https://doi.org/10.17895/ices.pub.19271867

ICES Marine Science Symposia, 219: 340–342. 2003

Temperature and salinity fluctuations along the Basque Coast (southeastern Bay of Biscay), from 1986 to 2000, related to climatic factors

Victoriano Valencia, Ángel Borja, Almudena Fontán, Fiz F. Pérez, and Aida F. Ríos

Valencia, V., Borja, Á., Fontán, A., Pérez, F. F., and Ríos, A. F. 2003. Temperature and salinity fluctuations along the Basque Coast (southeastern Bay of Biscay), from 1986 to 2000, related to climatic factors. – ICES Journal of Marine Science, 219: 340–342.

Time-series of oceanographic and meteorological data collected off the Basque coast, SE Bay of Biscay, show tendencies concurring with the anomaly patterns described for the NE Atlantic area as a whole during the late 1980s and 1990s. Temperature and salinity maxima were reached in the early 1990s after a period of dry and relatively warm winters related to the dominance of south and westerly winds. In the SE corner of the Bay of Biscay, this atmospheric regime increases the occurrence of Eastern North Atlantic Central Water (ENACW) over the continental shelf. Other maxima were recorded during the second half of the 1990s, but the correspondence between the increase of temperature and salinity and the occurrence of ENACW type waters is lower than in the previous period of observation. It would appear that the same climatic regime that favours the intrusion of the ENACW into the SE Bay of Biscay is also associated with warm and dry weather conditions that maintain the temperature-salinity characteristics of the Atlantic Central Waters in this area.

Keywords: Bay of Biscay, climate, decadal changes, Eastern North Atlantic Central Water, temperature-salinity.

V. Valencia, A. Borja, and A. Fontán: Fundación AZTI, Herrera Kaia Portualdea, z/g. 20110 Pasaia (Gipuzkoa) Spain [tel: +34 943 004800; fax: +34 943 004801 e-mail: vvalencia@pas.azti.es; aborja@pas.azti.es; afontan@pas.azti.es]. F. F. Pérez and A. F. Ríos: Instituto de Investigación Mariñas (CSIC) Cl Eduardo Cabello, 6. 36208 Vigo, Spain [e-mail: fiz@iim.csic.es; aida@iim.csic.es]. Correspondence to V. Valencia.

Introduction

Oceanographic data collected at 43°30′N 2°W over the continental shelf of the SE Bay of Biscay (Figure 1) show a significant coupling with the meteorological data collected in the same region of the NE Atlantic Ocean (Valencia, 1993; Valencia *et al.*, 1996). The monthly time-series of temperature and salinity (from surface to 100 m water depth) for the shelf waters of the Basque coast from 1986 to 2000 show tendencies that concur with the general anomaly patterns described for the NE Atlantic Ocean during the late 1980s and 1990s. The simultaneous increase in temperature and salinity of the surface waters from the mid-1980s until 1992 has been reported by several authors, both from coastal monitoring and from oceanic cruises, all around the intergyre zone of the NE Atlantic (e.g. Dauvin *et al.*, 1991; Ellett and Turrell, 1992; Valencia, 1993, Pingree, 1994). This anomaly pattern has been related to local climatic variables (air temperature, precipitation minus evaporation balance, river run-off), as well as to external driving factors such as the atmospheric circulation represented by the North Atlantic Oscillation index (Pérez *et al.*, 1995; Valencia *et al.*, 1996; Pérez *et al.*, 2000). For other periods, dissimilar tendencies have also been reported, e.g. Lavín *et al.* (1998) describe the increase in temperature and the strong decrease of salinity during the period 1991–1995.

