A biogeochemical model for North and Northwest Iberia: some applications

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INSTITUTO ESPAÑOL DE OCEANOGRAFÍA

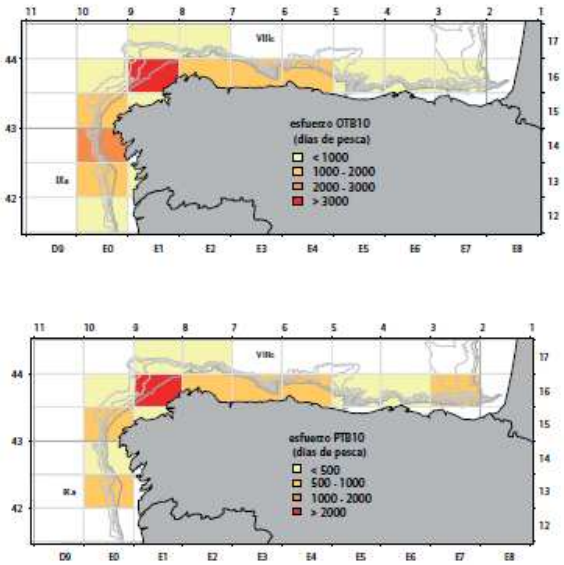
IEO tasks and duties

- To carry out **scientific research** in the fields of oceanography and sea sciences.
- To **advice the government** in terms of fishing and marine policies.
- To **represent Spain** in international organizations that have to do with fisheries and marine sciences (like ICES)
- To **promote cooperation** in terms of marine research among regional, national and international organizations.
- To **train marine researchers** and diseminate oceanographic knowledge.

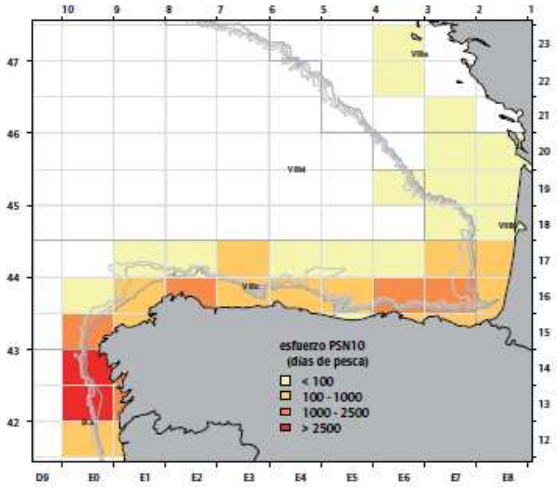
Contribution to PIB

- **In Spain:** 1% including transformation and commercialization
- **Highly fishing dependent areas:** 10%.
- The most important fishing region in Spain is **Galicia** by far.

Bottom trawling fishing effort



Purse-seine fishing effort



Castro, J. et al. (2011): Atlas of the spanish fishing fleets in Spanish and Eurropean-atlantic waters. *Temas de Oceanografía*, IEO

The IEO modeling group

- Providing insight on circulation off N and NW Iberia for ecosystem studies in support to the intense IEO ecosystem research in the area.
- The main interest is on high resolution shelf and slope processes (upwelling, river plumes, slope currents. . .)
- Coupling of the physical model to marine ecosystem models and Lagrangian models.

Project REPRODUCE
Marifish EraNet

Understanding the mechanisms that drive the recruitment process, i.e. the appearance of a new generation of individuals in a fish stock.

Project ASIMUTH
FP7 Space Theme

ASIMUTH aims to Develop forecasting capabilities to warn of impending harmful algal blooms (HABs).

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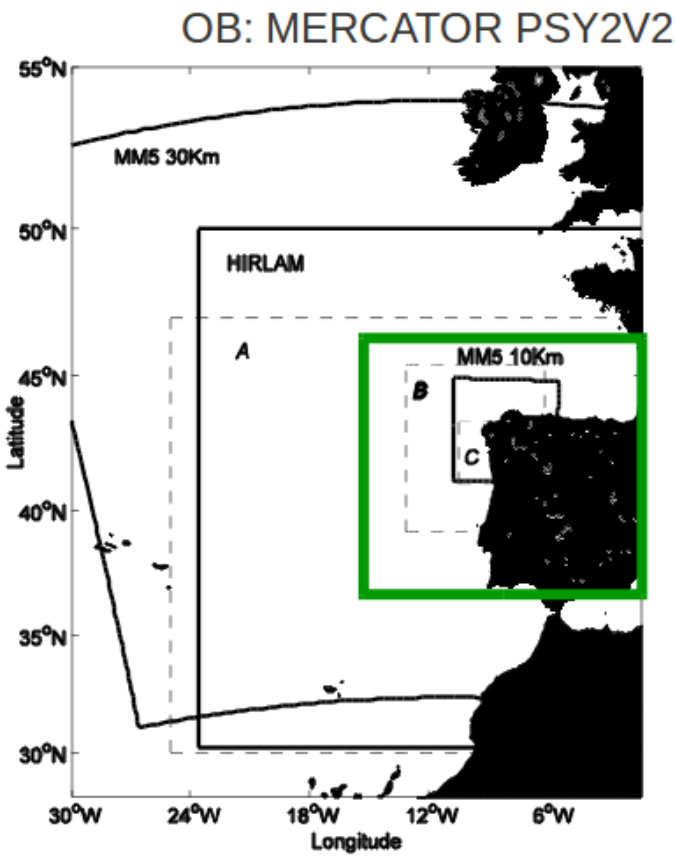
Configuration



Hydrodynamics+Biogeochemistry

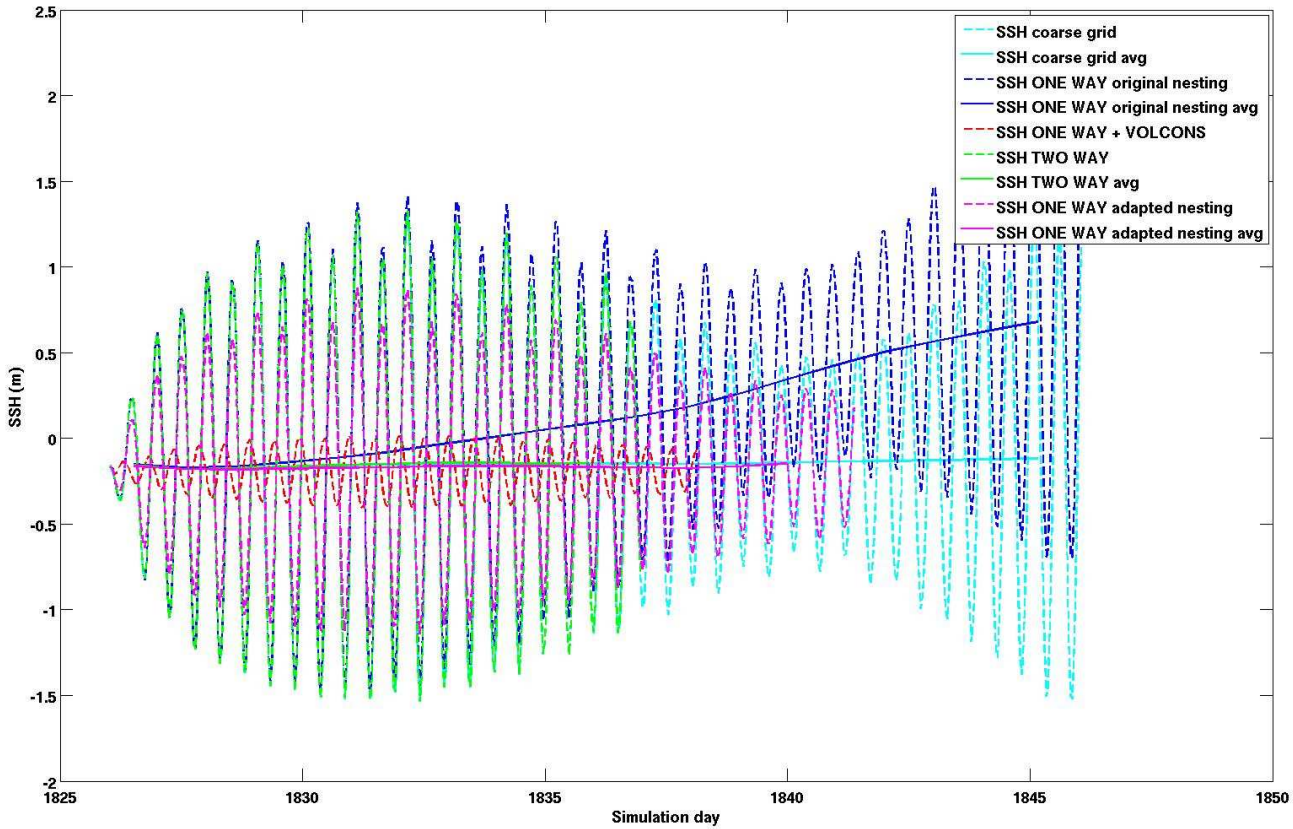
- ROMS Rutgers version 3.5
- 30 vertical levels
- 3.5km horizontal resolution.
- Rivers
- Simulated period: 2005-**2006-2007** and 2012-2013

Only hydrodynamics

- Operational model
  - Roms Agrif
  - One way nesting
  - Simulated period: from 2009 till January 2014
- New operational model
  - Roms Rutgers 3.7
  - ~~One way nesting~~
  - Simulated period: from January 2014-now

