The Effects of Climate Change on the World's Oceans

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Projecting climate change impacts on regional marine ecosystems using OSMOSE

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Ifremer

IRD

Workshop 10: Intercomparison of fisheries and marine ecosystem models

Main assumption:
Size-based predation

PROCESSES

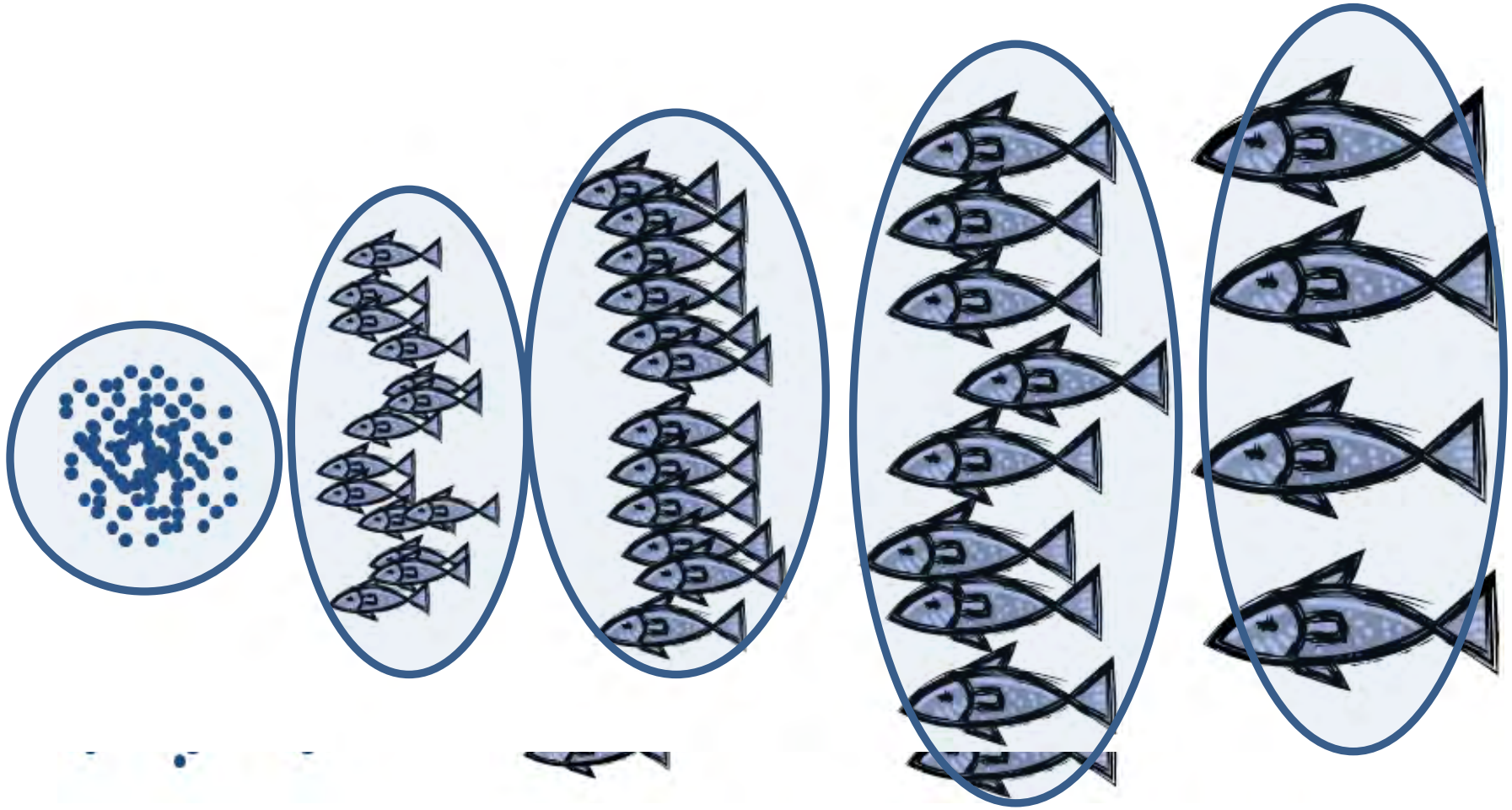|	
1	Spatial distribution
2	Natural mortality
3	Explicit predation
4	Growth *or* Starvation
5	**Fishing mortality**
6	Reproduction

OSMOSE (Shin and Cury 2001, 2004) is a multispecies Individual-based model (IBM) which focuses on fish species.

www.osmose-model.org

OSMOSE IS A STOCHASTIC MODEL

OSMOSE: *Object-oriented Simulator of Marine biOdiverSity Exploitation*
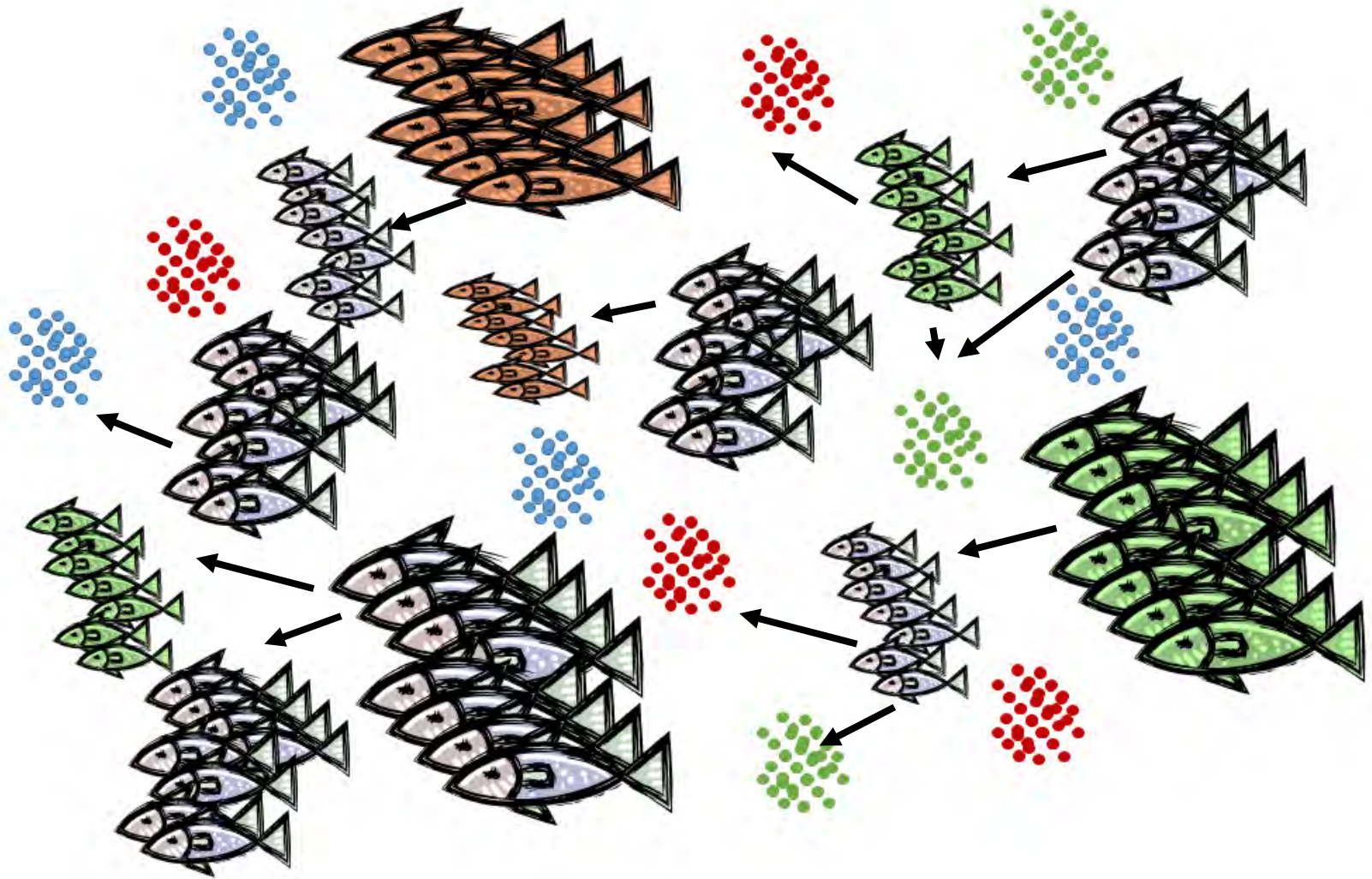
OSMOSE

- OSMOSE simulates "schools".
- Each school share a set of properties: species, age, length, and its characterized by its spatial position and abundance .

OSMOSE

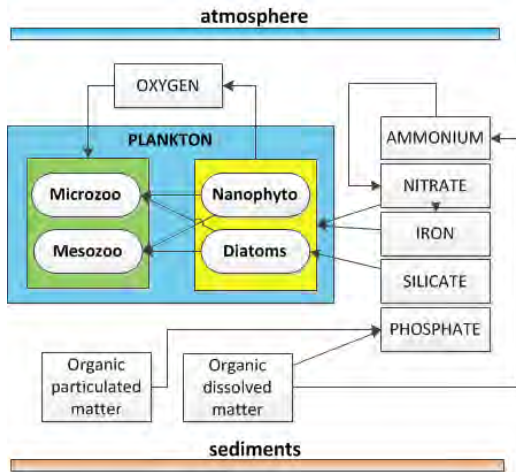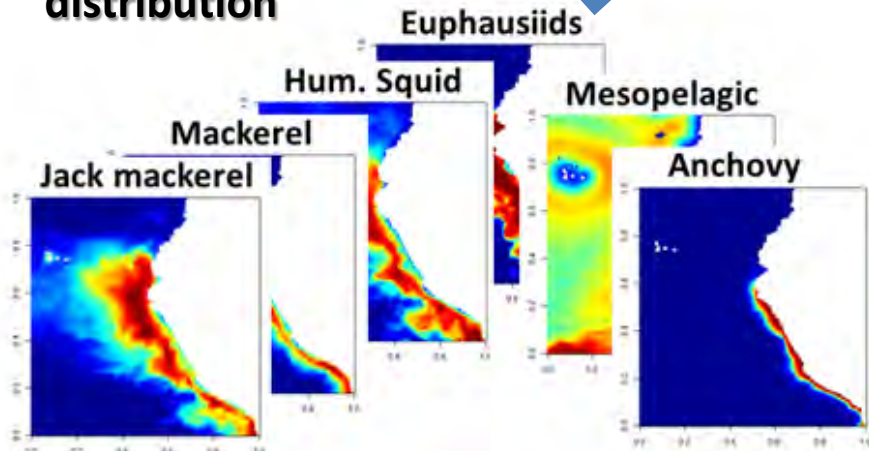**Fish will eat each other if they can!**

Size-based predation + spatial co-ocurrence.

