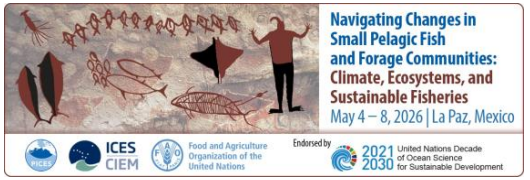
CIENCIAS MARIÑAS GALICIA



DEMON
Dissipation of Energy in Ocean Models and Connectivity

Numerical modelling of Early Life Stages of small pelagic in the Atlantic Iberian Margin and the Mediterranean Sea for fish stock assessment

Luz M. García-García*, Sofía González-Pérez, Daniel Rodríguez-Abal, Manuel Ruiz-Villarreal, Adrián Sanjurjo-García, Gonzalo González-Nuevo, Justino Martínez, Emilio García-Ladona, Jordi Isern-Fontanet, Ana Sabatés

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INSTITUTO ESPAÑOL DE OCEANOGRAFÍA
CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

MINISTERIO DE CIENCIA E INNOVACIÓN
UNIÓN EUROPEA
FONDO EUROPEO DE DESARROLLO REGIONAL
"Una manera de hacer Europa"
AGENCIA ESTATAL DE INVESTIGACIÓN

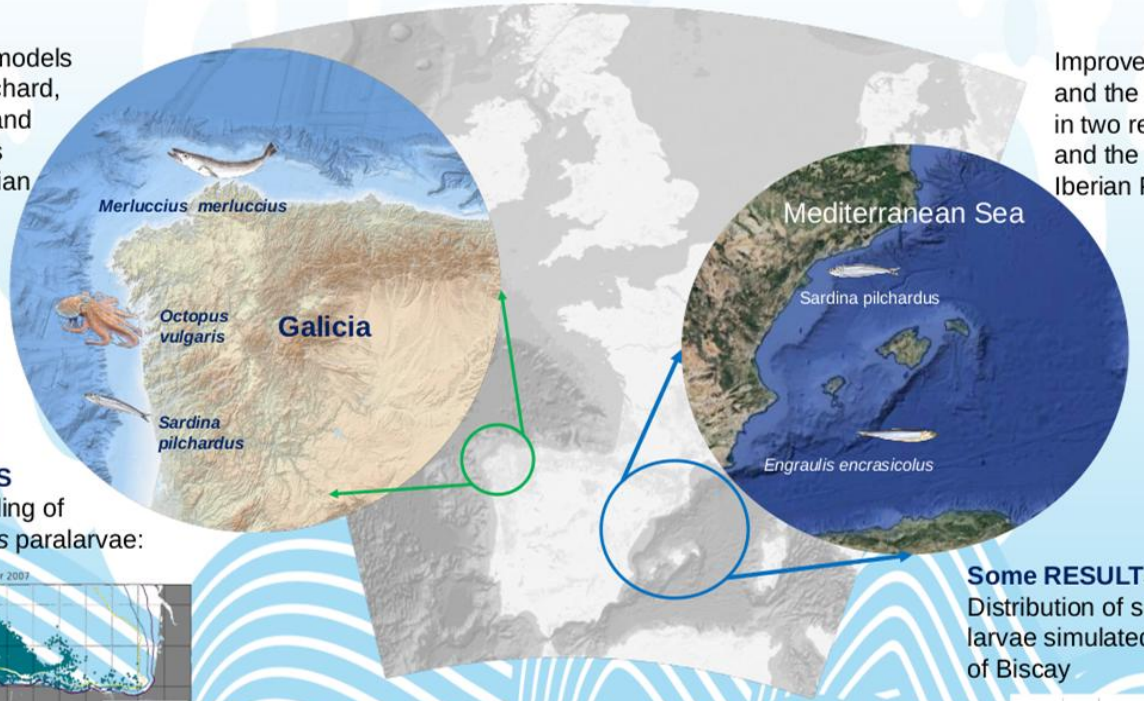
GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN
Plan de Recuperación, Transformación y Resiliencia
XUNTA DE GALICIA
Financiado por la Unión Europea
NextGenerationEU
FEMP-FEMPA

CIENC
MA

Project PHYSTOFISH (Physics to Fisheries)

Project DEMON (Dissipation of Energy in Ocean Models and Connectivity)

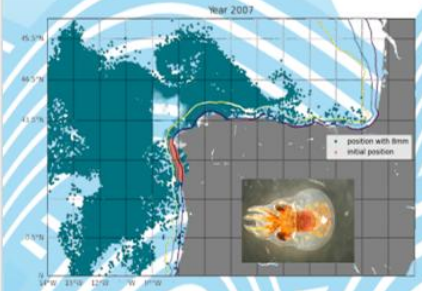
Implement E2E models for European pilchard, European hake and common octopus fisheries in Galician waters.



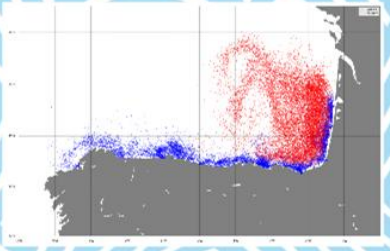
Improve the hydrodynamic models and the Lagrangian ELS models in two regions: the Mediterranean and the North and North-Western Iberian Peninsula.

Study the larval dispersal and connectivity of European pilchard and anchovy.

Some RESULTS
Dispersal modeling of *Octopus vulgaris* paralarvae:



Some RESULTS
Distribution of sardine and anchovy larvae simulated by the model in the Bay of Biscay



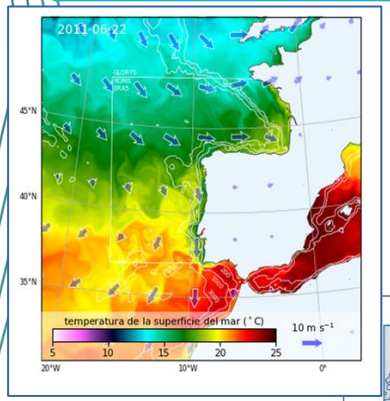
** Galicia Marine Science programme is part of Complementary Science Plans for Marine Science of Ministerio de Ciencia e Innovación included in the Recovery, Transformation and Resilience Plan (PRTR-C17.I1). Funded through Xunta de Galicia with NextGenerationEU and the European Maritime Fisheries and Aquaculture Funds.*

A biophysical model for the Early Life Stages of SPF

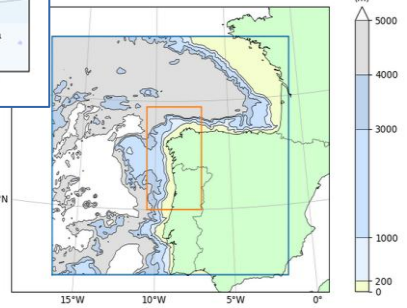
CIENCIAS MARIÑAS GALICIA

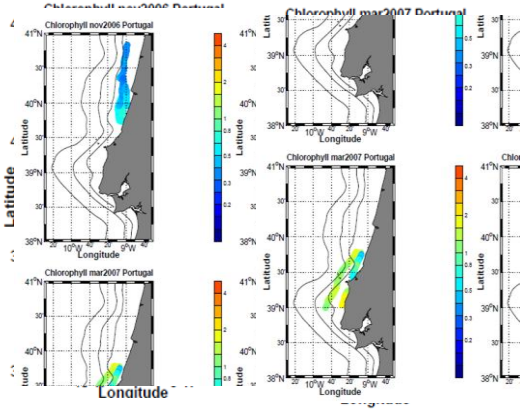
DEMON
Dissipation of Energy in Ocean Models and Connectivity

Hydrodynamic model (3D)
- ROMS Rutgers
- 30 vertical levels
- 3.5 km horizontal resolution
- Meteorological forcing
- Tides
- Rivers



Velocities
Turbulence
Temperature
Salinity
Density





Biogeochemical model N2PZD2 (nutrient sources)
- Fennel et al, 2006

Phyto
Zoo

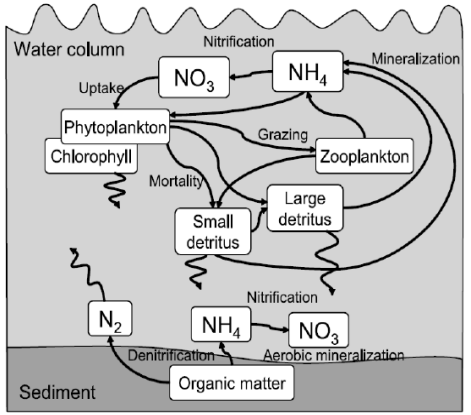


Figure 1. Biological model schematic.

Lagrangian IBM model
- Offline, Ichthyop or OpenDrift
- Physical processes (advection and dispersion)
- Biological behaviour of Early Life Stages (growth, buoyancy, vertical migration, etc.)