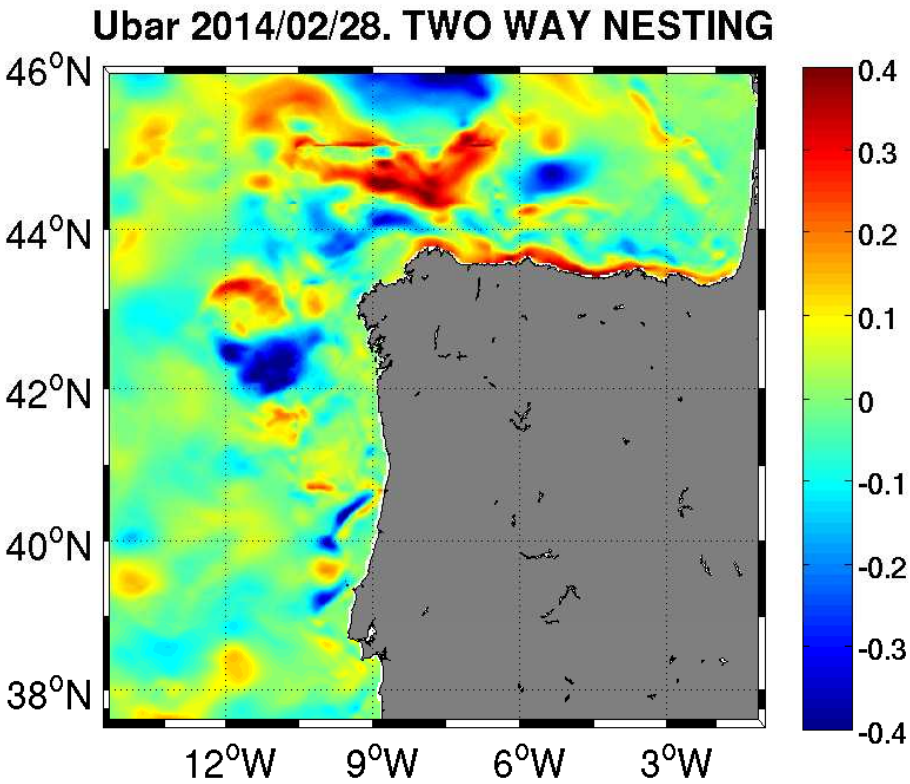
Some nesting tests....ROMS Rutgers 3.7

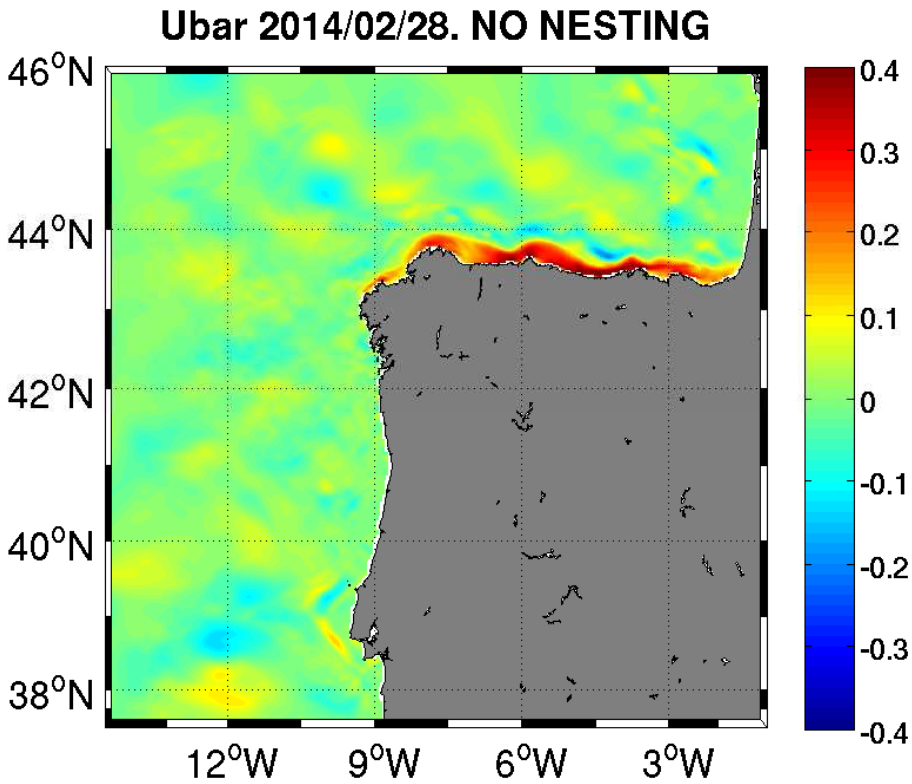
One way nesting



Some nesting tests....ROMS Rutgers 3.7

Two way nesting





Debreu et al., 2012. Two-way nesting in split-explicit ocean models....

N2PZD2 Model: Fennel 2006

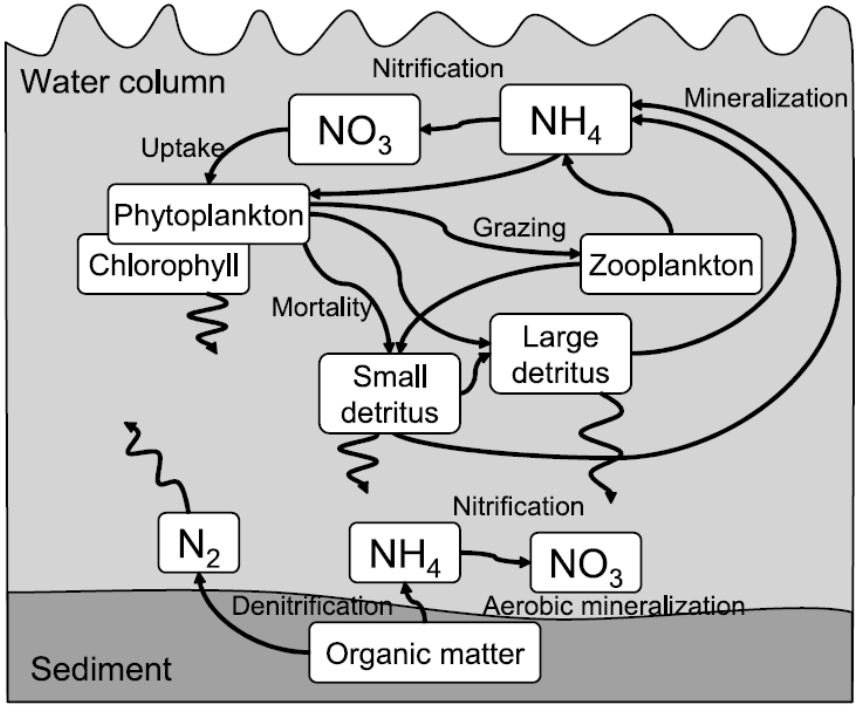


Figure 1. Biological model schematic.

Fennel, K. et al. (2006): Nitrogen cycling in the Middle Atlantic Bight: Results from a three-dimensional model and implicatiosn for the North Atlantic nitrogen budget. *Global Biogeochemical Cycles*, 20

Code tunning

fennel.h

```
!=======================================================================
!  Start internal iterations to achieve convergence of the nonlinear
!  backward-implicit solution.
!=======================================================================
!
!  During the iterative procedure a series of fractional time steps are
!  performed in a chained mode (splitting by different biological
!  conversion processes) in sequence of the main food chain.  In all
!  stages the concentration of the component being consumed is treated
!  in fully implicit manner, so the algorithm guarantees non-negative
!  values, no matter how strong s the concentration of active consuming
!  component (Phytoplankton or Zooplankton).  The overall algorithm,
!  as well as any stage of it, is formulated in conservative form
!  (except explicit sinking) in sense that the sum of concentration of
!  all components is conserved.
```

- We ensured that all the consumption terms are treated implicitly (phytoplankton mortality, zooplankton excretion)
- We switched off processes when concentrations of species went below a reasonable threshold (already done for zoo and phyto)

Tracers advection scheme

We use `TS_U3HADVECTION` instead of `TS_MPDATA`

Configuration details: initial and boundary conditions

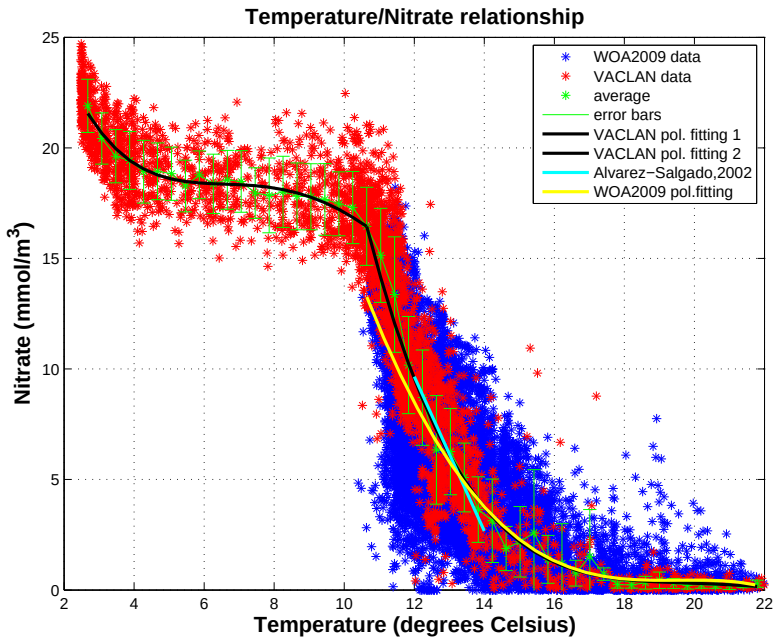
Nitrate: the limiting nutrient in the area

- **CLIMATOLOGY:** NODC World Ocean database 2009 (WOA2009)
- **T/NO_3 relationships**

Configuration details: initial and boundary conditions

Nitrate: the limiting nutrient in the area

- ~~**CLIMATOLOGY:** NODC World Ocean database 2009 (WOA2009)~~
- **T/NO_3 relationships**. **We want to include nutrient variability through the boundaries!!!**



NW Iberia upwelling system

- Reliable characterization of the Eastern North Atlantic Central Water (ENACW).
  - Álvarez-Salgado et al., 2002
- IEO-VACLAN data
- WOA2009 data

Configuration details: initial and boundary conditions. Variability???

Role of convective winter mixing on nutrient availability.

