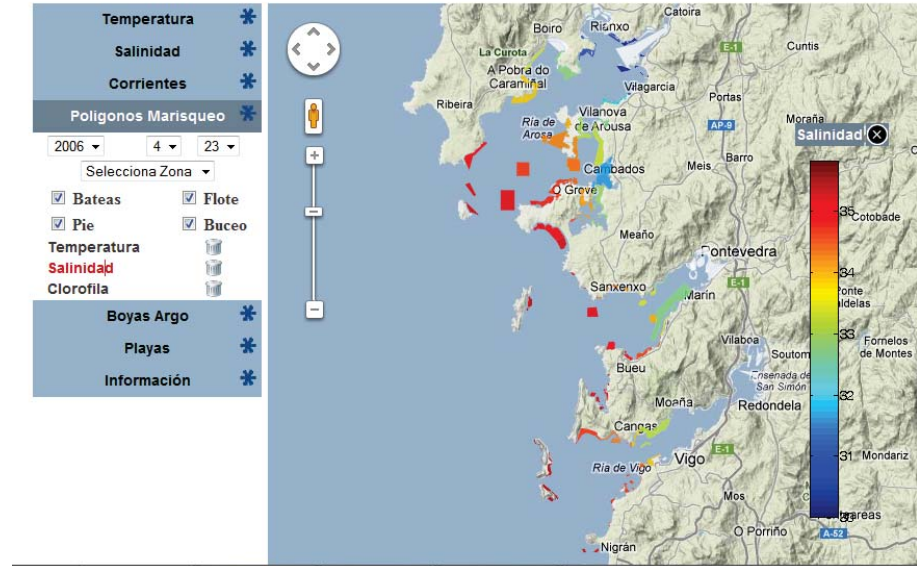
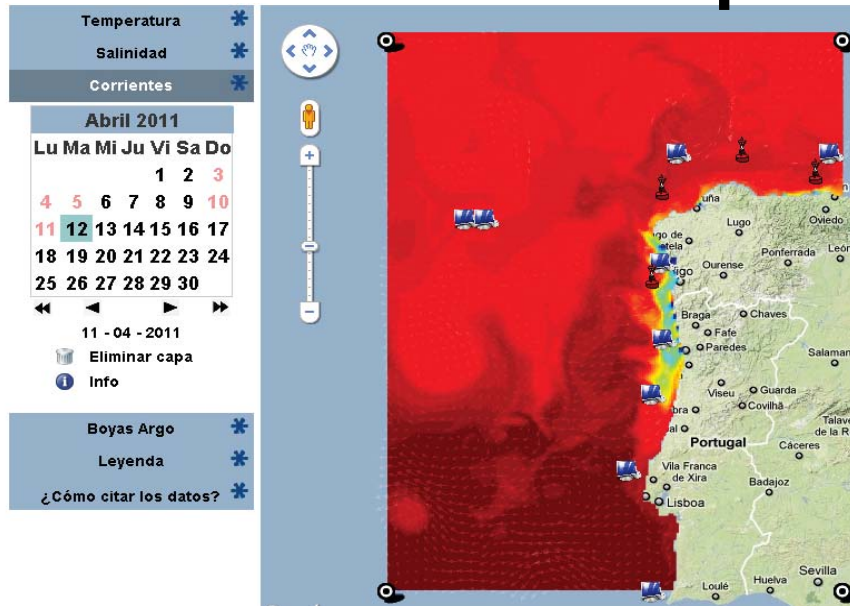


Modelado aplicado a acuicultura y pesquerías



Series Temporales ⓘ



Manuel Ruiz Villarreal
Instituto Español de Oceanografía, A Coruña



INSTITUTO ESPAÑOL DE OCEANOGRAFÍA



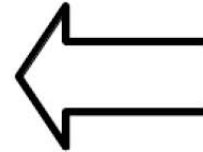
IEO tasks and duties

- To carry out **scientific research** in the fields of oceanography and sea sciences.
- To **advise 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 disseminate oceanographic knowledge.

ICHTHYOP LAGRANGIAN MODEL (Lett et al., 2008)

- Advection and dispersion of particles (superindividuals)
- Biological behaviour
 - Growth depending on temperature for eggs and larvae + all the processes before

Offline coupling



- Velocities
- Vertical diffusion coefficients
- Temperature

ROMS PHYSICAL MODEL

- 3.5Km horizontal resolution
- OBC: MyOcean2 (Mercator)
- Atmospheric forcing: Meteogalicia.
- Rivers

Online coupling



ROMS ECOLOGICAL MODEL (Fennel et al., 2006)

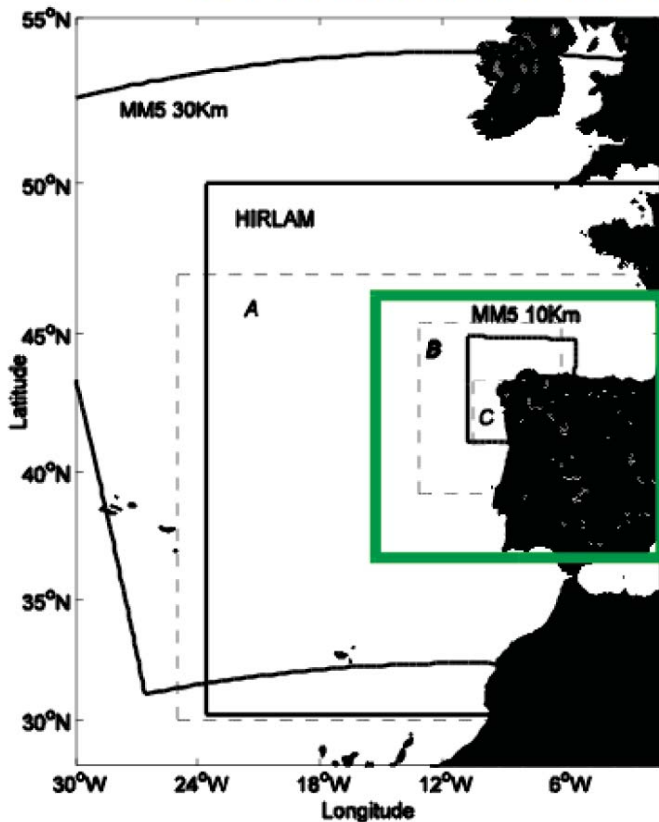
- N2PZD2 model + chlorophyll
- OBC: Temperature/NO3 relationship obtained from IEO data (Vaclan cruises 2003-2008).

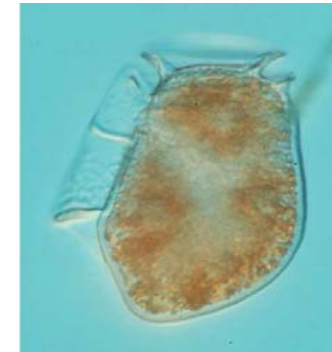
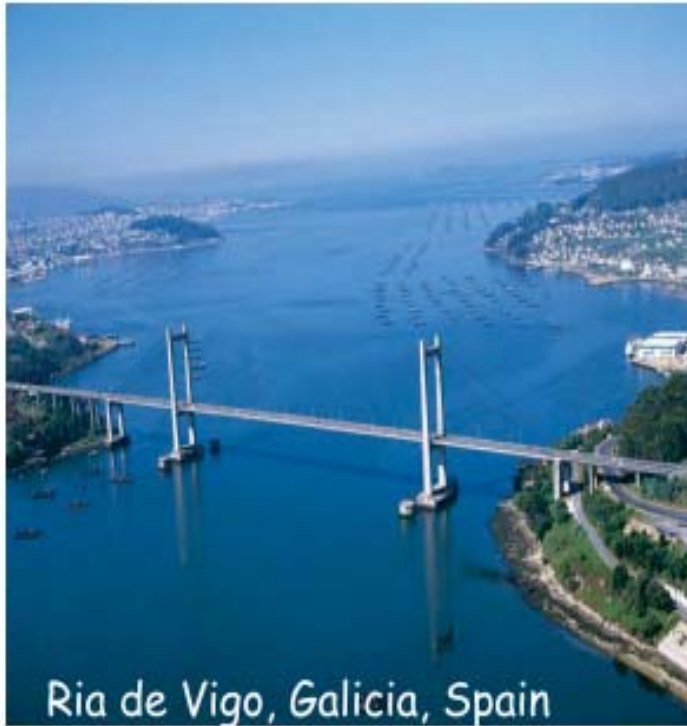
Offline coupling



Zooplankton

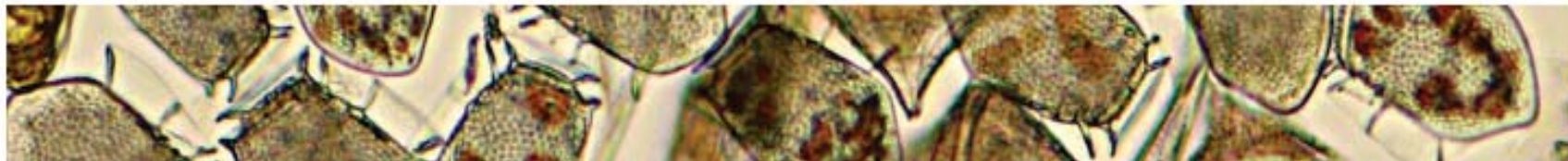
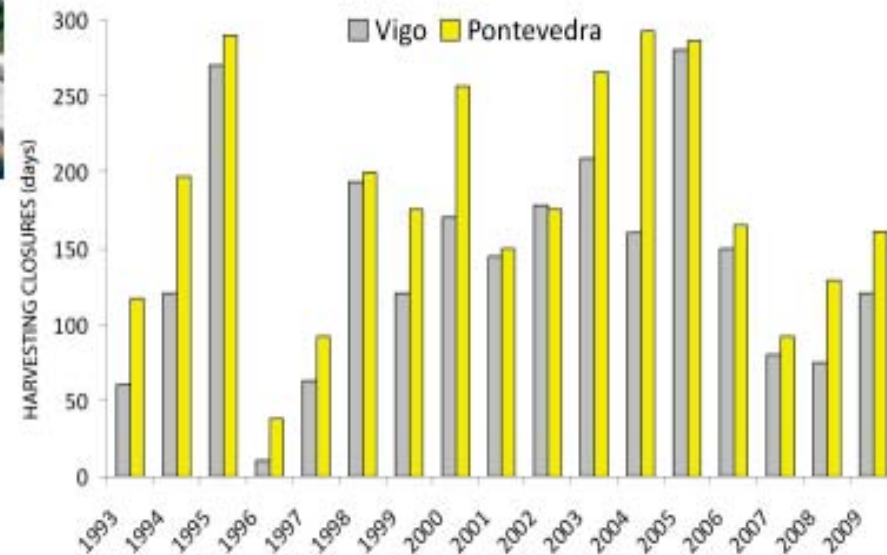
OB: MERCATOR PSY2V2

