PLANKTON STRUCTURE A IN SHALLOW COASTAL ZONE AT ADMIRALTY BAY, KING GEORGE ISLAND WEST ANTARCTIC PENINSULA (WAP): COMPOSITION OF PHYTOPLANKTON AND INFLUENCE OF BENTHIC DIATOMS

http://dx.doi.org/10.4322/apa.2014.035

Denise Rivera Tenenbaum[1,*], Priscila Lange[1,3], Luciano F. Fernandes[2], Mariana Calixto-Feres[2], José Juan Barrera-Alba[1], Virgínia M. T. Garcia[3]

[1]Laboratório de Fitoplâncton Marinho, Instituto de Biologia, Universidade Federal do Rio de Janeiro – UFRJ, Rio de Janeiro, RJ, Brazil
[2] Departamento de Botânica, Setor de Ciências Biológicas, Universidade Federal do Paraná – UFPR, Curitiba, PR, Brazil
[3] Laboratório de Fitoplâncton e Microorganismos Marinhos, Instituto de Oceanografia, Universidade Federal do Rio Grande – FURG, Rio Grande, RS, Brazil

*e-mail: deniser@biologia.ufrj.br

Abstract: *The phytoplankton composition and biomass are being monitored in Admiralty Bay, Antarctic Peninsula since 2002 to detect possible interannual changes on a long-term monitoring perspective. In this report, we present the results of the 2009/2010 monitoring program regarding the phytoplankton composition during the PROANTAR XVIII operation. The community was dominated by both planktonic and benthic diatoms. A total of 140 species were found, many of them awaiting further morphological studies to determine their specific identity. A preliminary assessment of habitat preferences was made, showing that the diatoms in the Admiralty Bay came from distinct substrates like ice, rocks, sediments, plankton and macroalgae. These results indicate that benthic microalgae, particularly diatoms, play an important role in primary productivity of the pelagic community in inshore waters. The next steps will be to refine identification to analyse the whole water samples and to relate the results with the environmental and hydrographical features in Admiralty Bay.*

Keywords: phytoplankton, monitoring, Admiralty Bay, Antarctic Peninsula

Introduction

Phytoplankton is the main contributor to primary production in the Antarctic food web, making the organic carbon available to most of the higher trophic level consumers; for instance, the krill *Euphausia superba* (Knox, 1994). Summer phytoplankton blooms, are usually composed of diatoms (e.g. *Fragilariopsis*, *Nitzschia*, *Porosira* and *Corethron*), particularly when the preceding winter is a long one, and the ice cover is greater, offering more substrate for diatoms apart from the water column, which is, in turn, dominated by *Asteromphalus*, *Chaetoceros*, *Thalassiosira* (El-Sayed & Fryxell, 1993). After the decaying of diatom bloom, the prymnesiophyte *Phaeocytis* predominates. In warmer winters cryptophytes become also important affecting small zooplankton consumers such as krill and microcrustaceans (Moline *et al.*, 2004). The Antarctic phytoplankton, like other marine organisms, have been affected by the recent global climate changes registered over the past three decades. The main physical and chemical consequences to the water column are: 1) the progressive delay in ice covering during autumn and the earlier ice melting in Spring;

2) the warming of seawater southward; 3) the freshening of saltwater in neritic regions; and 4) alterations in nutrient concentrations. Moreover, the ozone depletion has led to a dramatic increase of damaging ultra violet radiation, which has been shown to induce photoinhibition of photosynthesis in phytoplankton. Therefore, the phytoplankton community can be used as indicator of global changes, especially when long term data is gathered in monitoring stations, providing more consistent results and allowing for the prediction of future negative effects from human interference. Indeed, some studies have already detected a shifting in phytoplankton communities due to climate changes along the Western Antarctic Peninsula (WAP). In the northern region, phytoplankton is being replaced by temperate, ice avoiding non-diatom species, with a concurrent decline of primary production, while in the southern sector the phytoplankton has increased in biomass contribution, becoming diatom based and displaying higher production (Montes-Hugo *et al*., 2009). These strong latitudinal shifts at the base of the food web can be the cause of the observed reorganization of the biota in the Northern region of the Antarctic Peninsula in recent years, especially the krill *Euphausia superba* and the Antarctic silverfish *Pleurogramma antarcticum*. A phytoplankton monitoring program was established in 2002 at Admiralty Bay, aiming to record the composition, biomass and its relationship with environmental parameters in shallow waters (<30 m) during the Antarctic summer. On a long term perspective, this study can lead to the detection of changes in species composition and abundance, associating them both to local and the global changes, as well as the anthropogenic impacts inside the bay due to human activities. In this paper the first results of the 2009-2010 phytoplankton monitoring at Admiralty Bay during the XXVIII PROANTAR (Brazilian Antarctic Operation) are reported, as well as a preliminary discussion about the diversity of diatoms associated to their different substrate preferences.