OSMOSE forcings: Species distribution maps and plankton
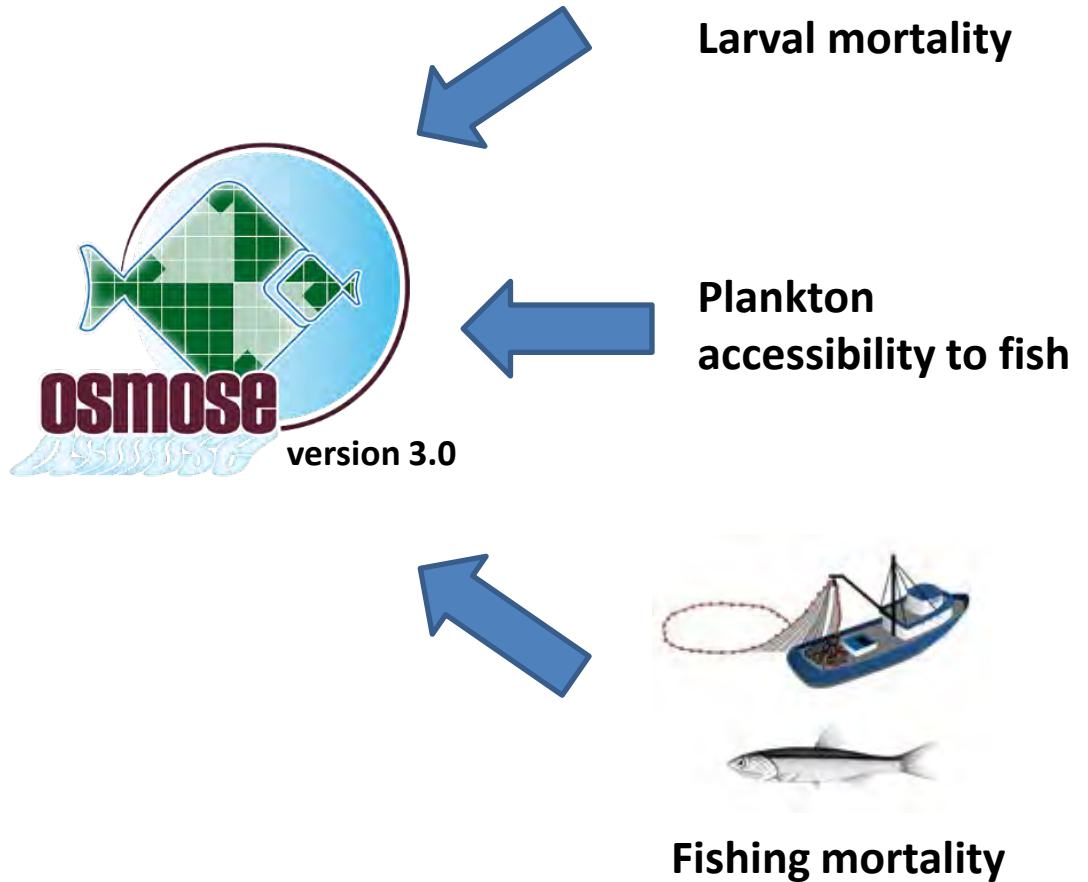

ROMS-PISCES Echevin et al. 2012

Fish spatial distribution

version 3.0

Oliveros-Ramos 2014

OSMOSE parameters

Larval mortality

Plankton accessibility to fish

version 3.0

Fishing mortality

8 species explicitly modelled: 312 parameters

Oliveros-Ramos et al. 2017

OSMOSE

1992-2008

Spatial resolution: 1/6°
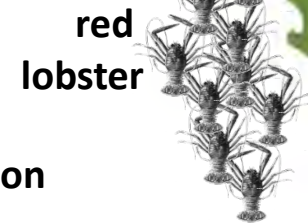**6 °N – 20 °S**
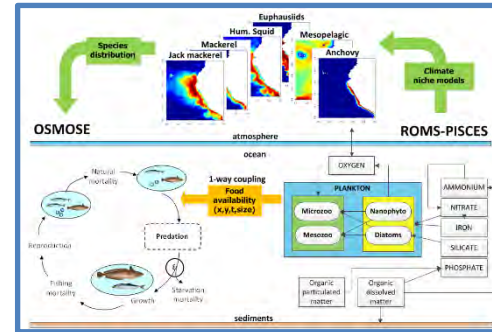**93 °W – 70 °W**

ROMS-PISCES

- **Species modeled:**
  - **6 fish, 1 cephalopod, 1 crustacean, macro-zooplankton.**

- **Plankton:**
  - **Forcing of ROMS-PISCES**
  - **4 plankton groups**

Humboldt squid

red lobster

macrozooplankton

mesopelagics

sardine

chub mackerel

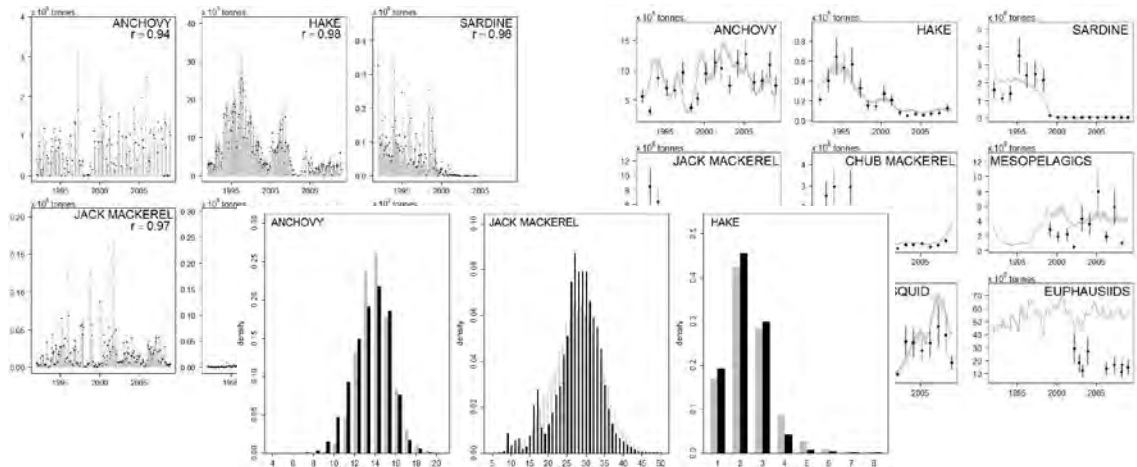anchoveta

Jack mackerel

Peruvian hake
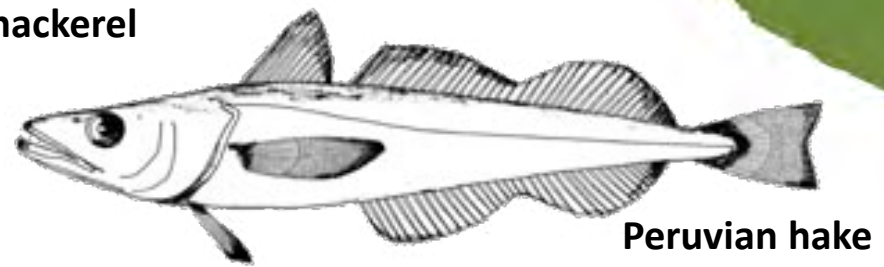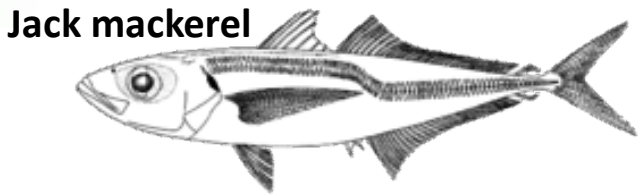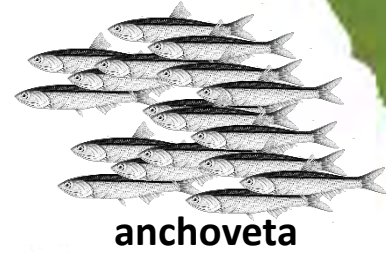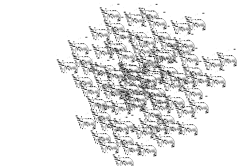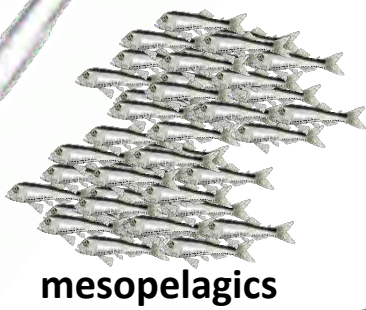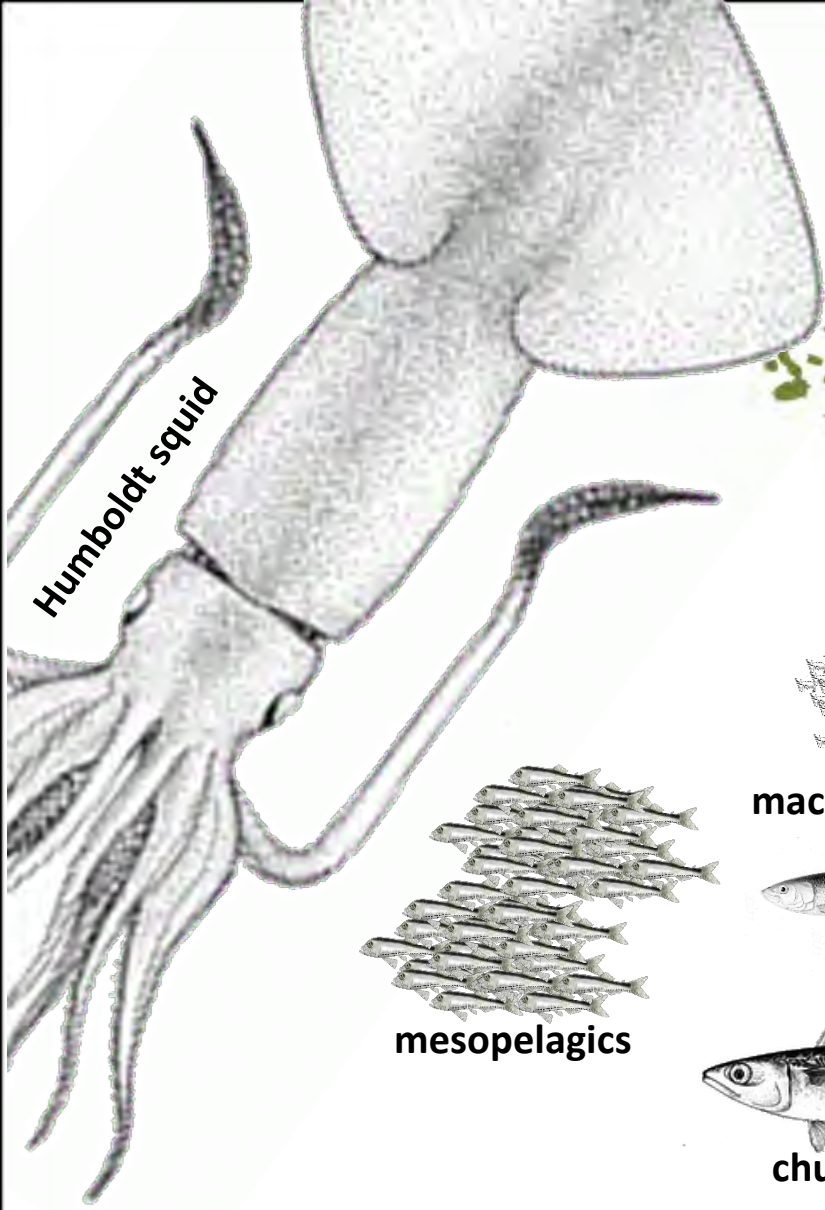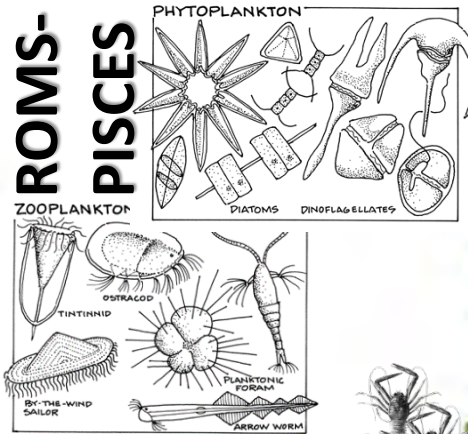
E2E model: ROMS-PISCES-OSMOSE