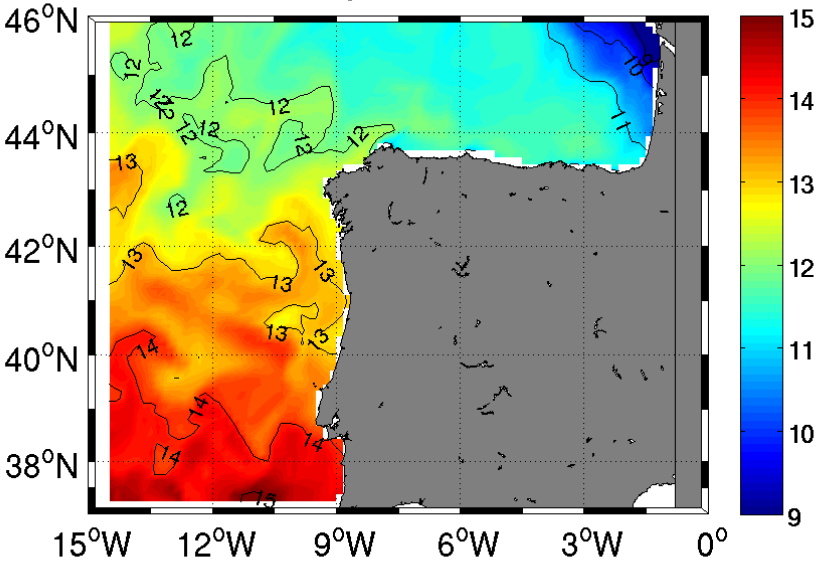
Hartman et al., 2010

Hartman et al., 2012

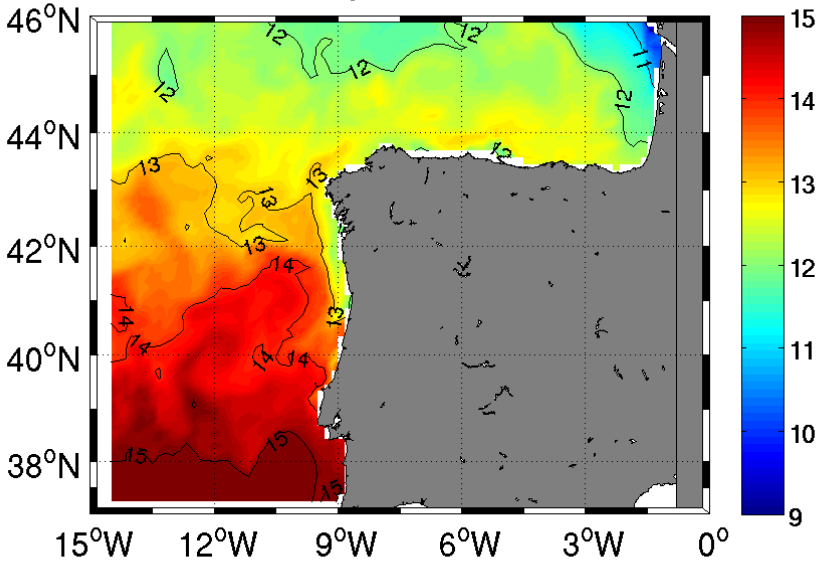
Inter annual variation in mixed layer depth (MLD) and Productivity (NCP) assessed using oxygen data

Year	MLD ARGO 0.5°C (m)	NCP $_{mld\ (DO)}$ (Mol C m^{-2})
2005/2006	469	20.91
2006/2007	212	10.07
2007/2008	265	10.53
2008/2009	439	19.91
2009/2010	476	16.91

A) Minimum temp. Mercator. Year: 2006



B) Minimum temp. Mercator. Year: 2007



Configuration details: initial and boundary conditions. Variability???

Role of convective winter mixing on nutrient supply.

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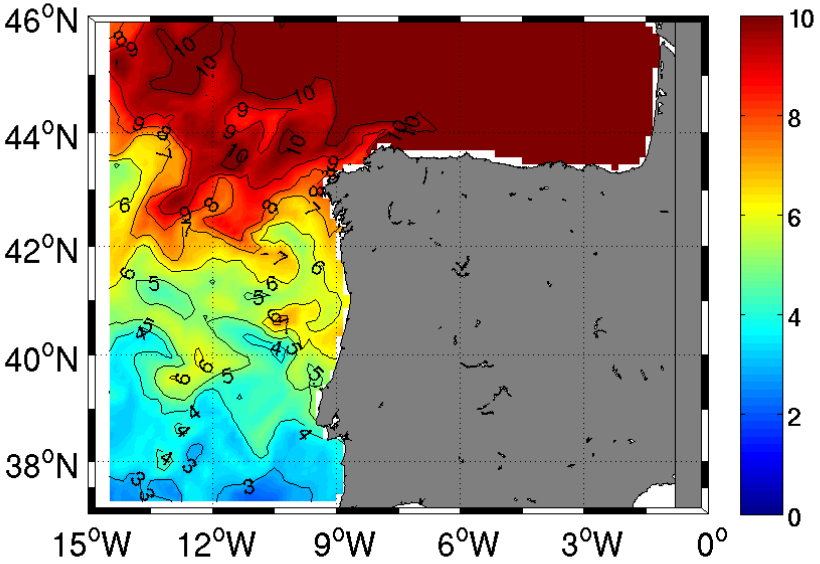
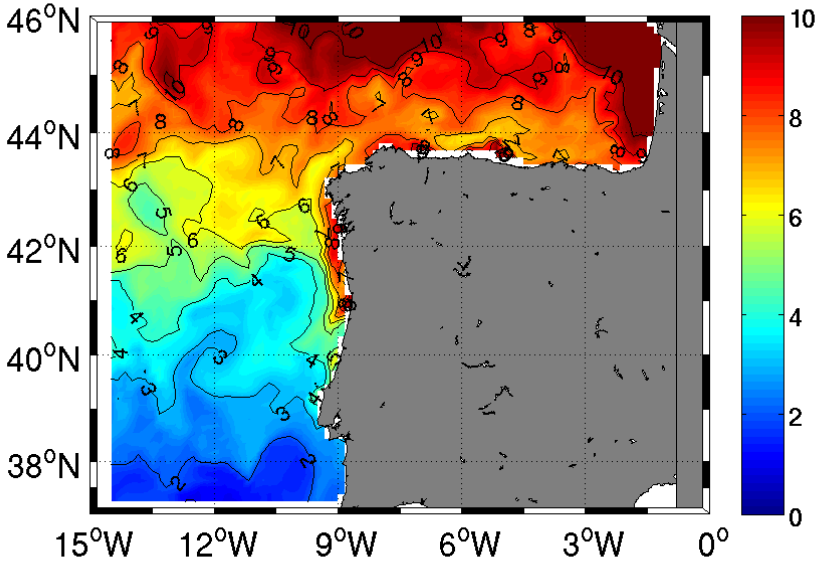
C) Maximum NO_3 from Mercator temp. Year: 2006



D) Maximum NO_3 from Mercator temp. Year: 2007



Configuration details: parameters

- Shift from diatoms to dinoflagelates as the bloom advances. E.g.

  Tilstone (2003)

- Interest on the **spring bloom**: unique phytoplancton functional group will be DIATOMS (*Chaetoceros socialis*).

  Bode (1996), Bode (1998)

Adapted parameters

- K_{NO3} (mmol NO3/m3): Half saturation constant for Nitrate uptake. $\frac{NO3}{K_{NO3}+NO3}$

Default	Mixed diatoms Ria Vigo	Sel. value
0.5 (Fennel et al., 2006)	0.37 (Seeyave et al., 2013)	0.25

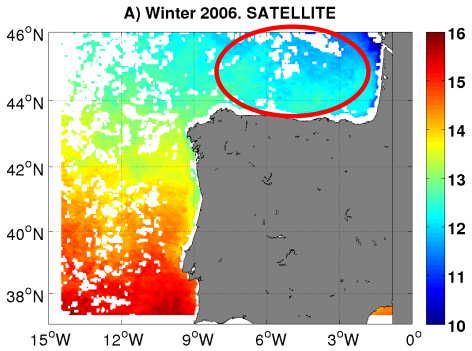
- α: initial slope of the P-I curve (mol C g $\mathrm{Chl}^{-1}(\mathrm{Wm}^{-2})^{-1}\mathrm{d}^{-1}$).

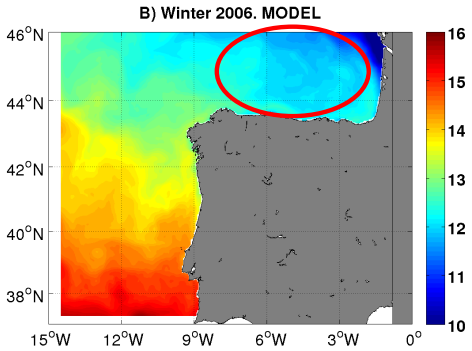
Default	Sel. value
0.025(Fennel et al., 2006)	0.05 (Bode and Varela, 1996, 1998)

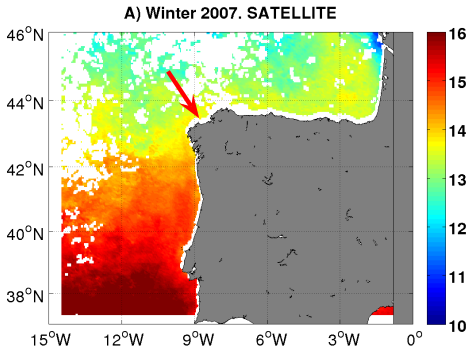
- g_{max}: maximum grazing rate for zooplankton (day^{-1}).

