CHANGES IN THE DISTRIBUTION OF COASTAL PELAGIC RESOURCES OFF PORTUGAL: OBSERVATIONS AND WORKING HYPOTHESES

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Survey data collected in the past two decades off Portugal are currently being reviewed to identify changes in the distribution and abundance of small pelagic fishes. For example, data from 15 ichthyoplankton surveys were recently analysed (Stratoudakis *et al.* submitted) to describe the distribution of sardine eggs and larvae off Portugal during 1985-2000. Binomial models fitted to presence/absence data from three DEPM surveys show that the area of egg cover off Portugal significantly decreased from 11800 km^2 in 1988 to 7000 km2 in 1997 and 7400 km^2 in 1999. Standardised data from all surveys show a decline in the mean probability of egg presence within the Portuguese continental shelf from the mid-1980s to late 1990s. This decline is due to a marked reduction in the egg abundance in the northern Portugal spawning ground (Fig. 1), partly compensated by moderate increases in the southwestern and southern Portugal spawning grounds. Similar regional patterns are observed in the mean probability of larvae presence over time, but the reduction in the north is less marked than for the eggs (this comparison ignores the presence of sardine larvae beyond the continental shelf in the 1980s). Comparable changes are observed in Portuguese sardine catches and the acoustically estimated distribution area of sardine. Recent preliminary analysis of trawl data from acoustic surveys (1982-2000) has shown decadal differences in the depth distribution of sardine (being caught in deeper waters during the 1980s) and in the area of distribution of other pelagic species (*e.g.* bogue and chub mackerel were caught in a wider area and more frequently during the 1990s). This northern expansion of species with a more subtropical distribution (bogue and chub mackerel) could be explained by the increase in temperature observed over the last decades in the eastern North Atlantic (Brander *et al.* 2001).

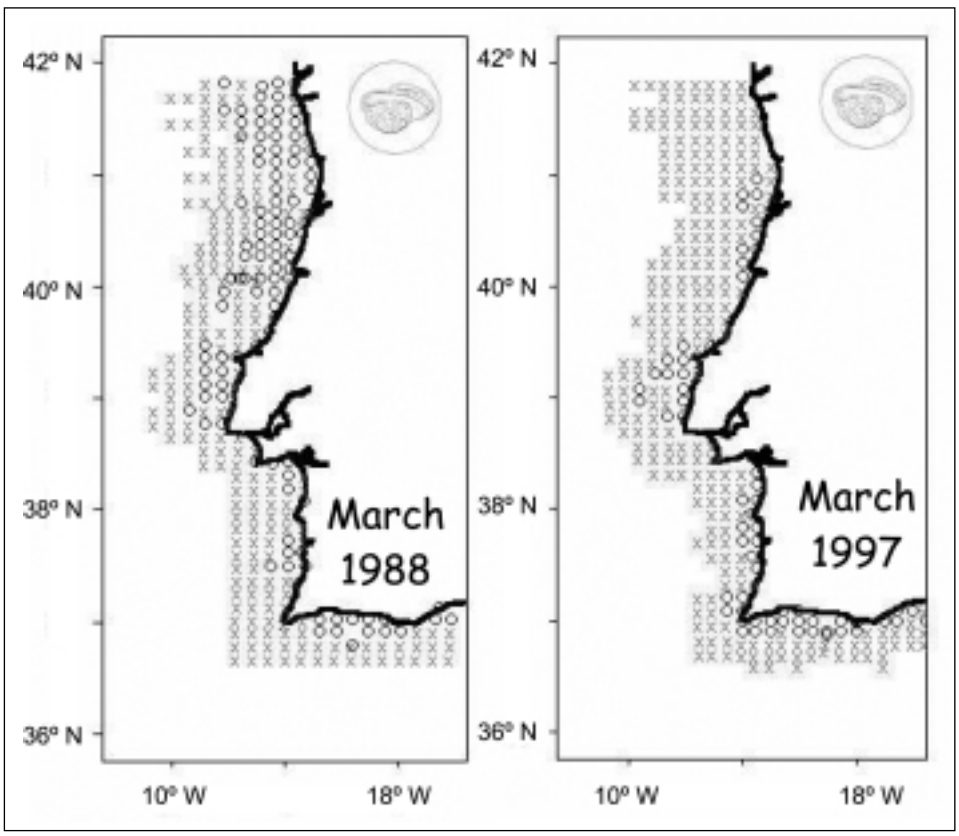

Fig. 1

Although the reasons for the observed changes are not clearly understood, they seem to be climate driven. Borges *et al.* (submitted) found an highly significant correlation between NAO and the winter northerly winds, and a significant correlation between wind conditions and the catch of sardine one year later. The long-term changes in alongshore winds off Portugal during the last decades related to NAO conditions lead to variations in the patterns of upwelling in the region, and are related to decadal - scale

