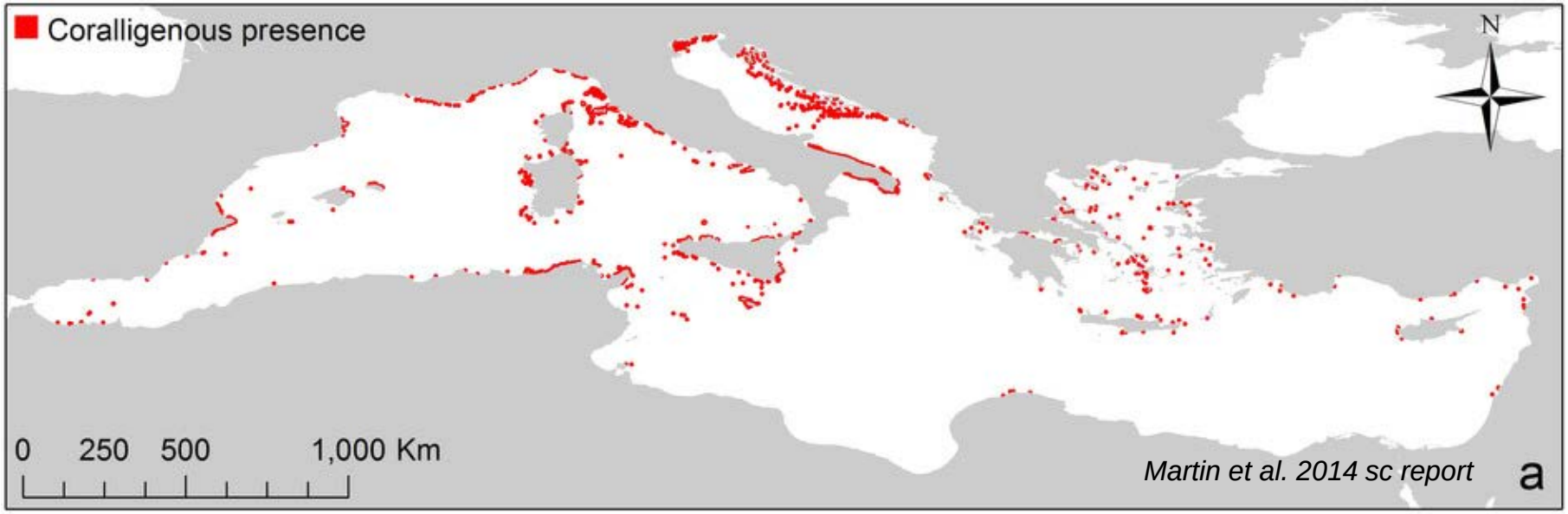
.

Predictive variable	Relative importance (max=1)
Nitrate concentration	1.00
Silicate concentration	0.93
Bathymetry	0.77
Sea Surface Temperature (mean)	0.76
Salinity	0.75
Distance to river mouths	0.75
Phosphate concentration	0.69
pH	0.65
Bottom salinity	0.56
Photosynthetically Available Radiation	0.52
Calcite concentration	0.50
Euphotic depth	0.50
Sea Surface Temperature (annual range)	0.50
Population pressure	0.44
Bottom temperature	0.43