Transport
Survival
Connectivity

A Lagrangian IBM for SPF Early Life Stages

CIENCIAS MARIÑAS GALICIA

DEMON
Dissipation of Energy in Ocean Models and Connectivity

OpenDrift

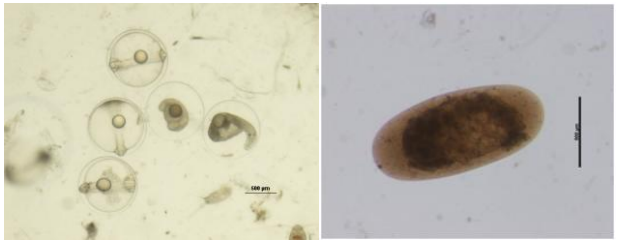
	Lagrangian model (offline)	Egg (<2.8 mm)	Yolk-sac larva (2.8–4.5 mm)	Feeding larva (>4.5 mm)
Physical processes	Horizontal advection	×	×	×
	Vertical advection	×	×	×
	Horizontal dispersion	×	×	×
	Vertical dispersion	×	×	×
Biological processes	Temperature dependent development/growth	×	×	
	Food limitation (LTL model)			×
	Development dependent buoyancy	×		
	Vertical migration			×

From a model

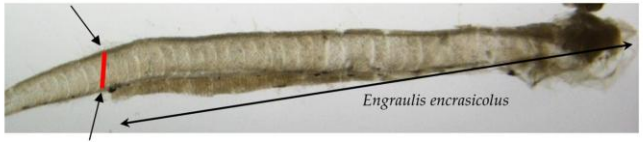
From cruises or lab experiments

	Yolk-sac	Autonomous
Anchovy	3.5 mm	4.5 mm
Sardine	4.0 mm	5. 5mm

Egg

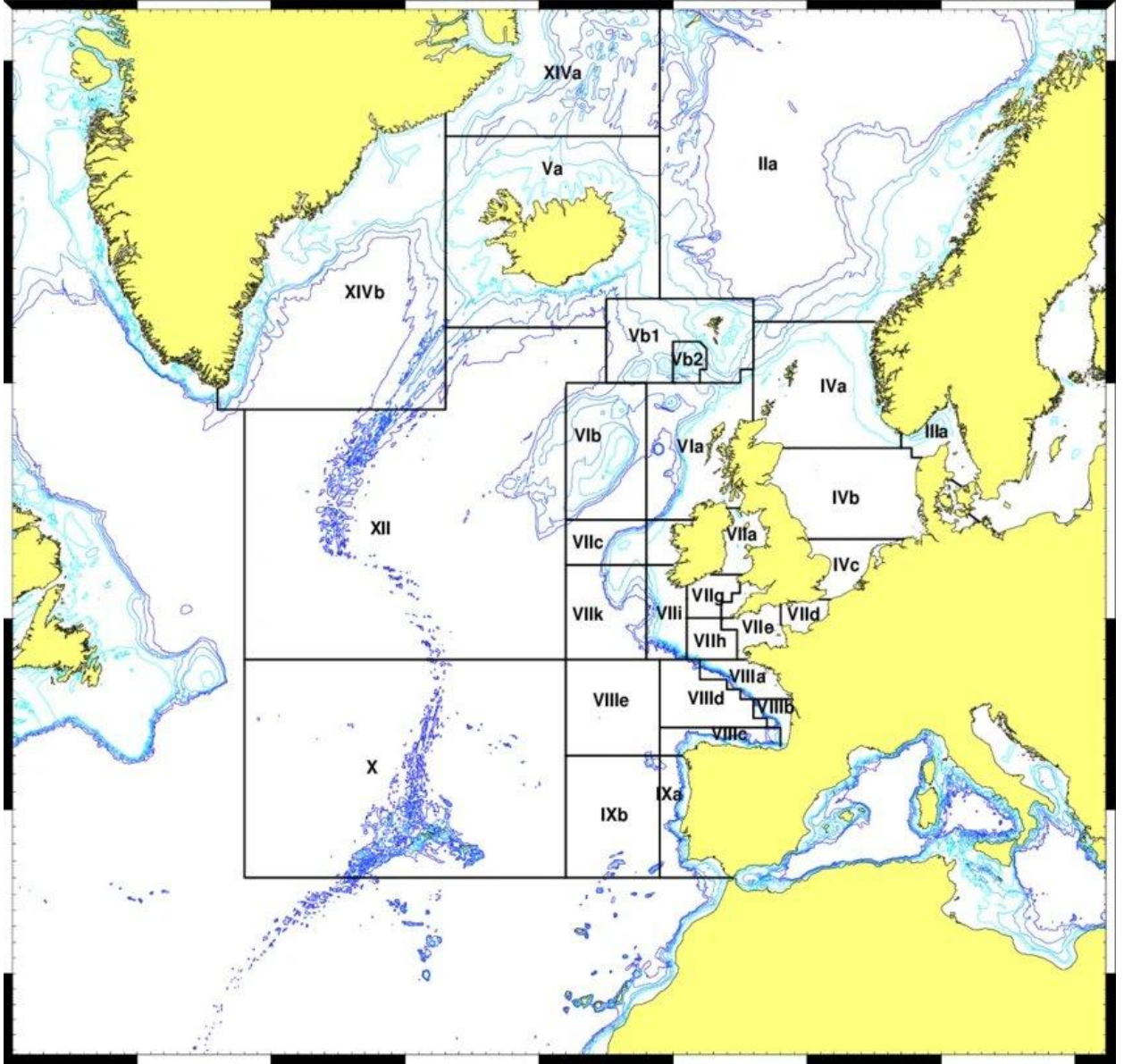


Larvae

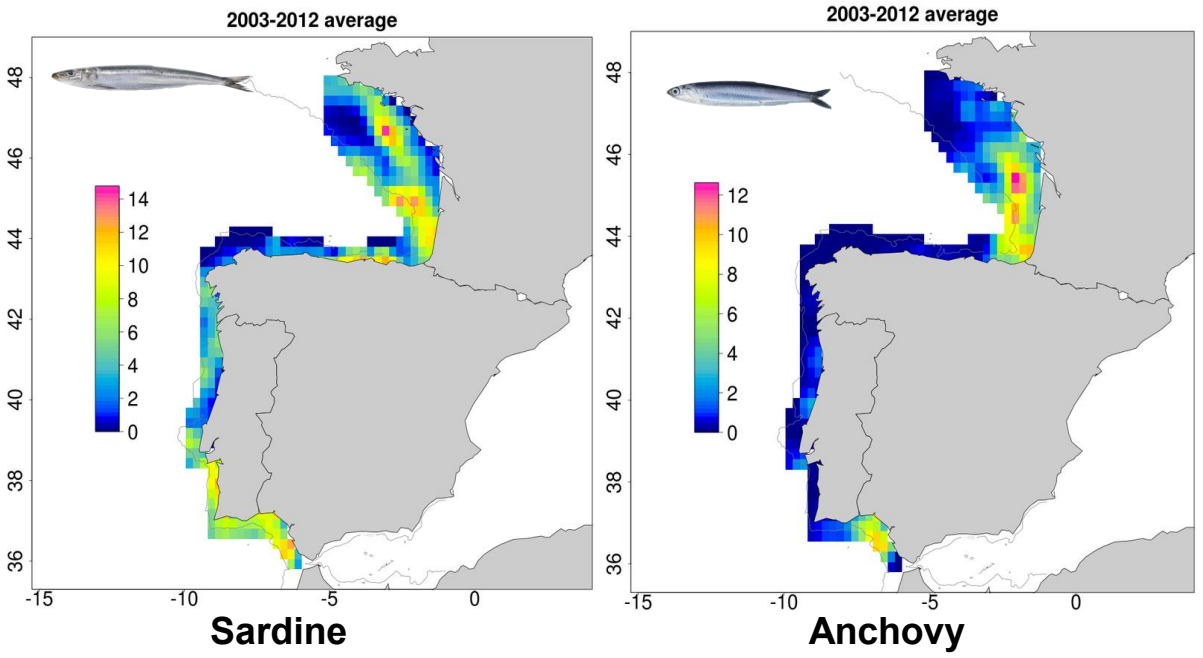


CIENCIAS MARIÑAS GALICIA

ICES areas:
VIIIc & IXa

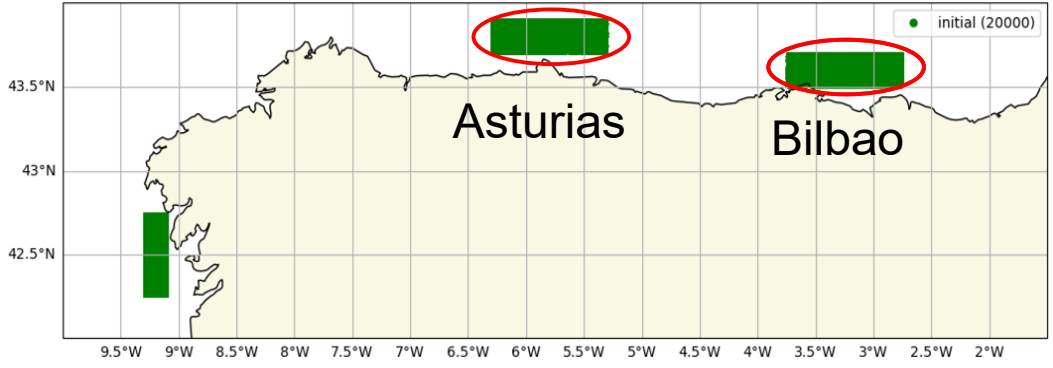


Sardine and Anchovy spawning areas: where are eggs released?



Egg density from CUFES surveys (average 2003-2012). ICES WGAEGG

We know from the IEO PELACUS cruise **2025** that high density of eggs was observed in the green areas

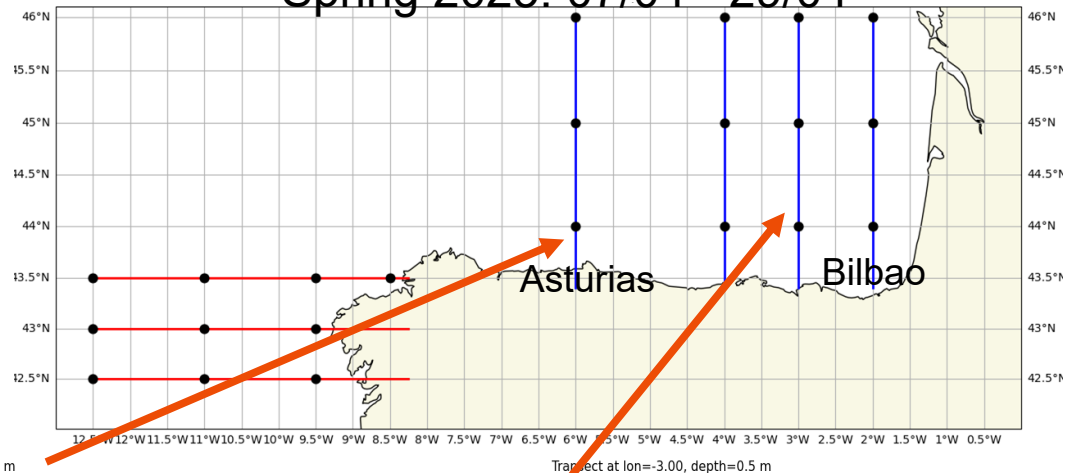


Sardine and Anchovy spawning: when are eggs released?

