



➤ Fish distribution's shifts due to climate change in the Northeast Atlantic: using a hierarchical filtering approach on marine-estuarine opportunist species

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5th most important stressor for marine biota (Penn & Deutsch, 2022)

45% of marine species at risk of extinction (Poloczanska et al. 2013)

➔ Deleterious alterations in the ecophysiological and/or biological processes of marine species (Parmesan, 2006)

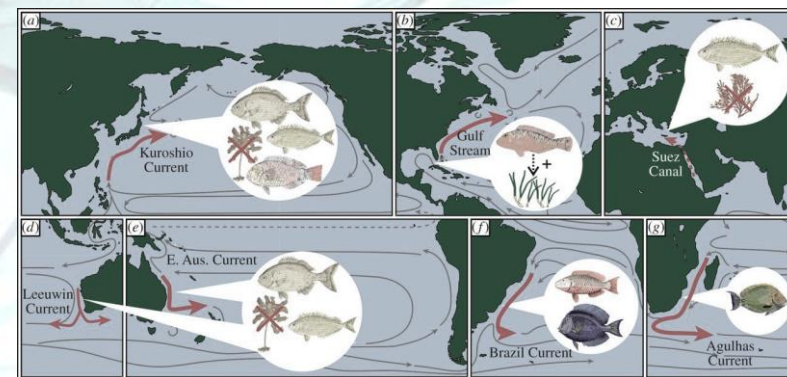
➔ Species range shifts to track their thermic niche and/or prey movements (Poloczanska et al. 2013)

- Species range size changes (Thorson et al. 2016)
- Poleward species range shifts (Parmesan & Yohe, 2003; Pinsky et al. 2013; Thorson et al. 2016)
- Deepening and distance from the coasts (Perry et al. 2005; Dulvy et al. 2008)
- Marine communities' **tropicalization** phenomenon in some temperate marine regions

Cold-water species' declines due to their range **contractions**

Arrival of emerging warm-water species due to their range **expansions**

(Cheung et al. 2012 ; Costa et al. 2014; Auber et al. 2017; Bañón et al. 2017; Le Marchand 2020)



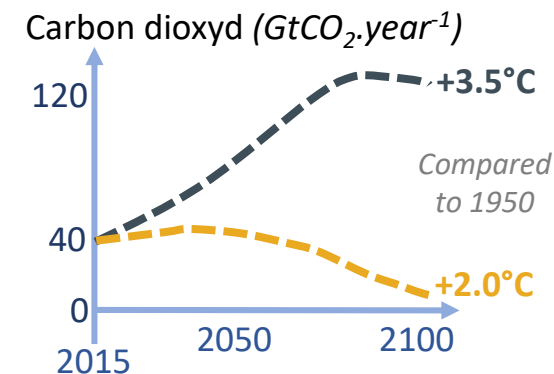
Vergés et al. 2014



1. Are there any evident distribution shifts in environment suitability range in response to anthropogenic climate change for the **end of the 21st century?**

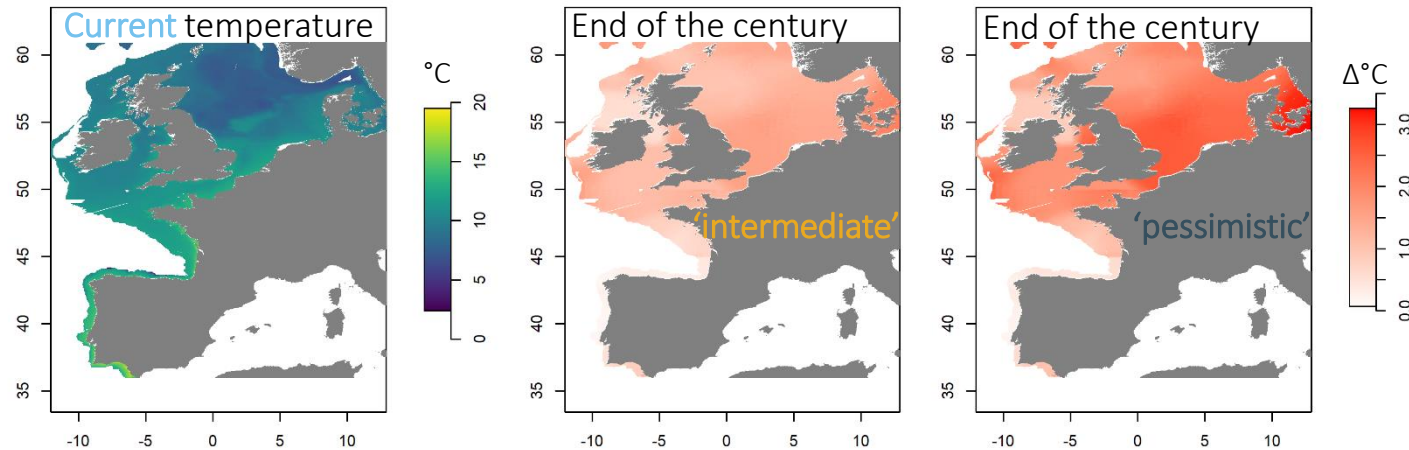
Northward range shifts, and/or **deepening**, and/or **seawardness** ?

