

# The Mediterranean Sea as a trap for endemic fishes facing climate change

Frida Ben Rais Lasram<sup>1,2</sup>, Francois Guilhaumon<sup>2</sup>,  
Samuel Somot<sup>3</sup>, Wilfried Thuiller<sup>4</sup> and David Mouillot<sup>2</sup>

<sup>1</sup> Laboratoire Ecosystèmes et Ressources Aquatiques UR03AGRO1, Institut National Agronomique de Tunisie, Tunisia

<sup>2</sup> Laboratoire Ecosystèmes Lagunaires UMR 5119, Université Montpellier 2, France

<sup>3</sup> Météo-France, Toulouse, France

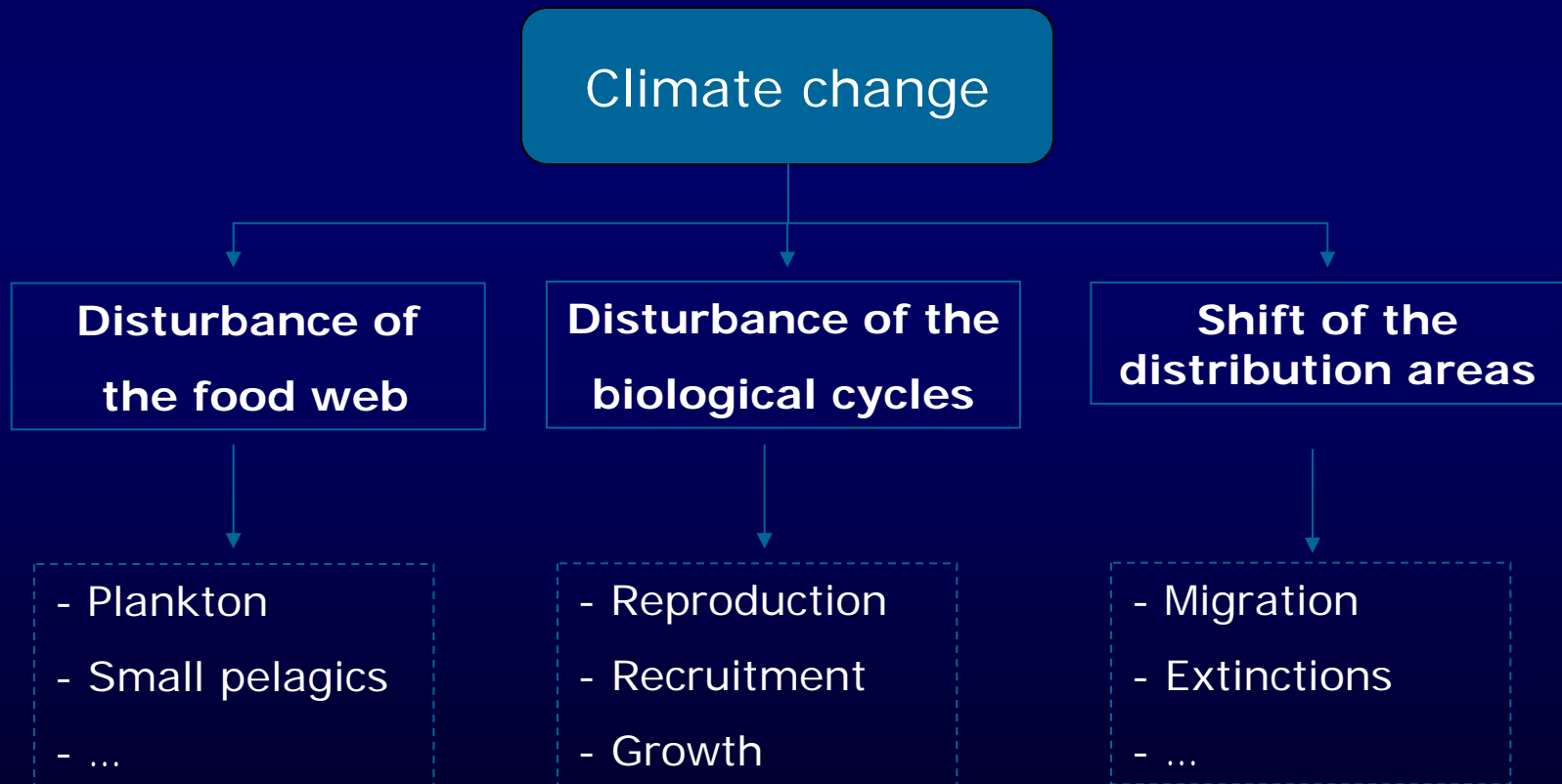
<sup>4</sup> Laboratoire Ecologie Alpine, UMR 5553, Université J. Fourier, Grenoble, France

