Projecting Marine-Estuarine Opportunist fish distributions in the Northeastern Atlantic Ocean, under different climate scenarios

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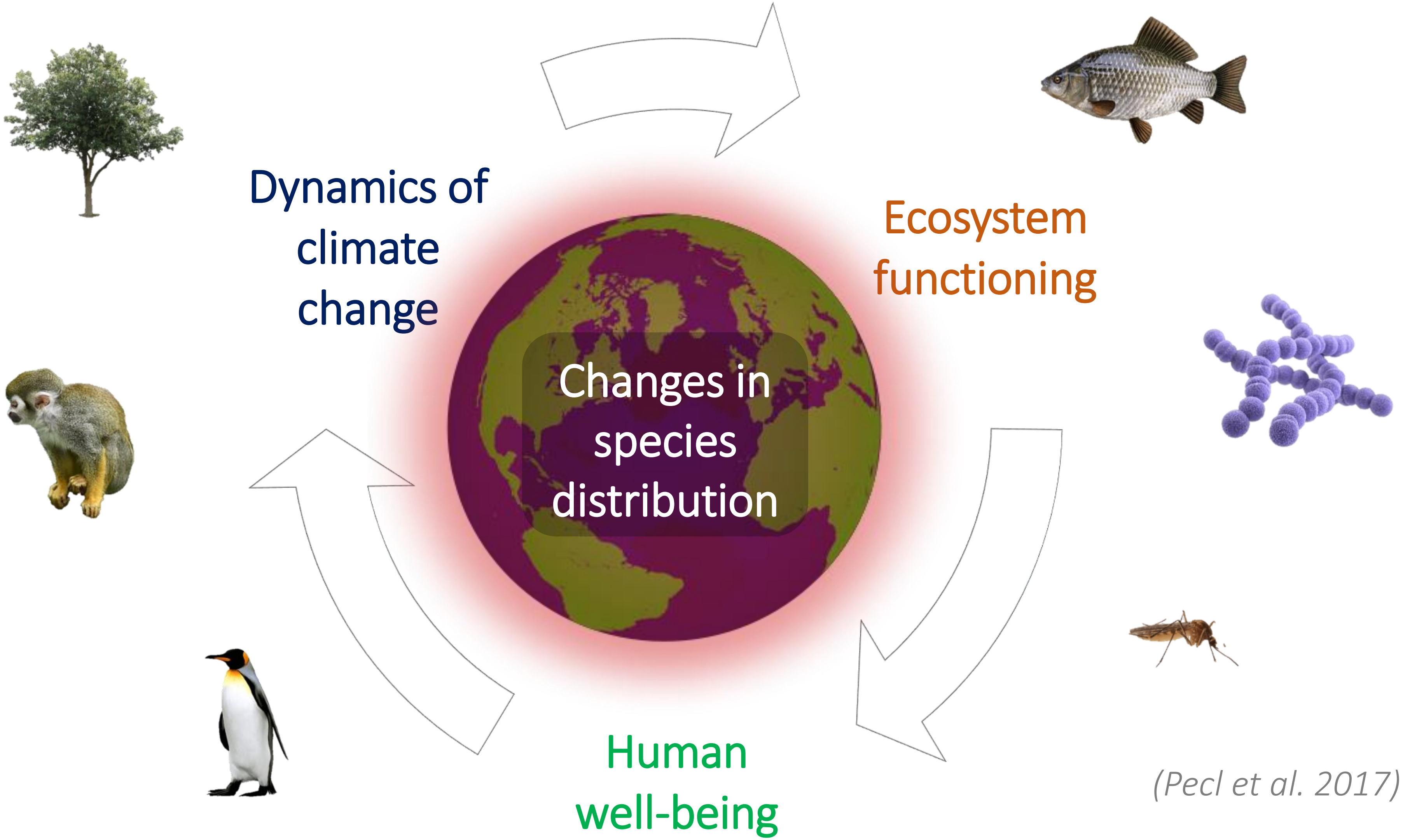
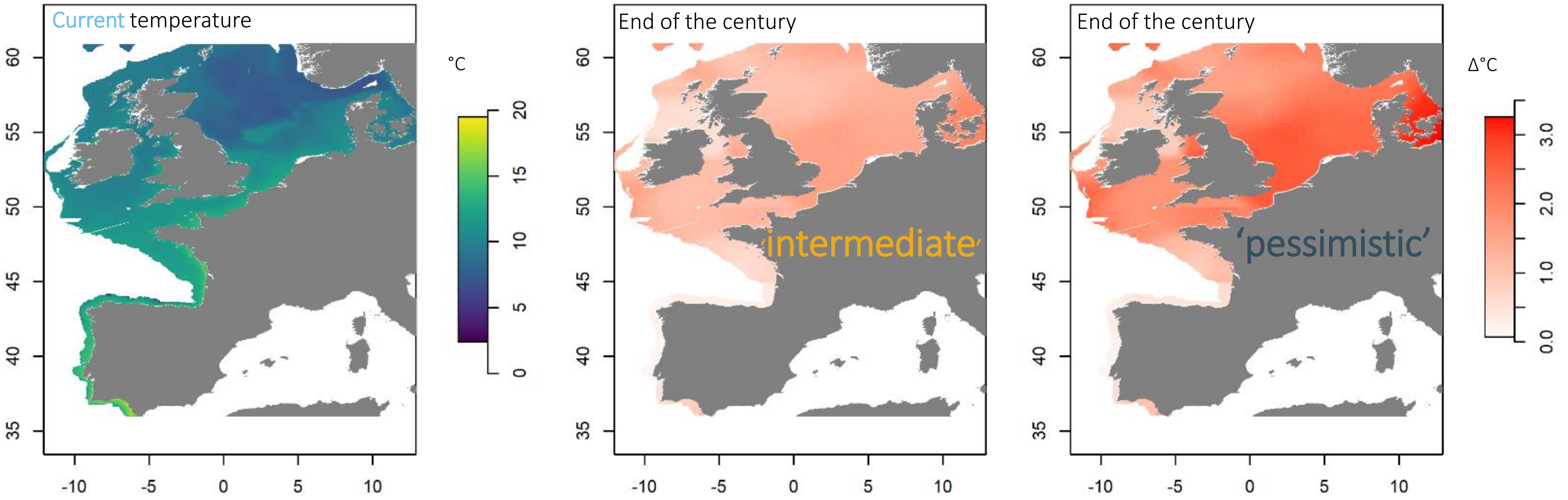
GLOBAL WARMING

Ecosystems and human well-being impacted by biodiversity redistribution



(Pecl et al. 2017)

- Temperate biogeographic transition zones increasingly exposed to climate change *(Ter Hofstede et al. 2010 ; Horta e Costa et al. 2014)*



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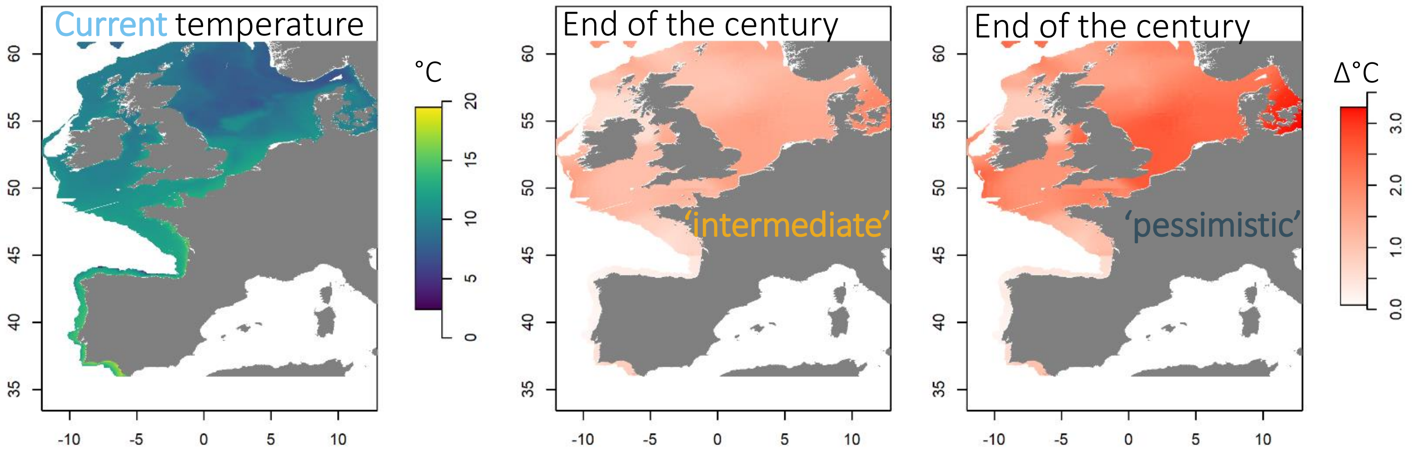

- Biogeographic affinities of marine-estuarine opportunist species *(Yang, 1982)*

 Seabass, *Dicentrarchus labrax*

 Flounder, *Platichthys flesus*

 Plaice, *Pleuronectes platessa*

 Common sole, *Solea solea*

Sub-boreal / temperate

'Boreal'
(northern, cooler water)

 Meagre, *Argyrosomus regius*

 Senegalese sole, *Solea senegalensis*

Sub-tropical

'Lusitanian'
(southern, warm water)

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Main working hypotheses

- Core and margins shifts of future environment suitability distributions (poleward range shifts, deepening, distance from the coasts)

- More evident shifts expected for sub-tropical species than for sub-boreal/temperate species

- More evident shifts expected under the ‘pessimistic’ than under the ‘intermediate’ climate scenario

Methodological approach

- ‘Hierarchical filters’ concept = combining the predictions of both final biomod2 ensemble forecasting

- Combination of

  Large-scale and time-varying bioclimatic variables

  Fine grained and no-time varying habitat variables

(Thuiller et al. 2009 ; Hattab et al. 2014 ; Fournier et al. 2017 ; Ben Rais Lasram et al. 2020)