Results and discussion

The Basque coast has some distinctive climatic, geographic, and morphodynamic characteristics and

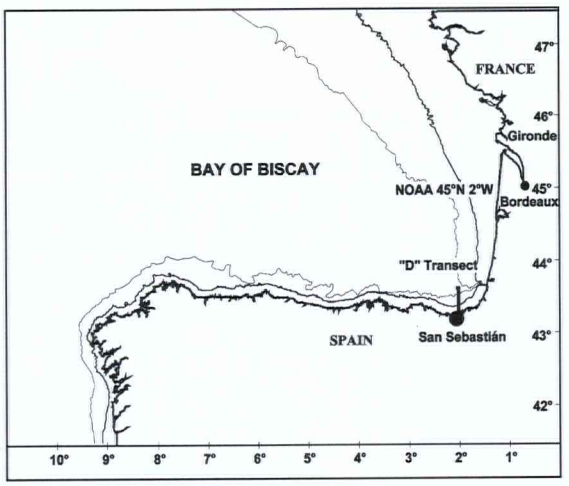

Figure 1. Study area. The southeastern Bay of Biscay and the Basque coast. Meteorological data and SST daily data are from INM and from the Aquarium of San Sebastián. Gironde river flow data are from Bordeaux. The vectorial wind data are from NOAA (45°N 2°W). *In situ* hydrographic data are from D transect of AZTI starting from San Sebastián.

is a convergence area. Calculations of the Ekman transport along the Spanish (east to west) and French (north to south) coasts indicate the dominance of onshore transport. Results based on vectorial wind data obtained from NOAA for 45°N 2°W give an average yearly value of 125 $m^3 s^{-1} km^{-1}$ for the total Ekman downwelling in the area (Valencia *et al.*, 1996). The concavity of the SE corner of the Bay of Biscay produces a continental influence in this region and hence the shelf waters of this area are colder in winter and warmer and less saline in summer than the waters of the areas located westward at equivalent latitudes. Hence, Eastern North Atlantic Central Water (ENACW) entering the SE Bay of Biscay is modified and frequently loses its characteristic T–S relationships, not only in the layer above the seasonal thermocline but also in the whole water column over the continental shelf out to the 120-m isobath (Valencia, 1993).

Nevertheless, against a background of variability within the coastal waters, data series of temperature and salinity for the coastal area and the adjacent continental shelf reflect the general tendencies described for the NE Atlantic. Changes in trends of temperature, salinity, residence time, and the proportion of the water column occupied by ENACW-type waters have been observed throughout the 1986–2000 period.

The observed changes may have been the result of a change in the magnitude of inflow of ENACW to the SE Bay of Biscay, or a change in the characteristics of that water mass (e.g. Pollard and Pu, 1985; Dickson *et al.*, 1988). A combination of climatic parameters affecting the T–S signature of the water masses (the in situ modification hypothesis) and those determining the circulation of the water masses (the advective hypothesis) may be considered for the assessment of the cause and effect of the observed anomaly patterns.

As a first approximation, the air temperature may be considered representative of the main thermal atmosphere–ocean interchanges. The precipitation minus evaporation balance and the river run-off may be considered as the main variables related to changes observed in salinity. The eastward and northward transport of water can be related to upwelling and downwelling, respectively, along the Basque and French coasts.

Monthly averages of the atmospheric temperature at San Sebastián correlate significantly with the monthly average sea surface temperature ($r^2 = 0.90$; $\alpha < 0.0001$; d.f. = 178). Even if the autocorrelation between data sets of time-series is taken into account (lag 1 residual autocorrelation = 0.30) the relationship between air temperature and SST remains statistically significant ($\alpha < 0.01$).

Figure 2 shows the accumulated anomalies of quarterly average flow of the Gironde River, the precipitation in San Sebastián, and the average salinity (100 m water depth) of the shelf waters along the Basque coast. The form of the curve of the accumulated river flow anomalies is similar to other variables related to the thermal and saline balance within the shelf waters (e.g. hours of sunshine, relative humidity, evaporation, precipitation minus evaporation balance), especially in the timing of extreme values.

On the other hand, almost all the points within the hydrographic series associated with changes in the tendency of the T–S characteristics of the waters in the SE Bay of Biscay, and the occurrence of ENACW

