

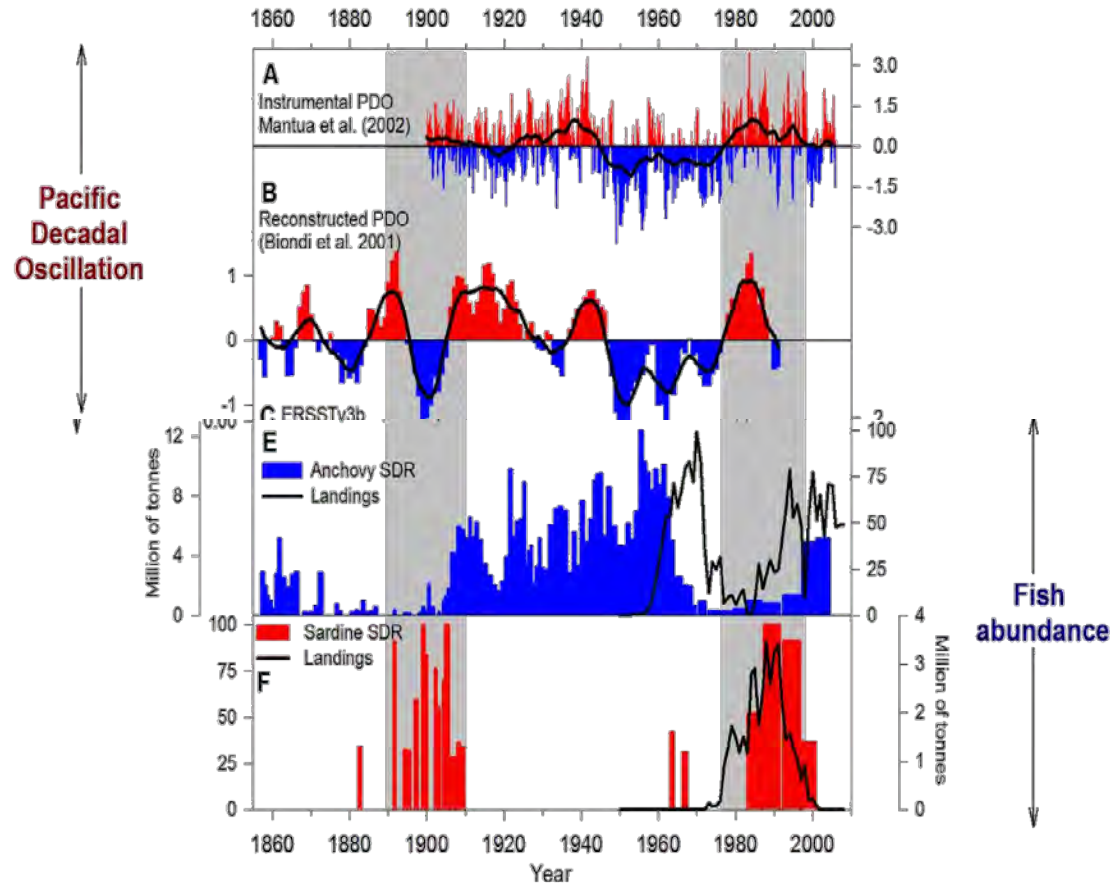
Climate change scenario experiments predict a future reduction in small pelagic fish recruitment in the Humboldt Current system

Timothée Brochier, Vincent Echevin, Jorge Tam, Alexis Chaigneau, Katerina Goubanova and Arnaud Bertrand



1 - Introduction

The Humboldt current system:
(Current) High productivity, and variability of SPF abundance at a variety of spatiotemporal scales. No clear cycles (e.g. PDO) or alternations.



Pacific
Decadal
Oscillation

Fish
abundance

Larval dynamics is a strong
constraint to recruitment

Salvatteci et al. (this symposium)

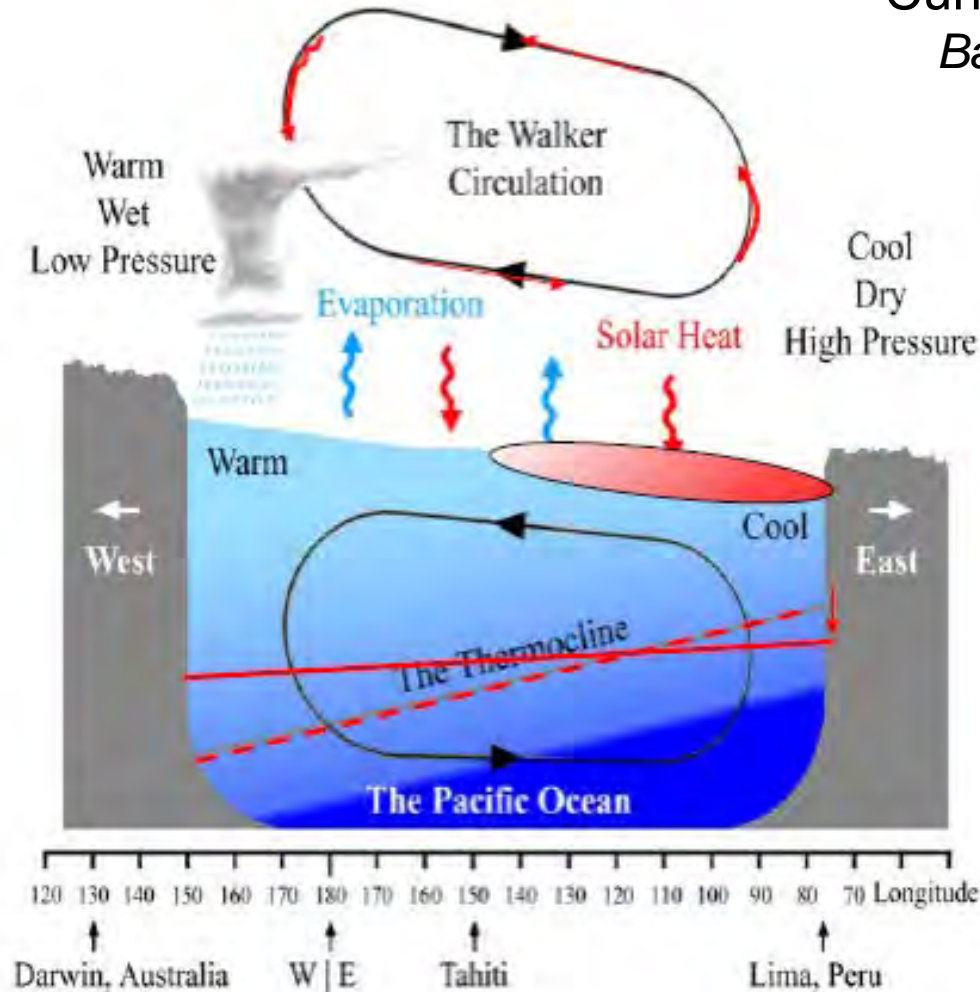
→ Impact of climate change on larval survival (retention in nursery area)?