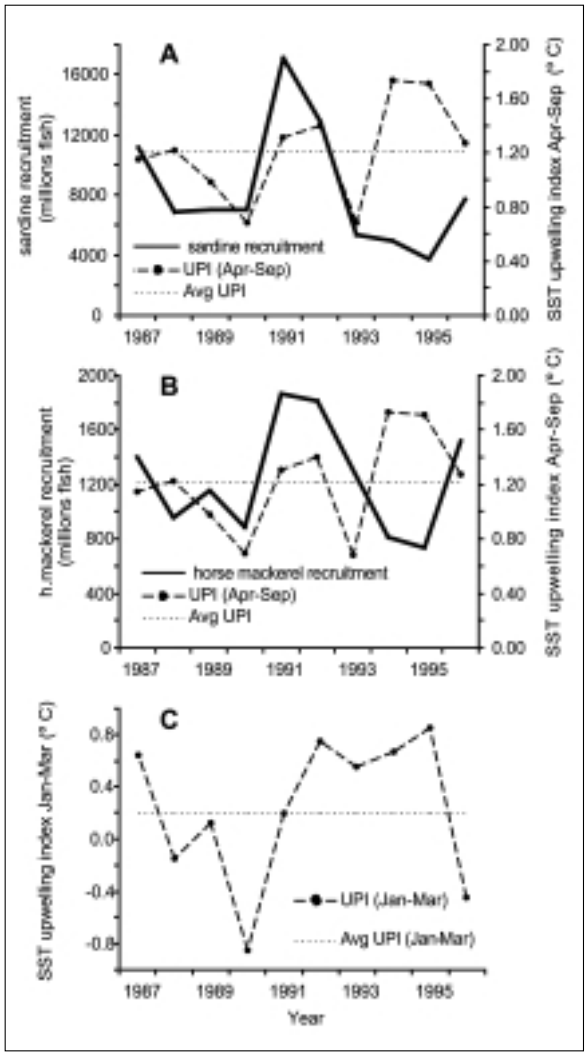

Fig. 2

fluctuations in the annual catch of sardine. Santos *et al.* (2001). have shown that the variability of upwelling patterns is a crucial factor in the recruitment dynamics of small pelagic fish species. Intense and frequent upwelling events during the spawning season (winter) have a negative impact on the recruitment of these species in the Portuguese west coast, limiting its success even if beneficial upwelling conditions occur later during the summer upwelling (feeding) season (Fig. 2). These findings led to the hypothesis that observed changes in the distribution and abundance of pelagic resources off Portugal are related to the increase of upwelling events, reported in the last decades, during the spawning season.

In order to test that hypothesis the SURVIVAL Project (PRAXIS/P/CTE/11282/1998) is conducting process-oriented studies, including *in situ* and remotely sensed observations of physical and biological parameters, as well as modelling activities using the Regional Ocean Modelling System (ROMS) and an Individual-Based Model (IBM). The project aims to study the impact of the physical processes (mainly upwelling events during the spawning season) on the dispersal and survival of small pelagic fish (mainly sardine) eggs and larvae (Santos and Borges 2000).

The results of the SURVIVAL cruise in February 2000 revealed that a coastal upwelling event occurred during almost the entire survey with the exception of the last few days. The event is clearly observed in satellite-derived sea surface temperature (SST) distributions, meteorological data (wind and sea level pressure data), and in current meter records. Sardine larvae and eggs were more abundant over the shelf break (Fig. 3), in contrast to what is known from previous ichthyoplankton surveys conducted by IPIMAR in the last decades, in which larvae were mainly found in the middle-shelf region (at a bottom depth ~100 m). It was also found that the mean length of larvae caught during the cruise increased meridionaly, from the southernmost to the northernmost cruise stations. These results constitute evidence of the impact of winter upwelling events and the poleward slope current on the distribution of larvae and eggs off western Iberia, and the implications of these factors on egg and larval survival are being further investigated. Finally, the preliminary ROMS-IBM simulations were in accordance with these field results, which reinforce the interest for future applications of these modelling techniques in the Western Iberian Upwelling Ecosystem.