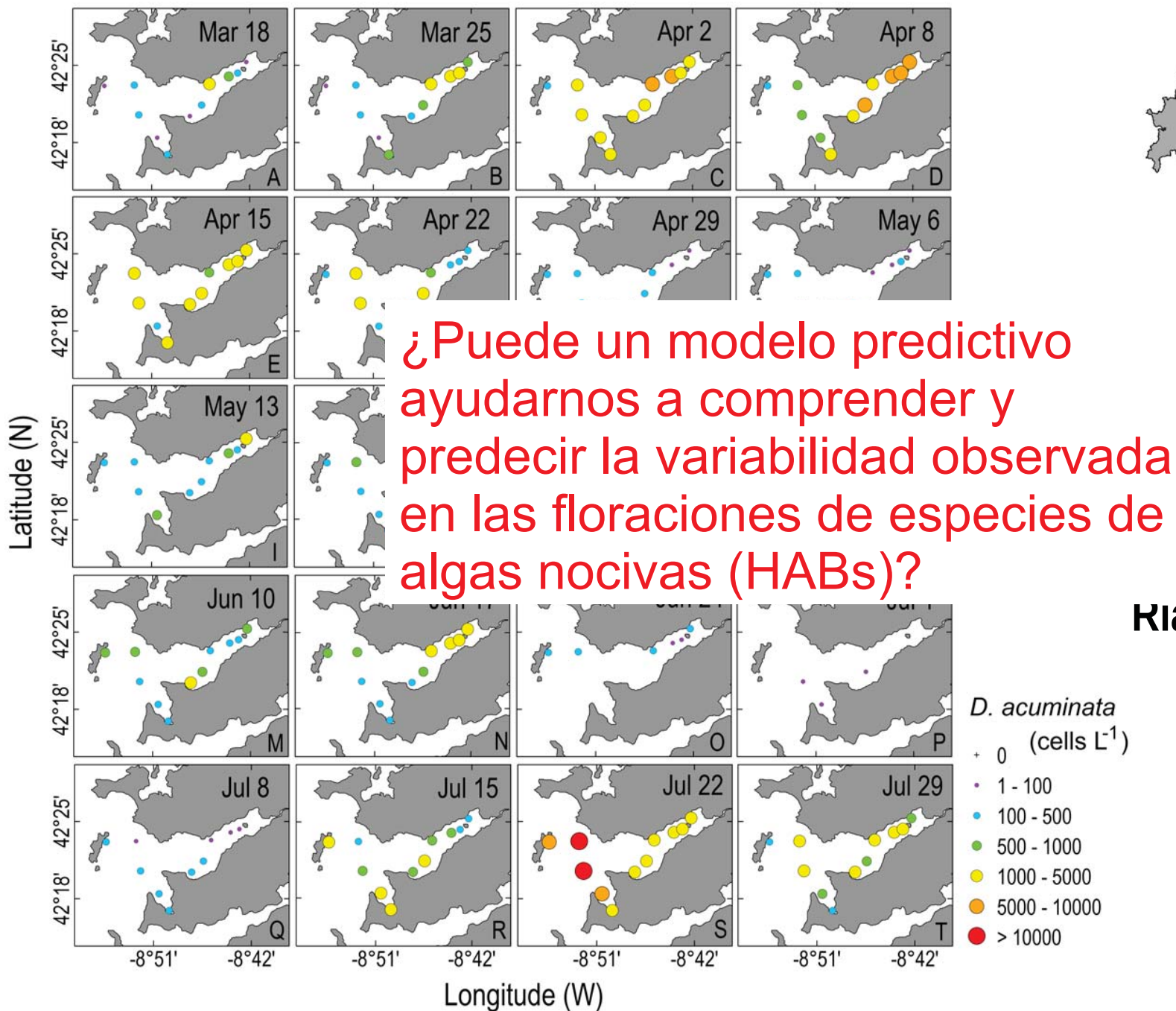




Dinophysis spp.

Días de cierre por toxina diarreica en polígonos bateiros de la Ria de Vigo y de la Ria de Pontevedra (Datos de INTECMAR www.intecmar.org)



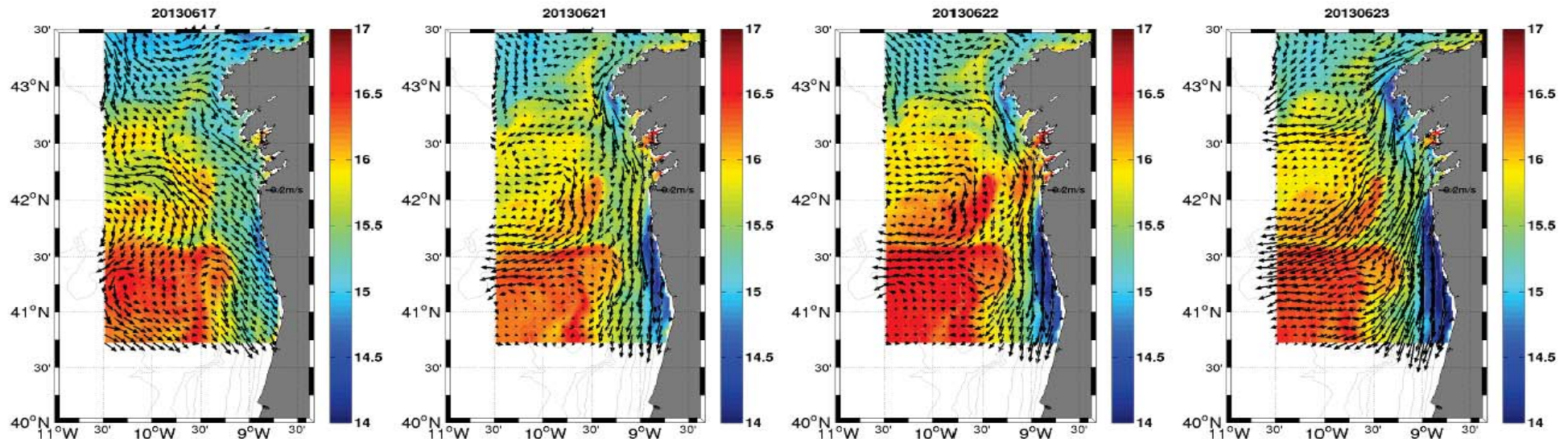
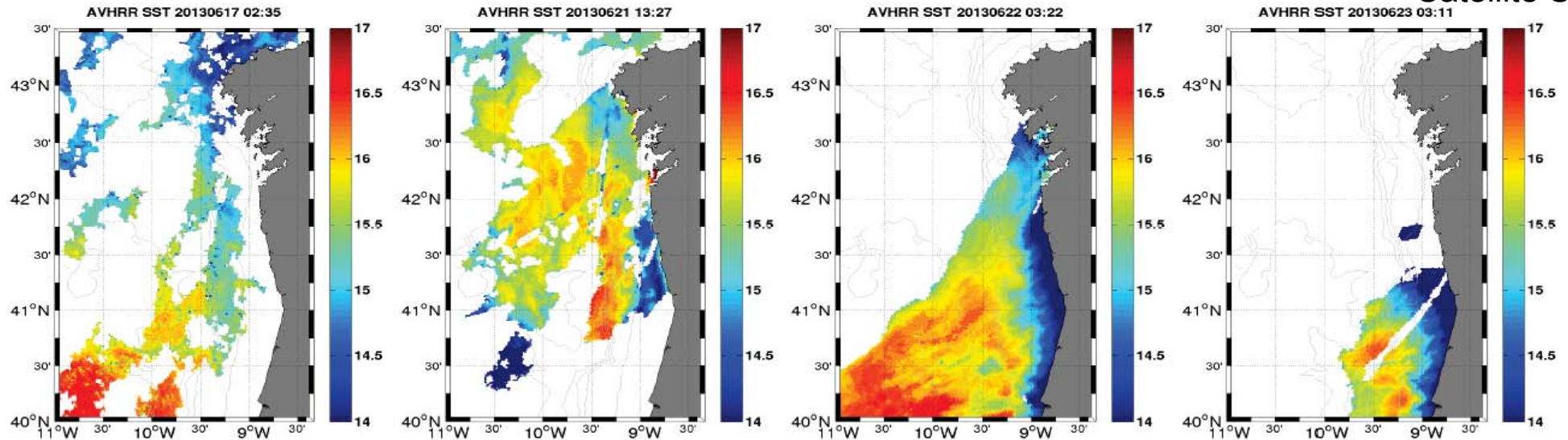


Ria de Pontevedra

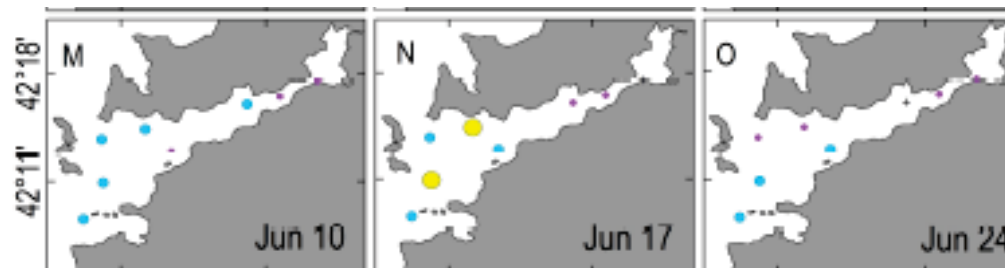
Dinophysis acuminata concentrations in weekly monitoring stations
(Data from INTECMAR, Xunta de Galicia)

Spring 2013: variability in *D. acuminata* vs. variability in oceanographic conditions

