https://doi.org/10.17895/ices.pub.19271861

ICES Marine Science Symposia, 219: 337–339. 2003

Aspects concerning the occurrence of summer upwelling along the southern Bay of Biscay during 1993–2000

Julio Gil and Ricardo Sánchez

Gil. J., and Sánchez, R. 2003. Aspects concerning the occurrence of summer upwelling along the southern Bay of Biscay during 1993–2000. – ICES Marine Science Symposia, 219: 337–339.

The occurrence of coastal upwelling along the southern Bay of Biscay in response to easterly winds shows clear seasonal variability, with peak development centred during the spring and summer. The historical series (1993–2000) of autumn temperatures has allowed identification of different patterns of upwelling. One of the main conclusions deals with the non-permanent character of the upwelling fringe along the Galicia–Cantabrian coast. This feature is related to the magnitude, time-span and synoptic occurrence of the winds. The occurrence of westerly winds pushes warm waters onto the coastal regions and leads to a reversal of the current pattern over the continental shelf. This may affect the survival of fish recruits *via* reduced primary production and its subsequent affect on zooplankton.

Keywords: Bay of Biscay, hake recruitment, upwelling.

J. Gil and R. Sánchez: Instituto Español de Oceanografía, PO Box 240, E-39080, Santander, Spain [tel: +34 94227 5033; fax: +34 94227 5072; e-mail: julio.gil@st.ieo.es, rleal@ualg.pt]. Correspondence to J. Gil.

Introduction

Meridional displacements of the Azores High govern meteorological conditions offshore of the Iberian Peninsula. In summer, the Azores High drifts towards the north and the trade winds blow from the northeast along the Cantabrian and Galician coast. A conspicuous upwelling appears along with an equatorward surface flow. On the contrary, the weakening or southward migration of the Azores High leaves the western Iberian Peninsula under the influence of westerly winds. The upper layer circulation pattern is characterized by a poleward surface flow with absence of coastal upwelling.

In the Cantabrian Sea during summer the water mass distributions over the shelf and adjacent areas depend on the strength of the upwelling. If upwelling is strong and persistent, there is a coastal band of cold, upwelled water over the shelf area, an intermediate zone of warm-core anticyclonic mesoscale eddies, and cool waters along the outer slope. On the other hand, if summer upwelling is weak or the wind regime is westerly, the picture is different, with warm water over the shelf and relatively cool water off the shelf break (Sánchez and Gil, 1999). In this article the changes in the upwelling strength off northern Spain during the 1990s are examined.

Data and methods

Data come from the Spanish autumn bottom-trawl surveys between 1993 and 2000. Sampling stations were distributed throughout the continental shelf, slope, and adjacent oceanic area to resolve mesoscale features. The wind data come from a Seawatch buoy anchored at 43°44′N, 6°10′W (http//www.puertos.es/clima.html). To show the variability in upwelling strength, the temperature field at 50 m was chosen. At this level, the horizontal temperature gradients are maximum and the temperature front between the onshore-upwelled waters and warm offshore waters is clearly defined.

Results and discussion

The early autumn distribution of water masses along the Cantabrian Sea depends to a great extent on the wind regime prevalent in July and August. Unfortunately, buoy wind measurements are available only from 1997 onwards. The wind time-series shows that in July–August 1997, the u-component of wind (east–west) was persistently negative (towards the west), clearly under the influence of the easterly trade winds. On the contrary, in 1998, the zonal wind was predominantly westerly from the middle of July to the end of August. As a result, two different oceanographic situations were observed in the two years. In 1998 (Figure 1B) coastal upwelling was weak. There was general intrusion of warm water over most of the Cantabrian Sea shelf area. A radically different situation occurred in 1997 (Figure 2B), when a strip of warm water (over 16°C) separated the coastal band of cold upwelled water from the cool offshore oceanic water.

Three different hydrographic patterns were observed between the years 1993 and 2000. The first one corresponds to a distribution of water masses similar to 1998 and was also observed in 1993, 1999, and 2000 (Figures 1A–D). The upper homogeneous layer was deep and temperatures at 50 m were relatively high. An intense pycnocline between 50 m and 100 m was ubiquitous (not shown). The second pattern was similar to 1997 and also observed in 1994 (Figures 2A, B) when a conspicuous temperature front separated the coastal band of cold upwelled water from the offshore warm waters. The narrowness of the coastal upwelling permitted a succession of anticyclonic warm cores eddies to develop over offshore areas but relatively close to the shelf. Finally, in 1995 and 1996 (Figures 3A, B) the width of the cold coastal band was considerable, yet it did not appear as a continuous feature along the shelf area. The non-continuous nature of the upwelling may reflect wind reversals.

The establishment of any of these hydrographic patterns brings about important, ecological consequences. When upwelling is absent along the shelf area, the intense thermocline that separates the waters at 50 m (~17°C) from those at 100 m (~12°C) limits the vertical diffusion of nutrients onto the euphotic layer. In contrast, when upwelling takes

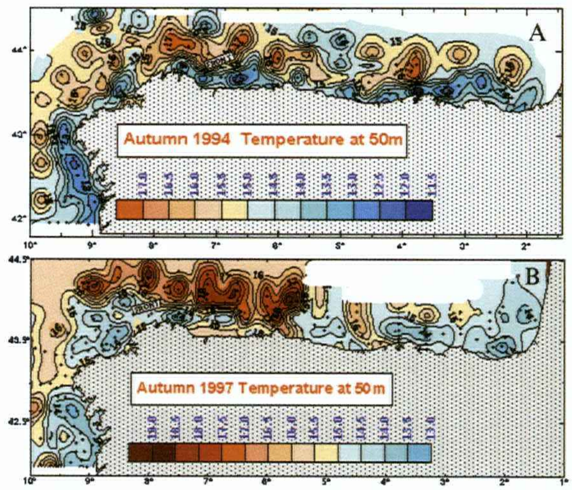

Figure 2. Temperature at 50 m (A) 1994, and (B) 1997.