2. Much more greater under the ‘pessimistic’ scenario (IPCC, SSP5-RCP8.5) than under the ‘intermediate’ scenario (SSP2-RCP4.5) ?



Northeast Atlantic = temperate biogeographic transition zone increasingly exposed to warming

(Brander et al. 2003; Hofstede et al. 2010)



6 marine-estuarine opportunist species with different biogeographic affinities (Yang, 1982)



Flounder, *Platichthys flesus*



Plaice, *Pleuronectes platessa*



Seabass, *Dicentrarchus labrax*



Common sole, *Solea solea*

'Sub-boreal'
(northern, cold-water)



Meagre, *Argyrosomus regius*



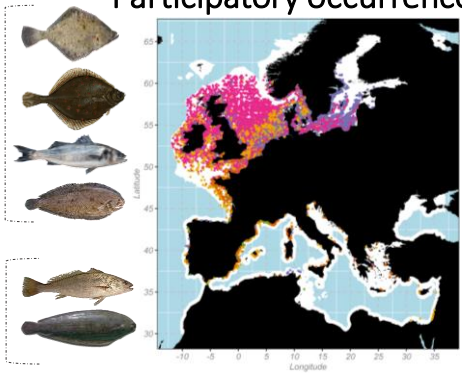
Senegalese sole, *Solea senegalensis*

'Sub-tropical'
(southern, warm-water)



Sub-tropical

Sub-boreal



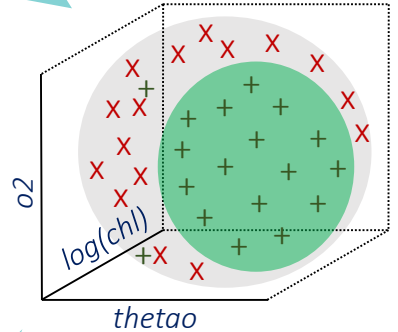
GBIF
Global Biodiversity Information Facility

OBIS
OCEAN BIOGEOGRAPHIC INFORMATION SYSTEM

iNaturalist

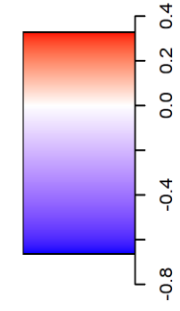
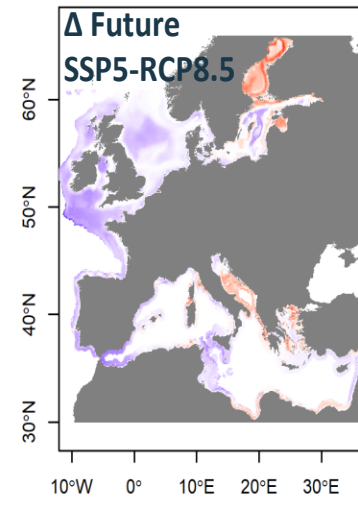
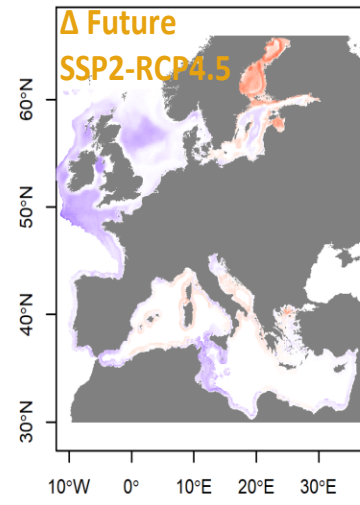
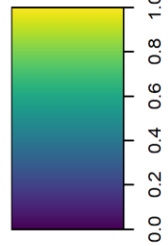
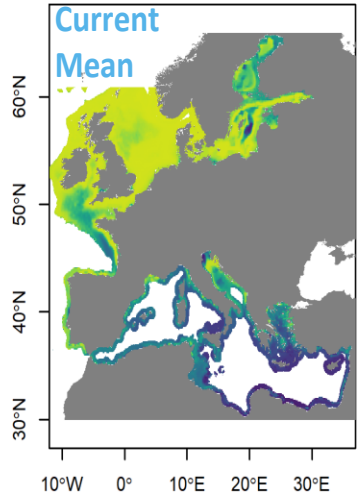
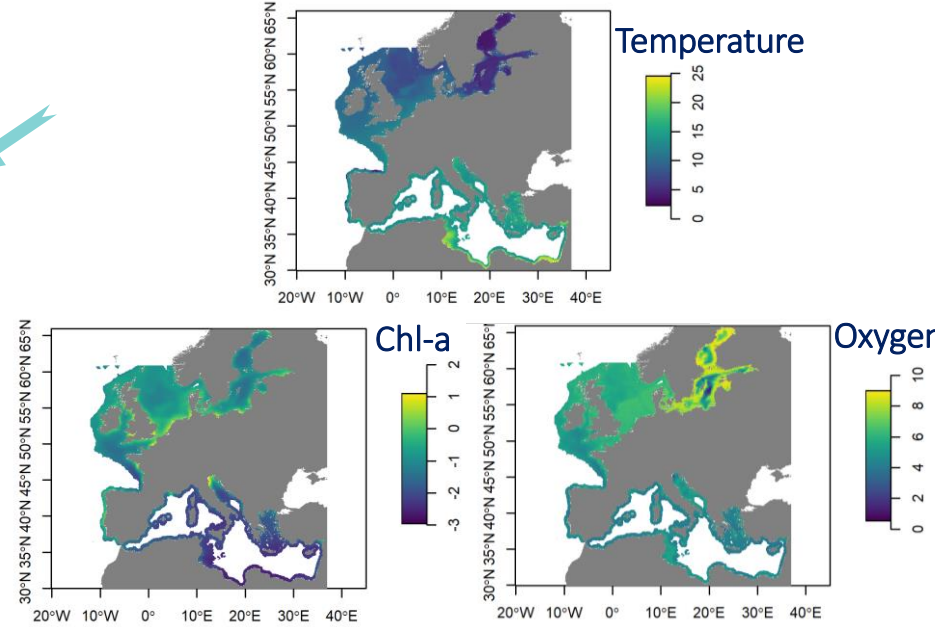
Ver+Net+

