SPANISH CATCH AND EFFORT DATA STANDARDIZATION OF SOUTHERN EUROPEAN HAKE (*MERLUCCIUS MERLUCCIUS*)

Working Document for the benchmark

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Abstract

The southern stock of European hake (*Merluccius merluccius*) constitutes an important resource for the Spanish and Portuguese fishing fleets. The Spanish fleet fishes this species using various types of trawling techniques, gillnets, and bottom-set lines which target different components of the population. Current stock assessment includes abundance indices from surveys and from commercial trawlers for model calibration purposes. However, this commercial catch and effort data did not account for the entire diverse nature of the fleet in terms of fishing techniques potentially providing a biased index. Here, we standardize hake catch-effort data from the Spanish fleet operating in Iberian waters (8.c and 9.a) using two fishery-dependent sources: observers information for trawlers and gillnets from 2003 to 2020, and logbook data for the hook and line métier from 2009 to 2020. The standardization process was based on fitting mixed-effects models to each métier data independently assuming a Gamma distribution with a log link using the INLA approach. Results provided evidences of the importance of vessel size and haul duration for obtaining higher catches whereas fishing in deeper waters was only beneficial for the gillnets. Seasonality and spatial variability varied depending on the studied métier, and the temporal trends were roughly stable over the study period with the exception of the otter trawls that showed a slight increase. The standardized indices were combined into 2 new indices that were later used for the new stock assessment of the species.

Keywords: Catch-effort standardization, multi-gear, INLA, European hake, Northwest Iberian waters

INTRODUCTION

The southern stock of European hake (*Merluccius merluccius*) constitutes an important resource for the Spanish and Portuguese fishing fleets (Murua, 2010). The Spanish fleet targeting this species is characterized for being a multi-gear fleet operating in multiple fishing grounds along the Northwest Iberian Peninsula and the Cantabric Sea from coastal waters to deeper areas up to ~800 m. The fleet includes vessels using various types of trawling techniques, gillnets, and bottom-set lines which target different components of the population, from smaller individuals by the trawlers to larger specimens by the gillnets and hooks.

The stock assessment was carried out using GADGET until 2020, and included abundance indices from the Portuguese and Spanish surveys performed in autumn as part of the IBTS system (e.g. Izquierdo et al., 2021). Moreover, Spanish sales notes and owners associations data from trawlers compiled by IEO were further used up until 2012 for model calibration purposes (ICES 2020).

However, this commercial catch and effort data did not account for the entire diverse nature of the fleet in terms of fishing techniques potentially providing a biased index. Hence, the objective of the current analysis was to standardize hake catch-effort data from the Spanish fleet operating in Iberian waters (8.c and 9.a) using two fishery-dependent sources of data covering the whole range of gears targeting hake all along the year and spatial domain.

MATERIAL AND METHODS

Data were obtained from i) onboard observers for 3 trawl métiers (“baka”: OTB_DEF_>=55, “jurelera”: OTB_MPD_>=55, and “pareja”: PTB_MPD_>=55) and 1 gillnet métier (“volanta”: GNS_DEF_80_99) from 2003 to 2020, and from ii) logbooks for bottom-set longlines (“palangre”: LLS_DEF) from 2009 to 2020. The hook and lines included two IEO sub-métiers, the proper bottom-set longlines (LLS11) and smaller lines (PAL11), that were pooler together for the modeling purposes. These two fishery-dependent types of data are routinely compiled by the IEO as part of its mandate under the European Data Collection Framework. Depending on the source, the data for each haul or fishing trip *i* included: the catch, fishing operation information such as haul duration (HD) and depth (DE) for the observers' data and fishing time (FT) for the logbook data, the vessel characteristics such as the length overall (LOA), the date of the catch, and spatial information including coordinates for the observers' data and ICES rectangle for the logbook data. A summary of the available data is presented in Table 1.

The standardization process was based on fitting mixed-effects models to each métier data independently assuming a Gamma distribution with a log link using the INLA approach (Bakka et al., 2018).