# Introduction

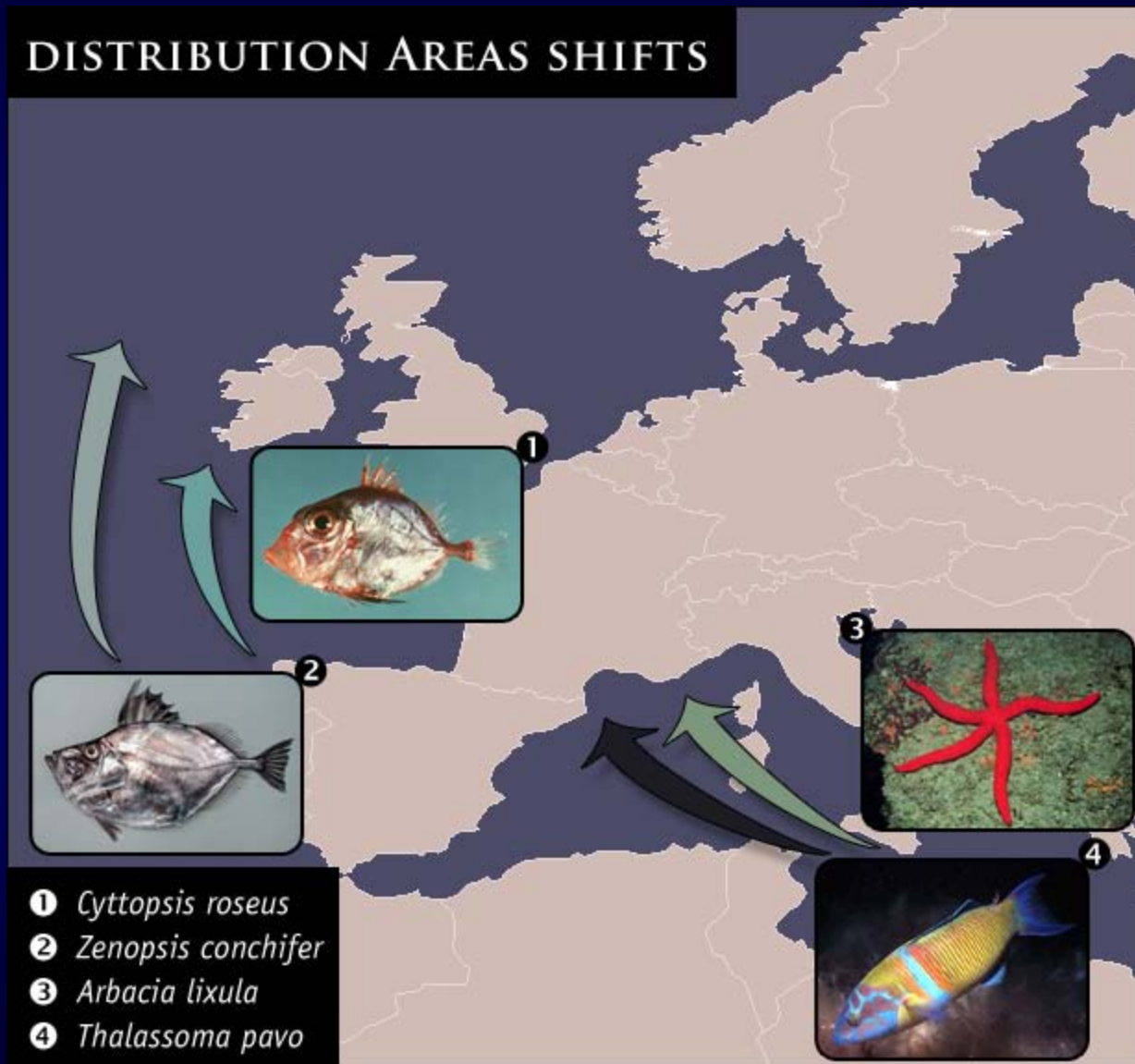
- Over the past 100 years, climate has warmed by  $0.61^{\circ}\text{C}$  and temperatures are expected to continue rising over the earth.
- A large quantity of evidence has been accumulated towards an ecological impact of this climate change on ecosystems.

# Introduction

- Over the past 100 years, climate has warmed by  $0.61^{\circ}\text{C}$  and temperatures are expected to continue rising over the earth.
- A large quantity of evidence has been accumulated towards an ecological impact of this climate change on ecosystems.