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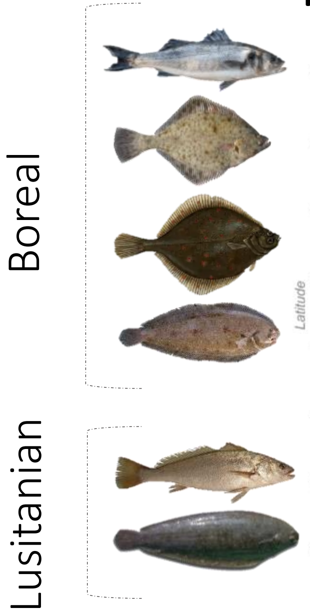
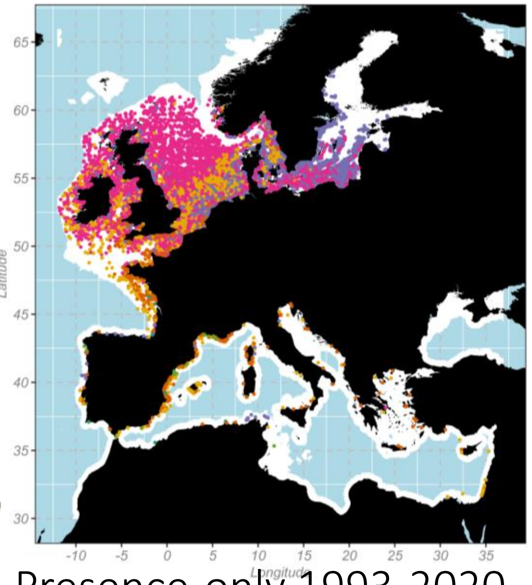
Participatory occurrence data





GBIF Global Biodiversity Information Facility

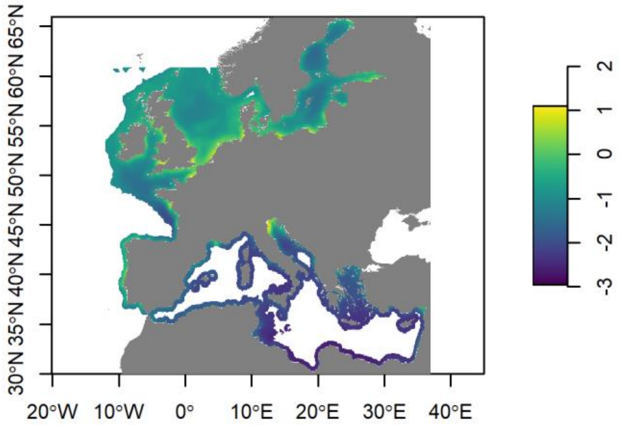
OBIS OCEAN BIOGEOGRAPHIC INFORMATION SYSTEM

iNaturalist

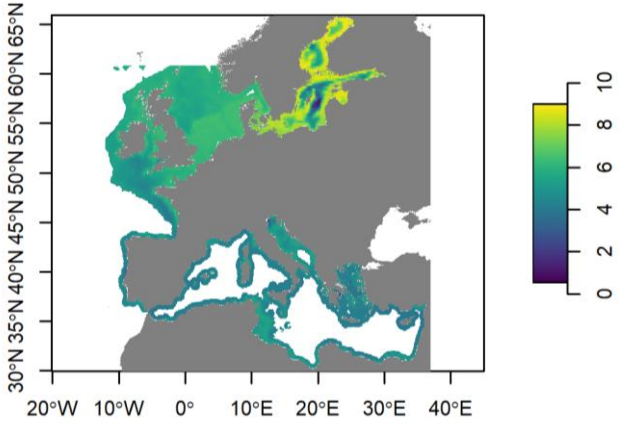
Vert-Net

Presence-only 1993-2020
< 300 m or < 50 km the coast

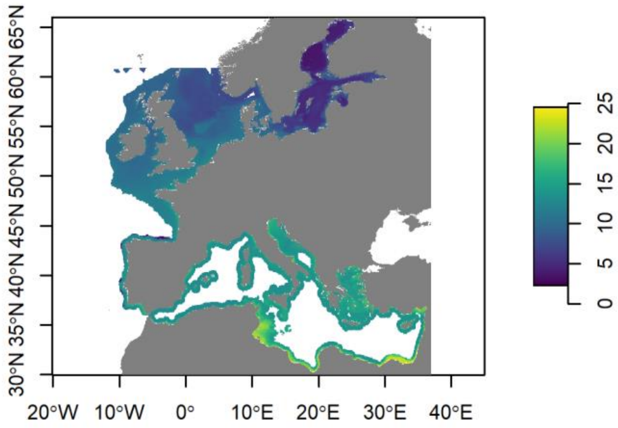
Bioclimatic variables *(Kristiansen & Butenschön, 2022)*



Bottom chlorophyll-a (log mg.m^{-3})



Bottom dissolved oxygen (mL.L^{-1})



Bottom temperature (°C)

5-8 CMIP6 models used for the downscaling
1/12° (≈ 6-7 km)

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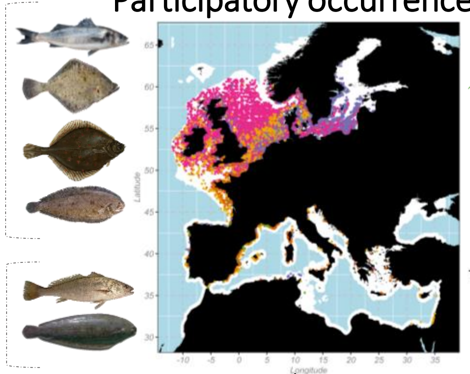
1. BIOCLIMATIC SUITABILITY MODELLING

Participatory occurrence data



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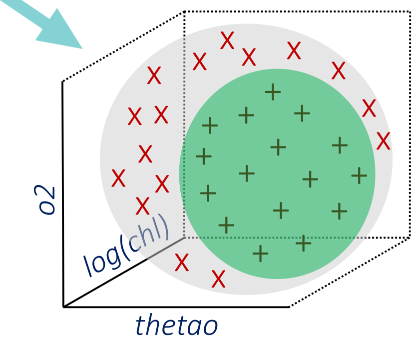
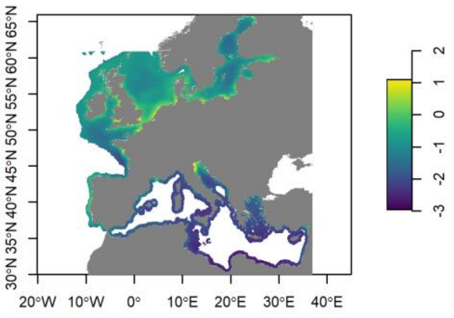
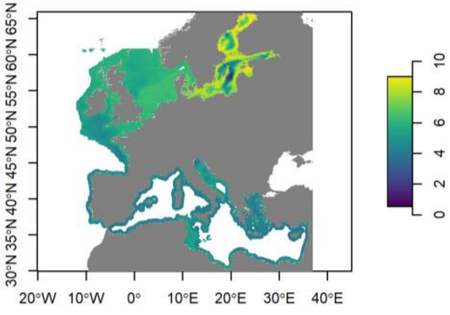
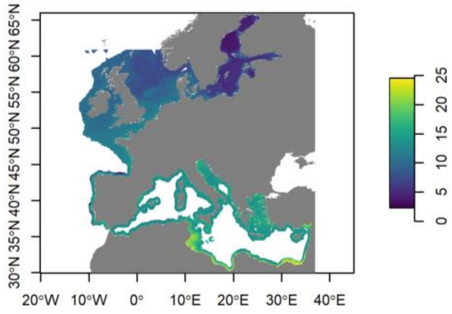


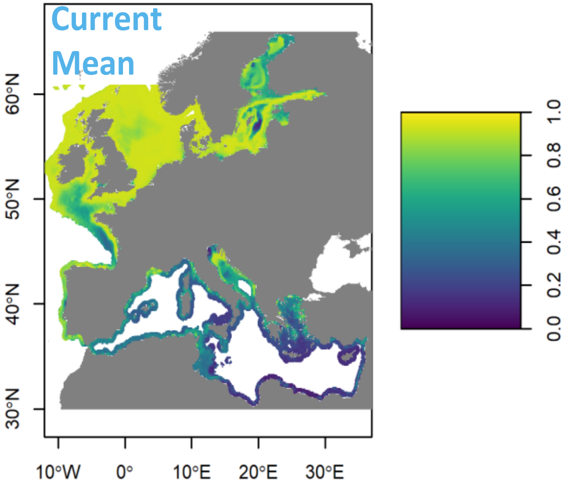
3D - Environmental space of the study area with approximation of the species ecological niche and random generation of pseudo-absence data

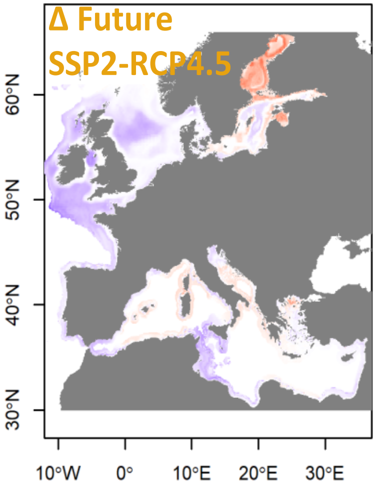
Bioclimatic variables *(Kristiansen & Butenschön, 2022)*

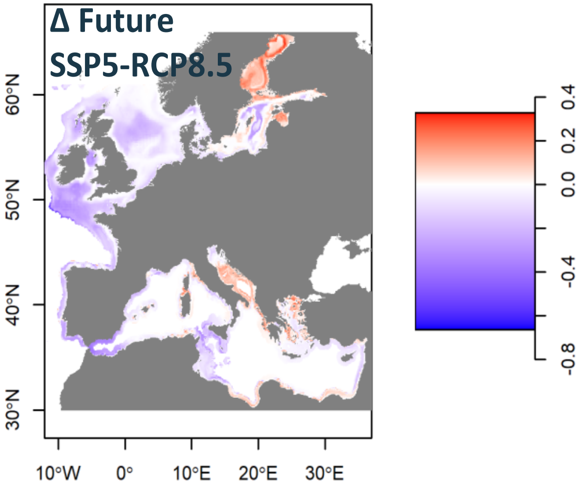

Bottom chlorophyll-a (log $mg.m^{-3}$)