Participatory occurrence data

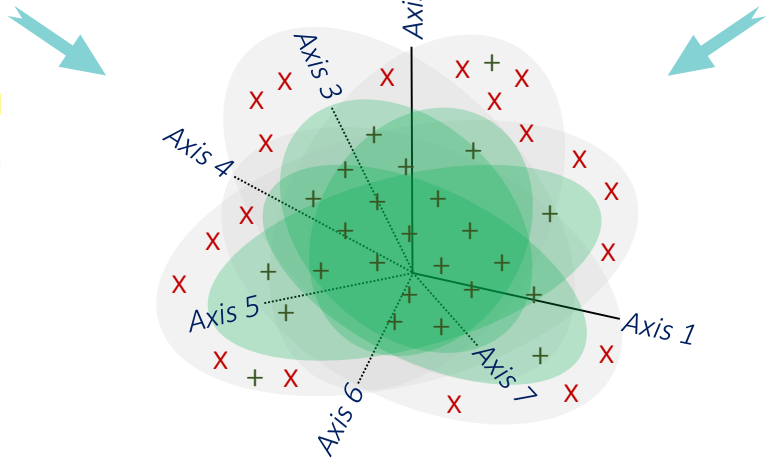
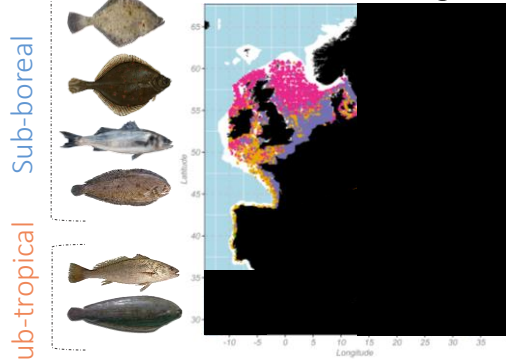


3D - Environmental space of the study area with approximation of the species ecological niche and random generation of pseudo-absence data

Bioclimatic variables (Kristiansen & Butenschön, 2022)

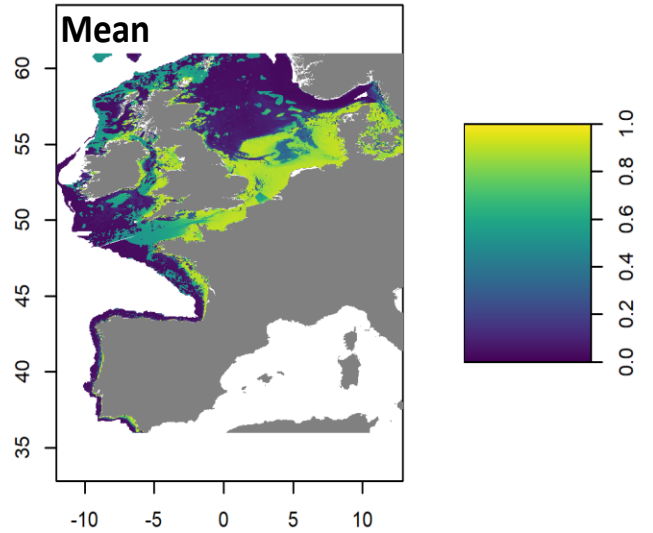
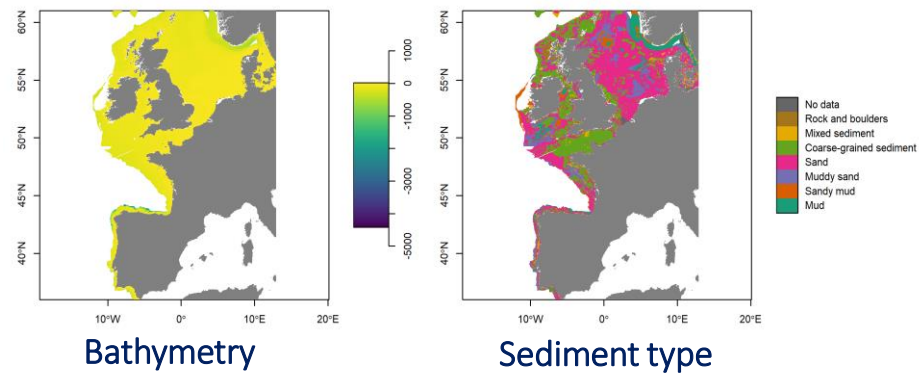