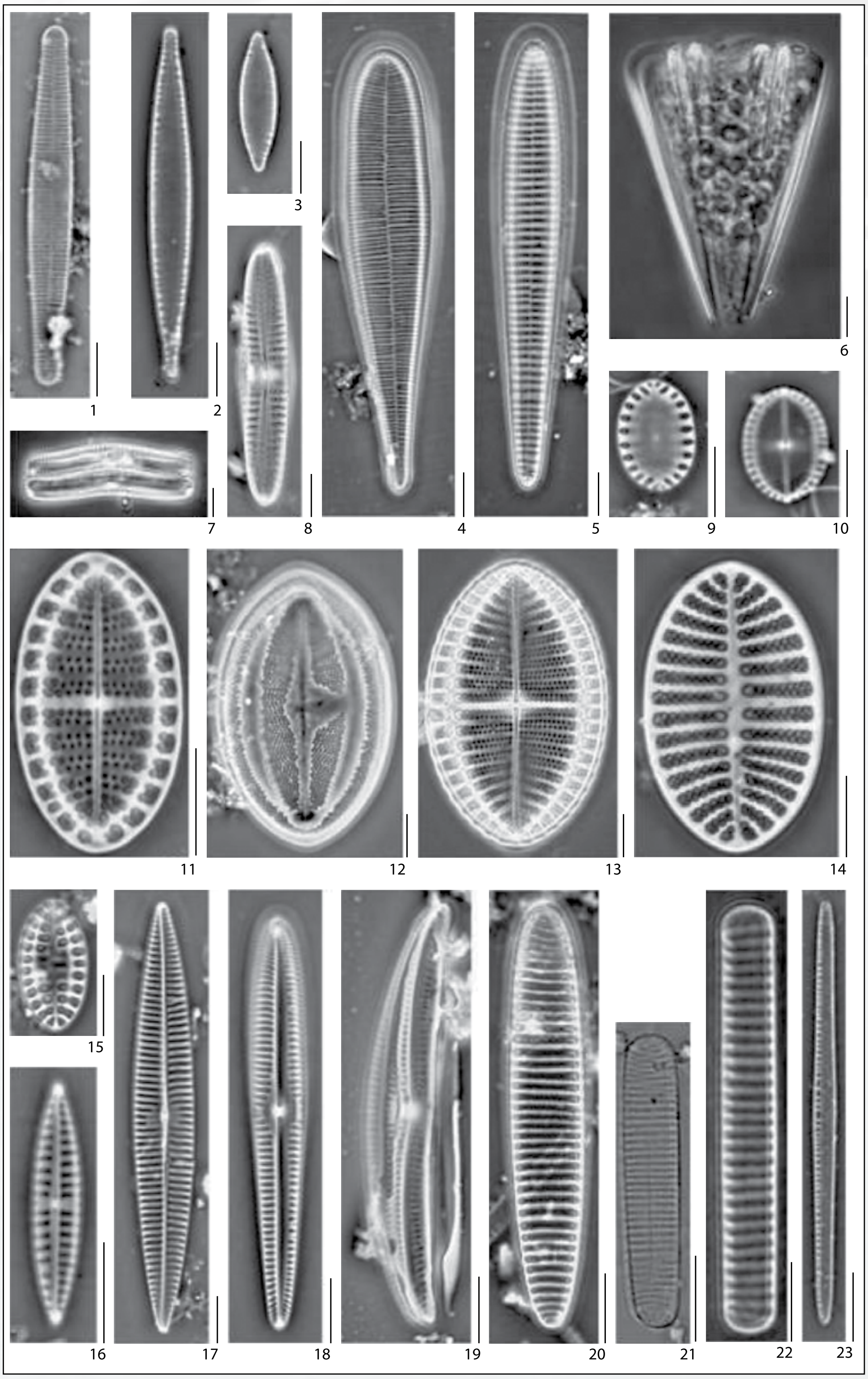
Material and Methods

Water samples were fixed with buffered formaldehyde (final concentration 2%) and analysed by the settling technique (Utermöhl, 1958) using an Olympus IX70 inverted microscope at 200 to 400 x magnification. Live samples were observed at EACF laboratory immediately after the sampling processes. A 20 µm mesh plankton net was towed from the bottom to the surface of all the stations. Samples were screened alive to record delicate or abundant species, and then preserved in formaldehyde 2% final concentration. Frustules were cleaned following the technique of Hasle and Fryxell (1970). Permanent slides were prepared using Naphrax (r.i. = 1.74) as mounting media and observed in Light Microscopy using a Olympus IX-70 equipped with phase and differential contrast systems. A Philips LX30 scanning electron microscope was used under 10-20 KV acceleration voltages. For Transmission Electron Microscope observations, a small drop of cleaned or distilled water washed material was gently placed onto 150 mesh nickel grids coated with Formvar and Carbon. Grids were air dried and kept in desiccators until the TEM sessions with a Jeol JM120 EXII electron microscope. Terminology followed Round *et al*. (1990) and Hasle and Syvertsen (1997).

Results

A total of 140 species has been found for the time being, many of them still awaiting further examination to determine their species level. Diatoms were by far the phytoplankton dominant group (Plate 1, Figures 1-23). A few cells of