# Introduction

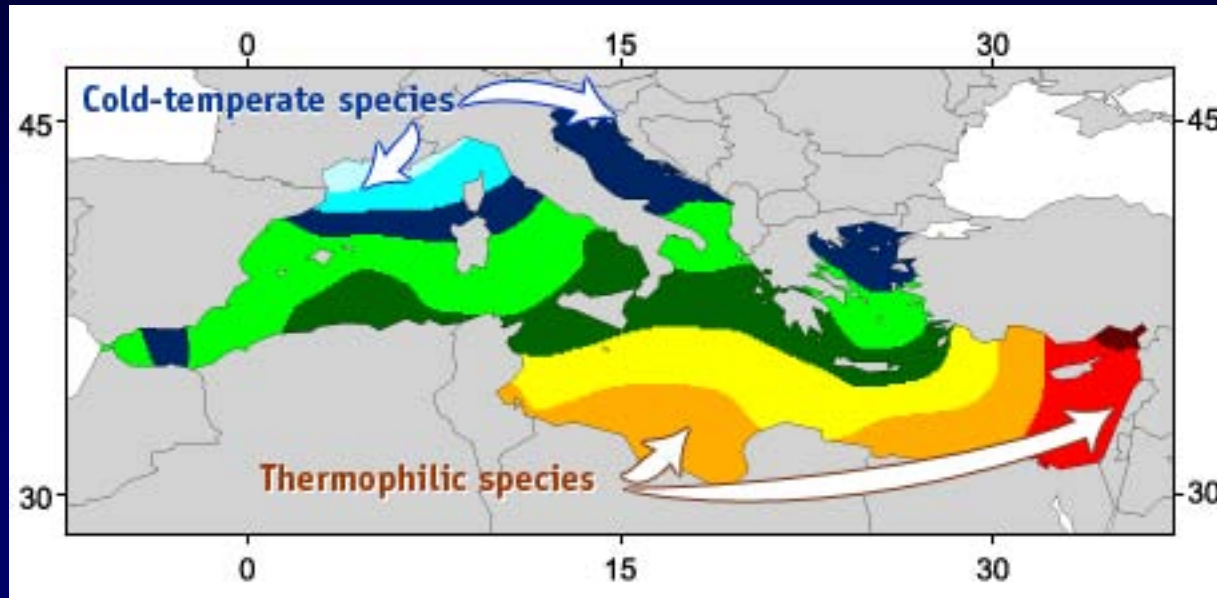


# Introduction

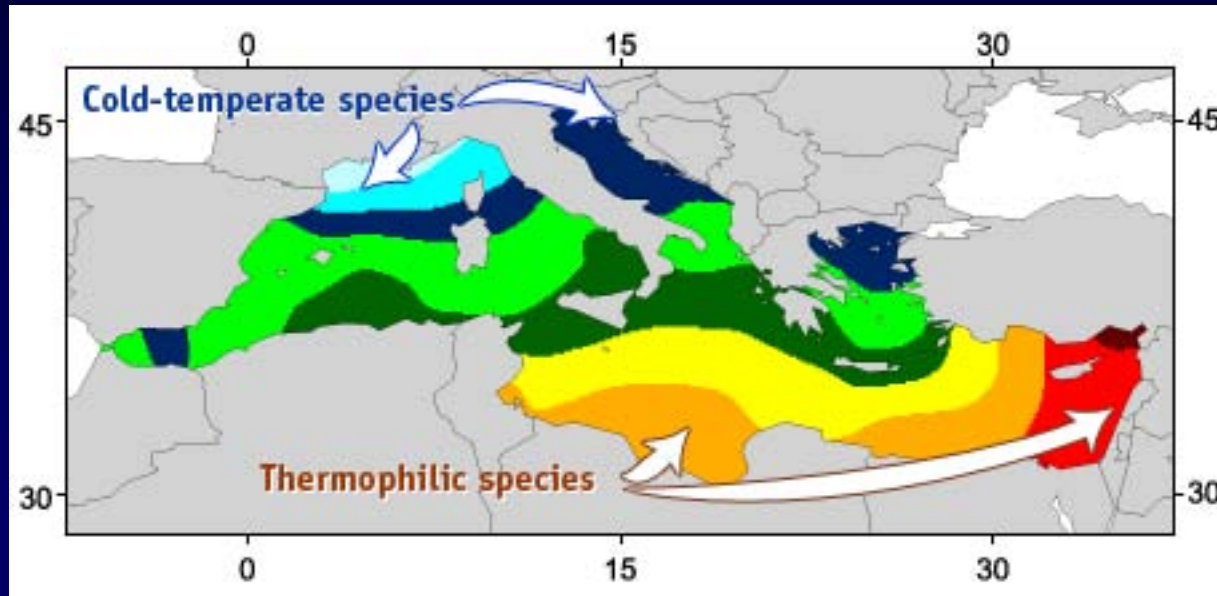


- 0.32% of the global oceanic volume
- 10% of endemism

# Introduction



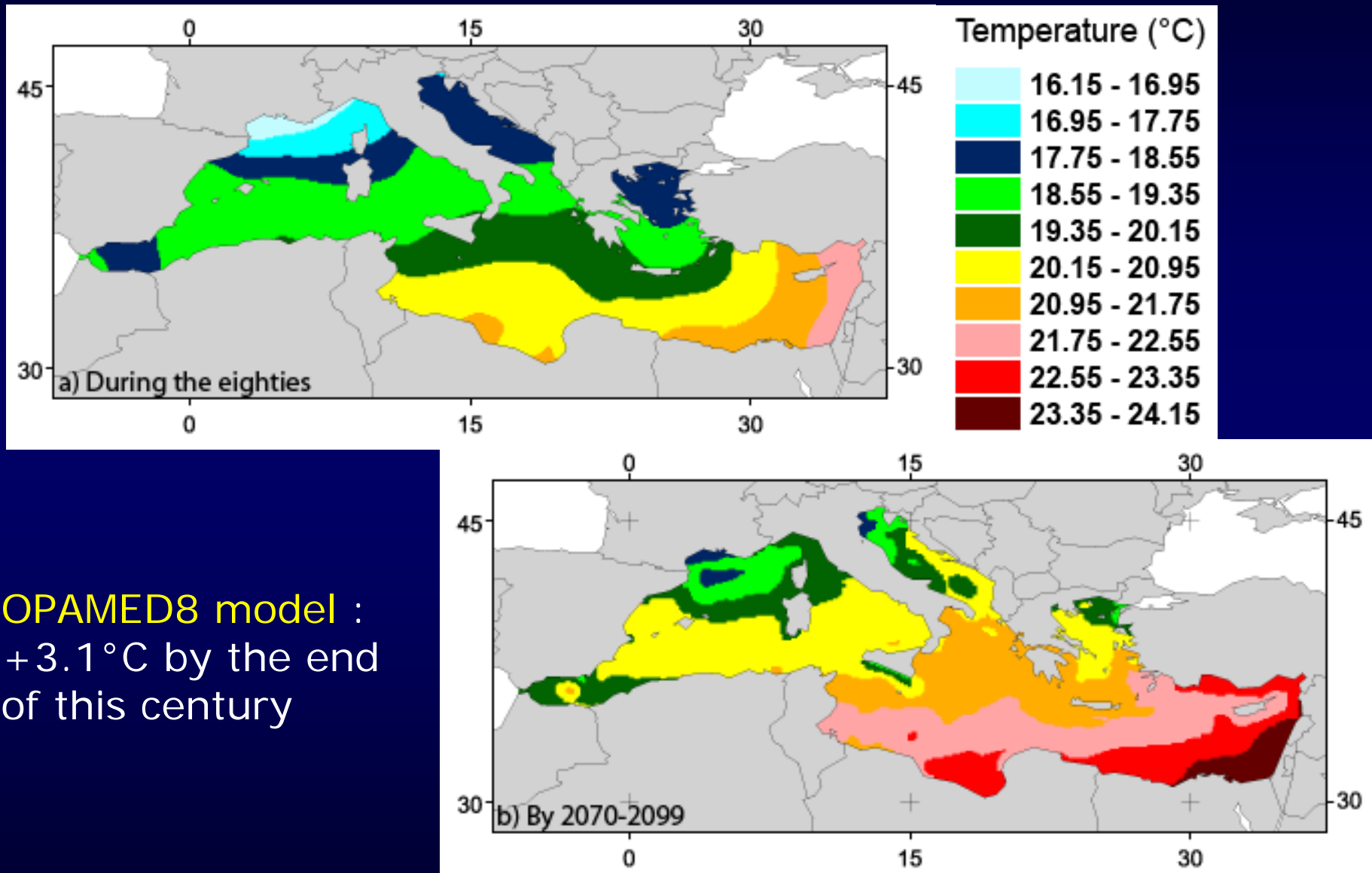
# Introduction



This pattern tends to disappear with global warming:

- Since the 1980s, thermophilic species of the southern Mediterranean appear more frequently in the northern and colder parts
- The abundance of some boreal species has dramatically decreased

# Introduction





# Introduction

In the Mediterranean Sea, we can expect:

- The gradual replacement of cold-temperate species by thermophilic ones and their northward shifting.
- If the northern part of the Mediterranean continue to warm, endemic cold-temperate species risk to get extinct because they cannot escape or establish elsewhere.

# Introduction

## Questions

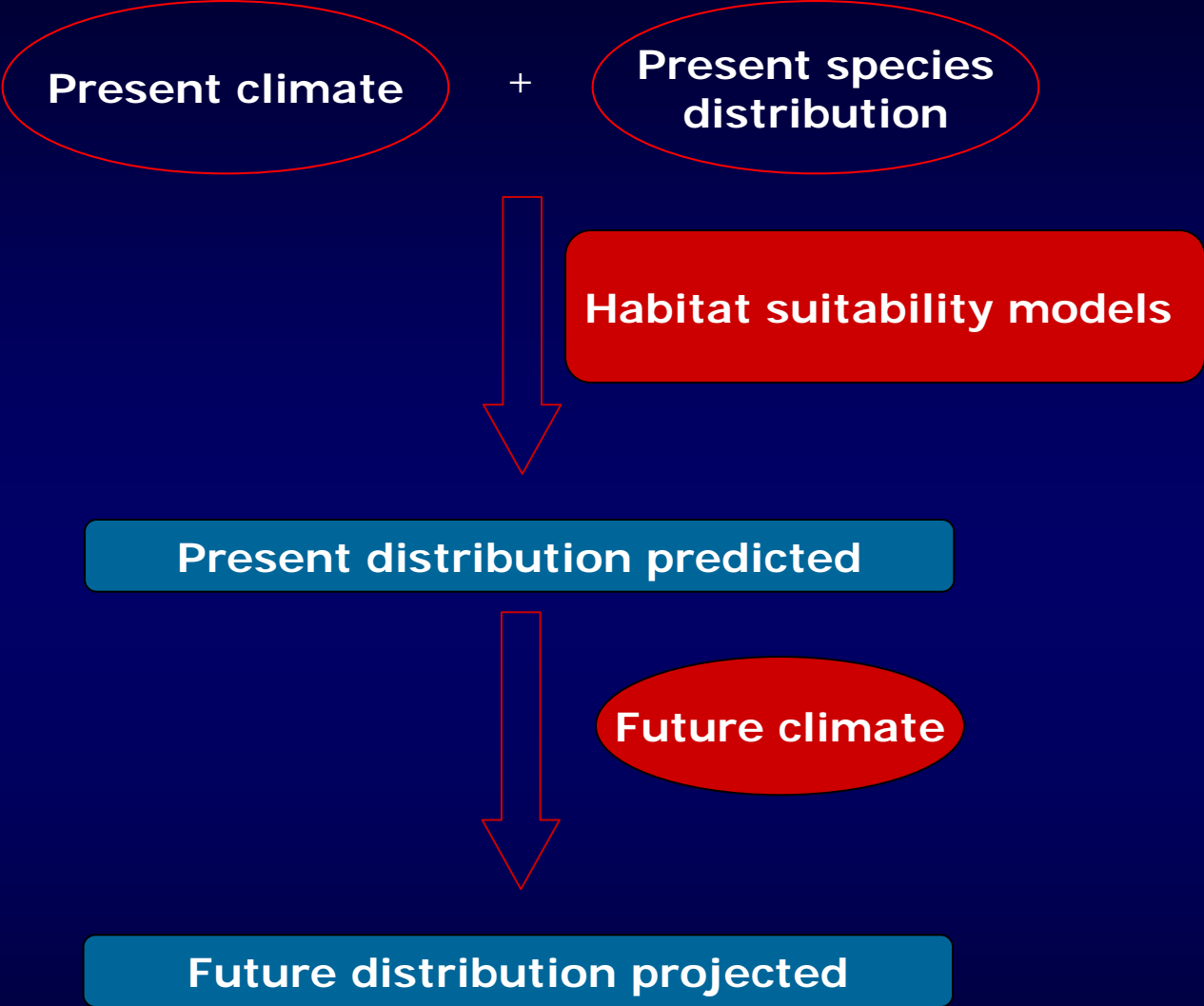
- How vulnerable are endemic fish species to climate warming in the Mediterranean by the middle and the end of the century?
- What extent of endemic species turnover may occur under climate warming?