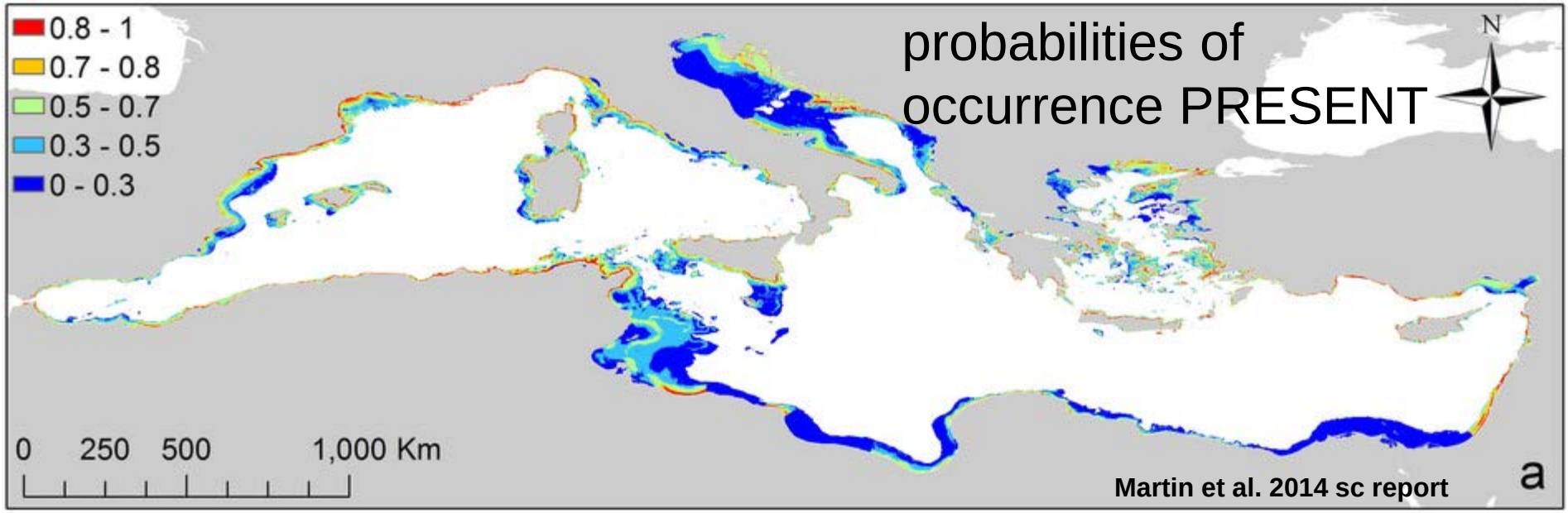
Scardi et al. PlosOne

Effects on species: coralligenous

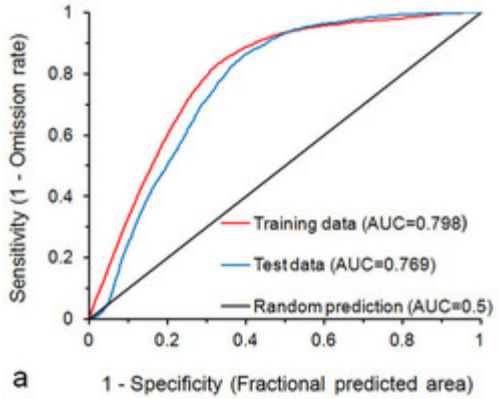


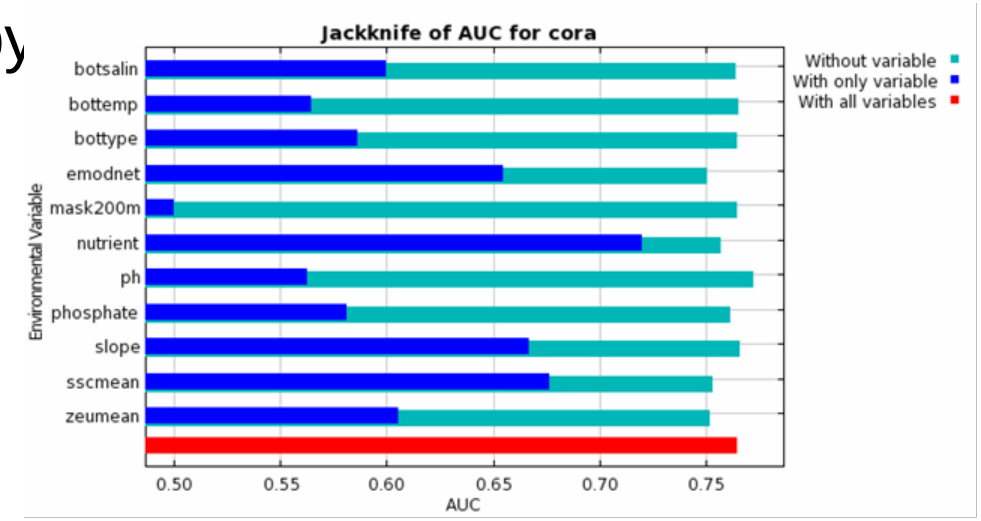
Coralligenous outcrop is a collective term that refers to a very complex biogenic structure mainly created by the outgrowth of encrusting calcareous algae on hard substrata in dim light conditions: a hot spot of biodiversity