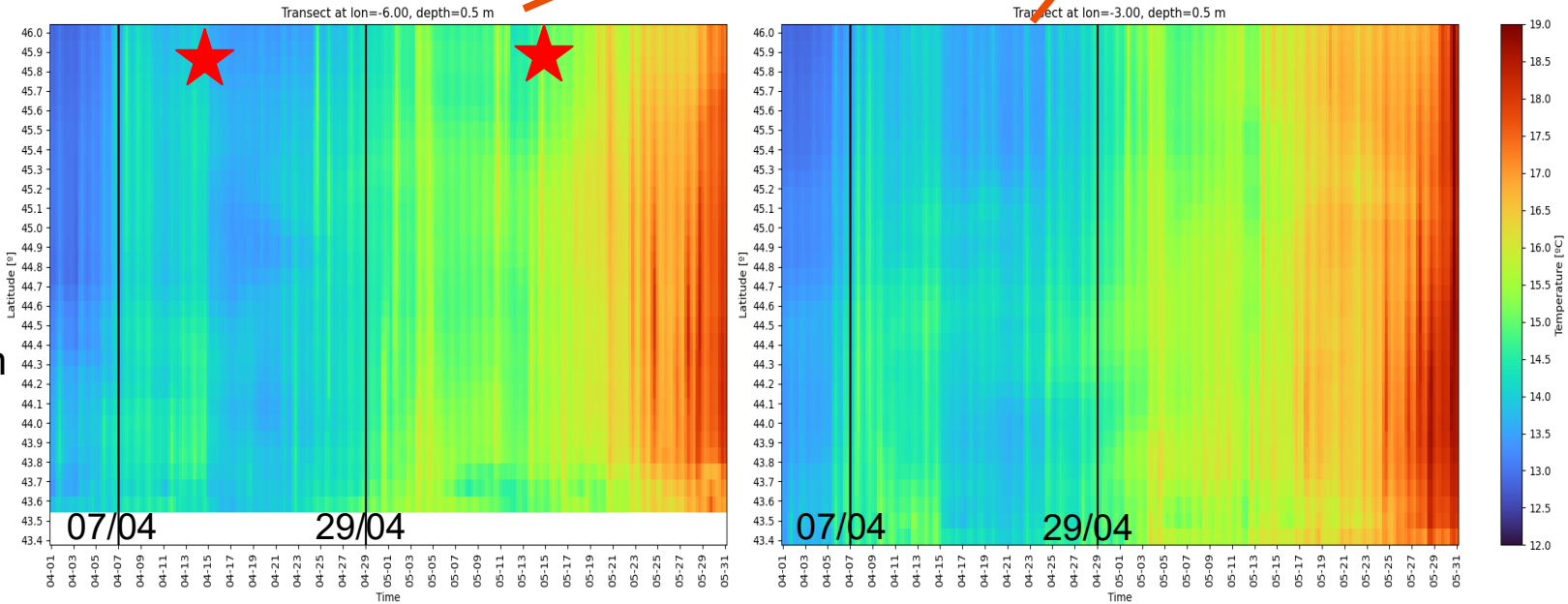
- Sardine spawning peak in the Cantabrian sea: April
- Sardine spawning peak off the portuguese coast: autumn
- Anchovy spawning peak in the Cantabrian sea: May

PELACUS 2025 cruise

Spring 2025: 07/04 - 29/04



Hövmoller SST plots: April and May 2025 from CMEMS Global Ocean Physics Analysis and Forecast product (GLO)



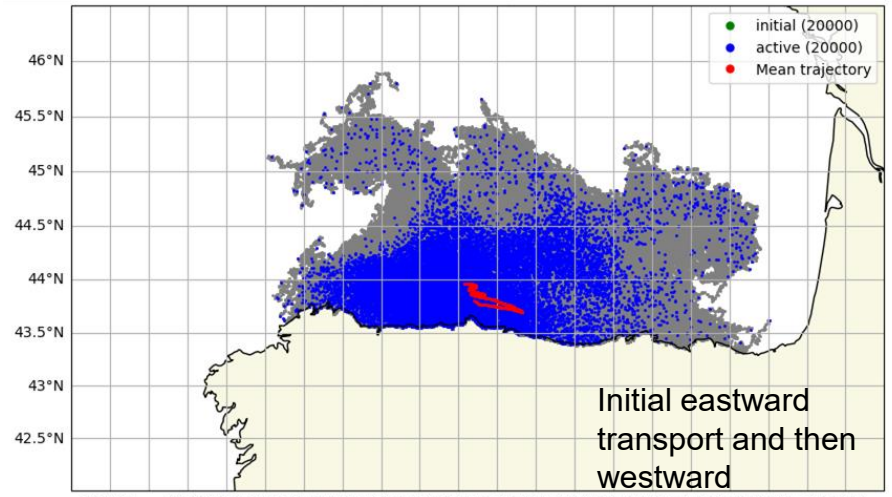
Simulations (40 days): Anchovy IBM forced by GLO model