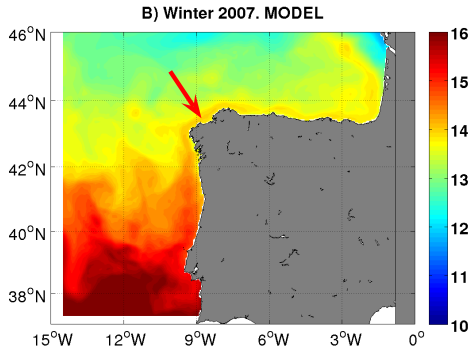
Default	Sel. value
0.6 (Fennel et al., 2006)	1 (based on Kone, 2005)

SST: AVHRR vs. Model









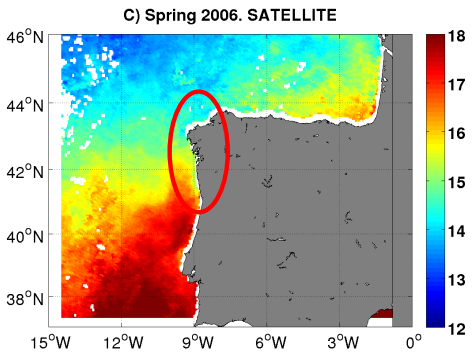
Satellite 2006

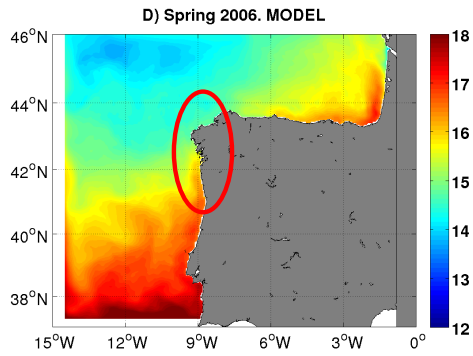
Model 2006

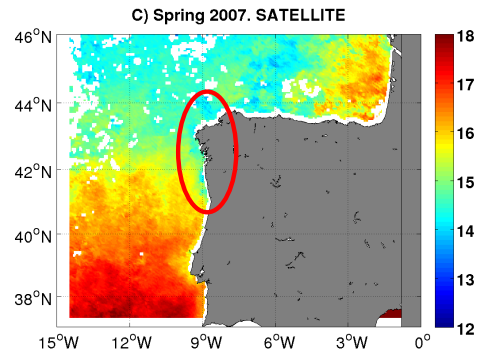
Satellite 2007

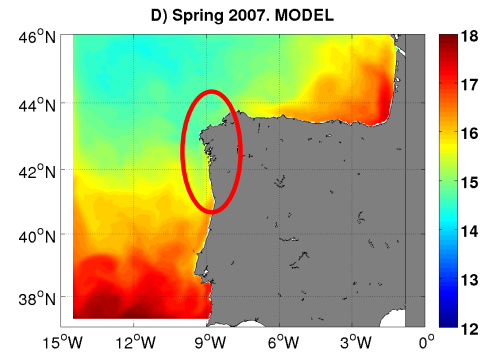
Model 2007

SST: AVHRR vs. Model









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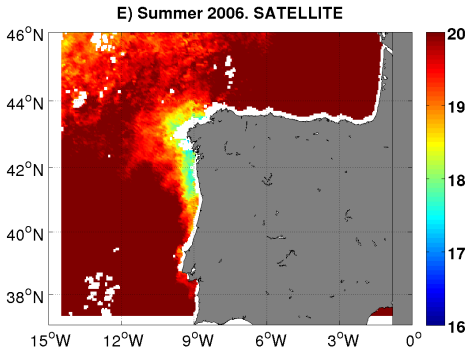

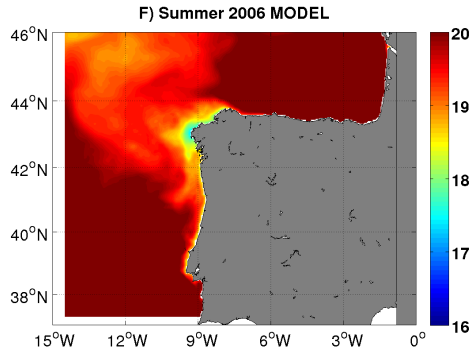

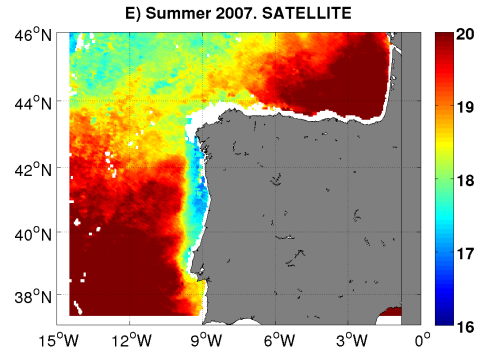

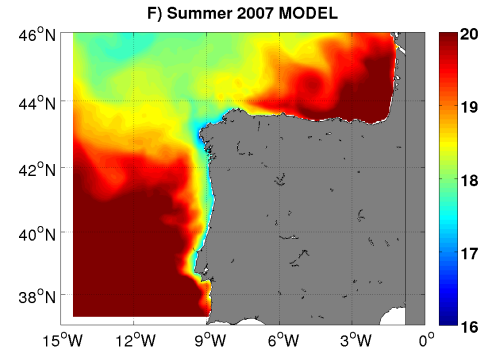

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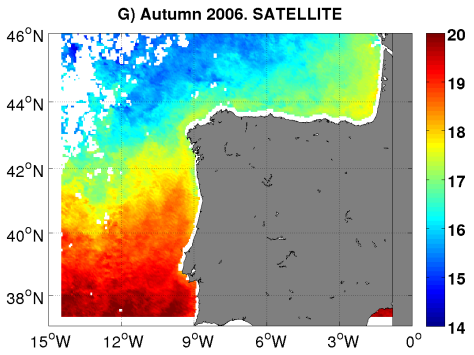
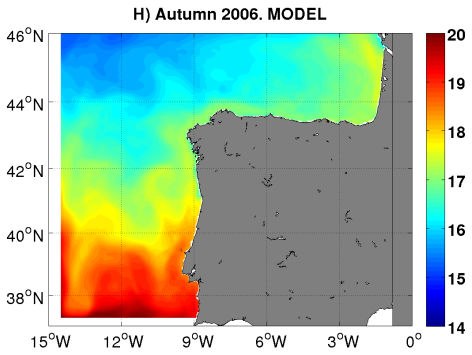
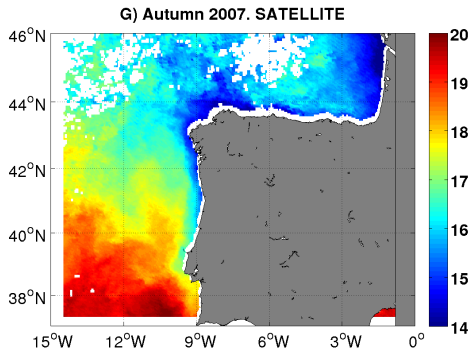
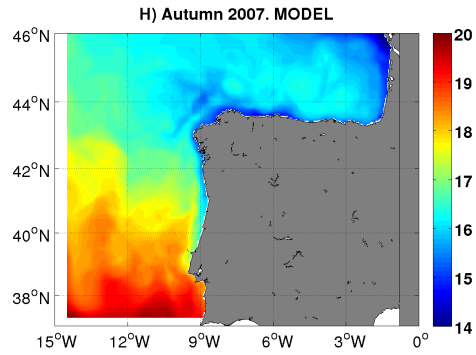