# Introduction

## Questions

- How vulnerable are endemic fish species to climate warming in the Mediterranean by the middle and the end of the century?
- What extent of endemic species turnover may occur under climate warming?

**Habitat suitability models**



# Methods

## 1. Species data

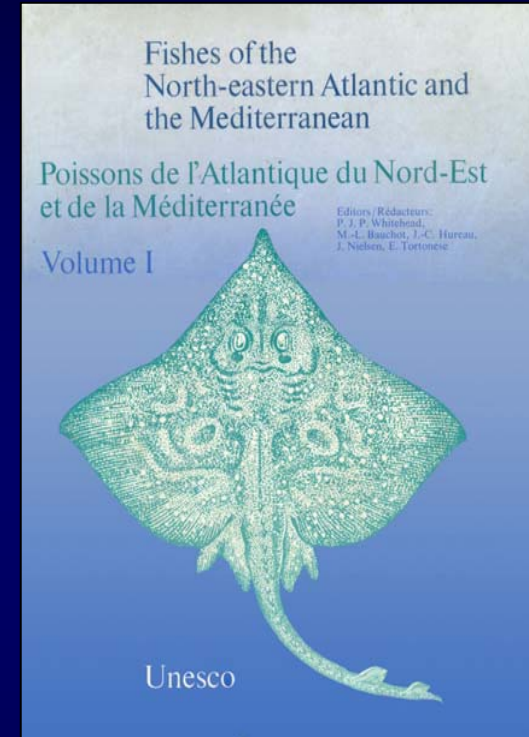
75 endemic species

1. DB on the distribution areas



2. DB on ecological information to evaluate the **degree of specialization**:

- Habitat generalist / habitat specialist
- Diet generalist / diet specialist



# Methods

## 2. Temperature data

- **Present climate:** SST from the Data server of the NOAA
- **Future climate:** SST projected by the OPAMED8 model (Somot et al. 2006) for 2041-2060 and 2070-2099

# Methods

## 3. Models calibration & evaluation

- **BIOMOD** (Thuiller 2003)
  - Generalized Linear Models (GLM)
  - Generalized Additive Models (GAM)
  - Classification Tree Analysis (CTA)
  - Generalized Boosting Models (GBM)
  - Random Forest (RF)
  - Surface Range Envelop (SRE)
  - Mixture Discriminant Analysis (MDA)
  
- Calibration : random sample of the initial data (80%)
- Evaluation : the remaining 20%
- Criterion : True Skill Statistic (TSS)

# Methods

## 4. Models projections

- No evidence of the superiority of one model emerged
- In order to take advantage of each model and to reduce uncertainty, we used the Weighted Average consensus Method:

$$W_i^{TSS} = \frac{\sum_j (TSS_j \times m_{ji})}{\sum_j TSS_j}$$



# Methods

## 5. Species vulnerability

Threat categories (IUCN, 2001) depending on the projected reduction of suitable habitat

- **Extinct** (EX): a projected range loss of 100%
- **Critically endangered** (CR): a projected range loss >80%
- **Endangered** (EN): a projected range loss >50%
- **Vulnerable** (VU): a projected range loss >30%
- No concern (NC): a projected range loss <30% or expansion

