

I. Introduction

European anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) are the two most important small pelagic species in the Mediterranean. Anchovy spawns during the summer period (May to August) whereas sardine spawns during the winter period (November to March). In the present work the spawning habitat of the two species was modelled based on ichthyoplankton data undertaken in the northern Aegean Sea, the Sicily Strait and the Spanish waters. Estimated models were subsequently used to predict the probability of anchovy and sardine spawning in the study areas and the entire Mediterranean Sea during the same month of the year.

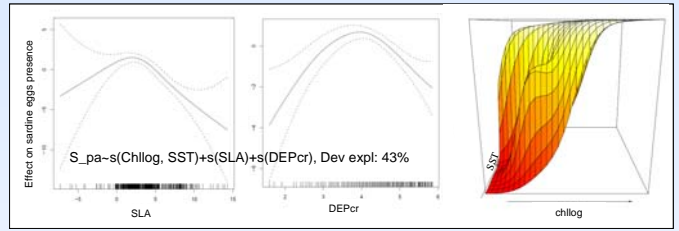


Fig 3. GAM results of sardine spawning in Spanish waters for December 2006-2008. SST: Sea Surface Temperature in °C, CHL: Chlorophyll in mg/ml³, DEP: Bathymetry in m, SLA: Sea Level Anomaly in cm

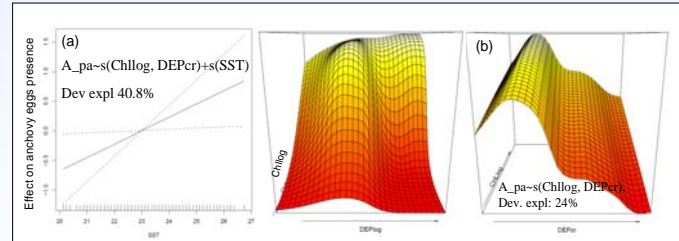


Fig 4. GAM results of anchovy spawning (a) northern Aegean Sea for June 2003-2006 (b) Sicily Strait for July 2003-2005 and sardine spawning SST: Sea Surface Temperature in °C, CHL: Chlorophyll in mg/ml³, DEP: Bathymetry in m.

Results of the final GAM model are presented as plots of the best-fitting smooths for the effect of the environmental variables on sardine or anchovy eggs' presence (Figs. 3, 4). Model validation indicated good discrimination ability for both models as in most cases the estimated values of AUC exceeded 0.80 (Elith et al., 2006). The models for the two species (June and December) were applied for the entire Mediterranean Sea in order to map areas with higher probability of anchovy and sardine spawning (e.g. resultant maps for 2006 and 2005 are presented in Fig. 5).

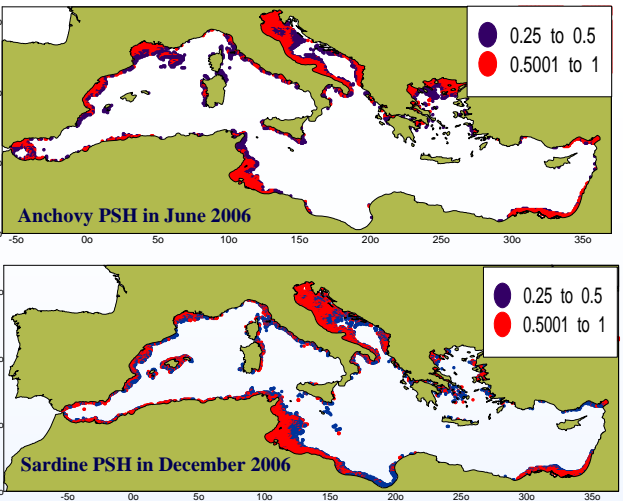


Fig 5. Mediterranean Sea. Map of areas representing anchovy and sardine potential spawning habitat (PSH) based on the GAM model from the northern Aegean Sea in June and Spanish waters in December, respectively. Colours indicate probability of spawning.