calibration

DATA

Reproduce observed data (1992-2008): time series of landings, biomass, catch-at-length
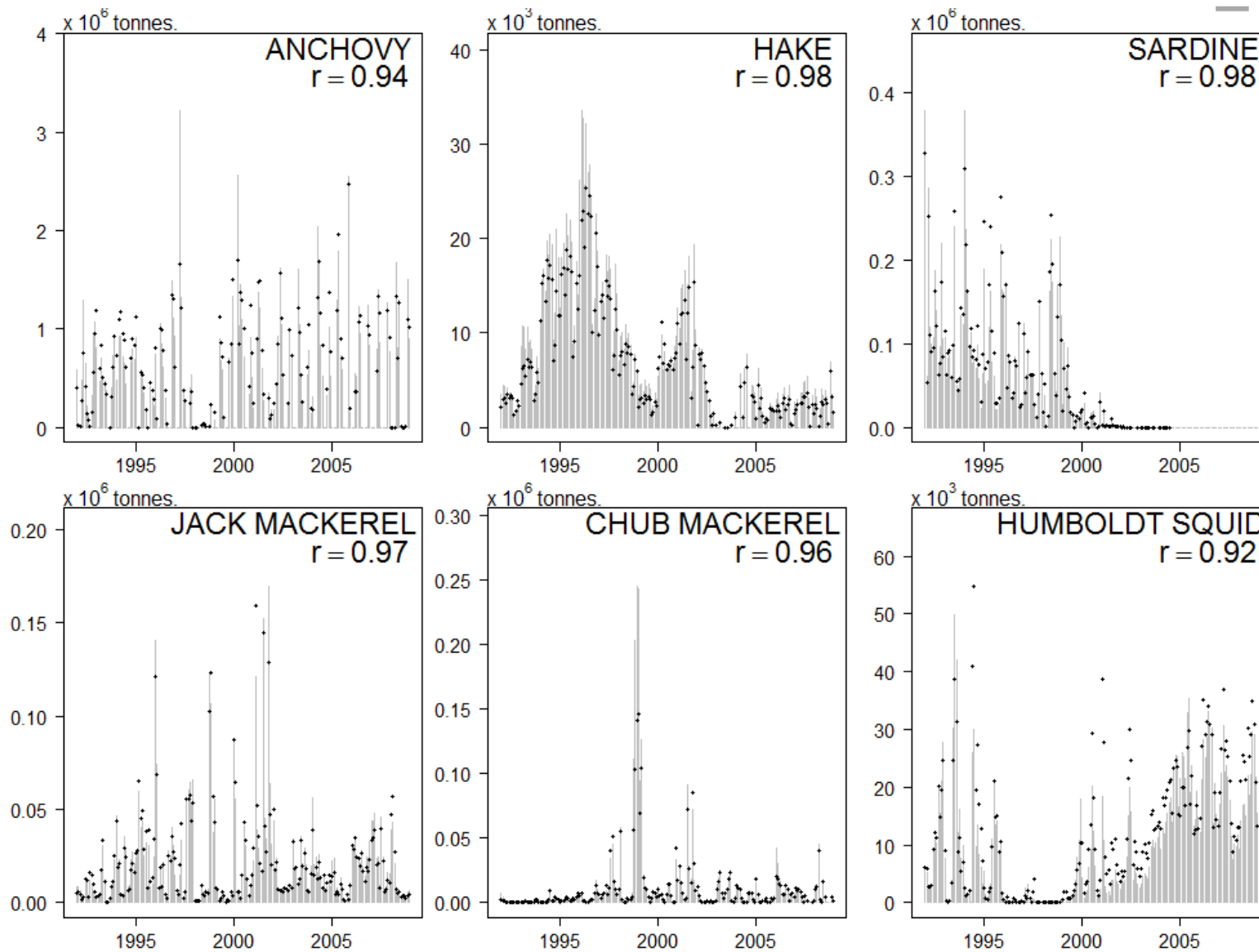
Calibration of OSMOSE

Parameterization

- Fishing mortality (F)
  - F average estimated for all harvested species.
  - Annual deviates, discrete steps.
  - Seasonal variability: variable between years, estimated from landings distribution.
  - Selectivity models used for harvested species: logistic, normal and log-normal. Selectivities are estimated for species with cath-at-age information, fixed for the others.

- Larval mortality (L)
  - L average estimated for all species
  - Annual deviates, splines.
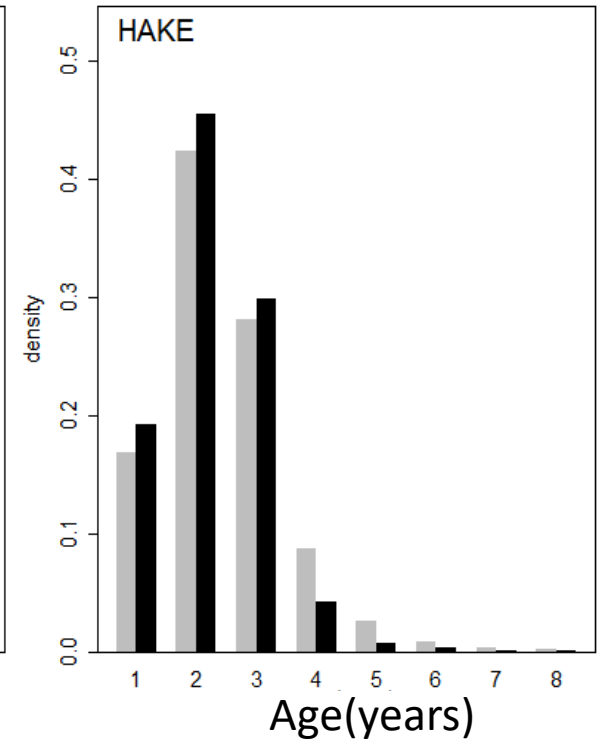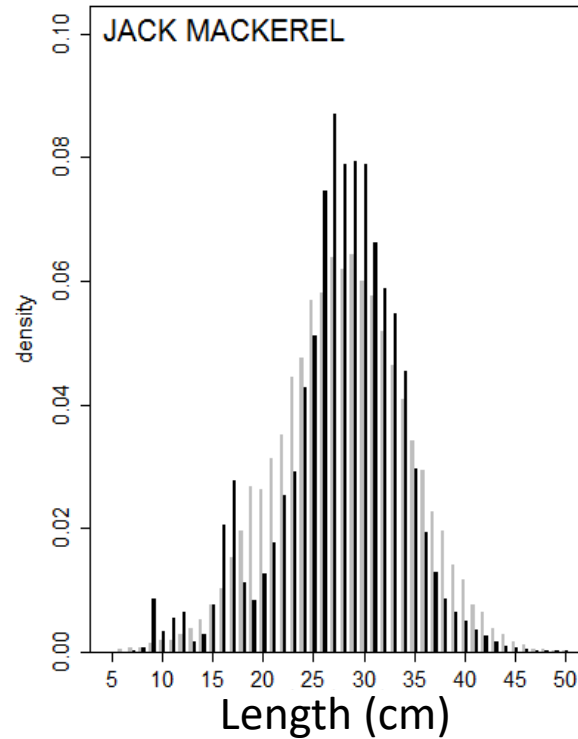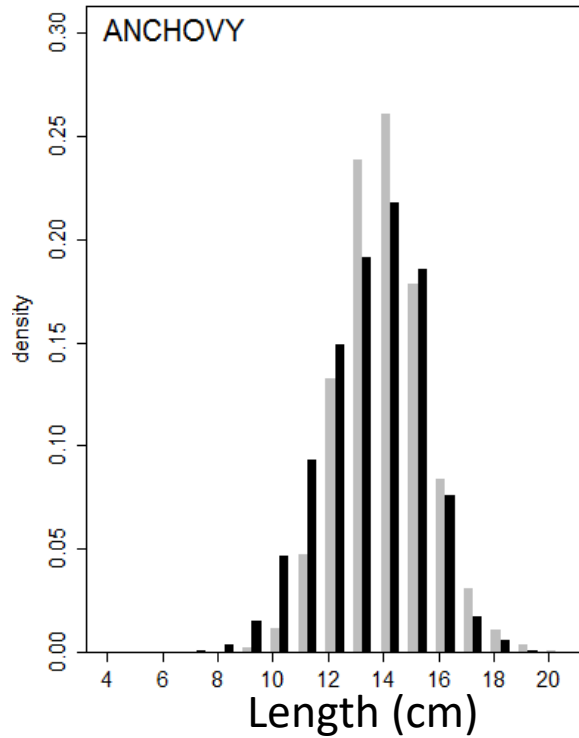 - Seasonal variability: periodic, only used for anchovy.

Calibration results – Monthly catches

- Observations
- Model

Oliveros-Ramos et al. 2017

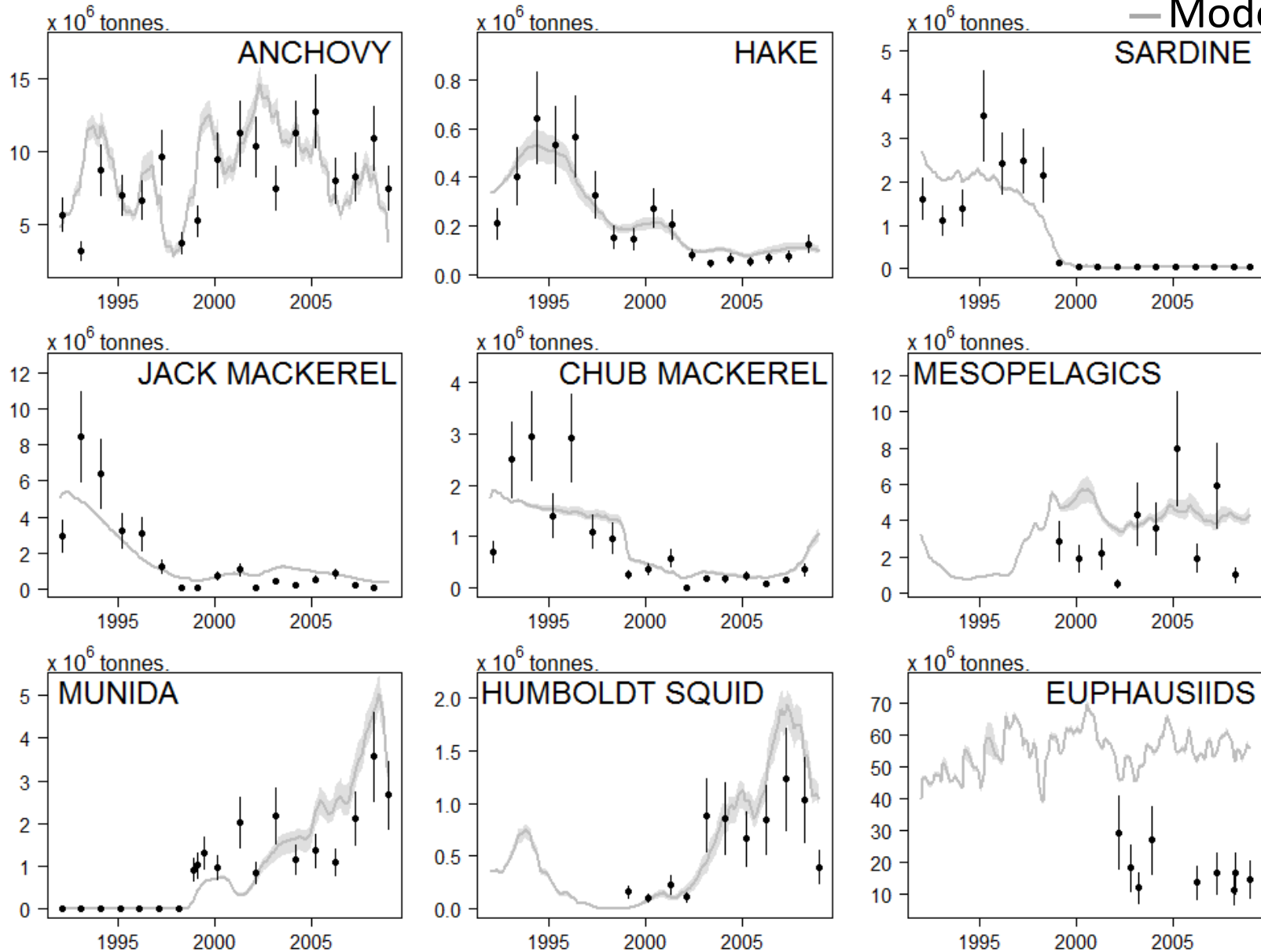# Calibration results – Catch at age/length

