Modelling the ecosystem and population dynamics of anchovy in the Bay of Biscay

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Collaboration IFREMER
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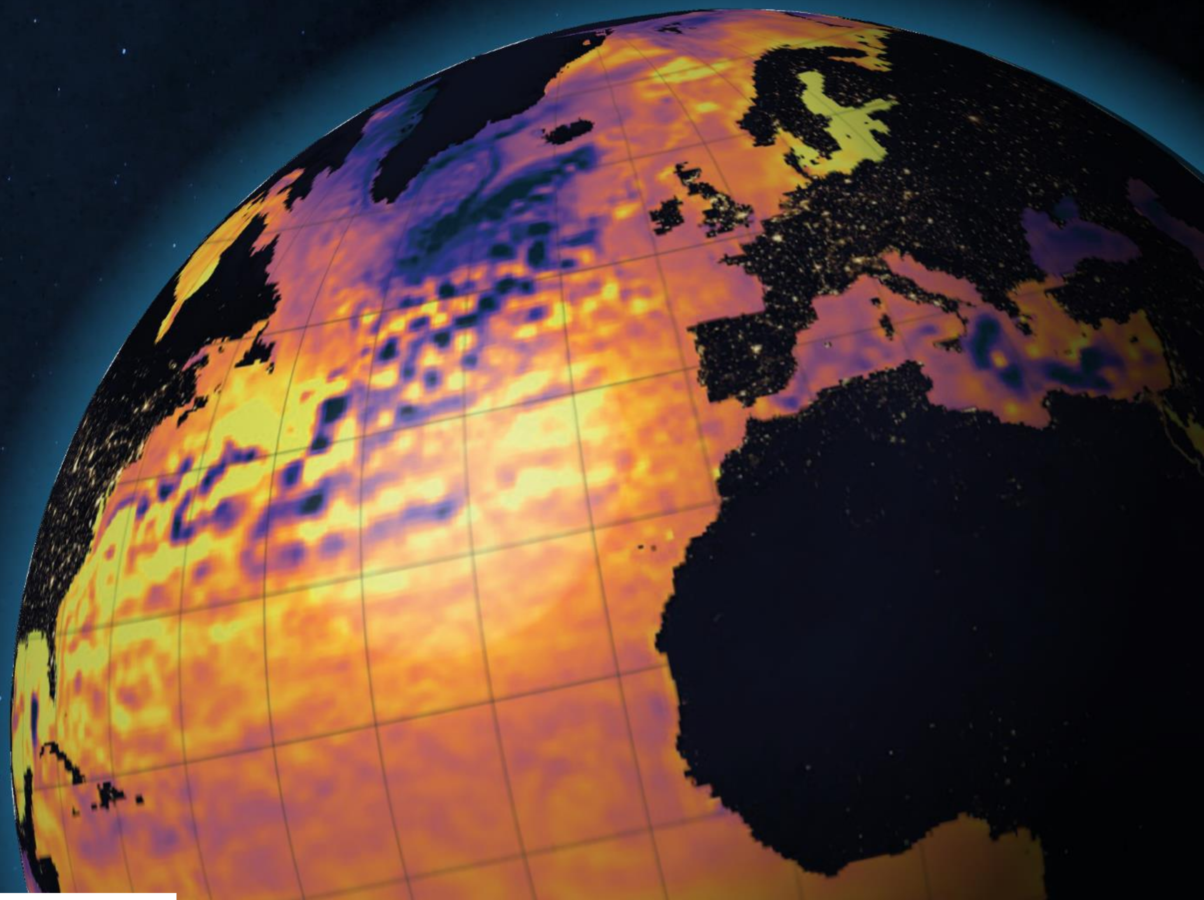
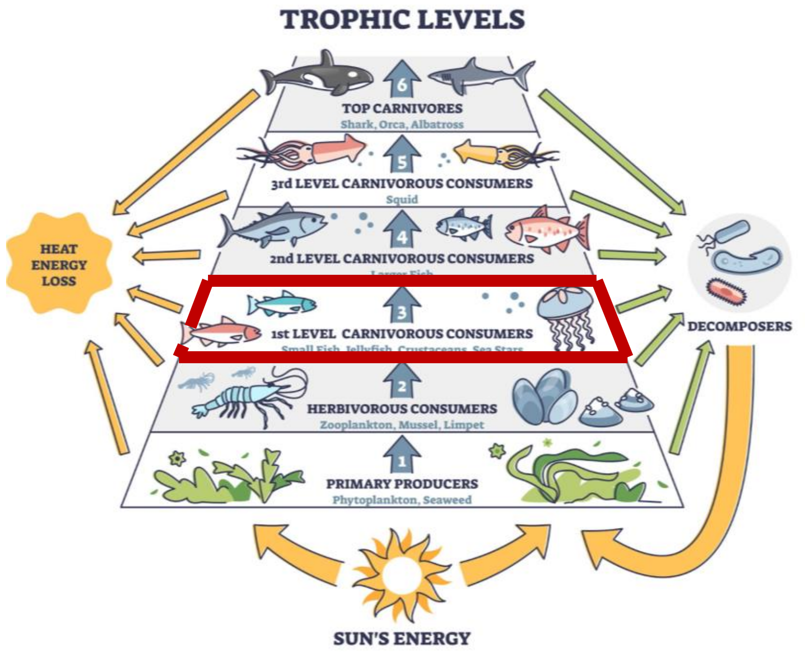