Especially, for anchovy the model in June predicted well the main spawning grounds of both species in the Mediterranean Sea (northern Aegean, western Adriatic, Sicily Strait, Gulf of Lions and Catalan coast, Alboran Sea).

IV. References

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II. Materials & Methods

Data coming from ichthyoplankton surveys that were carried out in June 2003-2006 (northern Aegean Sea) and July 2003-2005 (Sicily Strait) were used for modeling the potential spawning habitat (PSH, Planque et al., 2007) of anchovy. Data from December 2006-2008 (Spanish waters) were used for modeling the PSH of sardine (Fig. 1). Statistical models (Generalised Additive Models-GAMs) were used to model the relationship between anchovy and sardine eggs presence/absence and mean monthly values of satellite environmental data along with bathymetry data. Pooled data from all the examined years per study area in order to define the set of parameters that describe the PSH of the two species. The methodology followed for the selection of the final GAM model is described in Giannoulaki et al., 2008.

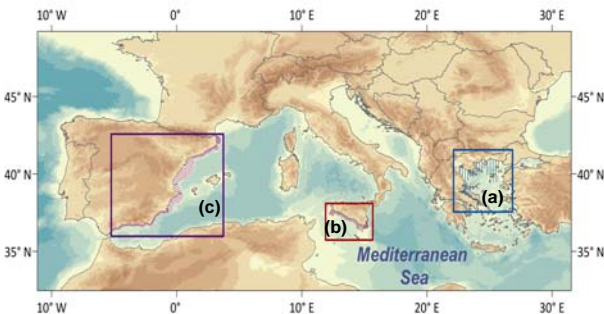


Fig 1. Map of the study areas. (a) northern Aegean Sea (b) Sicily Strait and (c) Spanish waters

Furthermore, a specific set of satellite conditions was attributed to a specific probability of anchovy and sardine spawning. In a next step, the areas with a specific set of satellite conditions corresponding to different probabilities of anchovy and sardine spawning were plotted based on the mean monthly satellite values measured for the entire Mediterranean basin, at a GIS resolution of 4 km in each studied year. To evaluate the predictive performance of the final models we used the Receiver Operating Characteristic (ROC)-plots and the area under the Receiver Operating Characteristic curve (AUC) for each examined year (Elith et al., 2006).

III. Results & Discussion

Indicative maps of the distribution and abundance of anchovy and sardine eggs in the studied areas are presented in Fig. 2, respectively. Anchovy eggs were occurring at higher abundance in areas with shallower, more productive and warmer waters in the northern Aegean Sea (Schismenou et al. 2008, Fig.2a) and in the coastal, more productive, shallower waters of the north-west part of the Sicily Strait where nutrient rich, cold deep water enriches the upper water layers (Lafuente et al., 2002, Fig. 2b). Sardine eggs were presenting higher abundance in the more productive shallower waters of the Alboran Sea and the Tramontana region (Fig. 2c).

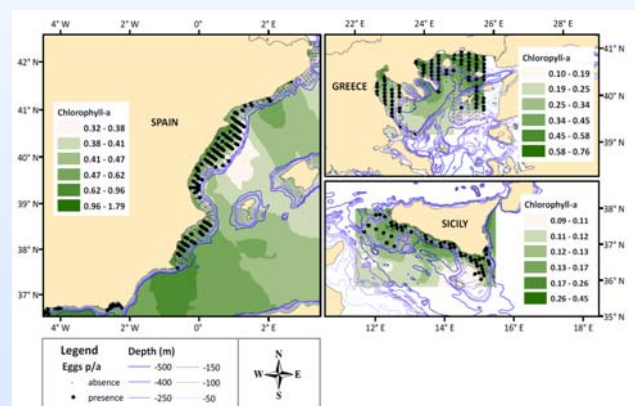


Fig 2. Distribution maps of anchovy at (a) the northern Aegean Sea in June 2006 (b) Sicily Strait in July 2005 and sardine eggs at the Spanish waters in December 2006. Respective Chl distribution and bathymetry is also shown.