Effects on biodiversity: coralligenous



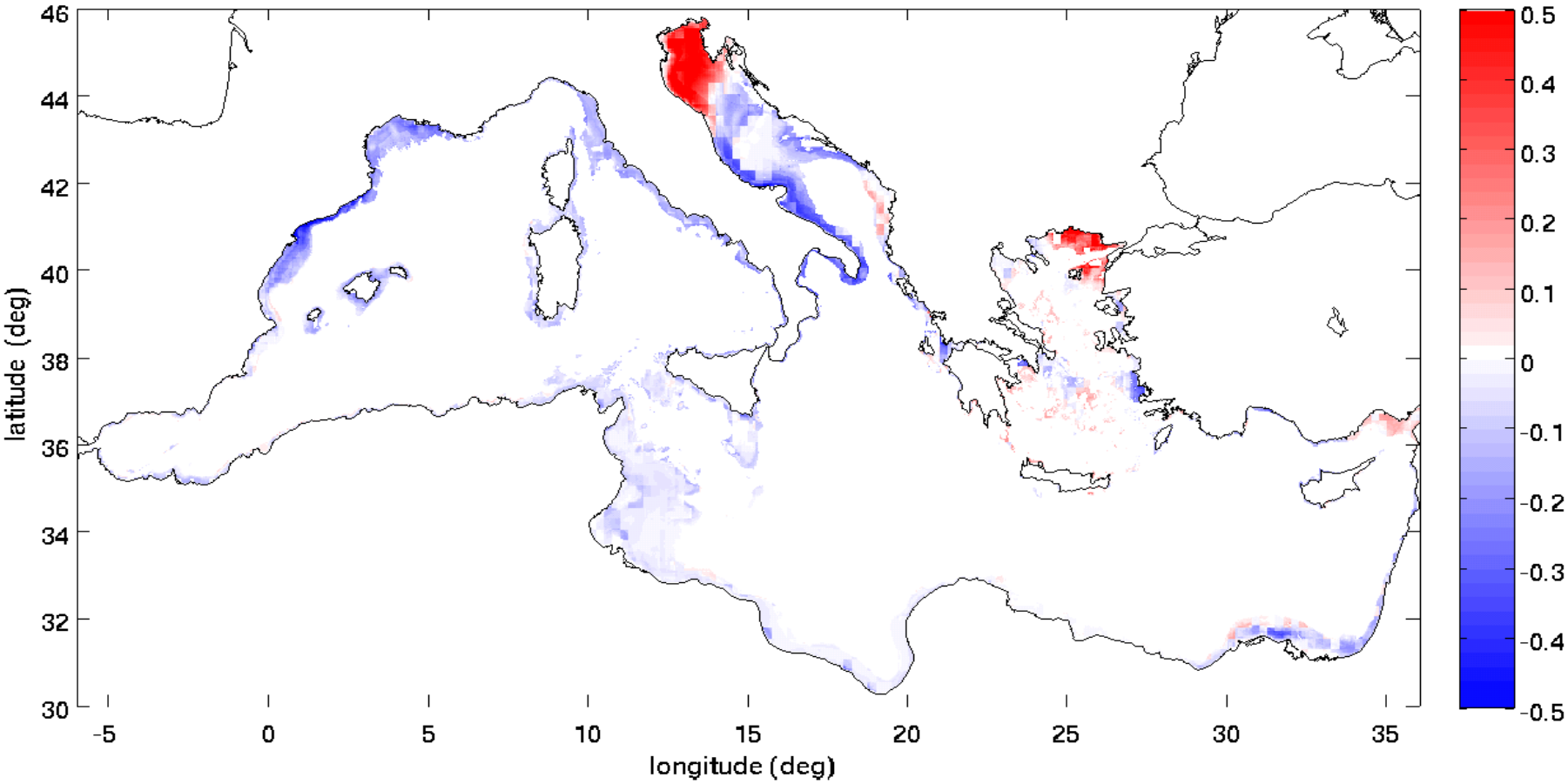
max_ent (maximum entropy





Effects on biodiversity: coralligenous

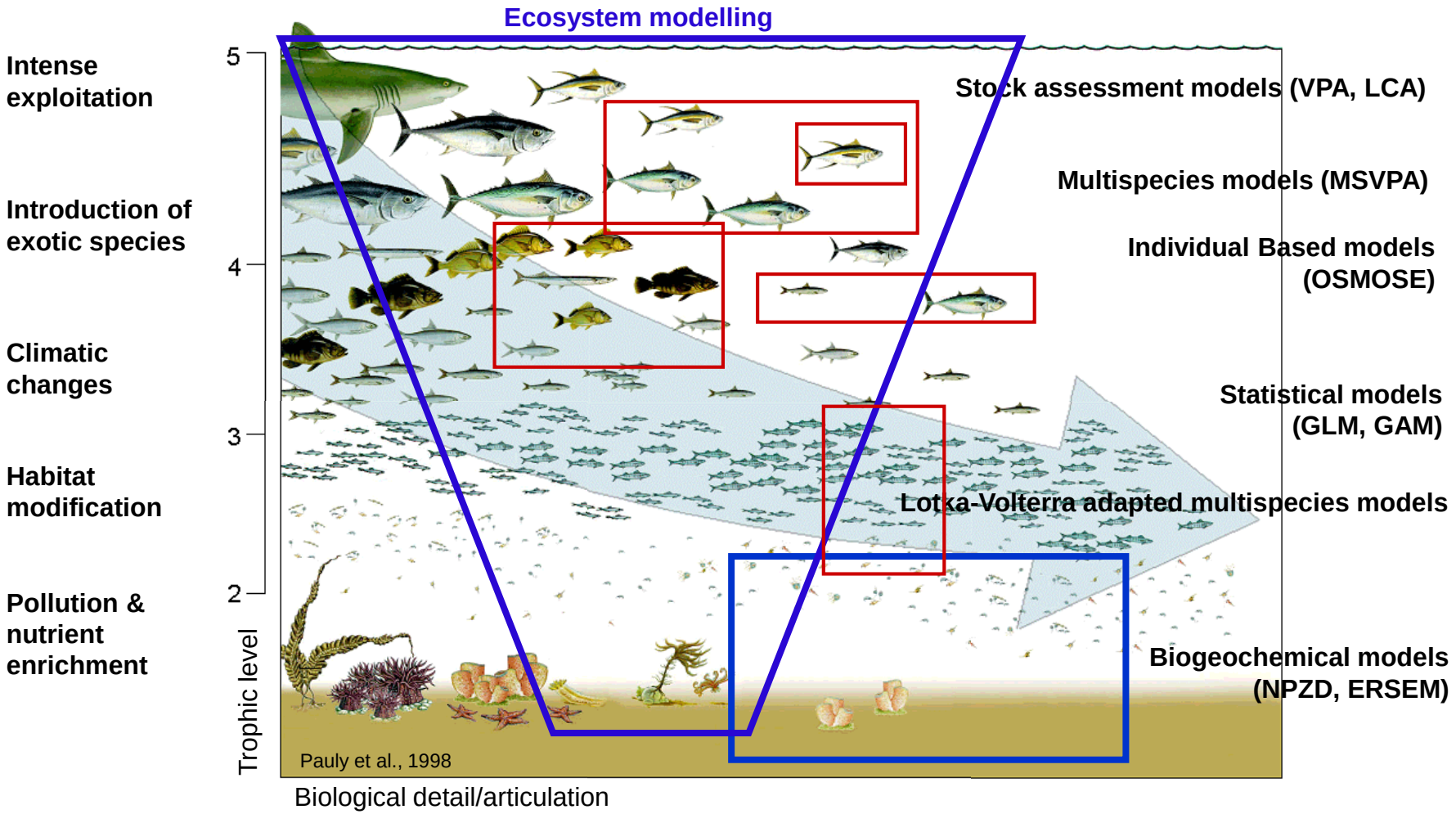
CHANGES in occurrence probabilities for coralligenous



Large areas of the Mediterranean will become inospitable to coralligenous

Integrating processes and impacts for an Ecosystem approach

Integrating biological processes and species interaction with different impacts (including the multitarget and multigear fisheries) helps understanding cumulative impacts, permits to highligh trade-offs: tools for decision support.

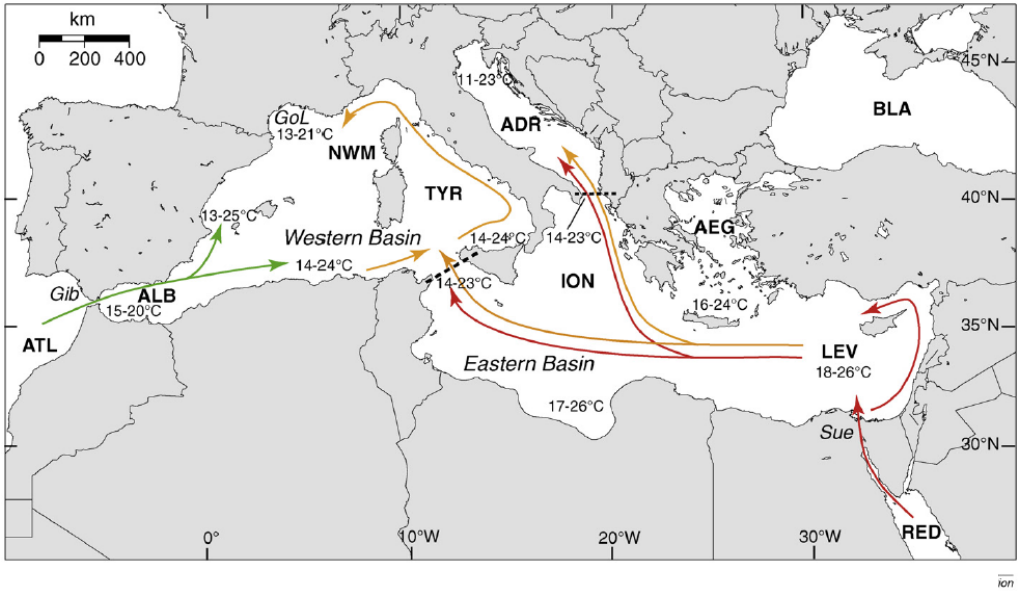


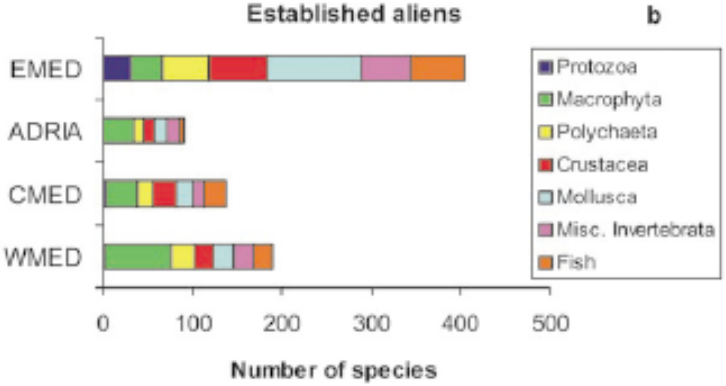
Rose et al. (2010), Mar. Coast. Fish., 2: 115-130.

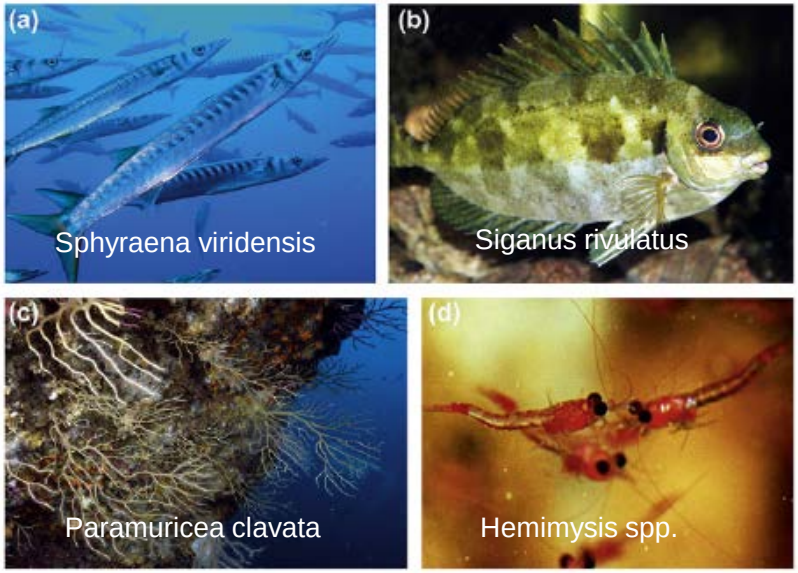
Invasive species

Invasive species in the Mediterranean are mainly Indo-Pacific species that find their way to or sea through the Suez Canal, actively or transported. The tropicalization of the Med favour their establishment