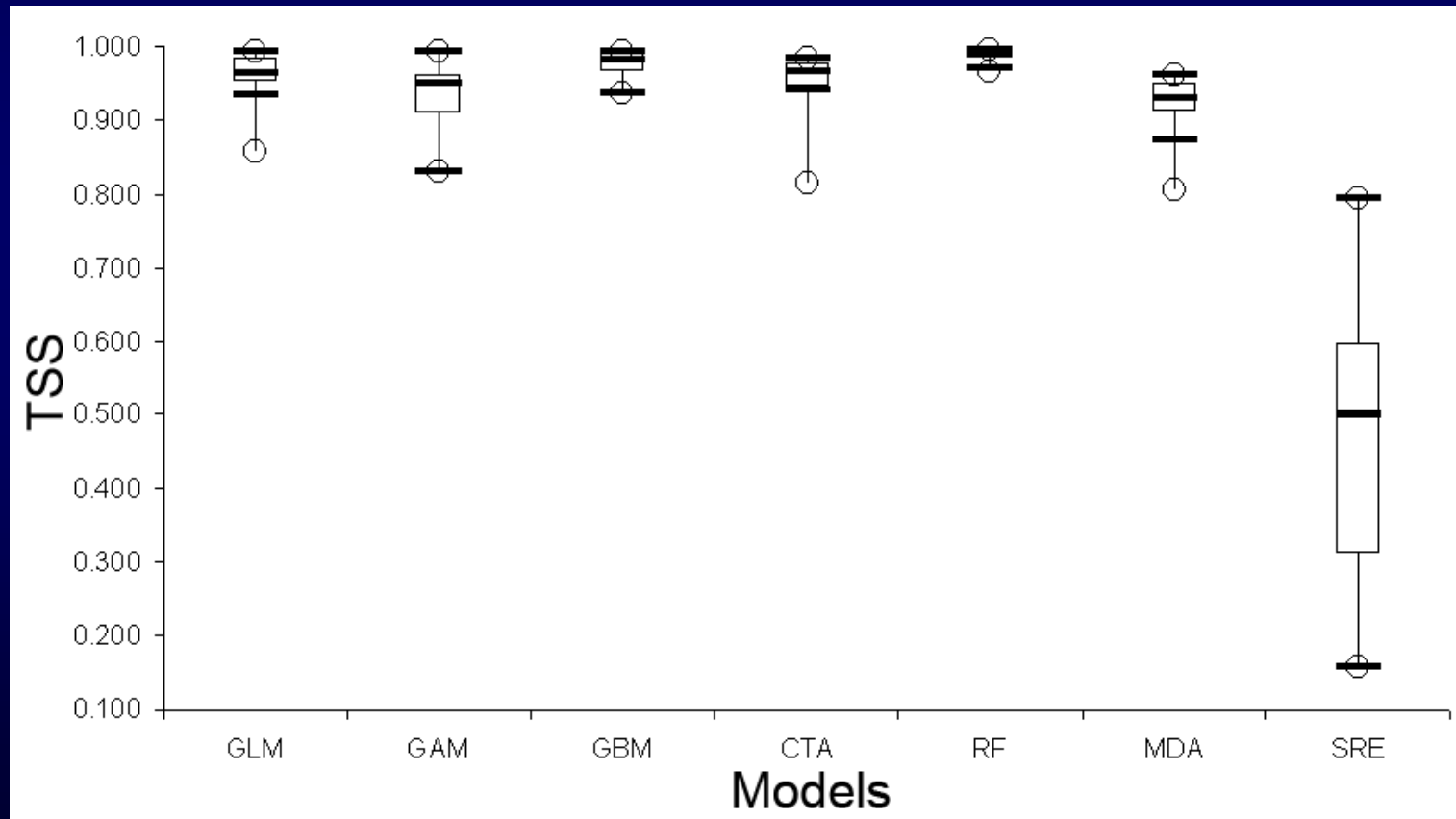
## 6. Species turnover

$$TO = \frac{(P+G)}{(RS+G)} \times 100$$

# Results

## 1. Model predictions

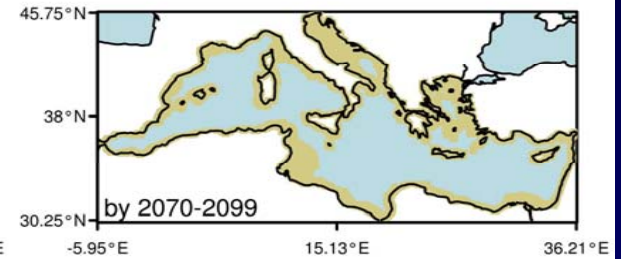
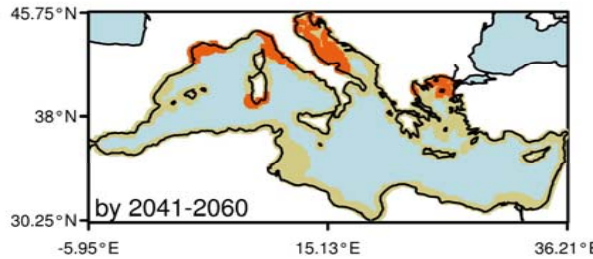
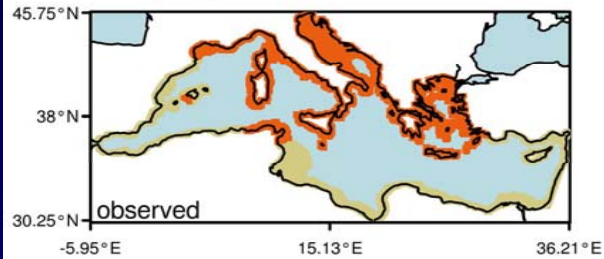
- Excellent predictive accuracy except for SRE
- Average TSS=0.89