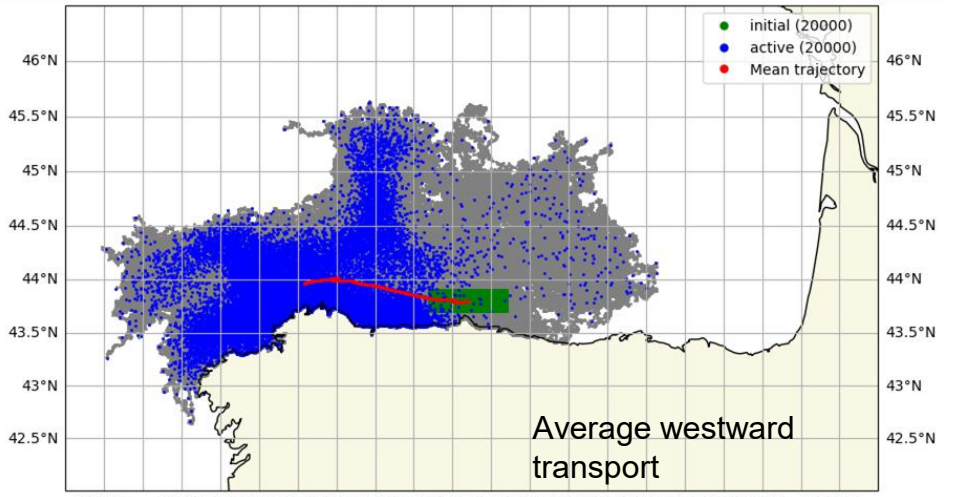
April 15th 2025

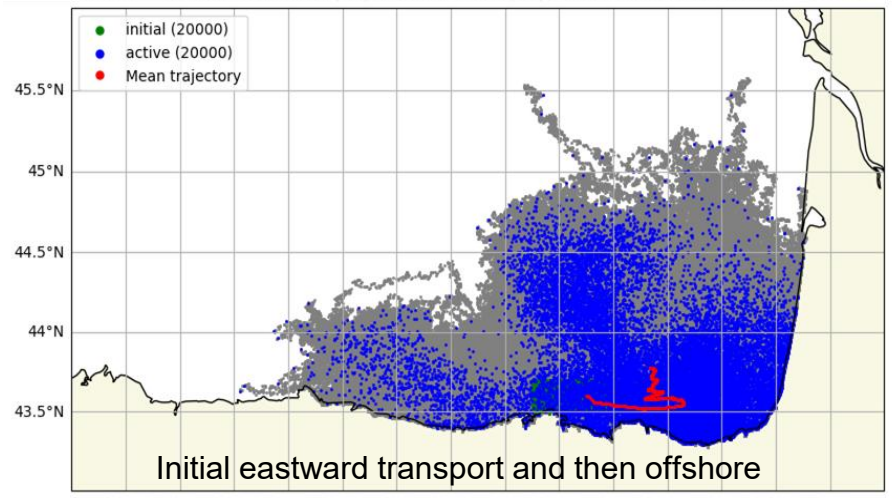
May 15th 2025

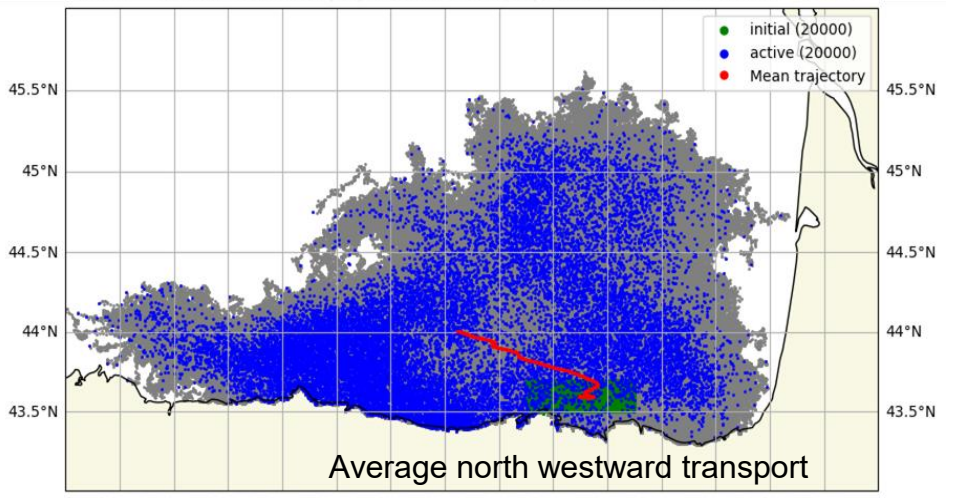
Asturias

Bilbao

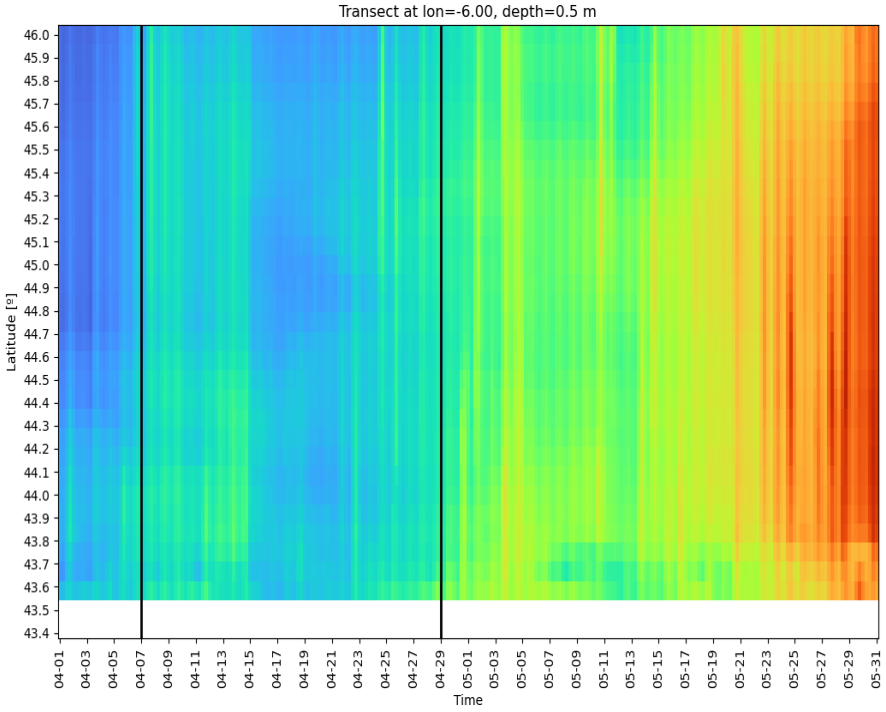


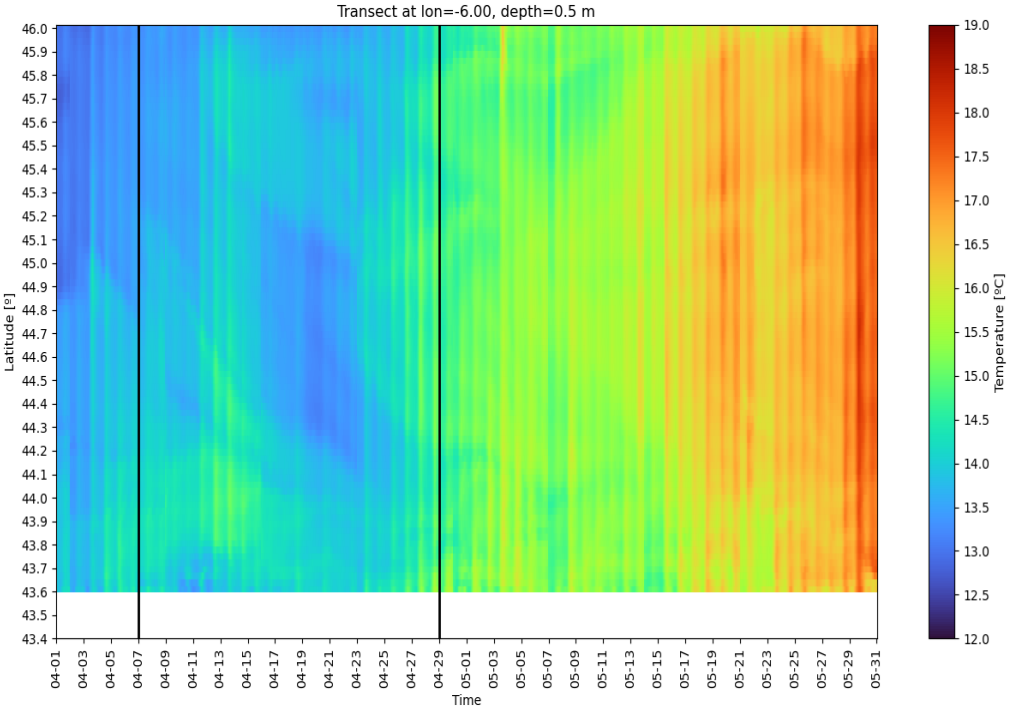






Hövmoller diagrams in Asturias



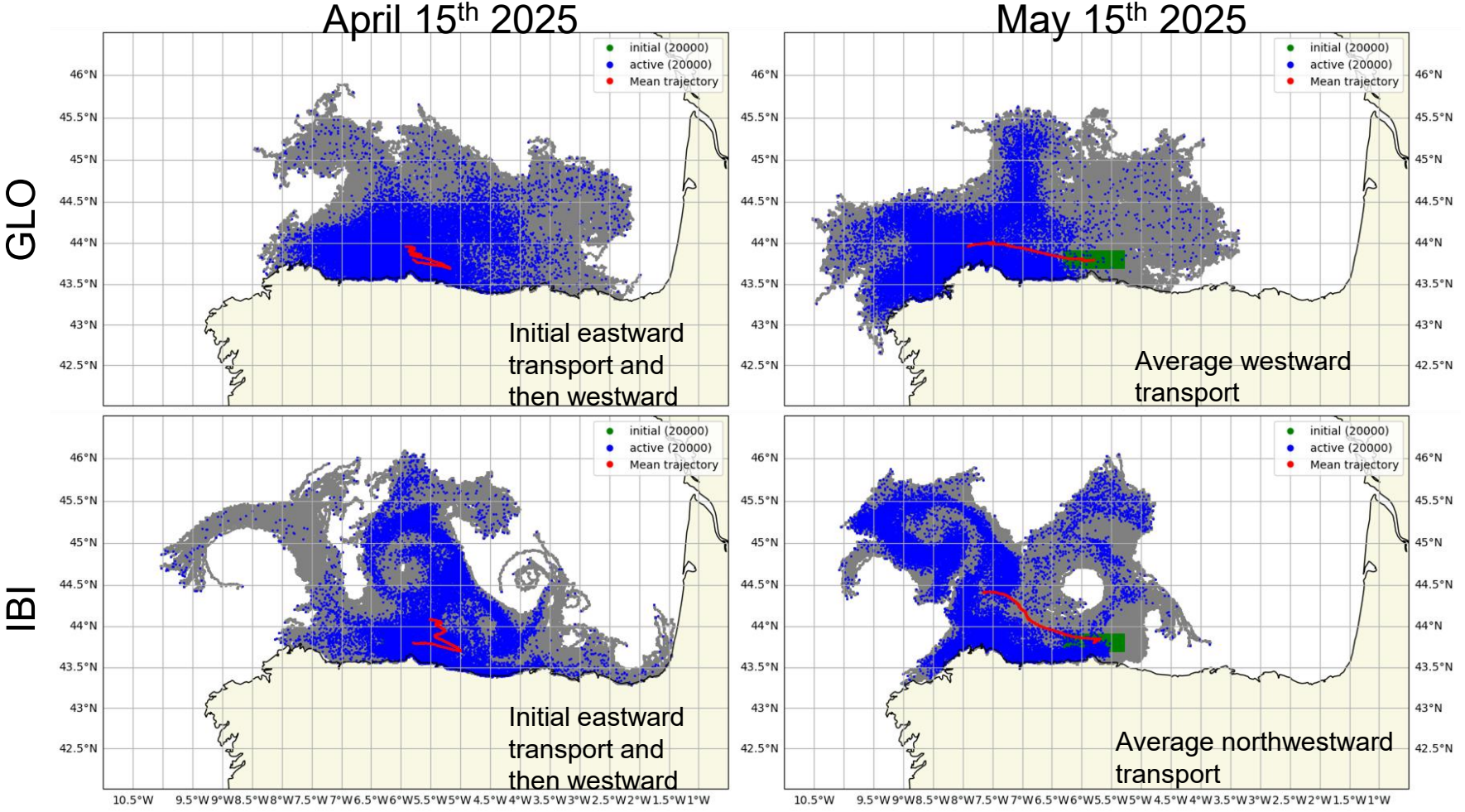


GLO:
Global Ocean Physics Analysis and Forecast (1/12º)

IBI:
Atlantic-Iberian Biscay-Irish-Ocean Physics Analysis and Forecast (1/36º)