Zenetos et al. 2010





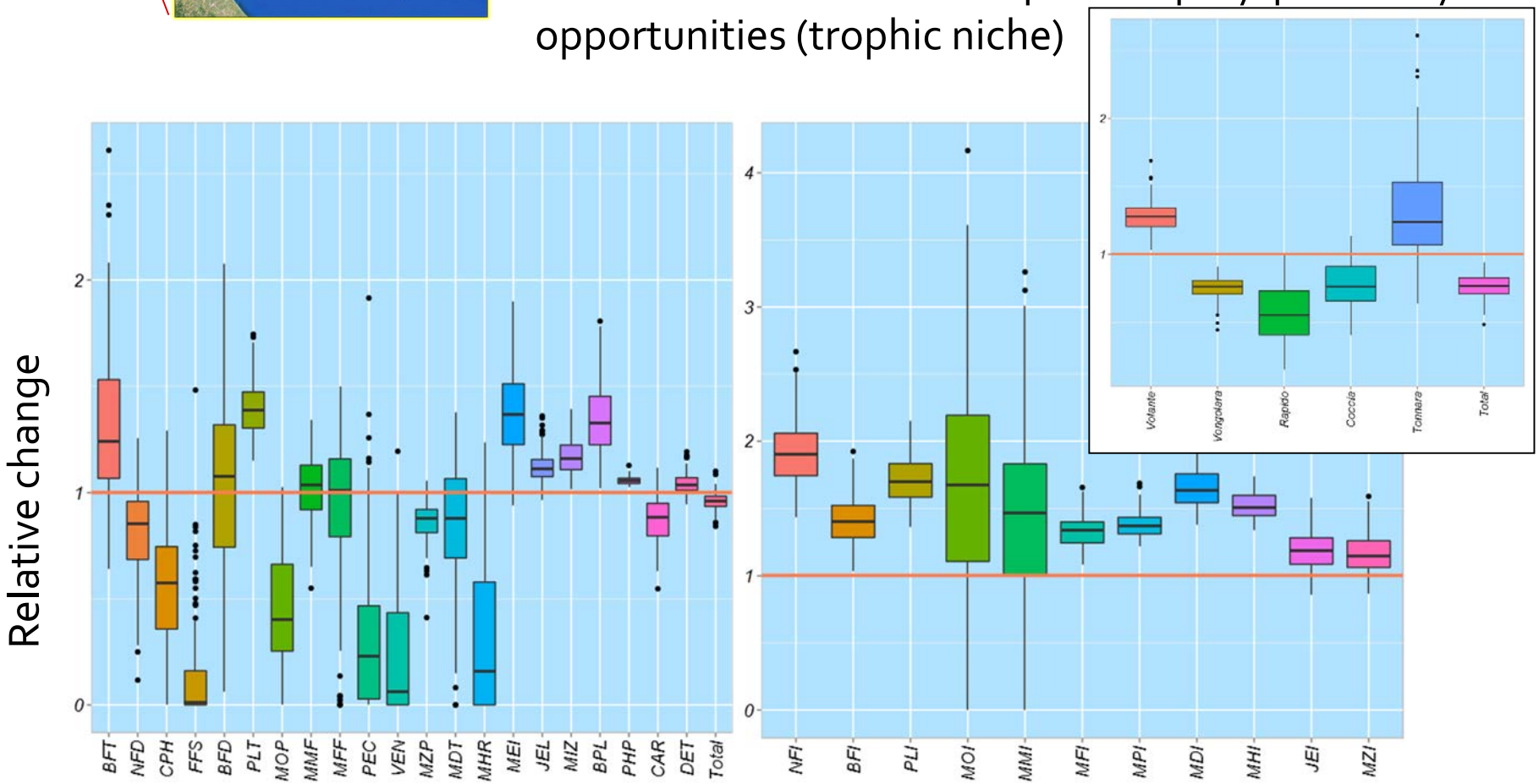


Invasive species can i) compete with resident species; ii) overgraze preys; iii) overgrowth for absence of natural predators; iv) reduce vital habitat for local species
Anyway some can have commercial value

Lejeusne et al. 2010

Ecosystem approach to species invasion

Temperature increase of 1°C in 10 years, results taken at 30 years. Results show that success of invasion depends not only on thermal preference but also on complex prey-predatory opportunities (trophic niche)