Introduction

Climate change in the Humboldt Current System: Physical forcings

- Changes in Equatorial atmospheric circulation: the Walker cell

Current increase in coastal wind (e.g. Bakun, 1990; Sydeman et al., 2014)



But models predict that Global warming should weaken the Walker cell

Vecchi et al. (2006), Vecchi and Soden (2006)



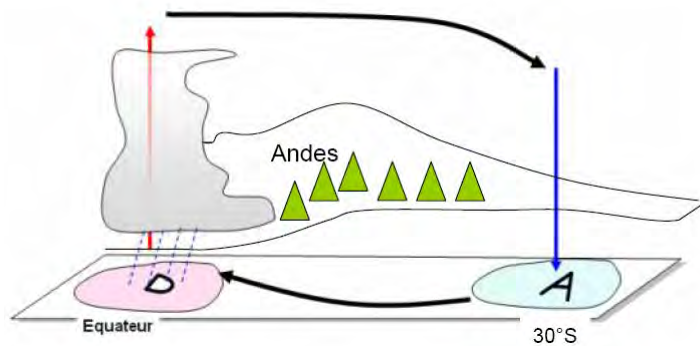
Weakening of coastal winds along the Peruvian coast?

Introduction

Climate change in the Humboldt Current System: Physical forcings

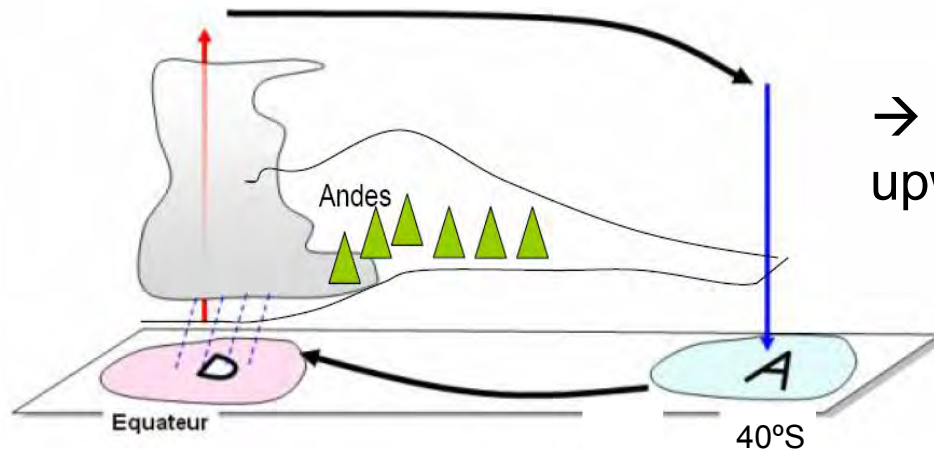
- Changes in longitudinal atmospheric circulation: the Hadley cell

Current Climate



Global warming : poleward shift of the Hadley Cell (*Falvey and Garreaud, 2009; Goubanova et al., 2011*)

Futur Climate

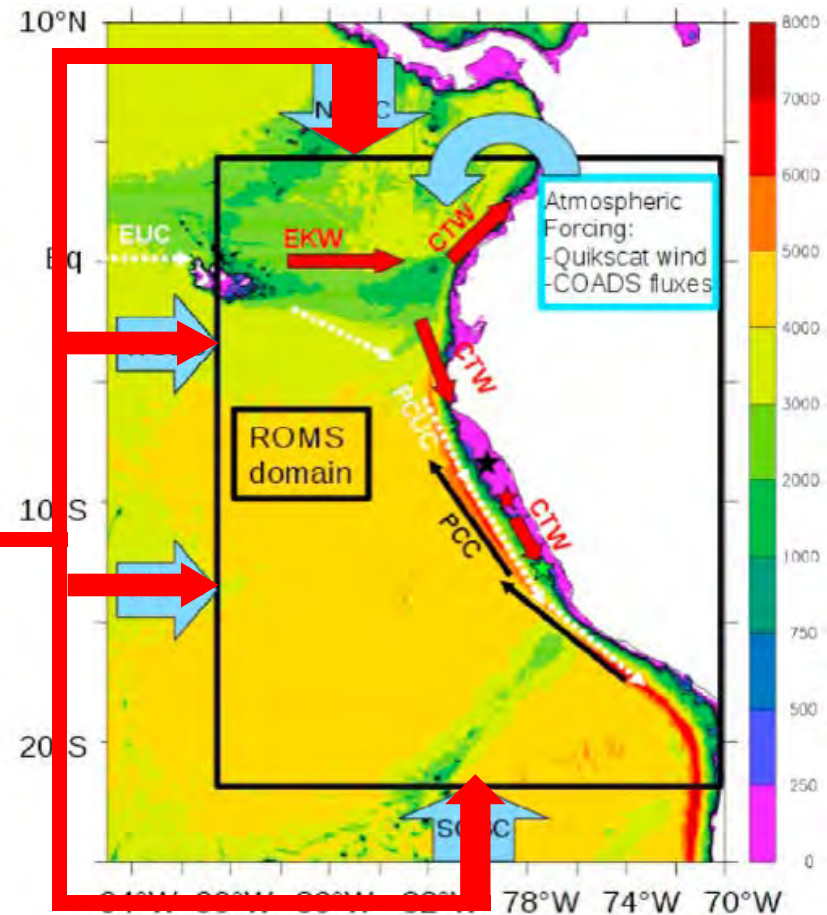
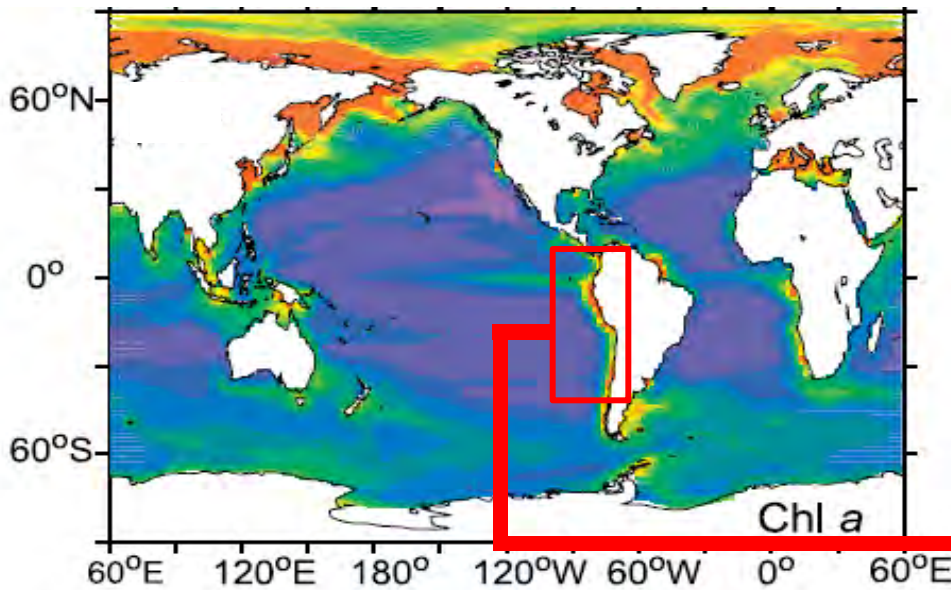