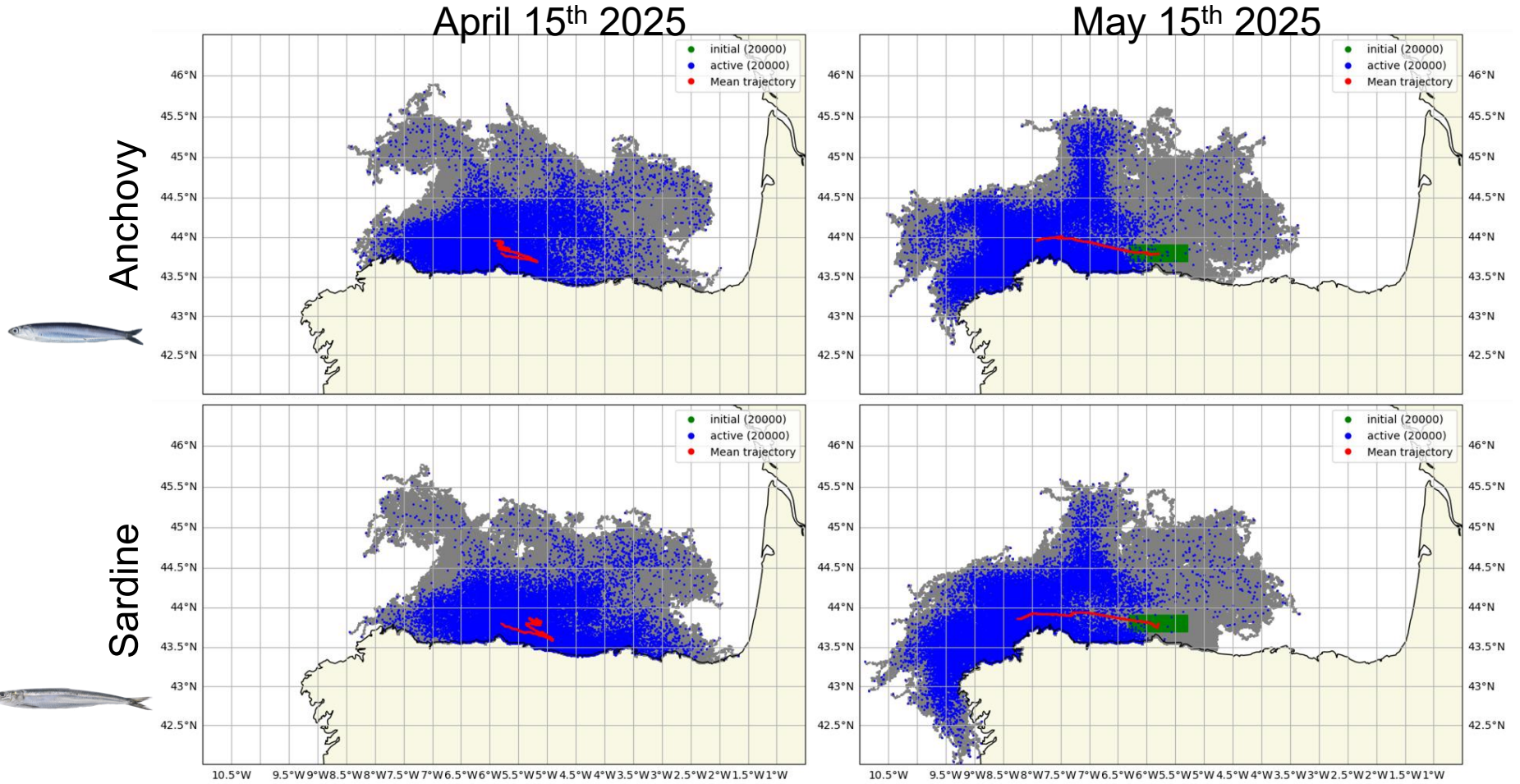
Copernicus Marine Service

Simulations (40 days): Anchovy IBM in Asturias



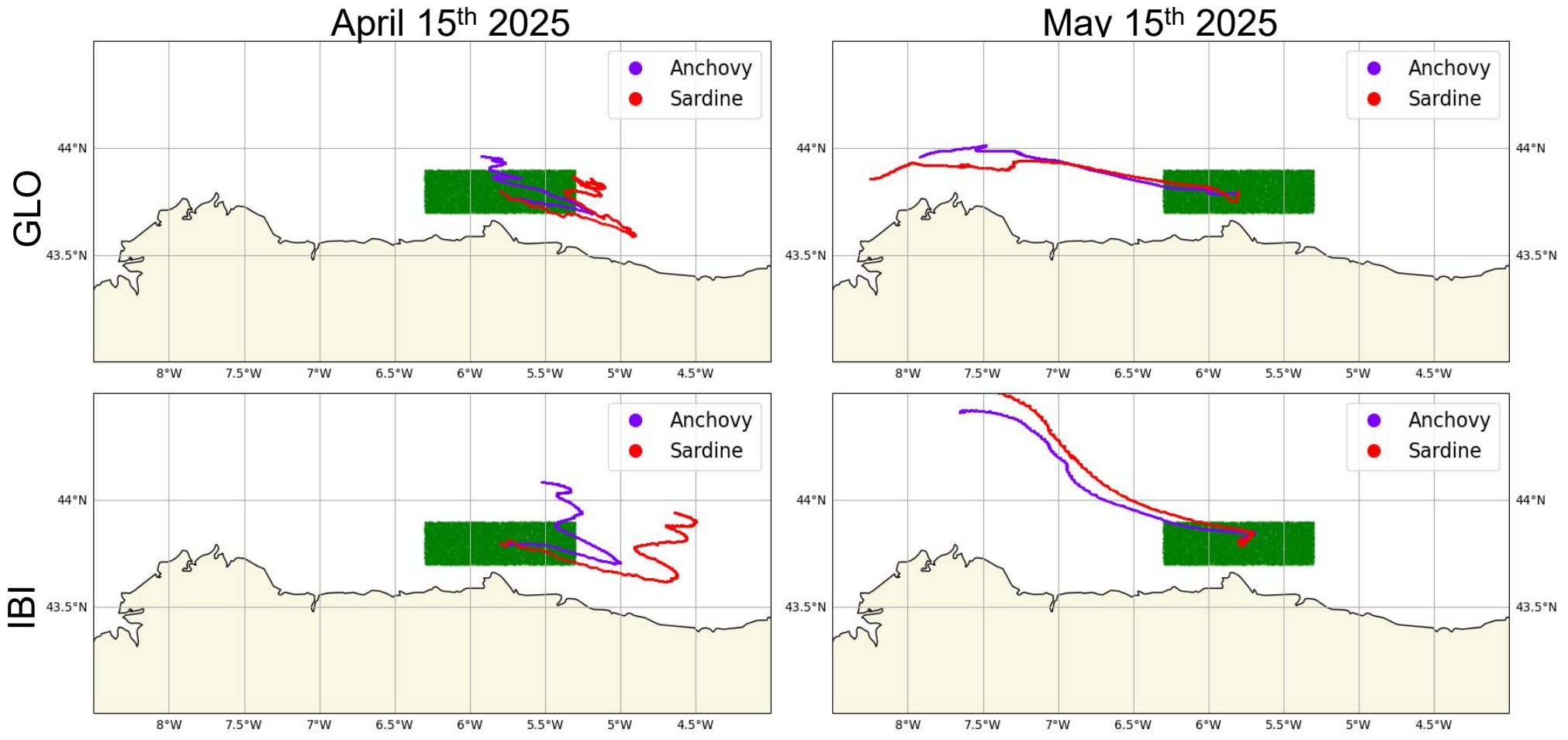
Different dispersion depending on models, but average patterns are similar

Simulations (40 days): Anchovy IBM vs sardine IBM forced by GLO



Apparent similar dispersion patterns of both species but clear differences

Simulations (40 days): Anchovy IBM vs sardine IBM Asturias



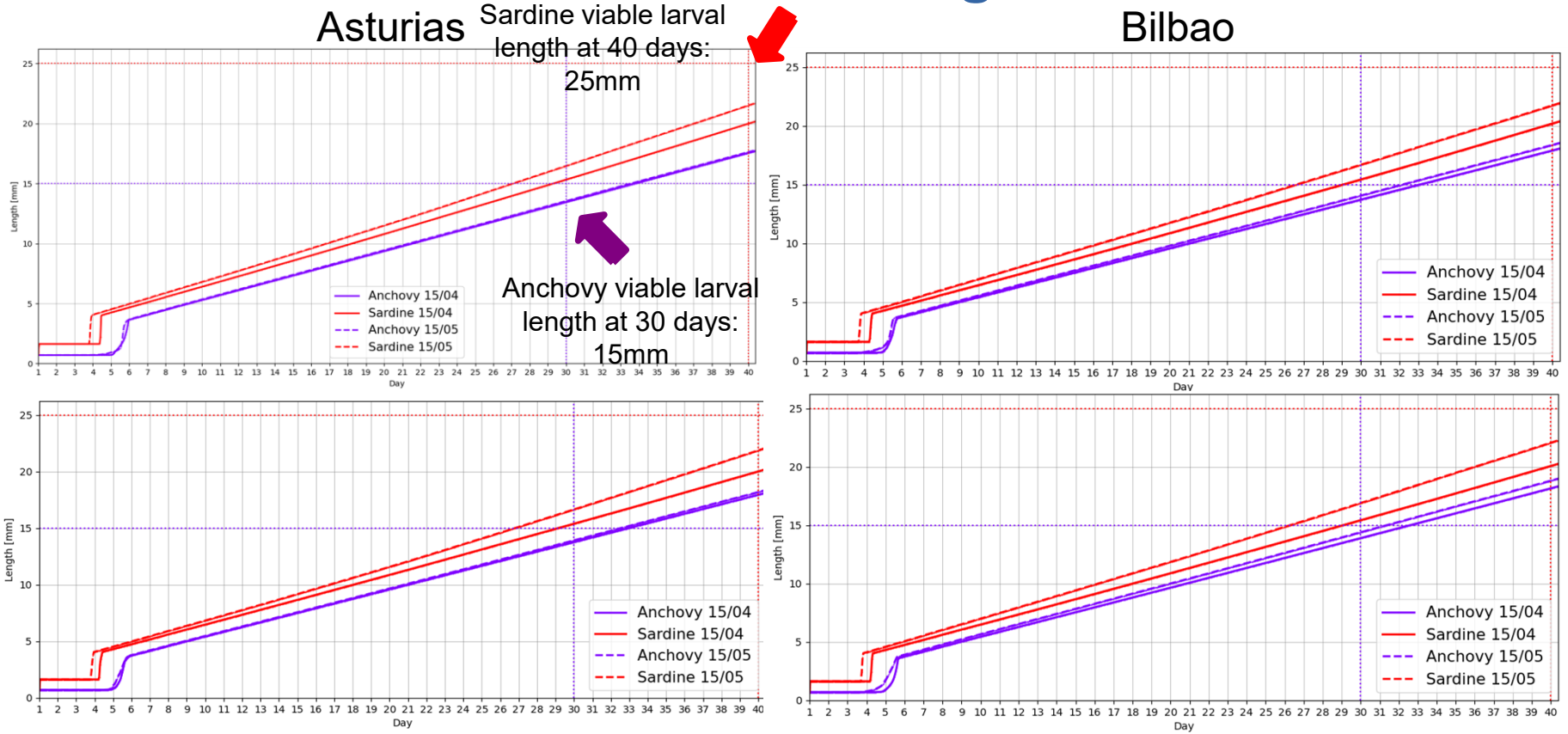
Larvae mean length

Asturias

Bilbao

GLO

IBI



Grown depending on temperature with no food limitation: maximum potential growth.

- Sardine far to reach on average the viable larval length: could suggest bad recruitment year
- Anchovy very close to reach the viable larval length at age 30: could suggest good recruitment year

ICES area: VIIIc

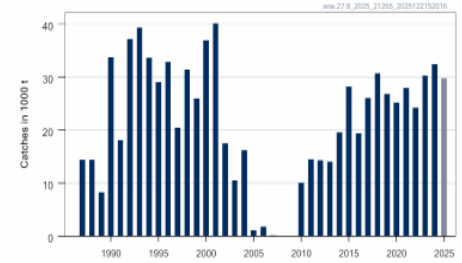
ICES Advice on fishing opportunities, catch, and effort
Bay of Biscay and the Iberian Coast ecoregion
Published 12 December 2025

Anchovy (*Engraulis encrasicolus*) in Subarea 8 (Bay of Biscay)

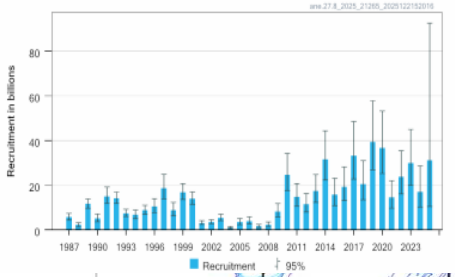
Stock development over time

Spawning-stock size is above B_{lim} and B_{PA}; no reference points for MSY $B_{trigger}$ or fishing pressure have been defined for this stock.