NECCTON
NEW COPERNICUS CAPABILITY FOR TROPHIC OCEAN NETWORKS

This project has received funding from Horizon Europe RIA under Grant Number 101081273 and the UK Research and Innovation

Context

Anchovy
(small pelagic fish species)



Anchovy school

Economical aspect

- ❖ Several species exploited all around the world (Peru, Chile, California Japan, East Asia, Europe, Brazil, Southern Africa, Australia)
- ❖ Important source of protein to the World population (directly or through fish meal for aquaculture)

Ecological aspect

- ❖ Populations showing large natural fluctuations related to climate / environment*
- ❖ Key species supporting large predator species (fish, mammals and seabirds)
- ❖ Fisheries generate by-catch of protected species (e.g., Dolphins in the Bay of Biscay)

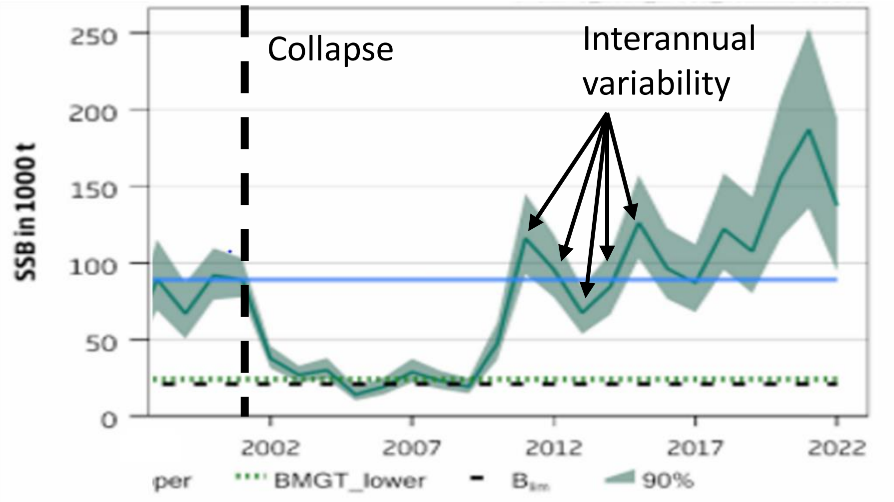
* e.g., Schwartzlose and Alheit (1999)

Context

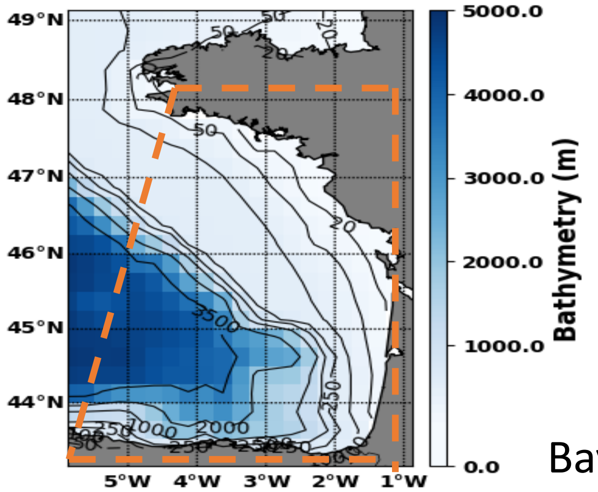
Common anchovy (Engraulis encrasicolus) population in the Bay of Biscay

Temporal fluctuation

- High interannual variability
- Population collapse at the beginning of the 21st century → fisheries closed for 5 years



Evolution of the stock of biomass of anchovy able to reproduce
(ICES WGHANSA Reports, 2022)



Bay of Biscay

- Reproducing temporal and spatial fluctuations and the collapse
- Studying the factors behind these fluctuations (environmental, fisheries)
- Producing scenarios (climate, closure of fishing zones).

