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Community metabolism, phytoplankton size structure and heterotrophic prokaryote production in a highly productive upwelling zone off northern Chile

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ABSTRACT: We investigated the ecological factors affecting net ecosystem metabolism (as the ratio of gross primary production to community respiration) by studying functional relationships between total and fractionated autotrophic biomass, heterotrophic prokaryote production, nutrients and net ecosystem metabolism, considering short-term (daily) and seasonal scales of variability in oceanographic conditions and wind stress. These studies were performed at 2 coastal upwelling sites off northern Chile (Chipana, ~21° S; Mejillones, ~23° S) in winter 2005, summer 2006, winter 2006 and summer 2007. Changes in the direction and persistence of the upwelling, which is driven by wind stress on a synoptic scale (6 d), appeared to be an important factor modulating phytoplankton size structure. Gross primary production did not show seasonality, probably because of the permanent equatorward wind regime off northern Chile. The phytoplankton community was dominated by the microphytoplankton size fraction (>20 µm), which was largely responsible for the variability of the total phytoplankton biomass. We found that the increase in contribution of large phytoplankton cells could generate net autotrophy in response to increased nitrate concentrations in the mixed layer, emphasizing that the degree of decoupling between gross primary production and community respiration may be primarily controlled by upwelling. Our results showed that the degree of coupling between heterotrophic prokaryote production and gross primary production as well as the amount of organic matter processed by prokaryotes vary with changes in the dominance of autotrophic and heterotrophic processes in the microplanktonic community.

KEY WORDS: Phytoplankton size structure · Net ecosystem metabolism · Prokaryote net production · Upwelling system · Humboldt Current System

INTRODUCTION

The rationale for ecological models of carbon transfer in pelagic food webs that support high fish landings is based on the idea that large phytoplankton can be transferred to fish through an efficient herbivorous food web (Steele 1974). Nevertheless, empirical evidence has demonstrated that prokaryotes and their microprotozoan predators account for a large fraction of the ocean metabolism and represent an alternative pathway for carbon and energy other than the classical food chain (Pomeroy 1974, Sieburth et al. 1978, Williams 1981, Azam et al. 1983, Jahnke & Craven 1995).

The Humboldt Current System (HCS) off Chile is one of the most productive ecosystems of the world (Montecino et al. 2006), with primary production rates

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