→ Southward extension of the upwelling area?

2 - Regional downscaling of a numerical simulation

Global Model IPSL-CM4 (resolution ~200 km)

Regional Model ROMS/PISCES (resolution ~20 km)

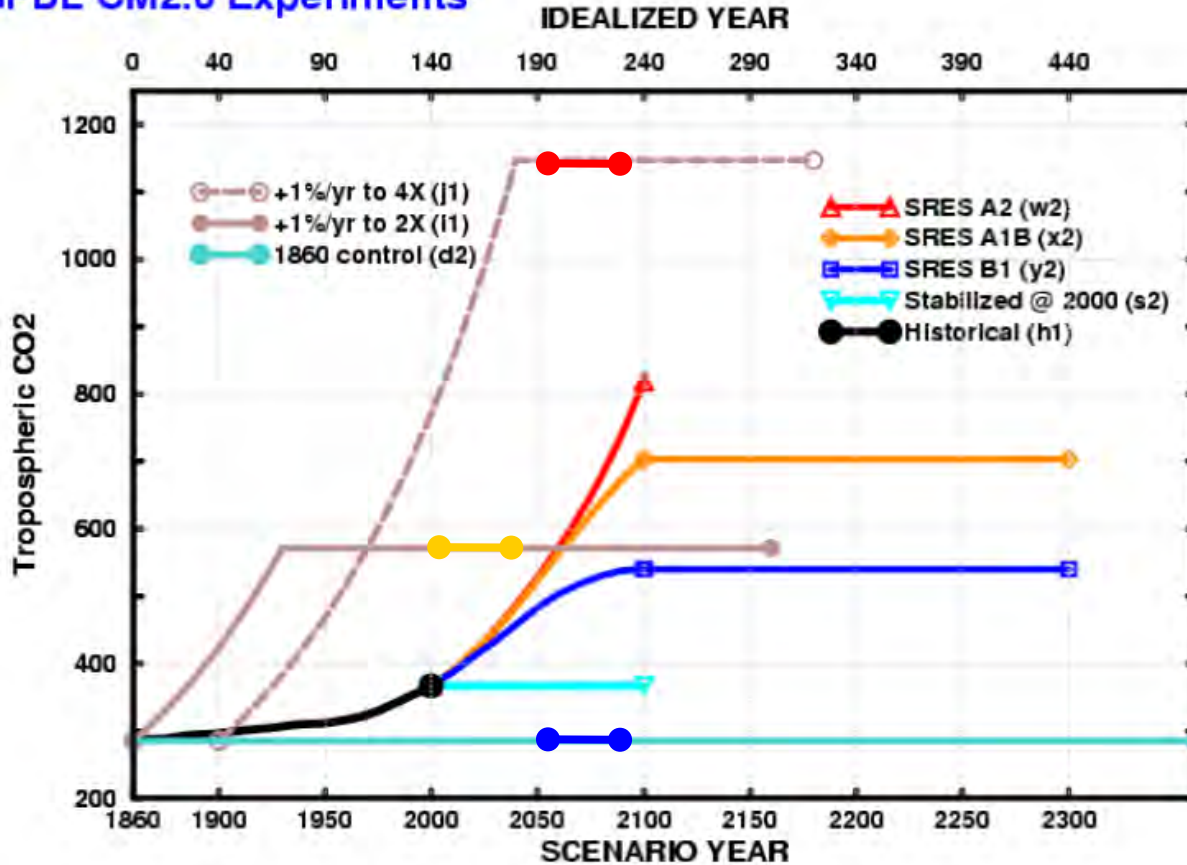


Initial and border conditions for physics and biogeophysics

Regional Downscaling

Choice of the climate projection scenario

GFDL CM2.0 Experiments



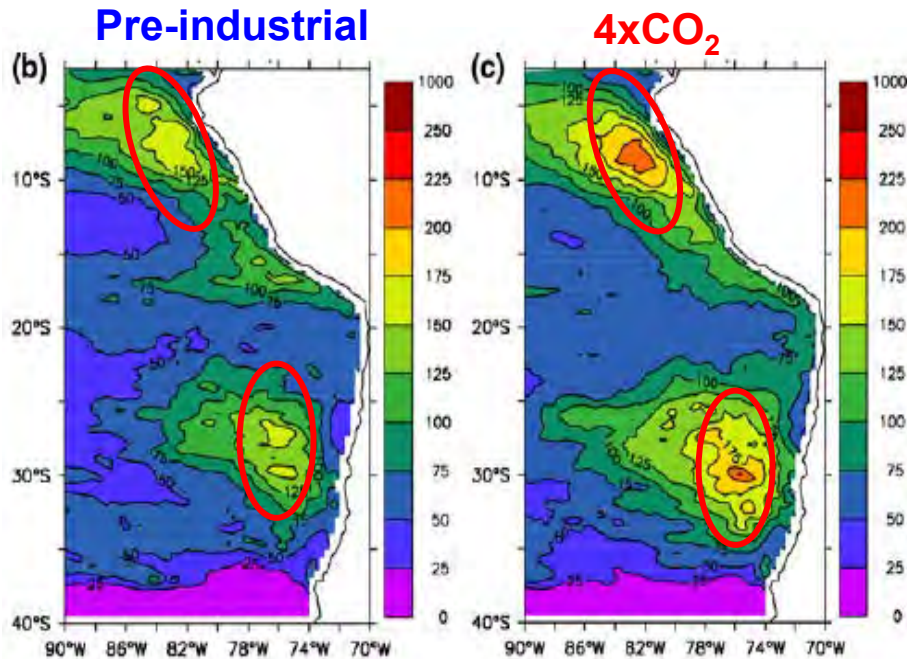
- Extreme scenario (Trump) (~2100) CO2 x4 compared to preindustrial level: **4CO2**
- Moderate climate change (~2050) CO2 x 2 compared to preindustrial level: **2CO2**
- Control scenario (no climate change): CO2 constant at the preindustrial level: **PI**