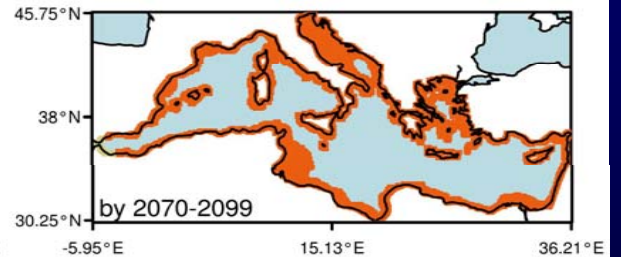
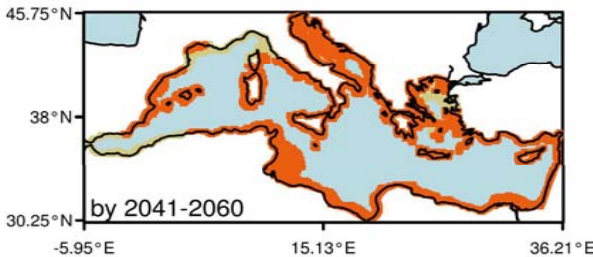
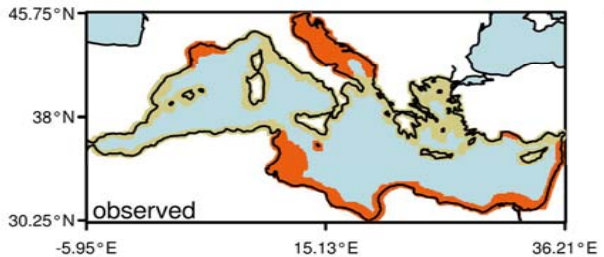
# Results

