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PLANKTON STRUCTURE A IN SHALLOW COASTAL ZONE AT ADMIRALTY BAY, KING GEORGE ISLAND, WEST ANTARCTIC PENINSULA (WAP): CHLOROPHYLL BIOMASS AND SIZE-FRACTIONATED CHLOROPHYLL DURING AUSTRAL SUMMER 2009/2010

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Abstract: *Chlorophyll a concentration and size structure of the phytoplankton community were studied in Admiralty Bay in early and late summer of 2009/2010, using spectrofluorometry chlorophyll analysis. Chlorophyll a biomass was generally low (<5 µg.L^{-1}) and showed a relatively spatial homogeneity. In this study the contribution of size fractions (<2 µm, 2-10 µm and >10 µm) in chlorophyll a biomass was analyzed for the first time in Admiralty Bay. Size fraction <10 µm represented more than 80% of the chlorophyll a concentrations.*

Keywords: size structure, spectrofluorometry, Antarctic, King George Island

Introduction

Phytoplankton pigments (chlorophylls, carotenoids, phycobiliproteins) remain a major source of information on biomass, community structure, dynamic, and physiological state of phytoplankton (Neveux *et al.*, 2009). Among the pigments, chlorophyll *a* concentration is used to access biomass of phytoplankton. Chlorophyll *a* distribution in the Southern Ocean showed high spatial and temporal variability (Marrari *et al.*, 2008). The area surrounding the South Shetland Islands along the Antarctic Peninsula, where King George Island is located, exhibits high phytoplankton biomass during the austral summer, with high nutrients and low chlorophyll (HNLC) conditions in Drake Passage to the north and in the Bransfield Strait to the south (Hewes *et al.*, 2009).

The size distribution of the primary producers plays an important role in the trophic organization of marine ecosystems and in the global flux of organic matter towards the aphotic layer (Jacques & Panouse, 1991). Size structures of phytoplankton communities are quantitative expressions of the relative success of certain different community size compartments to survive or grow in an essentially unstable environment controlled by physical and chemical characteristics (Rodriguez & Guerrero, 1994). Recent studies demonstrated that in the West Antarctic Peninsula (WAP), picoplankton and nanoplankton are the dominant groups, with microplankton diatoms being the second group in abundance (Montes-Hugo, 2009). In this study we presented the preliminary results of the monitoring program of chlorophyll *a* biomass and chlorophyll *a* size fraction conducted in Admiralty Bay, King George Island, during the summer of 2009/2010.

Materials and Methods

Study area

Admiralty Bay (62° 03'-12' S and 58° 18'-38' W), located at King George Island (Figure 1), is a deep fjord-like embayment with 500 m maximum depth at its centre (Rakusa-Suszczewski *et al.*, 1993). The waters from the bay mix with the deep oceanic waters from the Bellingshausen and Weddell Seas at its southern opening, which connects to the Bransfield Strait (Rakusa-Suszczewski, 1980; Lipski, 1987). The maximum depth varies between 60 m at the shores and 500 m in the centre of the bay. Deep currents generated by tides, frequent upwellings, vertical mixing and current velocities of 30-100 cm.s^{-1} in the 0-100 m surface stratum are characteristic of the bay (Rakusa-Suszczewski *et al.*, 1993).

Sampling

The fractionate analysis of chlorophyll *a* was performed from splits of the 5 L water sample collected using a Niskin bottle from the surface, middle water column and near the bottom (≈30 m) at five stations in December 2009 and in February 2010. At the same time temperature and salinity analyses were carried out by the Laboratório de Química Orgânica Marinha (LabQOM), Instituto Oceanográfico da Universidade de São Paulo.

Chlorophyll *a* and phaeophytin *a*

Water samples (2 L) were filtered onto Whatman® GF/F (Ø 47 mm) for total pigment analyses, while 0.8-2 L were used for the size structure study. In the latter case, during late summer sampling at CF, MP and AR stations (Figure 1), water sampled at 3 depths was fractionated by serial filtration on 10 μm and 2 μm polycarbonate filters and GF/F (Ø 47 mm). The filters were folded, placed into a 1.2 mL cryotube and immediately quick-frozen in liquid nitrogen (−196 °C) and stored at −80 °C. For pigment extraction, GF/F filters were dipped in 5.4 mL of 100% acetone (final concentration ≈90% acetone taking into account water retention by the filter (≈0.621 ± 0.034 mL) and ground

