Ecological basis to embrace temporal assessment and spatial management of the European hake (*Merluccius merluccius*) in the northern Iberian Peninsula

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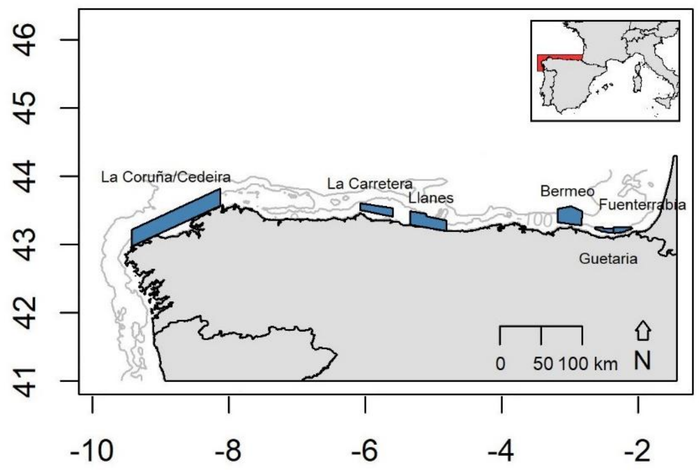


Study area and fishing trawl temporal closures [1] (O. AAA/2534/2015, 17 of November)

Introduction

Objective: Modelling distribution and abundance of hake recruits and study the temporal persistence of the areas with the highest concentration.

Fisheries data often can be influenced by the environmental features of its own habitat and biotic processes that are spatially structured [2]. In most of research studies and stock assessment models, this variability is not explicitly taken into account.

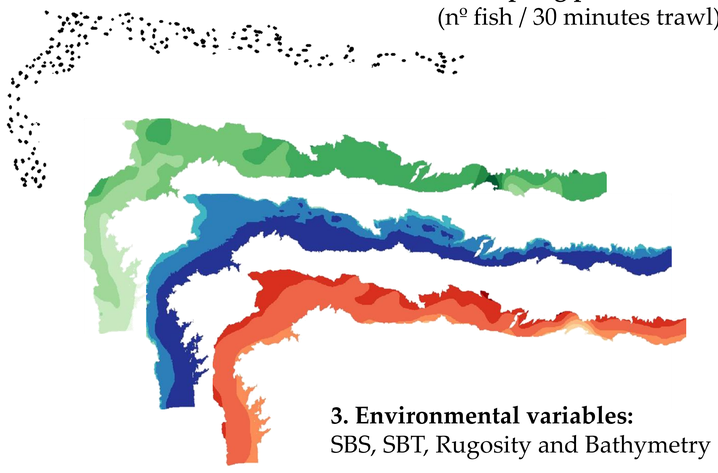
Here, we apply a **Hurdle Bayesian hierarchical spatio-temporal model** [3] as a solution for the common problems with fisheries abundance data:

- Spatial and temporal correlation for a medium-big scale process.
- Non linear trends for environmental variables.
- Zero inflation data.

Spatio-temporal data

1. Recruits data (individuals < 21cm length) collected by DEMERSALES scientific surveys (2005-2016).

2. Sampling points: DPUE (nº fish / 30 minutes trawl)



3. Environmental variables: SBS, SBT, Rugosity and Bathymetry

Shared Component Hurdle Modelling

Final model

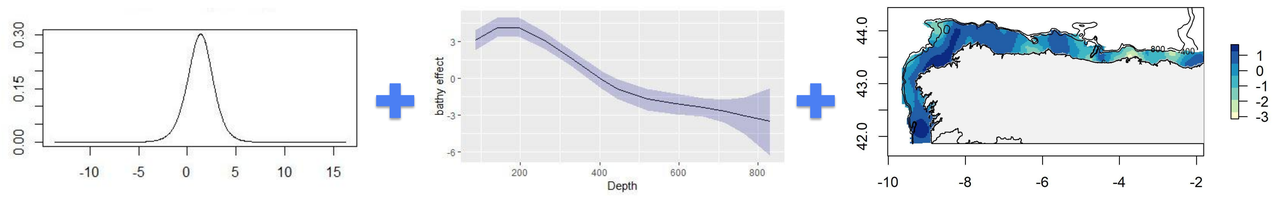
$$logit(\pi_{st}) = \alpha^{(1)} + \sum_{i=1}^{I} f_i(x_{is}) + U_{ST}$$

Intercept $\alpha^{(1)}$

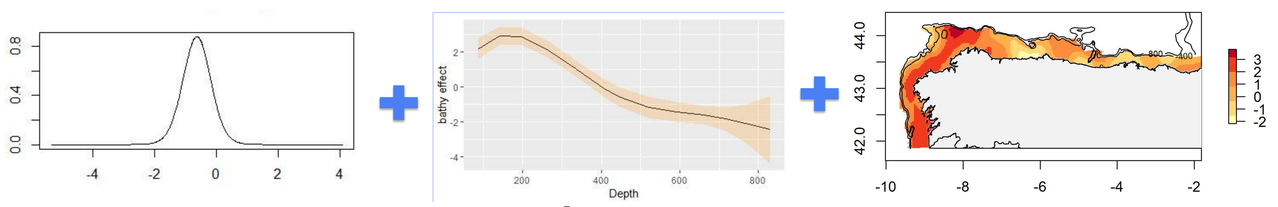
Smoothed bathymetry "RW2" $\sum_{i=1}^{I} f_i(x_{is})$