Oliveros-Ramos et al. 2017

━ Observations
━ Model
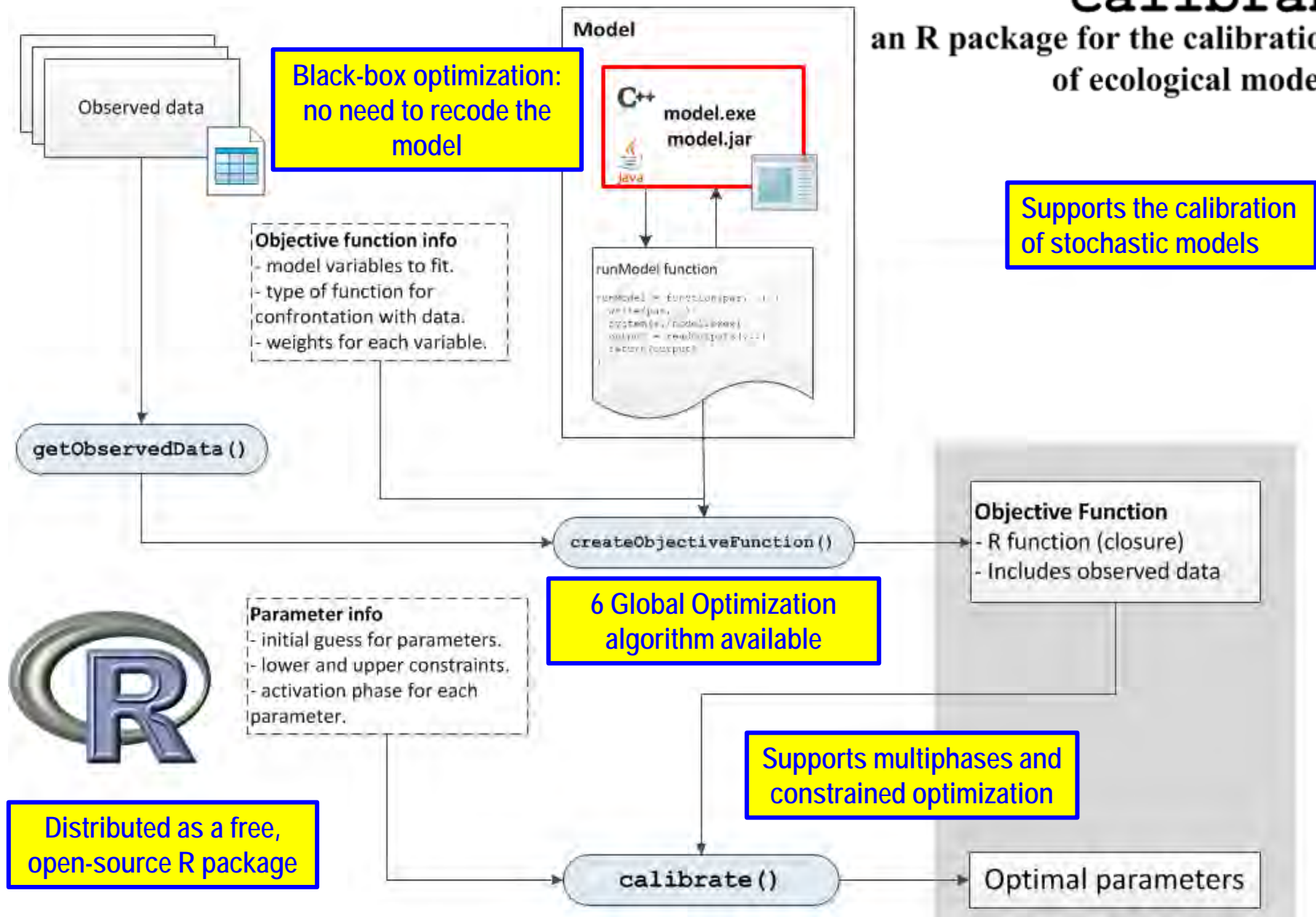
Calibration results – Species biomass
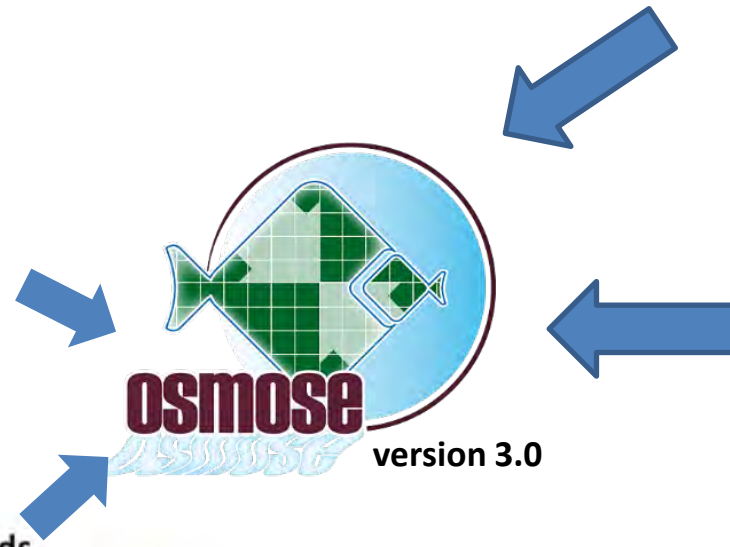
- Observations
- — Model

Oliveros-Ramos et al. 2017

calibraR
an R package for the calibration
of ecological models

https://CRAN.R-project.org/package=calibrar

OSMOSE: Simulation inputs

ROMS-PISCES
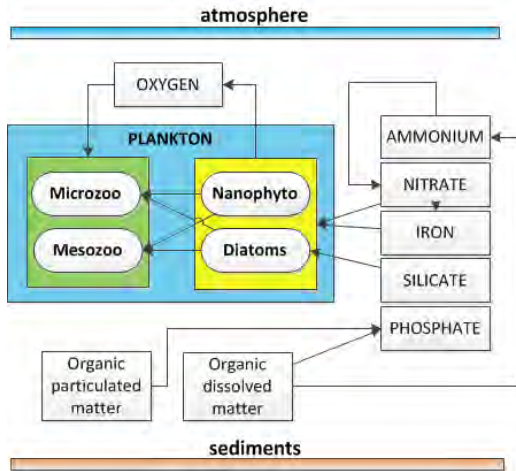
Larval mortality

Plankton accessibility to fish

Fish spatial distribution

version 3.0

Euphausiids

Hum. Squid

Mackerel

Jack mackerel

Mesopelagic

Anchovy
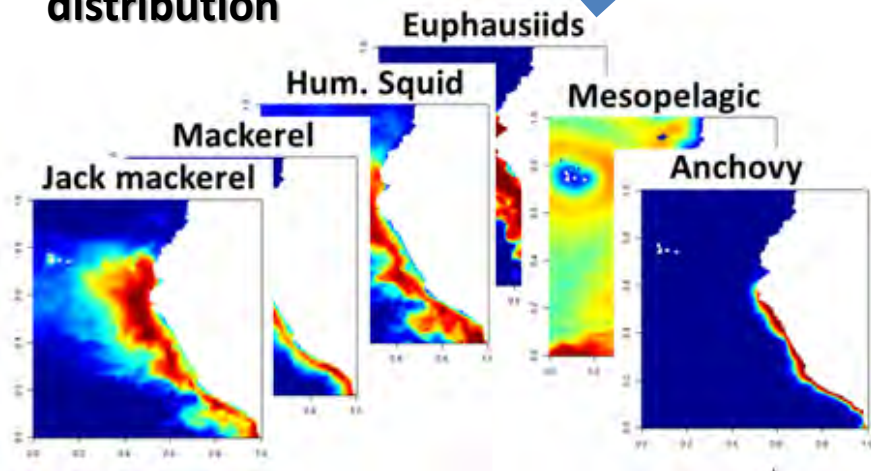
Fishing mortality

How to produce the model inputs for the period 2009-2100?
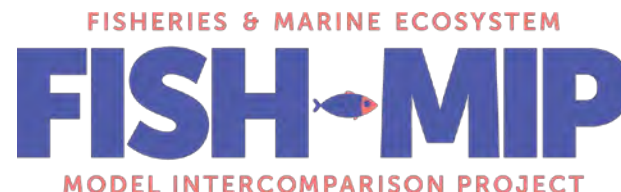
A protocol for the intercomparison of marine fishery and ecosystem models: Fish-MIP v1.0

Derek P. Tittensor[1,2], Tyler D. Eddy[2,3], Heike K. Lotze[2], Eric D. Galbraith[4,5], William Cheung[3], Manuel Barange[6,7], Julia L. Blanchard[8], Laurent Bopp[9], Andrea Bryndum-Buchholz[2], Matthias Büchner[10], Catherine Bulman[11], David A. Carozza[12], Villy Christensen[13], Marta Coll[14,15], John P. Dunne[16], Jose A. Fernandes[7,17], Elizabeth A. Fulton[11,18], Alistair J. Hobday[11,18], Veronika Huber[10], Simon Jennings[19,20,21], Miranda Jones[3], Patrick Lehodey[22], Jason S. Link[23], Steve Mackinson[19], Olivier Maury[24,25], Susa Niiranen[26], Ricardo Oliveros-Ramos[27], Tilla Roy[9,28], Jacob Schewe[10], Yunne-Jai Shin[25,29], Charles A. Stock[16], Philip J. Underwood[1], Jan Volkholz[10], James R. Watson[26], Nicola D. Walker[19]
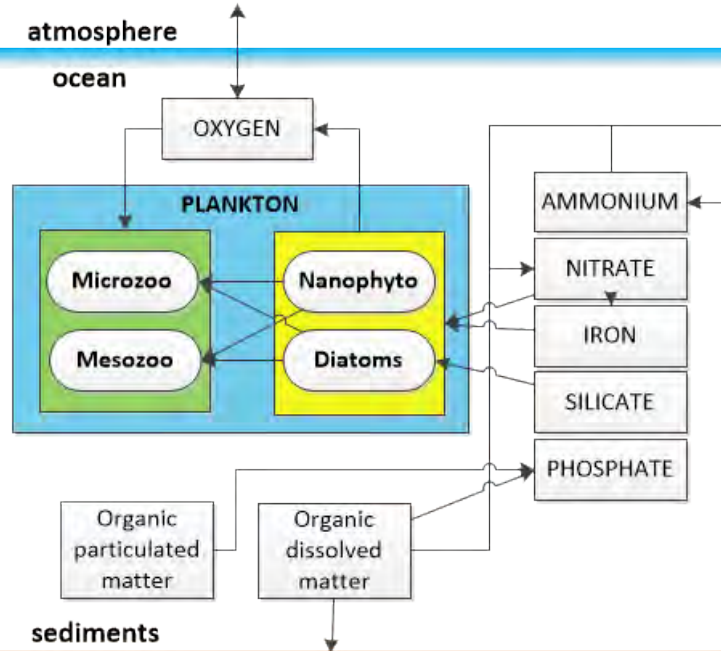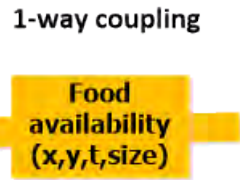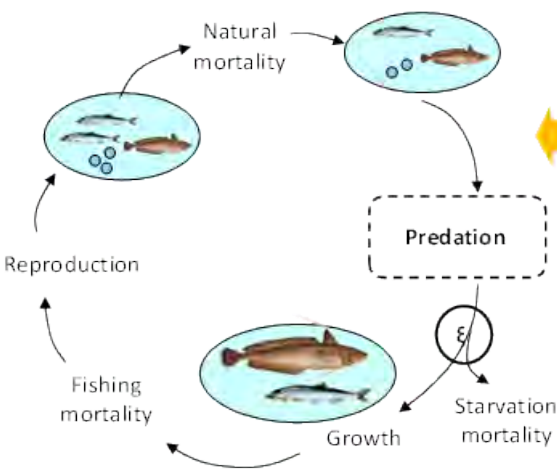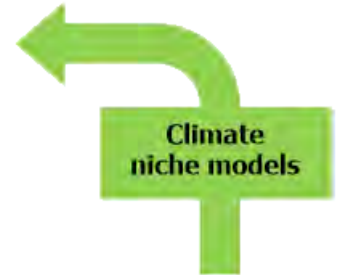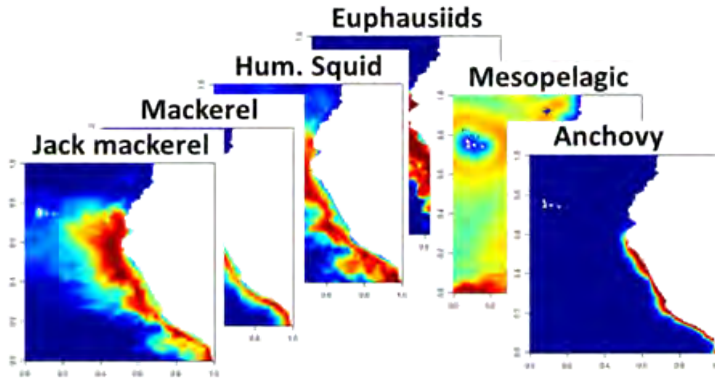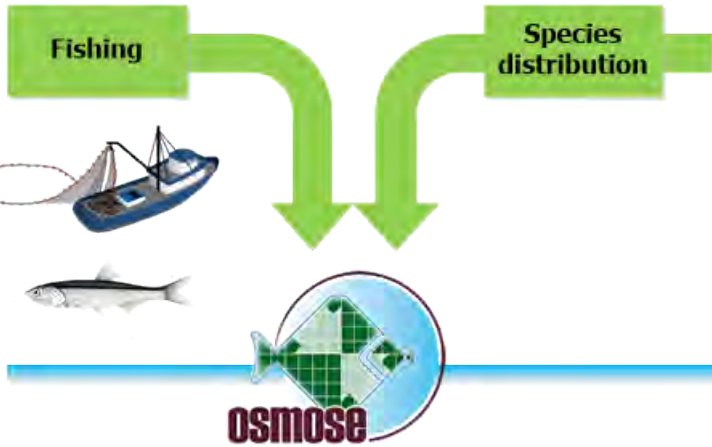
OSMOSE forecast