Scientific & fishing data



Principal Component Analysis of mixed data
 7D - Habitat space of the study area
 with approximation of the species habitat and
 random generation of pseudo-absence data

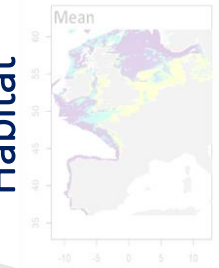
Habitat variables (EMODNET)



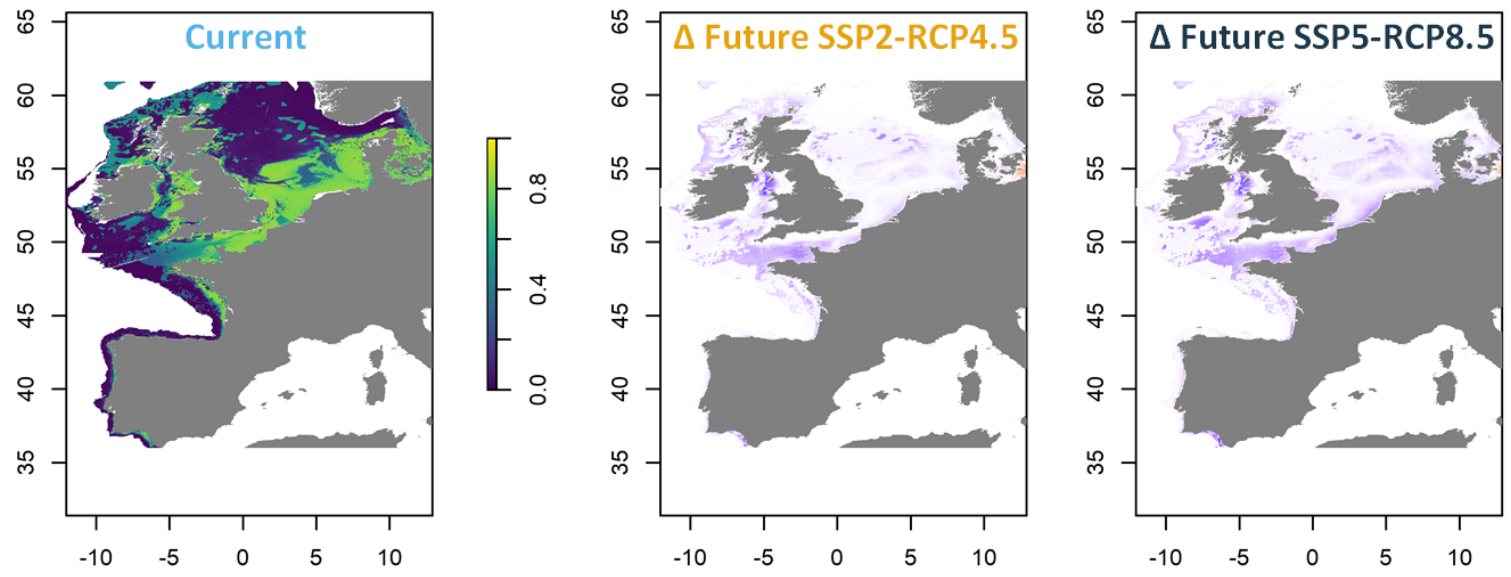
Bioclimatic



Habitat



Combined

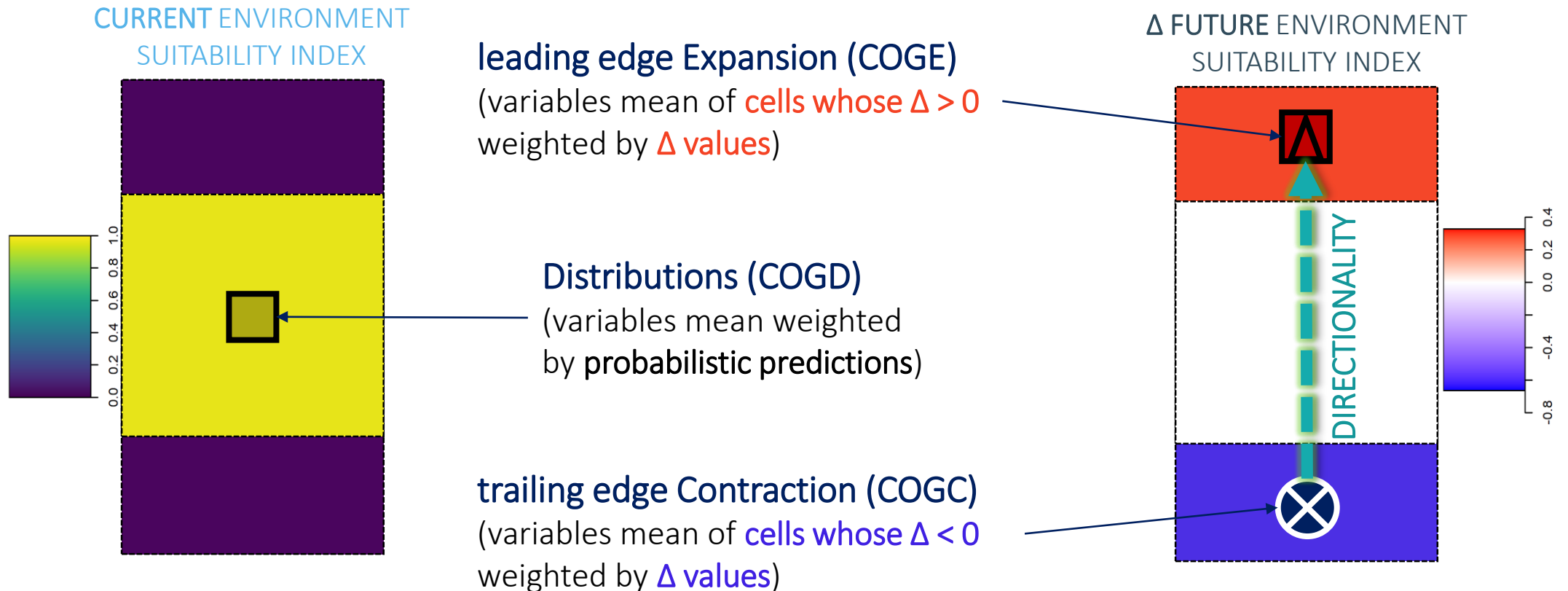