Catches



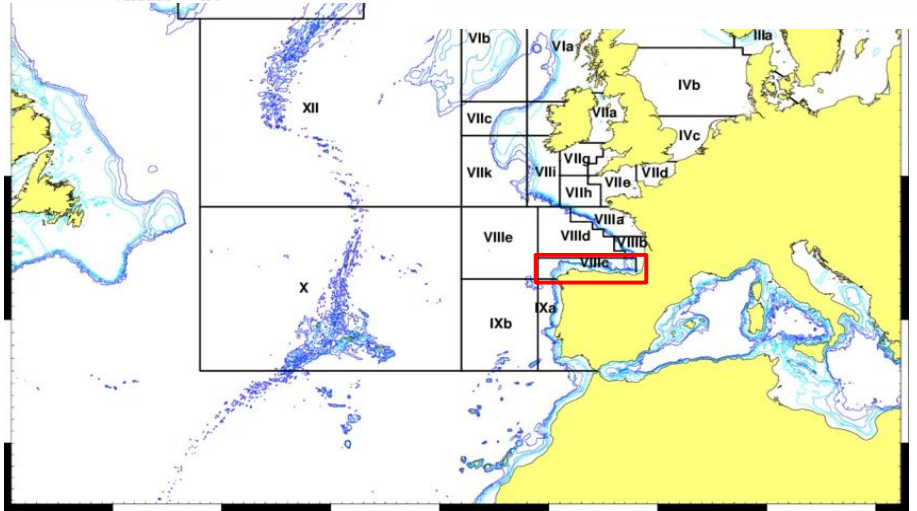
Recruitment (age 0)



Anchovy

Increased recruitment in 2025

With all caution: model results shown so far are in accordance



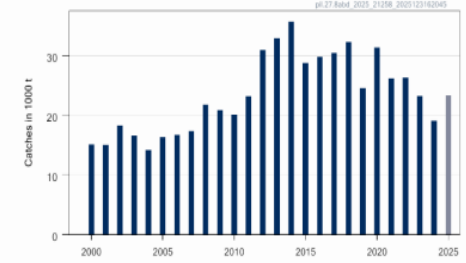
ICES Advice on fishing opportunities, catch, and effort
Bay of Biscay and the Iberian Coast ecoregion
Published 12 December 2025

Sardine (*Sardina pilchardus*) in divisions 8.a–b and 8.d (Bay of Biscay)

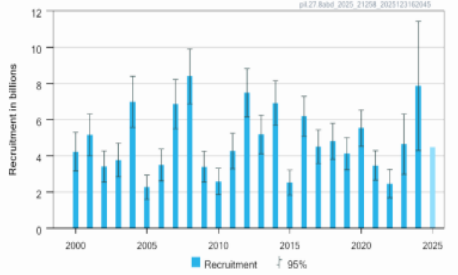
Stock development over time

Fishing pressure on the stock is above F_{MSY}; spawning-stock size is below MSY $B_{trigger}$ and B_{PA} but above B_{lim}.

Catches



Recruitment (age 0)

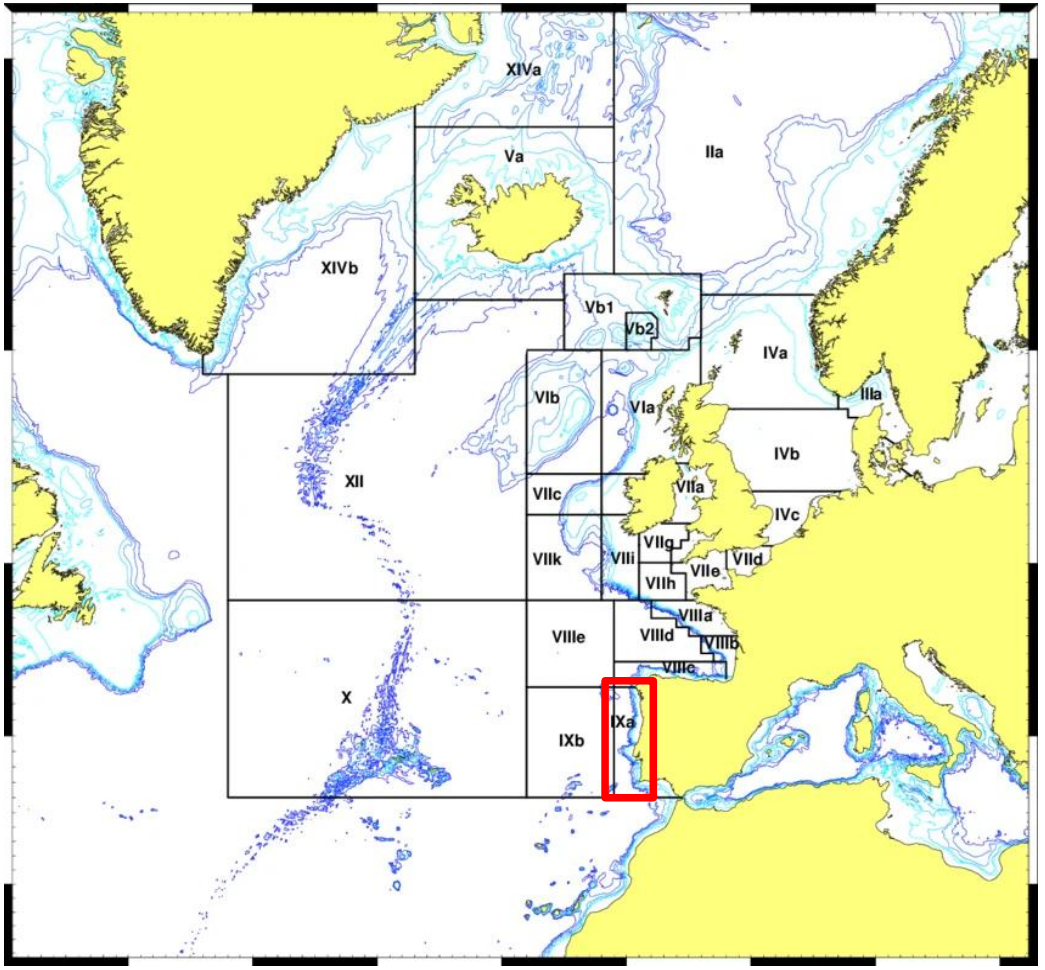


Sardine

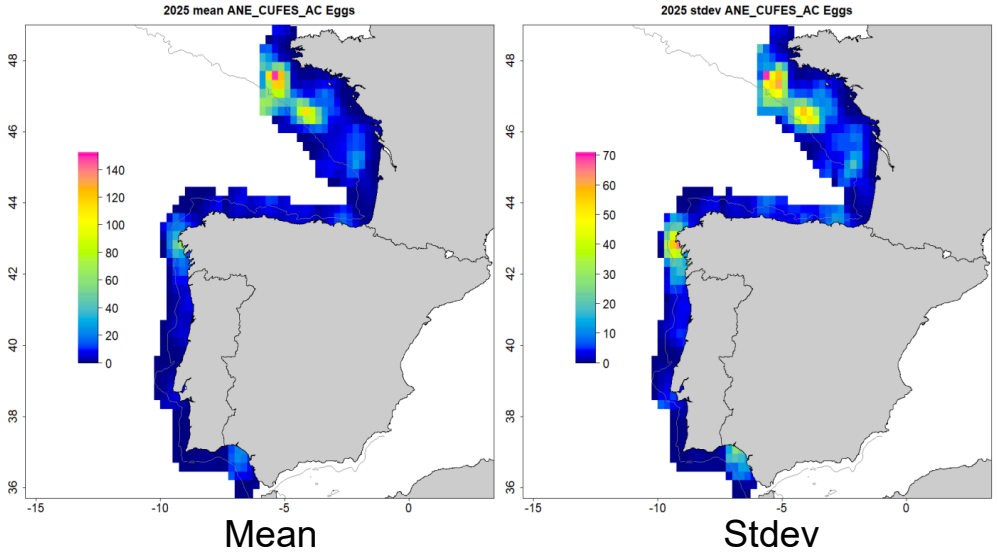
Decreased recruitment in 2025

What about Galicia?