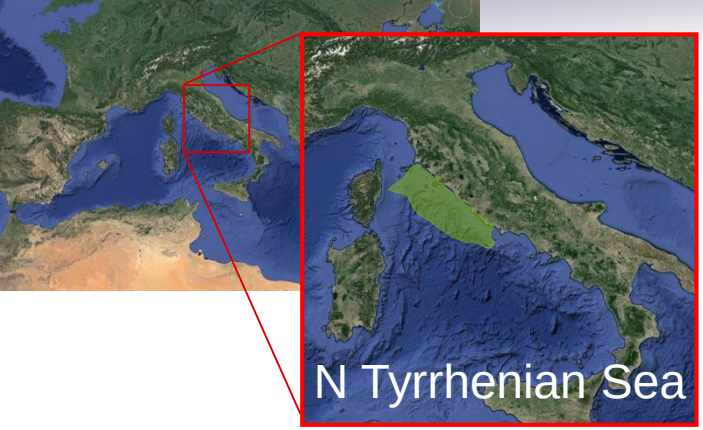


Libralato et al. 2015

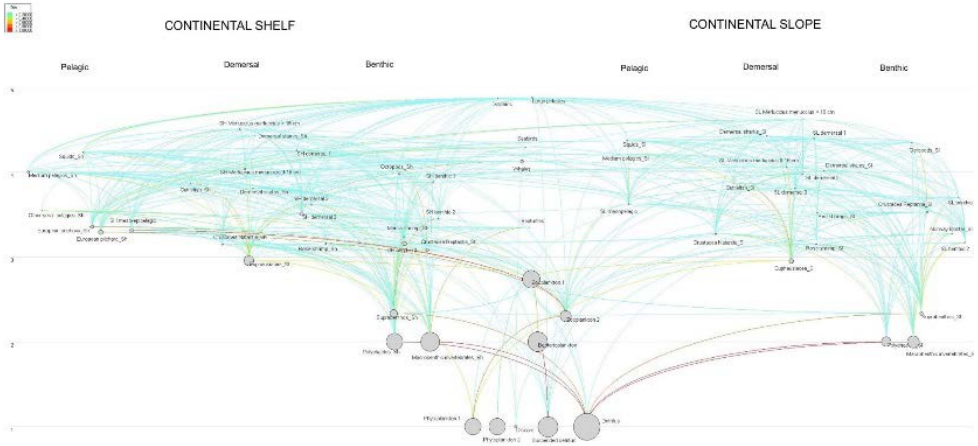
Residents

Invasive

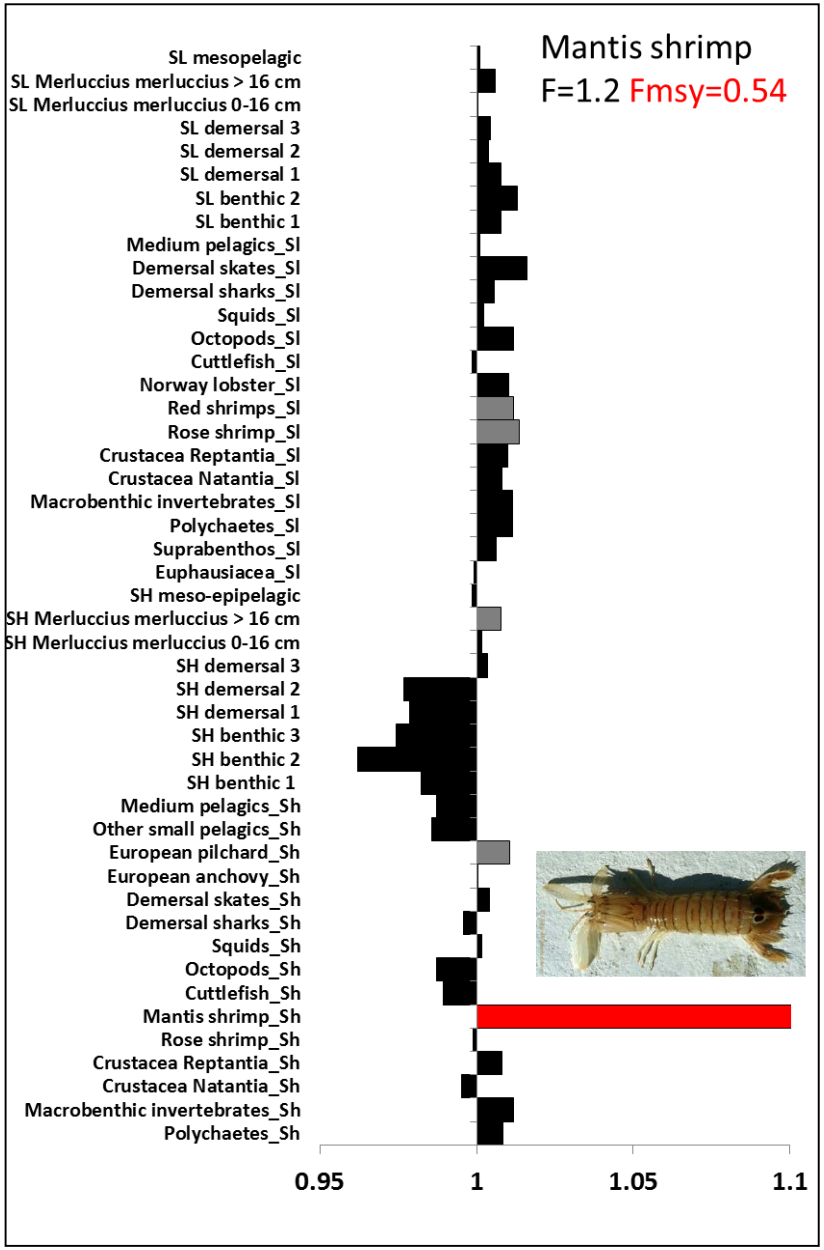
Ecosystem approach to multitarget fisheries



62 functional groups (3 non living groups; 5 plankton groups; sea birds; turtles; sharks and rays; invertebrates; fishes); 4 fishing fleets (trawl; seine; passive net; longline)