CMIP5 inputs

Resolution: 1ºx1º
Time horizon:
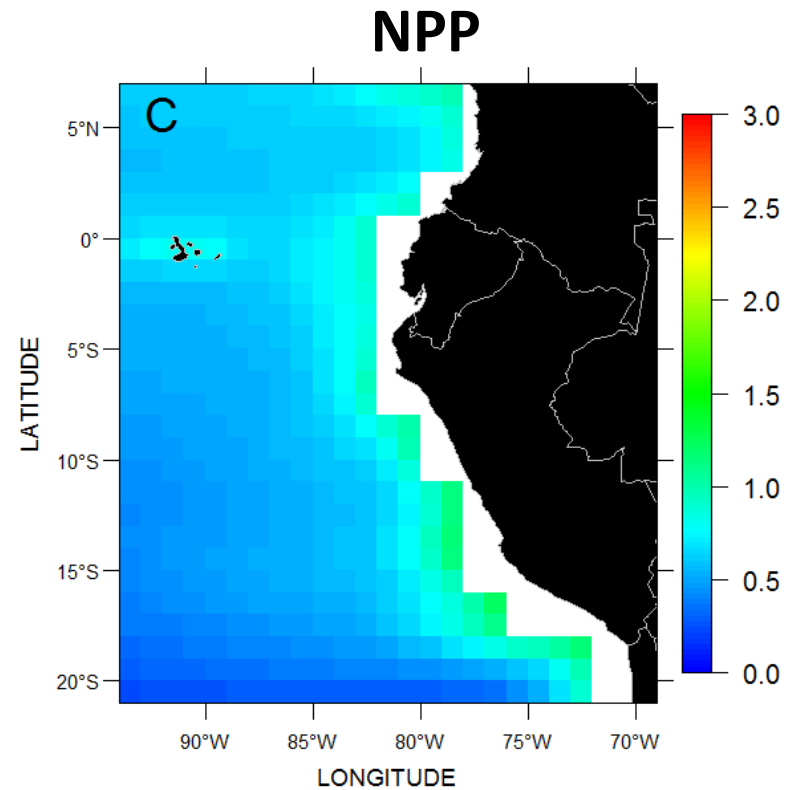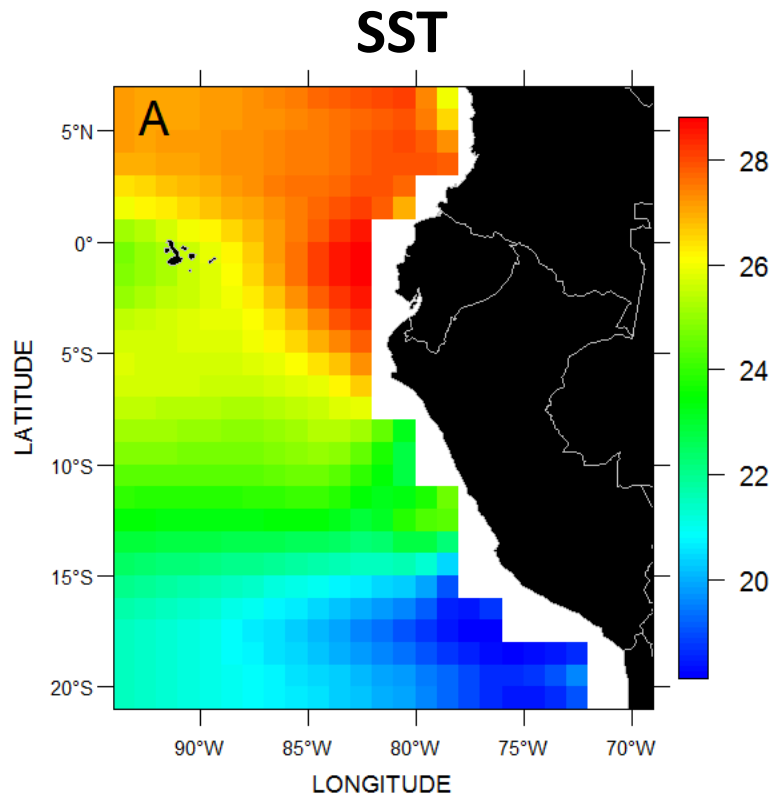   1950-2005 (historical)
        2006-2100 (RCP 2.6, 4.5, 6.0 and 8.5)

Resolution: 1ºx1º
Time horizon:
        1950-2005 (historical)
        2006-2100 (RCP 2.6, 4.5, 6.0 and 8.5)

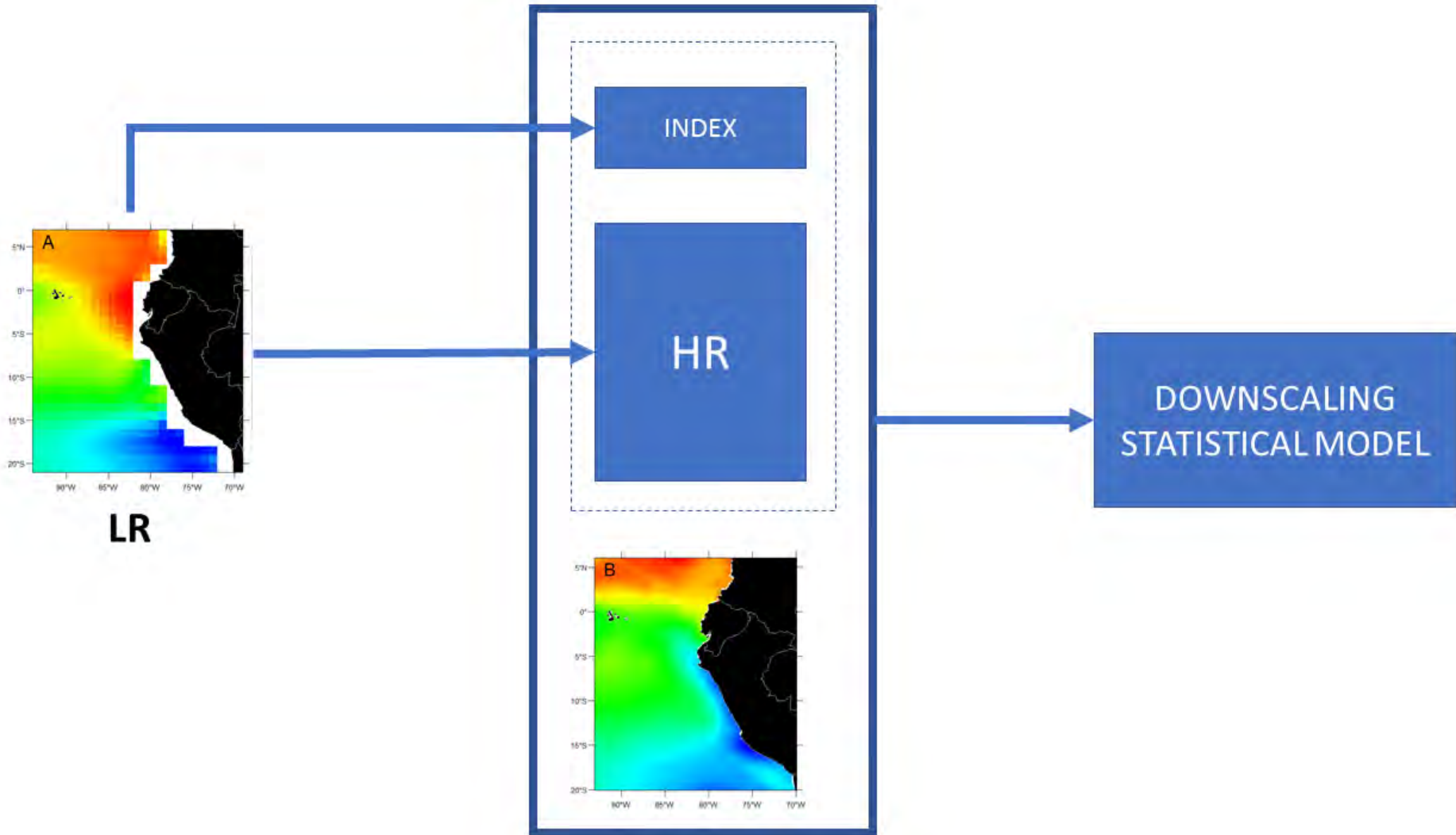# Global Climate Models: 2006-2100

SST

NPP

- Low resolution
- No coastal dynamics
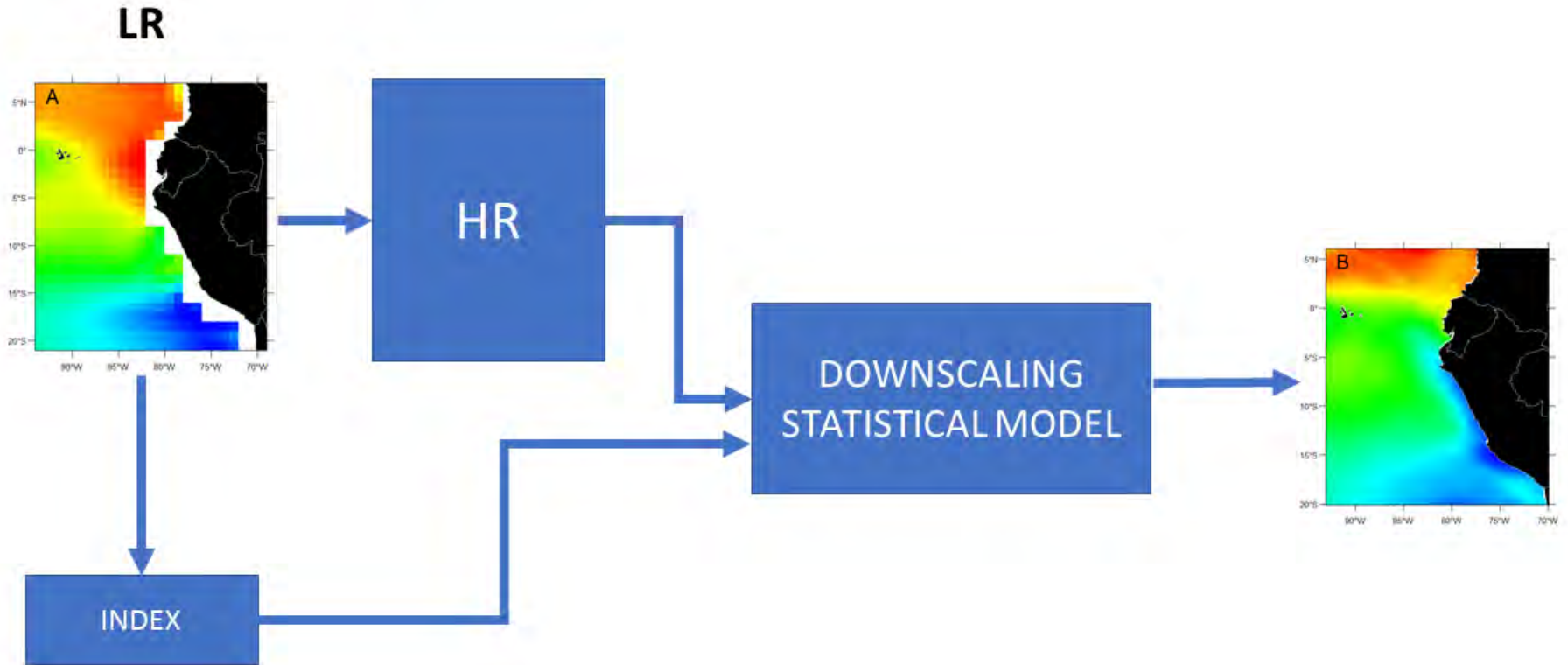- Inter-model variability