Bottom dissolved oxygen ($mL.L^{-1}$)


Bottom temperature (°C)







5-8 CMIP6 models used for the downscaling
1/12° (≈ 6-7 km)
1993-2020 for calibration
2001-2020 for the current distribution projection
2080-2099 for the future distribution projection under two climate scenarios:
the SSP2-RCP4.5 'intermediate' and SSP5-RCP8.5 'pessimistic' scenarios

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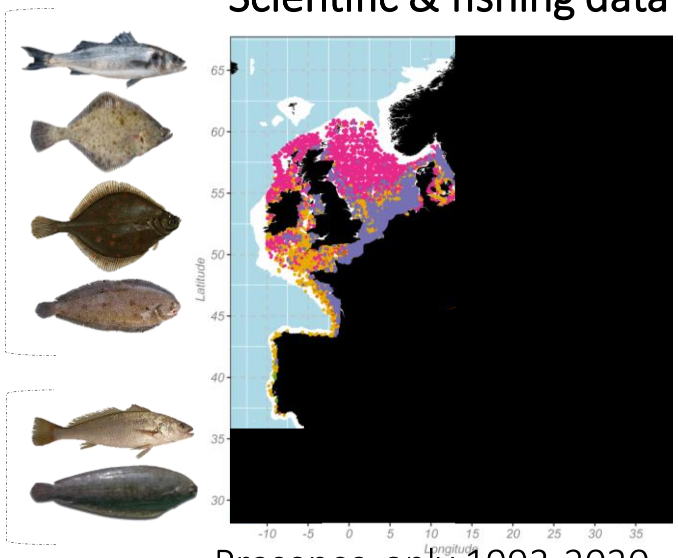
Scientific & fishing data

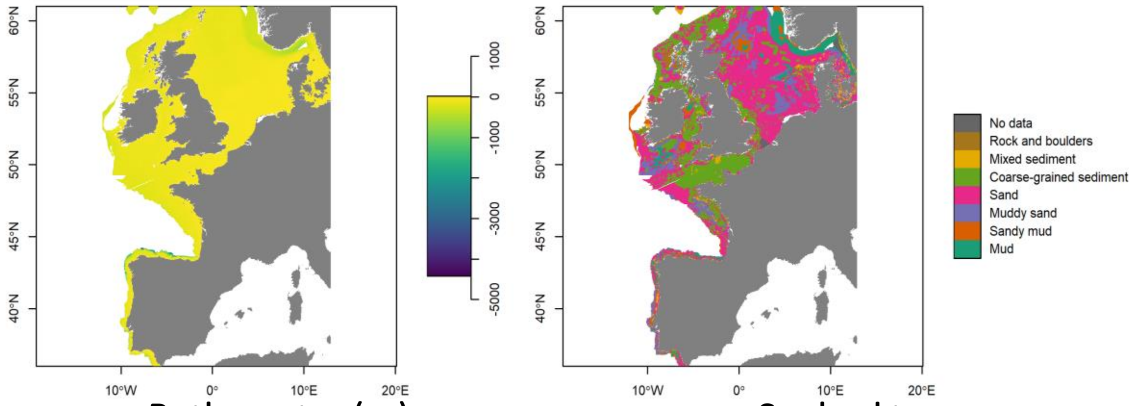


Ifremer

ICES CIEM International Council for the Exploration of the Sea / Conseil International pour l'Exploration de la Mer

Presence-only 1993-2020
< 300 m or < 50 km the coast

Habitat variables *(EMODNET)*



Bathymetry (m)

Seabed type

1/100° (≈ 800 m)
Species-specific zone in **Northeast Atlantic** with the most data for calibration
Northeast Atlantic for projection

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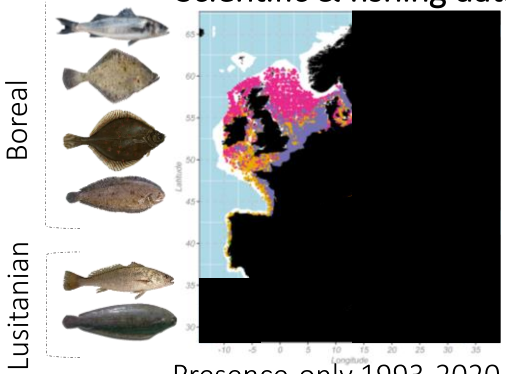
2. HABITAT SUITABILITY MODELLING

Scientific & fishing data



Ifremer

ICES CIEM

Presence-only 1993-2020
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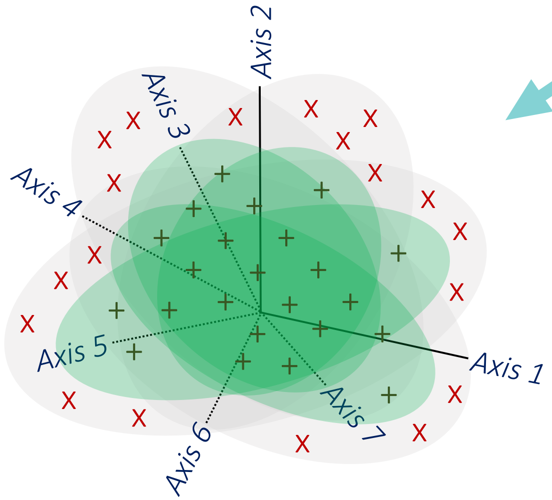
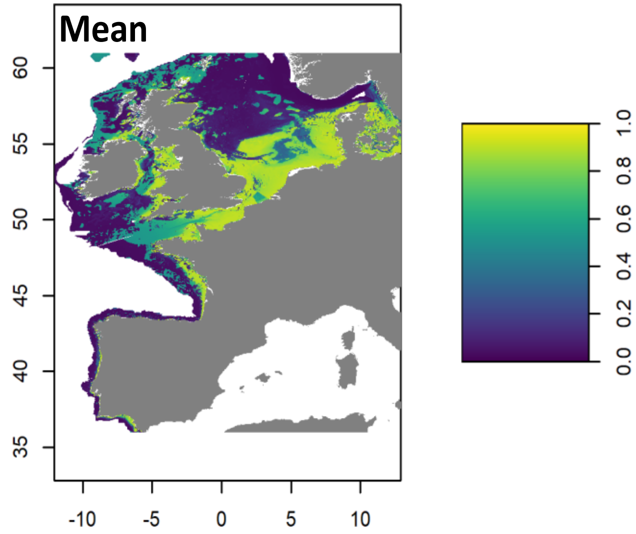


Principal Component Analysis of mixed data
(Hill & Smith, 1976)
7D - Habitat space of the study area
with approximation of the species habitat and
random generation of pseudo-absence data



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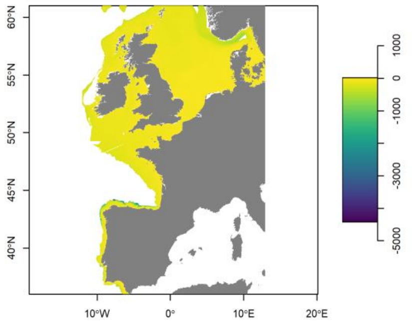
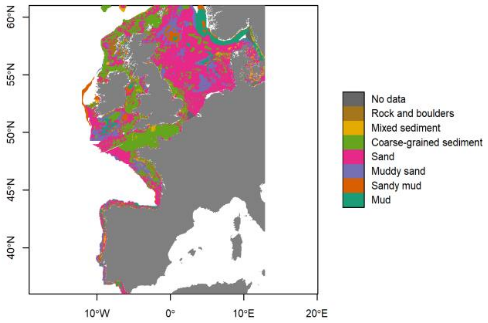


Bathymetry (m)



Seabed type

1/100° (≈ 800 m)
Species-specific zone in Northeast Atlantic
with the most data for calibration
Northeast Atlantic for projection

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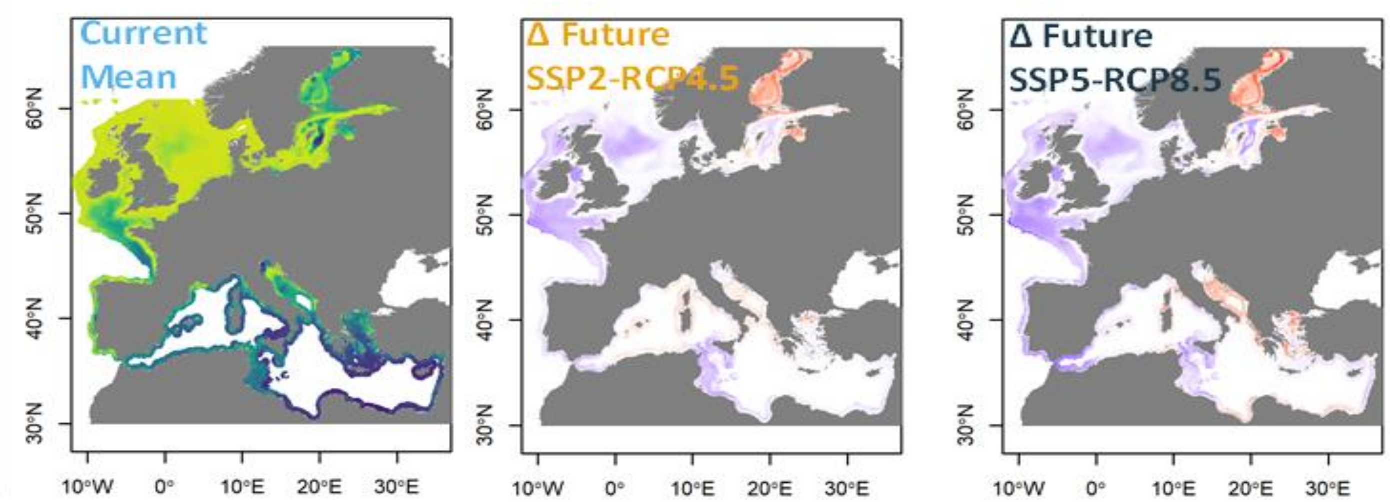
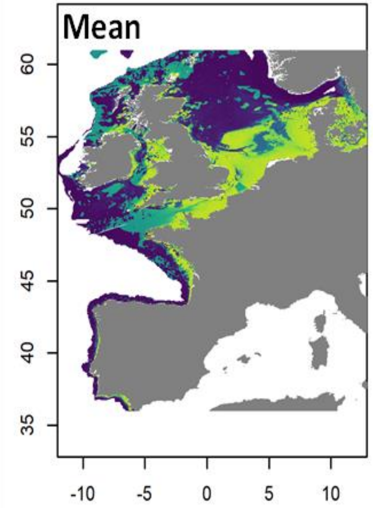
3. ENVIRONMENT SUITABILITY