For the observers' data the model was of the following form:

$$C_i = \alpha + \text{Year}_i + \text{Quarter}_i + \text{LOA}_i + \text{HD}_i + \text{DE}_i + u_i \qquad [1]$$

Where u_i is a spatial correlated random effect which is a Gaussian Markovian Random Field (GMRF) with mean 0 and covariance matrix Σ (Bakka et al., 2018). The Matérn correlation function was used to parametrize the covariance matrix, and parameters were approximated by the stochastic partial differential equation (SPDE) method (Krainski et al., 2019) over an irregular mesh of a different number of vertices depending on the available data for each métier (Table 1). For the model depicted in equation 1, we assigned vague priors (the default in R-INLA) for all the fixed parameters due to a lack of prior information. However, for the hyperparameters defining the SPDE, that is, the range (r) and the standard deviation (σ) of the spatial random field, we used penalized complexity priors as described by Fuglstad et al. (2019), assuming that the probability of r (the distance at which spatial autocorrelation is small) was < 50 km = 0.01, and the probability of σ was > 2 = 0.01. All predictors were standardized to mean 0 and standard deviation 1.

For the logbook data the model was of the following form:

$$C_i = \alpha + \text{Year}_i + \text{Quarter}_i + \text{LOA}_i + \text{FT}_i + a_r + \epsilon_i \qquad [2]$$

Where a_r is a random intercept at the ICES rectangle level assumed to follow a normal distribution with mean 0 and variance σ_a^2, and ϵ is and error term assumed to follow a normal distribution with mean 0 and variance σ^2. All predictors were standardized to mean 0 and standard deviation 1.

The resultant standardized indices were combined in one index weighting each series by the inverse of their variance after scaling the indices dividing by their mean.

All data treatment and analyses were performed with the software R (version 4.1.2, R Core Team 2021) and using the package 'R-INLA 21.11.22' (Lindegren and Rue 2015).

RESULTS

Data summary

A summary of the data available for each source and métier combination is shown in Table 1. Within the observers data, the otter trawl was the métier that counted the largest number of observed hauls whereas the gillnetters counted the smallest number of observations. For the logbook data, the hook and line métier, had considerably many more available observations. For all métiers, the percentage of zeros was very small and those cases were kept in the modeling procedure by adding a constant value equal to one. The spatial distribution for observers and logbook data is shown in Figure 1 and 2, respectively.

Observers models

Models for the trawling métiers revealed similarities and differences (Fig. 3–5). In particular, an increase in haul duration was related to larger catches, and hauls in deeper waters resulted in less yield (Fig. 3A, 4A and 5A). On the other hand, larger otter trawls and midwater trawls caught more hake, whereas larger pair trawls did not necessarily resulted in more catch (Fig. 3A, 4A and 5A). Regarding season, otter trawls had more catches in winter while that season was less important for the other two trawling métiers (Fig. 3A, 4A and 5A). The time trends did not show highly remarkable patterns with the exception of bottom trawlers for which catches slightly increased over the study period (Fig. 3B, 4B and 5B). Once accounted for the fixed effects, the random spatial fields showed overall differences with “hotspots” for the otter trawl and the midwater trawl located in the Galician coast, while larger catches for the pair trawls occurred to the east of the Cantabric Sea (Fig. 3C, 4C and 5C).

The model for the gillnets showed that hake catch increased with vessel length and haul depth; however, longer hauls did not result in a higher yield (Fig. 6A). Catches for this métier decreased from winter to autumn (Fig. 6A), were roughly stable since 2009 (Fig. 6B), and the random spatial field showed larger catches in the northern part of the Galician coast (Fig. 6C). Nonetheless, all results for this métier should be treated with caution given the small number of observations and particularly in the Galician Atlantic coast.

Logbook models

The model for the hook and line métiers showed that hake catch increased with vessel length and duration of the fishing operations (Fig. 7C). Catches for this métier were larger in spring and significantly lower in summer and autumn (Fig. 7C), and were roughly stable during the study period (Fig. 7B). The random intercept showed that larger catches for this métier occurred in more oceanic waters to the east of the Cantabric Sea and off the Finisterre zone, whereas minimal catch were located to the south of the Galician coast and in shallower waters to the east of the Cantabric Sea (Fig. 7A).

Combination of indices

The combined indices resulted in two trends, presented in Fig 8.