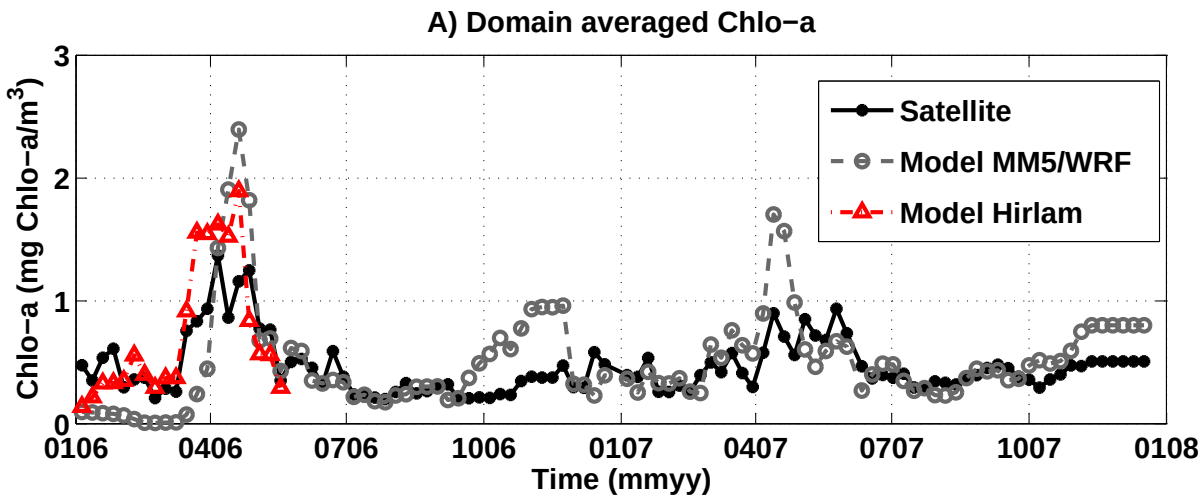
Satellite 2006

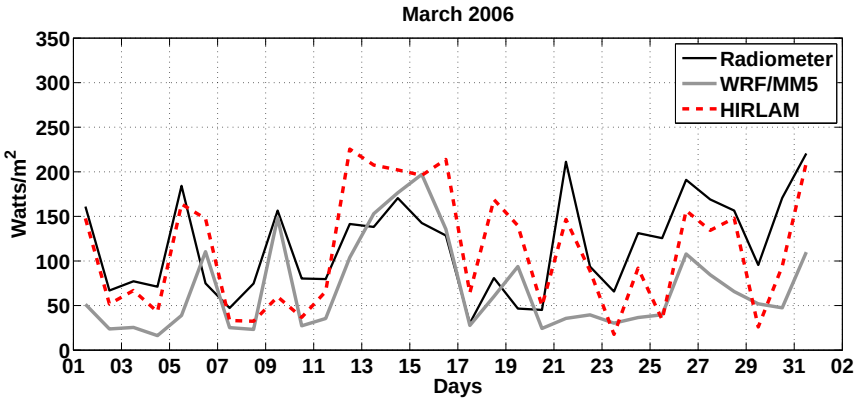
Model 2006

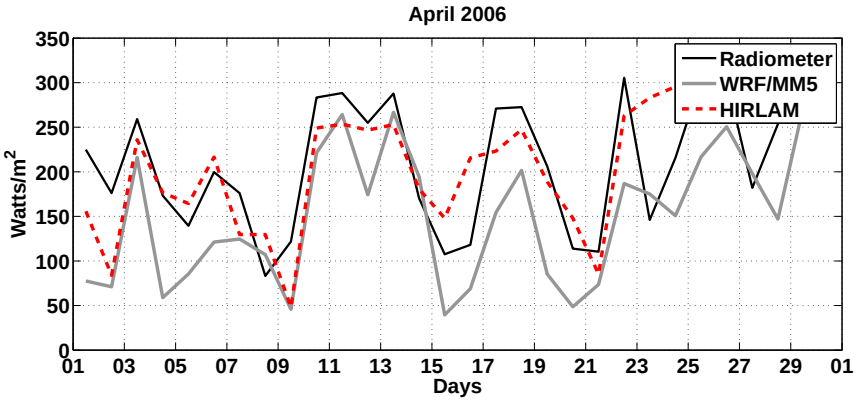
Satellite 2007

Model 2007

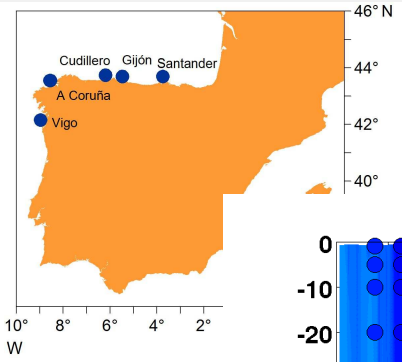
Chlorophyll-a: MODIS-OC3 vs. model



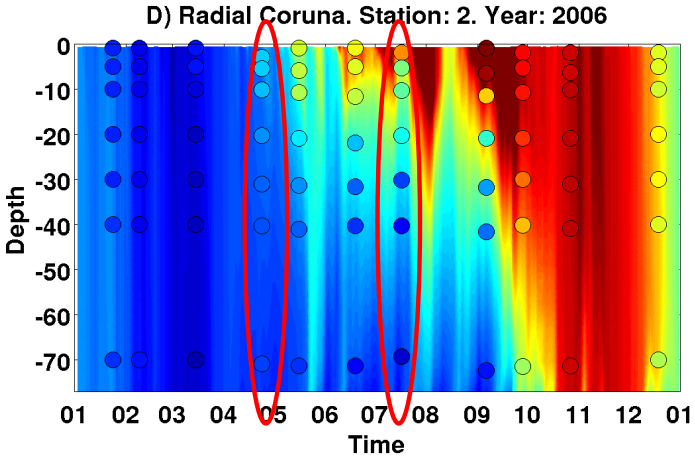


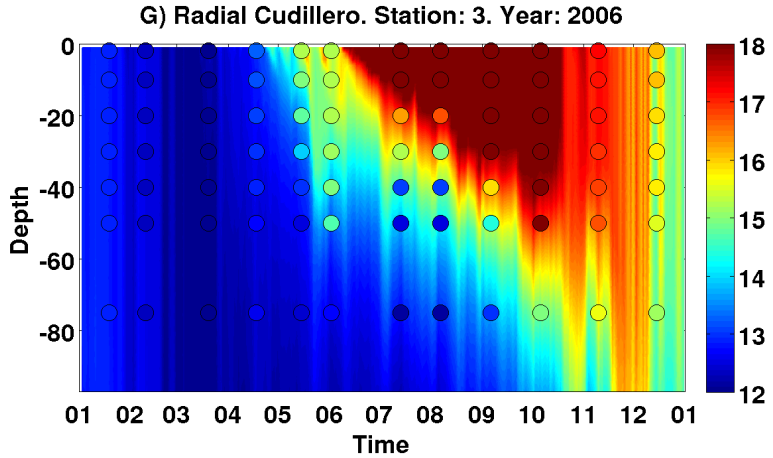


Temperature: Radiales (IEO) vs. model

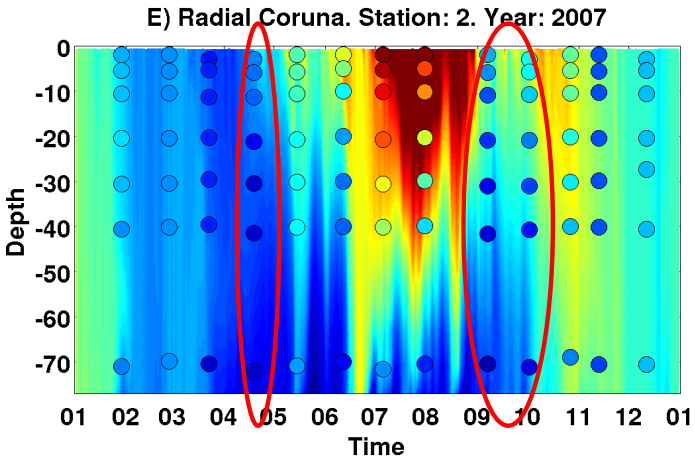


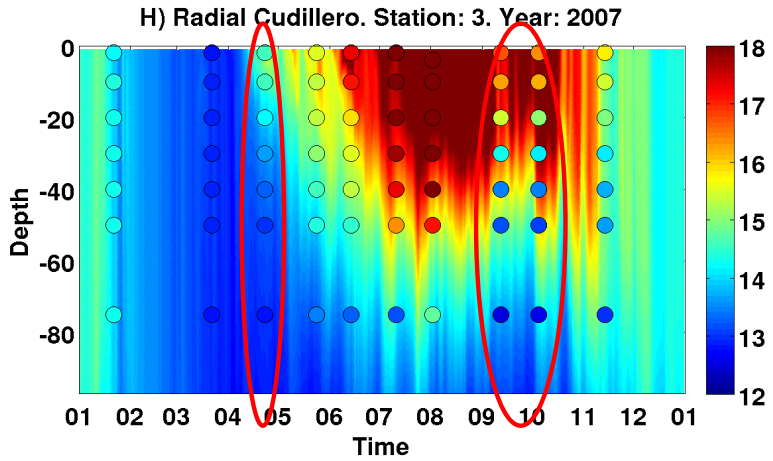
2006



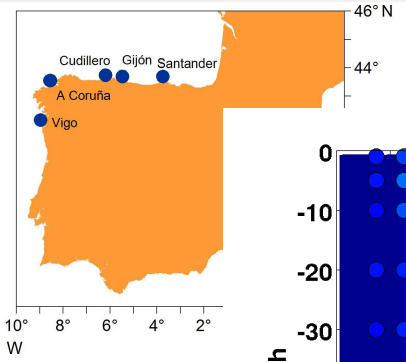


2007





Chlorophyll: Radiales (IEO) vs. model



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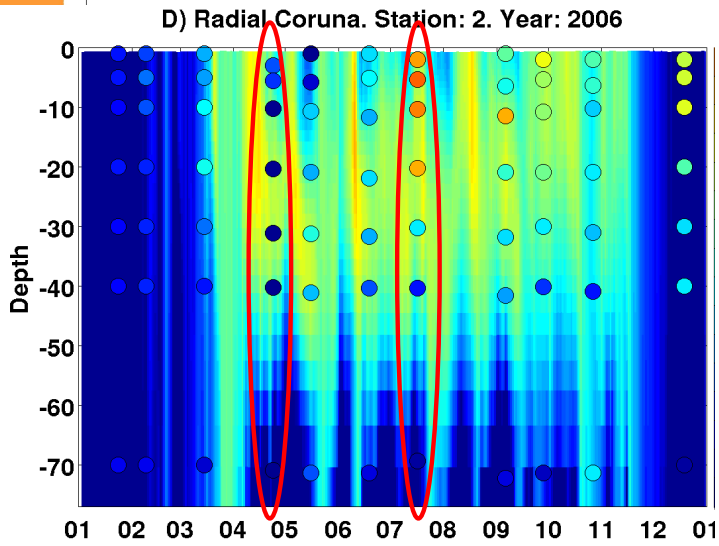