Satellite SST

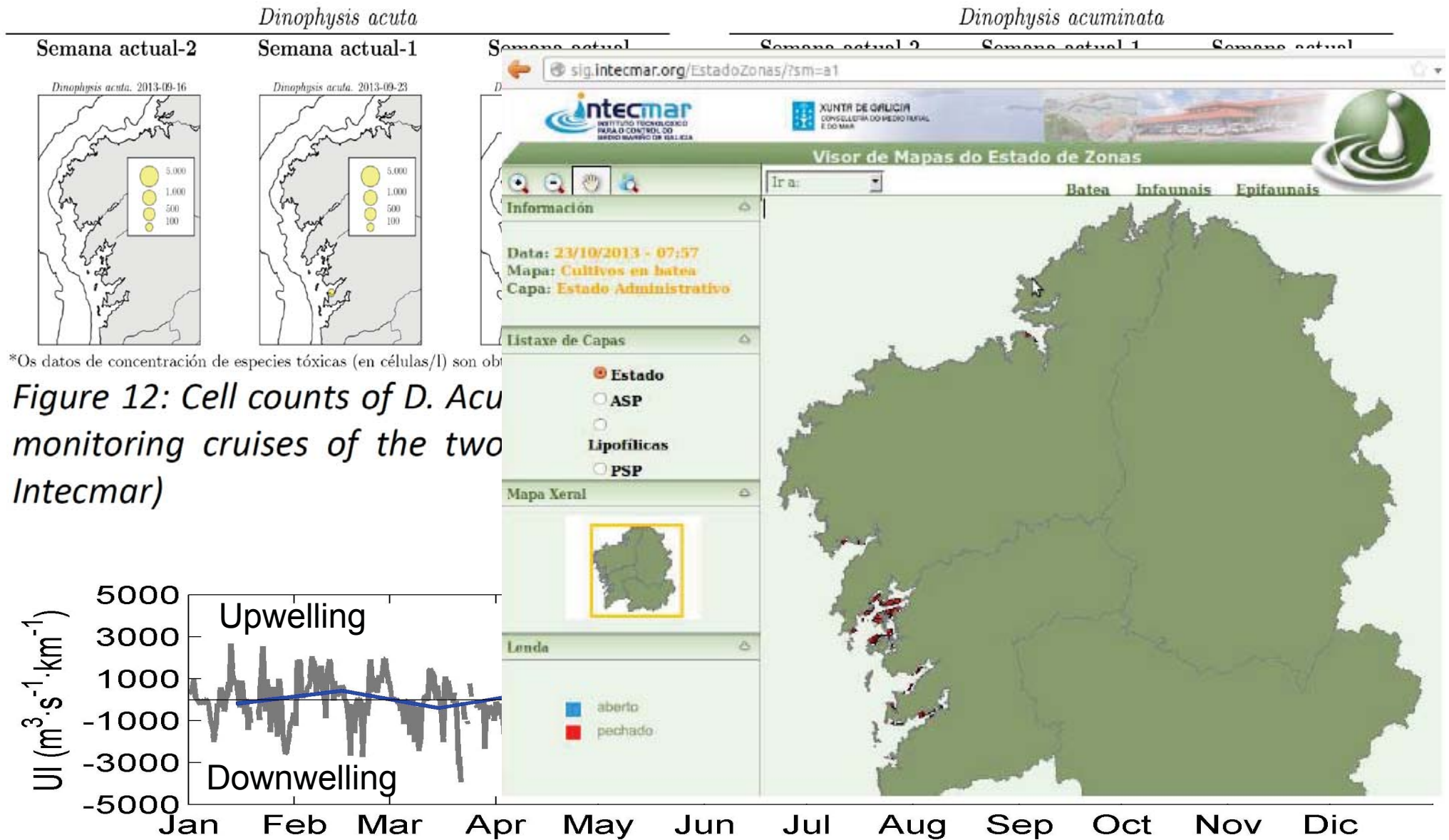


Model surface current and temperature



Upwelling pulse
Water renewal in the ria

Autumn 2013: High *D. acuta* (and *D. acuminata*) concentrations (prolonged closures)



*Os datos de concentración de especies tóxicas (en células/l) son obtidos a través das campañas de monitorización realizadas polo Intecmar.

Figure 12: Cell counts of *D. Acu* monitoring cruises of the two Intecmar)



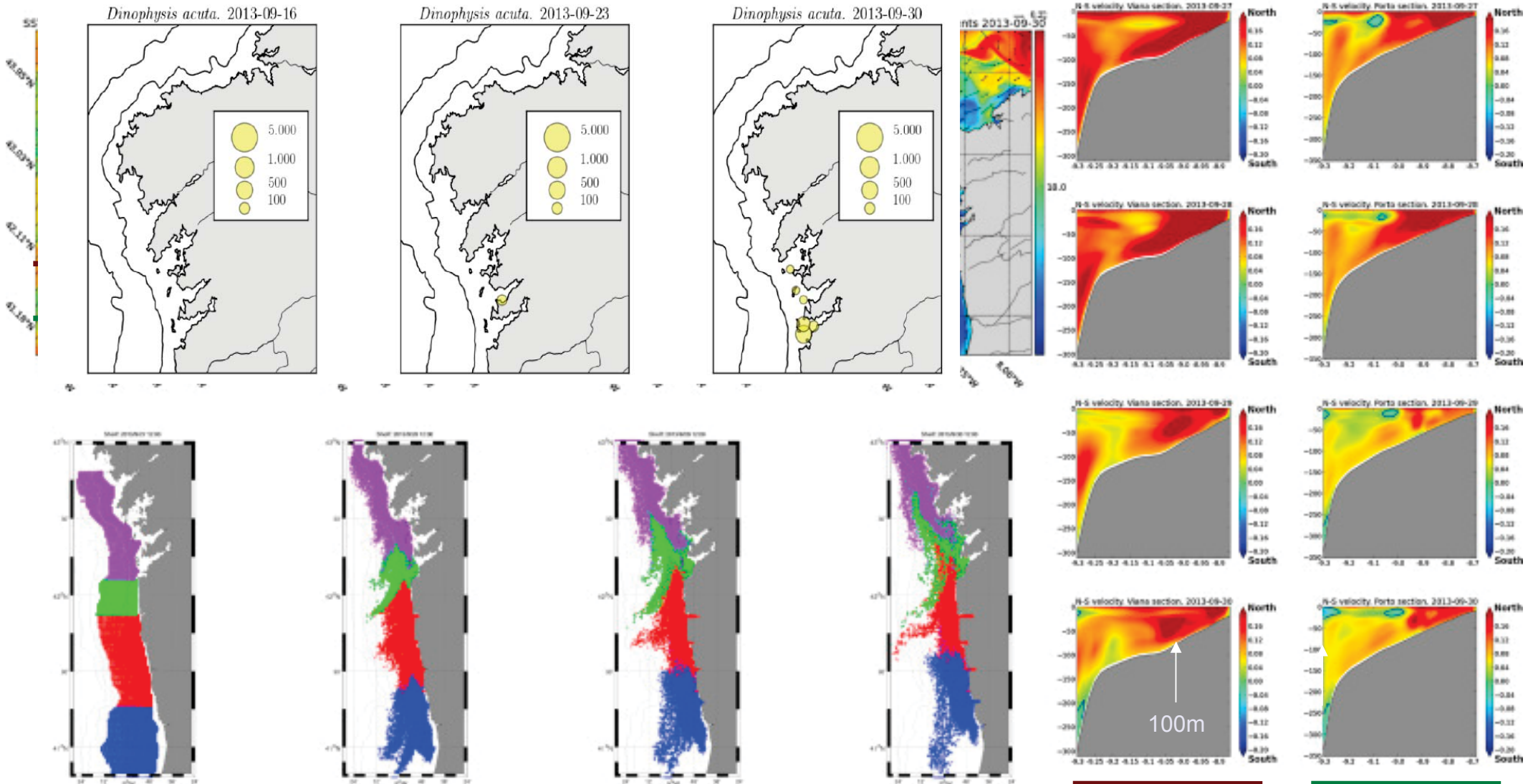
Autumn 2013: *Dinophysis acuta* and Along-shore transport

PILOT BULLETIN



1. Models: surface temperature and currents. Shelf circulation

2013/09/27 (0d) 2013/09/28 (1d) 2013/09/29 (2d) 2013/09/30 (3d) Northwards shelf current



Ruiz-Villarreal et al. 2016 Harmful Algae

Viana

Porto

Es posible "predecir" el riesgo de los eventos de HABs (especialmente DSP) en Galicia?

El modelo de circulación proporciona información del transporte de los blooms de *Dinophysis spp* entre rías y de la retención y exportación hacia y desde las rías. El acoplamiento entre mareas y eventos de viento (afloramiento y hundimiento), al que está acoplado el ciclo de vida de *Dinophysis spp.*, pueden describirse con modelos numéricos de circulación que representan la variabilidad del sistema.

Durante los blooms de otoño de *D. acuta*, las predicciones de advección a lo largo de la costa y hacia y desde la costa constituyen una herramienta para la predicción del riesgo de cierres de polígonos marisqueros

Pilot HAB Bulletin (status of harmful and toxic algae)

Week 30: 21 - 27 July, 2013
Week 31: 28 July - 3 Aug 2013

Ireland: Current conditions and Predictions
 Botolin report (last week) [whole tissue long-line mussels and oysters]
 AZP toxine: Yes, maximum on west (0.17 µg/g) east
 DSP toxine: Yes, maximum on west (0.17 µg/g) and southwest (0.12 µg/g) east
 PSP toxine: No
HABs report (last week)
 Dinophysis spp.: Yes, blooms off along the western seaboard. Maximum levels on west coast with 'H' concentrations for the predominant species (group of minor cells).
 Alexandrium spp.: Yes, maximum on north coast (>100 cells/L). No levels also present on west and southwest coast.
 Karenia mikimotoi: Yes, maximum on west coast (16,000 cells/L).
 Alexandrium: No blooms; present on south coast (maximum = 200 cells/L).

Ireland HISTORIC TRENDS
 DSP 2013 (Summer, Tenthredin) week 30 include water users over 100 persons.
 DSP 2013 (Summer, Tenthredin) week 31 include water users over 100 persons.
 DSP 2013 (Summer, Tenthredin) week 32 include water users over 100 persons.
 DSP 2013 (Summer, Tenthredin) week 33 include water users over 100 persons.
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 DSP 2013 (Summer, Tenthredin) week 96 include water users over 100 persons.
 DSP 2013 (Summer, Tenthredin) week 97 include water users over 100 persons.
 DSP 2013 (Summer, Tenthredin) week 98 include water users over 100 persons.
 DSP 2013 (Summer, Tenthredin) week 99 include water users over 100 persons.
 DSP 2013 (Summer, Tenthredin) week 100 include water users over 100 persons.

Prediction for this week:
 AZP toxine: No
 DSP toxine: No
 PSP toxine: No
 Dinophysis spp.: No
 Alexandrium spp.: No
 K. mikimotoi: No

Why do we think this?
 DSP: A large downwelling event is predicted for Sunday 25th to 27th July. Two weeks ago, a healthy environment observation (>200 cells/L) was present south of Ireland, in the Cork, Donegal and Galway regions. It is very likely this group will be advected into the bay with the frontal event. Good evidence of Chlorophyll maximum and density increase in the west and south coast.
 PSP: Likely the Alexandrium bloom in Cork Harbour region on the last spring tide in June. Conditions are not favourable for PSP. PSP is not expected in Cork Harbour.
 K. mikimotoi: No blooms predicted in the next week.

Pilot bulletin on the status of Harmful and Toxic Algae

Week 41, 9th - 15th Oct 2013

SAMS *Karenia mikimotoi* abundance in current and preceding 3 weeks within ASIMUTH project domain in Argyll

Current status:
K. mikimotoi at two sites but densities do not cause concern.