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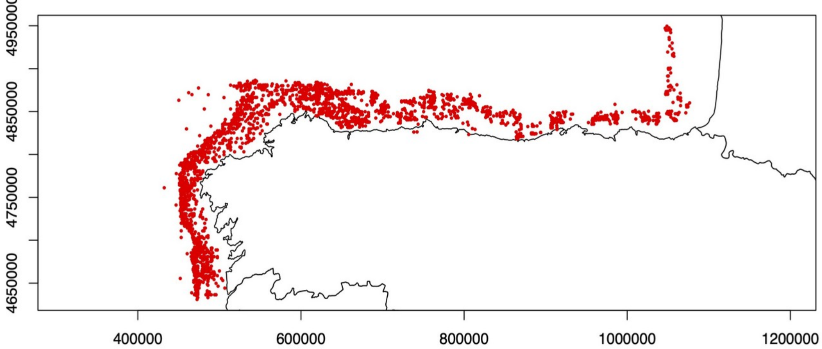
TABLES

Table 1. Summary of available data for each data type and métier combination.

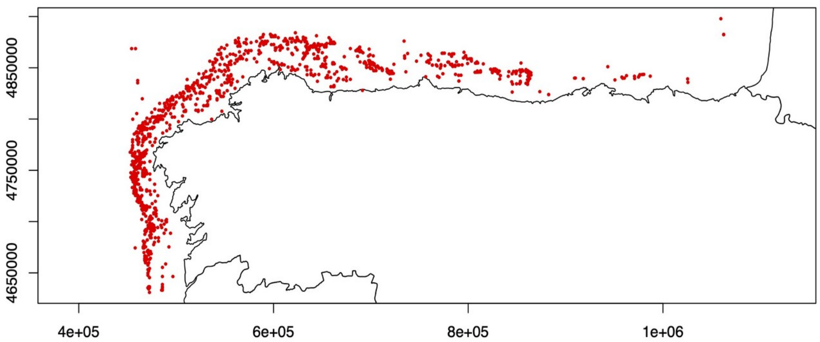
Source	**Métier**	**Years**	**Hauls/trips/ operations**	**Unique vessels**	**Unique days**	**Zeros (%)**	**Mesh vertices**
Observers	OTB_DEF	2003−2020	3109	69	975	4.78	1049
Observers	OTB_MPD	2003−2020	1173	50	496	6.90	977
Observers	PTB_MPD	2003−2020	513	43	455	3.51	595
Observers	GNS_DEF	2008−2020	352	20	134	1.40	601
Logbooks	LLS_DEF	2009−2020	43594	363	3499	1.74	NA

FIGURES

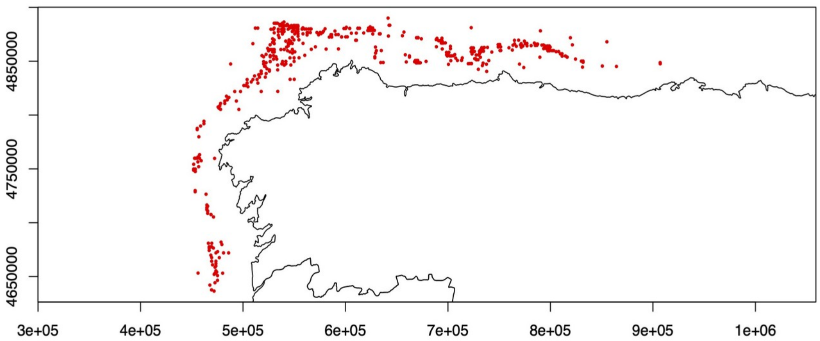
(A) Bottom otter trawl (OTB_DEF_>=55)



(B) Midwater otter trawl (OTB_MPD_>=55)



(C) Bottom pair trawls (PTB_MPD_>=55)



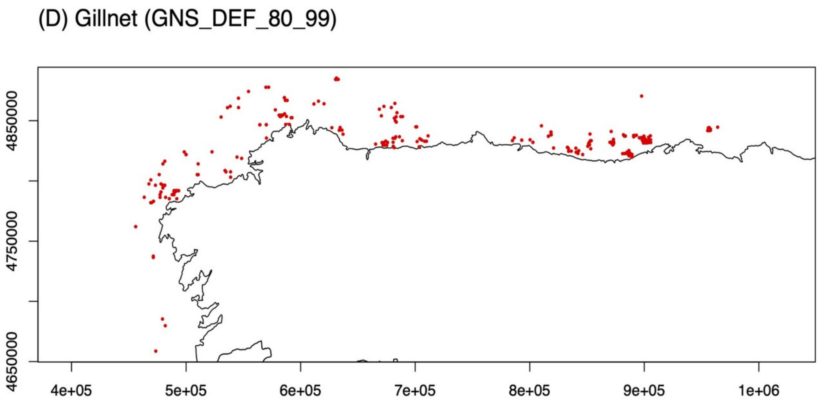


Figure 1. Location of observers' data for the three trawling métiers (A−C) and the gillnet (D).