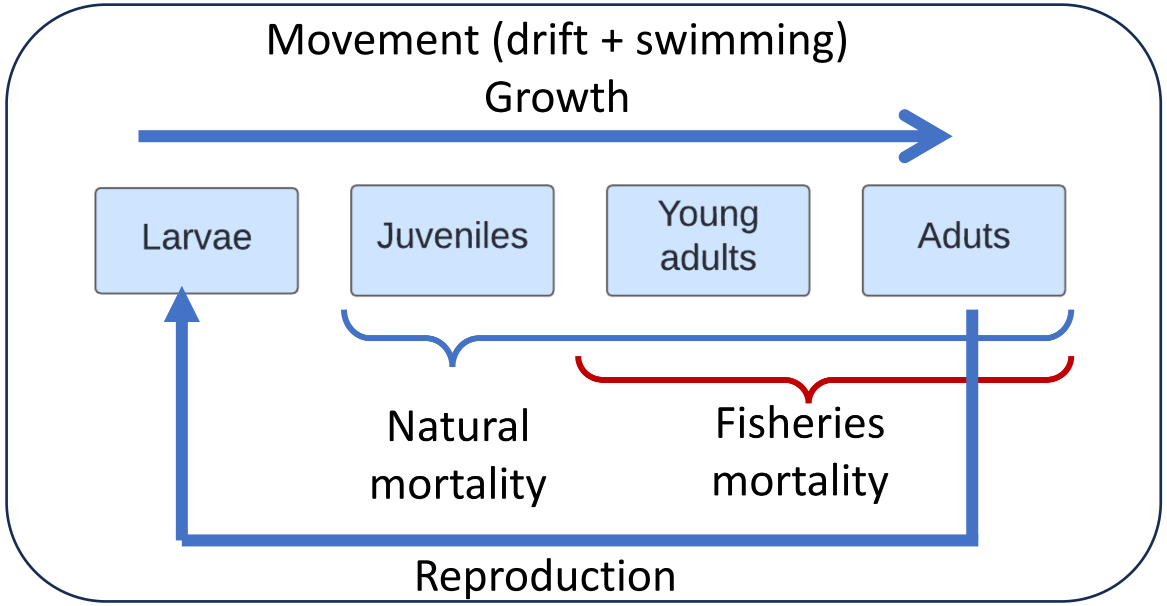
Modelling the entire population, taking into account natural and fishing-related mortality

Introduction

SEAPODYM-Fish (Spatial Ecosystem And Population Dynamics Model)

. Eulerian approach . Parametrised

. Integrate optimisation method (likehood maximum)



Imputs :
temperature, currents, zooplankton, micronekton

Outputs :
Stock biomass (total or by stage and region)
Fishing impact

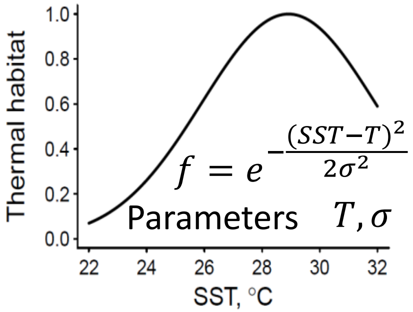
Dependence on the stock of anchovy biomass

- Mortality (natural (predation and senescence) and fisheries)
- Recruitment (ability of young fish or eggs to survive to adulthood)
  - Mortality (heavy predation during early life stages)
  - **Spawning process** (survivability of eggs and larvae released into a body of water)

Spawning habitat

Spawning process and area ⟷ Depending on physical and biogeochemical environmental conditions