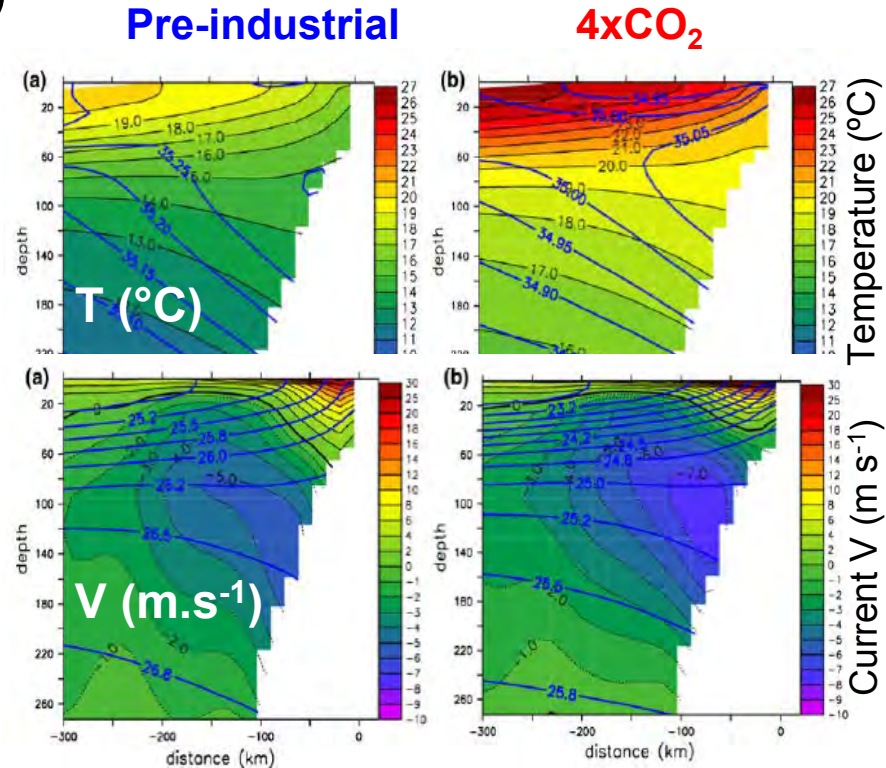
Regional Downscaling

Changes in Currents and Stratification

Surface currents :
Changes in Eddy Kinetic Energy
(= intensity of 50-100 km radius eddies)



Changes in vertical structure



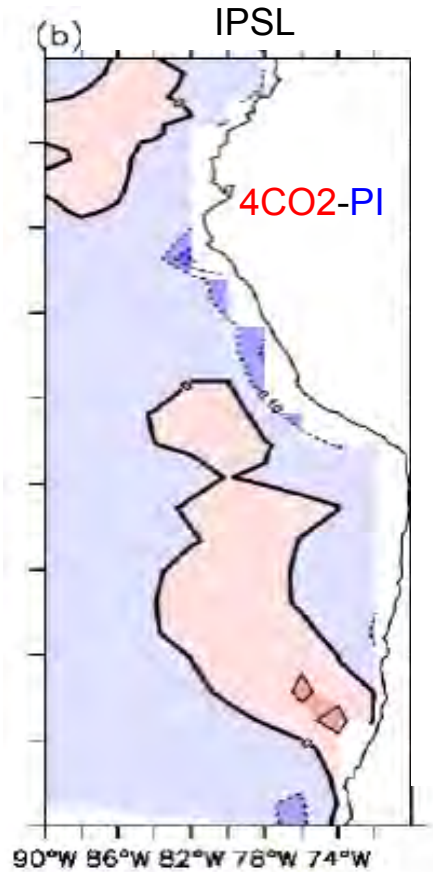
→ strong warming → increase stratification

→ Changes in currents and mesoscale activity

Regional Downscaling

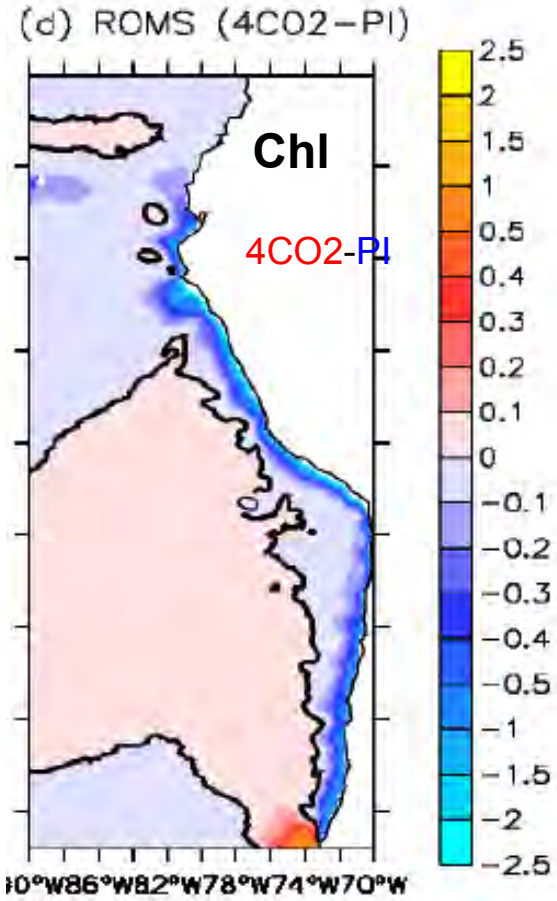
Changes in Primary production

Changes in nutrients contents (0-200 m) and surface Chla in IPSL-CM4:



≠

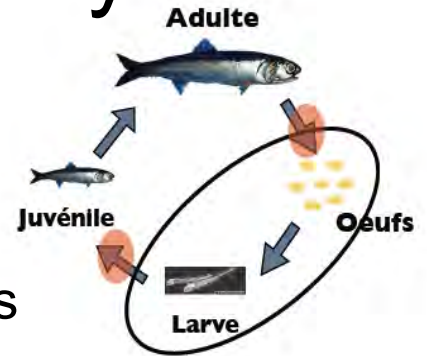
Changes in Chla in ROMS-PISCES:



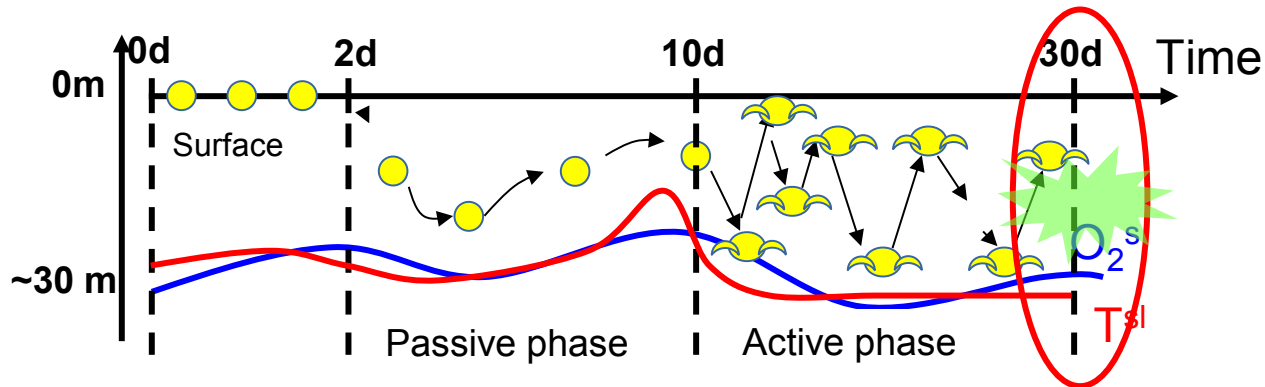
Predicted decrease in coastal PP

Climate change impacts are stronger (better resolved) in the regional model

3 - Impacts on SPF nursery



- Lagrangian IBM tool *Ichthyop* (Lett et al., 2008)
- Horizontal movements: passive transport by the currents
- Vertical movements: Buoyant (eggs), passive (yolk-sac), and active larvae (DVM)



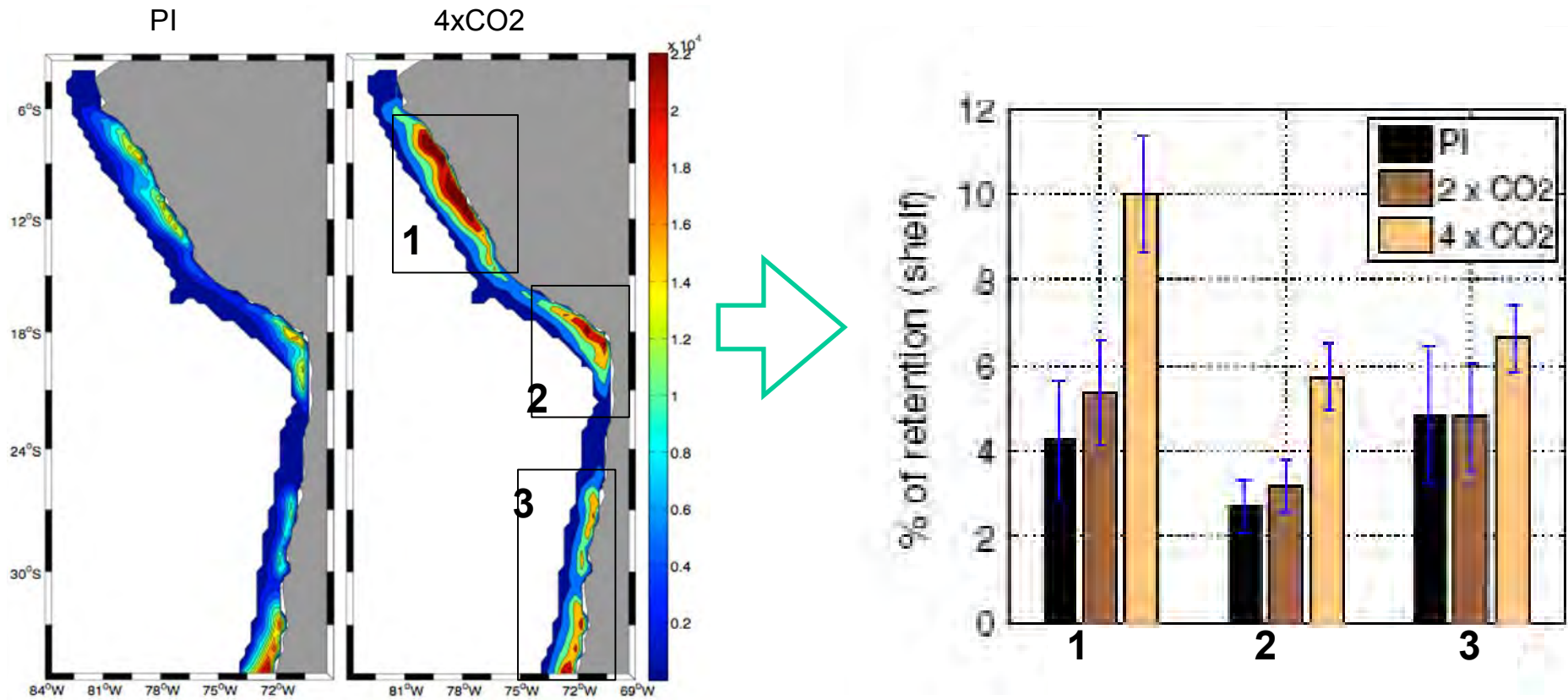
- Mortality:
 - if $T < T^s$ and $O_2 < O_2^s$ (i.e. below from the surface layer)
 - if transported outside nursery area
- «Recruitment» = % larvae that survived at 30 days

