Variability in *Engraulis encrasicolus* distribution patterns in the southern Bay of Biscay based on acoustic survey data (1997–2012)

Carmen Hernández (1), Begoña Villamor (1), Rafael González-Quiros (2), Jorge Landa (1), Magdalena Iglesias (3), M. Begoña Santos (4)

(1)Instituto Español de Oceanografía (IEO). Centro Oceanográfico de Santander, Promontorio de San Martín s/n, 39004 Santander. Spain; (2)Instituto Español de Oceanografía (IEO), C.O. Gijón, Avenida Príncipe de Asturias, 70 bis 33212 Gijón (Asturias). Spain; (3)Instituto Español de Oceanografía (IEO), C.O. Baleares, P.O. Box 291, Palma de Mallorca. Spain; (4)Instituto Español de Oceanografía (IEO), C.O. Vigo, Cabo Estay Canido s/n, 36200 Vigo. Spain. Presenter contact details*:* carmen.hernandez@st.ieo.es

Introduction

We use trawl catch data routinely collected as part of the annual pelagic survey programme PELACUS, the objective of which is to provide acoustic abundance estimates of the main shelf pelagic fish species to: (1) Describe spatio-temporal variation in anchovy presence and (2) model anchovy habitat requirements.

Material and Methods

From 1997 to 2012, a total of 657 hauls was carried out by the Spanish annual spring acoustic survey PELACUS. The survey covers each year the continental shelf from 30 to 250 m depth and from Portuguese Spanish border to the Spanish French one.

Descriptive generalized additive models (GAM) were used to model the spatio-temporal patterns of distribution in three ways to: (1) describe the spatio-temporal variability in species presence or absence in the hauls, (2) determine the extent to which the previously modelled spatial component of variation in species presence or absence in the hauls could be explained by environmental variables? (depth, SST, etc.) (i.e. Habitat modelling), (3) determine whether the possible (significant) interannual variation found in the presence of *E. encrasicolus* could be related to changes in stock abundance (ICES, 2011*).*

Binomial GAMs with a logit link were used for the presence or absence data. Continuous explanatory variables were fitted as smoothers. The maximum number of d.f. for smoothers was restricted to 3 (k =4) to avoid over-fitting. Backward selection was used.

Results and Discussion

Describing anchovy presence/absence

The final model included year, and the main effects plus interaction of latitude and longitude (Table 1, Figure 1 and 2). Including haul duration significantly improved overall model fit (F-test, $P < 0.05$) although its individual effect was not significant. The model explained 28 % of the deviance in anchovy presence.

Table 1. Results of the model for describing anchovy P/A.

Presence/Absence ~ s(Lat, Lon) + s(Year) + s(Duration)				
Variable	**edf**	**Ref.df**	**Chi.sq**	**p-value**
s(Lat, Lon)	12.413	14.158	85.762	3.02e-12***
s(Year)	1.398	1.636	34.944	4.75e-08***
s(Duration)	1.525	1.864	5.521	0.0556

The 3-D smoother obtained between effects of latitude and longitude for the presence of *E. encrasicolus* showed interactions, as indicated from irregularities in the form of the surface. In particular, it is apparent that there were stronger longitudinal trends along the west coast than along the north coast, presumably because longitude is a proxy for depth on the west coast (Figure 1).

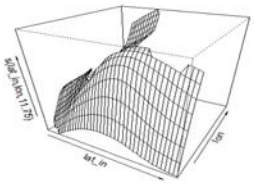

Figure 1.
3-D smoother for the effects of lat and lon on fish presence.

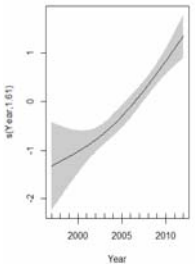

Figure 2.
Smoother for the effect of year on fish presence in the hauls.

Figures 1 and 2 shows the spatial and temporal variability in anchovy presence in the hauls. Anchovy presence increased towards the eastern part of the surveyed area and along the time series.

Explaining anchovy presence/absence

The final model showed that anchovy presence in the hauls increased significantly with the Spawning Stock Biomass (SSB) (Table 2) and decreased significantly with increasing depth (Figure 3). The model explained a smaller proportion of deviance (9%) but probably it could be improved by introducing other environmental variables.

Table 2. Results of the model for explaining anchovy P/A.

Presence/Absence ~ s(SSB) + s(Depth)				
Variable	**edf**	**Ref.df**	**Chi.sq**	**p-value**
s(SSB)	1.926	1.995	32.38	9.46e-08***
s(Depth)	2.167	2.548	18.82	0.000228***

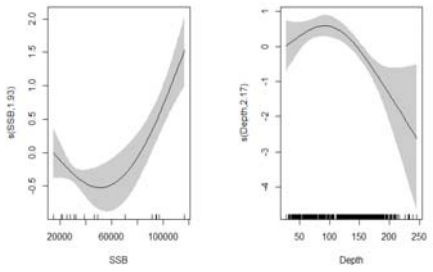

Figure 3. Smoothers for the effect of SSB and depth on fish presence in the hauls.

This study has shown how descriptive statistical models may be used to capture the nature of spatio-temporal variation in a species distribution. These models identified clear spatial patterns in the presence of *E. encrasicolus*, with abundance highest closer to the coast. Same results were obtained by Santos *et al.* (2013) in the same area of study.

Future work will also need to determine which part of this variation can be ascribed to other environmental factors that are generally considered to be important determinants of fish distribution [e.g., sea surface temperature (SST), chlorophyll, etc] and fish abundance.

References

ICES(2011).ICES Advice Book 7: Bay of Biscay and Iberian Atlantic Waters. Available at http://www.ices.dk/sites/pub/Publication Reports/ICES Advice/2011/ICES ADVICE 2011 BOOK 7.pdf

Santos, M.B., González-Quirós, R., Riveiro, I., Iglesias, M., Louzao, M. and Pierce, G.J., 2013. Characterization of the pelagic fish community of the North Western and Northern Spanish shelf waters. Journal of Fish Biology, 83: 716-738.