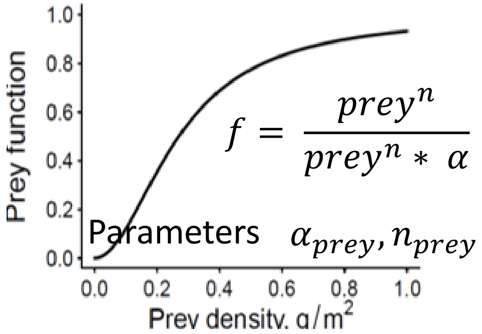
Thermal habitat



Optimal temperature and temperature window

×

Prey function



Minimum food requirement

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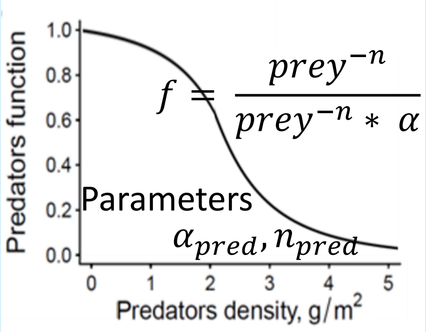
Predator function



Maximum predator limit

=

Spawning Habitat Hs [0,1]

- = 0 absence of larvae
- ≠ 0 possibility of presence depending of the presence of adults

Forcing data

Thermal habitat : Sea Surface Temperature (IBIRYS 1/12°)

Prey function: Zooplankton (SEAPODYM-LMTL 1/12°)

Predator function: Micronekton in epipelagic layer (SEAPODYM-LMTL 1/12°)

Micronekton = organism between 2 and 20 cm long capable of swimming independently of the current

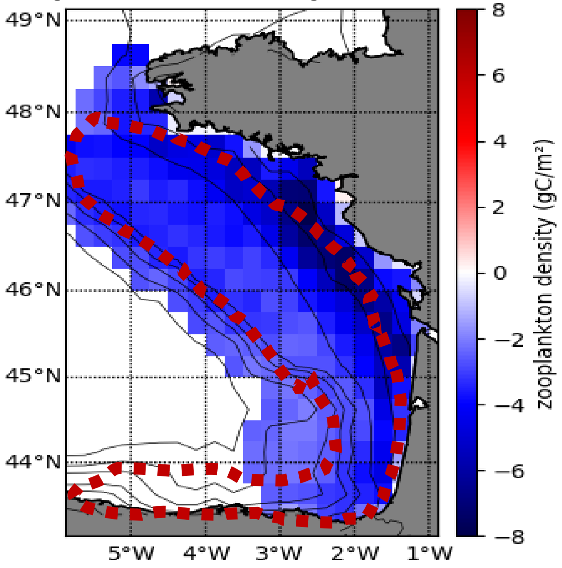
Zooplankton optimisation

- Set parameters for functions
- Check input data
- Estimate spawning habitat

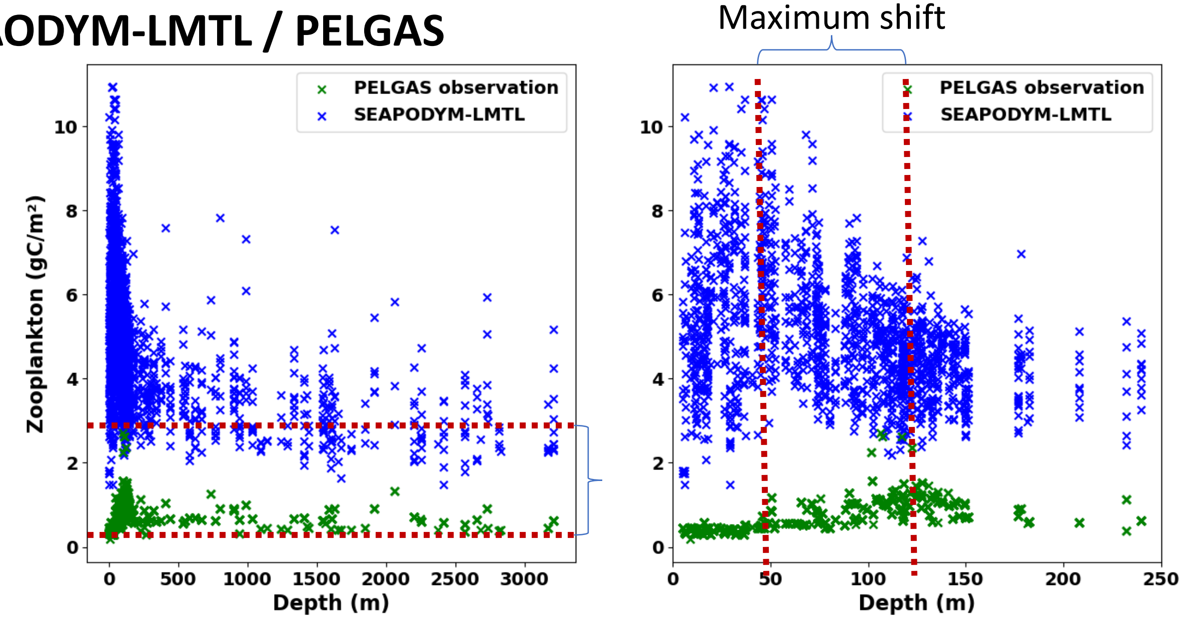
→ Comparison within situ data PELGAS data (Ifremer survey, month of May (2000-)

