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Wind forcing and short-term variability of phytoplankton and heterotrophic bacterioplankton in the coastal zone of the Concepción upwelling system (Central Chile)

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ABSTRACT

Along South-Central Chile, upwelling-favorable winds do not blow steadily equatorward, and may remain calm or even reverse for periods of 2–8 days shifting the balance between water column stability and replenishment of inorganic nutrients to the photic zone. In this study, we focus on the short-term variability of phytoplankton and heterotrophic bacterioplankton associated with the temporal variability in upwelling at a single nearshore station at the entrance of Coliumo Bay, Central Chile. In situ sampling took place every other day between 24 January and 14 February 2007. Observed variability of wind, sea surface temperature, and surface chlorophyll concentrations during the preceding weeks and throughout our experiments indicated that nearshore productivity was tightly coupled to local upwelling conditions. Gross primary production remained relatively low (22.5 ± 6.1 μg C L^{-1} h^{-1}) during the first 8 days (24 January–1 February), and increased six fold (142.4 ± 67.1 μg C L^{-1} h^{-1}) during the second period (3–14 February). Average in situ chlorophyll concentrations increased from 2.0 ± 0.6 mg m^{-3} to 6.3 ± 3.8 mg m^{-3} over the same period.

Bacterial Carbon Demand presented higher values (5–29.2 μg C L^{-1} h^{-1}) during the first 6 days of sampling and lower values (<0.1 μg C L^{-1} h^{-1}) for the rest of study period. Our results show that both biological productivity and the structure of the planktonic community can vary considerably due to short-term changes in wind conditions. Hence, previous productivity estimates for the Concepción upwelling ecosystem – based on observations gathered at lower frequencies – may not truly reflect its productivity potential.

1. Introduction

Recurrent coastal upwelling is one of the main factors promoting the exceptionally high productivity of the Humboldt Current System (HCS) (Daneri et al., 2000). Along the Chilean coast, the upwelling of nutrient-rich subsurface water occurs during episodes of strong S–SW winds (Strub et al., 1998; Figueroa and Moffat, 2000). The region off Concepción (~36°30′S) corresponds to the widest section of the continental shelf along the HCS (Sobarzo and Djurfeldt, 2004) and supports a large proportion of Chilean fish landings (Cubillos et al., 1998; FAO, 2006). The highest primary production rates reported for this region have been observed in October (Daneri et al., 2000), when the seasonal intensification of upwelling-favorable winds takes place. These upwelling-favorable winds, however, do not blow steadily towards the equator. In fact, periods of relaxation or even reversal of meridional winds can last from 2 to 8 days in this region (Peterson et al., 1988; Letelier et al., 2009). Upwelling favorable wind stress predominates from September to April reaching a maximum between December and February (Letelier et al., 2009).

Whereas the breakdown of stratification caused by upwelling replenishes the photic zone with inorganic nutrients, the relaxation of upwelling provides the necessary stability to trigger phytoplankton blooms (Daneri et al., 2000). These pulses of primary production, in turn, fuel heterotrophic activity in the coastal pelagic ecosystem (e.g. Barbosa et al., 2001; Cuevas et al., 2004; Kuznar et al., 2009). It follows that the temporal and spatial variability of the alongshore wind forcing may have drastic effects on both primary production and the structure of the pelagic food webs in upwelling ecosystems, which may ultimately determine net biogeochemical fluxes within these regions (Vargas et al., 2007). In this study, we assessed the variability of the biological production in relation to wind variability over a short time scale (days to weeks) at a coastal station near the entrance of Coliumo Bay, Chile. We used concurrent measurements of primary production,

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