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Seasonal changes in microzooplankton feeding behavior under varying eutrophication level in the Bahía Blanca estuary (SW Atlantic Ocean)

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ABSTRACT

Dilution experiments were conducted during a two-year survey in the Bahía Blanca estuary (SW Atlantic Ocean) to evaluate seasonal variations of microzooplankton grazing (m) and phytoplankton growth (μ). The trophic interactions between these groups were investigated in relation to anthropogenic eutrophication. For this purpose, two sites exposed differently to sewage input in the estuary were selected. The percentage of primary production grazed by microzooplankton averaged 79%, although this percentage showed high seasonal variability. The lowest consumer control was found in winter and summer, and was associated with high density of chain-forming diatoms. Conversely, the microzooplankton grazing exerted heavy control on phytoplankton biomass during spring and fall, in concurrence with the highest density of nanoflagellates. Results showed average differences between μ and m close to zero during most of the annual cycle, suggesting microzooplankton control of autotrophic prey in the two sites. Under high exposure to sewage, however, experimental results evidenced the prevalence of non-linear feeding response, poor trophic phasing at low phytoplankton growth rate and lower reactivity of microzooplankton grazing. Regardless their exposure to sewage input, microzooplankton was an important loss term of phytoplankton in the estuarine system and appear as a primary factor defining phytoplankton biomass accumulation.

1. Introduction

Microzooplankton grazing is an important pathway of phytoplankton loss in most aquatic systems, from the oligotrophic open-ocean to nutrient rich coastal waters (Calbet and Landry, 2004). They can rapidly synchronize productivity patterns and stabilize phytoplankton populations due to their short generation time (Strom, 2002). This rapid trophic response can minimize algal export to bottom layers, and thereby reduce the impact of disruptive algal blooms (Stoecker et al., 2005).

Several methods have been used to quantify in situ grazing rate of microzooplankton. The size-fractionation method, based on the incubation of different size fractions of plankton (Capriulo and Carpenter, 1980; Sato et al., 2007; Burian et al., 2013), assumes that consumers are larger than their prey, so micro- and nano-sized consumers can be separated from prey by filtering seawater through different mesh sizes. The grazing effect is then estimated by comparing prey growth rate in the presence and absence of consumers. Microzooplankton grazing can be also assessed by measuring the uptake of fluorescently-labeled tracers (Sherr et al., 1987). This approach has been successfully applied for the determination of grazing rate on homogeneous prey assemblages (Albright et al., 1987; Callieri et al., 2002; Sanders and Gast, 2011). Different prey taxa, however, may stain optimally with different dyes and staining protocols (Martínez et al., 2014), which makes the measurement of grazing on natural mix prey assemblages difficult. To date the most widely used method for the estimation of microzooplankton grazing is the dilution technique (Landry and Hassett, 1982). Its widespread use has generated a great amount of information that allowed comparing the impact of microzooplankton grazing on the global scale (Calbet and Landry, 2004; Schmoker et al., 2013). The technique is based on the reduction of encounter rate between consumers and their prey by the serial dilution of natural seawater with particle-free seawater. It has the advantage of simultaneously measuring microzooplankton grazing and phytoplankton growth assuming that the impact of grazing is linear with respect to the dilution factor (Landry et al., 1995). Several factors can modify the linear functional response of microzooplankton in dilution experiments. For instance, consumers may exhibit different growth rates along the dilution gradient (Dolan et al., 2000; First et al., 2007), and prey concentration may saturate microzooplankton feeding, thereby changing the clearance rate of consumers (Gallegos, 1989; Moigis, 2006).

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The Bahía Blanca estuary is a highly productive and eutrophic system located in the south western Atlantic Ocean coast, Argentina. The area is characterized by pronounced seasonality that shapes the annual cycle of plankton. Phytoplankton show two recurring productivity events occurring during summer and winter (Guinder et al., 2010, 2013). During the warmer season, zooplankton are characterized by the presence of omnivorous copepods and high ciliate biomass while during the colder season, mesozooplankton are dominated by herbivorous copepods and detritivore cirriped larvae and microzooplankton abundance remains low (Berasategui et al., 2009; Barría de Cao et al., 2011; Dutto et al., 2012). In the last three decades, the estuary has experienced cumulative organic pollution due to the dumpling of untreated sewage (Lara et al., 1985; Marcovecchio et al., 2008). Previous studies conducted on the sewage plume showed high phytoplankton biomass and dominance of small-sized, non-siliceous algae (López Abbate et al., 2015). The potential pathways of phytoplankton loss, however, has received less attention (Diodato and Hoffmeyer, 2008; Dutto et al., 2014).

This study aims to determine the effect of organic pollution on the trophic relationship between microzooplankton and their prey. Growth and grazing rates were measured by the dilution technique during a two-year survey in two sites with different exposures to sewage inputs in the Bahía Blanca estuary. The working hypotheses are that strong temperature gradient due to high seasonality controls the impact of microzooplankton grazing on phytoplankton, and that anthropogenic nutrient loading further interferes on microzooplankton grazing by affecting phytoplankton yield and composition.

