Workshop
Human impacts on Mediterranean marine ecosystems and the economy
MONACO, 18-19 October 2017

Mediterranean fisheries and climate change

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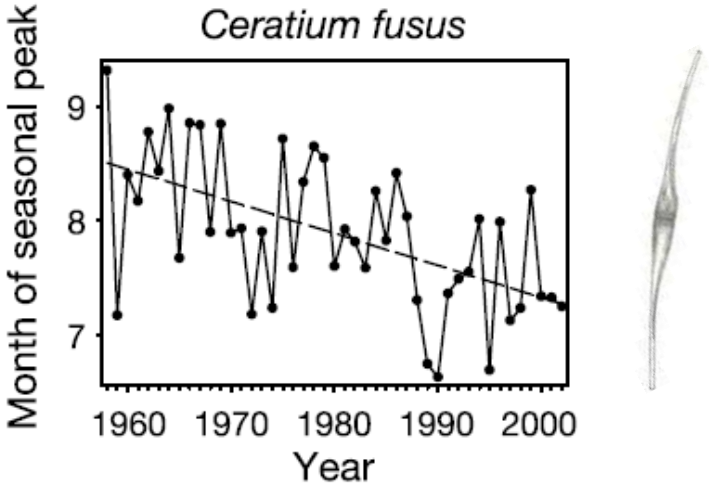
How species react in response to climate change ?