INRAE



Directionality and displacement shifts of the Centres Of Gravity for

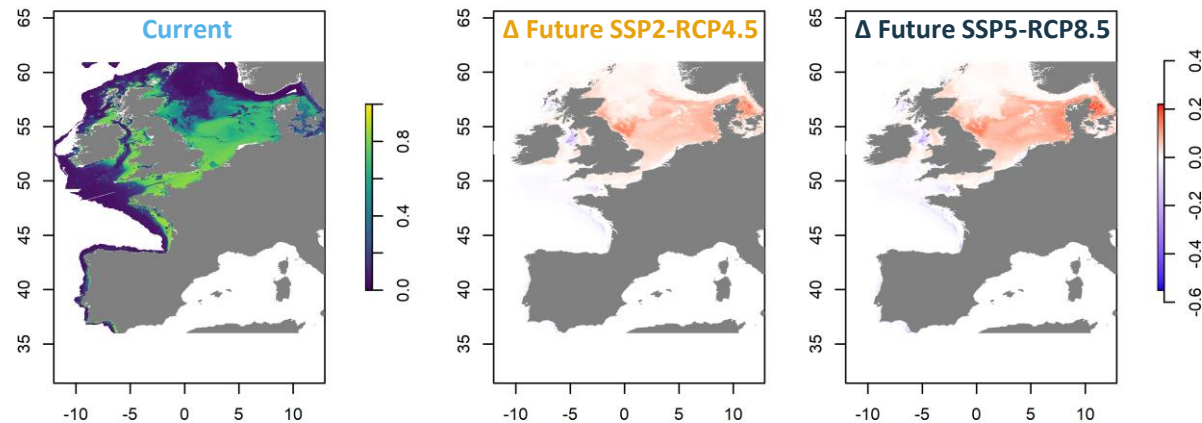
- Geographic coordinates
- Distance to the nearest coast / Bathymetry
- Bioclimatic variables



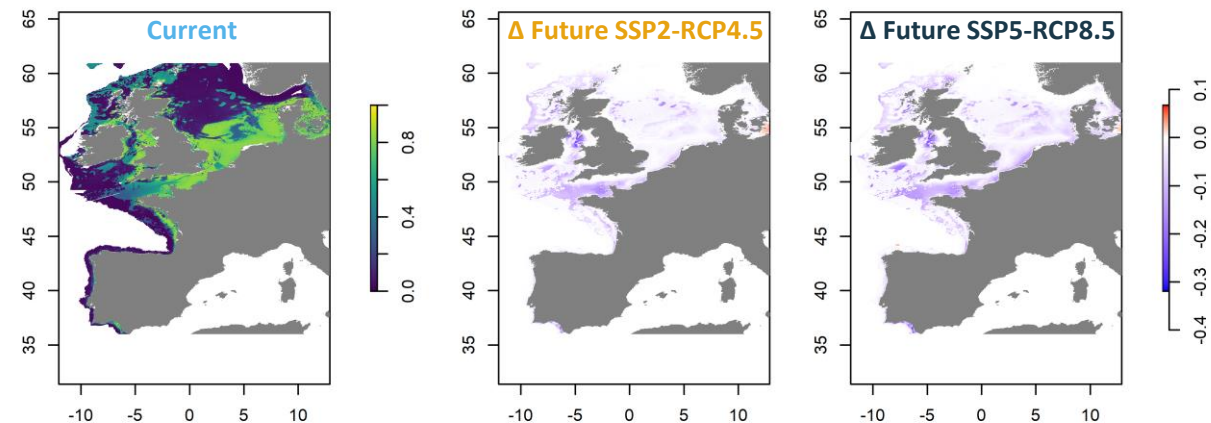
(Hiddink et al. 2014 ; Thorson et al. 2016 ; Friedland et al. 2018, 2021 ; Pinsky et al. 2020)