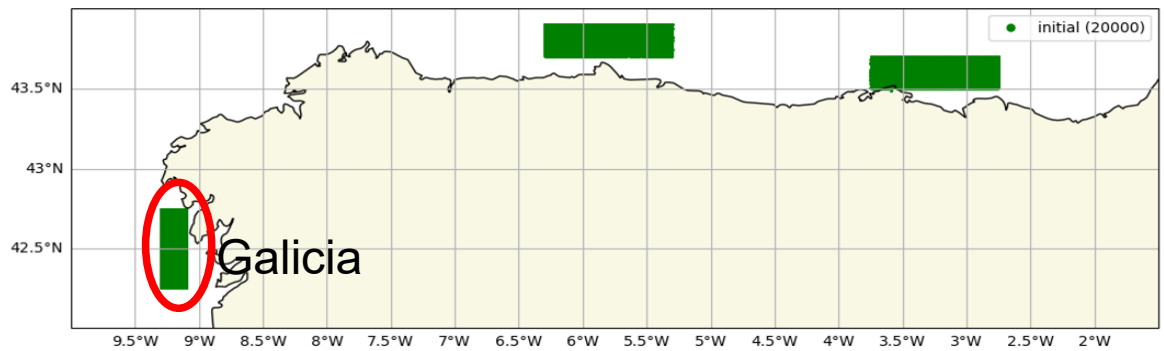
ICES areas: VIIIc & IXa

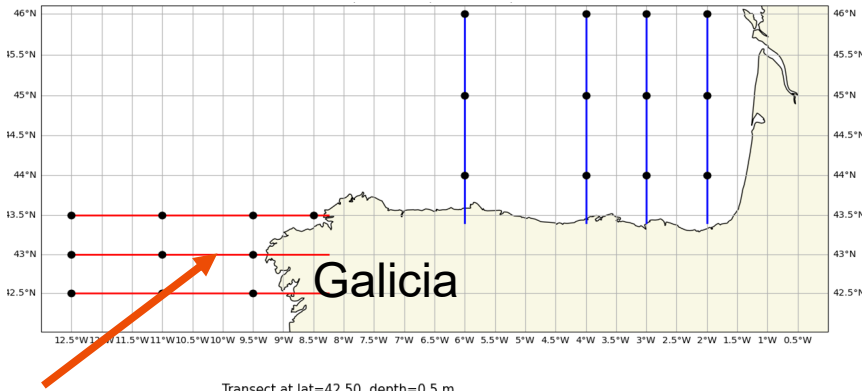


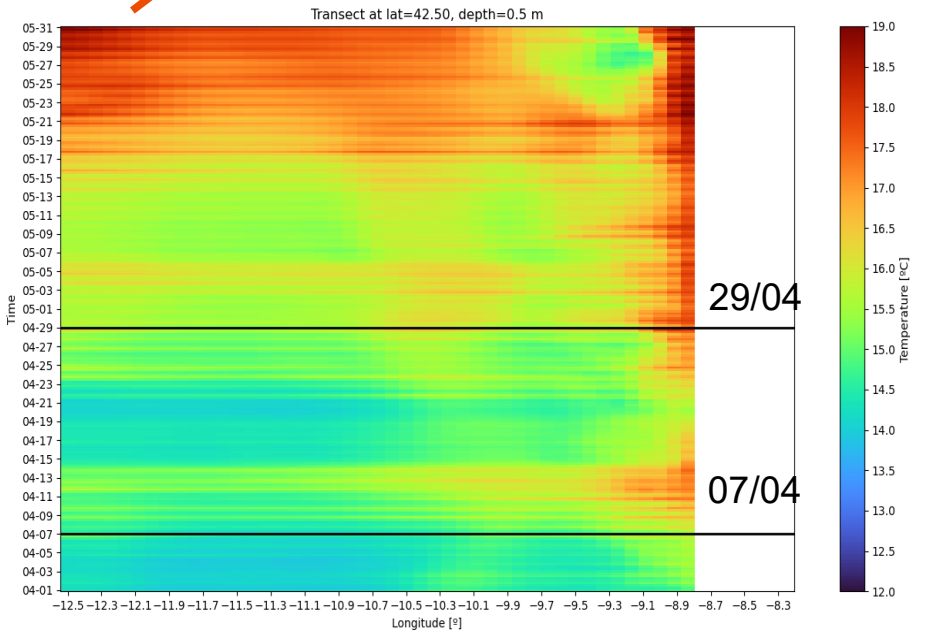
Anchovy spawning: when and where are eggs released?



Anchovy egg density from CUFES surveys **2025**. ICES WGAEGG



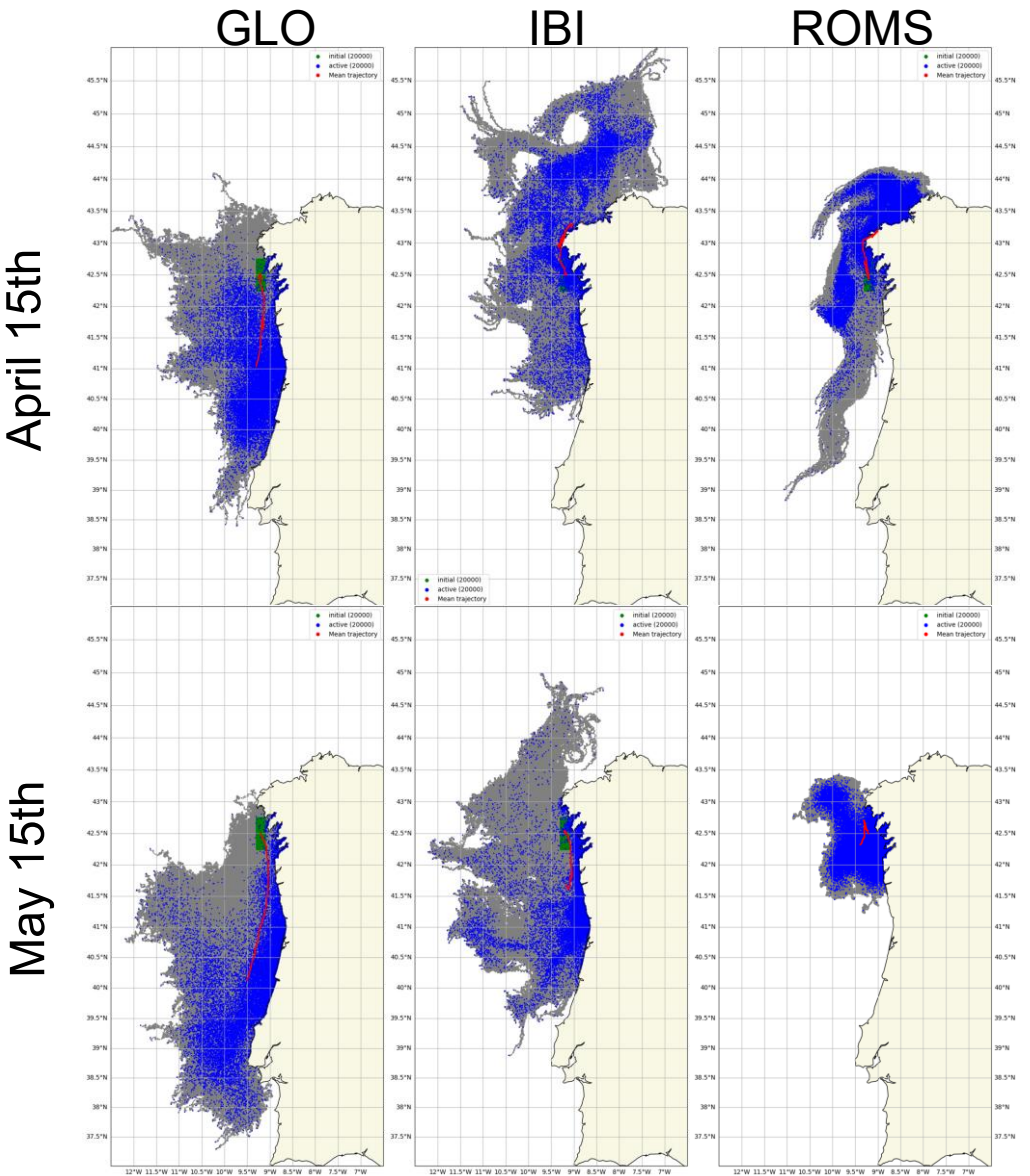




Simulations: Anchovy IBM in Galicia

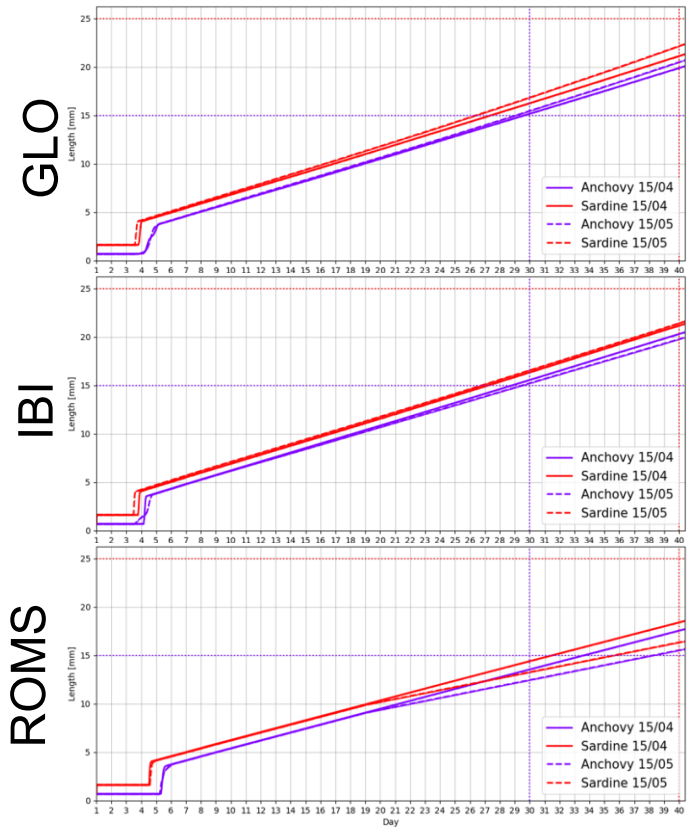
meteogalicia

Regional model: ROMS 2km



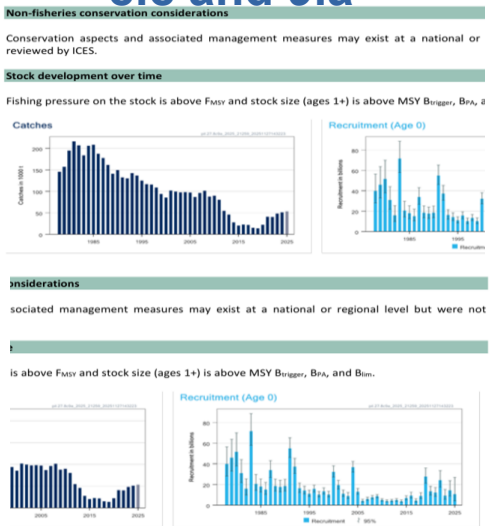
Simulations: Anchovy IBM vs sardine IBM in Galicia