STAY and **ADAPT**

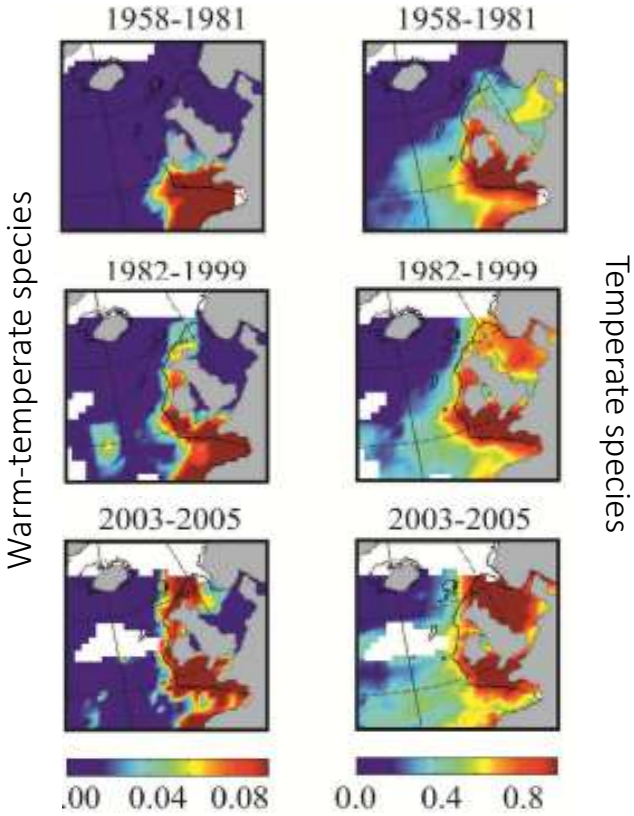
OR

MIGRATE
to a more favorable environment

Ex: Phenological changes



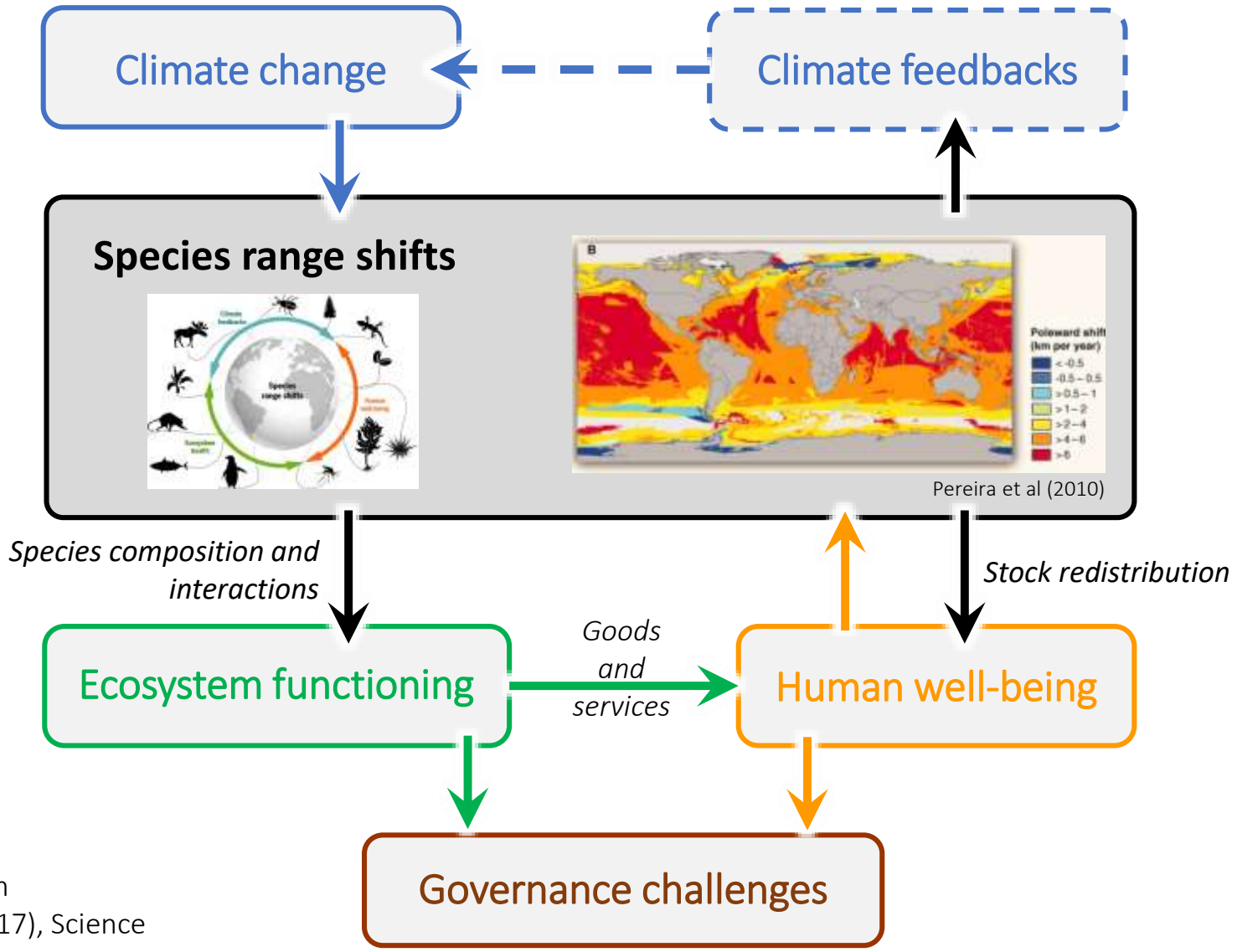
Edwards and Richardson, 2004



Beaugrand et al., 2002

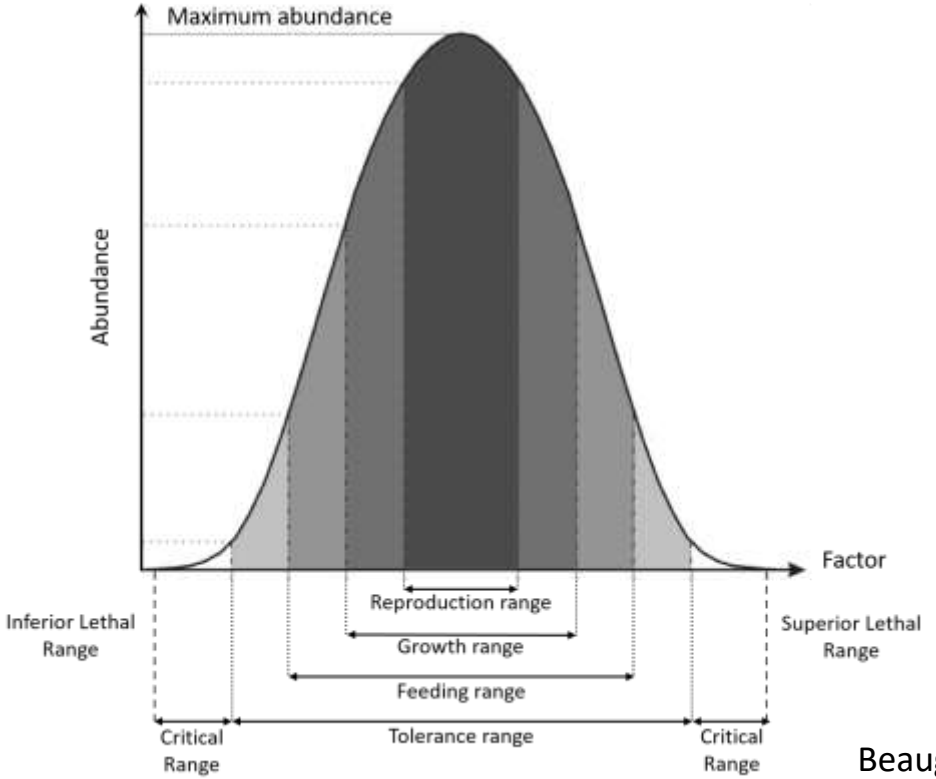
Examples of local adaptation remain scarce because CC is often happening too fast for species to adapt

Species Range shifts and human well-being

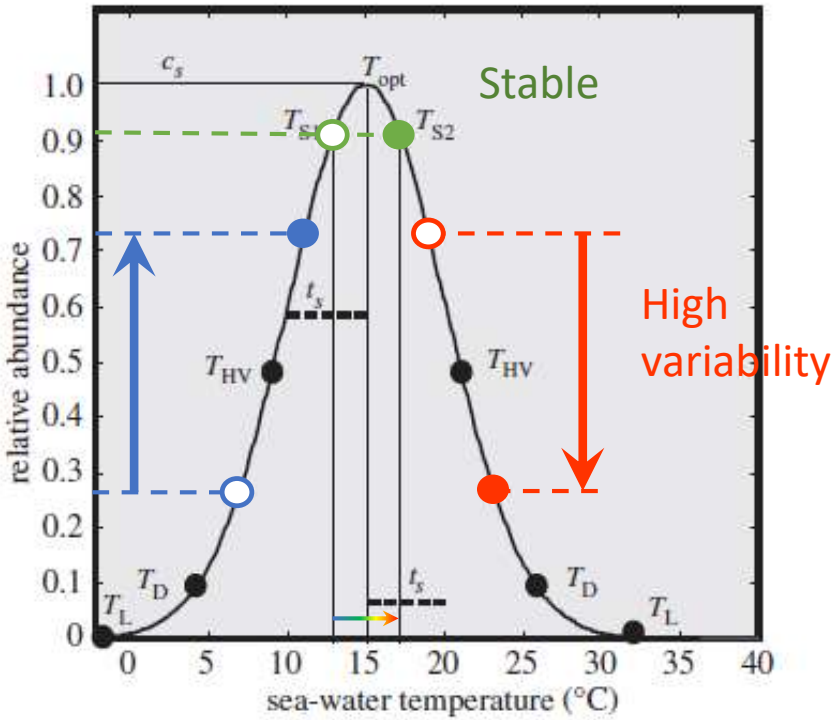


Adapted from
Pecl et al (2017), Science

Why climate change affects species' range ?