## 2. Species vulnerability

*Gobius geniporus*

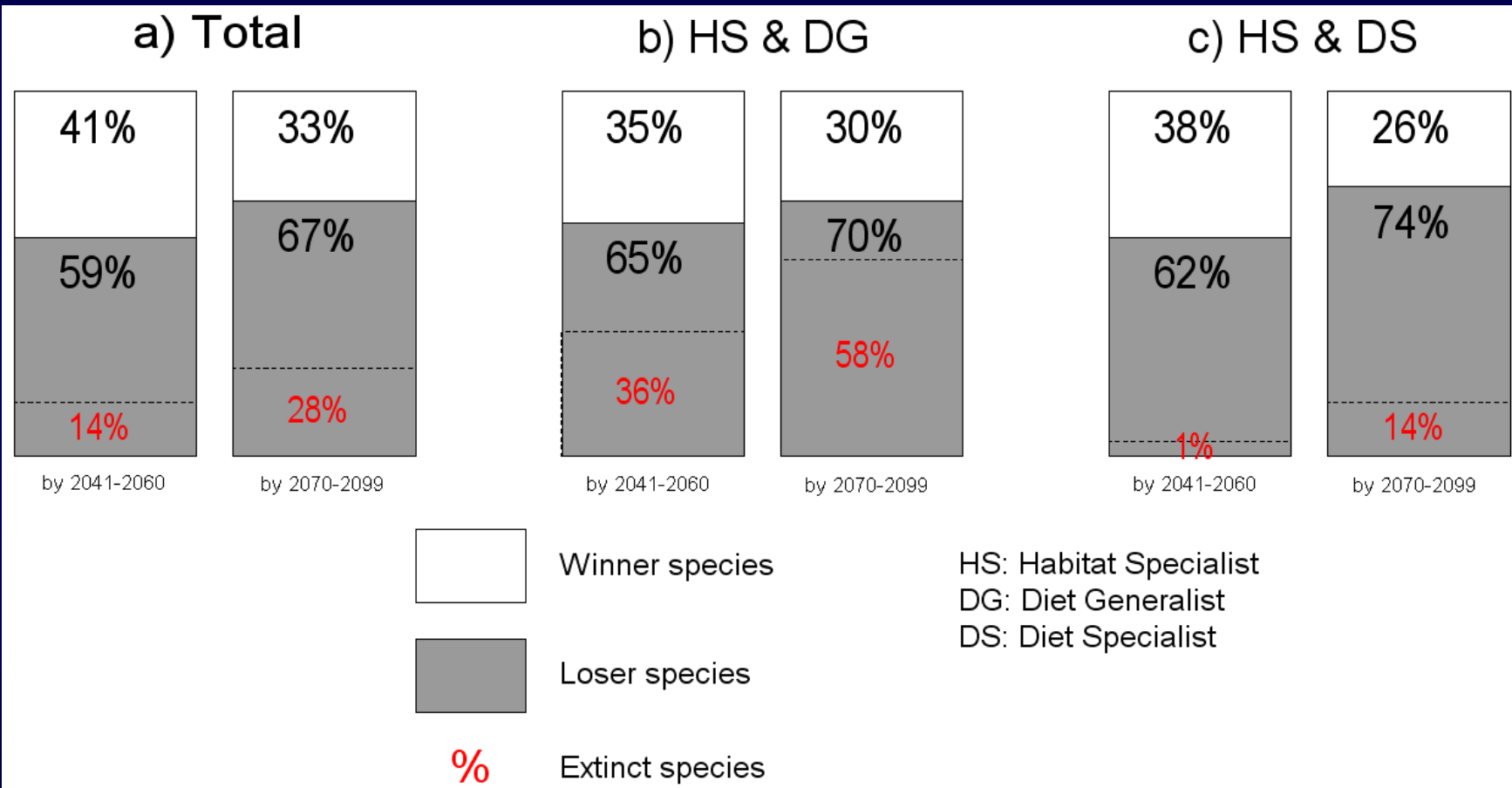


*Solea aegyptiaca*



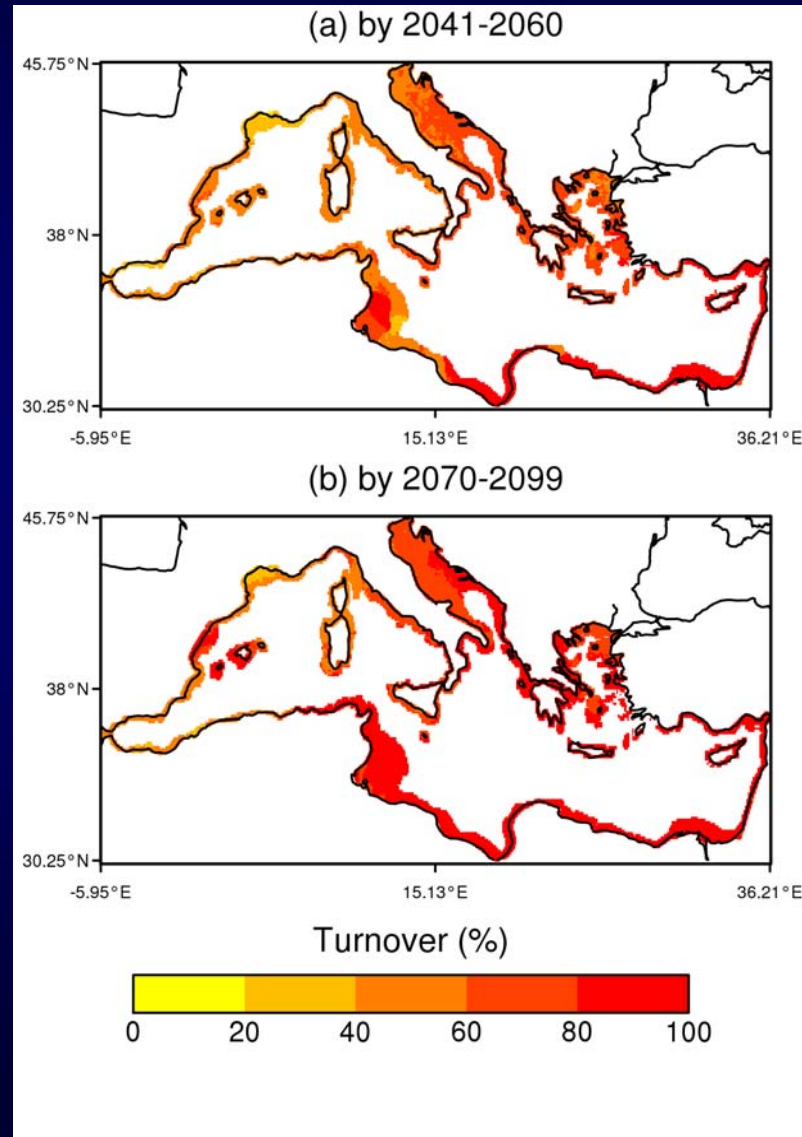
# Results

## 2. Species vulnerability



# Results

## 3. Species turnover



# Conclusion

- Projections based on a consensus method revealed that:

	2041-2060	2070-2099
Endemic species on the IUCN Red List	35%	60%
Extinct endemic species	8%	19%
Coldest areas of the Mediterranean	will act as a <b>sanctuary</b> for cold-temperate species	will act as a <b>trap</b> , driving those species to extinction

# Conclusion

**Abiotic pressure**

Climate change

**Biotic pressure**

Exotic species

**Human activities**

Pollution, overfishing

# Conclusion

**Abiotic pressure**

Climate change

**Biotic pressure**

Exotic species

**Human activities**

Pollution, overfishing



Increase of the endemic species vulnerability



BEN RAIS LASRAM F., GUILHAUMON F., SOMOT S., THUILLER W. & MOUILLOT D. The Mediterranean Sea as a "cul-de-sac" for endemic fishes facing climate change. *Global Change Biology* (in press)

Thank you for your attention

Special thank for the organizing committee  
for the financial support