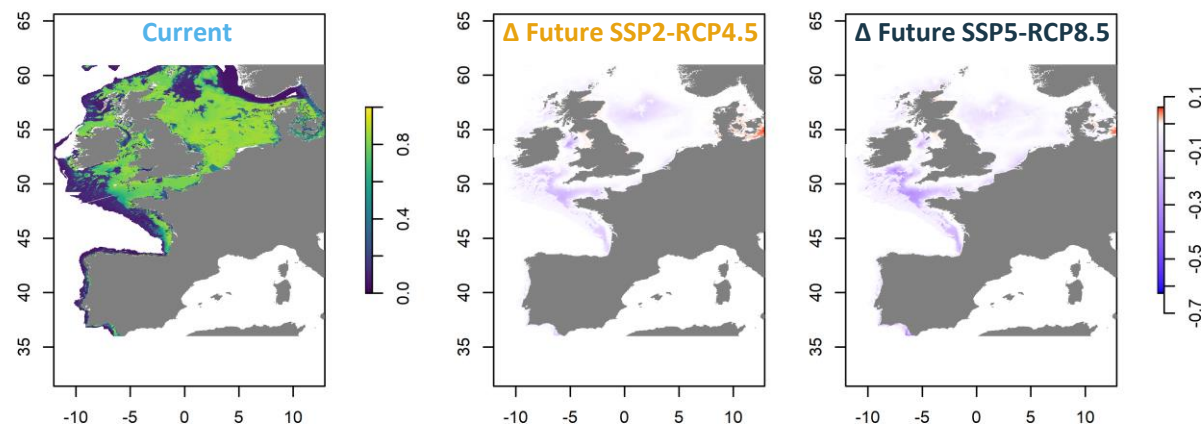
Dicentrarchus labrax



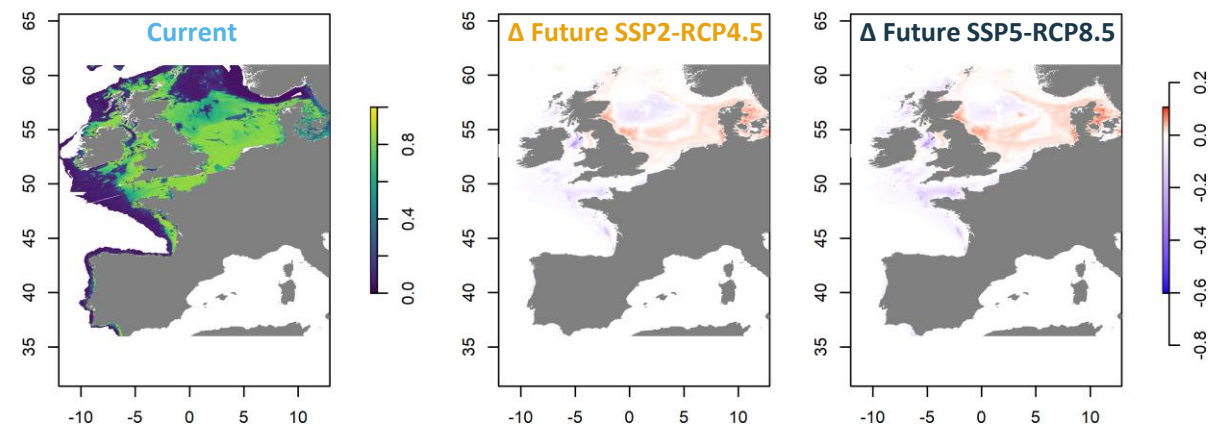
Platichthys flesus

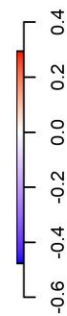
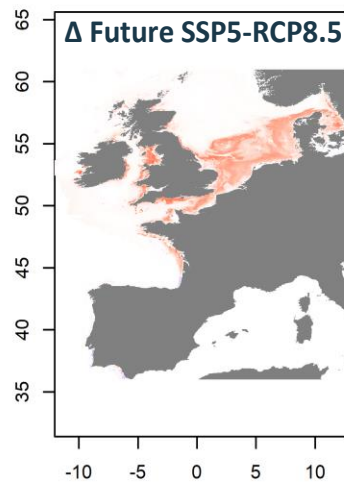
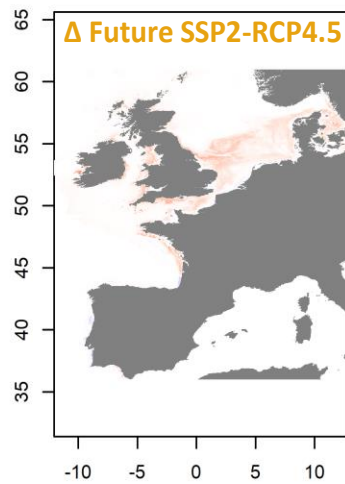
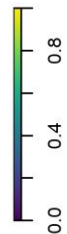
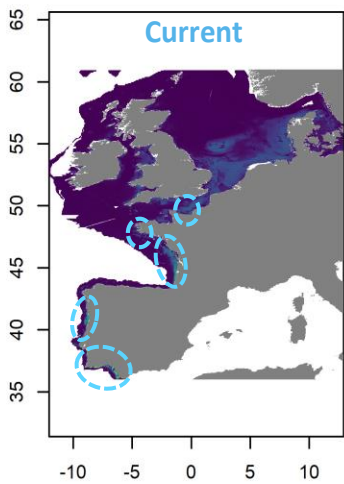
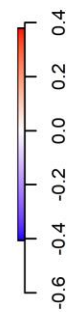
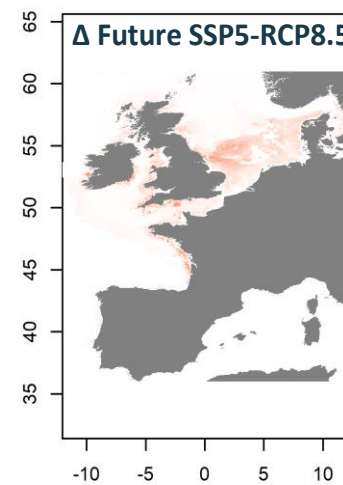
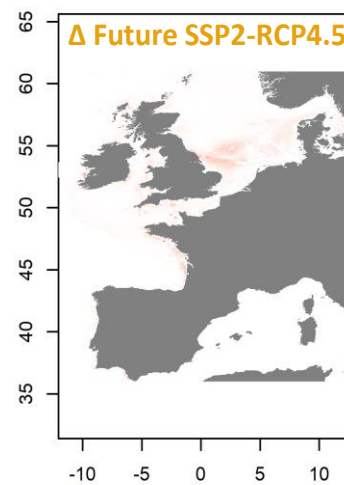
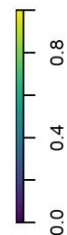
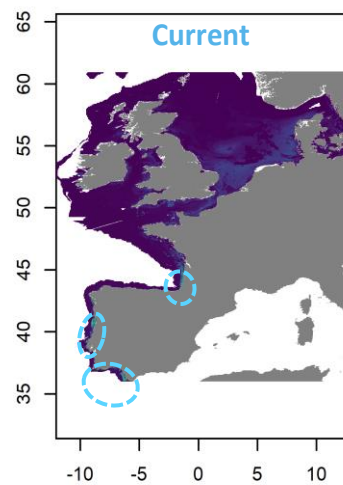