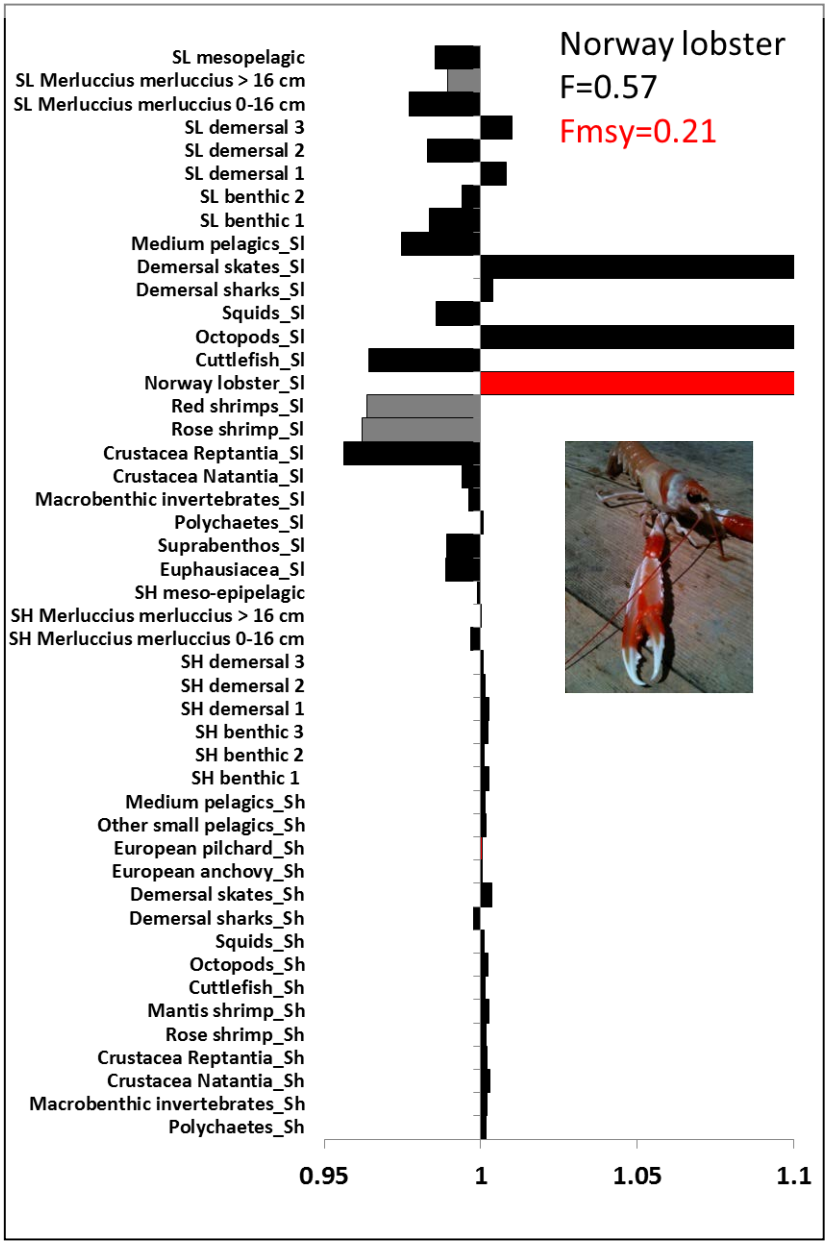


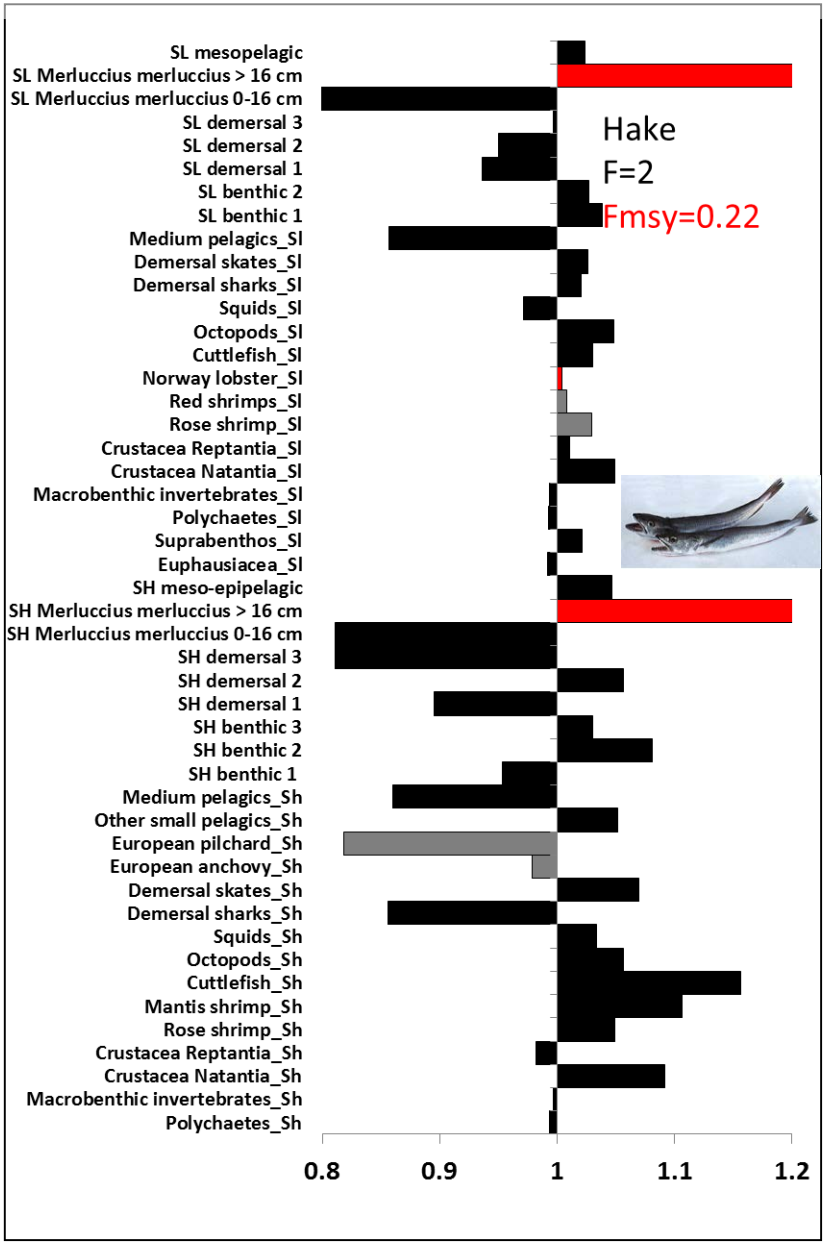
What is the effect of applying Fmsy on the assessed species?
Assuming capability to manage selectivity perfectly…..



Changes in comm. Catches: -1%

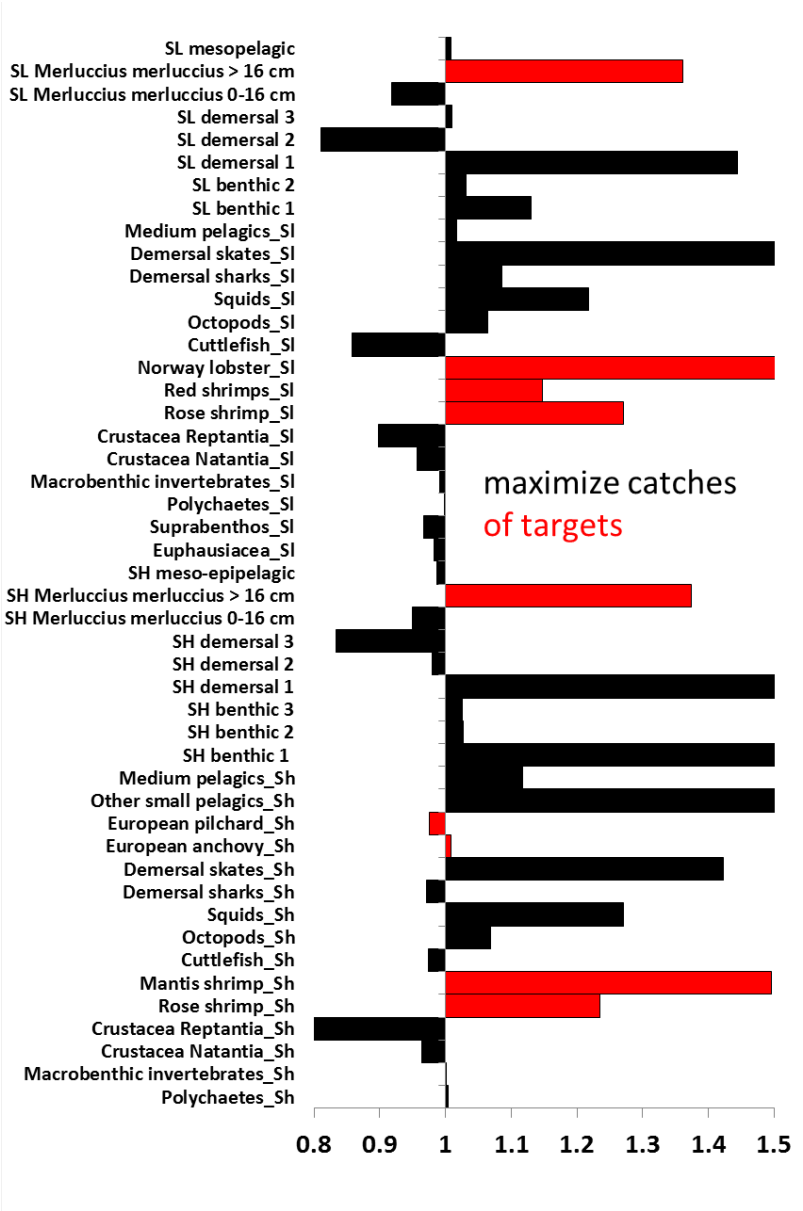
Ecosystem responses to fisheries targets by species