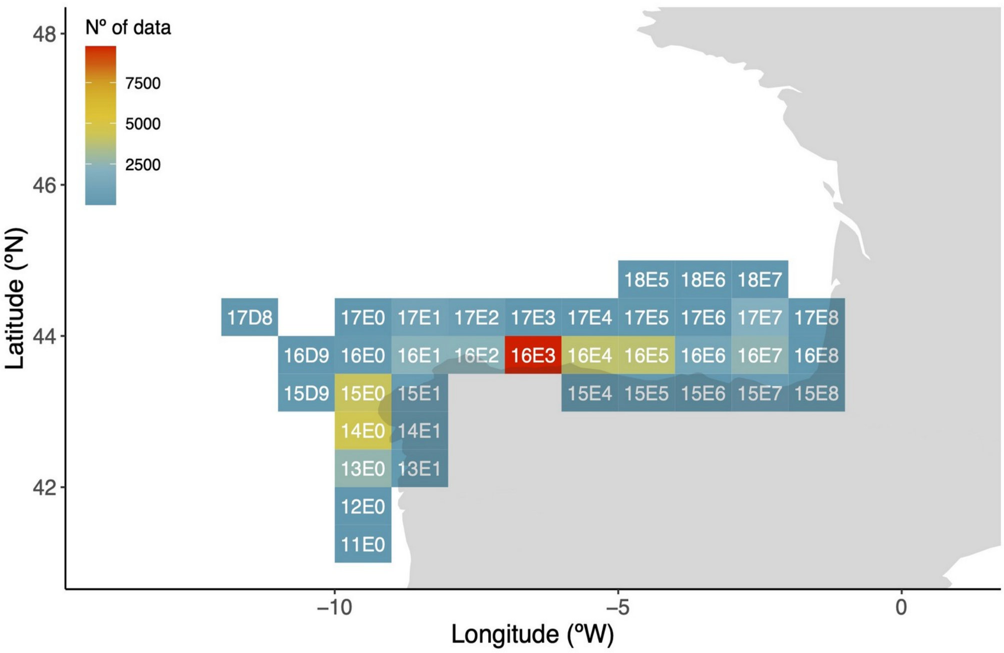


Figure 2. Distribution of logbook data in each ICES rectangle for the hook and line métier (LLS_DEF). The alphanumerical code of each ICES rectangle is indicated in white color.