Bioclimatic



Habitat



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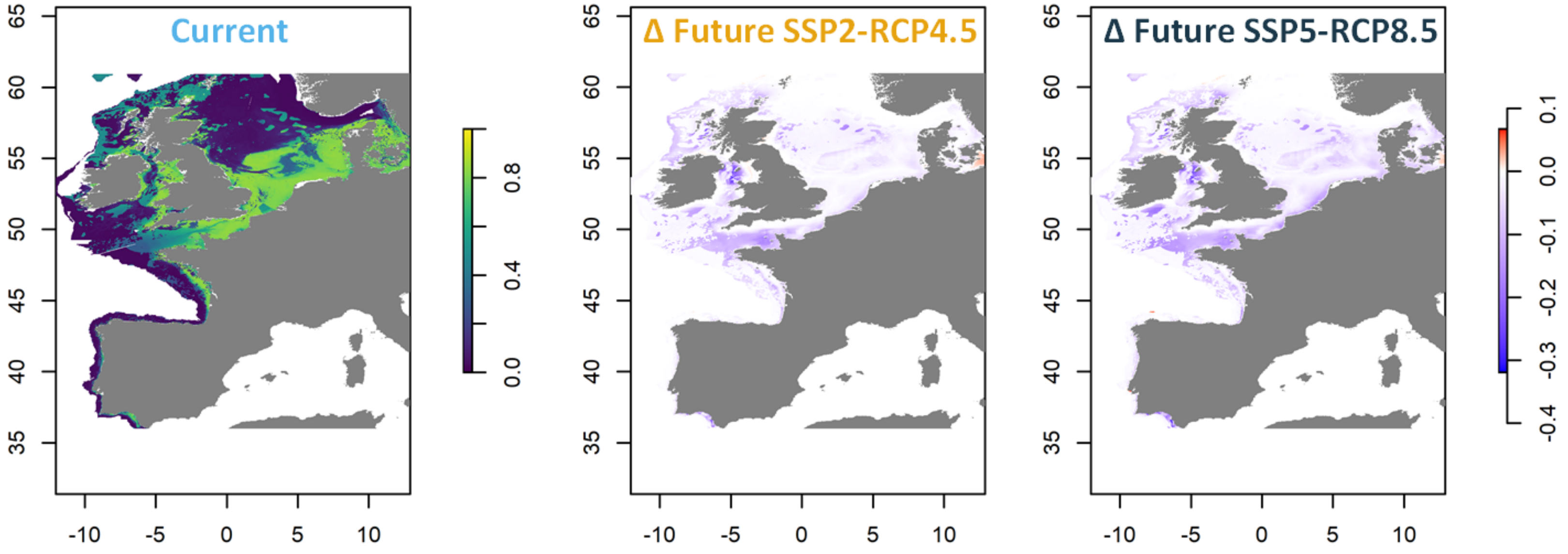
Δ Future
SSP5-RCP8.5

Mean

Combined


Current
Δ Future SSP2-RCP4.5
Δ Future SSP5-RCP8.5
65
60
55
50
45
40
35
-10
-5
0
5
10
0.0
0.4
0.8
0.1
0.0
-0.1
-0.2
-0.3
-0.4

Indicators of distribution shifts in environment suitability

Directionality and displacement shifts for geographic coordinates / distance to the nearest coast / bathymetry / bioclimatic variables of the Centres Of Gravity of

- Distributions (COGDs) (variables mean weighted by probabilistic predictions)
  - ⇨ core distribution where bioclimatic conditions assumed to be suitable
- leading edge Expansions (COGEs) (variables mean of cells whose Δ > 0 weighted by Δ values)
  - ⇨ core areas where environment suitability ↗
- trailing edge Contractions (COGcs) (variables mean of cells whose Δ < 0 weighted by Δ values)
  - ⇨ core areas where environment suitability ↘

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

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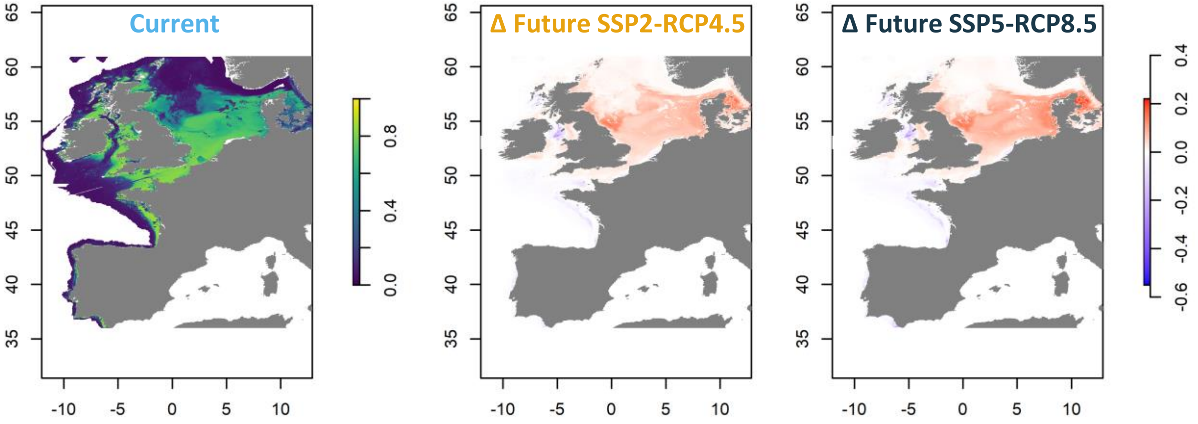
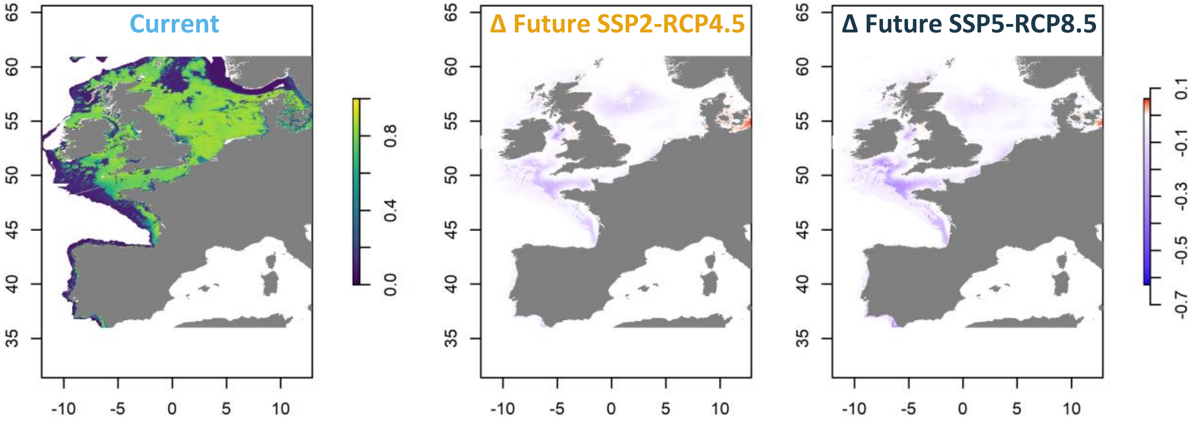
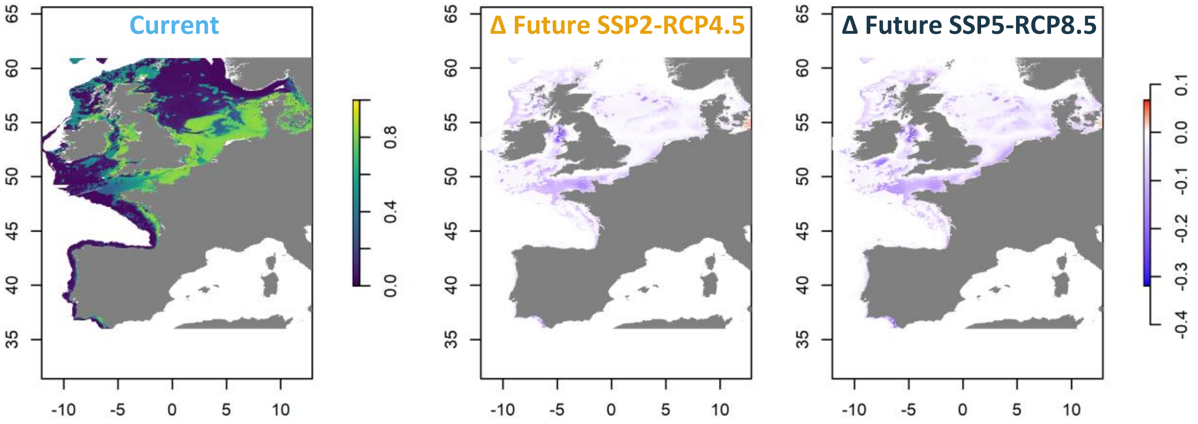
Dicentrarchus labrax