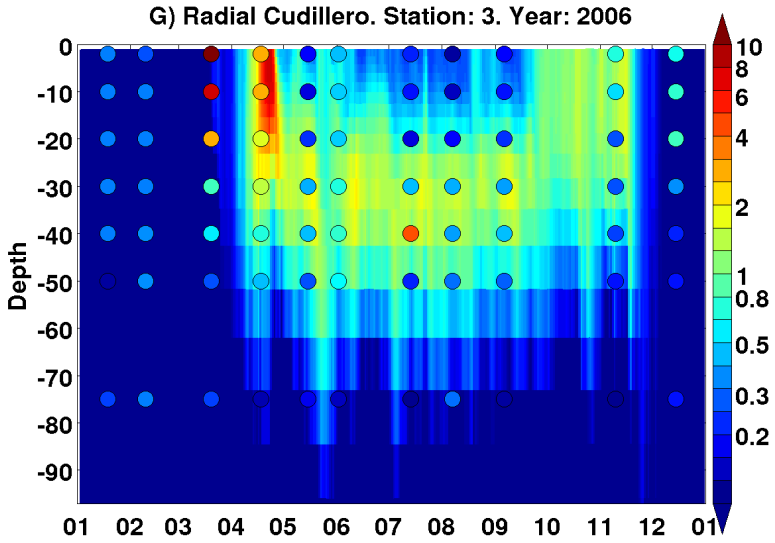

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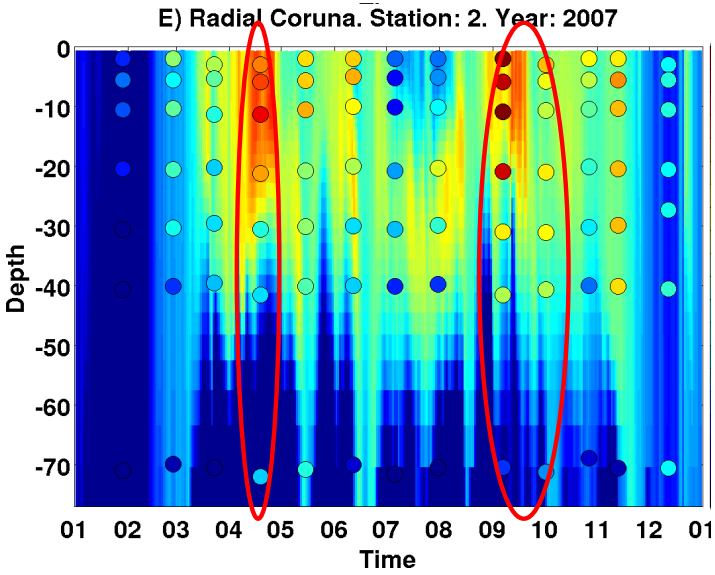
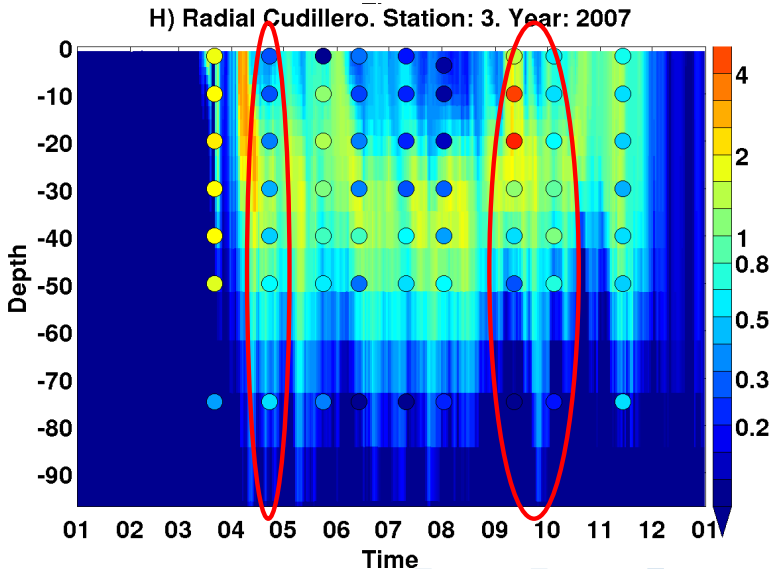
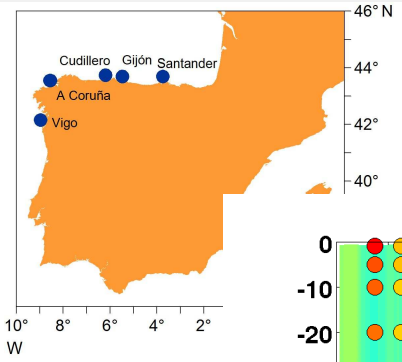
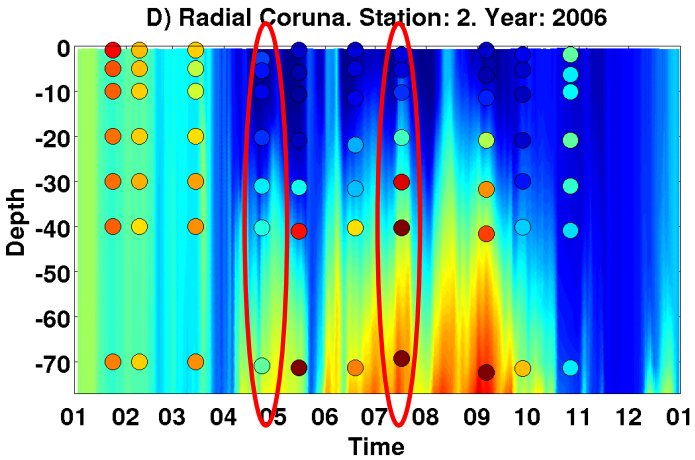