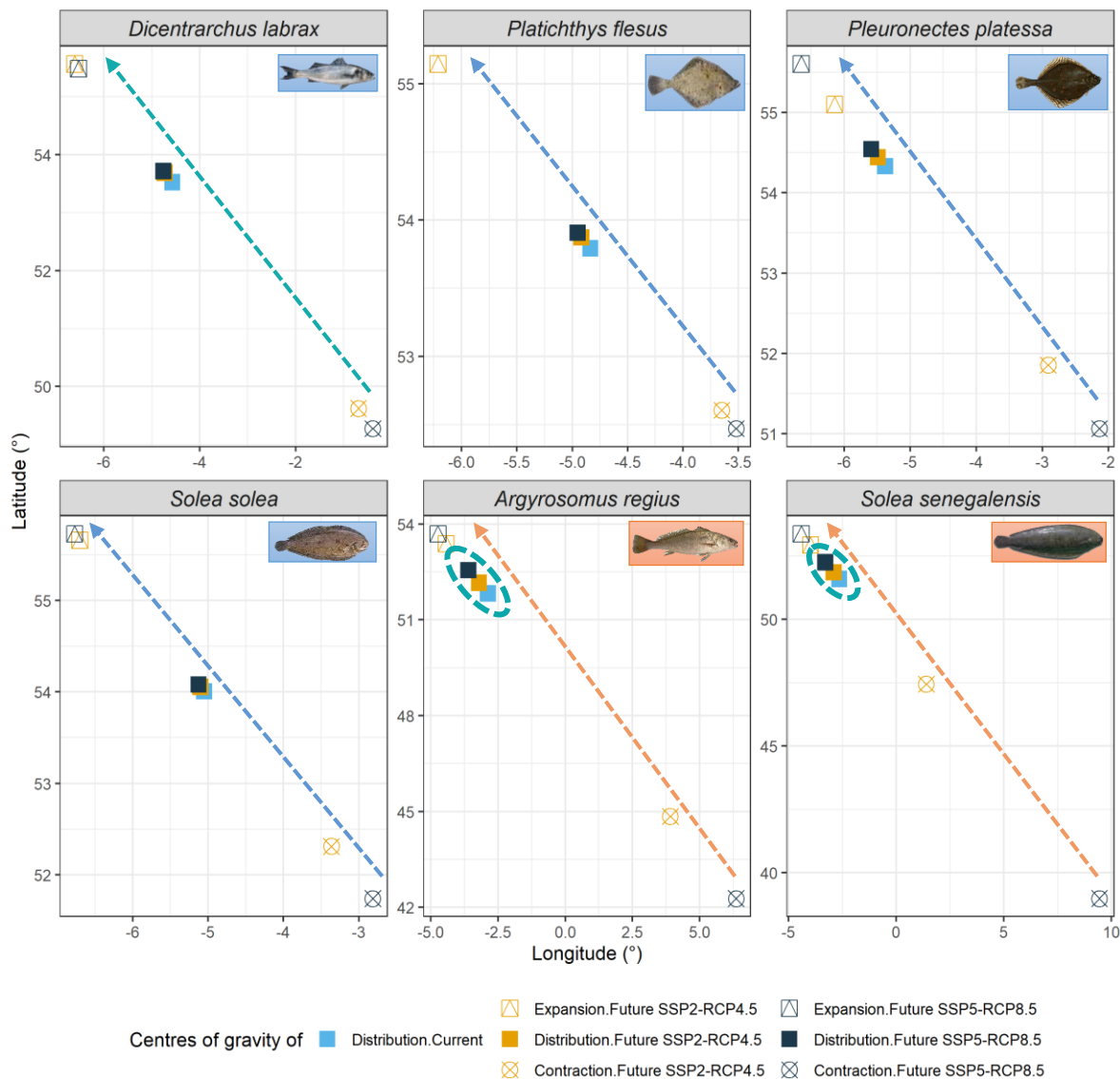
Pleuronectes platessa



Solea solea

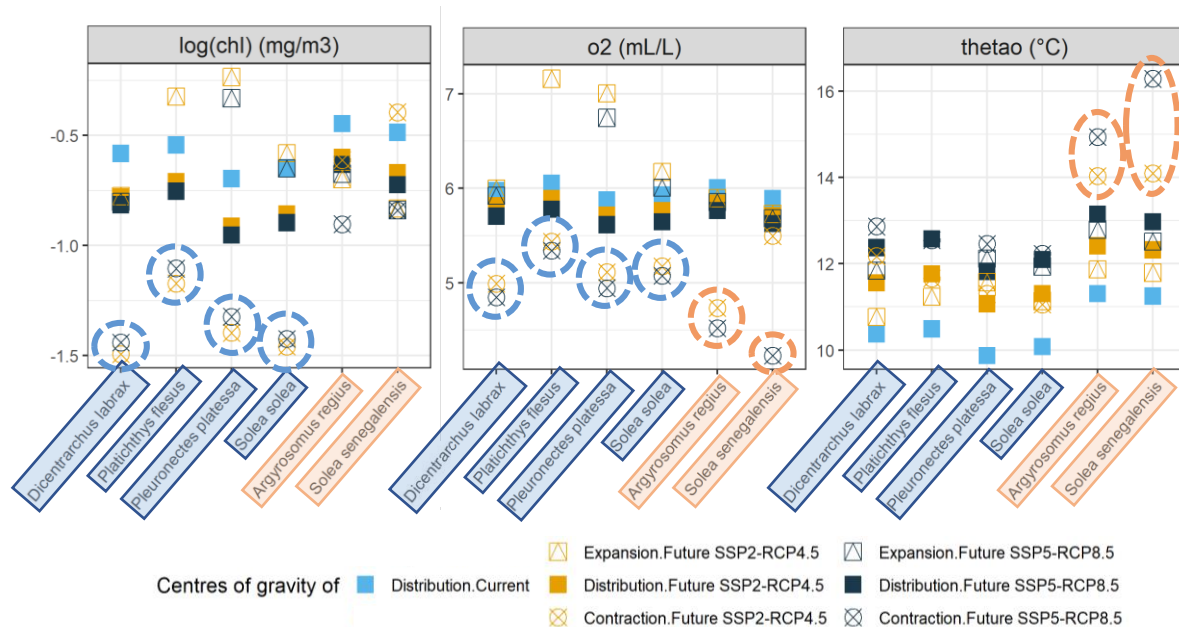


Argyrosomus regius*Solea senegalensis*



- Global and significant **north-westward** shift of increase in environment suitability index
- More to the north (69-75%) than to the west (25-28%)
- Northward shifts of COGDs more greater for **'sub-tropical' species** ($10 \text{ km.decade}^{-1}$ or $43 \text{ km.}^{\circ}\text{C}^{-1}$) compared to **'sub-boreal' species** ($1 - 3 \text{ km.decade}^{-1}$ or $4 - 12 \text{ km.}^{\circ}\text{C}^{-1}$)





- ‘Sub-boreal’ species will contract from areas that would tend to experience **lower chlorophyll-a** and **dissolved oxygen levels**
- ‘Sub-tropical’ species will contract from areas that would tend to experience **higher temperature** and **lower dissolved oxygen levels**



- Anthropogenic climate change induce a significant north-westward shift of increase in environment suitability

→ as also reported for other fish species in the Northeast Atlantic

(Núñez-Riboni et al. 2019; Boyd et al. 2020)



From zooplankton



To top predators

→ for other taxa in the Northeast Atlantic

(Wynn et al. 2007; Frederiksen et al. 2013; Chust et al. 2014)

→ in other northern temperate marine regions like the U.S Northeast continental shelf



Cod



Atlantic Mackerel

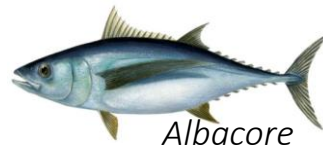


Red hake



Smooth dogfish

- Greater northward expansion for 'sub-tropical' species than for 'sub-boreal' species



Albacore

Like 'sub-tropical' Northeast Atlantic species
(Chust et al. 2019)



Atlantic Mackerel

Like 'sub-boreal' Northeast Atlantic species
(Bruge et al. 2016)

- Effects of climate change differ depending on the species affinity, and may be indirect (Pinsky et al. 2020)

- Future research: Models of connectivity between marine and estuarine environments to evaluate novel fish assemblage in nursery habitats





➤ Thank you for your attention