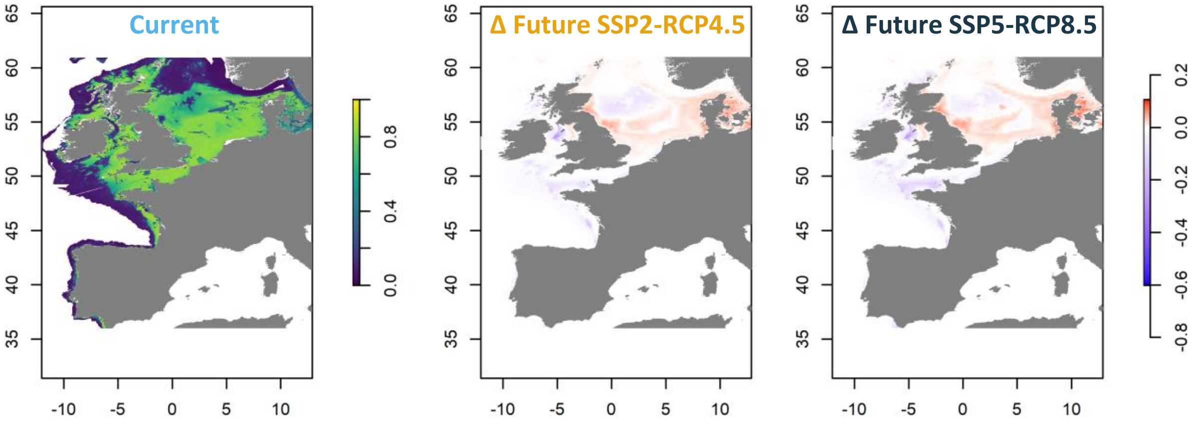
Pleuronectes platessa



Platichthys flesus



Solea solea



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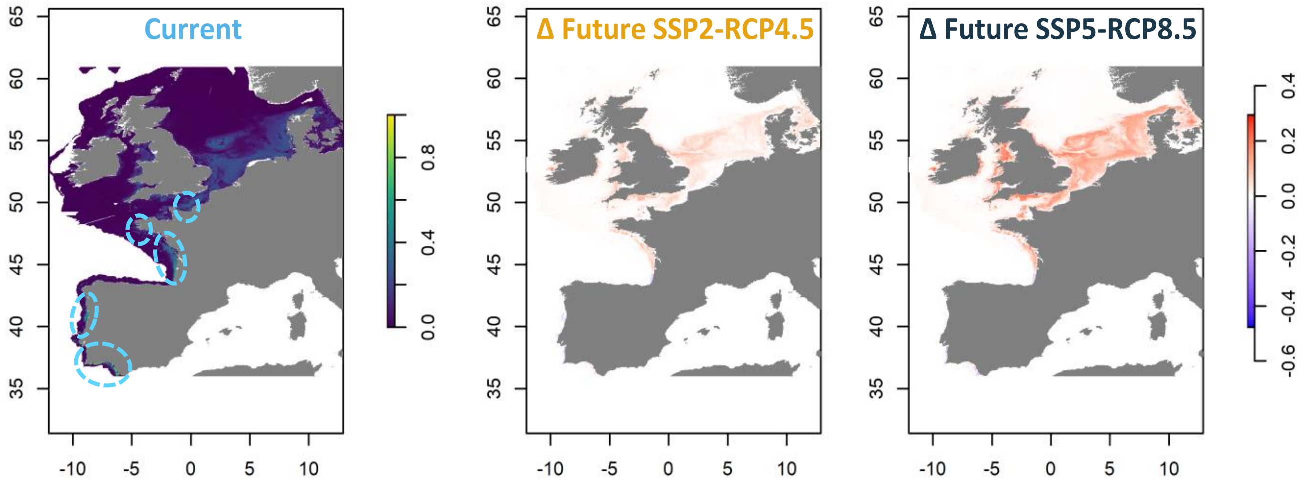
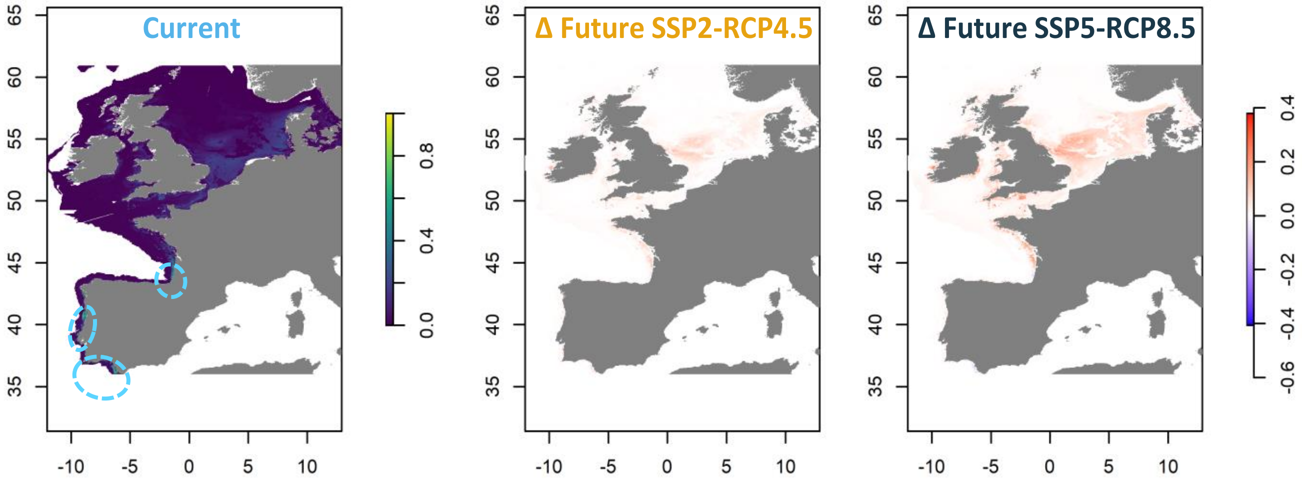
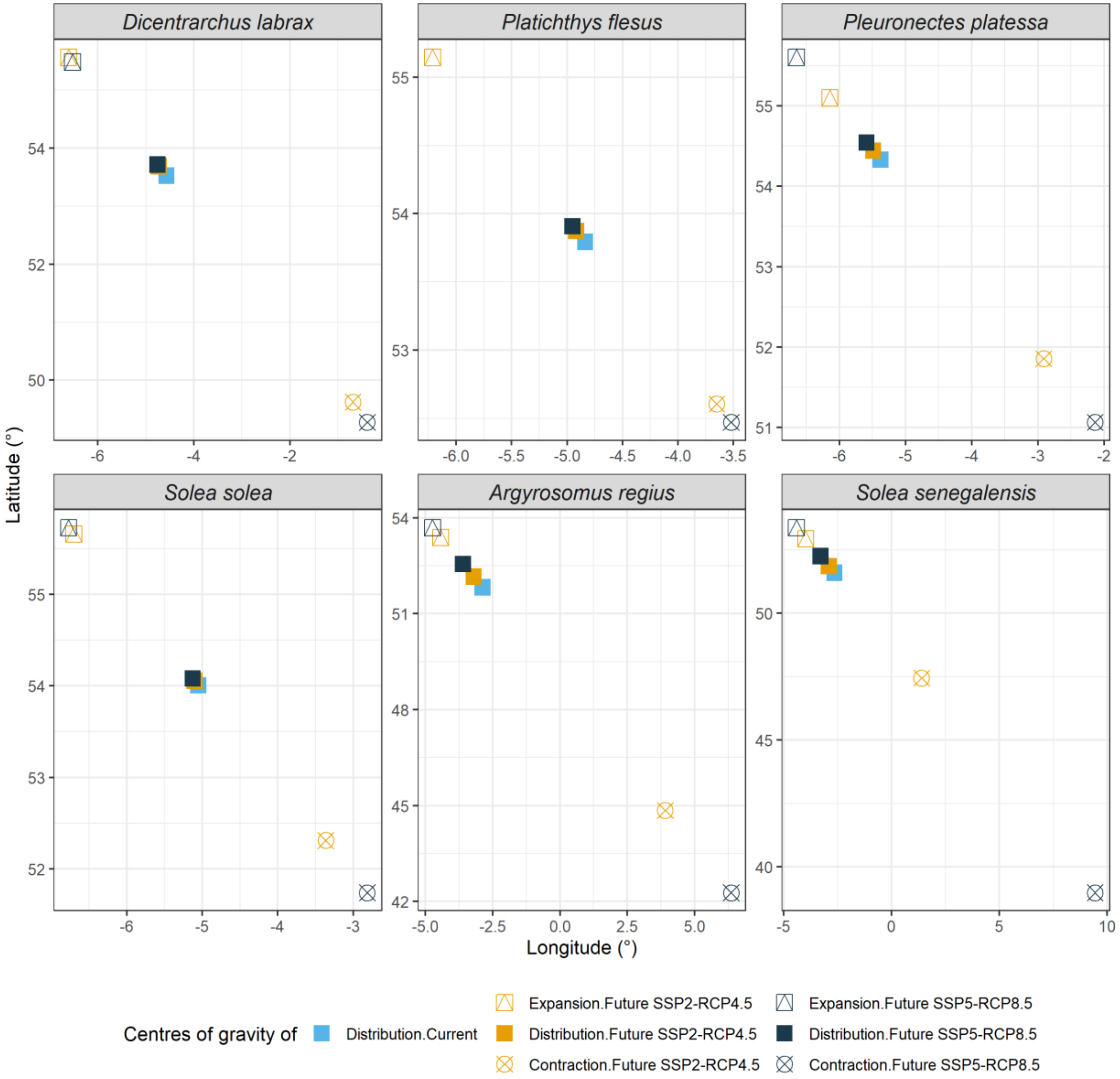
Argyrosomus regius