Predictions:
K. mikimotoi continues to remain low in magnitude. Now likely to pose little danger to fin fish farming operations.

Why do we think this:
 Whole cell abundance has increased on Colonsay densities are low.
 Satellite chlorophyll concentrations does not indicate areas of concern.

Scotland wide Satellite Chlorophyll

ASIMUTH Aquatic Biomonitoring and Integrated Modelling for the Governance of Blue and Green Water
K. mikimotoi is enumerated within samples collected at shellfish monitoring sites. Surface chlorophyll is derived from MyOcean satellite products.

PILOT BULLETIN

1. Models: surface temperature and currents. Shelf circulation

2013/09/27 (0d) 2013/09/28 (1d) 2013/09/29 (2d) 2013/09/30 (3d)

HAB and Shellfish harvesting warning bulletin

Week 38: 16 - 22 of September 2013

Current condition and forecast

Current condition
 Due to the presence of phytoplankton producer of marine toxins or toxin levels above regulatory values, shellfish harvesting from the following production areas are temporarily banned: L3, L4 & L5, Avonora, Abulice lagoon and Mondego and Tejo estuaries. The satellite image show hot-spots of chlorophyll in these areas.

Forecasts
 In areas L2 and L3 there is an increase in the concentration of *Pseudo-nitzschia* spp., including *P. australis*. L2 can be closed. In front of Avonora, *Dinophysis acuminata* concentration remains high and closures by DSP are maintained. The model indicates that blooms will move offshore and slightly to the south.
 Due to the low concentration of *Dinophysis* spp. (DSP producer) the catch and capture of bivalves may be open in the area L8.

Sea surface temperature
 The sea surface water temperature evidence the upwelling of cold waters along the west coast, well visible in areas L1, L2, L3. On the south coast the sea surface water temperature is higher, but it is within the expectable patterns for this time of year.

Chlorophyll concentration
 Along the west coast and from areas L1 to L5 there is occurrence of high chlorophyll spots associated with cold water.

bulletin pilote [état des algues toxiques dans le Golfe de Gascogne]

Semaine 48: 29 - 6 Nov. 2013
Prévision: + 3 jours

France: Conditions actuelles et Prédictions

Rapport de Biotoxines de la semaine 48 - Synthèse réalisée à partir des bulletins de surveillance hebdomadaires.
 ASP toxine: Concentration > au seuil légal (20 µg/L) au large de Concarneau et de plusieurs stations situées dans les baies des coquilles Saint-Jacques. Les concentrations élevées à Lorient seraient éphémères (voir bulletin) et aucune autre mesure n'est encore disponible.
 AZA toxine: Non
 DSP toxine: Non
 PSP toxine: Non

Rapport sur les concentrations en Algues toxiques
 Pseudo-nitzschia: Oui, mais avec des concentrations faibles (<4000 cellules/litres) observées dans la zone de Douarnenez et Concarneau.
 Dinophysis: No
 Alexandrium: No
 Karenia mikimotoi: No

Prévision pour la prochaine semaine:
 ASP toxine: Pas prévue, forte décroissance dans les zones concernées.
 AZA toxine: Inconnue
 DSP toxine: Inconnue
 PSP toxine: Inconnue

Pourquoi ces prévisions ?
 AZA, DSP et PSP: Fin de période de saison. La période de contamination phytoplanktonique étant terminée, la situation devrait rester stable jusqu'à février/mars 2014.
 ASP: Les concentrations devraient décroître localement pendant les prochains jours, particulièrement dans les coquilles St-Jacques.

La fréquence d'échantillonnage durant la période hivernale étant réduite, la réalisation de bulletins de prévisions s'arrête à partir de cette semaine.

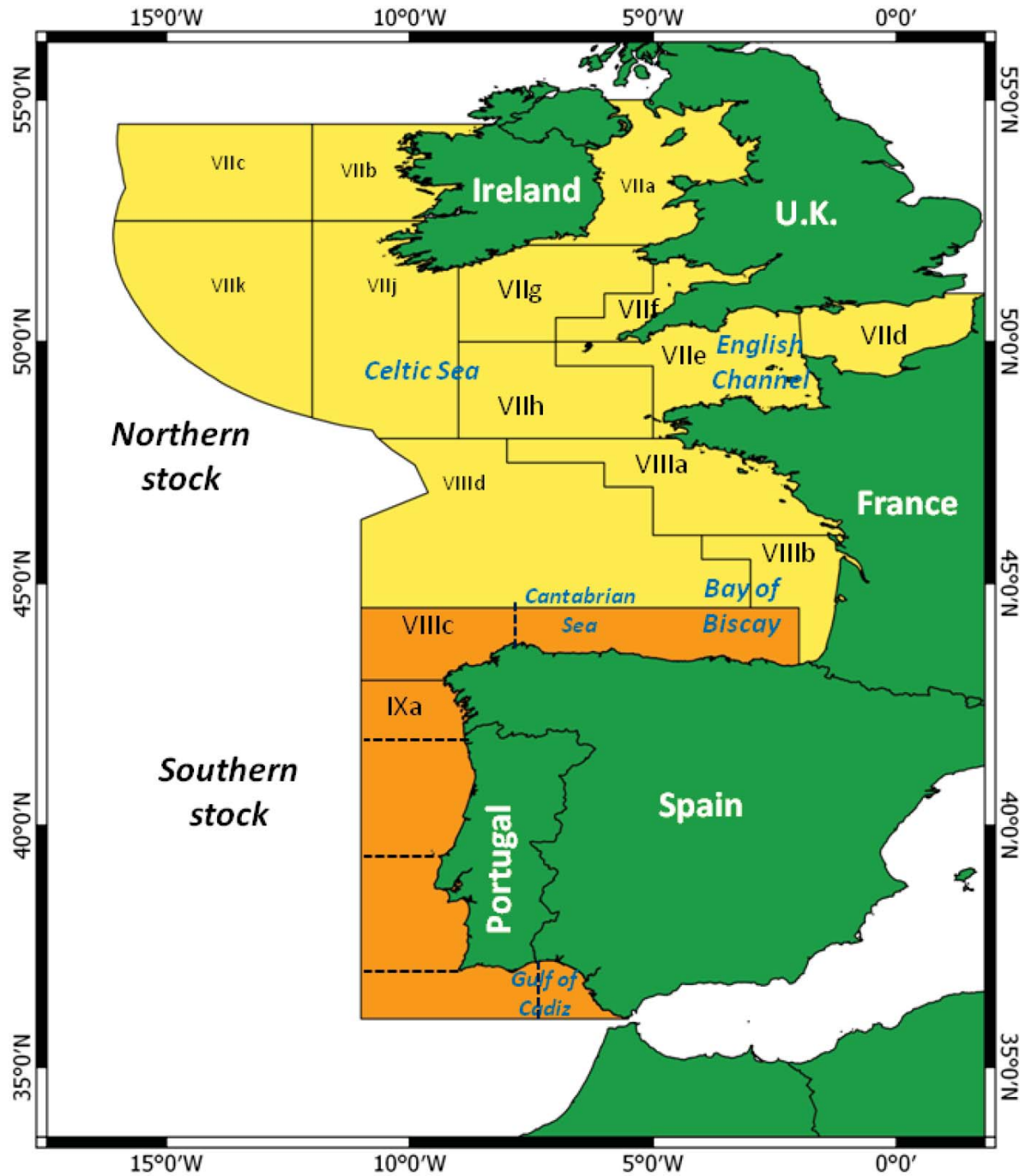
Concentrations d'ADN relatives (Bulletin d'Information - France)

| ZONES | Points | Couplages | Asp (µg/L) | Pseudo-nitzschia (cell/L) | Dinophysis (cell/L) | Karenia mikimotoi (cell/L) |
|---|--------------------|--------------------|------------|---------------------------|---------------------|----------------------------|
| Baie de Lorient - Lorient | Lorient | Lorient | 01/10/2013 | 1 | 1000000 | 0 |
| | | | 02/10/2013 | 1 | 1000000 | 0 |
| Baie de Brest - Brest | Brest | Brest | 01/10/2013 | 1 | 1000000 | 0 |
| | | | 02/10/2013 | 1 | 1000000 | 0 |
| Baie de Douarnenez - Douarnenez | Douarnenez | Douarnenez | 01/10/2013 | 1 | 1000000 | 0 |
| | | | 02/10/2013 | 1 | 1000000 | 0 |
| Baie de Concarneau - Concarneau | Concarneau | Concarneau | 01/10/2013 | 1 | 1000000 | 0 |
| | | | 02/10/2013 | 1 | 1000000 | 0 |
| Baie de Morlaix - Morlaix | Morlaix | Morlaix | 01/10/2013 | 1 | 1000000 | 0 |
| | | | 02/10/2013 | 1 | 1000000 | 0 |
| Baie de Saint-Jacques - Saint-Jacques | Saint-Jacques | Saint-Jacques | 01/10/2013 | 1 | 1000000 | 0 |
| | | | 02/10/2013 | 1 | 1000000 | 0 |
| Baie de L'Île-Rousse - Ile-Rousse | Ile-Rousse | Ile-Rousse | 01/10/2013 | 1 | 1000000 | 0 |
| | | | 02/10/2013 | 1 | 1000000 | 0 |
| Baie de L'Île-de-Sein - Ile-de-Sein | Ile-de-Sein | Ile-de-Sein | 01/10/2013 | 1 | 1000000 | 0 |
| | | | 02/10/2013 | 1 | 1000000 | 0 |
| Baie de L'Île-de-Bréhat - Ile-de-Brehat | Ile-de-Brehat | Ile-de-Brehat | 01/10/2013 | 1 | 1000000 | 0 |
| | | | 02/10/2013 | 1 | 1000000 | 0 |
| Baie de L'Île-de-Grand-Berri - Ile-de-Grand-Berri | Ile-de-Grand-Berri | Ile-de-Grand-Berri | 01/10/2013 | 1 | 1000000 | 0 |
| | | | 02/10/2013 | 1 | 1000000 | 0 |
| Baie de L'Île-de-Longue - Ile-de-Longue | Ile-de-Longue | Ile-de-Longue | 01/10/2013 | 1 | 1000000 | 0 |
| | | | 02/10/2013 | 1 | 1000000 | 0 |

Position de la masse d'eau actuelle

- Origine de la masse d'eau (J-15)
- Position moyenne de la masse d'eau (J-15 à J)
- Position de la masse d'eau dans 3 jours (J+3)