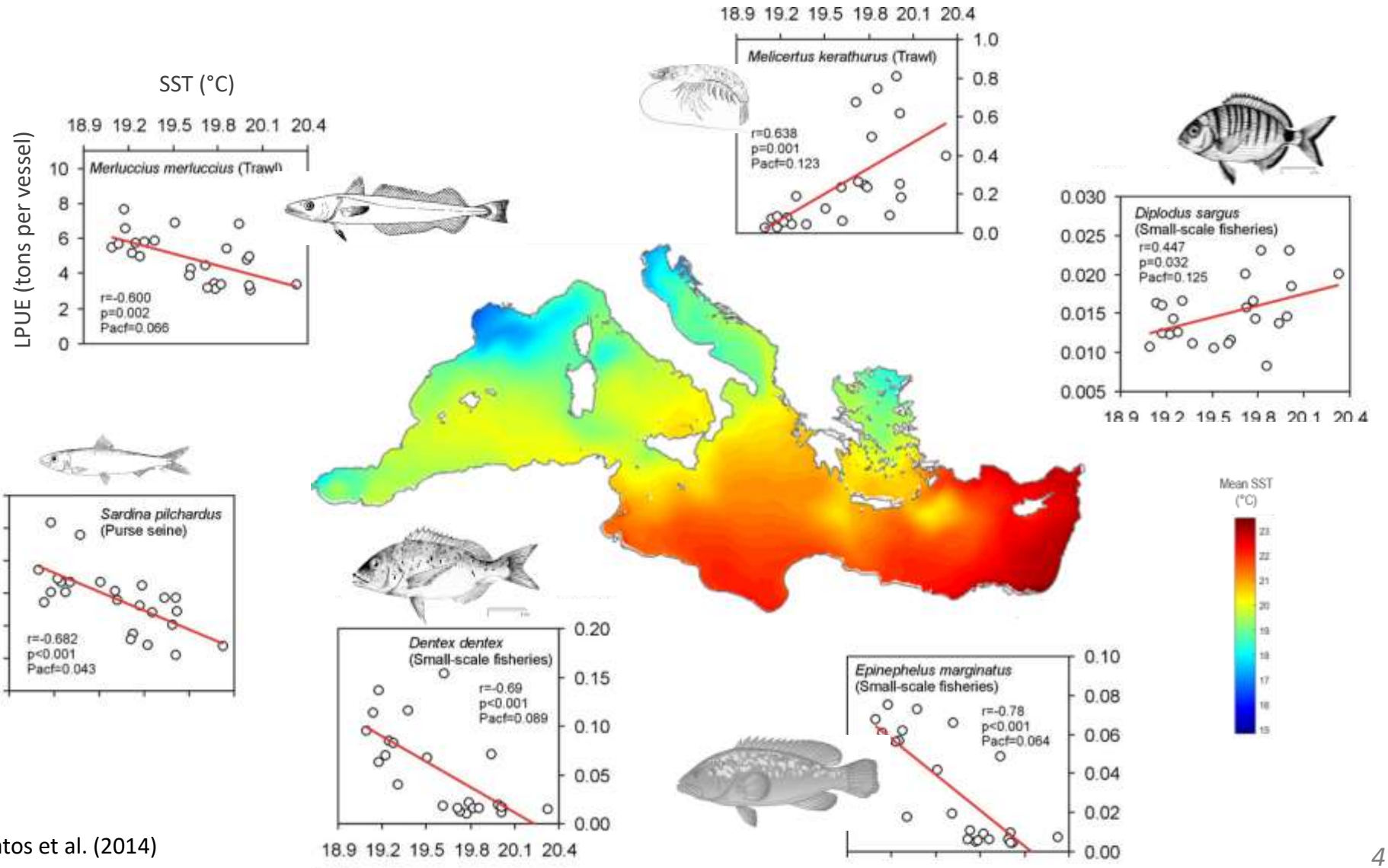
Remarkable points



Beaugrand (2014)

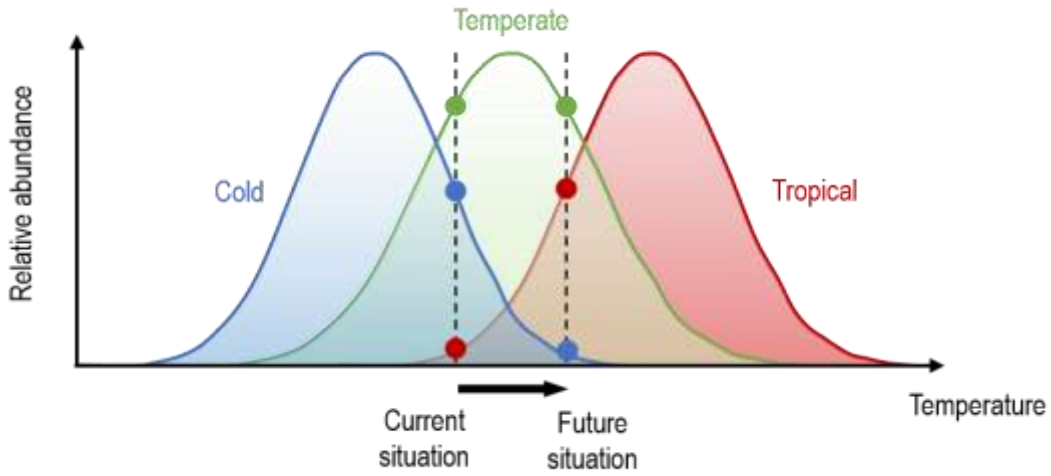
The interaction between the environment and the species vary according to the position of the environmental regime along the niche

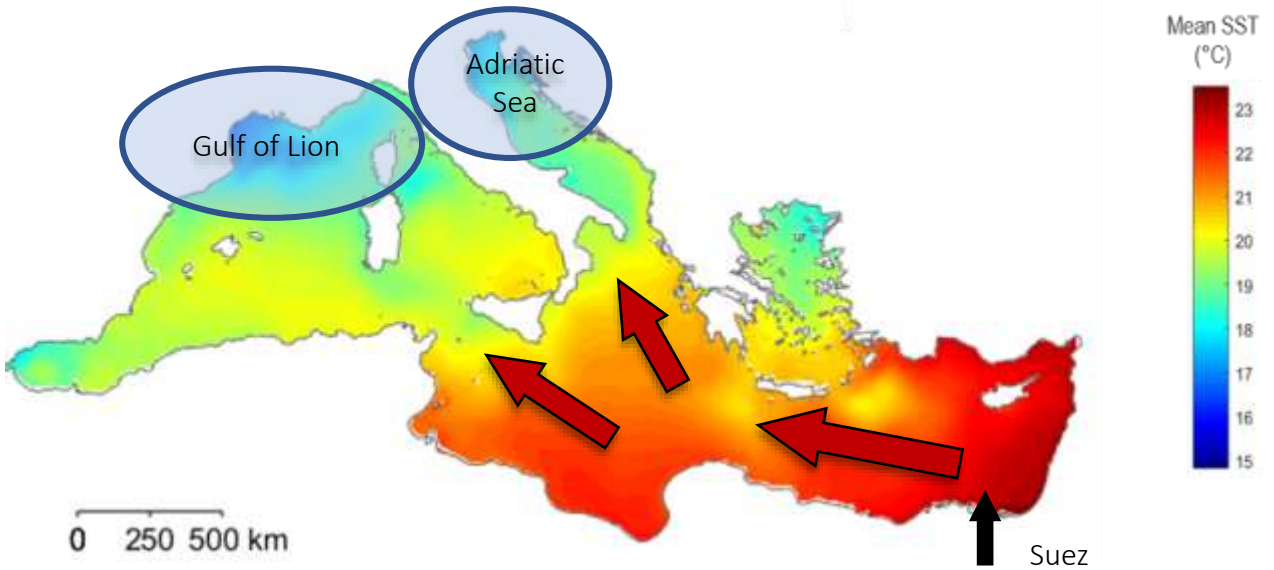
Mediterranean fisheries and climate change



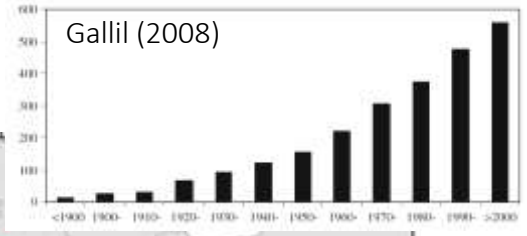
Tzanatos et al. (2014)

