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PLANKTON STRUCTURE OF THE SHALLOW COASTAL ZONE AT ADMIRALTY BAY, KING GEORGE ISLAND, WEST ANTARCTIC PENINSULA (WAP): CHLOROPHYLL BIOMASS AND SIZE-FRACTIONATED CHLOROPHYLL DURING AUSTRAL SUMMER 2010/2011

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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 2010/2011, using spectrofluorometry chlorophyll analysis. The contribution of three size fractions: picoplankton (< 2 µm), ultraplankton (2-10 µm) and microplankton (> 10 µm) in chlorophyll a biomass was analysed. Chlorophyll a biomass increased from early to late summer and showed a relatively spatial homogeneity. During early summer biomass was co-dominated by ultra and microplankton size classes in with account 84% of Chla biomass, while in the late summer >10 µm size classes dominated completely Chla concentrations (88%).*

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. In Antarctic waters, chlorophyll *a* and rates of primary production are generally low, yet concentrations of inorganic nutrients are very high (Mitchell & Holm-Hansen, 1991). Chlorophyll *a* distribution in the Southern Ocean also showed high spatial and temporal variability (Marrari *et al.*, 2008).

Although chlorophyll biomass is important, it does not necessarily draw out the relationships between primary producers and other organisms higher up the food chain (Gin *et al.*, 2000). This inconvenient can be largely elucidated by assessing the size structure of the plankton community. 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 *et al.*, 2009). In this study we present the preliminary results of the monitoring program of chlorophyll *a* biomass and chlorophyll *a* size fraction biomass conducted in Admiralty Bay, King George Island, during the summer of 2010/2011.

Materials and methods

Study area

Admiralty Bay (62°03'-12'S, 58°18'-38'W), located at King George Island, 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 (Lipski, 1987). The maximum depth varies between 60 m close to the shore 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, 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 (≈ 30m) at five stations in six surveys (December 2010 to March 2011). Temperature was measured *in situ* while salinity analyses were carried out by the Laboratório de Química Orgânica (IO-USP).

Chlorophyll a

Water samples (0.3L) were filtered onto Whatman® GF/F (Ø 47 mm) for total pigment analyses, while 0.5-1L were used for the size structure study. In the latter case at CF, MP and AR stations, water sampled at 3 depths was fractionated by serial filtration on 10 μm and 2 μm polycarbonate filters and GF/F (Ø 47 mm) to access the pigment concentration of picoplankton (< 2 μm), ultra plankton (2-10 μm) and microplankton (> 10 μm). 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%