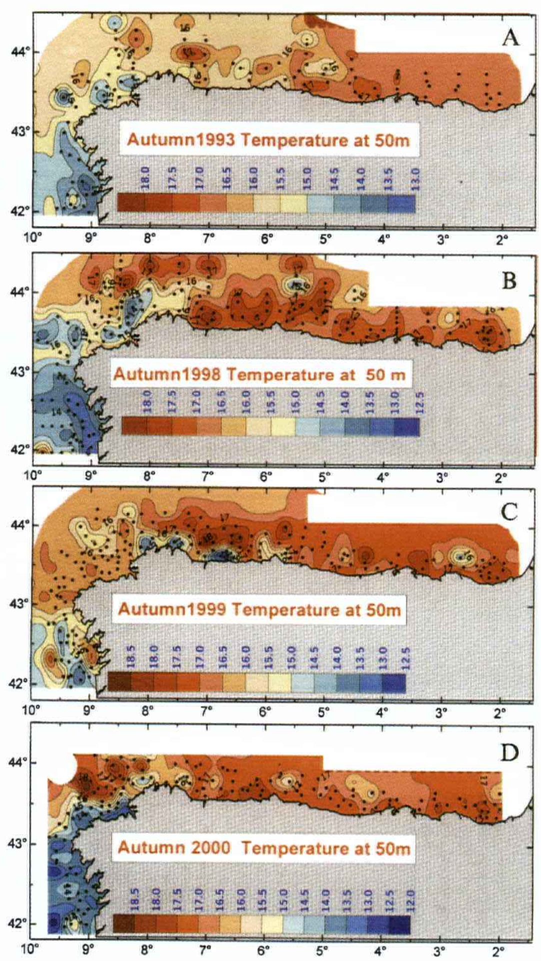

Figure 1. Temperature at 50 m (A) 1993, (B) 1998, (C) 1999, and (D) 2000.

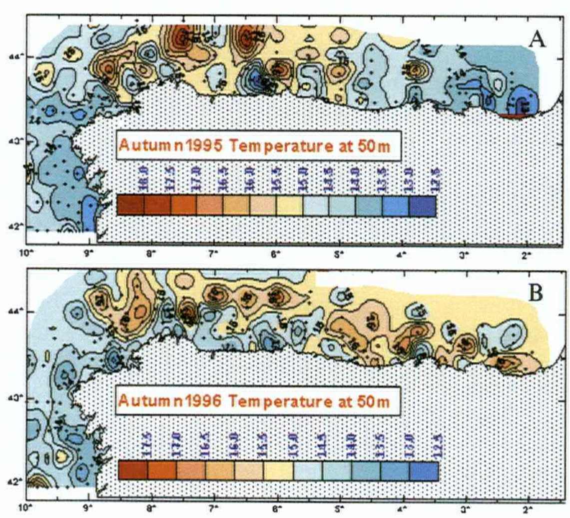

Figure 3. Temperature at 50 m (A) 1995, and (B) 1996.

place, the vertical temperature gradients are minimized and the vertical diffusion is enhanced.

The importance of the generation of mesoscale activity is also important, as shown by Gil (1995) and Gil *et al.* (2002). The presence of mesoscale structures (cyclonic and anticyclonic rings, meandering fronts, filaments) has been observed to enhance nutrification and to affect zooplankton and ichthyoplankton distributions. In the low upwelling strength years, the mesoscale activity is generally scarce, with nearly homogeneous horizontal temperature fields (see the 1993 temperature distribution). Conversely, in years when the upwelling is well developed (1994), there are strong horizontal temperature gradients and conspicuous mesoscale ring activity.

Relationships between recruitment of demersal fishes (such as European hake) and upwelling have been studied elsewhere (Sánchez and Gil, 1999; Sánchez *et al.*, 2002). It is proposed that the lack of mesoscale generation in years under upwelling unfavourable winds may affect the survival of fish recruits *via* reduced primary production and its subsequent effect on zooplankton and ichthyoplankton.

References

Gil, J. 1995. Inestabilidades, fenómenos de mesoescala y movimiento vertical a lo largo del borde sur del Golfo de Vizcaya. Boletín del Instituto Español de Oceanografía, 11: 141–159. (In Spanish.)

Gil, J., Valdés, L., Moral, M., Sánmchez, R., and Garcia-Soto, C. 2002. Mesoscale variability in a high-resolution grid in the Cantabrian sea (southern Bay of Biscay), May 1995. Deep-Sea I. (In press).

Sánchez, F., and J. Gil. 1999. Hydrographic mesoscale structures and Poleward Current as a determinant of hake (*Merluccius merluccius*) recruitment in southern Bay of Biscay. ICES Journal of Marine Science, 57: 152–170.

Sánchez, R., Sánchez, F., and Gil, J. 2003. The optimal environmental window that controls hake (*Merluccius merluccius*) recruitment in the Cantabrian Sea. ICES Marine Science Symposia, 219: 415–417. (This volume.)