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The distribution of chlorophyll-*a* and dominant planktonic components in the coastal transition zone off Concepción, central Chile, during different oceanographic conditions

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Abstract

The oceanographic setting and the planktonic distribution in the coastal transition zone off Concepción (~35–38°S, ~73–77°W), an area characterized by its high biological production, were assessed during two different seasons: austral spring with equatorward upwelling favorable winds and austral winter with predominately northerly winds. Oceanographic and biological data (total chlorophyll-*a*, particulate organic carbon, microplankton, large mesozooplankton >500 μm as potential consumers of microplankton) were obtained during two cruises (October 1998, July 1999) together with satellite imagery for wind stress, geostrophic flow, surface temperature, and chlorophyll-*a* data. The physical environment during the spring sampling was typical of the upwelling period in this region, with a well-defined density front in the shelf-break area and high concentrations of surface chlorophyll-*a* (>5 mg m^{-3}) on the shelf over the Itata terrace. During the winter sampling, highly variable though weakly upwelling-favorable winds were observed along with lower surface chlorophyll-*a* values (<2 mg m^{-3}) on the shelf. In the oceanic area (>100 km from the coast), cyclonic and anti-cyclonic eddies were evident in the flow field during both periods, the former coinciding with higher chlorophyll-*a* contents (~1 mg m^{-3}) than in the surrounding waters. Also, a cold, chlorophyll-*a* rich filament was well defined during the spring sampling, extending from the shelf out to 350–400 km offshore. Along a cross-shelf transect, the micro- and meso-planktonic assemblages displayed higher coastal abundances during the spring cruise but secondary peaks appeared in the oceanic area during the winter cruise, coinciding with the distribution of the eddies. These results suggest that the mesoscale

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features in this region, in combination with upwelling, play a role in potentially increasing the biological productivity of the coastal transition zone off Concepción.

Regional index terms: SE Pacific; Central Chile; Bio-Bio Region; Concepción

Keywords: Coastal upwelling off Concepción; Coastal transition zone; Cold filaments and eddies; Plankton distribution; Chlorophyll-*a* variability

1. Introduction

The Eastern Boundary Current (EBC) system off South America, the Humboldt Current System (HCS), is well known for its biological productivity, associated mainly with periodic coastal upwelling (Strub et al., 1998; Montecino et al., 2006), as occurs in other EBCs (Hutchings et al., 1995; Mackas et al., 2006). The HCS displays high mesoscale variability in the so-called coastal transition zone (CTZ), including the formation and persistence of structures such as filaments, eddies, and energetic meandering currents or jets (Hormazabal et al., 2004a), which are also characteristic of other upwelling EBCs (Lutjeharms et al., 1991; Strub et al., 1991; Barton et al., 1998; Chereskin et al., 2000; Strub and James, 2000; Joint et al., 2001). These structures have been shown to influence the distribution of biological components in the pelagic environment, mainly through the cross-shelf transport of plankton and the exchange of particulate and dissolved organic and inorganic matter between the productive shelf and the open, oligotrophic ocean (e.g., Shillington et al., 1990; Alvarez-Salgado et al., 2001; Barth et al., 2002; Arístegui et al., 2004; Mackas et al., 2005; Whitney et al., 2005). Cold coastal filaments and mesoscale eddies in the HCS have been documented off northern and central Chile (Uribe and Neshyba, 1983; Cáceres, 1992; Barbieri et al., 1995; Thomas, 1999; Morales et al., 2001; Sobarzo and Figueroa, 2001; Hormazabal et al., 2004a) but little information is available on their ecological impact upon the pelagic system and/or coastal–ocean exchanges of nutrients and organic matter (Marín et al., 2003; Barbieri et al., 2004; Hormazabal et al., 2004b; Correa-Ramirez et al., 2007).

The HCS region off central Chile (~30–40°S) is characterized by marked seasonality in upwelling activity, with upwelling-favorable, equatorward winds dominating during the austral spring–summer months (September–March), a shift to predominantly northerly to northwesterly directions in late autumn to winter (May–July), and transitional periods of variable winds in between (Saavedra, 1980; Shaffer et al., 1999). The area between 35 and 38°S has been identified as having the most intense and persistent upwelling activity, with Punta Nugurne (35°57′S) and Punta Lavapié (37°15′S) being the main upwelling centers, and Equatorial Subsurface Water (ESSW) the main source of upwelled water (Strub et al., 1998). Sobarzo et al. (2007) describe the seasonal changes in the hydrography of the coastal band along the 35–39°S region and distinguish two periods with different seasonal processes influencing the water column structure: October–March, when upwelling and increased solar radiation play a larger role, and May–July (austral winter), dominated by river influx and precipitation. This central region also displays a wide band (coast to 600–800 km offshore) of high eddy kinetic energy; here, mesoscale eddies (~200 km length) appear as coherent spatial structures during several months and propagate predominantly offshore (Hormazabal et al., 2004a). High-resolution numerical modeling for this region has suggested that baroclinic instabilities of coastal currents constitute the main source of eddies and meanders (Leth and Shaffer, 2001; Leth and Middleton, 2004); the bottom topography and coastline also appear to contribute to the path of coastal jets (Mesías et al., 2003) and to induce coastal upwelling at certain sites (Figueroa and Moffat, 2000). Also, cold upwelling filaments in the region have been described as recurrent features in austral spring and summer (Cáceres, 1992).

In terms of the biological and ecological characteristics of the coastal upwelling ecosystems off central Chile, several studies have dealt with the plankton community structure, key species' abundance and distribution, and/or phytoplankton biomass and production in nearshore areas (González et al., 1987; Avaria et al., 1989; Arcos et al., 1987, 1996; Peterson et al., 1988; Ahumada et al., 1991; Vargas et al., 1997; Castro et al., 2000; Rutllant and Montecino, 2002), and a few also cover the coastal transition zone (Castro et al., 1993; Daneri et al., 2000; Landaeta and Castro, 2002; Cuevas et al., 2004; Montecino et al., 2004; Yannicelli