dinoflagellates *Protoperidinum* spp., *Amphidinium* spp., *Gymnodinium* spp., *Gyrodinum* spp. and *Prorocentrum* spp. were detected. The silicoflagellate *Distephanus speculum* appeared in some samples. Although no quantitative assessment has been done until now, it is clear that some species are more abundant than others like *Corethron pennatum*, *Fragilariopsis* spp., *Thalassiosira* spp., *Achnanthes* sp. and *Fragilaria striatula*. A preliminary assessment of habitat preferences was made, showing that the diatoms in the Admiralty Bay came from distinct environs. The main diatom genera found in 2002-2010, and the potential substrate preference of each one are listed in Table 1.

There were 21 planktonic genera recorded, and 22 benthic (epiphytic, epilithic, epipsamic and eponthic),



Figures 1-23. Common species found in Admiralty Bay, Antartic Peninsula: 1) *Fragilaria striatula*; 2, 3) *Synedropsis recta*; 4) *Licmophora belgicae*; 5) *L. antarctica*; 6) *Licmophora* sp.; 7, 8) *Achnanthes brevipes*; 9, 10) *Cocconeis* sp.; 11) *Cocconeis* sp.; 12) *Cocconeis* "*antiqua*"; 13, 14) *Cocconeis* sp.; 15) *Cocconeis* sp.; 16) *Navicula* sp.; 17) *Navicula cf directa*; 18) *Pseudogomphonema kamtschaticum*; 19) *Amphora* sp.; 20) *Fragilariopsis obliquecostata*; 21) *Fragilariopsis curta*; 22) *Fragilariopsis cylindrus*; 23) *Pseudo-nitzschia* sp. Scale bar: 10 μm.

Table 1. List of genera (number of species) and habitat preference of commonly found diatoms in Admiralty Bay during 2002-2010 monitoring program of phytoplankton.