- ❖ Zooplankton
- ❖ Eggs → Spawning habitat eggs

Comparaison Zooplankton SEAODYM-LMTL / PELGAS



Zooplankton difference
Observation – Model
Mean may month 2006-2015



Zooplankton in function of depth (bathymetry)
between 0-3200m (left), 0-250m (right)

- ❖ **Global over-estimation of zooplankton model / observation**
- ❖ **Maximum shift**
  - **Model ≈ 50m**
  - **Observation ≈ 125m**

Extented spawning area

Zooplankton optimisation

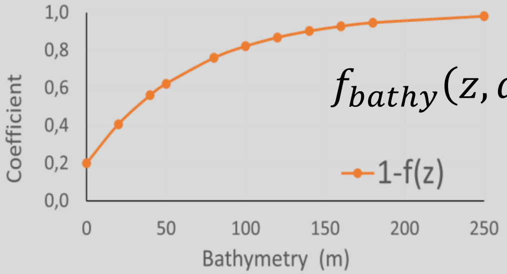
Corrections

Global over-estimation → Correction factor C_f

Maximum shift due to absence of benthos segment in SAEPODYM-LMTL

↓

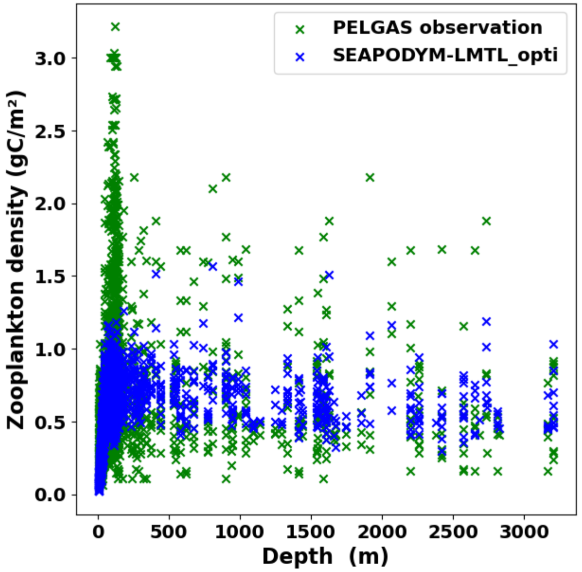
All the energy in the system goes into the pelagic system espacialy near the coast →

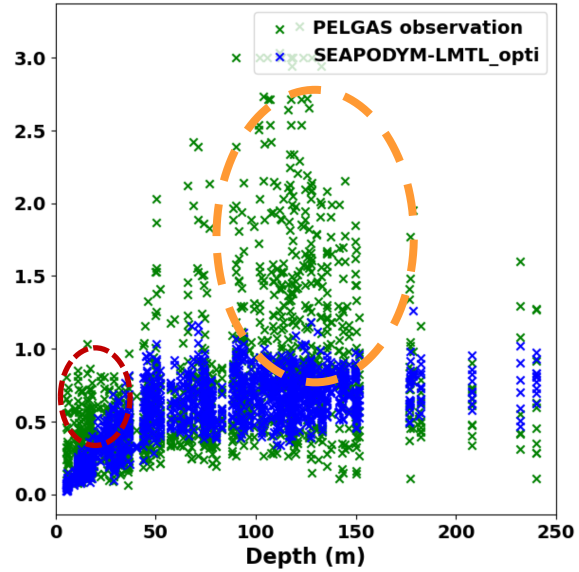


$$f_{bathy}(z,a,b) = (1-a) * e^{(-b*z)}$$

E_benthos = E * f(z)