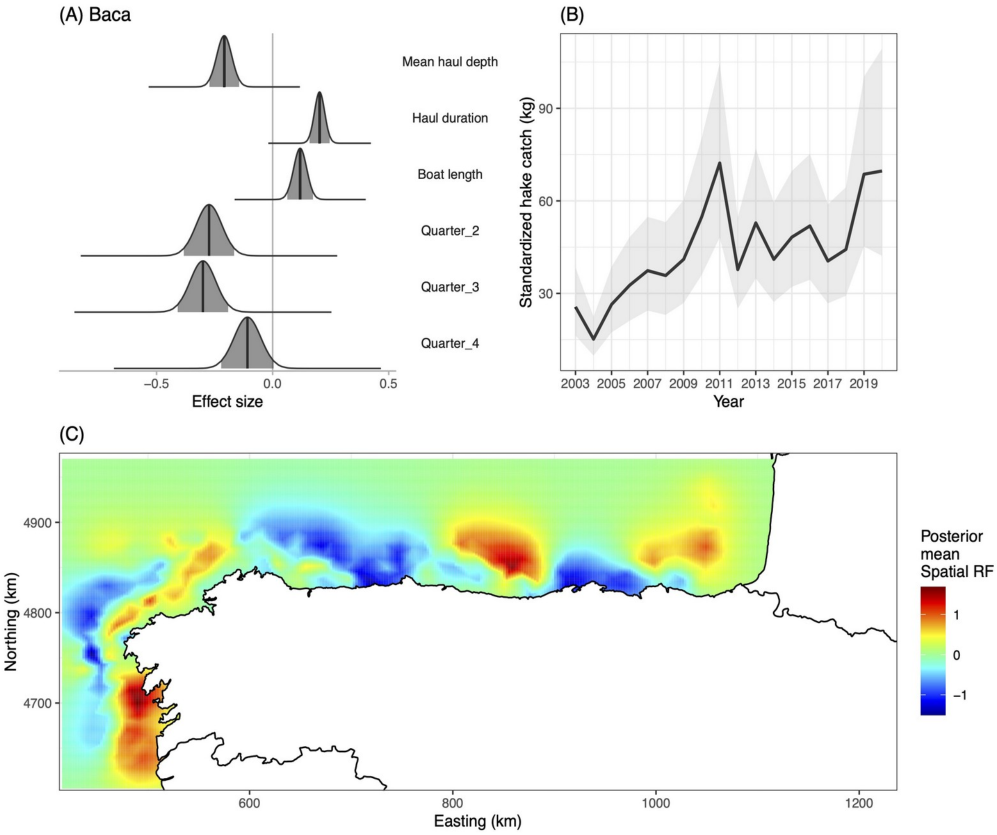


Figure 3. Results of the model fitted to the bottom otter trawl (OTB_DEF_>=55) observers data. (A) Posterior distribution of the fixed effects, (B) temporal trend in standardized catches, and (C) posterior distribution of the mean spatial random field. Note that predictions for the trend were computed for Quarter 1 and mean values for the continuous predictors.

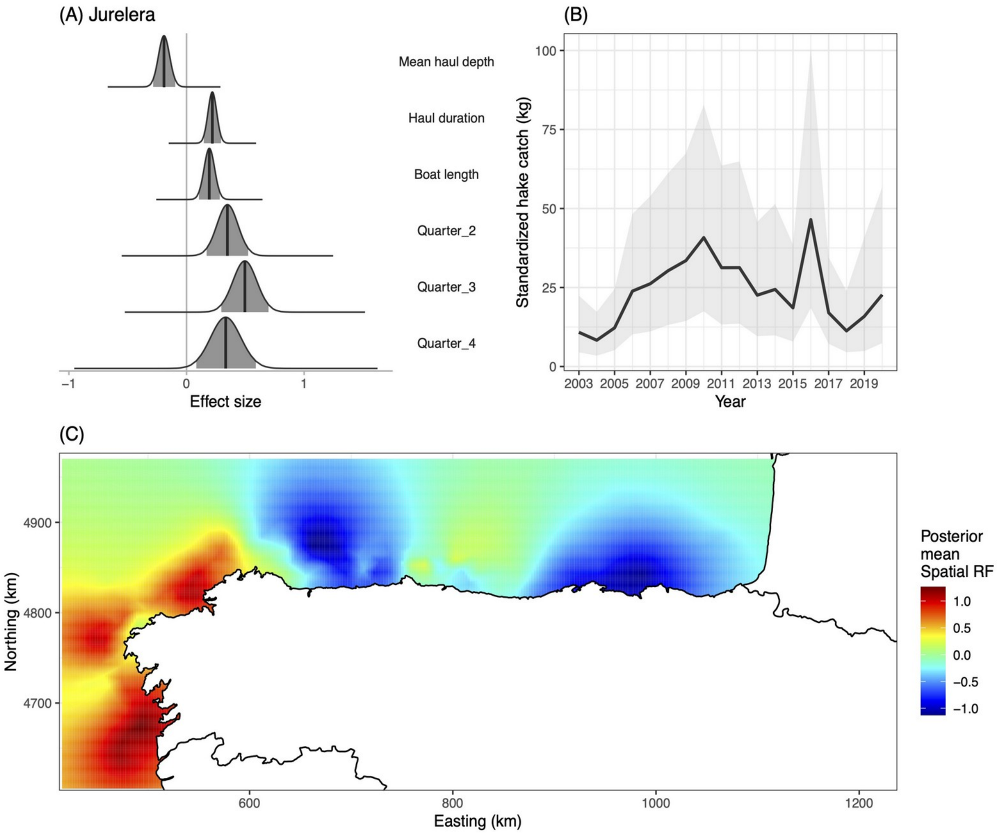


Figure 4. Results of the model fitted to the midwater otter trawl (OTB_MPD_>=55) observers data. (A) Posterior distribution of the fixed effects, (B) temporal trend in standardized catches, and (C) posterior distribution of the mean spatial random field. Note that predictions for the trend were computed for Quarter 1 and mean values for the continuous predictors.