Achnanthes (4) B	*Diploneis* (1) P,Ep,El	*Hantzschia* (1) Ep	*Pinnularia* (1) P	*Stauroneis* (1) P
Actinocyclus (2) P	*Entomoneis* (1) Ep,El	*Haslea* (1) E, B	*Plagiotropsis* (1) P	*Stellarima* (1) P
Amphora (4) B, P	*Ephemera* (1) P	*Licmophora* (6) B	*Pleurosigma* (2) Ep,El,P	*Surirella* (10) El, B
Asteromphalus (1) P	*Eucampia* (1) P	*Manguinea* (1) P	*Porosira* (2) P	*Synedra* (1) E, El
Chaetoceros (7) P	*Fragilaria* (1) Ep,Ep	*Melosira* (2) P	*Proboscia* (1) P	*Synedropsis* (2) B
Cocconeis (12) B	*Fragilariopsis* (10) Ep	*Membraneis* (1) P	*Pseudogomphonema* (2) B	*Tabularia* (1) B
Corethron (2) Ep, P	*Gephyria* (1) E	*Navicula* (12) B,P	*Pseudo-nitzschia* (2) P	*Thalassionema* (1) P
Coscinodiscus (3) P	*Gomphonema* (3) B	*Nitzschia* (7) B	*Rhizosolenia* (2) P	*Thalassiosira* (6) P
Cylindrotheca (1) Ep	*Grammatophora* (1) B	*Odontella* (3) P	*Rhoicosphenia* (1) B	*Thalassiothrix* (1) P
Dactyliosolen (1) P	*Gyrosigma* (1) Ep,El	*Parlibellus* (1) El	*Rhopalodia* (1) B	

B: benthic anywhere; E: epiphytic; Ep: eponthic; El: epilithic; P: planktonic.

all of them in the water column. During the phytoplankton analysis based on whole water samples used in the monitoring program, many species could not be identified (Lange *et al.*, 2007). This problem was partially solved when light microscope slides were prepared. Even so, many species still remained unidentified until more advanced techniques were used, like electron microscopy.

Discussion

A fairly high diversity of phytoplankton was found during the 2002-2010 monitoring, especially taking into account the contribution of benthic community to the water column. Usually diatoms dominated the composition and the biomass of the plankton community. Other research programs on phytoplankton monitoring, near the Polish Station have found similar results. Kopczynska (2008) reviewed the outcomes of plankton monitoring in Admiralty Bay and found the diatoms *Fragilariopsis, Pseudo-nitzschia* and *Thalassiora* to be abundant in inshore locations while *Proboscia* and *Thalasiosira* species were found at other sites. In our study, many microalgae (like *Cocconeis* and *Pseudogomphonema*) are known to live associated to a substrate in some way. It is becoming clear that they play an important role in the pelagic primary production during the austral summer. Several authors found that microphytobenthic diatoms were as important as the planktonic species, and even surpassed its biomass, in shallow areas and inlets around the Antarctic Peninsula (Ahn *et al.*, 1994, 1997; Kang *et al.*, 1997). The relevance of the origin of benthic diatoms as regards their substrate affinity has been emphasized, except for ice algae (s. review of Medlin & Priddle, 1990). There are four recent studies that specifically focus on benthic species other than originating from ice (Everett & Thomas, 1986; Kloser, 1998; Al-Handal & Wulff, 2009a, b). The authors analyzed the composition of microalgae growing on different substrates such as sediments and various macroalgae species in Potter Cove, Antarctic Peninsula, recording some preference for substrate among the diatoms, as well the large dominance of some genera like *Licmophora, Cocconeis, Pleurosigma* and *Pseudogomphonema*. All these authors claimed that the investigations on taxonomy and ecology of diatoms are urgently needed, especially because they have become scarce, and they can provide background data to evaluate the impacts of global changes over phytoplankton and microphytobenthos (Wulff *et al.*, 2009). In this preliminary examination of phytoplankton samples, some taxonomic and nomenclatural problems have been detected, which will be dealt with through electronic microscopy and closer examination of the literature. Despite taxonomical difficulties, it was possible in this research to underline the role of benthic diatoms in biodiversity and habitat ecology in the studied Antarctic environment.

Acknowledgements

To the Instituto Nacional de Ciência e Tecnologia Antártico de Pesquisas Ambientais, contracts CNPq n° 574018/2008-5 and FAPERJ n° E-16/170.023/2008. The Center of Electron Microscopy of UFPR for making available the laboratory facilities and the electron microscopes. Ministério do Meio Ambiente (MMA), Ministério de Ciência e Tecnologia (MCT) and Comissão Interministerial para os Recursos do Mar (CIRM). M. C.- F. is supported by the UFPR/Botany graduate program and the REUNI system.