Downscaling
- **Statistical**
- **Dynamical**

Bias correction

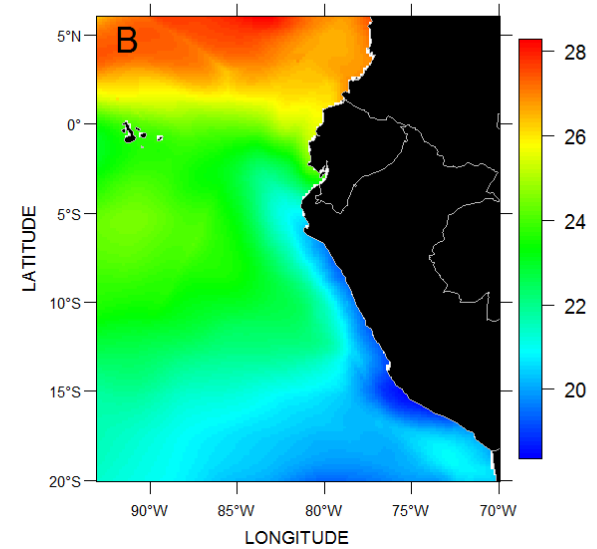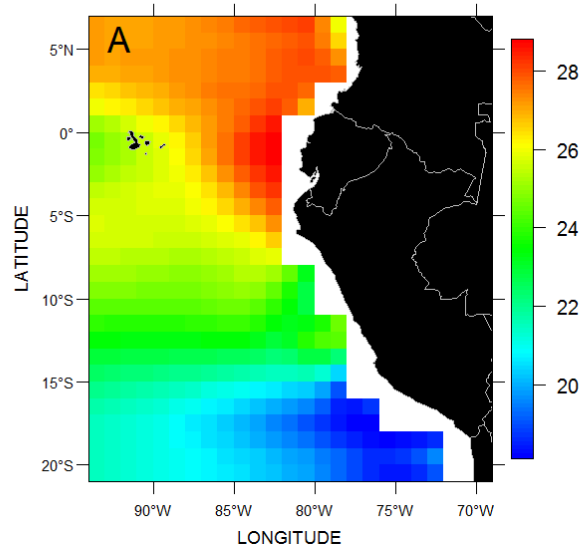# Statistical downscaling + bias correction:

Statistical downscaling: forecast
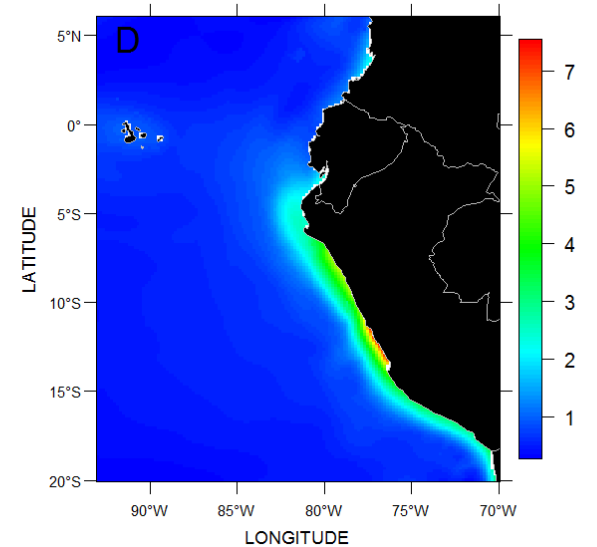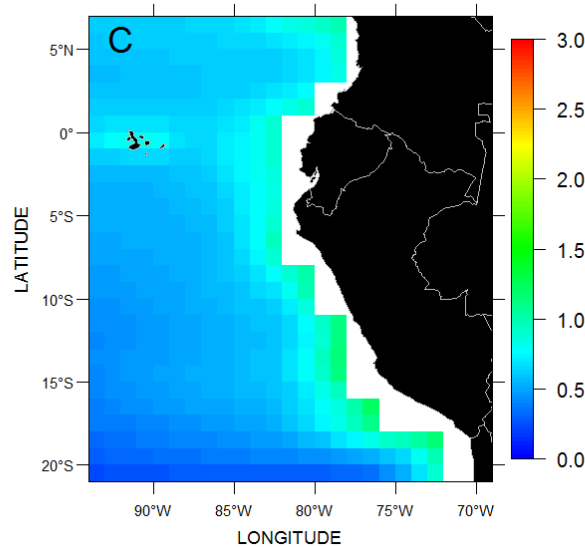
Statistical downscaling: results

1997-2005

SST

Reynolds OI

NPP

SeaWIFS +
MODIS

CMIP5 inputs

Resolution: 1ºx1º
Time horizon:
       1950-2005 (historical)
       2006-2100 (RCP 2.6, 4.5, 6.0 and 8.5)
Statistical downscaling for the Peruvian region (1/6ºx1/6º)

Resolution: 1ºx1º
Time horizon:
       1950-2005 (historical)
       2006-2100 (RCP 2.6, 4.5, 6.0 and 8.5)
Statistical downscaling for the Peruvian region (1/6ºx1/6º)
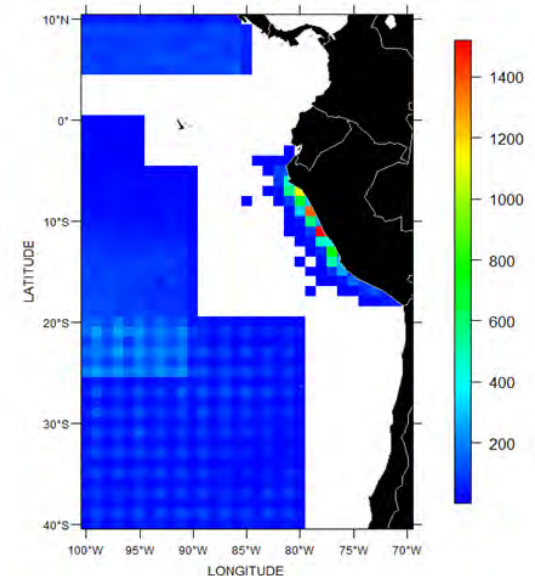
- **Dynamic downscaling** (Gevaudan et al., this conference)
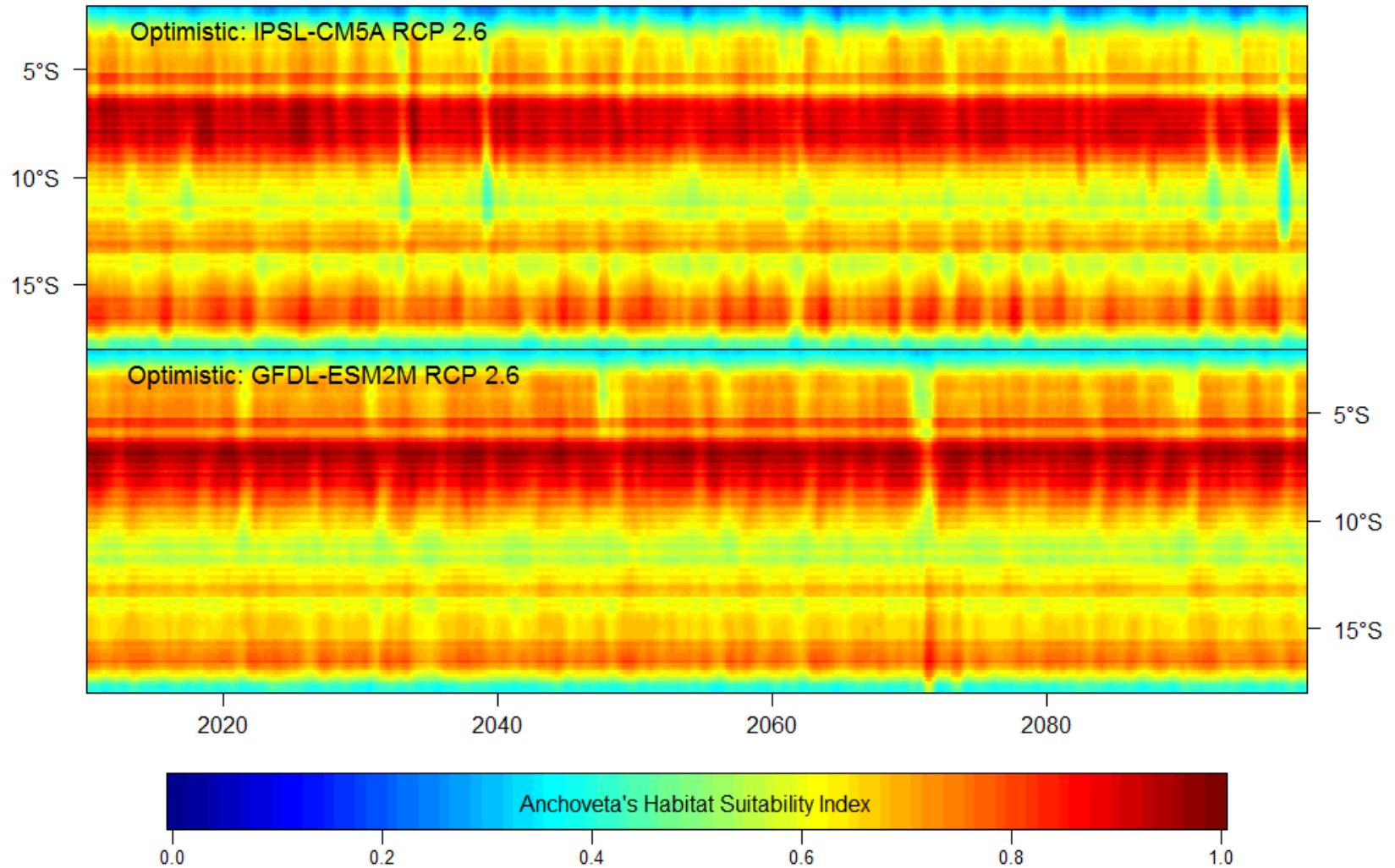   2000-2010 (historical)
       2011-2100 (RCP 2.6 and 8.5)
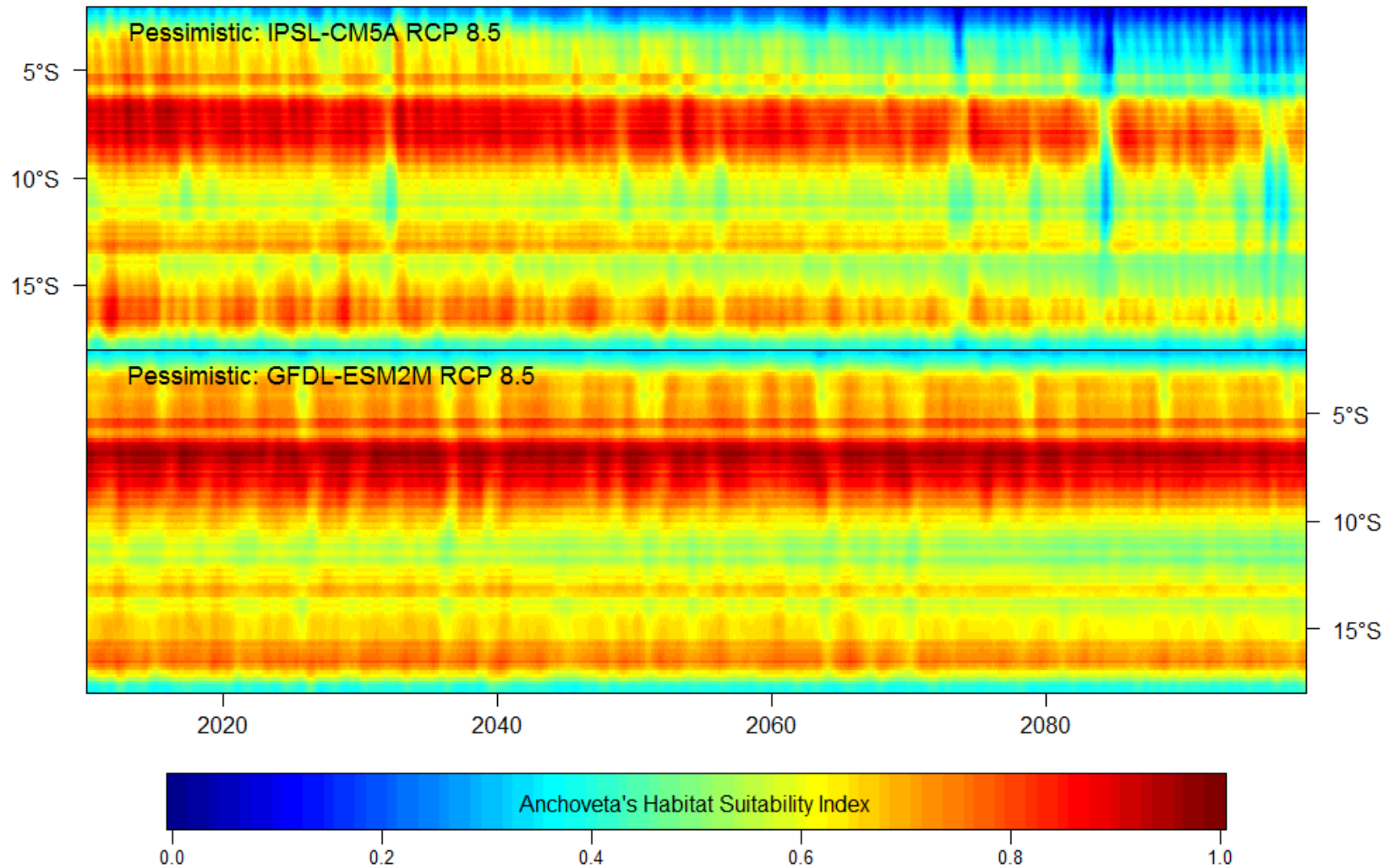
Spatial distribution modeling: methods