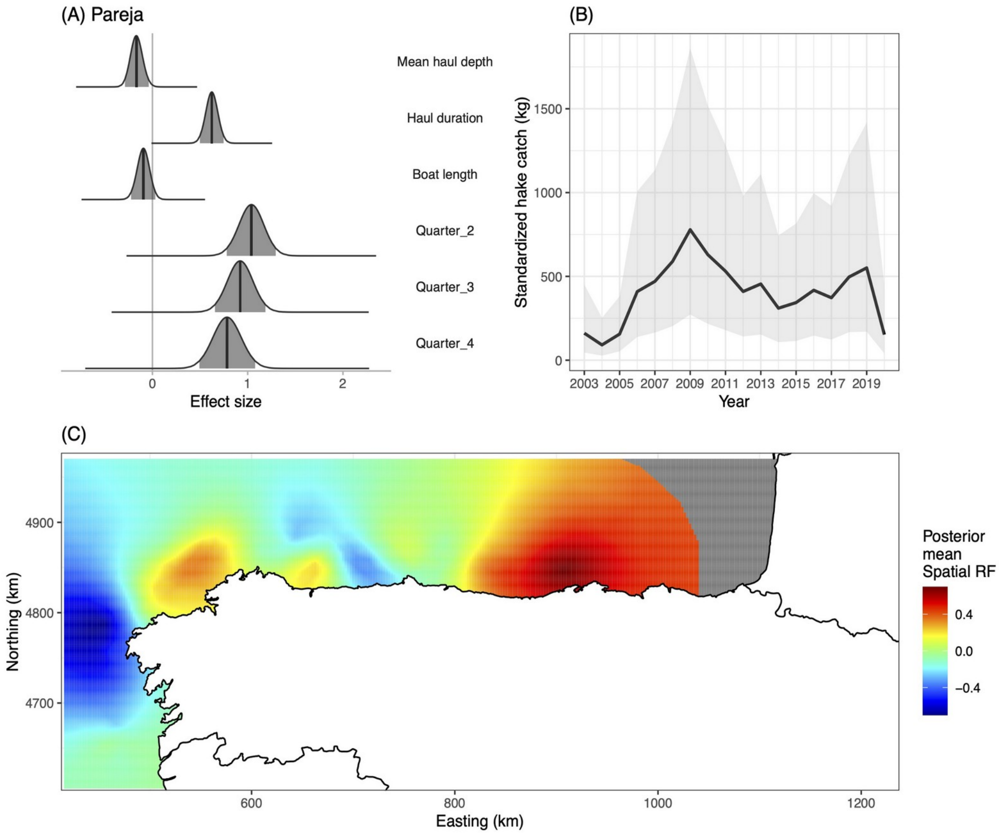


Figure 5. Results of the model fitted to the bottom pair trawls (PTB_MPD_>=55) observers data. (A) Posterior distribution of the fixed effects, (B) temporal trend in standardized catches, and (C) posterior distribution of the mean spatial random field. Note that predictions for the trend were computed for Quarter 1 and mean values for the continuous predictors.

