



The effects of a winter upwelling on biogeochemical and planktonic components in an area close to the Galician Upwelling Core: The Sound of Corcubi3n (NW Spain)

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ABSTRACT

To study the biogeochemical response and the coupling plankton–benthos to an unusual winter upwelling event a cruise was carried out in February 2005 in the Sound of Corcubi3n, near Cape Finisterre (NW Iberian Peninsula), the Galician upwelling core. This area represents the northern boundary of the Eastern North Atlantic Upwelling System (ENAS). The spatial distribution of plankton assemblages (phytoplankton and zooplankton), chlorophyll, physical and chemical parameters as well as diatom distribution in surface sediments, were studied in a total of 17 stations in the Sound. The upwelling processes caused an important accumulation of water in the inner Sound and near the Cape. This accumulation zone must be persistent through the upwelling events in the area, including those of summer, as indicated by the diatoms' distribution in the sediment. Unlike the summer upwelling events, the main effect of winter upwelling in the area is the increase in solar radiation due to the persistent clear skies. In this season nutrient supply is not critical due to water column mixing. The meteorological conditions were equivalent to those of early spring. As a result, both phyto- and zooplankton species assemblages were typical of spring blooms in Galician coasts. The bloom lasted for up to 6 days, as estimated from the availability and uptake of nitrogen forms. Winter blooms represented ca. 20% of total annual phytoplankton biomass, and 30% of the average biomass during summer upwelling, in the period 1997–2007, as estimated from the analysis of both, in situ and satellite derived chlorophyll.

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1. Introduction

Upwelling events in the ocean cause a re-fertilization of surface waters leading to an increasing of the biological productivity in coastal areas. For this reason, the coastal upwelling systems have received a great attention due to their biological importance: Benguela (Andrews and Hutchings, 1980; Monteiro and Largier, 1999), California (Di Lorenzo, 2003; Jones et al., 1988), Per1 (Nixon and Thomas, 2001), and the North Atlantic Upwelling System (Fraga, 1981), including the Canary Islands (Pelegri et al., 2005). The Eastern North Atlantic Upwelling System (ENAS) extends from 10° to 44° N (Wooster et al., 1976). The northernmost limit of this upwelling system is the north-western coast of the Iberian Peninsula. In this area upwelling events of ENACW [Eastern North Atlantic Central Water] are more frequent from March to September (McClain et al., 1986; Prego et al., 2007), causing a fertilization of surface waters, and an increase of primary production (Bode et al., 1996; Prego et al., 1999a;

Varela et al., 2005, 2008), leading to the high fishery and aquaculture yields in this region (Tenore et al., 1995). The maximum intensity of upwelling in the NW Iberian Peninsula occurs during summer, mainly in August (Blanton et al., 1984; Prego et al., 1999a; Varela et al., 2005).

Summer upwelling and its biogeochemical implications have been described in detail in the western, northern and middle Galician Rias (Prego and Bao, 1997; Varela et al., 1996, 2001, 2008; Varela and Prego, 2003). In contrast, winter upwelling has received little attention even though some authors claim respect to an increase of these winter events (1lvarez et al., 2003; Bakun, 1990; Bern1rdez et al., 2008; deCastro et al., 2000) in association with a increase of positive NAO indexes (Borges et al., 2003). This is a topic not exempt of controversy as other authors found evidences of a decreasing trend in the strength of upwelling in the western Iberian shelf (Lemos and Sans3, 2006). Recently, some upwelling events occurring out of the typical upwelling season have been reported for the Galician coast. Late autumn (deCastro et al., 2006) and winter upwelling events and their associated hydrographic (1lvarez et al., 2003), as well as biogeochemical effects (Prego et al., 2007; Varela et al., 2008), have been described for the first time in the Ria of Pontevedra.

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In this paper we describe the biogeochemical and plankton distribution patterns related to an out of season upwelling event during February 2005 in the Sound of Corcubión (Galicia, NW Iberian Peninsula). Winter upwelling events are unusual and therefore few studies have been carried out in the Galician coast, one in Pontevedra Ria (Álvarez et al., 2003; Prego et al., 2007; Varela et al., 2008), and the other one in the Northern Ria Alta O Barqueiro (Álvarez et al., 2009).

The Sound of Corcubión is located just SE of Cape Finisterre, and therefore in the area of the Galician upwelling core (Fraga, 1981; Varela et al., 2005). The aims of this study were: 1) To investigate the biogeochemical and biological response and coupling plankton–benthos during an unusual winter upwelling event in the area of Galician upwelling core. 2) To estimate how the phytoplankton bloom associated to upwelling persists, according to biomass concentration and nutrients availability. 3) To evaluate the relative contribution of winter blooms to the total annual phytoplankton production using the historical data of SeaWiFS chlorophyll for the area near Cape Finisterre during the period 1997–2007.

2. Methods

2.1. The area under scope

The Corcubión Sound is an open bay located in the NW of the Iberian Peninsula (Fig. 1) which outer limits are delimited by Cape Finisterre and Point Remedios. The area is about 130 km² with a mean depth of approximately 30 m. Lobeiras Islands are located in the middle of the sound. The Corcubión Sound is located to the north of Muros Ria, the northernmost of the Galician Rias Baixas. Unlike the Rias Baixas, the sound is very open with a strong oceanic influence. In addition, the supply of continental water is extremely reduced to play

an important role in the circulation of the zone, as it occurs in the nearby Rias Baixas where the continental water entering the system through the rivers is one of the main forces driving the circulation of those rias (Prego et al., 2007; Varela et al., 2008).

