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The ichthyoplankton assemblage and the environmental variables off the NW and N Iberian Peninsula coasts, in early spring

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ABSTRACT

Ichthyoplankton and mesozooplankton were sampled and fluorescence and physical environmental variables were measured off the NW and N Iberian Peninsula coasts, during April 2005. A total of 51 species of fish larvae, belonging to 26 families, were recorded. *Sardina pilchardus*, with 43.8% and 58.7% of the total fish egg and larval catches, respectively, dominated the ichthyoplankton assemblage. The study area was divided by a cross-shelf frontal structure into two hydrographic regions that coincided with the Atlantic and Cantabrian geographic regions. Ichthyoplankton abundance was higher in the Cantabrian region while larval diversity was higher in the Atlantic region. This was the main alongshore variability in the structure of the larval fish assemblage. Nevertheless, the stronger variability, related with the presence of a shelf-slope front, was found in the central-eastern Cantabrian region where two major larval fish assemblages, an "outer" and a "coastal", were distinguished. The Atlantic region, where the shelf-slope front was not found, was inhabited by a single larval fish assemblage. Canonical correspondence analysis revealed that, off the NW and N Iberian Peninsula coasts, the horizontal distribution of larval fish species in early spring may be explained by a limited number of environmental variables. Of these, the most important were the physical variables depth and sea surface temperature.

1. Introduction

Biological processes, such as the location and spawning strategy of adult fishes, the vertical distribution of fish larvae in the water column and their migratory behaviour are important in the horizontal distribution of ichthyoplankton and in the horizontal structure of the larval fish assemblage (e.g. Parrish et al., 1981; Gorbunova et al., 1986; Fiksen et al., 2007). Environmental variables, such as temperature, bottom depth and prey availability are also involved in ichthyoplankton distributions (e.g. Sherman et al., 1984; Auth and Brodeur, 2006; Muhling et al., 2008). Nevertheless, some mesoscale oceanographic processes seem to play a key role in the horizontal distribution of fish larvae and in the horizontal structure of the larval fish assemblage. Thus, shelf-slope fronts may work as retention and concentration mechanisms for larvae of neritic fish species and their food (e.g. Sabates and Olivar, 1996; Gonzalez-Quiros et al., 2004). In addition, they may prevent the onshore drift, into the shelf, of larvae of oceanic species. Whereas currents, Ekman transport, associated with coastal upwelling, and eddies may work as dispersion mechanisms for neritic fish larvae (e.g. Myers and Drinkwater, 1989; Sanchez and Gil, 2000; Santos et al., 2004). In any case, as in plankton communities (Mackas et al., 1985), biological–physical interactions seem to be important in determining patterns of horizontal distribution, but also the fate of fish larvae.

The oceanography off the Portuguese and Atlantic Spanish coasts is highly influenced by seasonal factors. During winter, the shelf-slope circulation is dominated, as in the other eastern boundary current systems, by a geostrophically balanced poleward flow (Frouin et al., 1990; Relvas et al., 2007), the Iberian Poleward Current (the IPC, Peliz et al., 2003). The IPC flows along the continental slope off the western Iberian peninsula and enters the Cantabrian Sea, reaching the southwest of France (Pingree and Le Cann, 1990; Frouin et al., 1990; Haynes and Barton, 1990). Wind regime seasonality is of critical importance for shelf currents in the region (Vitorino et al., 2002). Dominant south-westerly winds in autumn-winter induce downwelling and favour poleward flow, while dominant northerly winds in spring-summer are associated with coastal upwelling and equatorward flow (Botas et al., 1990; Haynes and Barton, 1991). However, much of the variability of the atmospheric forcing is concentrated on scales shorter than seasonal (e.g. Torres et al., 2003) and consequently, event-scale variability is important to the system. The transition from winter downwelling to summer upwelling conditions occurs around April (Fraga, 1981; Blanton et al., 1984). The first stages of this transition are characterized by large variability in circulation and

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in the distribution of physical properties, both on the shelf and offshore (Torres and Barton, 2007).

In the Atlantic region, the IPC may be instrumental in forming convergence zones over the shelf break (Relvas et al., 2007), while the intrusion of saline waters in the Cantabrian Sea generates a sharp thermohaline shelf-slope front (Fernandez et al., 1993; Lavin et al., 2005). Mesoscale eddies are also generated because of current instabilities and topographic forcing (Haynes and Barton, 1991; Sanchez and Gil, 2000). All these structures are important for the horizontal distribution of fish larvae, working as retention and/or poleward transport mechanisms and they may even influence the recruitment success of some fish species (Fernandez et al., 1993; Sanchez and Gil, 2000; Santos et al., 2004). In the same way, the equatorward flow during the upwelling season may carry out an equatorward transport of fish larvae (Chesney and Alonso-Noval, 1989; Lopez-Jamar et al., 1995).

The objectives of this study were to identify and quantify the composition of the ichthyoplankton assemblage, to study the horizontal structure of the larval fish assemblage and its relationship with the environmental variables off the NW and N Iberian Peninsula coasts, in early spring.