- Shape restricted generalize additive models

- Occurrence data:

- Presence records in the Peruvian coast between 1985 and 2008.

- Absence records (pseudo-absence where it is known that the anchovy is not distributed).

- Environmental data:
  - SST (°C) - Reynolds
  - SSS (ups) - SODA
  - NPP (mg/m³) – SeaWIFS + MODIS

  - **Variables we can get from future models.**
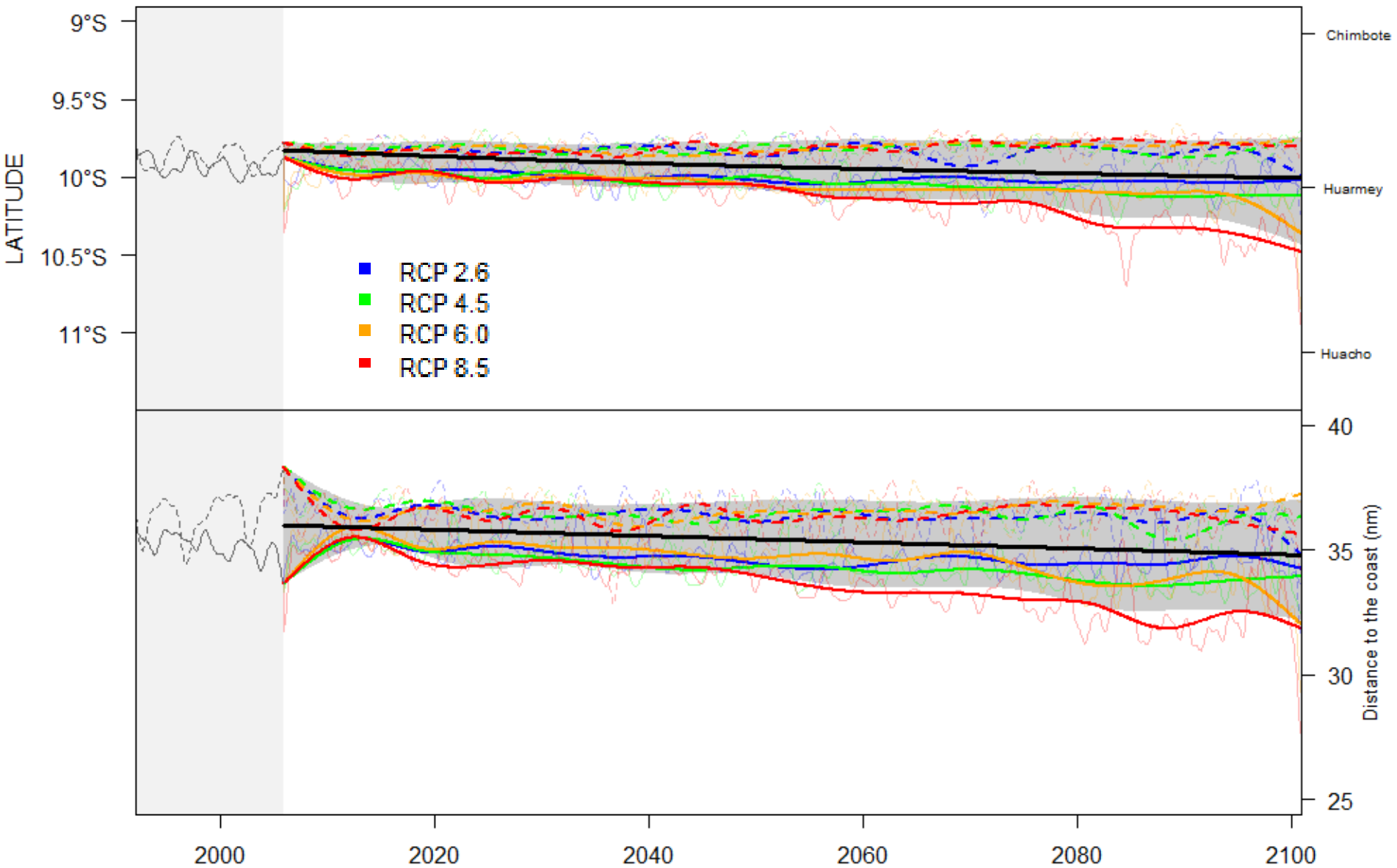
Shifts in spatial distribution: RCP 2.6

Shifts in spatial distribution: RCP 8.5

Pessimistic: IPSL-CM5A RCP 8.5

Pessimistic: GFDL-ESM2M RCP 8.5
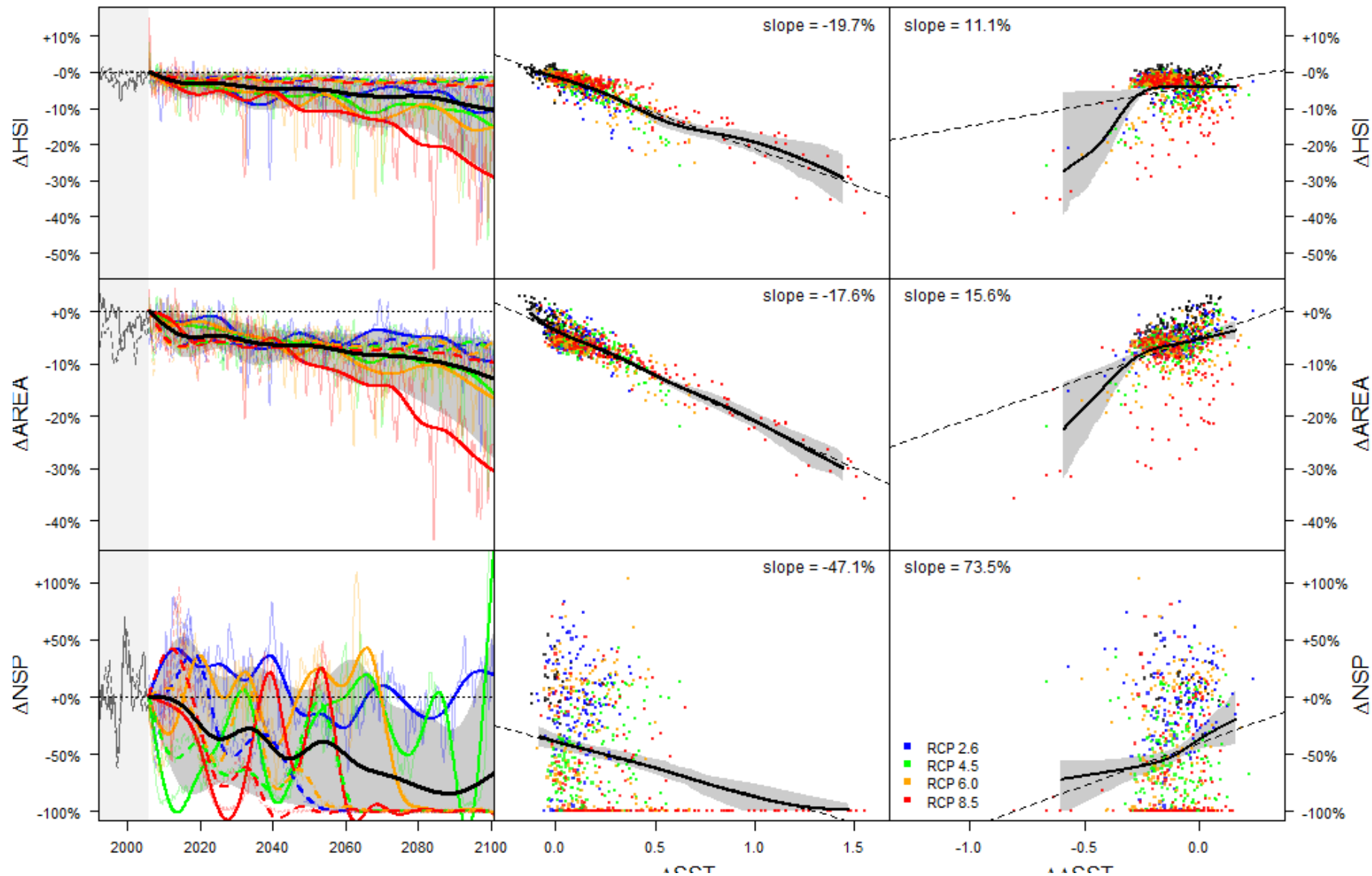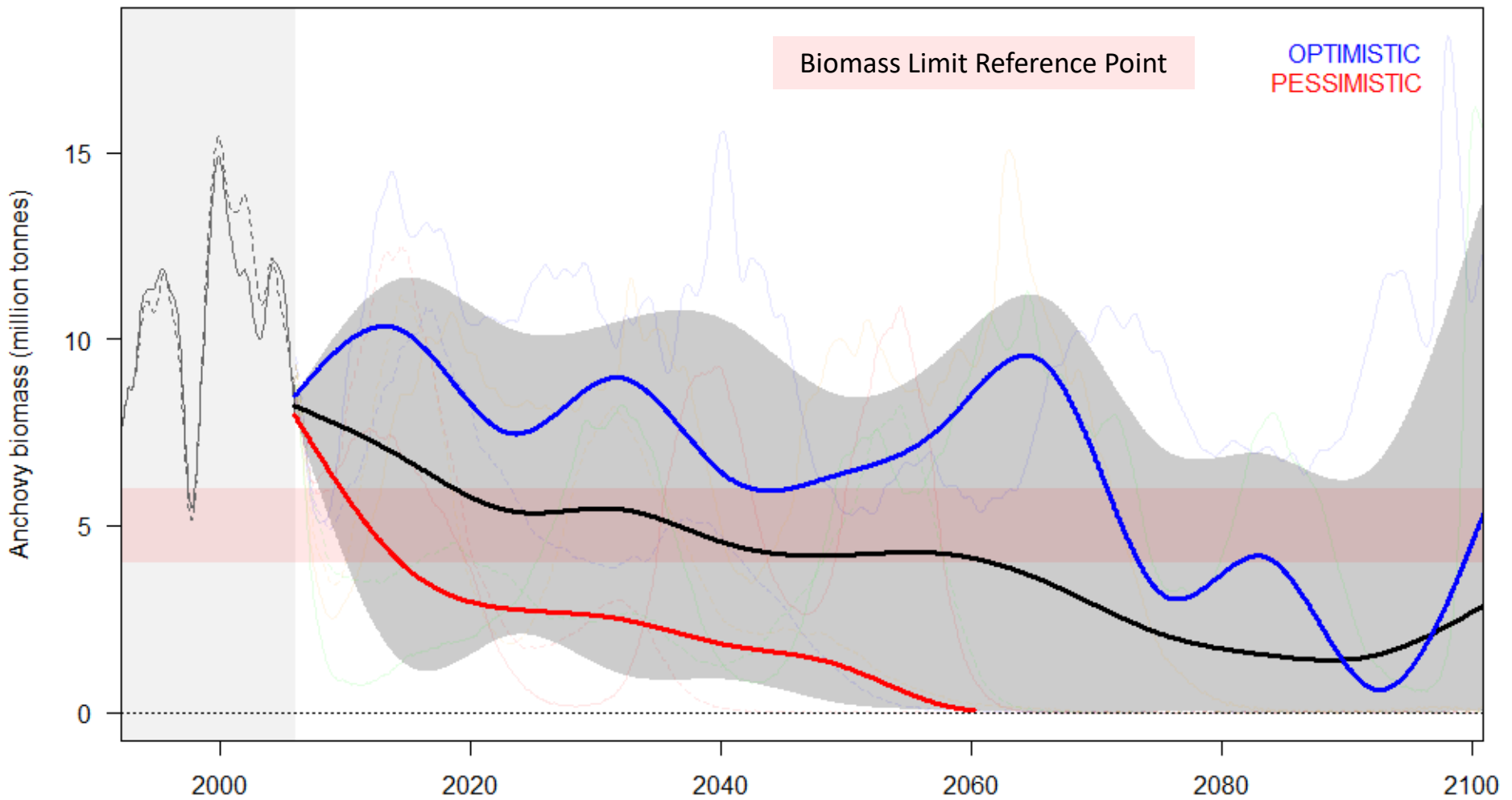
Anchoveta's Habitat Suitability Index