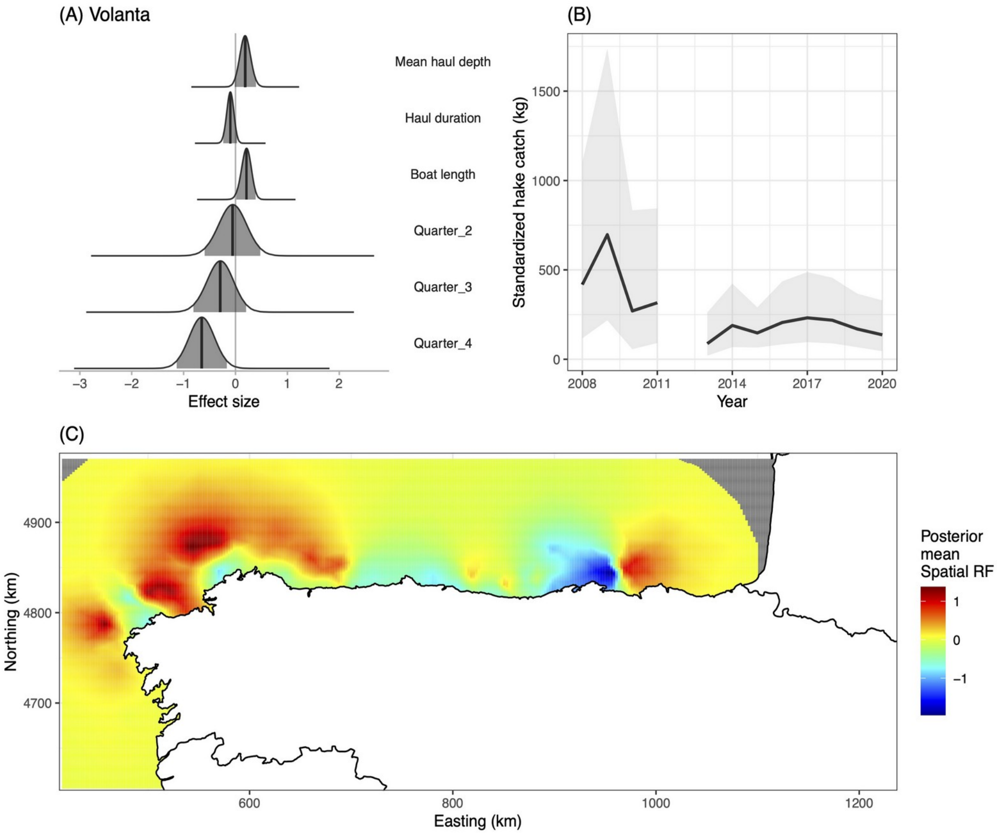


Figure 6. Results of the model fitted to the gillnetters (GNS_DEF_80_99) observers data. (A) Posterior distribution of the fixed effects, (B) temporal trend in standardized catches, and (C) posterior distribution of the mean spatial random field. Note that predictions for the trend were computed for Quarter 1 and mean values for the continuous predictors.