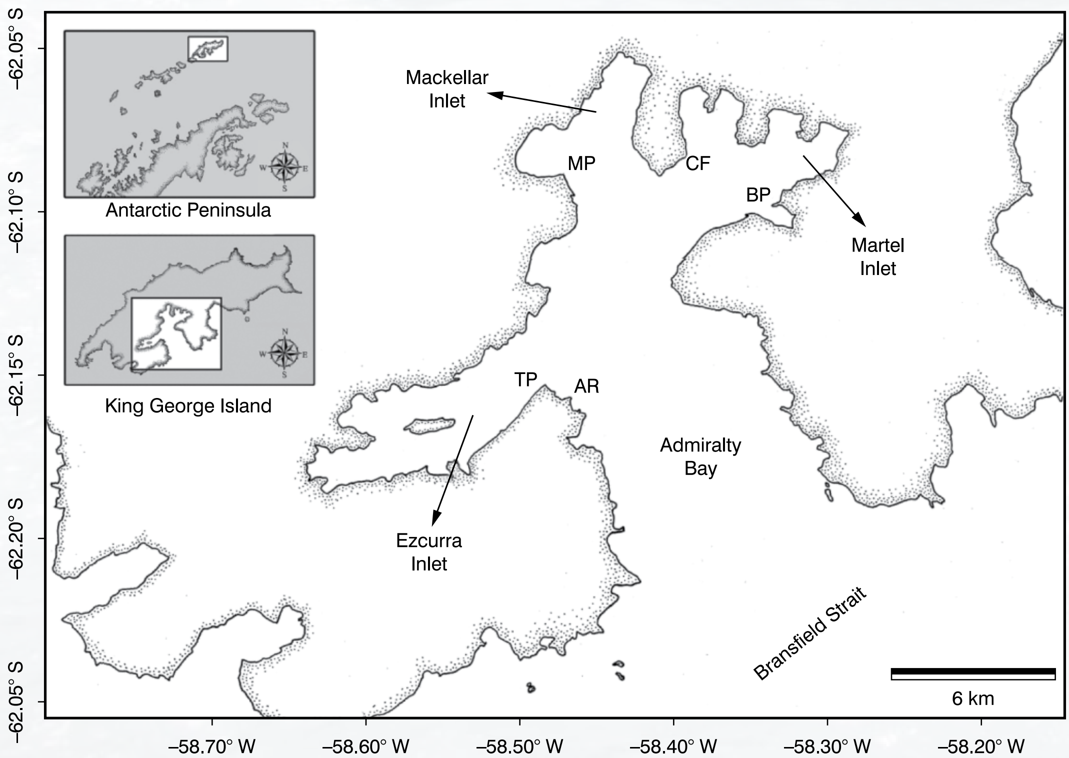

Figure 1. Study area (modified from Moura, 2009) with the position of the sampling sites: Ferraz Station (CF), Botany Point (BP), Machu Picchu (MP), Thomas Point (TP), Arctowski (AR).

with the freshly broken end of a glass rod, and left in the dark at 4 °C for a 12 hours extraction. Polycarbonate filters, on the other hand, were just left in the dark at 4 °C for a 24 hours in 5 mL of 90% acetone. Following extraction, the tubes were centrifuged for 5 minutes at 3500 rpm and the extracted fluorescence was measured with a Varian Cary Eclipse® spectrofluorometer. Concentrations of chlorophyll-*a* and phaeophytin-*a* were assessed using a modified version of Neveux and Lantoine's (1993) method. The modifications were as follows: 1) data acquisition was performed by recording the fluorescence emission spectra for each of 15 excitation wavelengths (3-nm increments from 390 to 432 nm), emission spectra were recorded at 4 nm intervals from 659-715 nm, yielding 29 data points for each spectrum. Pigment concentrations were estimated from the resulting 435 data points, and 2) where the least squares approximation technique was constrained to discard negative solutions.

Statistical analyses

Differences among surveys and sampling stations were tested using a One-Way ANOVA with a Kruskal-Wallis test ($p < 0.05$). Spearman's correlation factor was also calculated.

Results

Thermohaline structure

During the sampling period, water temperature was characterized both by spatial and vertical homogeneity. Early summer presented colder waters (0.09 ± 0.44 °C, n = 60) than those observed during late summer (0.81 ± 0.23 °C, n = 45). Negative values were observed during early summer and increased throughout the season (Figure 2a). Although salinity decreased during the sampling period, mean values were similar between early summer (34.2 ± 0.1, n = 60) and late summer (34.1 ± 0.2, n = 45) (Figure 2b). During late summer, inner sampling stations (CF, BP and MP) showed the greatest changes in surface salinity, mainly on 13th and 19th February (Figure 2b).