References

Al-Handal, A. & Wulff, A. 2009a. Marine epiphytic diatoms from the shallow sublittoral zone in Potter Cove, King George Island, Antarctica. Botanica Marina 51(5): 411-35.

Al-Handal, A. & Wulff, A. 2009b. Marine benthic diatoms from Potter Cove, King George Island, Antarctica. Botanica Marina, 51(1): 51-68.

Ahn, I.Y.; Chung, H.; Kang, J.S. & Kang, S.H. (1994). Preliminary studies on the ecology of neritic marine diatoms in Maxwell Bay, King George Island, Antarctica. The Korean Society of Phycology, 9: 37-45.

Ahn, I.Y.; Chung, H.; Kang, J.S. & Kang, S.H. (1997). Diatom composition and biomass variability in nearshore waters of Maxwell Bay, Antactica, during the 1992/1993 austral summer. Polar Biology, 17(2): 123-30.

El-Sayed, S.Z. & Fryxell, G.A. (1993). Phytoplankton. In: Friedmann, E.I. Antarctic Microbiology. New York: Willey-Liss p. 65-122.

Hasle, G.R. & Fryxell, G.A. (1970). Diatoms: cleaning and mounting for light and electron microscope. Transactions of American Microscopical Society, 89: 469-474.

Hasle, G.R. & Syvertsen, E.E. (1997). Marine Diatoms. In Tomas,C.R. (ed.), Identifying marine phytoplankton. Academic Press a division of Harcourt Brace and Company, San Diego, USA, 2:5-385.

Kang, J.S.; Kang, S.H.; Lee, J.H.; Chung, K.H. & Lee, M.Y. (1997). Antarctic Micro- and Nano-sized phytoplankton assemblages in the surface water of Maxwell Bay during the 1997 austral summer. Korean Journal of Polar Research, 8: 35-45.

Kloser, H. (1998). Habitats and distribution patterns of benthic diatoms in Potter Cove (King George Island, Antarctica) and its vicinity. Berichte zur Polarforschung, 299: 105.

Knox, G.A. (1994). The biology of the Southern Ocean. Cambridge University Press. 193: 220.

Kopczynska, E. (2008). Phytoplankton variability in Admiralty Bay, King George Island, South Shetland Islands: six years of monitoring. Polish Polar Research, 29(2): 117-39.

Lange, P.K.; Tenenbaum, D.R.; Braga, E.S.B. & Campos, L.S. (2007). Microphytoplankton assemblages in shallow waters at Admiralty Bay (King George Island, Antarctica) during the summer 2002-2003. Polar Biology, 30(11): 1483-92.

Medlin, L.K. & Priddle, J. (1990). Polar marine diatoms. British Antarctic Survey/NERC.

Moline, M.A.; Claustre, H.; Frazer, T.K.; Schofield, O. & Vernet, M. (2004). Alteration of the food web along the Antarctic Peninsula in response to a regional warming trend. Global Change Biology, 10: 1973-80.

Montes-Hugo, M.; Doney, S.C.; Ducklow, H.W.; Fraser, W.; Martinson, D.; Stammerjohn, S.E. & Schofield, O. (2009). Recent changes in phytoplankton communities associated with rapid regional climate change along the western Antarctic Peninsula. Science, 323: 1470- 73.

Round, F.E.; Crawford, R.M. & Mann, D.G. (1990). Diatoms: Biology & Morphology of the genera. Cambridge University Press: 747pp.

Utermöhl, H. (1958). Perfeccionamento del método cuantitativo de fitoplancton. Comun. Assoc. Int. Limnol. Teor. Apl. 9: 1-89.

Wulff, A.; Iken, K.; Quartino, M.L.; Al-Handal, A.; Wiencke, C. & Clayton, M.N. (2009). Biodiversity, biogeography and zonation of marine benthic micro- and macroalgae in the Arctic and Antarctic. Botanica Marina, 52(6): 491–507.