Changes in comm. Catches: **+0.2%** **-16.2%**

Optimizing catches for assessed species under EA



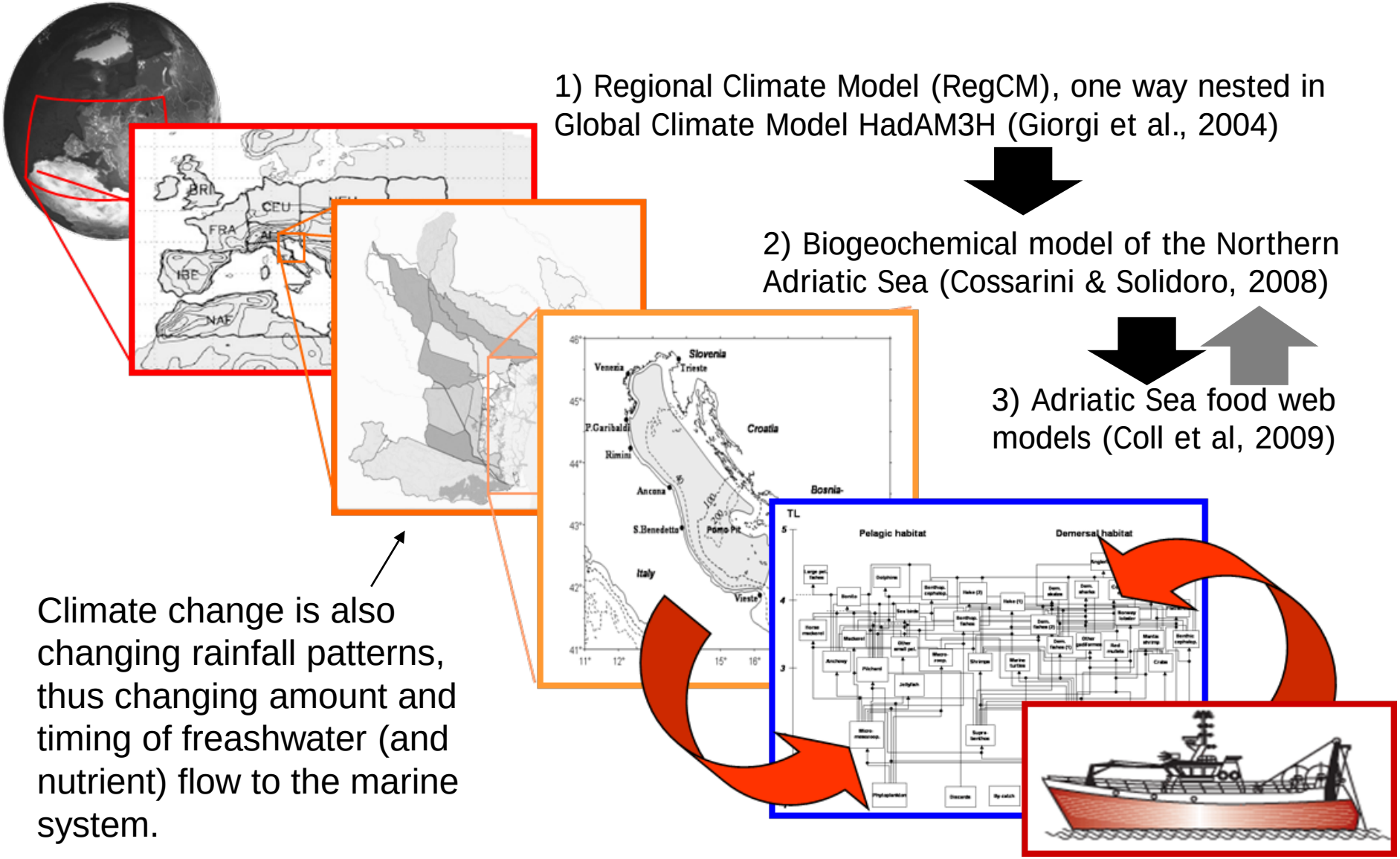
Changes in comm. Catches: -21.7%

Bottom trawlers	Purse seines	Passive polivalents	Longlines
0.52	0.76	1.20	1.49

	F_{MSY}	F_{MSY_E}
Rose shrimp	0.7	0.39
Mantis shrimp	0.54	0.75
Anchovy	0.43	0.30
Sardine	0.32	0.20
Hake	0.22	1.75
Red shrimp	0.35	0.29
Norway lobster	0.21	0.30

Optimizing fisheries landings for the 7 species under ecosystem approach result in fishing mortalities different than Fmsy and important changes in total catches

Integrating processes and impacts



1) Regional Climate Model (RegCM), one way nested in Global Climate Model HadAM3H (Giorgi et al., 2004)

2) Biogeochemical model of the Northern Adriatic Sea (Cossarini & Solidoro, 2008)

3) Adriatic Sea food web models (Coll et al, 2009)

Climate change is also changing rainfall patterns, thus changing amount and timing of freashwater (and nutrient) flow to the marine system.

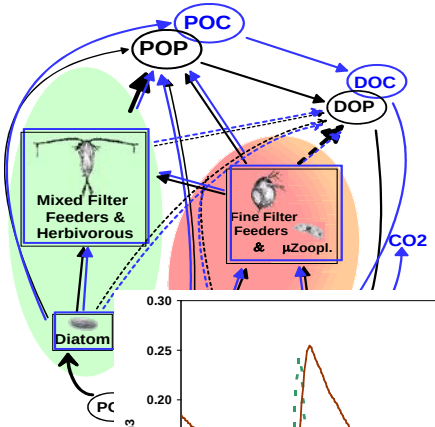
Climate and fisheries

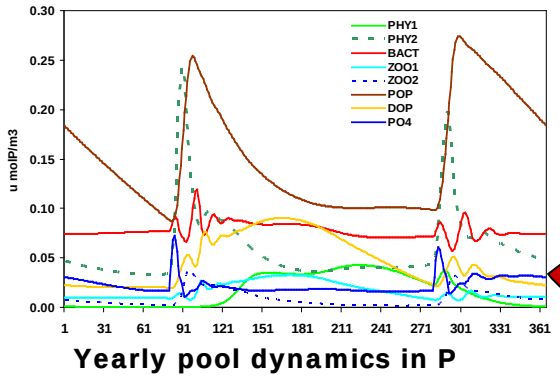
3 Climate scenarios

RF - Reference

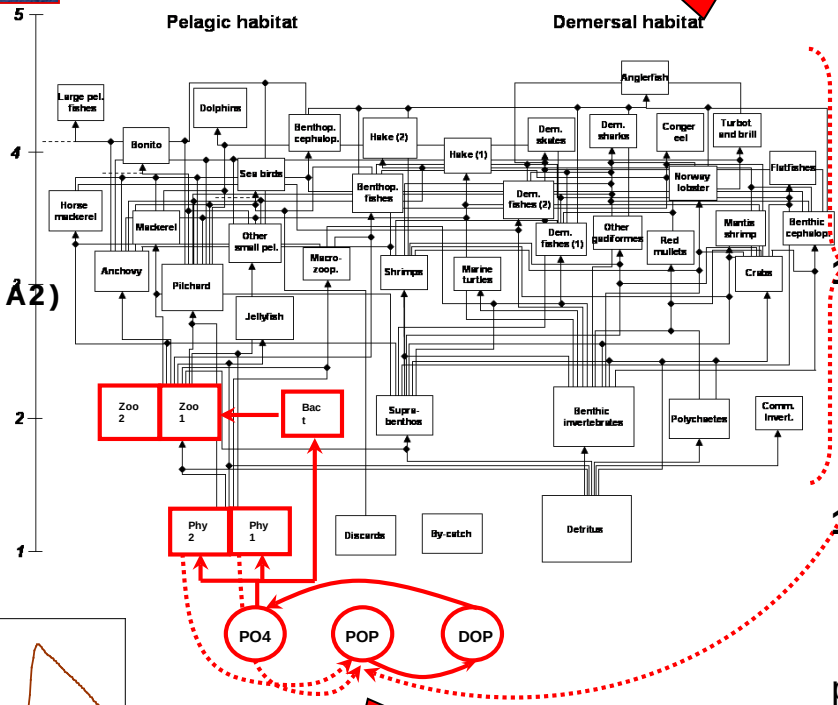
B2 – Local sustainability
(~ -25% inputs; ~IPCC B2)