Map 2: Delimitation of the Northern and Southern sardine stocks



Sardine in the Southern stock: VIIIc and IXa

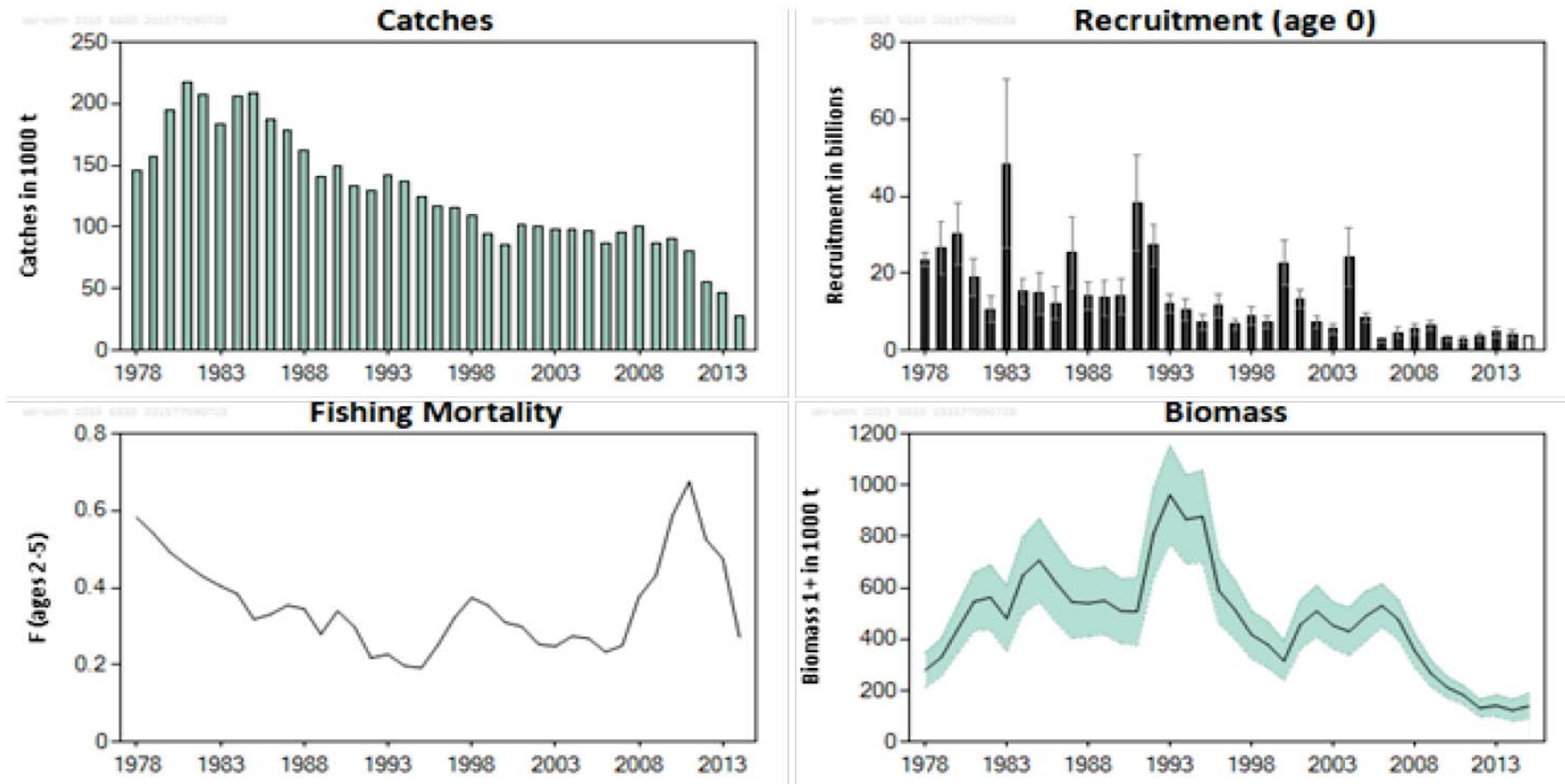
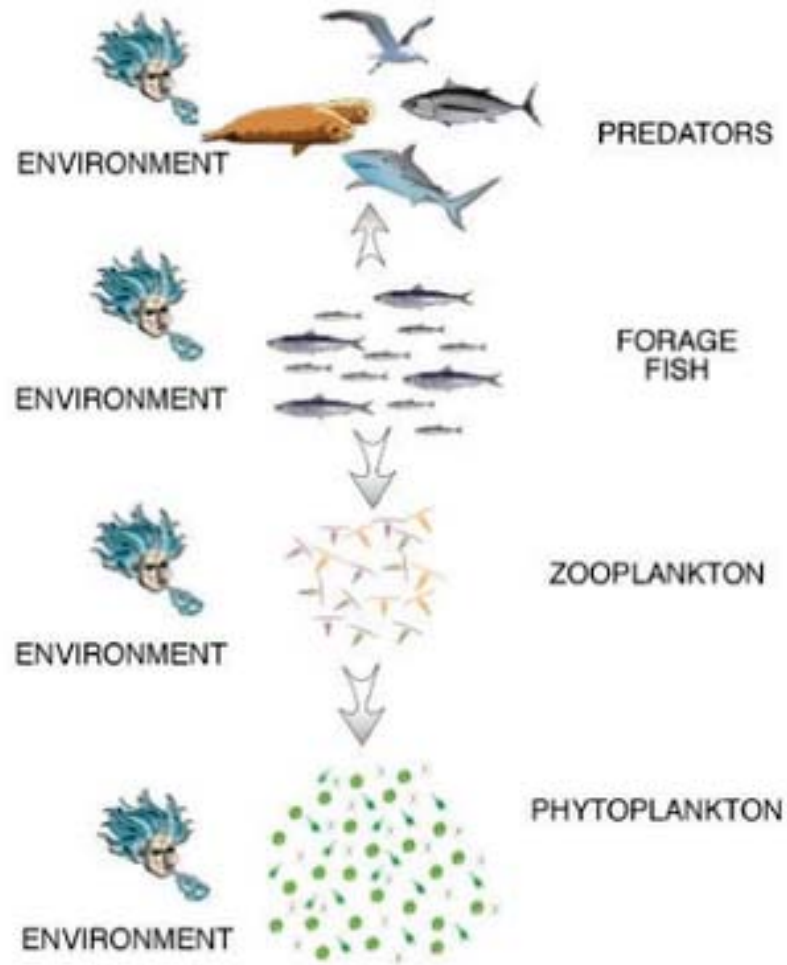


Figure 7.3.27.1 Sardine in Divisions VIIIc and IXa. Summary of stock assessment (weights in thousand tonnes). Predicted values are not shaded.

Modelos biofísicos aplicados a pesquerías



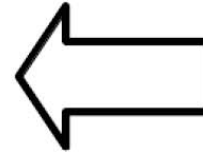
- Environment represented by climate - hydrodynamic ocean models
- Lower, intermediate and upper trophic levels represented by modules

Taken from Miguel Bernal presentation “Climate to fish to fishers”, Sete 2011

ICHTHYOP LAGRANGIAN MODEL (Lett et al., 2008)

- Advection and dispersion of particles (superindividuals)
- Biological behaviour
 - Growth depending on temperature for eggs and larvae + all the processes before

Offline coupling



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Online coupling



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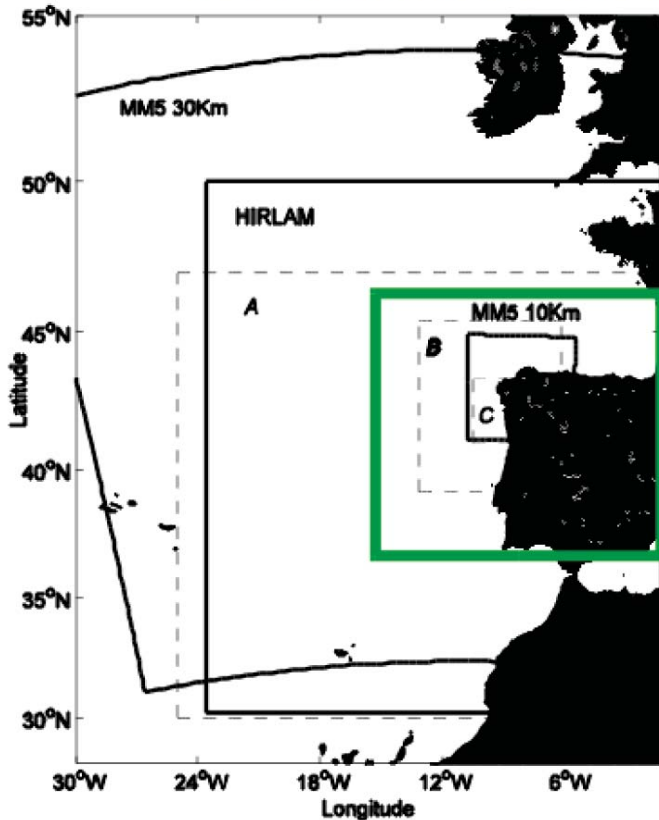
- N2PZD2 model + chlorophyll
- OBC: Temperature/NO3 relationship obtained from IEO data (Vaclan cruises 2003-2008).

Offline coupling



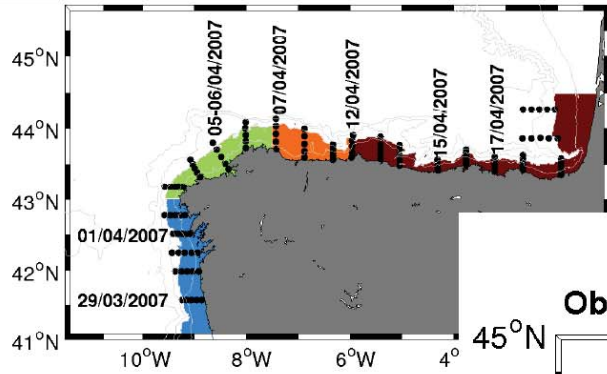
Zooplankton

OB: MERCATOR PSY2V2

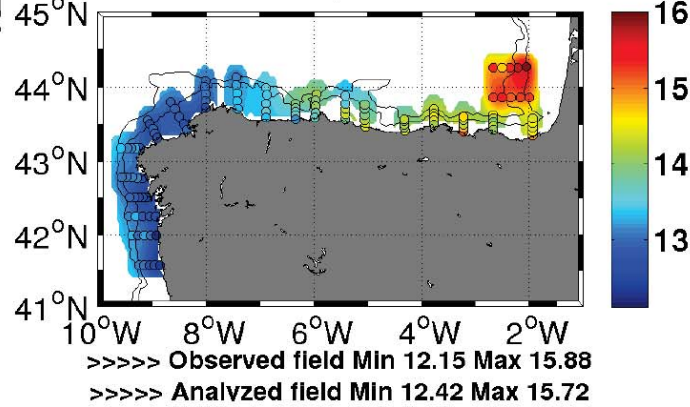


Environment: variability in spring during Pelacus cruises

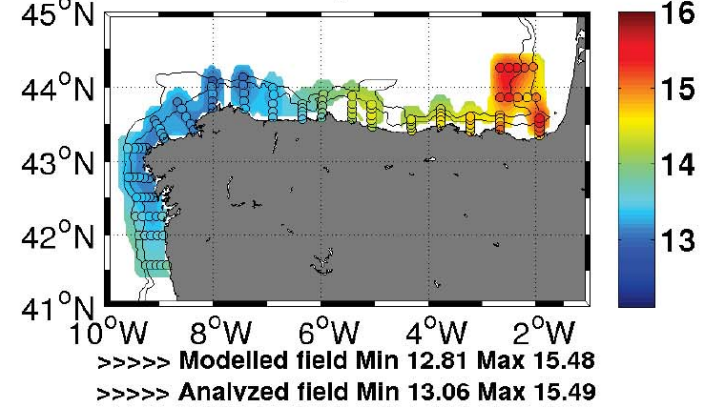
Pelacus cruise 2007: 27th of March 2007 to 23rd of April 2007