Chlorophyll a biomass and size structure

Chlorophyll-*a* (Chl*a*) biomass was often low, and varied from 0.34 μg.L^{-1} (± 0.07, n = 60) to 0.47 μg.L^{-1} (±0.21, n = 45) during early and late summer, respectively, with no great variability observed among stations and vertical profiles during each period. Values lower than 0.5 μg.L^{-1} were observed in 93% and 56% of the samples during late and early summer, respectively. Chl*a* increased in both periods, especially during late summer, when biomass varied from 0.24 to 0.65 μg.L^{-1} (Figure 3a). The increasing in Chl*a* biomass in late summer was positively correlated with water temperature ($r = 0.39$; $p < 0,05$). In late summer, picoplanktonic fraction (<2 μm) represented on average 37% (±8.4, n = 36) of Chl*a*, whereas the class size between 2-10 μm represented 44% (±3.7, n = 36) (Figure 3b). The fraction >10 μm accounted on average for only 19% (± 8.6, n = 36); and this contribution decreased over 50% towards the end of the sampling period, mainly due to the

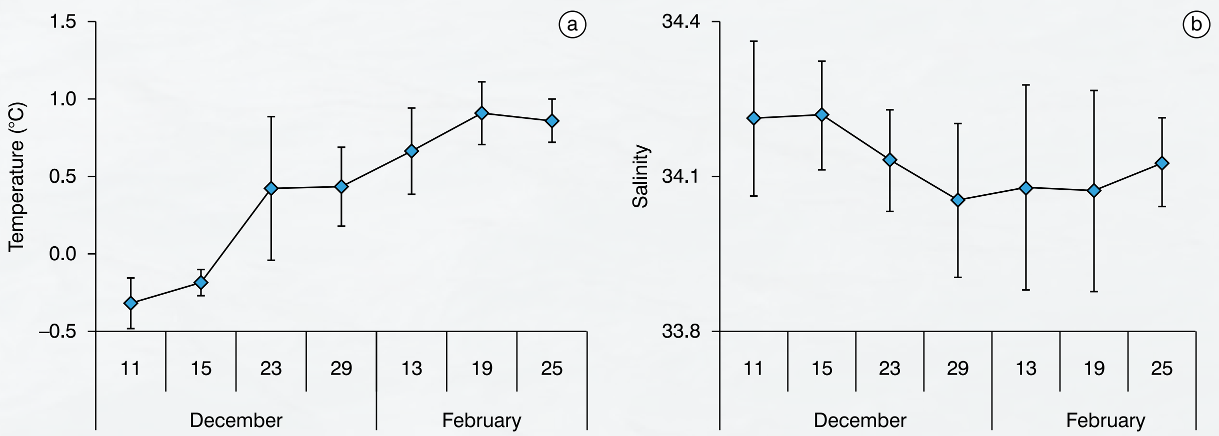

Figure 2. Temporal variation of water temperature °C (a) and salinity (b) in Admiralty Bay during December 2009 and February 2010.

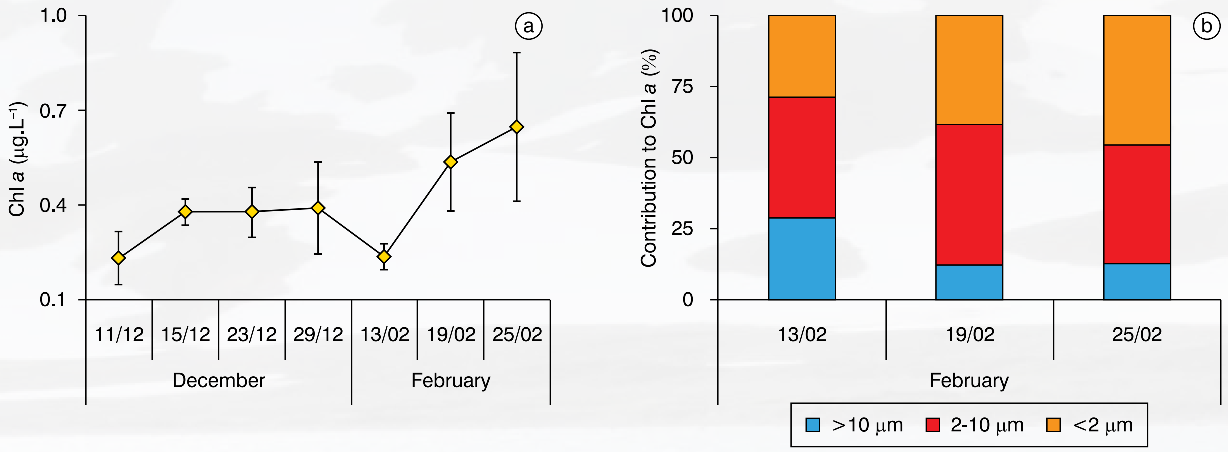

Figure 3. Temporal variation of Chlorophyll *a* : a) concentrations during December 2009 and February 2010, b) contribution to size distribution during February 2010.

increase of picoplankton contribution. As observed for total Chl*a* biomass, the vertical and spatial variability of size fractionated Chl*a* was not significantly different.