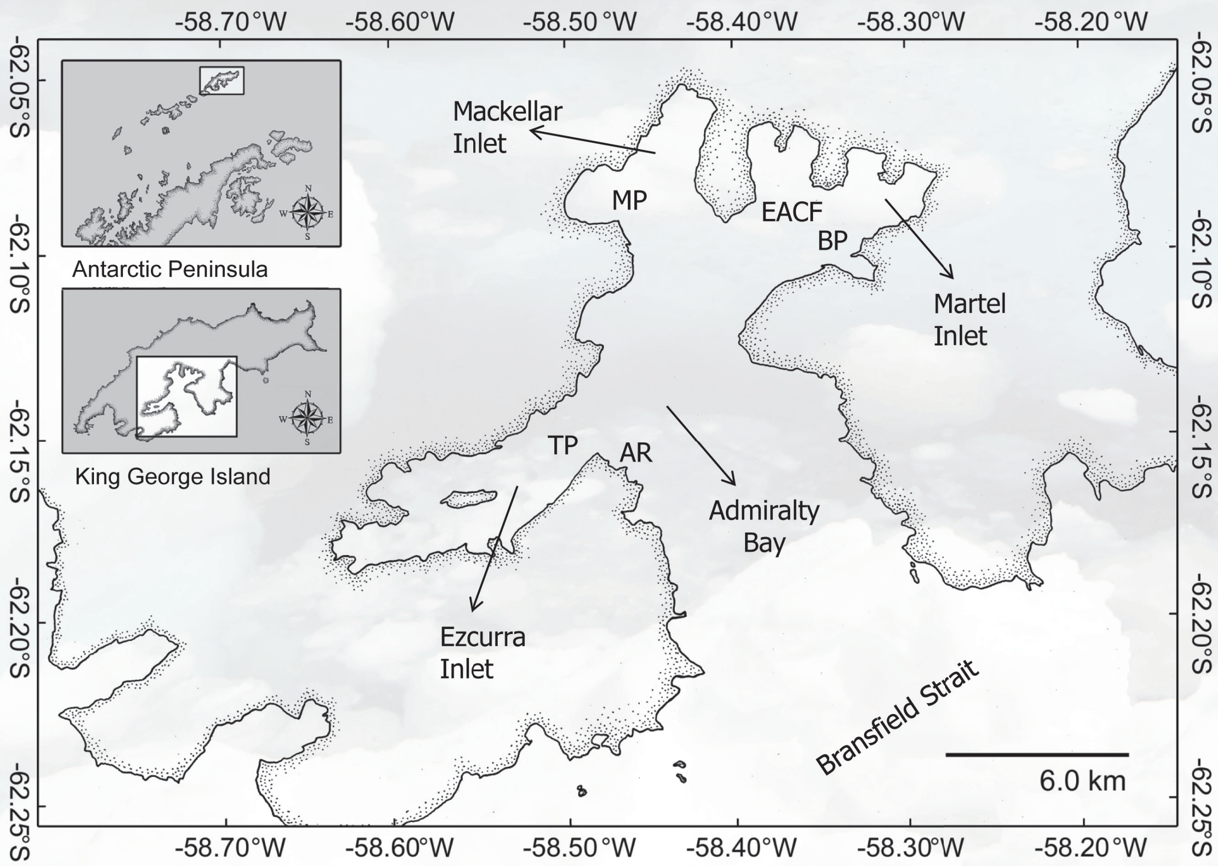

Figure 1. Study area with the position of the sampling sites: Ferraz Station (CF), Botany Point (BP), Machu Picchu (MP), Thomas Point (TP), Arctowski (AR), modified from Moura (2009).

acetone (final concentration ≈ 90% acetone taking into account water retention by the filter (≈ 0.621 ± 0.034 mL) and ground with the freshly broken end of a glass rod, and left in the dark at 4 ºC for a 12h extraction. Polycarbonate filters, on the other hand, were just left in the dark at 4 ºC for a 24h in 5 mL of 90% acetone. Following extraction, the tubes were centrifuged for 5 min at 3500 rpm and the extracted fluorescence was measured with a Varian Cary Eclipse® spectrofluorometer. Concentrations of chlorophyll *a* were assessed using a modified version of Neveux & Lantoine's (1993) method in Tenório *et al.* (2011).

Statistical analyses

Differences among surveys (n = 6), sampling stations (n = 5), vertical profile (n = 3) 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, thermohaline structure was characterized both by spatial and vertical homogeneity, except on the 21th February when temperature and salinity differed significantly in the water column. Early summer (December and January) presented colder waters (0.75 ± 0.42 °C, n = 54) than those observed during late summer (1.61 ± 0.15 °C, n = 25). Although salinity decreased slightly during the sampling period, mean values were similar between early summer (34.2 ± 0.2, n = 51) and late summer (34.1 ± 0.2, n = 30) (Figures 2a and 2b).

Chlorophyll a biomass and size structure

Chlorophyll *a* (Chl*a*) biomass increased from early to late summer from 0.54 ± 0.12 µg L^{-1} (n = 15) to 4.03 ± 1.33 µg L^{-1} (n = 15) and was positively correlated with temperature (r = 0.74, $p < 0.001$) (Figure 3a). Values lower than 1 µg L^{-1} were observed in 64% of the samples during early summer and only 17% in late summer. A significant spatial variability among each survey was not observed, except on 14th December and 21st February. BP showed biomass twice as high (0,72 µg L^{-1}) than the other stations during the first survey, while on 21st February the TP and AR presented biomass twice as superior (2,64 µg L^{-1}) to the inner stations located in Mackellar and Martel inlet.

In early summer, picoplanktonic fraction (< 2 µm) represented on average 17 ± 7% (n = 28) of Chl*a*, whereas ultraplankton represented 33 ± 10 % (n = 28) and microplankton accounted on average 51 ±11% (n = 28). In late summer, microplankton contribution to Chl*a* biomass increased and represented on average 88 ± 10% (n = 18) reaching over 93% at the end of the sampling period (Figure 3b). The vertical and spatial variability of size fractionated Chl*a* was not significantly different ($p > 0.05$).

Discussion

Late summer values of temperature and salinity observed were similar to those reported in previous studies (Lange *et al.*, 2007; Tenório *et al.*, 2011), however early summer water temperatures were higher than those observed during summer 2009/2010 in the same Bay (Tenório *et al.*, 2011).

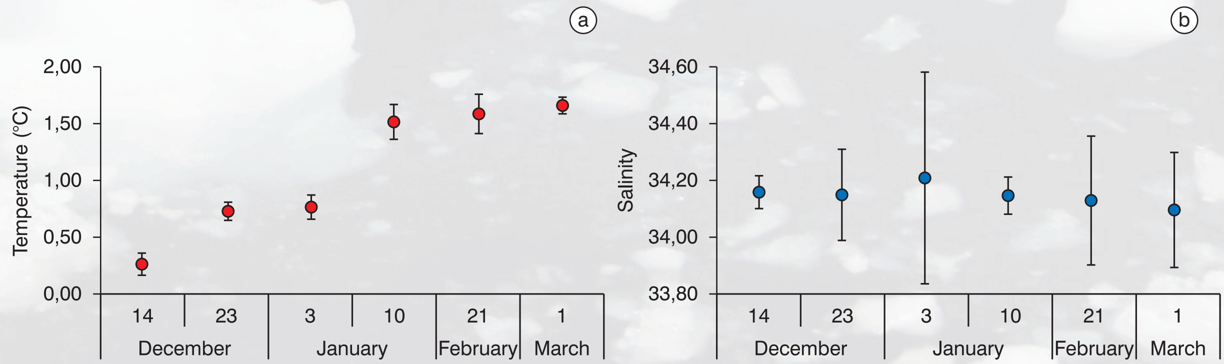

Figure 2. Temporal variation of water temperature (a) and salinity (b) in Admiralty Bay during December 2010 to March 2011.