Acknowledgements

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References

Borges, M. F., Santos, A. M. P., Crato, N., Mendes, H. and B. Mota. Submitted. North Atlantic Oscillation (NAO) and sardine population dynamics off Portugal. *Sci. Mar.*

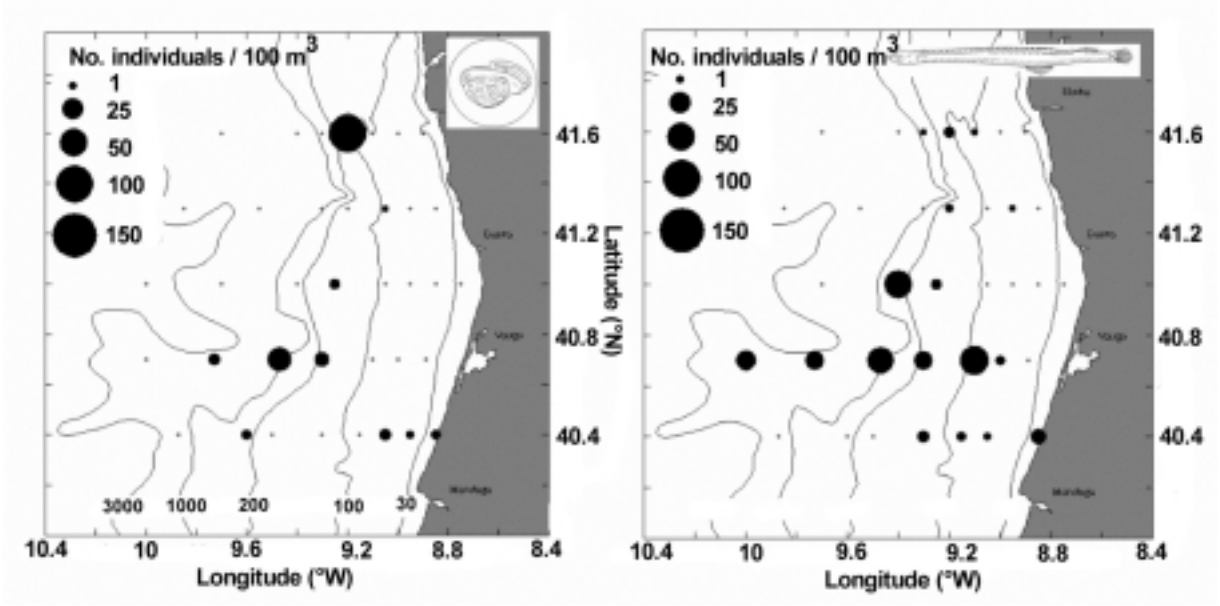

Fig. 3

Brander, K., Blom, G., Borges, M.F., Erzini, K., Henderson, G., MacKenzie, B., Magnussen, E., Mendes, H., Santos, A.M.P. and R. Toresen. 2001. Changes in fish distribution in the eastern North Atlantic; are we seeing a coherent response to changing temperature? *ICES Symposium on Hydrobiological Variability in the ICES Area, 1990-1999, The Second ICES Decadal Symposium, 8–10 August 2001, Edinburgh, Scotland, U.K.*

Santos, A. M. P. and M. F Borges. 2000. The activities of IPIMAR in the frame of GLOBEC. GLOBEC *Int. Newsl.*, 6(1): 15-17.

Santos, A. M. P., Borges, M. F. and S. Groom. 2001. Sardine and horse mackerel recruitment and upwelling off Portugal. *ICES J. Mar. Sci.*, 58(3): 589-596.

Stratoudakis, Y., Bernal, M., Borchers, D. and M. F. Borges. Submitted. Spatio-temporal changes in the distribution of sardine eggs and larvae off Portugal. *Fish. Oceanog.*

Figure Legends

Figure 1. Changes in sardine egg distribution off Portugal. The maps show the location of sampled stations for two DEPM egg surveys conducted by IPIMAR in March 1988 and 1997. Circles refer to stations where sardine eggs were found (adapted from Stratoudakis *et al.* submitted).

Figure 2: Annual upwelling indices (UPI) produced from satellite-derived SST anomalies between coastal and offshore areas (larger positive values indicate more intense upwelling conditions), and sardine (*Sardina pilchardus*) and horse mackerel (*Trachurus trachurus*) recruitment at age group-0 for the period 1987-1996: (a) UPI for the typical upwelling season of the west coast of Portugal (April-September) and sardine recruitment; (b) UPI during the typical upwelling season (April-September) and horse mackerel recruitment; and (c) UPI during winter (January-March), the spawning season of these fish species. The long-term mean of the upwelling index series is indicated by the horizontal dotted line (adapted from Santos *et al.* 2001).

Figure 3: Sardine egg (a) and larvae (b) distribution and abundance during the SURVIVAL cruise, 16-20 February 2000.