Solea senegalensis





Dicentrarchus labrax
Platichthys flesus
Pleuronectes platessa
Solea solea
Argyrosomus regius
Solea senegalensis
Latitude (°)
Longitude (°)
Centres of gravity of
Distribution.Current
Expansion.Future SSP2-RCP4.5
Distribution.Future SSP2-RCP4.5
Contraction.Future SSP2-RCP4.5
Expansion.Future SSP5-RCP8.5
Distribution.Future SSP5-RCP8.5
Contraction.Future SSP5-RCP8.5

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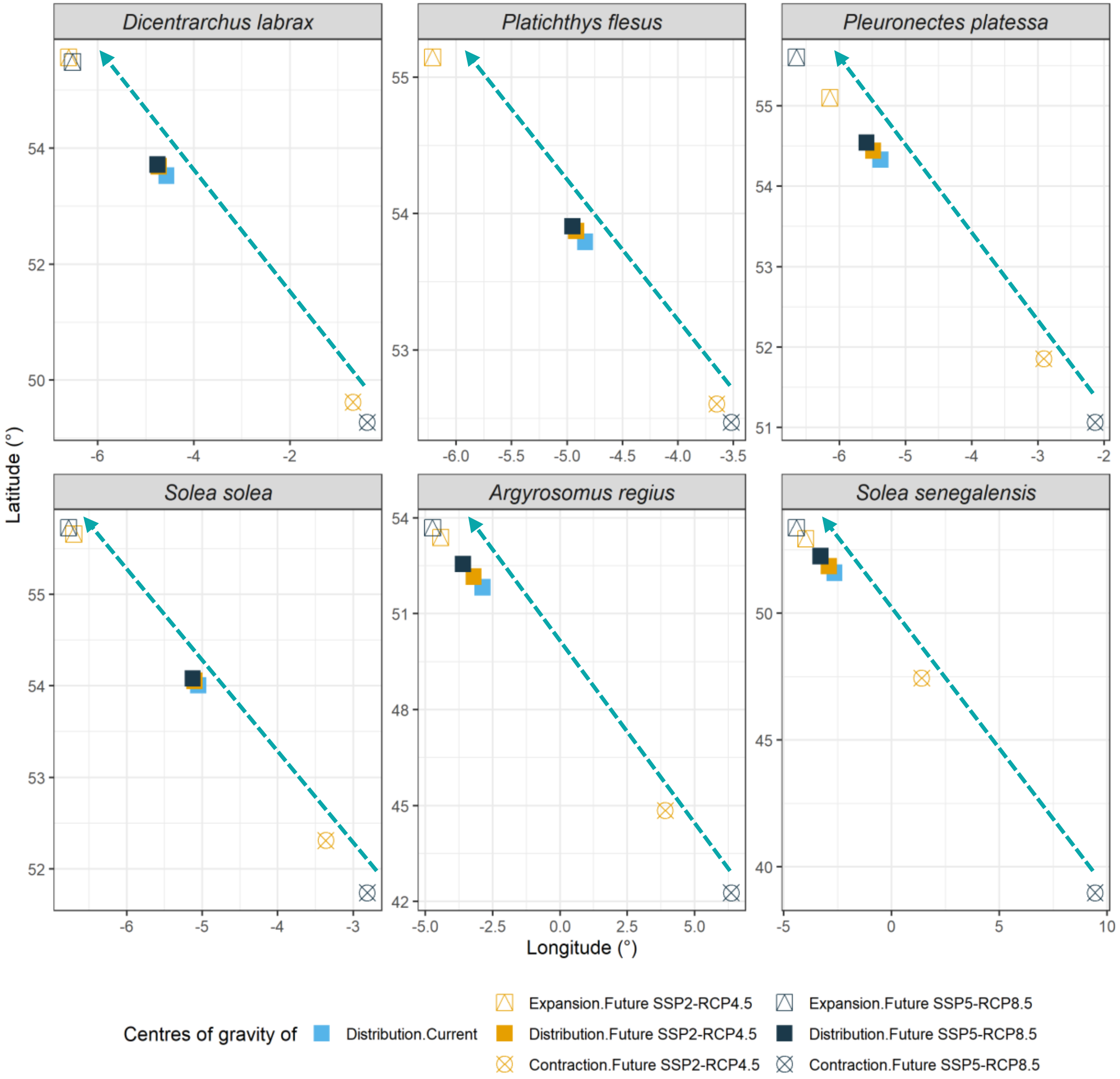
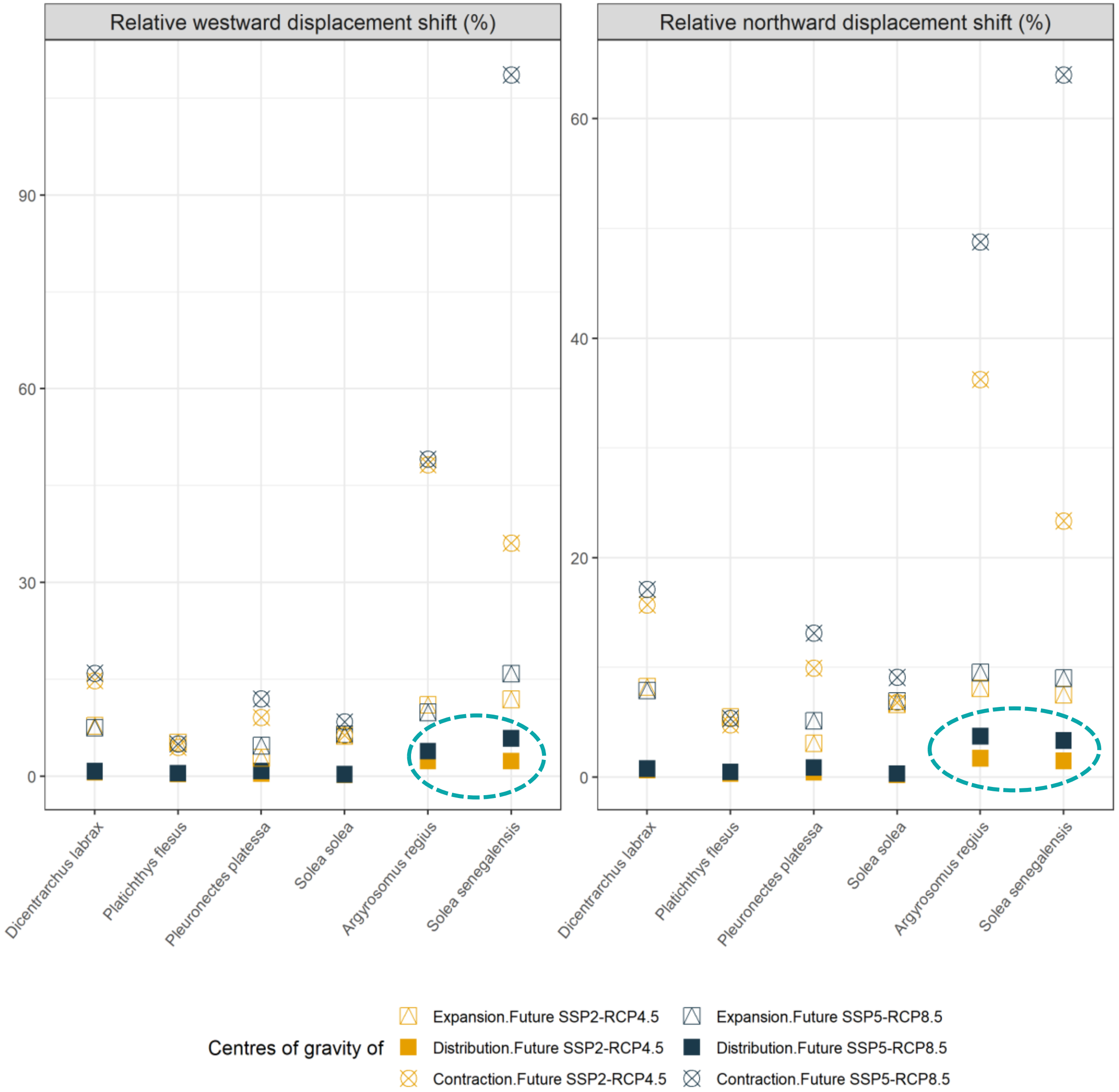


- Global and significant **north-westward** of the shift of ↗ in probabilistic environment suitability predictions
- **Mostly to the north** (69-75%) than to the west (25-28%)



- Global and significant **north-westward** of the shift of ↗ in probabilistic environment suitability predictions

- **Mostly to the north** (69-75%) than to the west (25-28%)

- Shifts of COGDs more pronounced for lusitanian species (**73-81 km north or 3-4%** relative to the height of the species range and **45-50 km west or 4-6%** relative to the width of the species range) compared to boreal species (**8-24 km north or 0-1%** and **5-14 km west or 0-1%**)