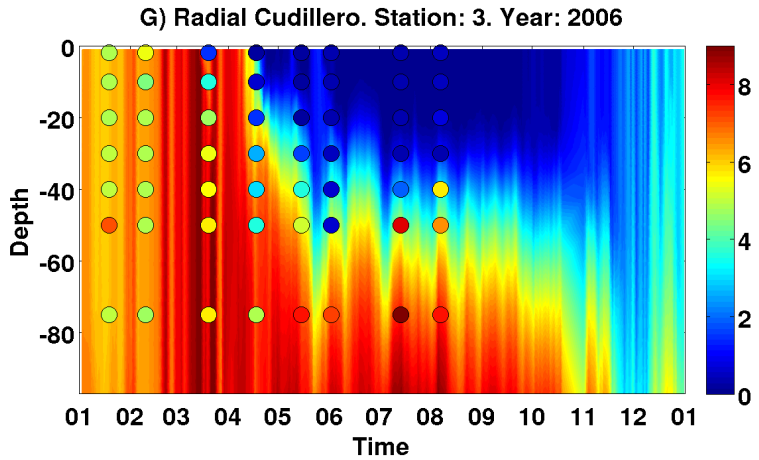


Nitrate: Radiales (IEO) vs. model

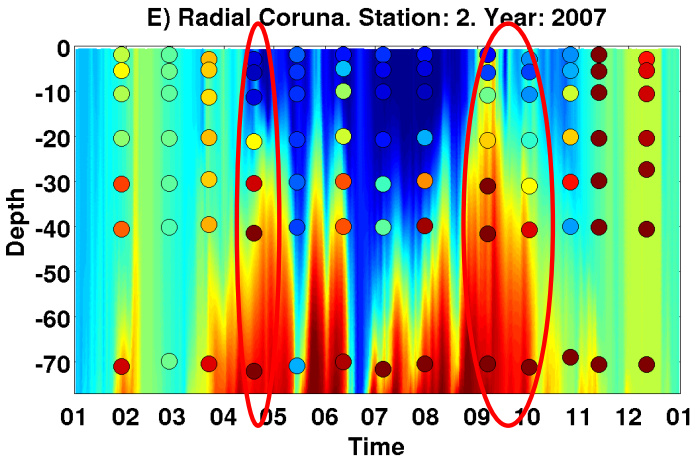


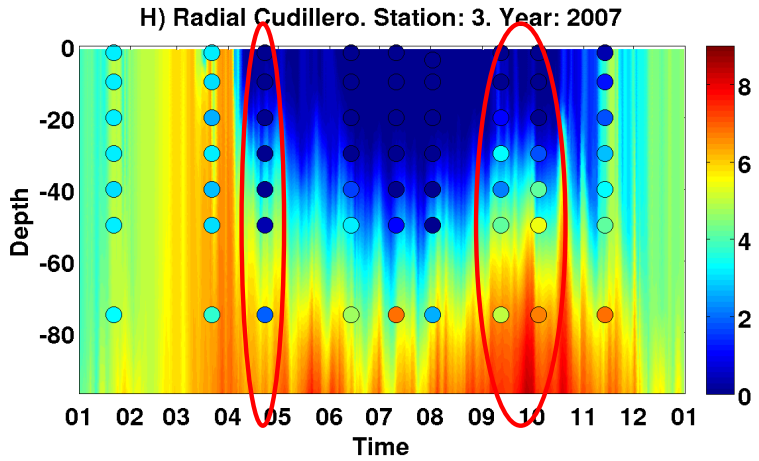
2006



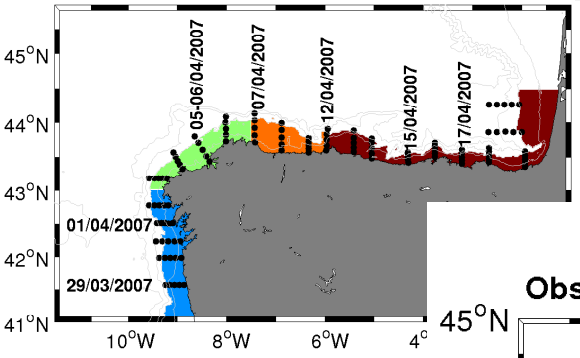


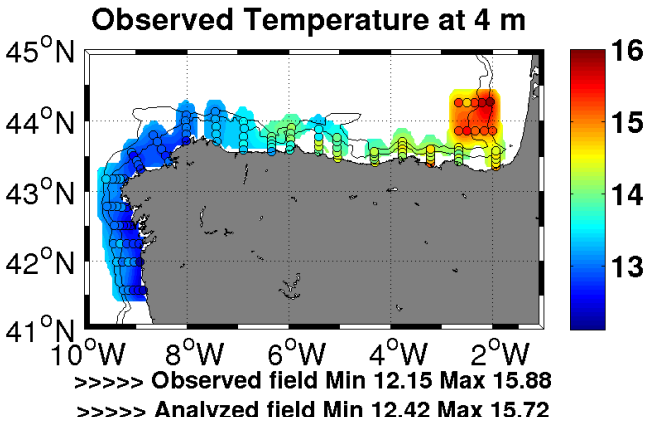
2007



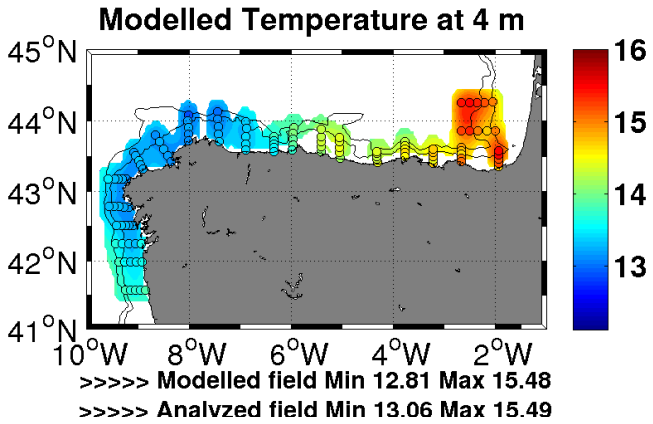


Pelacus cruise 2007: 27th of March 2007 to 23rd of April 2007

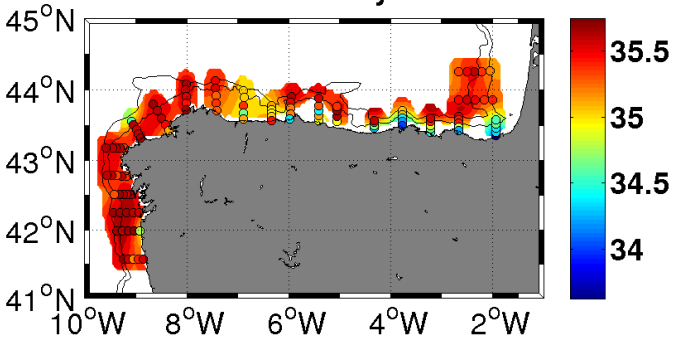




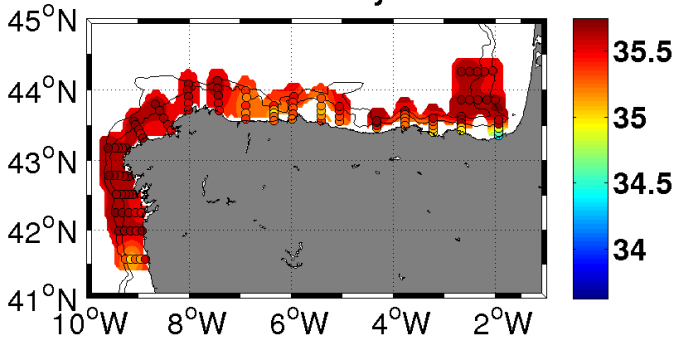
>>>>> Observed field Min 12.15 Max 15.88
>>>>> Analyzed field Min 12.42 Max 15.72



>>>>> Modelled field Min 12.81 Max 15.48
>>>>> Analyzed field Min 13.06 Max 15.49

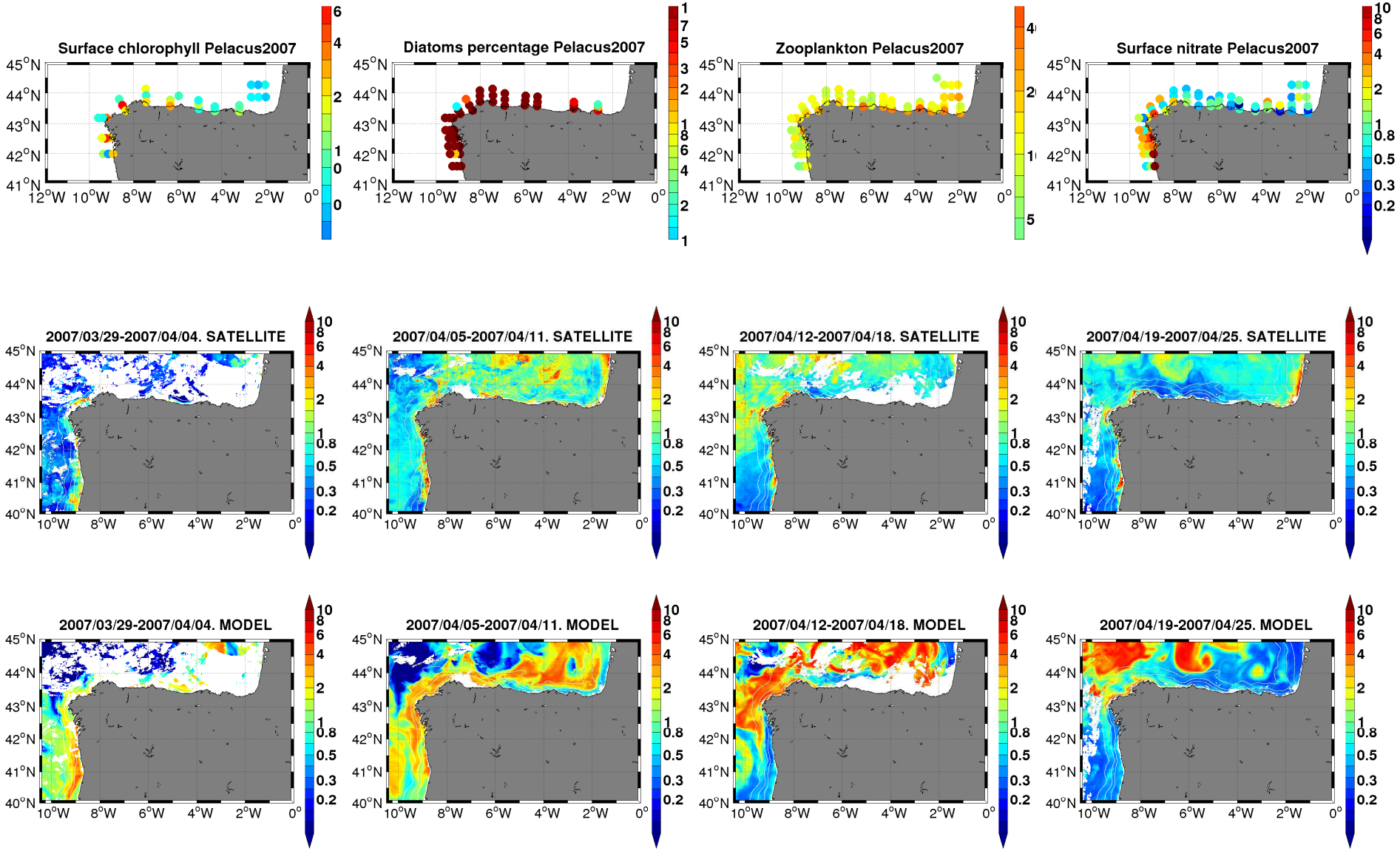


>>>>> Observed field Min 33.68 Max 35.69
>>>>> Analyzed field Min 34.18 Max 35.71



>>>>> Modelled field Min 34.37 Max 35.75
>>>>> Analyzed field Min 34.62 Max 35.75

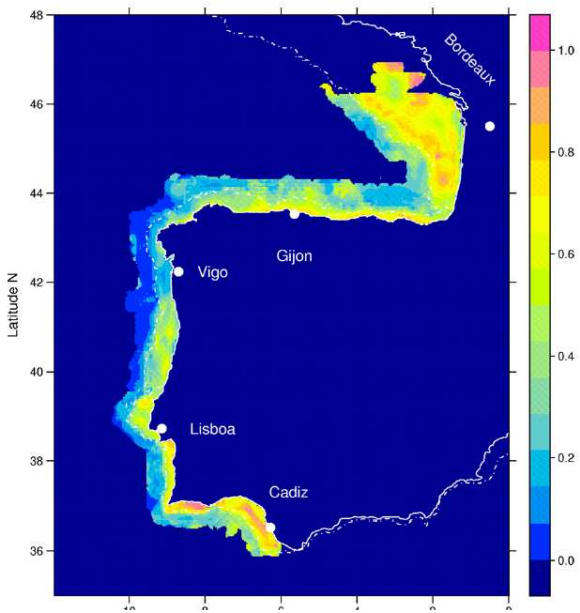
Pelacus cruise 2007: 27th of March 2007 to 23rd of April 2007

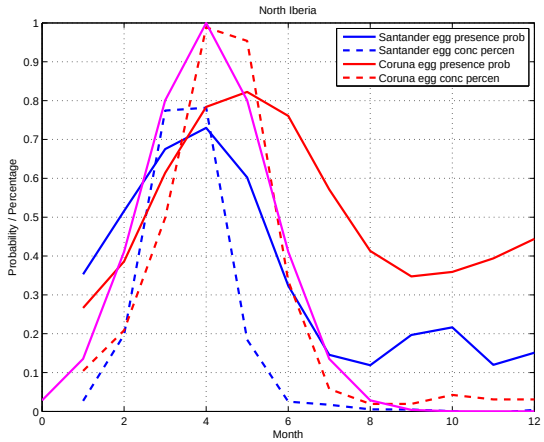


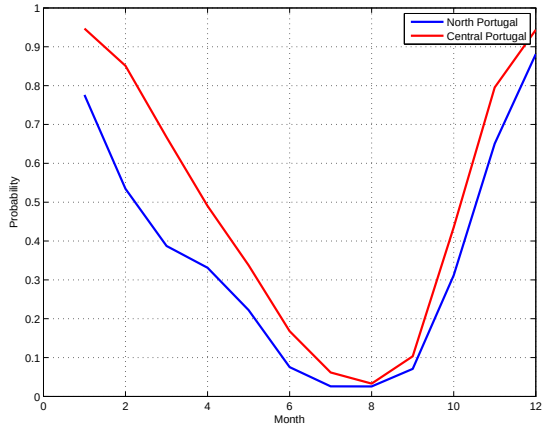
Objectives

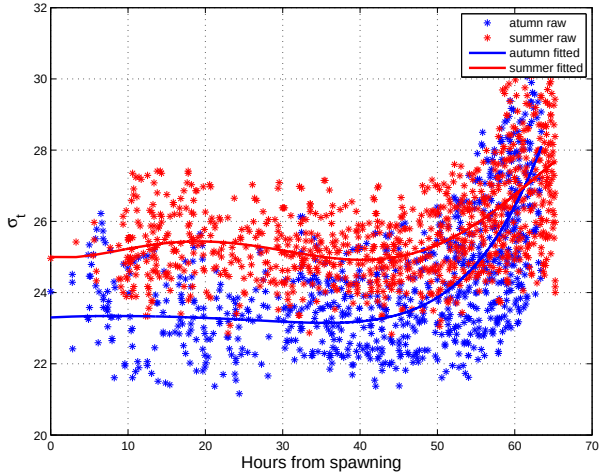
Understanding the mechanisms that drive the recruitment process, i.e. the appearance of a new generation of individuals in a fish stock.