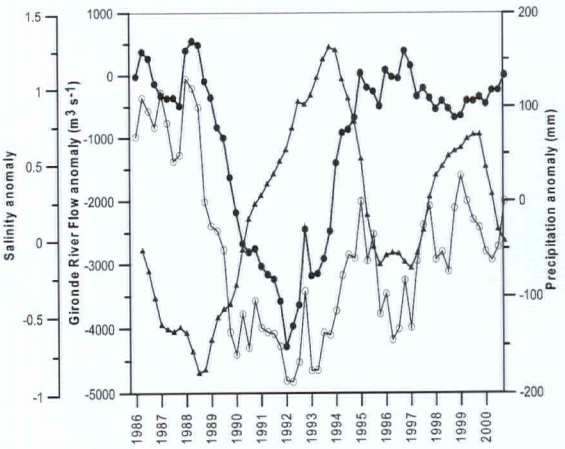

Figure 2. Accumulated anomalies (quarterly) of the Gironde River flow (solid dots), precipitation in San Sebastián (dots) and salinity in 100 m water column off the Basque coast (triangles).

in the area, are related to events of intensification or moderation of the eastward and poleward transports. The intensification of these transports is related to the dominance of southerly and westerly winds that provide simultaneously warm and dry weather in the area.

It would appear that the same climatic regime favouring the intrusion of ENACW into the SE Bay of Biscay is also associated with the warm and dry conditions that maintain the T–S characteristics of the Atlantic Central Waters in this area. The anomaly patterns and the relationships between the variables considered show similar tendencies to those observed in other areas of the intergyre zone of the NE Atlantic (Pérez *et al.*, 2000). Hence, the series of climatic and hydrographic data for the Basque coast reflect the general tendencies described for the NE Atlantic as a teleconnected response related to general indices of environmental forcing such as the NAO.

Acknowledgements

The meteorological data are from the Observatory of San Sebastián (Instituto Nacional de Meteorología). SST daily data are from the Aquarium of San Sebastián (Sociedad Oceanográfica de Gipuzkoa). Gironde river flow data are from the Harbour Authority of Bordeaux. The calculation of Upwelling Index is made from vectorial data furnished by NOAA. The Basque Government (Department of Agriculture and Fisheries) financed the project "VARIACIONES", which includes acquisition of the *in situ* data and review of the external time-series.

References

Dickson, R. R., Meincke, J., Malmberg, S., and Lee, A. J. 1988. The "Great Salinity Anomaly" in the Northern North Atlantic 1968–1982. Progress in Oceanography, 14: 103–151.

Dauvin, J. C., Joncourt, M., and Birrien, J. L. 1991. Température et salinité de l'eau de mer au large de Rosscoff de 1998 à 1990. Cahiers de Biologie Marine, 32: 545–550.

Ellett, D. J., and Turrell, W. R. 1992. Increased salinity levels in the NE Atlantic. ICES CM 1992/C: 20.

Lavín, A., Valdés, L., Gil, J., and Moral, M. 1998. Seasonal and inter-annual variability in properties of surface water off Santander, Bay of Biscay, 1991–1995. Oceanologica Acta, 21: 179–190.

Pérez, F. F., Pollard, R. T., Read, J. F., Valencia, V., Cabanas J. M., and Ríos, A. F. 2000. Climatological coupling of the thermohaline decadal changes in Central Water of the Eastern North Atlantic. Scientia Marina, 64: 347–353.

Pérez, F. F., Ríos, A. F., King, B. A., and Pollard, R. T. 1995. Decadal changes of the θ–S relationship of the Eastern North Atlantic Central Water. Deep-Sea Research I, 42: 1849–1864.

Pingree, R. D. 1994. Winter warming in the southern Bay of Biscay and Lagrangian eddy kinematics from a deep-drogued Argos Buoy. Journal of the Marine Biological Association of the United Kingdom, 74: 107–128.

Pollard, R. T., and Pu, S. 1985. Structure and circulation of the upper Atlantic Ocean north-east of the Azores. Progress in Oceanography, 14: 443–462.

Valencia, V. 1993. Estudio de la variación temporal de la hidrografía y el plancton en la zona nerítica frente a San Sebastián entre 1988 y 1990. Informes Técnicos del Departamento de Agricultura y Pesca del Gobierno Vasco, 52. 105 pp.

Valencia, V., Borja, A., and Franco, J. 1996. Estudio de las variaciones de parámetros oceanográficos y meteorológicos de interés para las pesquerías del Golfo de Vizcaya. Informes Técnicos del Departamento de Agricultura y Pesca del Gobierno Vasco, 75. 232 pp.