Impacts on SPF nursery

Changes in retention rate over the continental shelf

Good news

Increased larval retention over the continental shelf



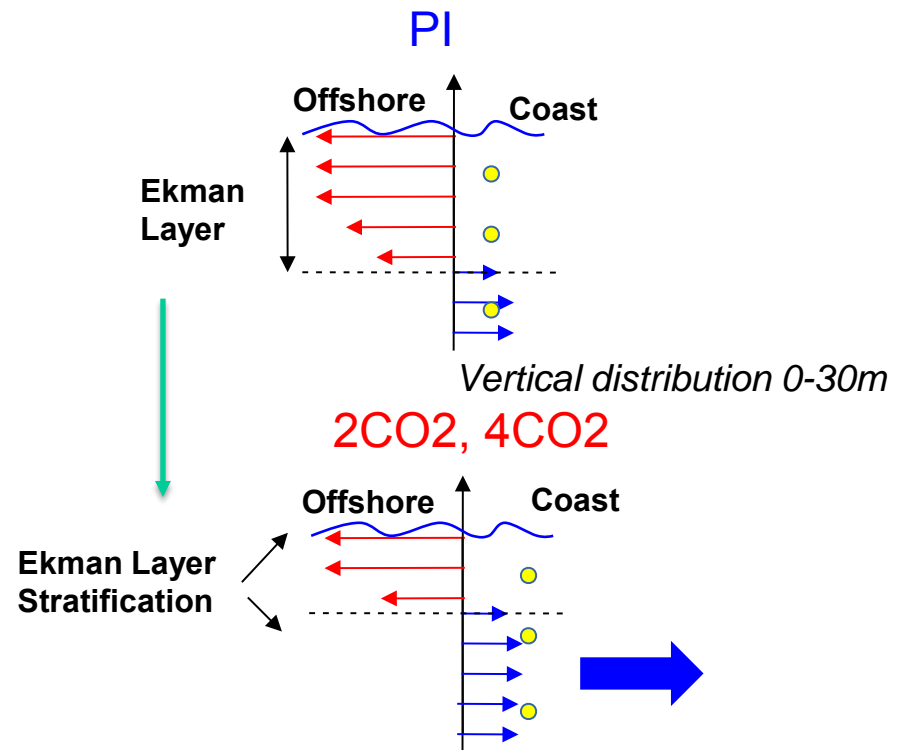
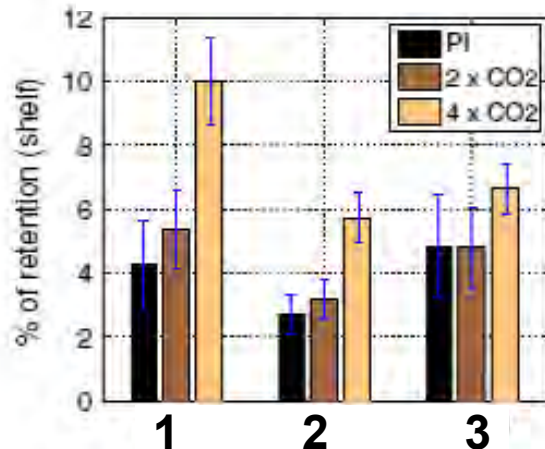
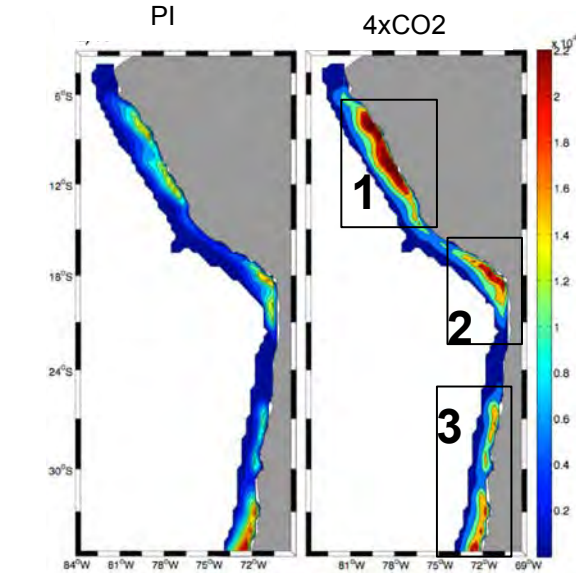
Impacts on SPF nursery

Changes in retention rate over the continental shelf

Increased larval retention over the continental shelf

Why? The cause differs according to the area

Zone 1 & 2: changes due to stratification:



larvae under the Ekman layer are transported towards the shore

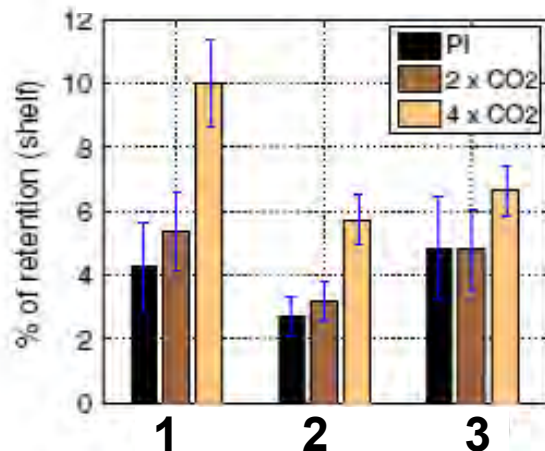
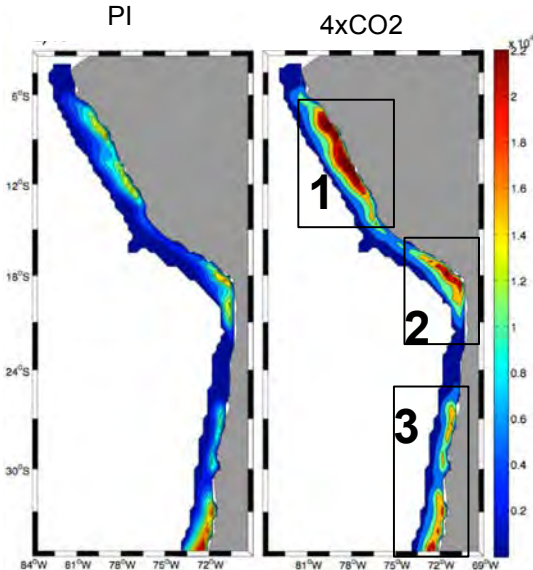
Impacts on SPF nursery