Spatio-temporal effect "Wst = ϱW st−1" U_{ST}

Binomial sub-model: distribution



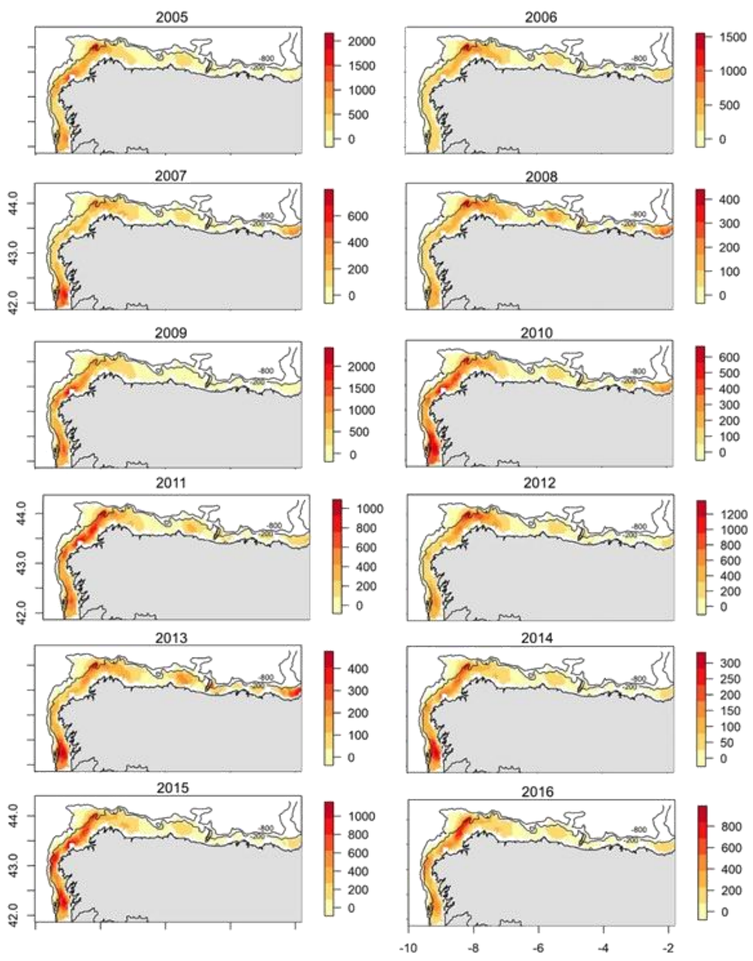
Gamma sub-model: abundance



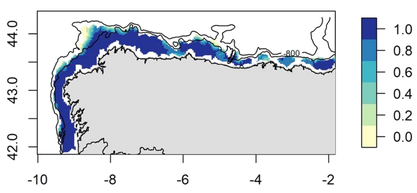
$$log(\mu_{st}) = \alpha^{(2)} + \sum_{i=1}^{I} \theta_i f_i(x_{is}) + U_{ST}$$

Predicted posterior mean

Abundance



Distribution



Binomial sub-model showed a constant spatial distribution over the years. Gamma sub-model showed fluctuations over the time.

- **Bathymetry** range for max. recruitment 140-200 m
- **SBS** and **SBT** were no relevant in the model
- **Identified Persistent areas :** "La Coruña" and "La Carretera" coinciding with fishing closure areas and the zone of "Rías Baixas" (42.25, -9.1)
- **Identified Intermittent areas :** "Llanes", "Bermeo" "Guetaria", "Fuenterrabía" coinciding with fishing closure areas and a zone in front of "Santander" (43.4, -3.5)

Conclusions

Persistent and intermittent areas in time, identified in this study, can have important implications for the **Marine Spatial Planning:**

- Establishment of **fishing closure areas** with a spatial-specific focus and precise estimation of associated depths.

- The output of the present model, which account for the spatio-temporal correlation and environmental influence, can be used as an **alternative input in stock assessment models.**

The application of Bayesian Hierarchical Models combined with the software **R-INLA** [4] allows to make inference in a very flexible way, computationally efficient and biologically intuitive.

[1] BOE (2015). España. Orden AAA/2534/2015, de 17 de noviembre, por la que se establece un Plan de gestión para los buques de los censos del Caladero Nacional del Cantábrico y Noroeste. Boletín Oficial del Estado, 30 de Noviembre de 2015, num.286, Sec. III.

[2] Pennino, M. G., Vilela, R., Bellido, J. M., & Velasco, F. (2019). Balancing resource protection and fishing activity: The case of the European hake in the northern Iberian Peninsula. *Fisheries Oceanography*, *28*(1), 54-65.

[3] Paradinas, I., Conesa, D., López-Quílez, A., & Bellido, J. M. (2017). Spatio-temporal model structures with shared components for semi-continuous species distribution modelling. *Spatial Statistics*, *22*, 434-450.

[4] Krainski, E. T., Gómez-Rubio, V., Bakka, H., Lenzi, A., Castro-Camilo, D., Simpson, D., ... & Rue, H. (2018). *Advanced Spatial Modeling with Stochastic Partial Differential Equations Using R and INLA*. Chapman and Hall/CRC.

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