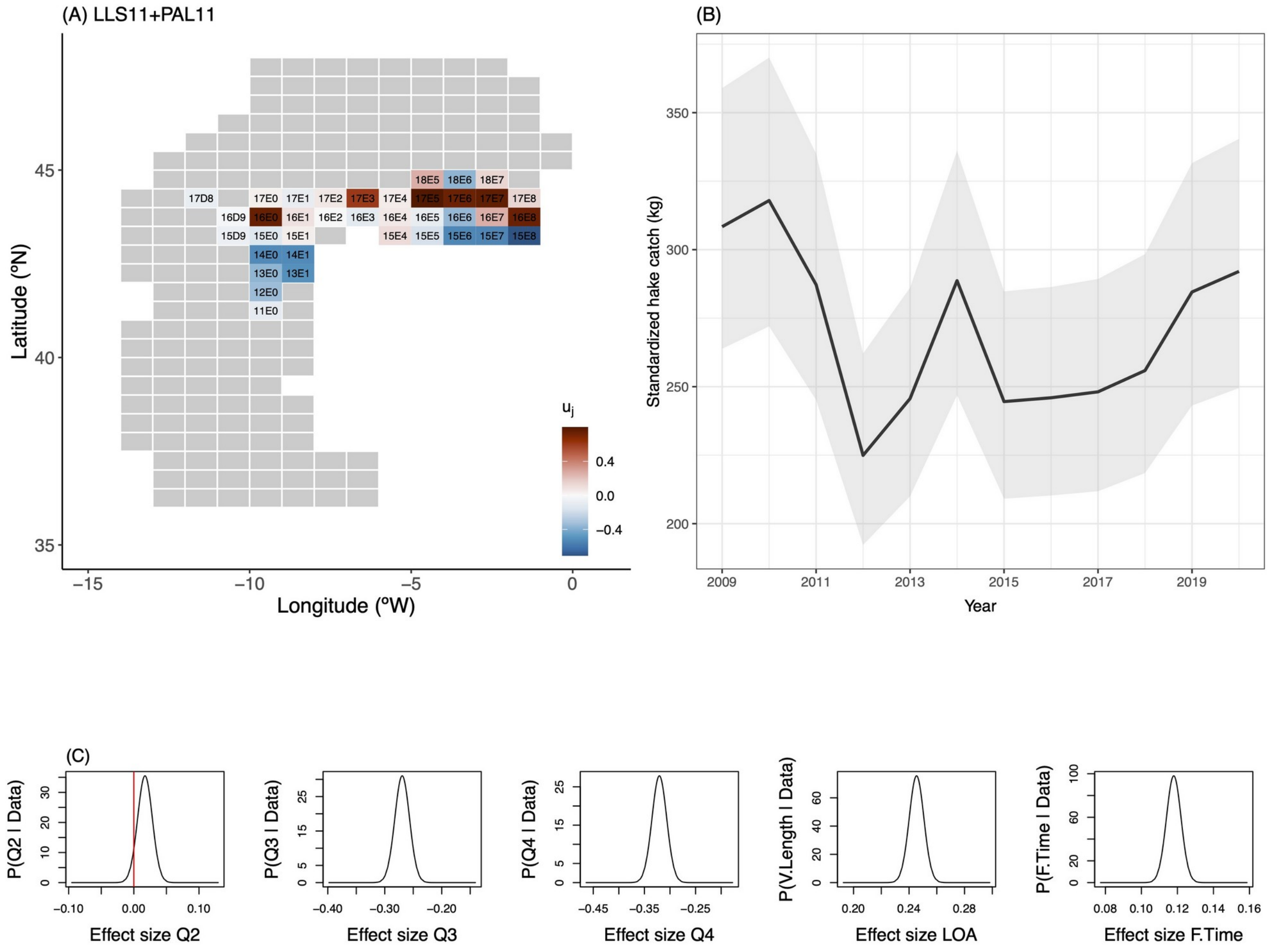


Figure 7. Results of the model fitted to the bottom-set longlines logbook data. (A) Spatial distribution of the ICES rectangle-level random effect, (B) temporal trend in standardized catches, and (C) posterior distribution of the fixed effects. The alphanumerical code of each ICES rectangle is indicated in black color. Note that predictions for the trend were computed for Quarter 1 and mean values for the continuous predictors.

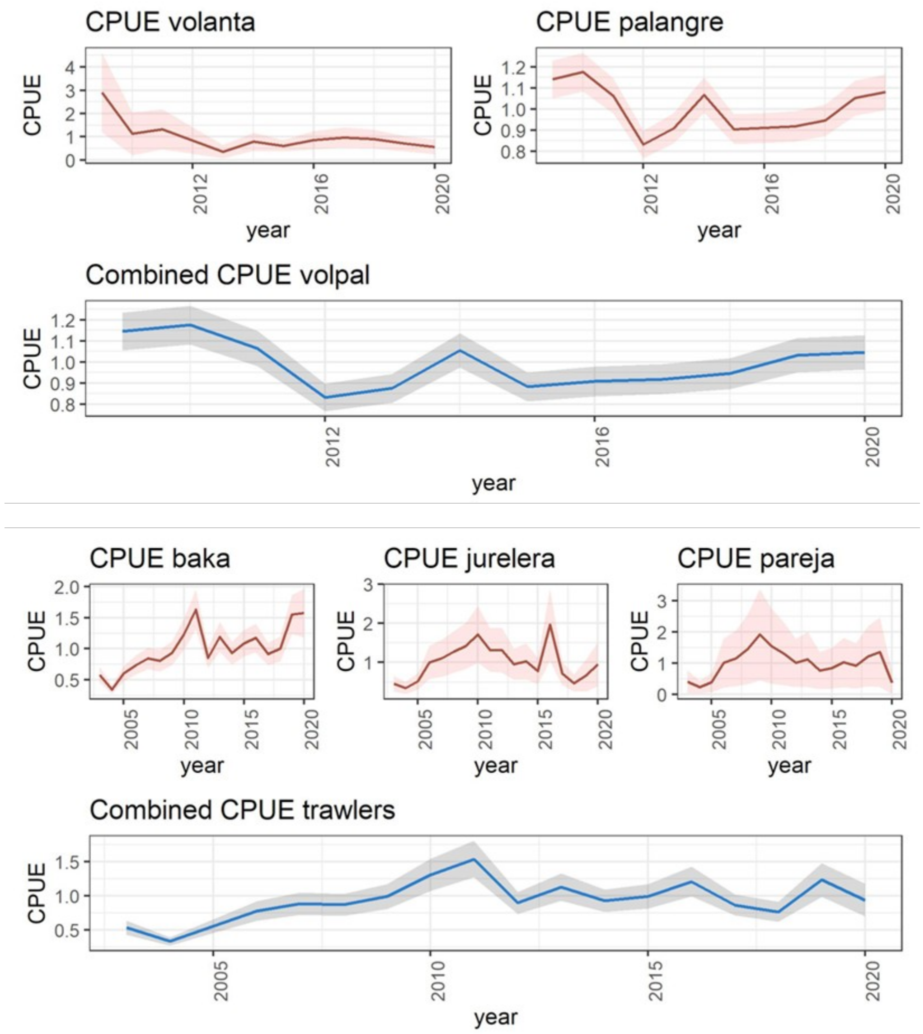


Figure 8. Combined indices for Volanta (gillneter) and Palangre (Longliners) and 3 different trawlers in one.