Due to the vicinity to the Galician upwelling core, the area is supposed to be under influence of upwelling events, as it has been described for neighbouring zones (Varela et al., 2005).

2.2. Water column sampling and sample processing

Cruise PresFis (Prestige-Finisterre)-0205 was carried out on 18th of February 2005 on board R/V Lura from the Instituto Español de Oceanografía to obtain measurements of hydrographic conditions, nutrient salts concentrations, organic matter, phytoplankton, and mesozooplankton in winter.

Upwelling index values were calculated in a 2° × 2° cell centred at 43°N and 11°W, using geostrophic wind speed derived from atmospheric pressure fields, following the methodology of Bakun (1973) and Lavín et al. (1991). Pressure data were supplied by the Spanish AEMET (State Meteorological Agency). The upwelling index is the magnitude of offshore or onshore flows of surface water and is equivalent to the Ekman transport derived from surface winds. A positive UI denotes favourable upwelling conditions (northerly winds and southward currents), and a negative UI, the contrary (southerly winds and northward currents). AEMET also provided historical data on environmental irradiance, from the period 1989 to 2007. The Spanish Ocean Observation System (Valdés et al., 2002) allowed the access to PAR (Photosynthetic Active Radiation) data for the period 1991 to 2007, measured in the near shelf off A Coruña.

A total of 17 stations were sampled with General Oceanics rosette, incorporating a CTD 25 SeaBird with PAR and fluorescence sensors as

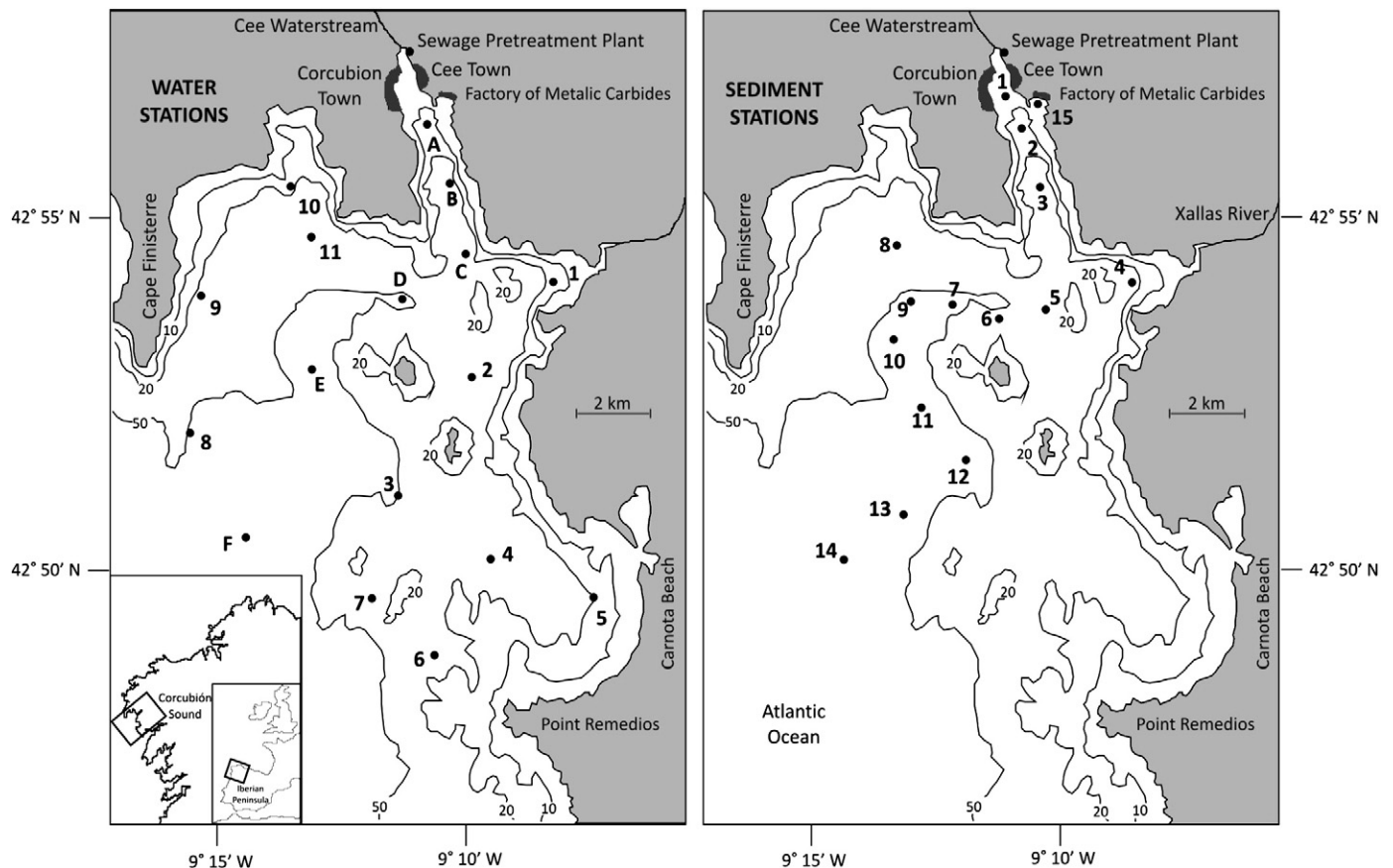


Fig. 1. Map and bathymetry (m) of the Corcubión Sound with water stations (left) and sediment stations (right) represented with black circles.

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