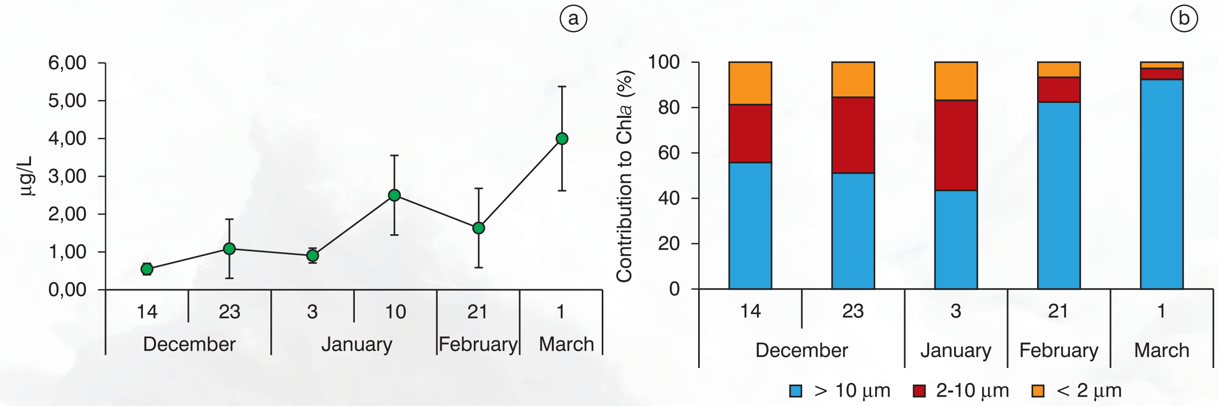

Figure 3. Temporal variation of Chlorophyll *a*: a) concentrations and b) contribution to size distribution in Admiralty Bay during December 2010 to March 2011.

Low Chl*a* biomass (~2 µg L^{-1}), as observed during early summer of 2010/2011, was commonly reported in previous studies in Admiralty Bay (Brandini, 1993; Lange *et al.*, 2007, Tenório *et al.*, 2011) as well as in adjacent areas (Brandini & Kutner, 1986; Kang & Lee, 1995) and in Antarctic oceanic waters (Platt *et al.*, 2003). In late summer the increase of biomass was mainly conditioned by the rise of temperature that melts the ice providing the micronutrient iron to phytoplankton growth (Martin *et al.*, 1991) and promoting water column stratification maintaining the phytoplankton in the euphotic zone (Lipski, 1987).

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 water column (Jacques & Panouse, 1991). During early summer biomass was co-dominated by ultra and microplankton representing 84% of Chl*a* biomass, while in the late summer only microplanktonic fraction dominated completely Chl*a* concentrations (88%). Previous studies in the same area have reported the dominance of 2-20 µm size fraction on phytoplankton (Brandini, 1993; Kopczynska, 2008) or microplanktonic diatom dominance as observed on James Ross Island (Weddell Sea) (Souza, 2012). In this sense, a positive correlation with total chlorophyll biomass and microphytoplankton cells count ($r = 0.77$, $p < 0.05$) was observed for Admiralty Bay by Barrera-Alba *et al.* (2012). Similarly, our results showed positive correlation between total Chl*a* and microplanktonic fraction concentration ($r = 0.67$, $p < 0.05$), pointing out that fraction was the main component of the phytoplankton community. However, this pattern was not observed in the previous study during the summer 2009/2010, when pico and ultraplankton dominated the Chl*a* biomass (Tenório *et al.* 2011). This variability of the size structure and functional composition of phytoplankton are closely linked to physical, chemical and biologic factor gradients in the coastal waters (Rodríguez *et al.*, 2002; Kang & Lee, 1995).

The temperature sensitivity of planktonic organisms suggests that Southern Ocean plankton communities may be particularly sensitive to global warming (Wright *et al.*, 2009). 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, highlighting that a short-term temporal variation study is necessary to understand the environmental effects on phytoplankton organisms. Phytoplankton populations were co-dominated by ultra and microplankton, which represented more than 80% of chlorophyll *a* concentrations. Chl*a* biomass and size fractionated studies in Admiralty Bay proved to be a good tool for monitoring the global effect of changes on the region.

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