The Mediterranean Sea: a biogeographical crossroad



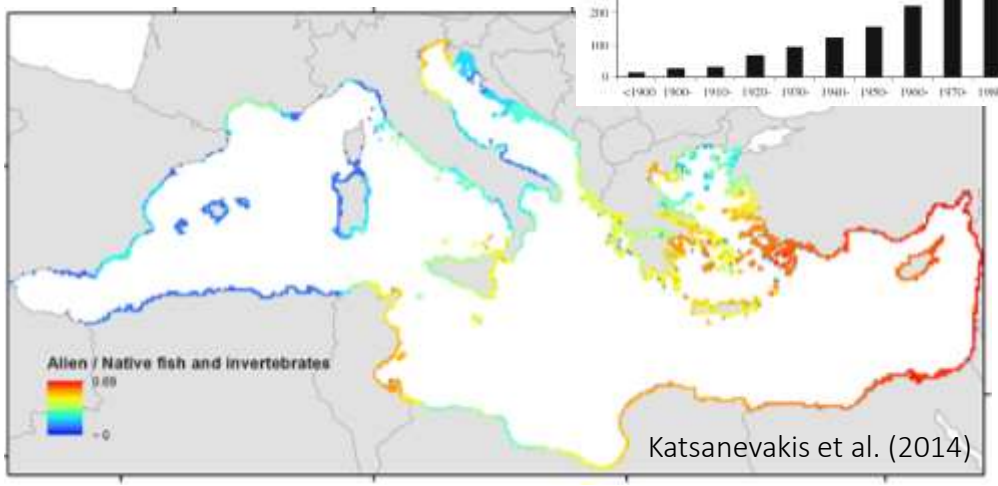


Exotic species in the Mediterranean Sea



Currently more than **1,000 of Exotic Species** in the Mediterranean Sea

(Zenetos et al, 2012)



Negative impacts on native fauna and ecosystems

Siganus luridus
Siganus rivulatus

deplete all algal biomass

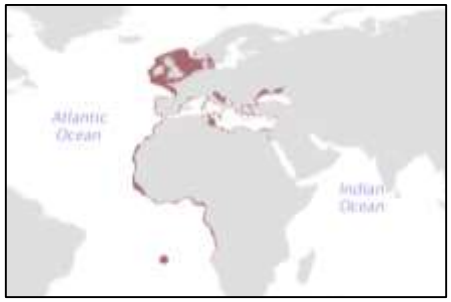
Sala et al (2011)

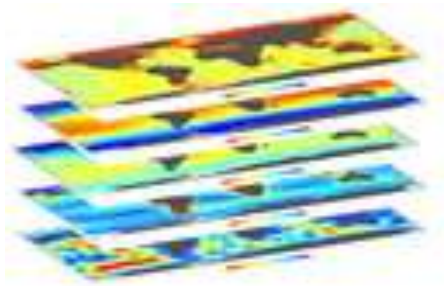
Provide new fishing opportunities

Some lessepssian fish are now harvested

- Rabbitfishes represent nowadays 70% of fish captures in Lebanon

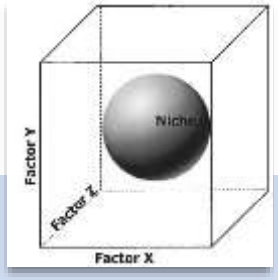
Predicting Species Distribution Using Ecological Niche Modeling





Objective

To predict the distribution of species in geographic space on the basis of a mathematical representation of their ecological niche.



Ecological niche definition

«The niche is the combination of environmental tolerance and resources required by an organism."

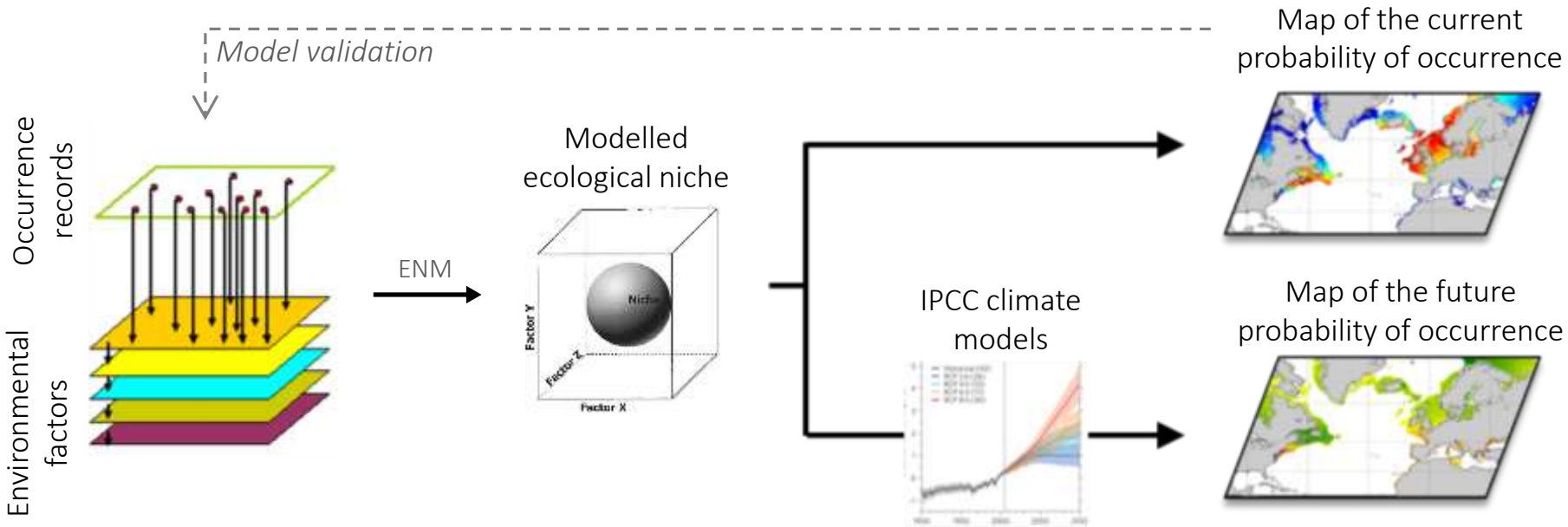
Hutchinson conceptualized this notion with the *n-dimensional hypervolume*

(Hutchinson, 1957)