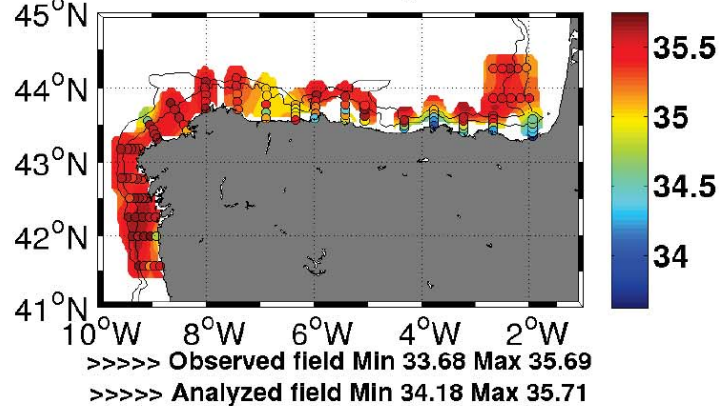
Observed Temperature at 4 m



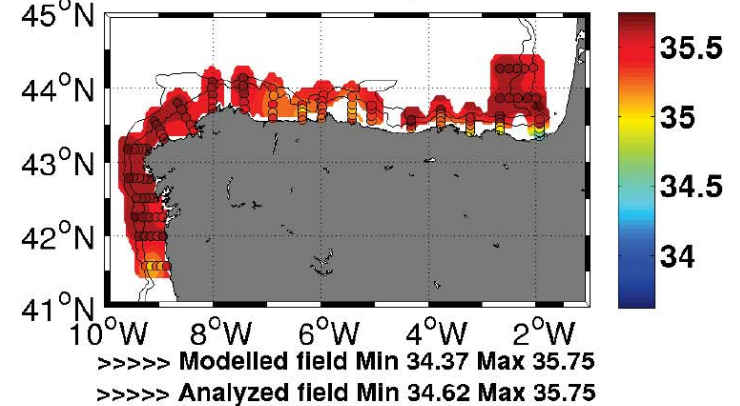
Modelled Temperature at 4 m



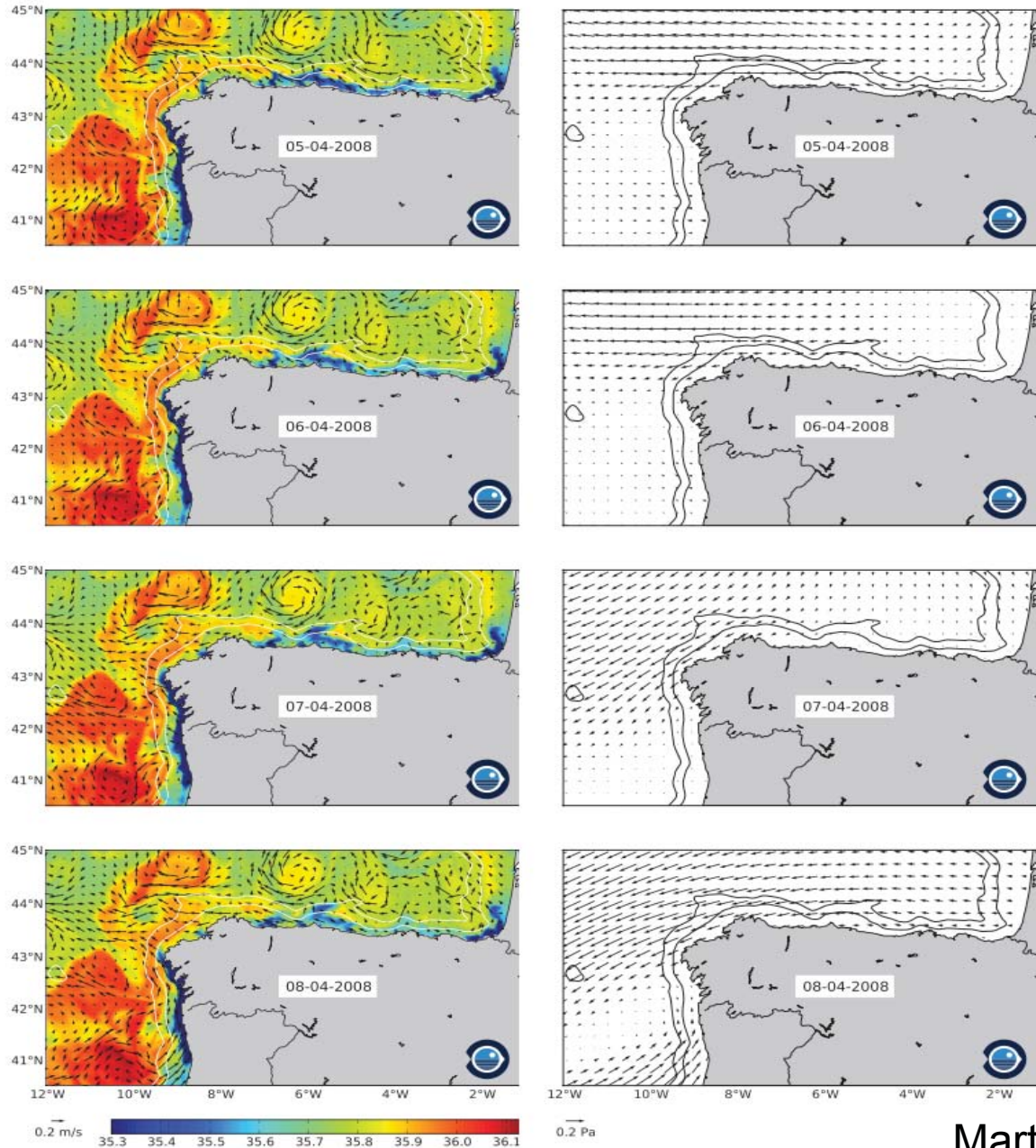
Observed Salinity at 4 m



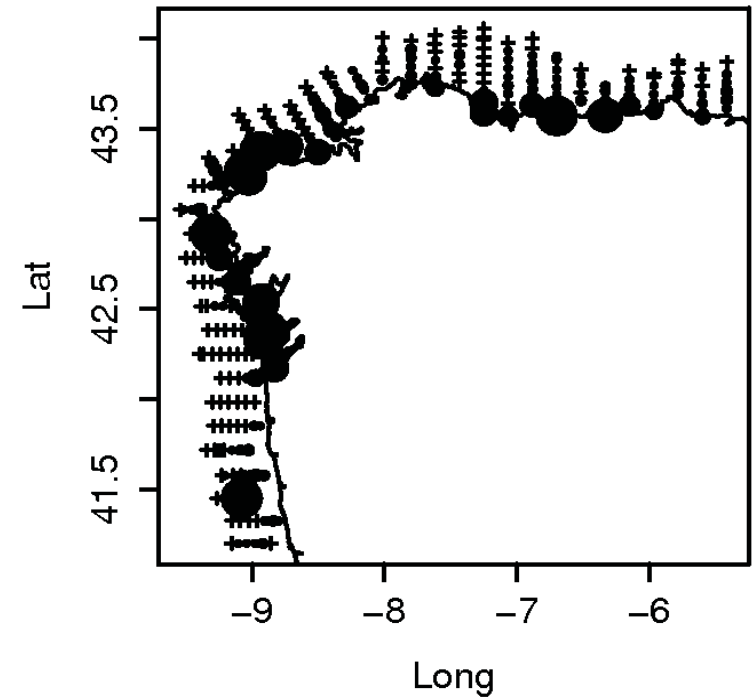
Modelled Salinity at 4 m



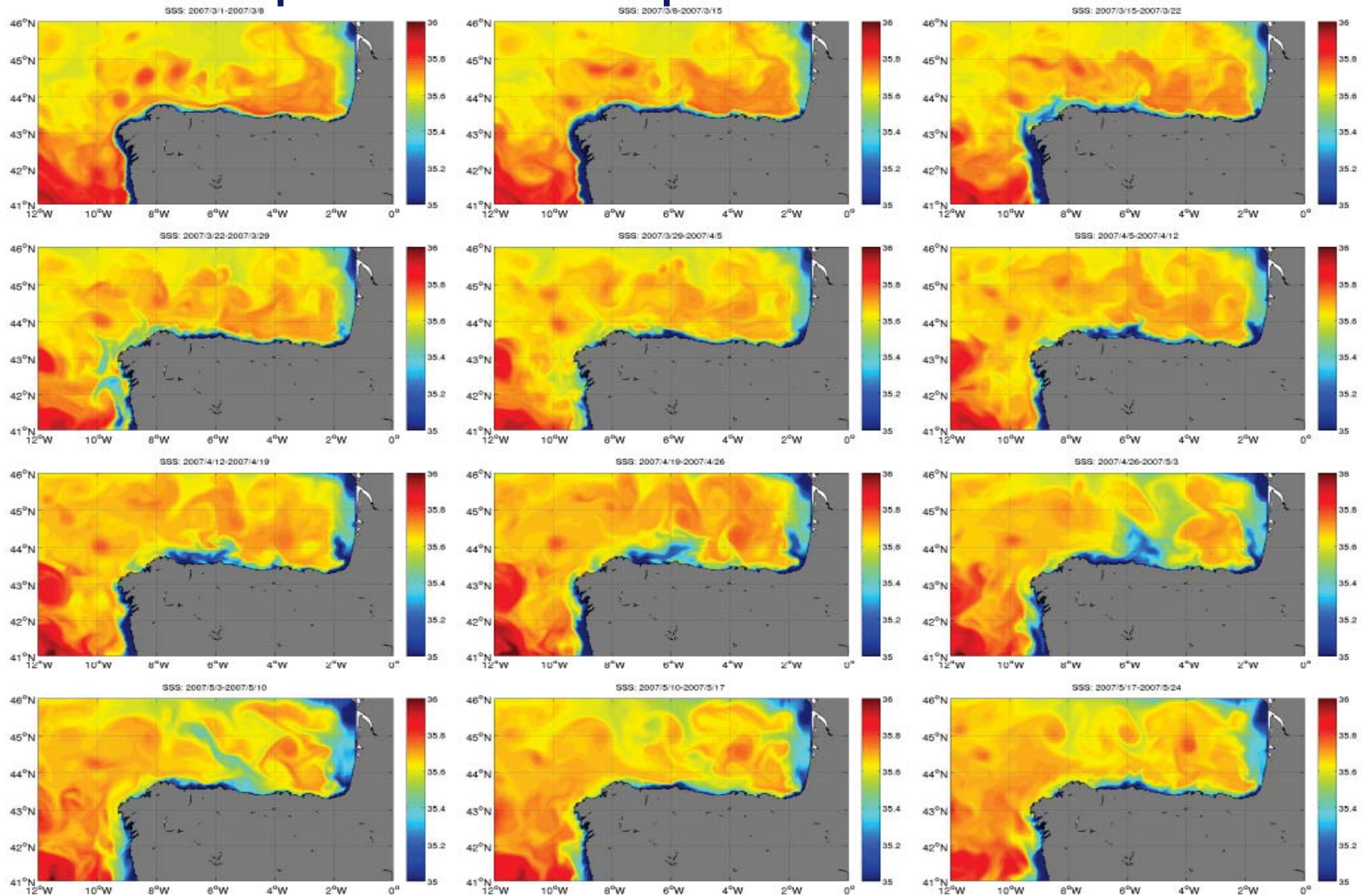
Respuesta a eventos de viento en primavera 2008