Discussion

Hidrology

Early and late summer values of temperature and salinity observed in the present study were similar to those reported in previous studies (Brandini, 1993; Lange *et al.*, 2007). The greatest variability in surface salinity observed during late summer at the most inner stations (CF, BP and MP) was mainly due to the inflow of freshwater, which increased from melting snow and glacial ice as a consequence of the rise in temperature.

Chlorophyll-*a*, an indicator of overall phytoplankton abundance and chlorophyll *a* size structure

Low Chl*a* biomass (<1 µg.L^{-1}), as observed in Admiralty Bay during late summer of 2009/2010, was commonly reported in previous studies (Brandini, 1993; Lange *et al.*, 2007) as well as on adjacent areas (Brandini & Kutner, 1986; Kang & Lee, 1995) and in Antarctic oceanic waters, despite high nutrient concentrations (Platt *et al.*, 2003). The relatively homogeneous vertical distribution during all the sampling period was also observed by Brandini and Rebello (1994).

The size distribution of the primary producers plays an important role in the trophic organization of marine ecosystems and in the global flux of organic matter towards the aphotic layer (Jacques & Panouse, 1991). The contribution of size fractions (<2 µm, 2-10 µm and >10 µm) to Chl*a* biomass at Admiralty Bay is described for the first time. In the Admiralty Bay, Chl*a* was co-dominated by pico (37%) and 2-10 µm size-class (44%), while cells >10 µm represented only 19% of the Chl*a* biomass. Previous studies in the same area have reported nano-size cell dominance on phytoplankton (Brandini, 1993; Kopczynska, 2008). Size-class distribution in the present study were similar to those observed in the vicinity of Elephant Island (Weber & El-Sayed, 1987), where the contribution to total Chl*a* ranged between 39-98% for nanoplankton and between 5-74% for picoplankton. Moreau *et al.* (2010) also observed a pico-nanoplankton dominance and microplankton in very low abundances at Melchior Archipelago (Antarctic Peninsula) during a spring-season study.

Phytoplankton biomass and growth in the water column at Admiralty Bay can be strongly influenced by wind-driven turbulence (Brandini & Rebello, 1994). In coastal areas wind-

driven turbulence may have a positive effect, leading to a phytoplankton biomass accumulation as a consequence of benthic diatoms (generally larger than 10 μm) resuspension, and, consequently, affecting secondary production. In this study they observed Chl*a* increasing during a low wind and water column stabilization period after an intense upwelling event promoted by wind stress. The low biomass and low contribution of cells >10 μm to Chl*a* observed in the present study suggest a long low-wind period; however, this will need to be checked later in our studies.

The temperature sensitivity of planktonic organisms suggests that Southern Ocean plankton communities may be particularly sensitive to global warming (Wright *et al.*, 2009). In the nearshore coastal waters along the Antarctic Peninsula, a recurrent shift in phytoplankton community structure, from diatoms to cryptophytes, has been documented (Moline *et al.*, 2004). A change in the size spectrum of Southern Ocean phytoplankton would be expected to have serious consequences for krill and other herbivores that are adapted to a diet of nano- and microplankton, and would also affect the dynamics of the microbial loop and the transport of carbon to the deep ocean (Wright *et al.*, 2009). These observations highlight the importance of a long-term monitoring study of Chl*a* size fraction data in this region.

Conclusion

The preliminary results of the present study showed a relatively spatial homogeneity in chlorophyll *a* concentration. Temporal variation presented a significant variability between early and late summer and among the three samplings during late summer, highlighting that a short-term temporal variation study is necessary to understand the environmental effects on phytoplankton organisms. Phytoplankton populations were co-dominated by nano and picoplanktonic cells, which represented more than 80% of chlorophyll *a* concentrations. Chlorophyll *a* biomass and size fractionated studies in the Admiralty Bay proved to be a good tool for monitoring the global effect of changes on the region.

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