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Modeling Iberian Sardine Early Life Stages dynamics

Luz María García-García(1), Manuel Ruiz-Villarreal(1), Marcos Cobas-García(1).
(1) Instituto Español de Oceanografía. Centro Oceanográfico de A Coruña. PaseoMarítimo Alcalde Francisco Vázquez, 10. A Coruña (15001). Spain. Presenter contact details: *lmgarciagarcia@hotmail.com*, Phone: *+34981205362*

Summary

The Iberian sardine (*Sardina pilchardus*) constitutes a traditional target species in western Iberia that remains to be economically important in Portugal and, to a lesser extent, in Galicia (NW Spain). The time series of recruitment shows ups and downs in the last decades. According to the ICES Advice 2013 for regions VIII and IX-a, the biomass of age 1 sardine and older has decreased since 2006 and recruitment has been below the long term average since 2005. In order to understand these fluctuations, a Lagrangian model to simulate sardine Early Life Stages (ELS), this is, egg and larvae stages, has been set up. The results of a high resolution hydrodynamic model for North and Northwest Iberia have been used as an input of the Lagrangian model Ichthyop (Lett *et al.*, (2008)) to simulate ELS advection and dispersion. Ichthyop has been adapted to sardine by including some biological behavior. A biogeochemical model coupled to the hydrodynamic model was also used to get some insight on recruitment for years 2006-2007.

Introduction

Recruitment results from a complex interplay between oceanographic conditions varying on a long period from spawning to the incorporation of juveniles to the population. The ELS, defined as the egg and larval stages, are believed to be the most critical period for recruitment for being more affected by the environmental conditions.

Spawning of the Iberian sardine occurs in two main areas: the Cantabrian Sea and the Western Portuguese shelf between the Nazare Canyon and the Minho river. Spawning is restricted to the shelf and takes place in a narrow temperature range (between 12 and 17C (Bernal *et al.*, (2007)). The spawning season varies between areas: in the Western Iberian coast it spans between September and May, peaking in November, whereas in the Cantabrian Sea, it takes place in Spring, peaking in April. We studied, by means of a coupled biophysical/Lagrangian model, the interaction between the ELS and the environment in a period ranging from autumn 2006 to autumn 2007, thus covering the spawning peaks of sardine both in the Atlantic coast and the Cantabrian sea.

Material and methods

Sardine ELS were modeled by means of a modified version of the Lagrangian software Ichthyop (Lett *et al*, (2008)), which was coupled offline to a 3D biophysical model. Mostly, Ichthyop was adapted to sardine. In this way, certain biological behavior was imposed to each Lagrangian particle (representing a super-individual), depending on the stage of development: eggs were consider to vary the density as a function of the development stage and grow depending on temperature. Yolk-sack larvae and self-feeding larvae growth was modeled as a function of temperature, being certain vertical migration patterns imposed. Moreover, the vertical dispersion subroutine of Ichthyop was updated, thus accounting for the effect of the vertical turbulence on the dispersion of the Lagrangian particles.

The 3D velocity fields and vertical dispersion coefficients that are used to move the Lagrangian particles in Ichthyop are obtained from the results of a configuration for West and North West Iberia of the ROMS model (www.myroms.org). This hydrodynamic model of approximately 3.5Km horizontal resolution is forced at the surface with the Atmospheric fields provided by the regional agency Meteogalicia (www.meteogalicia.es) and at the Open Boundaries with the results of the larger scale French model Mercator provided by My Ocean2 (www.myocean.eu). The nitrate-based Lower Trophic Level model by Fennel *et al*, (2006) was coupled to the hydrodynamic model in order to obtain the fields of chlorophyll. In this way, we could have an idea on the availability of food, which plays an important role in the success or failure of recruitment.

Results and discussion

According to the literature, spawning occurs preferably at periods of low offshore transport to maximize retention and ensure larvae feeding during spring upwelling. In this sense, recruitment would fail if particles are transported out of the shelf, where food conditions are more favourable.

In Figure 1 we show the portion of particles that are transported offshore depending on the spawning date and ground. On the West coast of Iberia retention was important during the spawning peak (autumn/winter). The same occurred in the Cantabrian sea during spring, meaning that the conditions at spawning seemed to be favourable for recruitment.

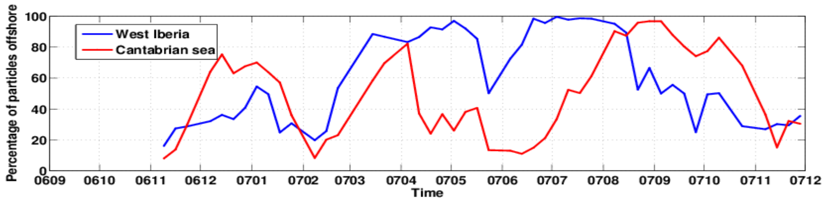

Figure 1: Percentage of particles transported offshore per spawning area.

In Figure 2 we show the center of mass of the Lagrangian particles that were released each moth from November 2006 till June 2007 in the West Coast of Iberia. The color scale corresponds to the concentration of chlorophyll obtained from the biological model. During autumn-winter 2006-2007, particles are mostly transported to the north, being the food availability concentrated on the shelf, whereas during/spring summer, the transport is directed to the southwest, being the concentration of chlorophyll higher on the shelf, although still high in some areas offshore.

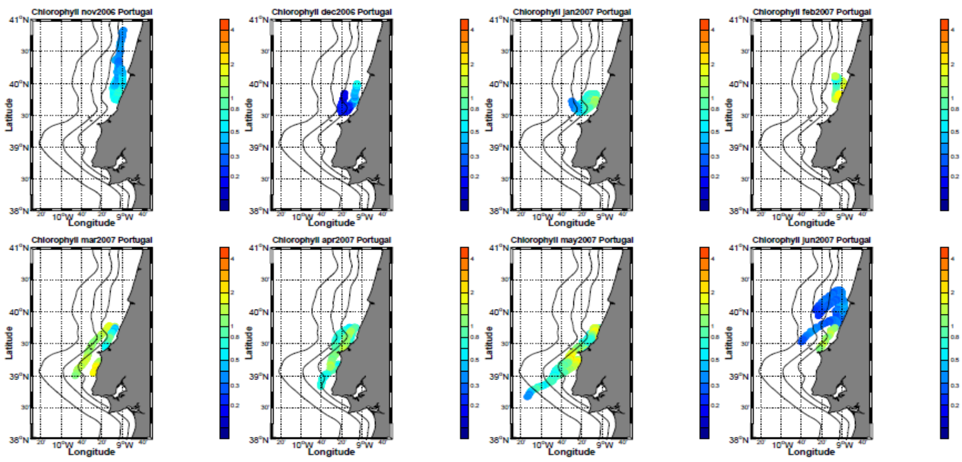

Figure 2: Chlorophyll-a concentration at the center of mass of the particles released from November 2006 - June 2007.

The trajectories of the particles crossed areas with apparently enough food. However, in that year, recruitment failed. The autumn of 2007 was very cold due to intense and sustained upwelling conditions, and mortality could have been very high, explaining the low recruitment of this year-class. Indeed, the quantification of mortality is necessary to complete this already highly-developed tool.

References

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