Shifts in spatial distribution: all RCPs
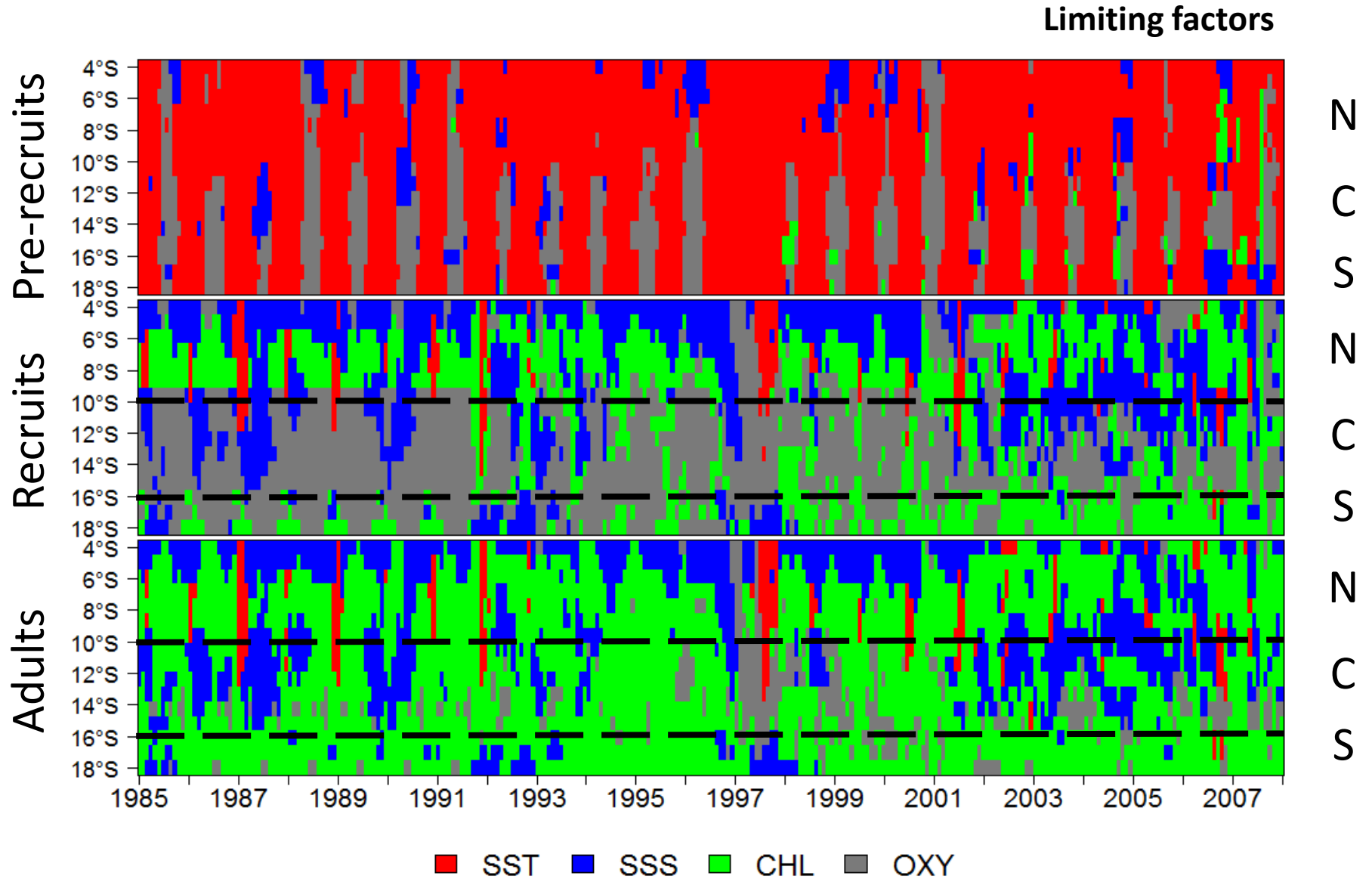
Impact on distribution and productivity

Changes in anchovy biomass

Perspectives

- Inclusion of the impact of O_2 in the simulations.
  - Downscaling for oxygen failed (oxycline)
  - Dynamical downscaling available, new statistical downscaling seems to work.
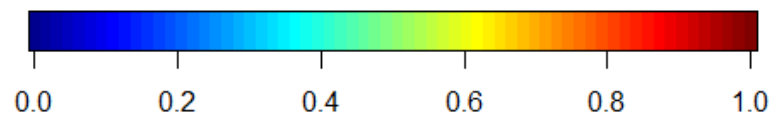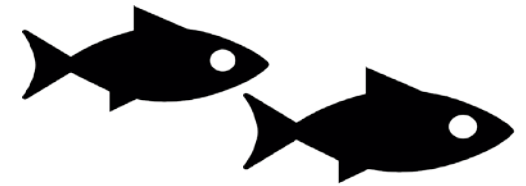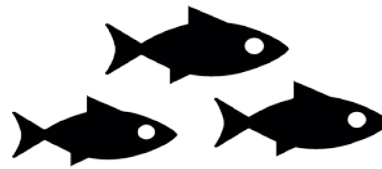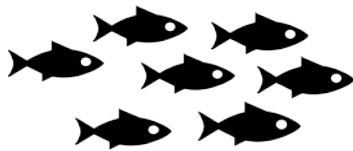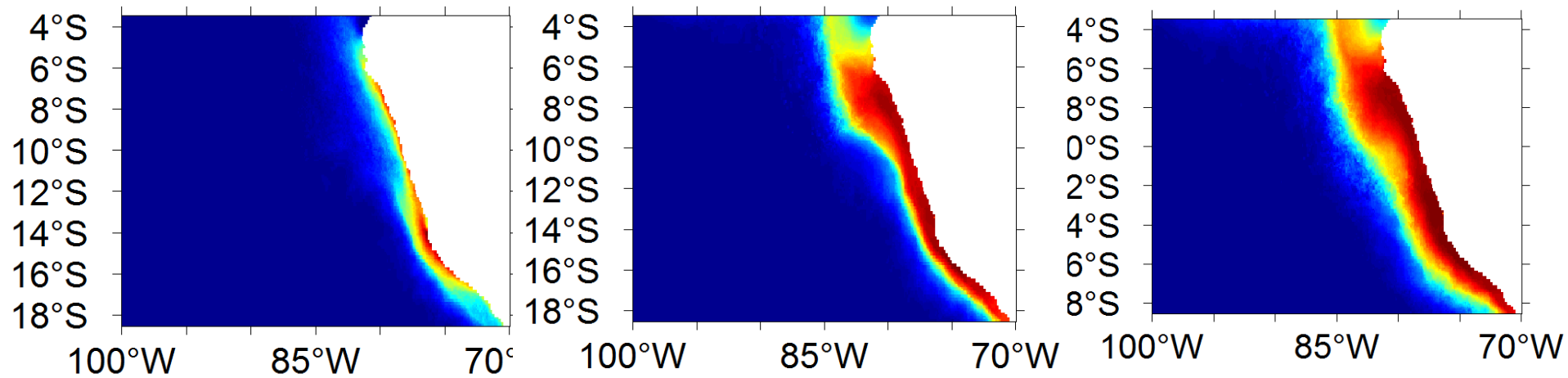
Perspectives

Lujan-Paredes et al., in prep.

Perspectives

Pre-recruits | Recruits | Adults

Perspectives

- Comparison with dynamical downscaling.
  - Bias correction still needed.
  - Test other downscaling approaches: k-nearest neighbors, simple interpolation.
- Dynamical downscaling
  - Better integration with fish models (plankton)
  - Validation of plankton

Perspectives

- Keep looking at the past:
    - New OSMOSE model for Northern Humboldt
    - New fisheries sub-module (**OSMOSE v4**)
    - New calibration 1958-2008 (Espinoza et al. in prep, **PISCES model**): longer historical analysis

Perspectives

- Keep looking at the past:
  - More detail on Humboldt Squid (stage-based spatial distribution, new predators – sperm whale, Hammerhead shark)
  - More detail on anchoveta (length-based spatial distribution, predation configuration, new predators)
  - Additional species: Land-based predators (birds and mammals), other squids.
  - More detail on fisheries (e.g. 3 fisheries for anchovy).

Acknowledments

Thanks!