Applications

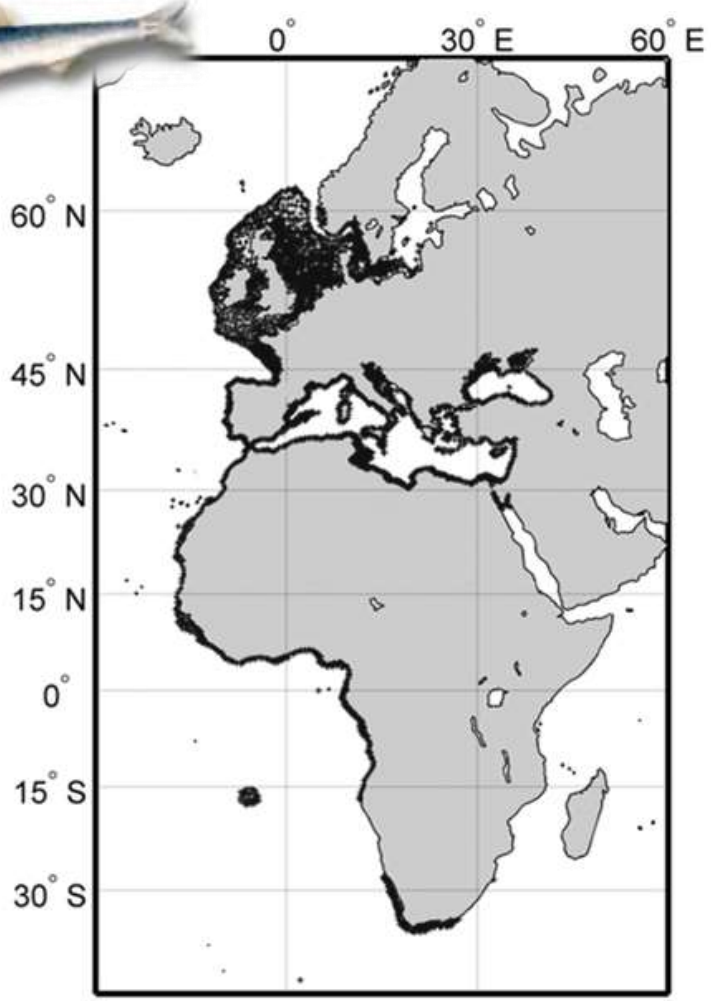
- Biogeography
- Conservation planning
- Disease risk assessment
- Species range shifts
- Biological invasions

Ecological Niche Models: how do they work ?

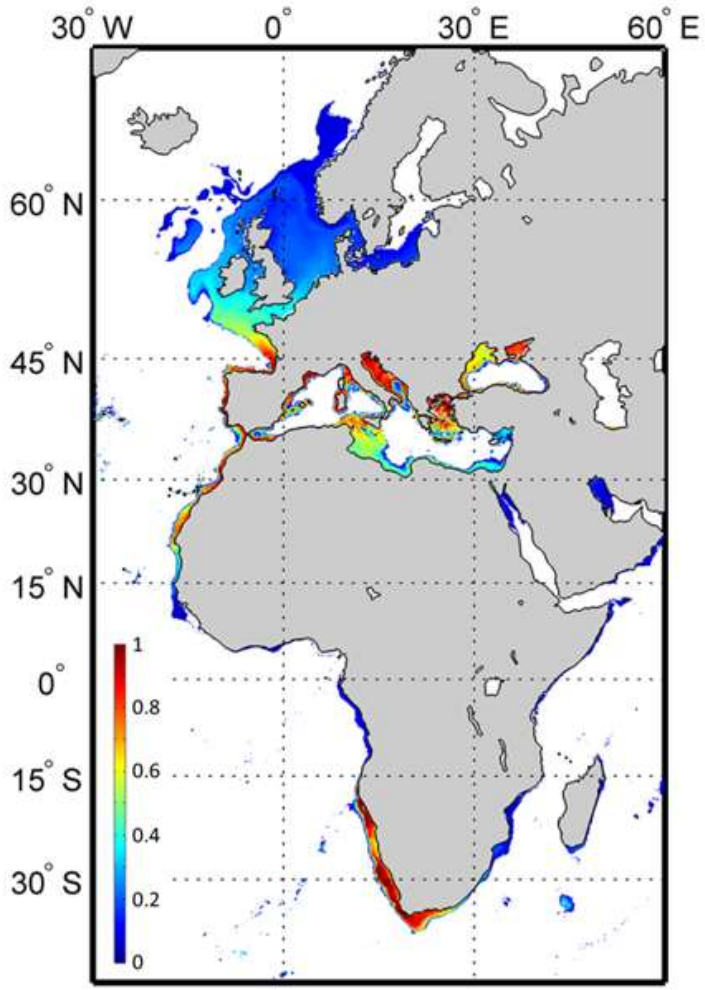


Projected range-shift of the European anchovy (*Engraulis encrasicolus*)