2008; Total eggs = 12722

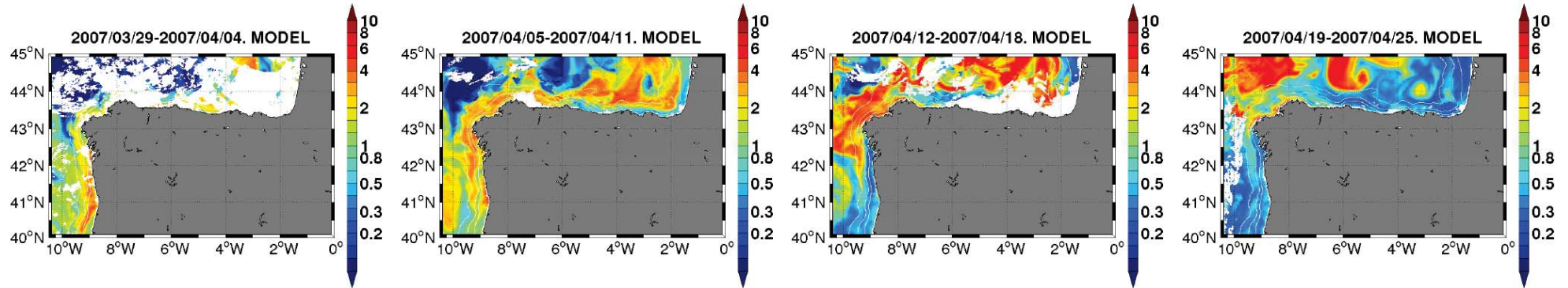
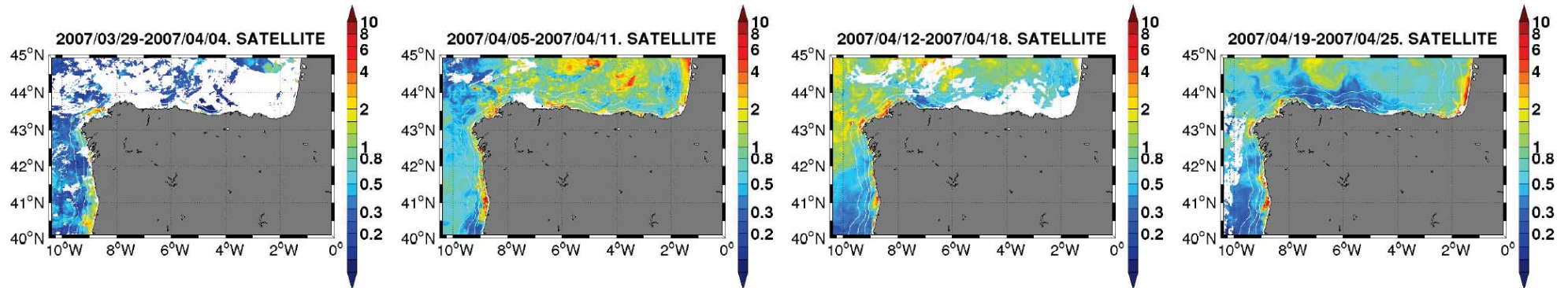
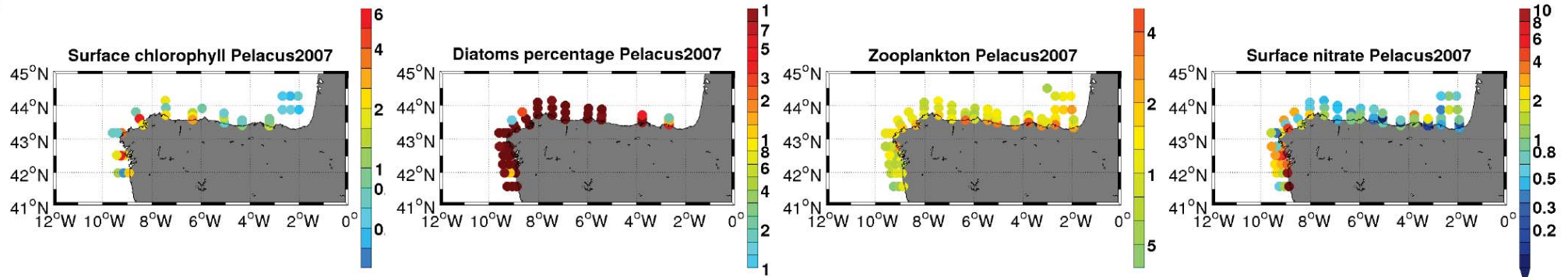


Medias semanales modeladas de salinidad superficial en primavera 2007



Variability in the plankton: Temporal and spatial variability of the spring bloom.

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



Cruise begins: W coast

Cruise ends NE coast

Zooplankton distribution (model) at the position of late sardine larvae (29 days after spawning)

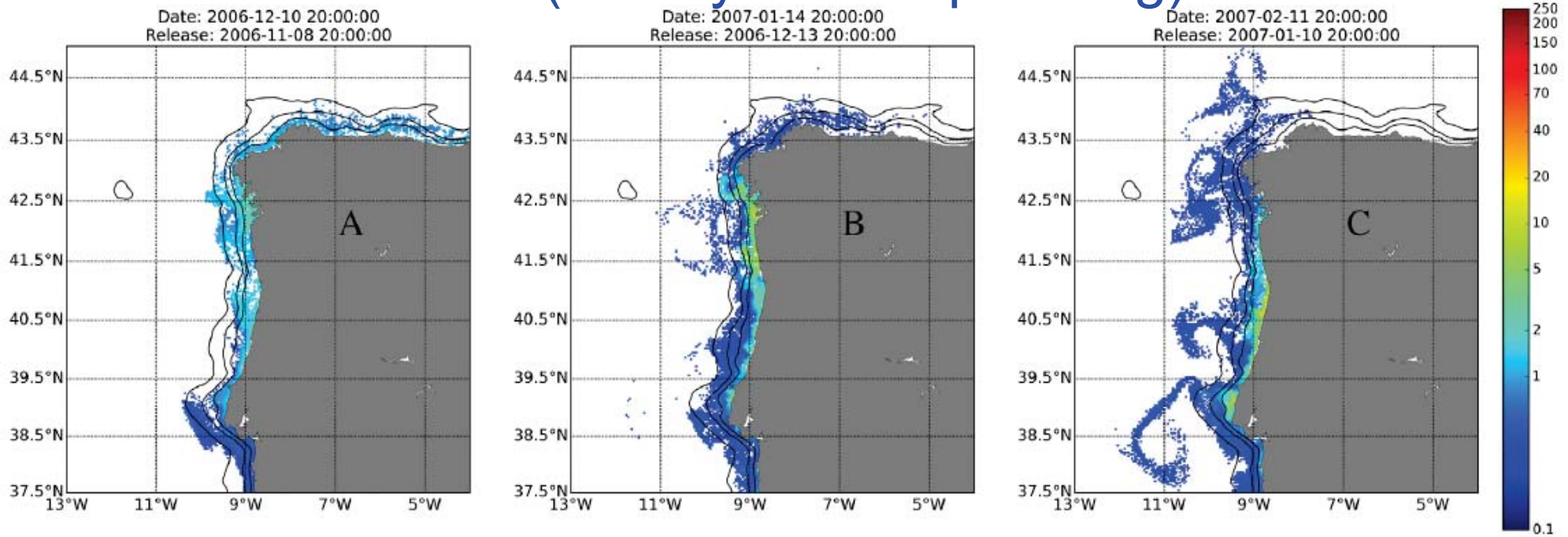


Fig. 14. Maps showing snapshots of the zooplankton distribution (in mg C/m^3) at the particle positions obtained 29 days (late larvae) after being spawned at the Portuguese coast at the dates indicated in each figure.