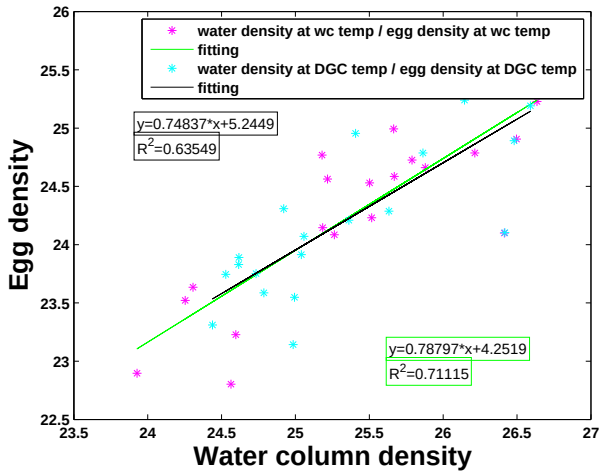
The model

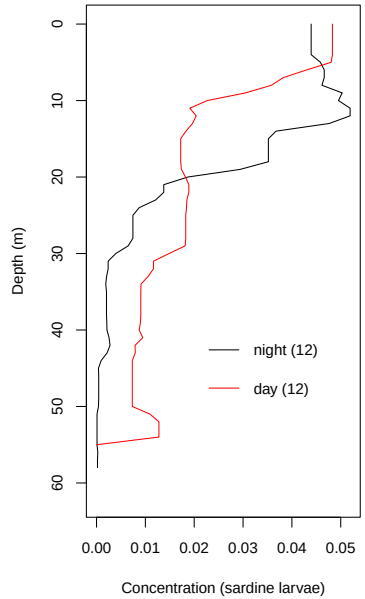

Bordeaux
Gijon
Vigo
Lisboa
Cadiz
Latitude N
Data from Coombs, 1985


North Iberia
Santander egg presence prob
Santander egg conc percen
Coruna egg presence prob
Coruna egg conc percen
Probability / Percentage
Month

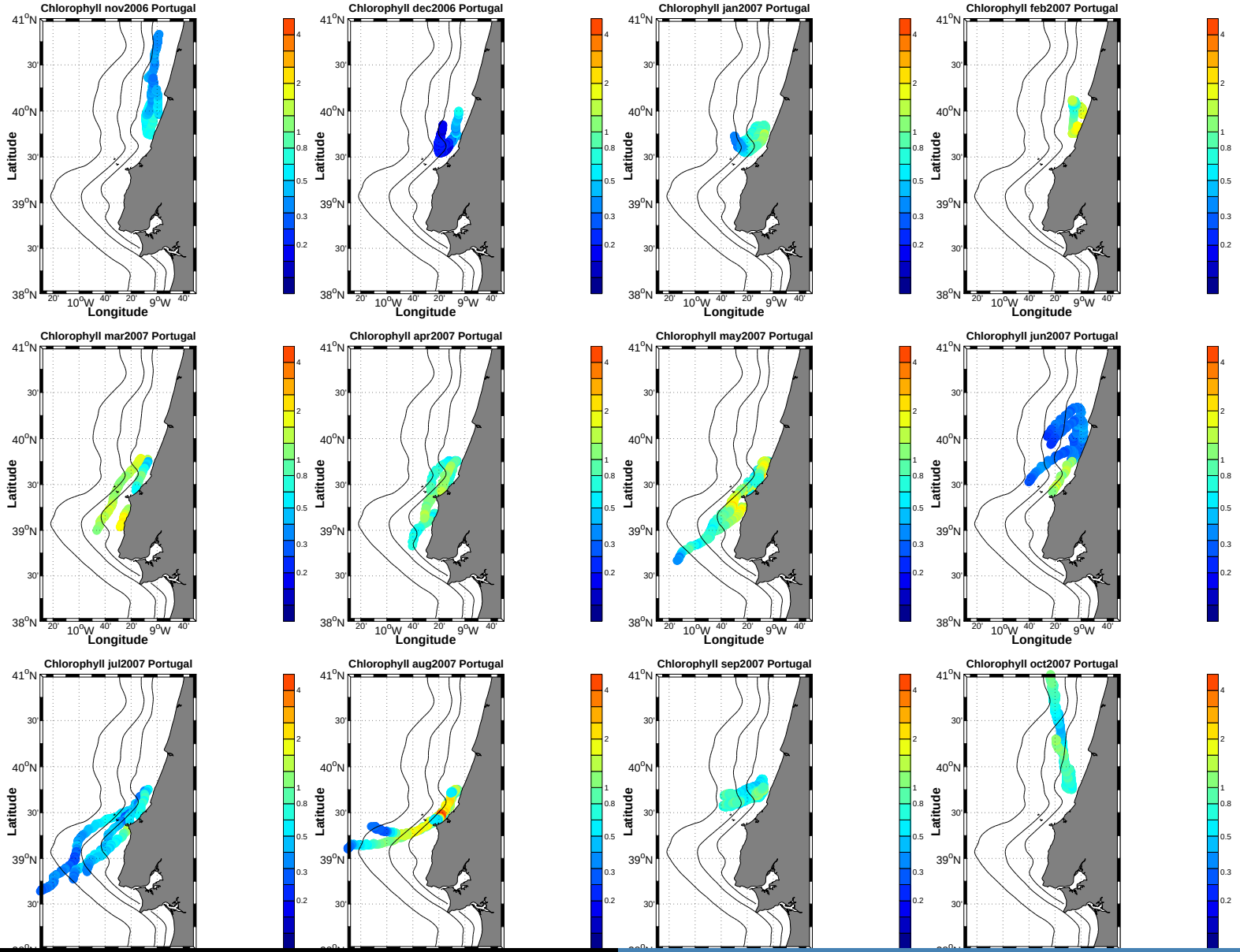

North Portugal
Central Portugal
Probability
Month


atumn raw
summer raw
autumn fitted
summer fitted
σt
Hours from spawning


water density at wc temp / egg density at wc temp
fitting
water density at DGC temp / egg density at DGC temp
fitting
y=0.74837*x+5.2449
R2=0.63549
y=0.78797*x+4.2519
R2=0.71115
Egg density
Water column density


night (12)
day (12)
Depth (m)
Concentration (sardine larvae)

Some results

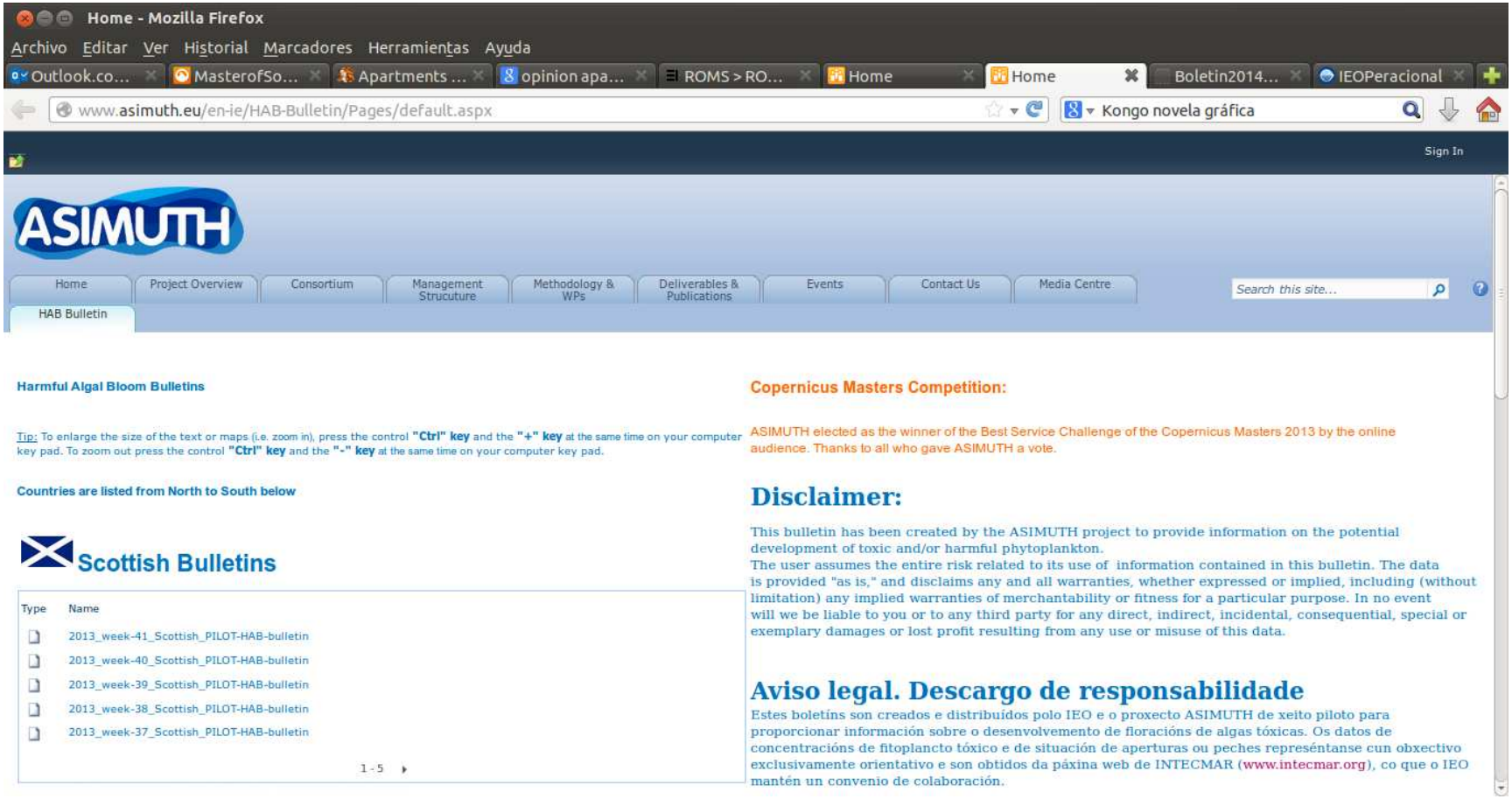


Objectives

A GMES-Copernicus downstream service to the European Aquaculture Industry

The delivery of a 3-4 day Harmful Algal Bloom forecast for the aquaculture industry situated along Europe's Atlantic margin

The HAB Bulletins



Thank you very much!!