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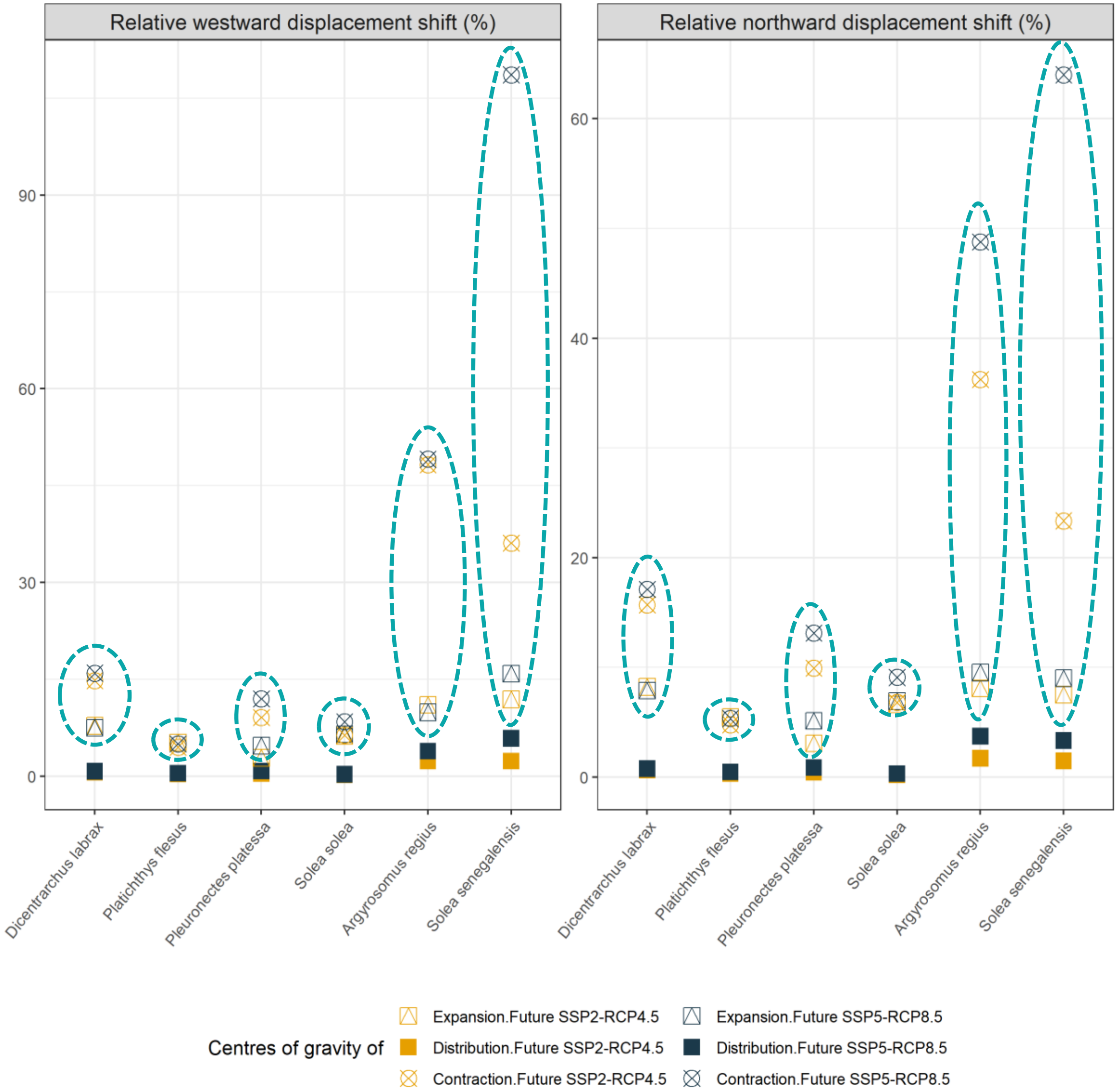

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- Overall, shifts much greater for COGEs and COGCs than for COGDs

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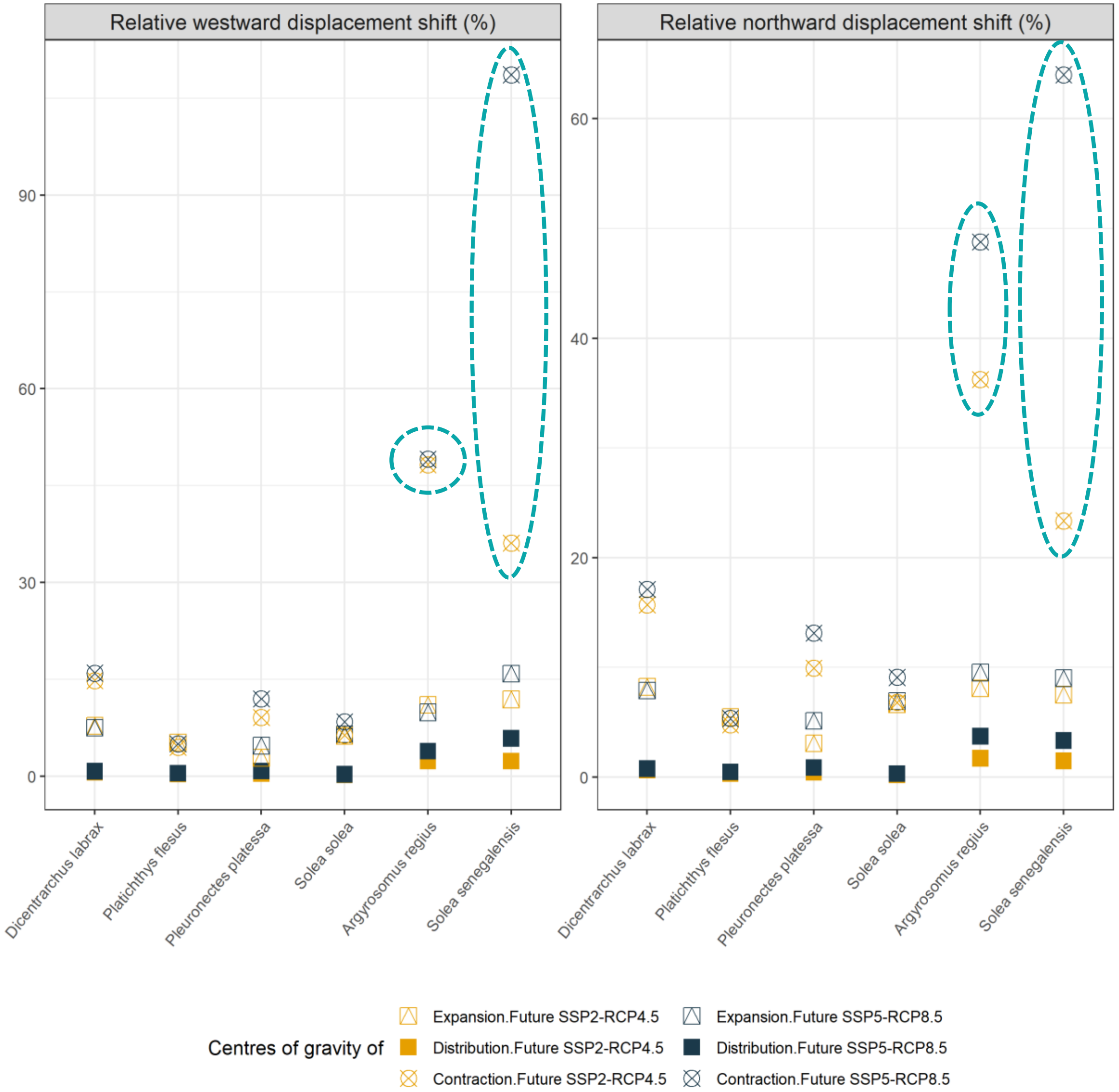

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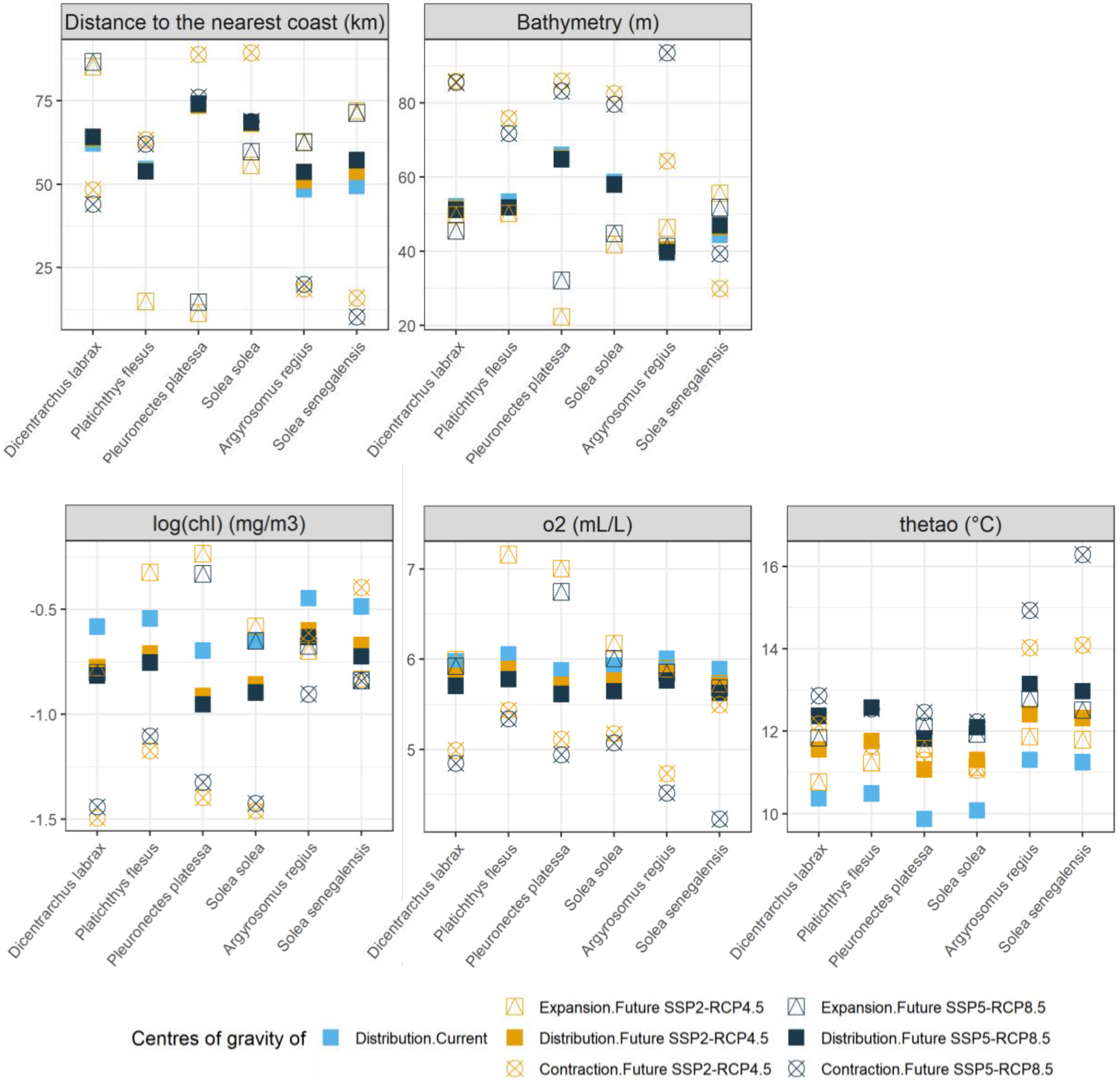
- Overall, **shifts much greater for COGEs and COGCs than for COGDs**