2. Materials and methods

2.1. Study area

The Bahía Blanca estuary (38°45′–39°40′S, 61°45′–62°30′W) is located in the south western Atlantic Ocean coast, Argentina (Fig. 1). This area shows a temperate climate with marked seasonality (Montecinos et al., 2000). The estuary is a shallow and vertically homogeneous system that shows inverted salinity gradient as it experiences low influence from continental drainage (annual mean 2.7 $m^3\ s^{-1}$), high evaporation rate and restricted water circulation in the inner reach (Perillo et al., 2001).

Two sampling sites were carefully selected by considering similar geomorphological features, but contrasting conditions with regard to their exposure to sewage input (Fig. 1). Both sites are located within tidal channels ranging 50–300 m width and 4–7 m depth. The first site, Bahía del Medio (BM), is not directly impacted by human stress (Baldini et al., 1999; Hoffmeyer and Barría de Cao, 2007), while the second site, Canal Vieja (CV), is directly affected by anthropogenic pollution since it is located within the channel that receives the untreated domestic effluent from the adjacent Bahía Blanca city (300,000 inhab.). The volume of sewage effluent represents 23% of total

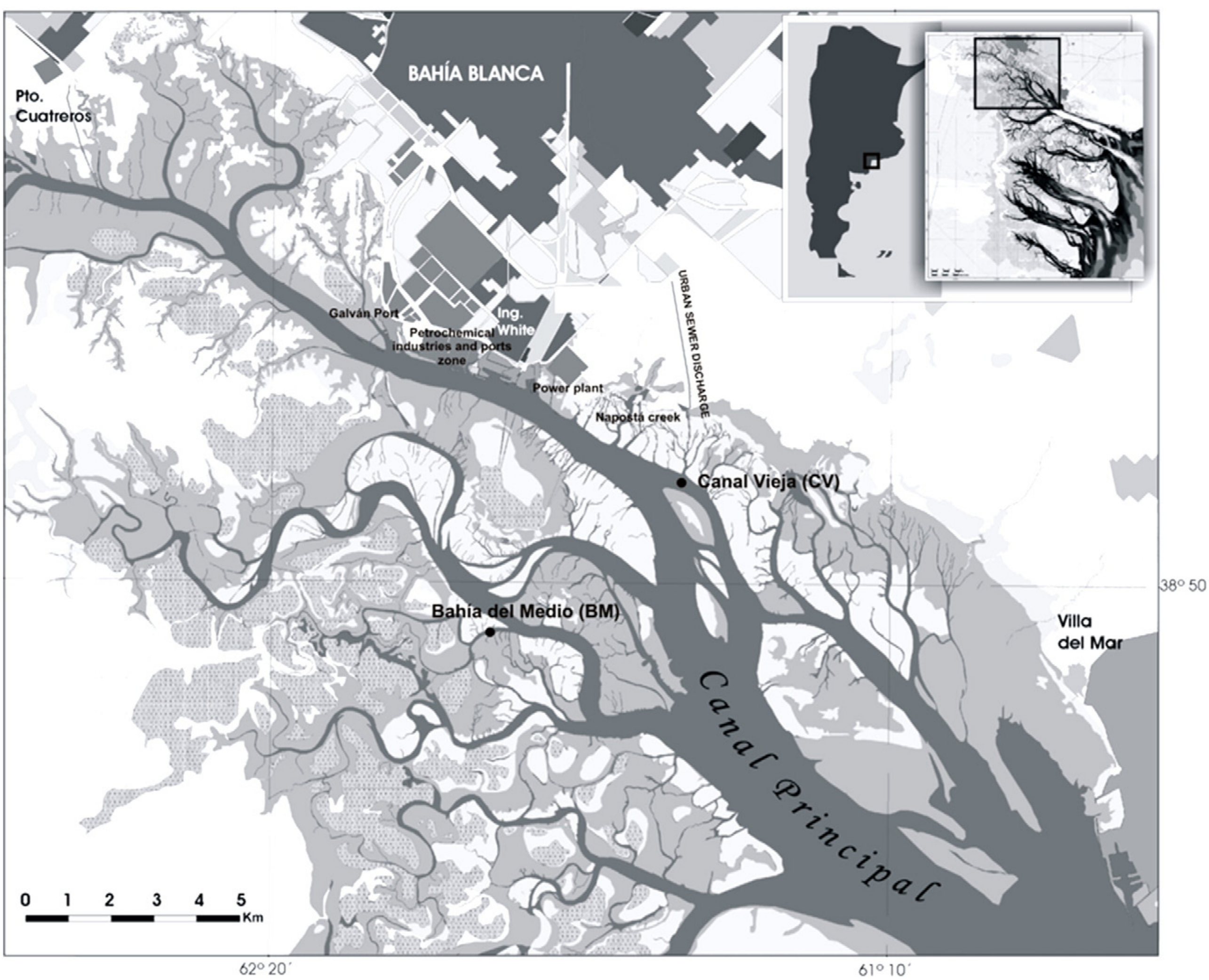

Fig. 1. Sampling area showing the location of two sampling sites exposed to low (Bahía del Medio, BM) and high anthropogenic eutrophication (Canal Vieja, CV).