Larvae mean length in Galicia

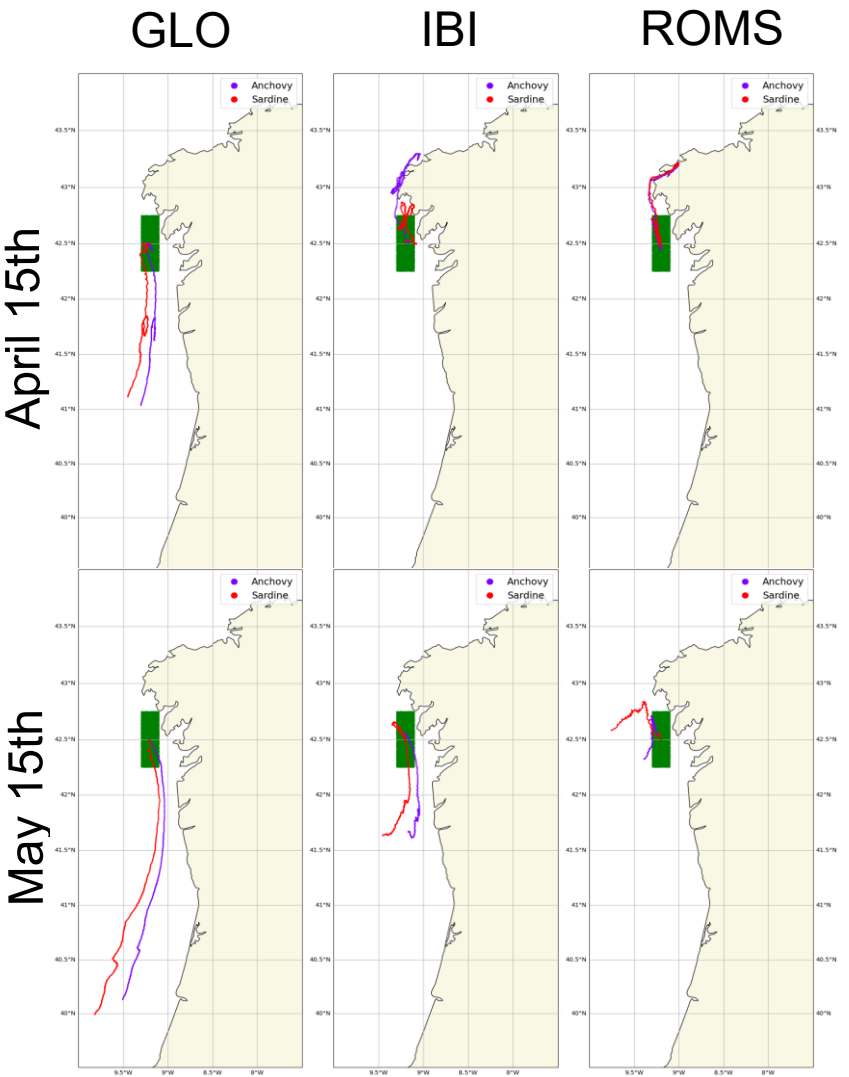


Sardine in divisions 8.c and 9.a

ICES CIEM

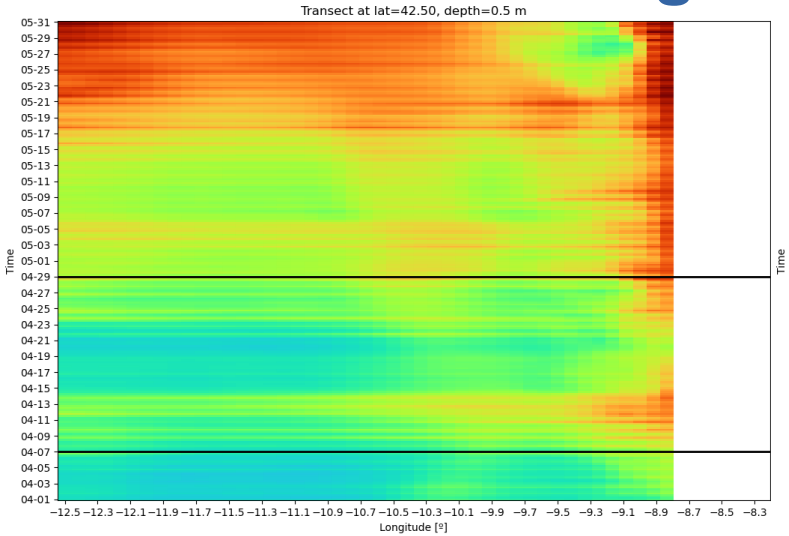


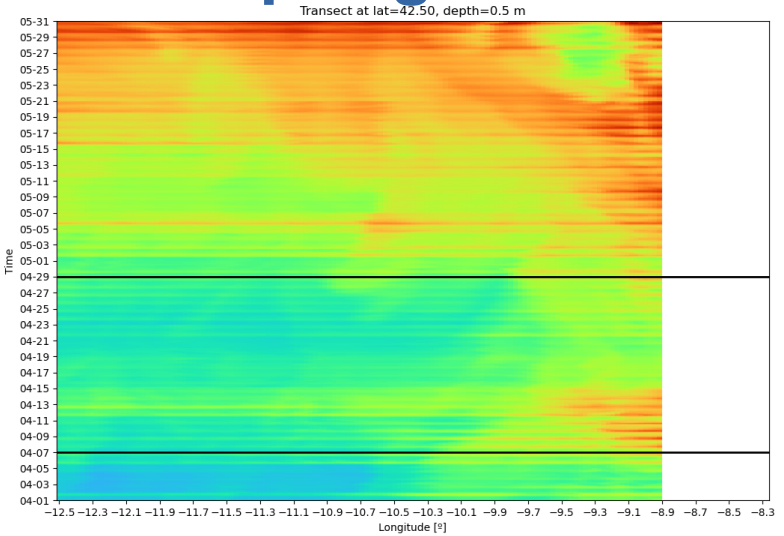
Larvae forced by ROMS grow less. Why?



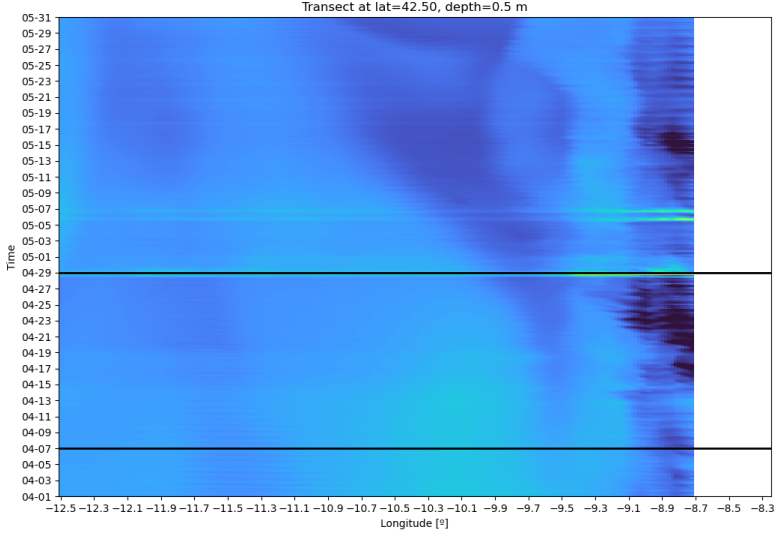
Hövmoller diagrams for spring in Galicia

GLO



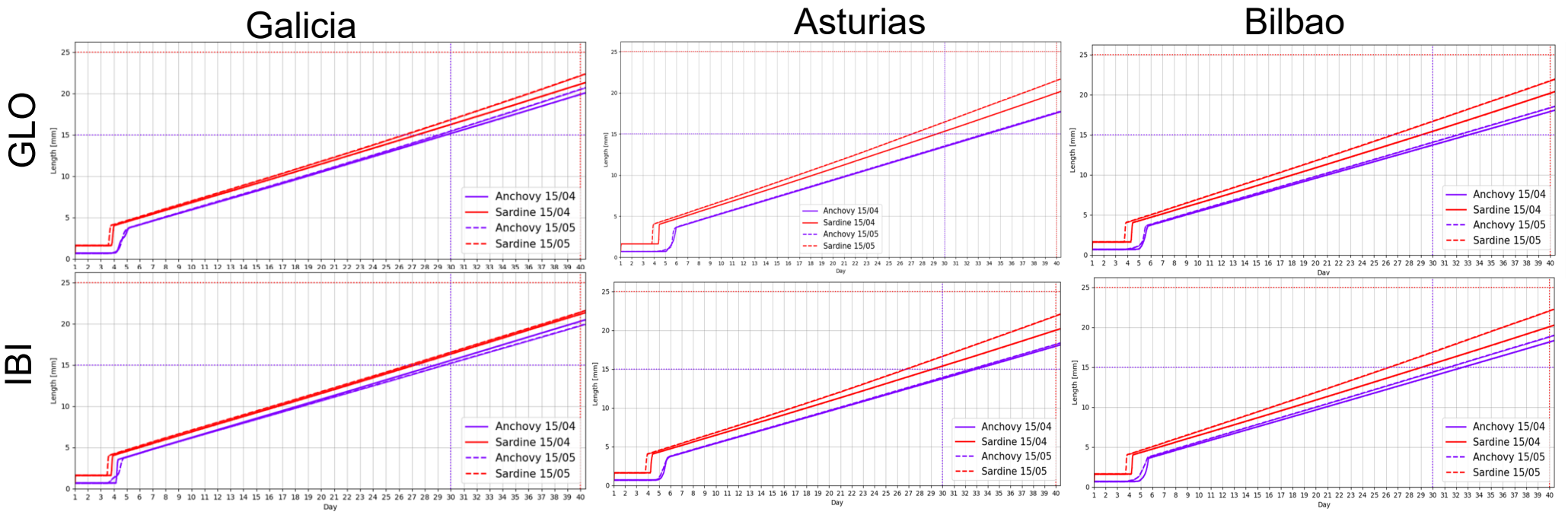


IBI



ROMS

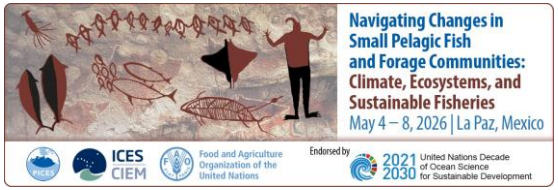
Larvae mean length in the three areas



Grown depending on temperature with no food limitation: maximum potential growth.

- Sardine and anchovy grow more in Galicia in this exercise for 2025

CIENCIAS MARIÑAS GALICIA



Summary and Conclusions

DEMON
Dissipation of Energy in Ocean Models and Connectivity

- We have shown model results for 2025 that illustrate the influence of environmental conditions on the distribution and growth of the Early Life Stages of two SPF species (sardine and anchovy).
- Models are key to capture the important effect of the short term temporal and spacial variability on the survival and connectivity of small pelagic fish.
- The choice of model is crucial to explain the observed variability.
- Lagrangian IBM models require a lot of data that should be easily available, providing all the necessary information. Our group is doing a big effort to move towards FAIR biological data and to make the biological information available through data platforms and services.
- During the project a workshop has been organized to study the integration between Lagrangian IBMs and stock assessment models. Lagrangian IBMs are recognized as the most robust tool for understanding the complex dynamics of fish ELS within a changing oceanic environment. We explored several ways of incorporating this environmental variability into stock assessment models. For a succesful integration it is important that:
  - The Lagrangian IBMs are focused to study problems that are important for fish assessment and management.
  - The results should be available through a constant communication between Lagrangian IBM modellers and stock assessment modellers.

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