- However, shifts much greater for COGCs than for COGEs especially for lusitanian species



- **A small shift for COGDs towards areas far from the coast** for lusitanian species

- **Significant shift** of ↗ in probabilistic environment suitability predictions towards
  - **Shallower areas closer to the coast** for flounder, plaice and common sole
  - **Deeper areas far from the coast** for Senegalese sole
  - **Shallower areas far from the coast** for seabass and meagre

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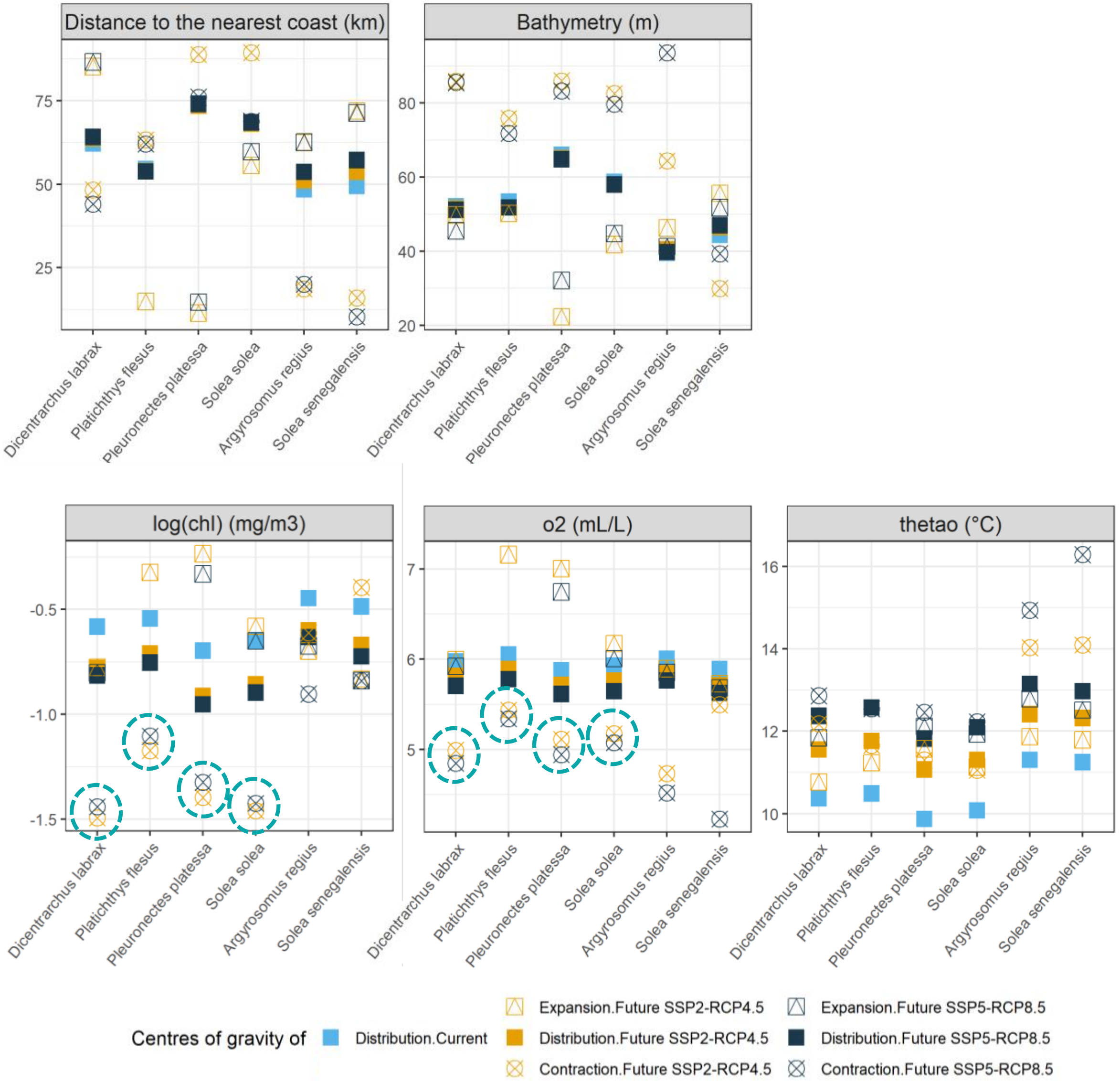

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- Boreal species will contract from areas that would tend to experience lower chlorophyll-a and dissolved oxygen levels

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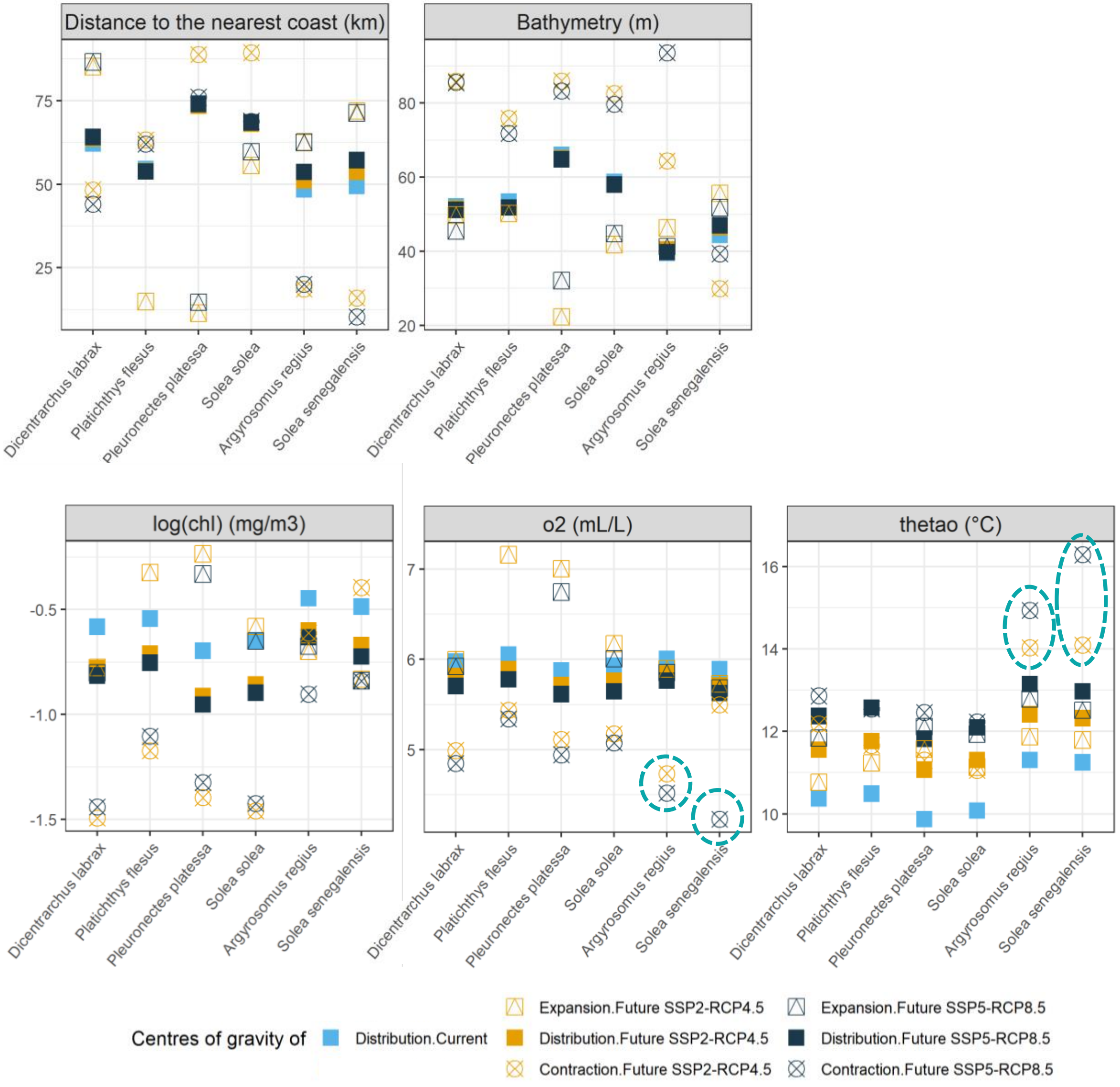

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  - **Shallower areas far from the coast** for seabass and meagre

- Boreal species will contract from areas that would tend to experience **lower chlorophyll-a and dissolved oxygen levels**

- Lusitanian species will contract from areas that would tend to experience **lower dissolved oxygen and higher temperature levels**

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Main conclusions and perspectives

- **Climate change induce a significant northwestward shift** of in probabilistic environmental suitability predictions (as also reported for other fish species: Perry et al. 2005 ; Dulvy et al. 2008 ; Chust et al. 2018)

- **Effects of climate change differ depending on the species** affinity, and may be **indirect** (due to the effects of temperature on chlorophyll-a and dissolved oxygen)

- The dynamics of **changes in boundaries more intense and complex** compared to changes in centres of distributions (Hastings et al. 2018 ; Pinsky et al. 2020)

- Future research will use **Hierarchical Modelling** of Species Communities (inclusion of the influence of biotic and random processes, species-specific life history traits and inter-species phylogenetic relationships), **Hybrid models** (inclusion of species-dispersal capacities and population dynamics' parameters) and **Models of connectivity** (between marine and estuarine environments to evaluate novel fish assemblage in nursery habitats).

Thank you for your attention