Observed occurrence records



Modelled distribution

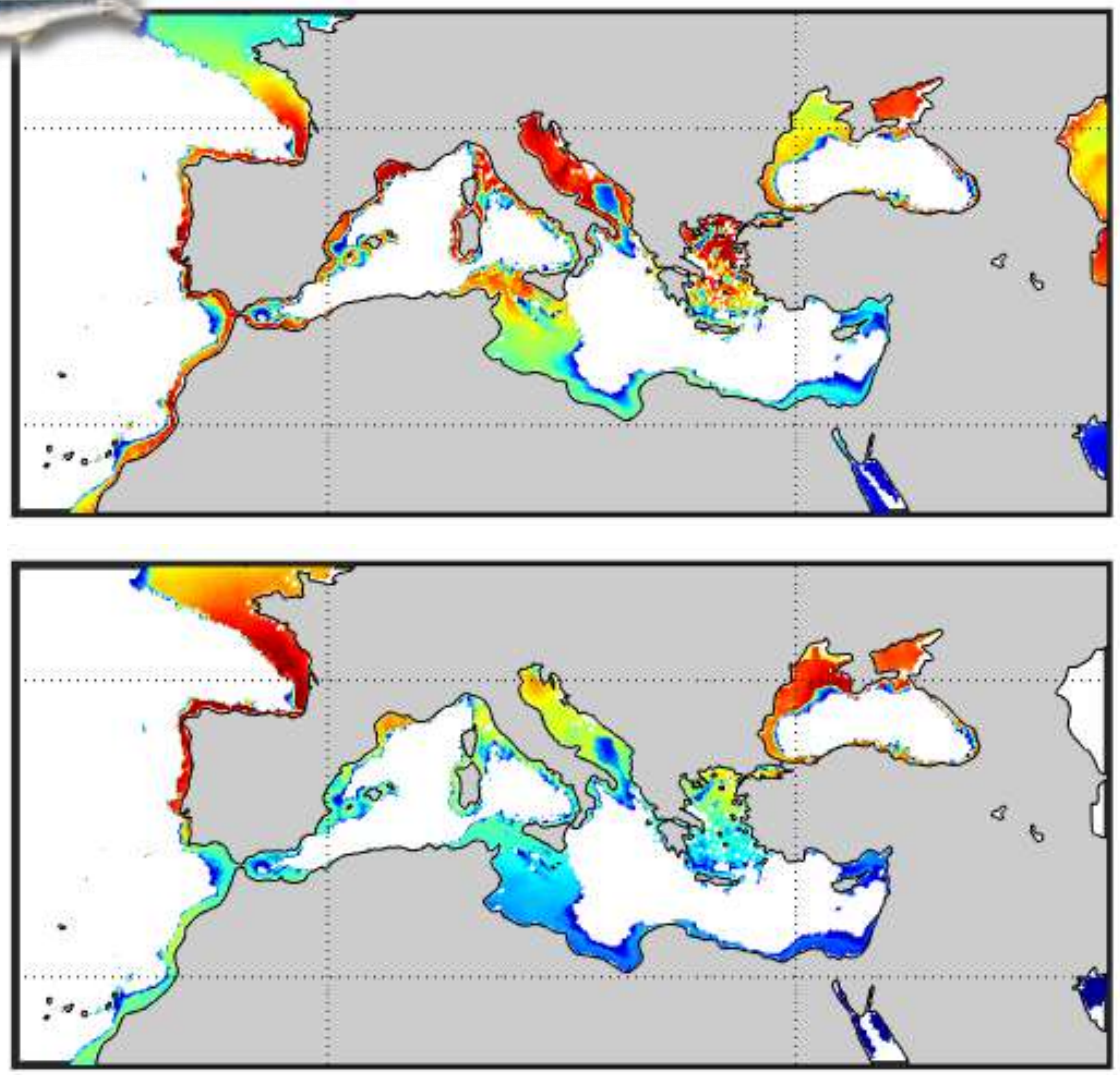


Raybaud et al (2017)

Projected range-shift of the European anchovy (*Engraulis encrasicolus*)

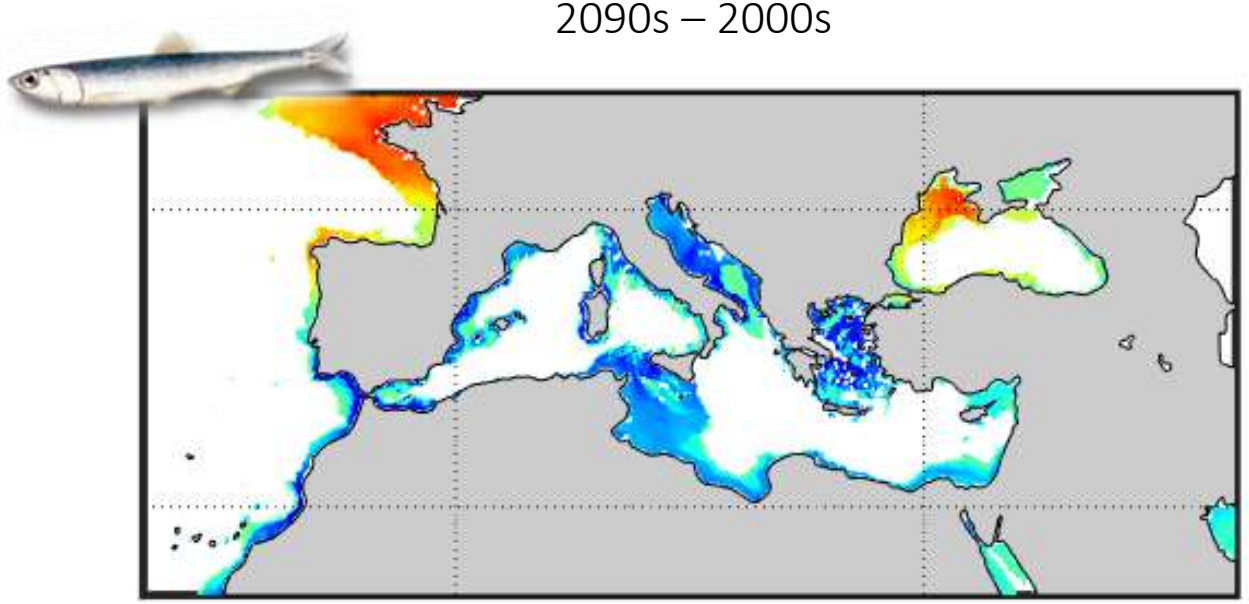
Current period

Decade 2090-2099
RCP8.5



Raybaud et al (2017)

Projected range-shift of the European anchovy (*Engraulis encrasicolus*)



Raybaud et al (2017)

- **Decline** in the probability of occurrence throughout the **whole Mediterranean Sea**
- **Highest decreases** in Aegean Sea, Adriatic Sea, off the Tunisia and Spain

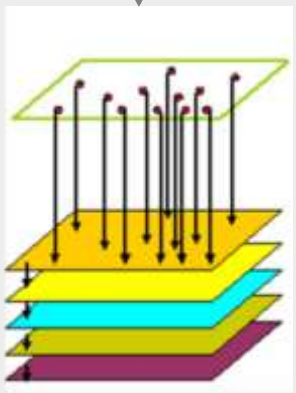
Ecological Niche Models to predict the invasion risk of exotic species

NATIVE AREA

Model validation

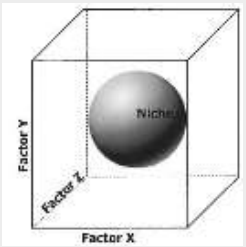
Occurrence records

Environmental factors

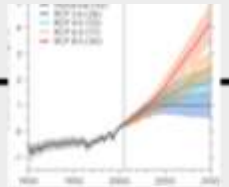


ENM

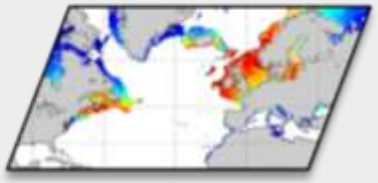
Modelled ecological niche



IPCC climate models



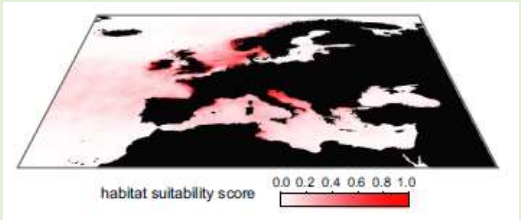
Map of the current probability of occurrence



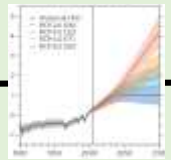
Map of the future probability of occurrence