E_pelagique = E * (1-f(z))

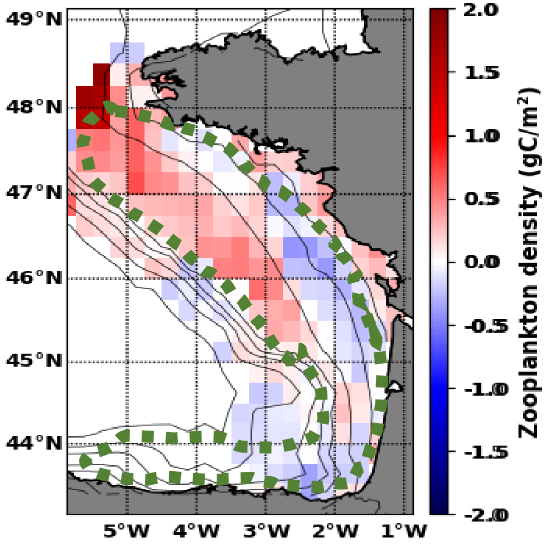




$C_f = 0,2$

$a = 0,\ b = 0,019$

Zooplankton in function of depth between 0-3200m (left), 0-250m (right)



Zooplankton difference Observation – Model optimised Mean may month 2006-2015

Correction

- **Global over-estimation of zooplankton model / observation**
- **Maximum shift**

Limitation

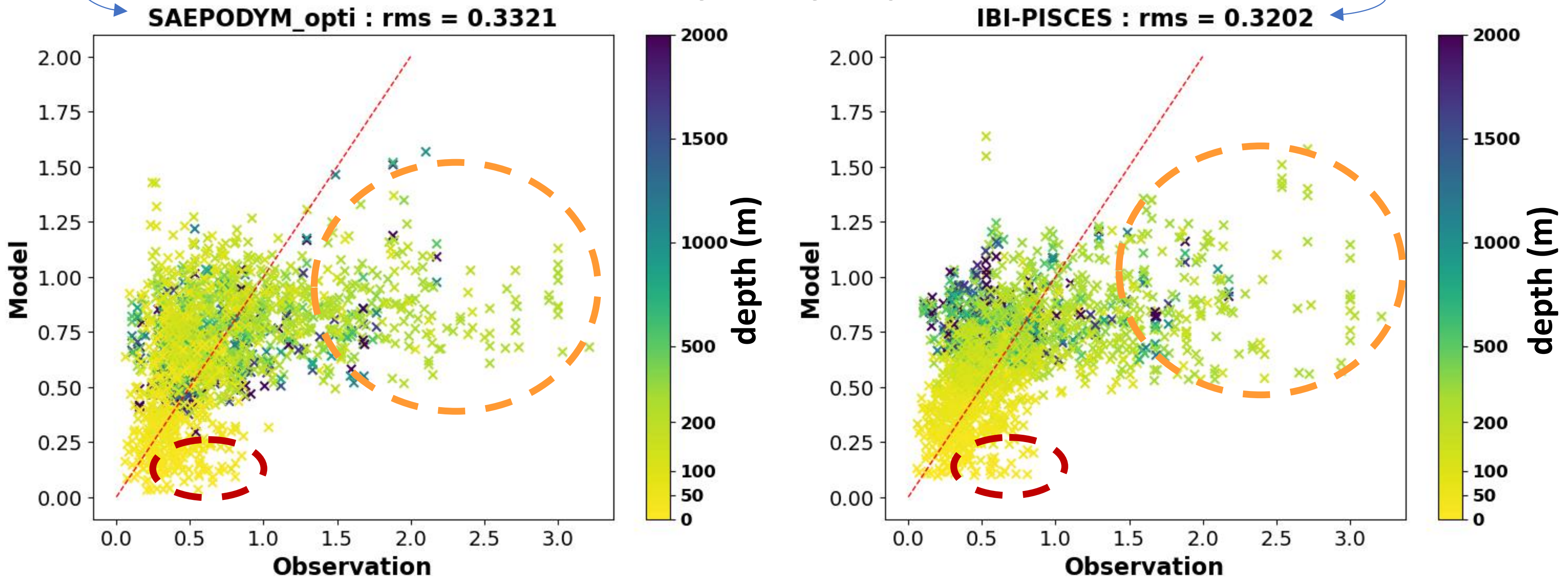
- **Under estimation, over correction**
- **Limitation of the maximum value**

Zooplankton optimisation

Model Zooplankton in fonction of zooplankton observed, according to bathymetry depth.