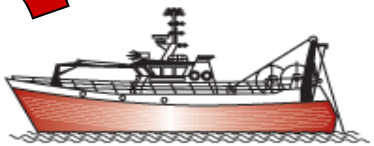
A2 – Market oriented
(mod. precipitation pattern; ~IPCC A2)





Yearly pool dynamics in P





27 fishing scenarios

1 baseline scenario

16 management scenarios by single commercial species
(Anchovy, Sardine, Hake, Red Mullet)

10 management scenarios by fleet
(changes in effort for bottom trawl, beam trawl, purse seine, mid water trawl, Tuna fleets)

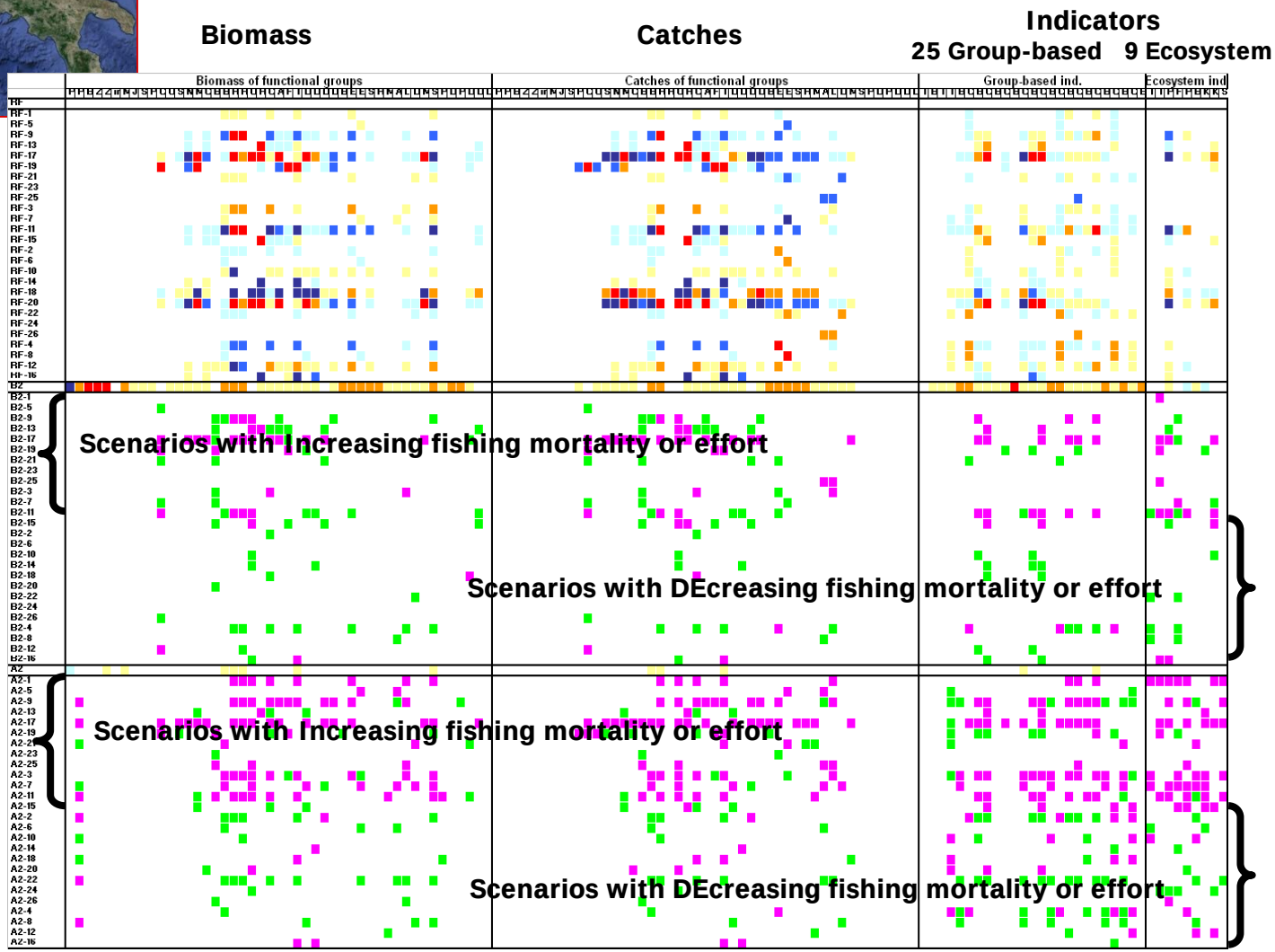
81 scenarios

We can look at synergistic or antagonistic effects of climate and fisheries in an ecosystem approach setting, considering not only biomass and catches by species but also ecosystem indicators.

Reference & anomalies due to fishing

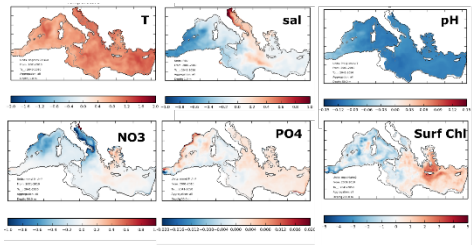
Climate vs Fishing

- synergies
- antagonism

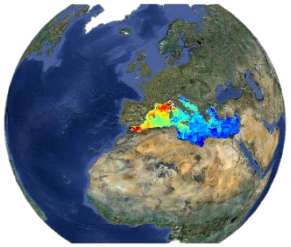


Libralato et al. (2016) in prep

Conclusions

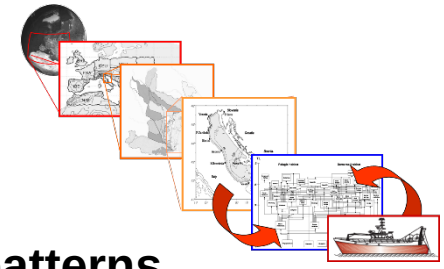


The Mediterranean complex system is under **several pressures** that acts simultaneously, have direct impacts but also important cascading effects



The seas are **complex 3D systems** and changes have important patterns in space that need to be considered: any approach need to consider spatial dimension opportunely

Ecosystem approach allows for considering the multiple stressors that influence dynamics of marine populations: this permits to highlight possible synergies and counteracting effects between stressors



Integration of food web representations with hydrodynamic & biogeochemical operational products allows us to embed **spatial patterns and connectivity**

NOTE

These tools require **integrating A LOT of information** (DATA)
The **uncertainties** in this approach are larger than classical approaches, but can safely provide **direction of change**

Thank you!

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