NON-NATIVE AREA

Invasion risk

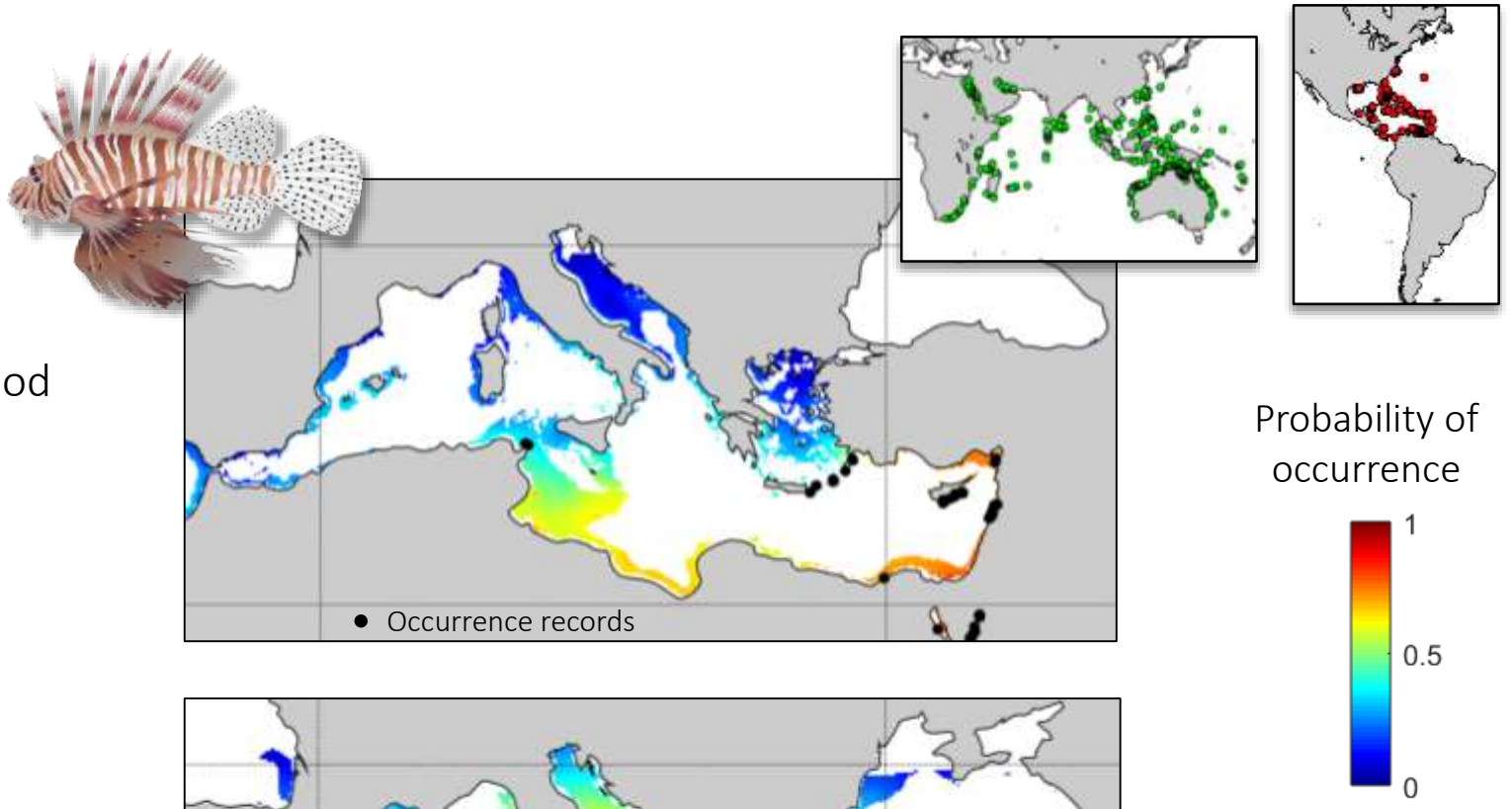


Potential probability of occurrence in the **non-native** region



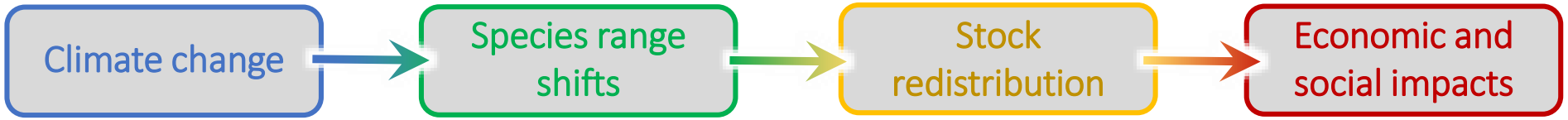
Maps of the **future probability** of occurrence in the **non-native** region

Climate-induced projected spread of the invasive lionfish (*Pterois sp.)*



Fontaine (2017)

From species range-shift to economic valuation



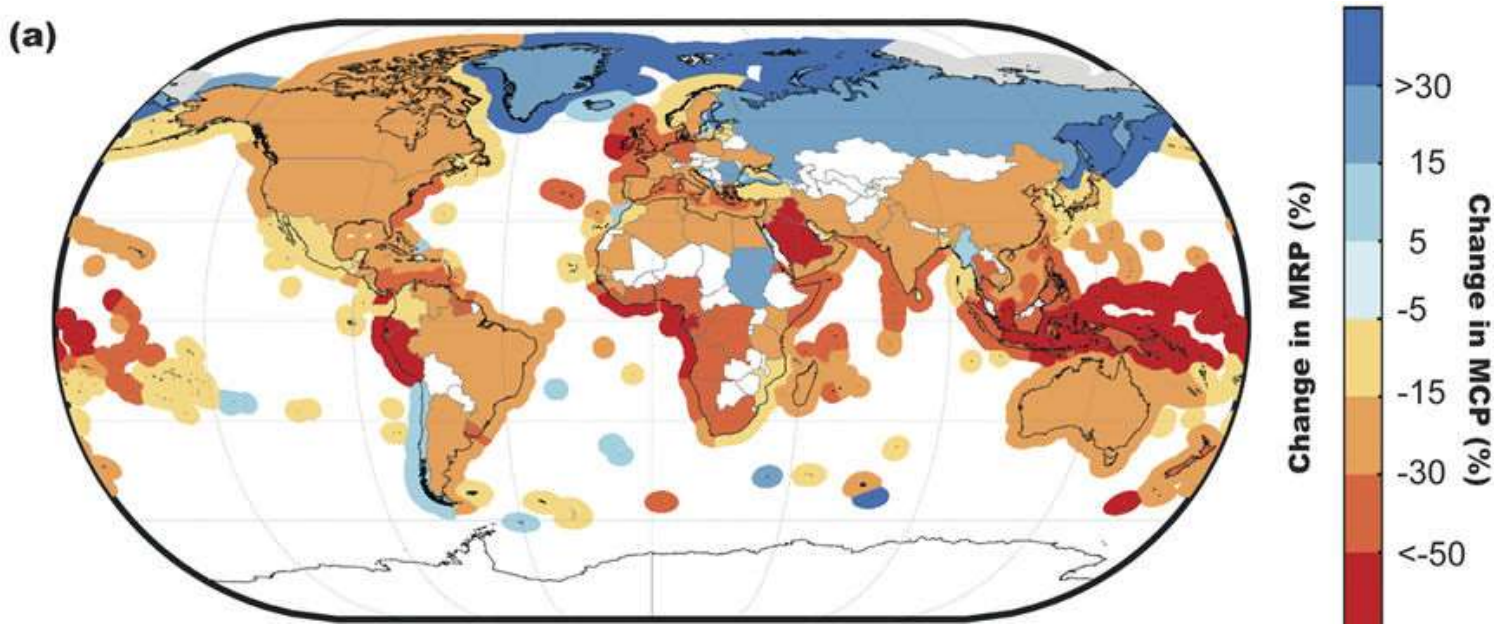
Approach used by Lam et al (2016) and Nereus program scientists:

Changes in Catch Potential —— *Ex-vessel price for each species* → Changes in Maximum Revenue Potential

From species range-shift to economic valuation

At a global scale …

Change in Maximum Catch Potential (MCP) and Maximum Revenue Potential (MRP) in the 2050s relative to the 2000s under RCP 8.5 scenario



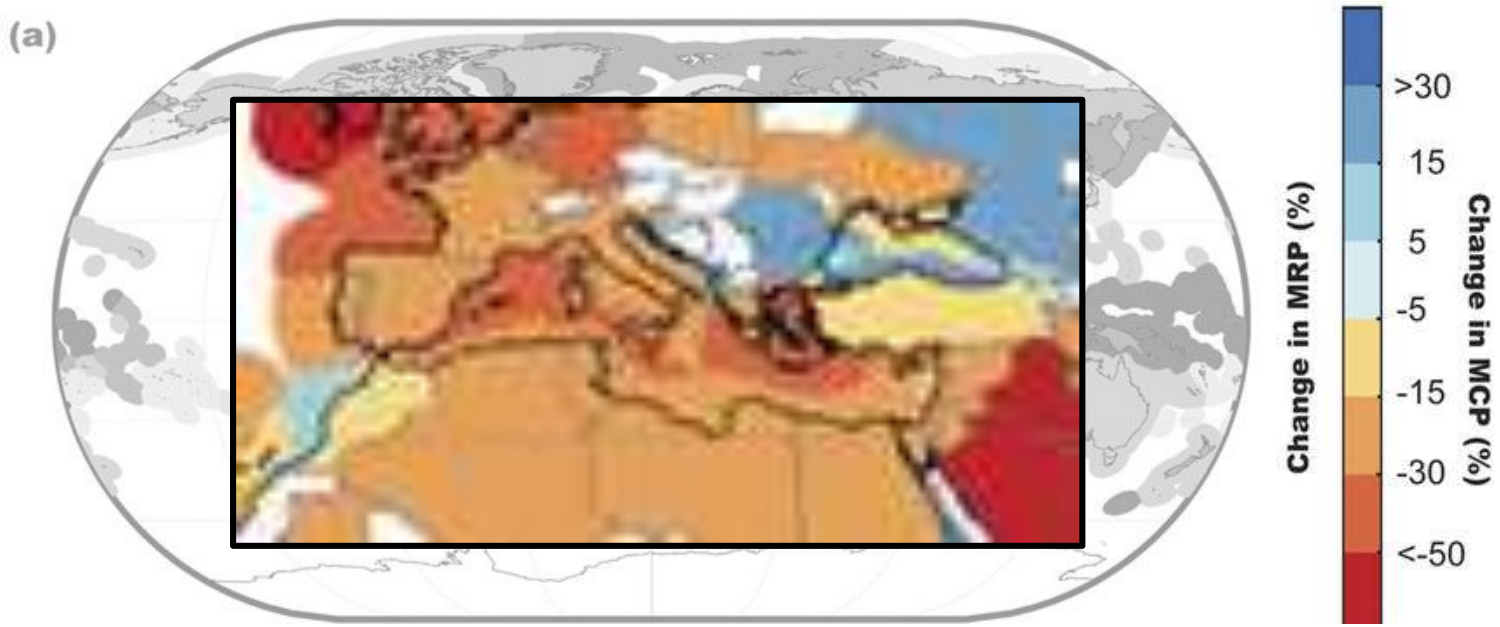
Lam et al (2016)

From species range-shift to economic valuation

In the Mediterranean Sea ?

Changes in Maximum revenue ↘ 15-50 % but

… the Mediterranean Sea is poorly detailed
… only ex-vessel price is taken into account



Lam et al (2016)

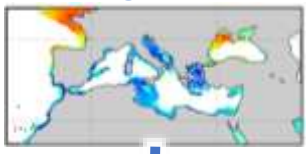
From species range-shift to economic valuation

Other approach proposed

Capacity to undertake planned adaptation

~ GDP per capita
~ Degree of dependence of fisheries to national economies
~ Proportion of industrial to small-scale fishing

Projected species range-shift



Vulnerability = Exposure + Sensitivity – Adaptative Capacity

Economic returns of fisheries

~ Total fisheries landings
~ Species ex-vessel price
~ Number of fishers
~ Level of fish protein dependency
~ Fisheries export values

Adapted from IPCC (2001) and Blasiak (2017)

Conclusions and future studies

- A major reorganisation of the main commercially exploited fish in the Mediterranean Sea is likely to take place within a century in response to climate change

  → is expected to reshape significantly the economic return of fisheries

- Most of the Mediterranean stock are overfished or fully-exploited. Synergistic effects of fishing and climate could precipitate the decline of fish stocks in some areas.

- A comprehensive evaluation of the projected changes is needed, gathering ecological and economic changes

Conclusions and future studies

- Ongoing PhD project (2017-2020): *Climate-induced changes in the geographical distribution of the main commercially exploited fish in the Mediterranean Sea*

  → Maps of current and future range of the main exploited fish

- Future challenge : To assess the influence of climate-mediated range shifts for the economy of the main countries bordering the Mediterranean Sea

  → Need a collaboration between ecologists and economists

  → Should consider all aspects to evaluate the vulnerability of each country (*i.e* exposure, sensitivity and adaptative capacity)

Thank you