2007

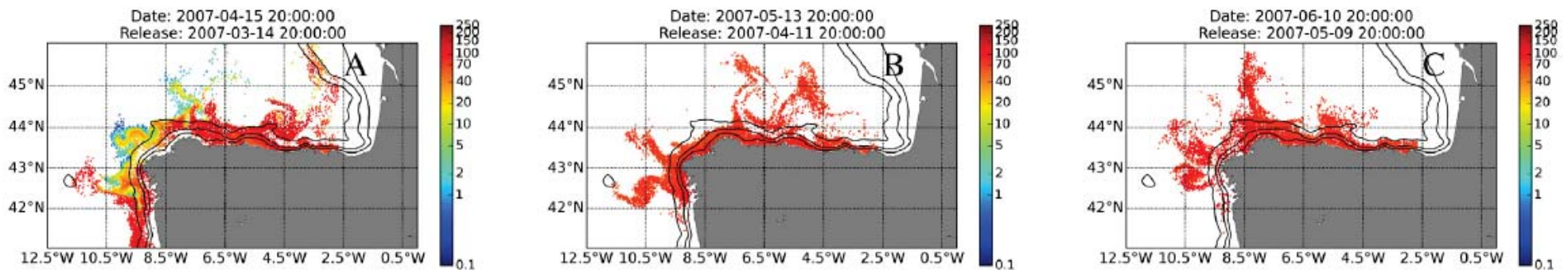
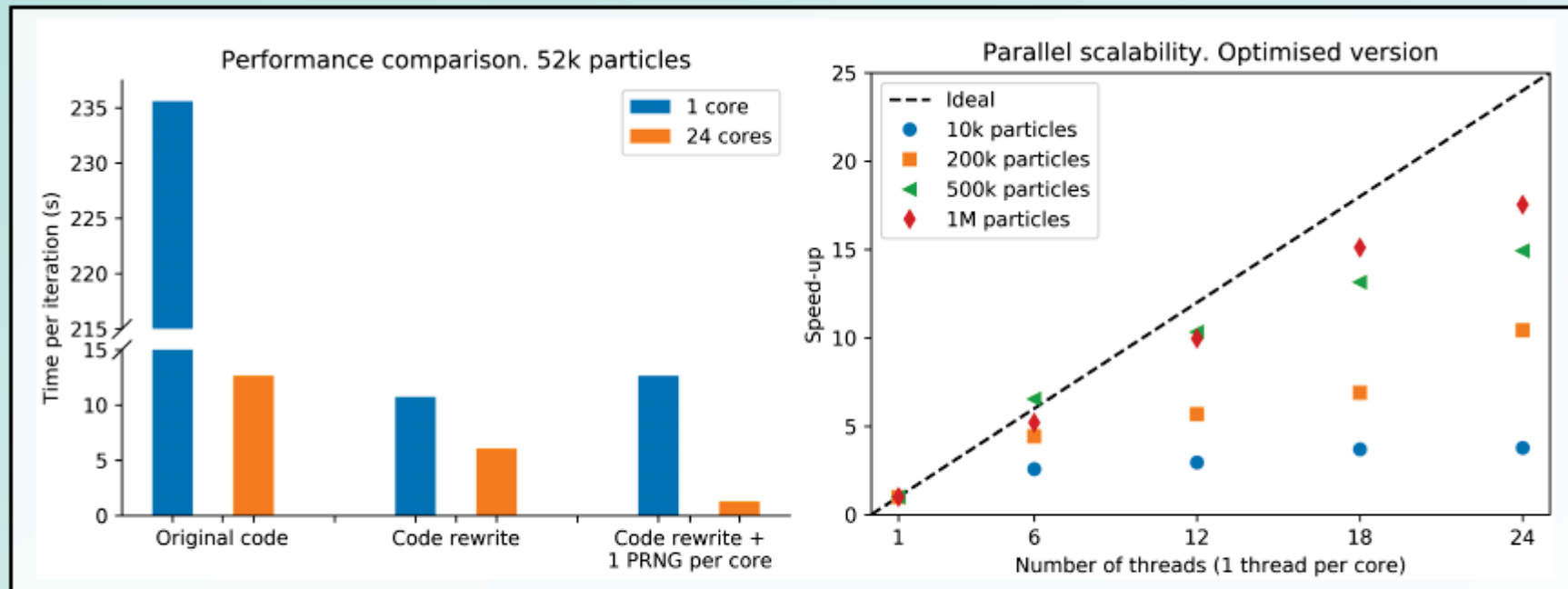


Fig. 16. Maps showing snapshots of the zooplankton distribution (in mg C/m^3) at the particle positions obtained 29 days (late larvae) after being spawned at the Cantabrian Sea coast at the dates indicated in each figure.

Off-line lagrangian particle tracking: Efficient implementation of a Vertical Dispersion algorithm

Ignacio Vidal-Franco⁽¹⁾, Manuel Ruiz-Villarreal⁽²⁾, Andrés Gómez-Tato⁽³⁾



Finisterrae II cluster: 2x Intel(R) Xeon(R) CPU E5-2680 v3 @ 2.50GHz

Java Hotspot 64 bit Server VM, 1.8.0_121-b13

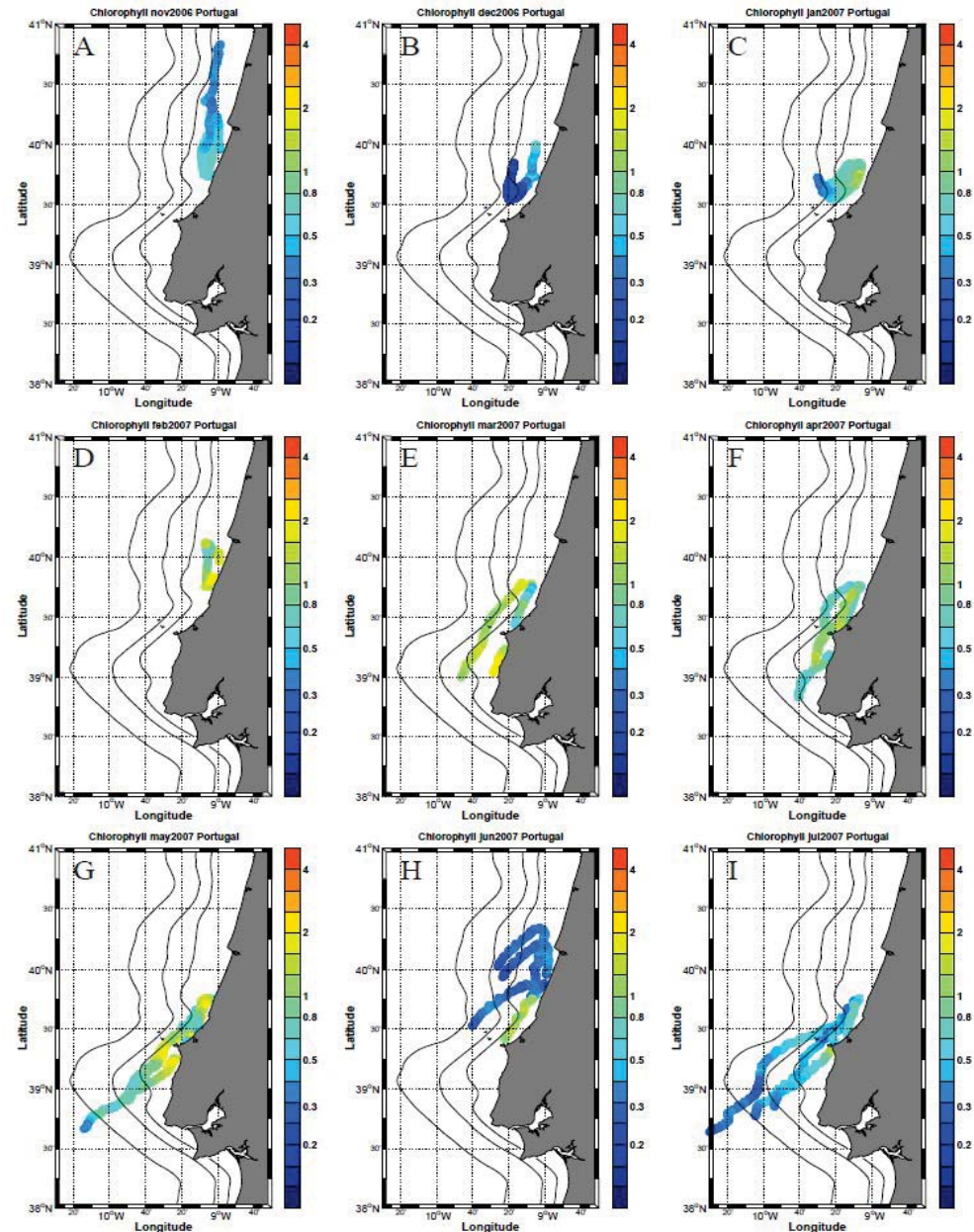
Optimization of the numerics of the offline Lagrangian model (vertical diffusion)

Optimization of the code for running in Finisterrae II:

more particles, more frequency of release, more years THEREFORE
simulations more representative of interannual variability sardine recruitment

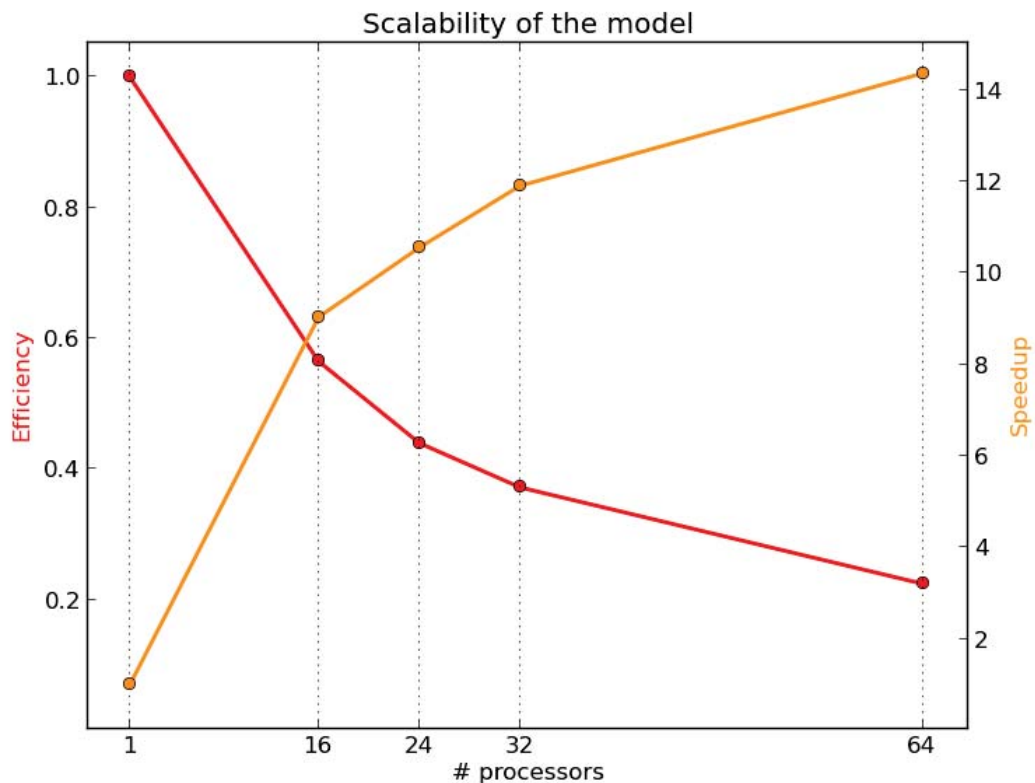
Products for marine resources: Decadal simulation (2000-)

- Hydrodynamical model coupled with ecological model:
 - Reanalysis using the Mercator analysis product for the Global ocean at $1/12^\circ$ (PSY4V2R2).
- Use of CESGA (Galician Supercomputing Center).
- Biophysical modelling
- **Aim:** fisheries (egg and larval drift, recruitment), HAB hindcasts (understanding the effect of circulation on HAB development and advection)



HPC supporting ocean services

Computing



Storage



Speed-up of simulations
Dedicated processor time for improving model configuration
Decadal simulations of the ecosystem requires scalable model

Around 54 Tb at CESGA for:
- output of interannual simulations of hydrodynamics + ecosystem
- forcing of offline Lagrangian models