$Model_{init} * f_c * (1 - f_{bathy})$

$Model_{init} * f_c$



Under estimation really near coastline < 50m

Maximum value observed missing in models 100-200m

Perspectives

- **Continue The correction and validation of zooplankton input**
  - Try another correction function?
  - Set up a group of migrating zooplankton in SEAPODYM-LMTL
  - Look for other data (seasonal dynamics ?)

- **Optimisation and simulation of spawning habitat**
  - Estimate the parameters of 3 functions: temperature, prey, predators
  - Revise the mechanisms (relationships) if needed
  - Simulate the spawning habitat/ analyse the variability and future changes

- **Optimisation of the population-fisheries model and simulations**
  - Optimise the whole population model (taking account of the effect of fishing)
  - Analyse environmental vs fishing impacts
  - Simulate scenarios (climate change or closure of fishing zones)

Ocean Predict

MERCATOR OCEAN INTERNATIONAL

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2021 2030 United Nations Decade of Ocean Science for Sustainable Development

SYMPOSIUM OP'24

ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Thank you!

Quentin Misi
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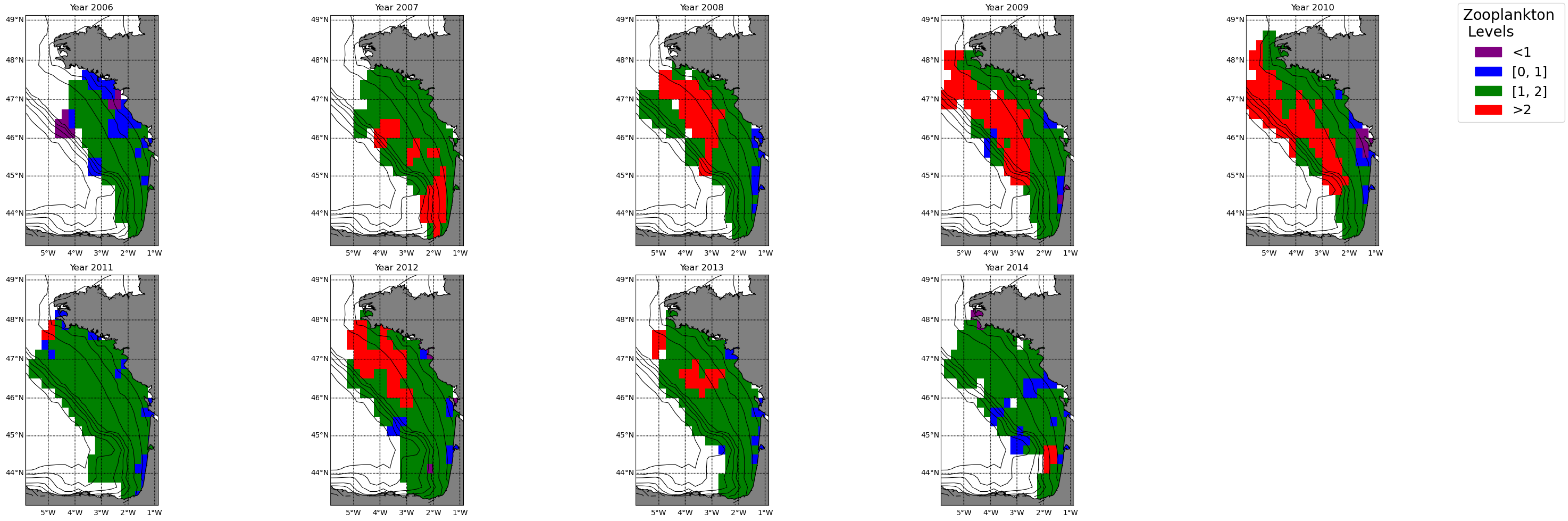
European Commission · Copernicus Marine Service · EU4OceanObs International Ocean Governance EU Component to Global Ocean Observations · Mercator Ocean International · esa · cnes Centre National d'Études Spatiales · Australian Government Bureau of Meteorology · Met Office · NERSC · Canada