Most of the ichthyoplankton surveys carried out off the Portuguese and Spanish coasts of the Atlantic Ocean and Cantabrian Sea had the aim of generating fishery-independent stock assessments. Consequently, most ichthyoplankton studies have been focussed on commercially important fish species, especially *Sardina pilchardus* (e.g. Garcia et al., 1992; Lopez-Jamar et al., 1995; Stratoudakis et al., 2003). However, no previous studies have examined the composition and structure of the whole larval fish assemblage along the northwest and north Iberian Peninsula coasts and the relationship between species distribution and the environmental variables.

2. Material and methods

2.1. Study area

The study area (Fig. 1) included the shelves and upper slope (coast ~500 m isobath) of two geographic regions: the Atlantic region, from approximately the mouth of the River Duero (Portugal) to Estaca de Bares cape, and the Cantabrian region, including the southernmost Aquitaine (France). A total of 100 stations, arranged in 20 transects perpendicular to the coastline (Fig. 1), were sampled during the Pelacus 0405 cruise, carried out from 5 to 29 of April 2005.

2.2. Data collection

Vertical profiles, to 5 m above the bottom, of temperature, salinity and fluorescence were obtained at each station with a CTD SeaBird 25. Cross-shelf frontal zones were located following the method proposed by Gonzalez-Nuevo and Nogueira (2005). This method is based on the automatic detection of the shift in the along-shelf sub-surface hydrographic properties, gathered under the state variable spiciness (Flament, 2002). Horizontal hydrographic fields were analysed with a standard optimal interpolation scheme (Bretherton et al., 1976; Pedder, 1993), using an isotropic Gaussian correlation. To calculate geostrophic velocity, the reference level was set to 150 dbar. In shallower stations, the dynamic height anomaly was extrapolated from the nearest deeper stations.

Fluorescence measurements were transformed into chlorophyll *a* (Chl *a*) concentrations (mg m^{-3}) according to the fluorescence–Chl *a* relationship obtained during the cruise.

Mesozooplankton and ichthyoplankton were sampled at three stations in each transect: at the coastal station, at the station located about the middle shelf and at the outer station (Fig. 1). Both were collected with a triple WP2 net (UNESCO, 1968) of 40 cm of mouth diameter equipped with nets of 200 μm of mesh size. Zooplankton hauls were vertical, from 100 m in depth to the surface, at the middle and outer shelf stations, and from 5 m above the bottom to the surface, at coastal stations. In every haul, one of the samples was selected to obtain the mesozooplankton biomass (MB). These samples were frozen on board and preserved frozen until they were analysed in the laboratory. Another sample was used to obtain the structure of the mesozooplankton community and for ichthyoplankton studies. These samples were preserved in a buffered 5% solution of formalin and seawater.

Dry weight of mesozooplankton biomass was obtained following Lovegrove (1966), and standardised to mg m^{-3}.

All fish eggs and larvae were sorted from the samples and counted. Fish larvae were identified to the lowest possible taxonomic level, but only eggs of *S. pilchardus* and *E. encrasicolus*

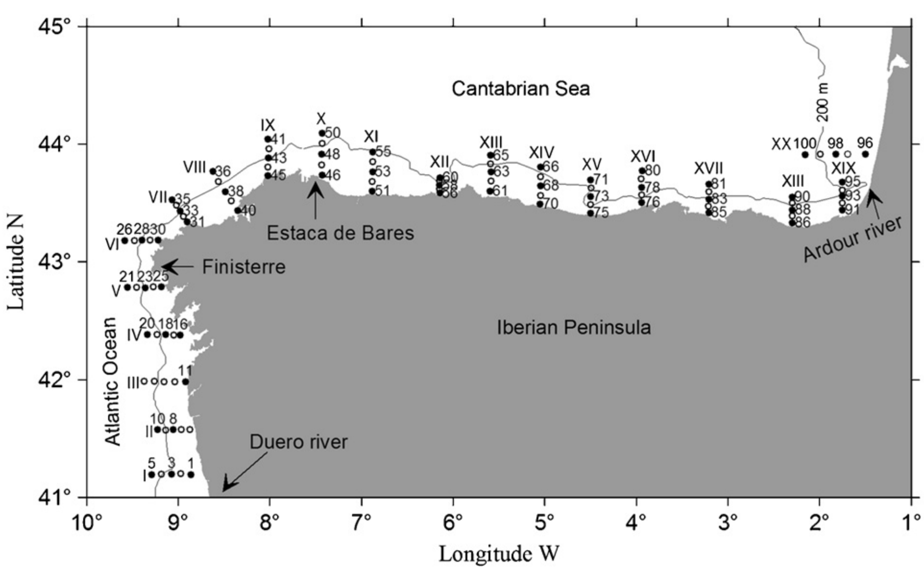

Fig. 1. Study area and station map. (○) stations sampled for hydrography, (●) Stations sampled for hydrography, zooplankton and ichthyoplankton. The different places referenced to in the text are indicated.