Changes in retention rate over the continental shelf

Increased larval retention over the continental shelf

Why? The cause differs according to the area

Zone 3: changes due Eddy activity



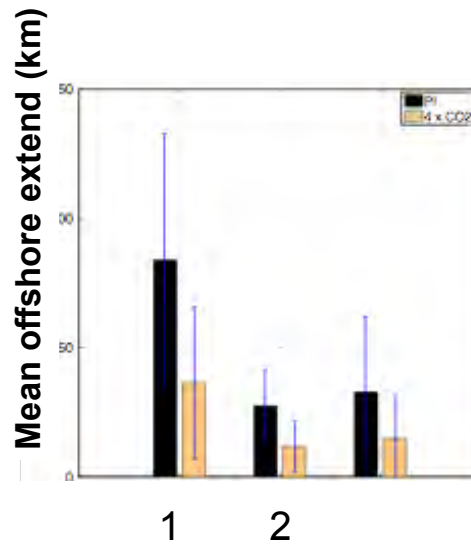
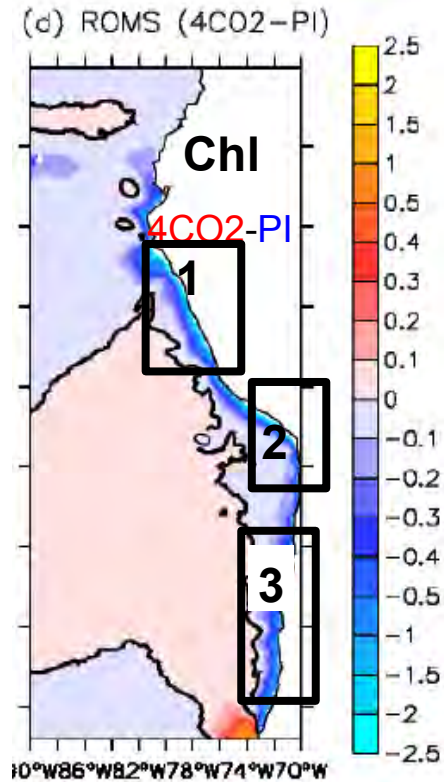
Rate of retention (%)		% increase (+) or decrease (-)	
PI	4 × CO2	PI → 4 × CO2	
Normal	5.0	6.5	+30%
No « eddy »	3.00 (-40%)	1.50 (-76%)	-50%

Impacts on SPF nursery

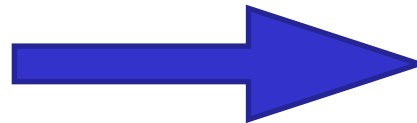
Changes in offshore extend of the nursery area

Bad news

Strong Reduction of the offshore extend of the productive area...

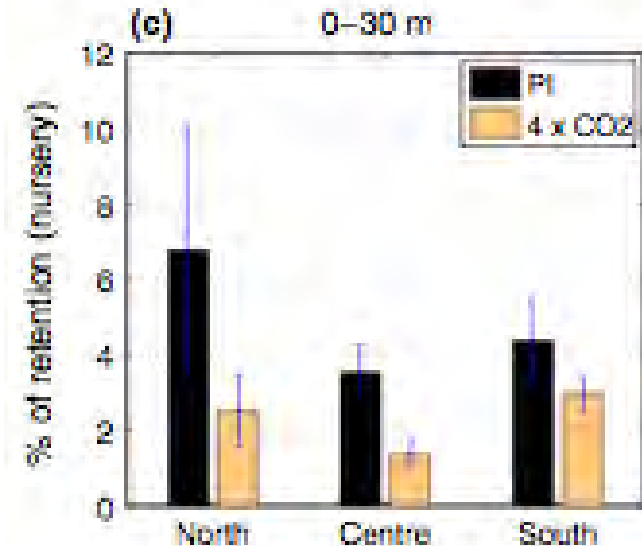


3



... not fully compensated by the increase in retention rate on the continental shelf

→ Global negative impact



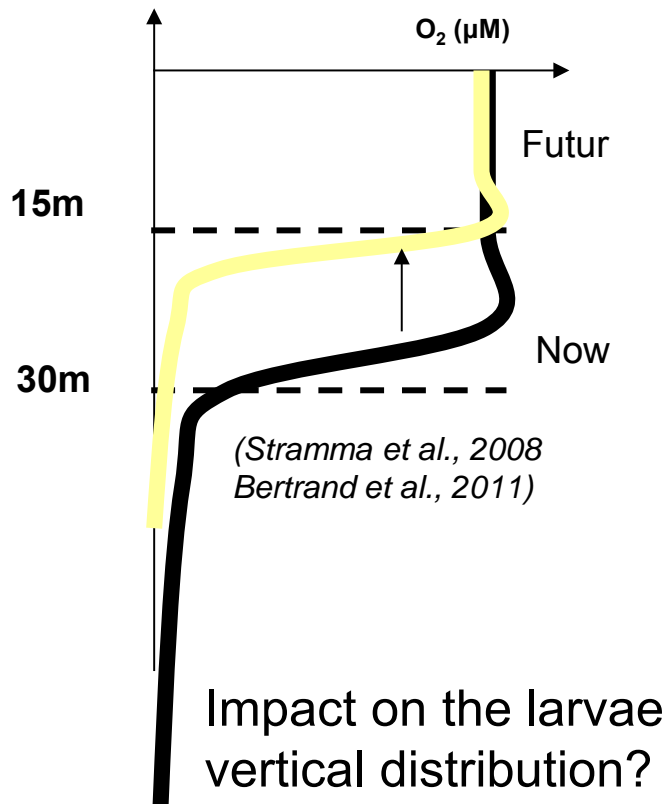
Decreasing rate of retention in the plankton rich area

Impacts on SPF nursery

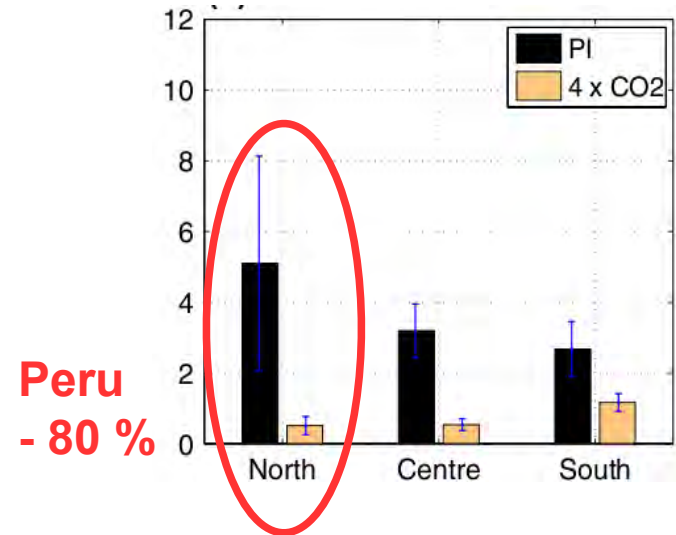
Changes in oxycline depth

Hypothesis: mean oxycline depth shift from 30 m to 15 m

Change in oxycline depth:



Combined effect of nursery area reduction and oxycline shoaling on larval survival:



Further reduce the larval retention in the nursery

Conclusions

Predicted impact of climate change in the Humboldt...