PELGAS zooplankton by category



Zooplankton : other imput

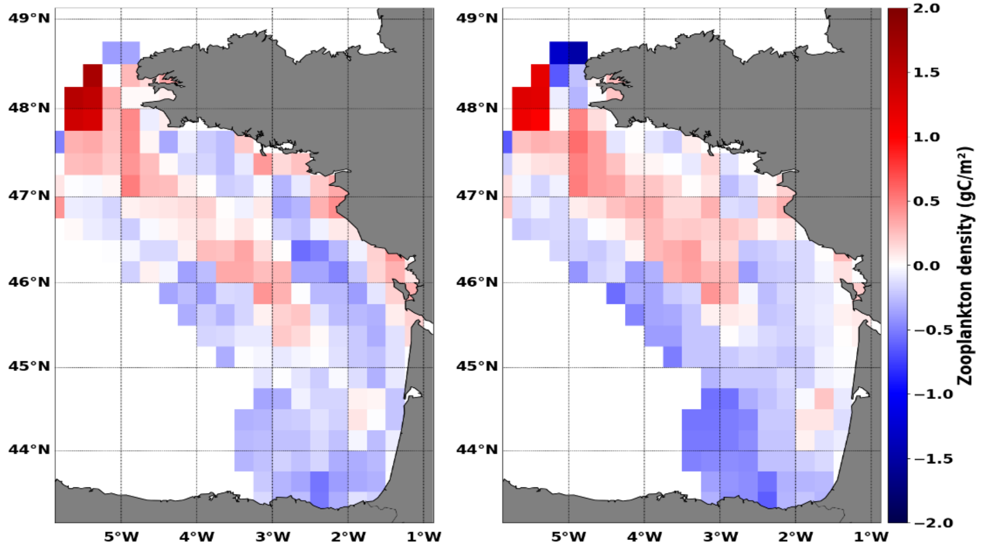
Use of IBI-PISCES

Avantages :
Only global overestimation easily corrected by the factorSimilar shape to observation, with a maximum at the same depth..

Limitations : Difficulties in representing annual variations(no assimilation of river imputs)

SEAPODYM-LTML corrected

IBI-PISCES corrected



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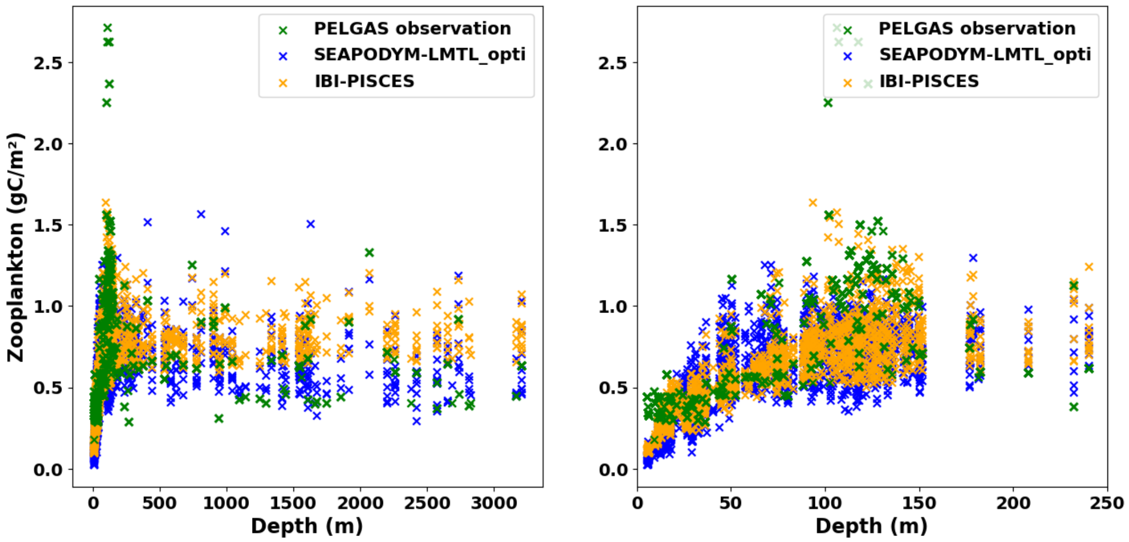

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