...in physical forcings:

- Weak changes in wind forcing in Peru
- Increase of upwelling winds in Chile
- Strong increase of stratification in the entire HCS

...in biogeochemical dynamics:

- Strong reduction in primary productivity (to be confirmed)
- Scenario of oxycline shoaling to be confirmed

...in SPF reproduction success:

Antagonist effects on larval retention/survival of:

- positive effect of the stratification (Ekman/Eddies)
- Negative effect of the production reduction (in IPSL-CM4)
- Strong reduction in larval survival in Peru, moderate effect in Chile

... overall negative effects for SPF

Conclusions

Limits of the study:

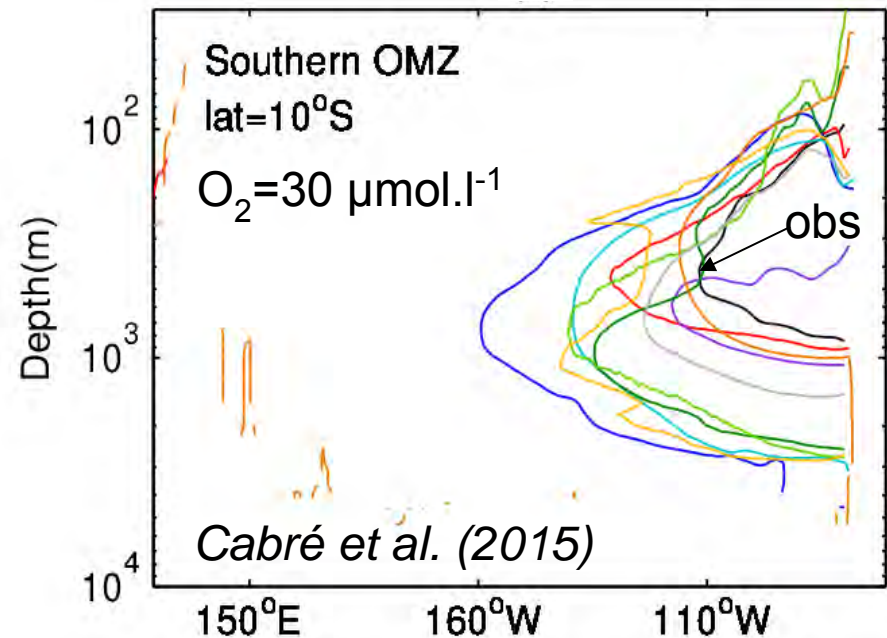
Simplified larval model (no predation and growth)

No submesoscale eddies and filaments due to spatial resolution (~20 km)

Missing processes such as tides, coastal winds, rivers...

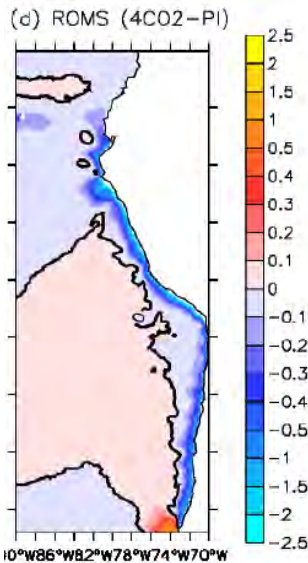
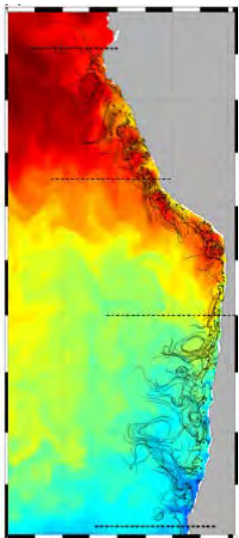
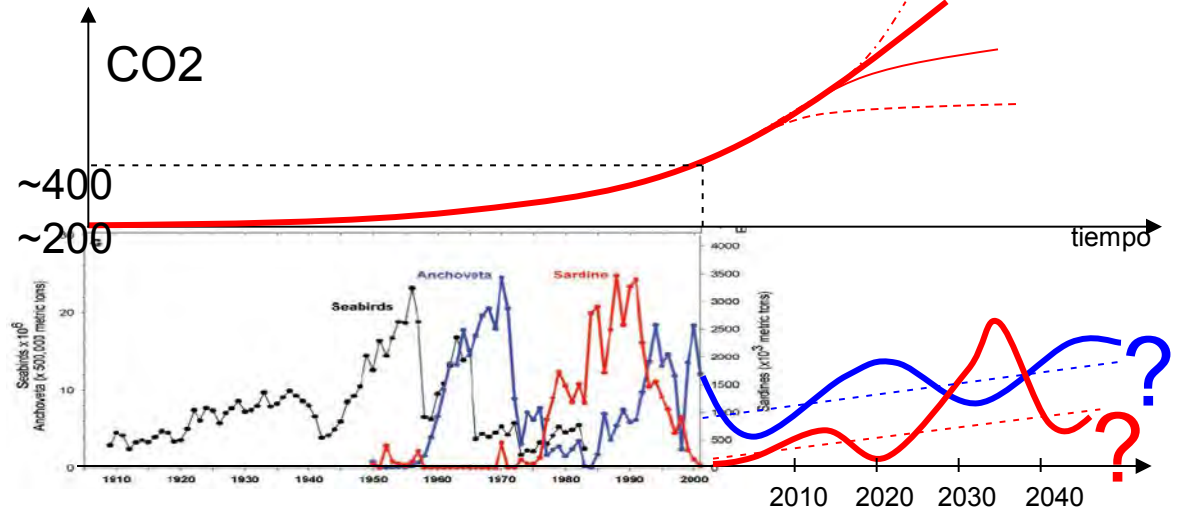
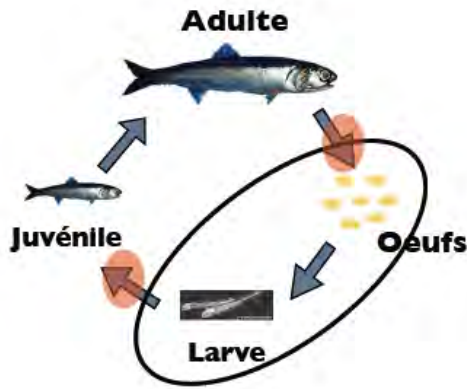
Only one climate model (IPSL-CM4) and extreme scenarios (PI, 4xC02)

Oxygen is not well simulated in climate models, with no clear trends



Thank you

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