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BENTHIC DIATOMS IN THE PLANKTON OF ADMIRALTY BAY (WESTERN ANTARCTIC PENINSULA): TAXONOMY AND POTENTIAL IMPLICATIONS TO THE PELAGIC COMMUNITY

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Abstract: *In coastal regions of Antarctica, primary production is a result of the interaction between four communities: cryophilic microalgae, phytoplankton, microphytobenthos and macroalgae. Microphytobenthos can be equally important to eponthic microbiota, or even hold the bulk of primary production in periods after the ice melting in late spring. Among the various groups forming the benthic community, diatoms are the most important photoautotrophs regarding diversity as well as the biomass available to the consumers. In this report we present a taxonomic survey of diatoms belonging to the Class Bacillariophyceae found in the plankton of Admiralty Bay, from samples collected between 2002 and 2010 in every December and February. A total of 53 species was recorded. The majority of the diatoms have benthic habit, usually associated to ice or rocks and macroalgae, indicating the influence of bottom communities over the superjacent plankton. Those species were recorded in the water column possibly due to the local hydrographic dynamics, which might resuspend cells from microphytobenthos. Regarding taxonomy, about 25 species are newly reported to Admiralty Bay, and several identification and nomenclatural problems were found. We recommend that the ongoing monitoring program in the region includes sampling of the benthic community looking for different substrates like ice, rocks and macroalgae, also aiming to determine the origin of benthic diatoms found in the plankton of Admiralty Bay.*

Keywords: Antarctic Peninsula, Coastal Zone, PROANTAR, Benthic Diatoms

Introduction

In coastal regions of Antarctica, the primary production is the result of interactions between four biotic communities: ice microalgae (cryophilic), phytoplankton, microphytobenthos and macroalgae. The relative contribution of cryophilic microalgae and phytoplankton has been intensively investigated, while the benthic environment lacks studies on ecology and biomass fluxes through the trophic web (Kang & Fryxell, 1993; Knox, 2006). Regarding microphytobenthos, though a few estimates of carbon stocks have been performed (Gilbert, 1991), other studies using cell densities as a parameter for evaluating the benthic biomass have already pointed out its significant role (Dayton *et al.*, 1986; Everett & Thomas, 1986). Moreover, a large fraction of the microphytobenthic cells is made available in the water column periodically, increasing the biomass stock available to the zooplankton (Ahn *et al.*, 1997). Indeed, Ligowsk (2000) found that benthic diatoms represented the major food item of the krill *Euphausia superba* in Admiralty Bay. In shallow neritic areas like bays and inlets, the highest densities of microphytobenthos are found in hard substrates (rocks and macroalgae) and bottom sediments (Dayton *et al.*, 1986; Gilbert, 1991; Corbisier *et al.*, 2004). Usually, diatoms (Phylum Bacillariophyta *sensu* Medlin & Kaczmarska, 2004) have been found to be the most

important. contributor to the pelagic system by comprising most of the phytoplankton biomass, as reported in Maxwell Bay (Ahn *et al.*, 1997), Davis Station (Everett & Thomas, 1986) and Admiralty Bay (Lange *et al.*, 2007).

In Admiralty Bay, King George Island, the microphytoplankton is generally originated from the adjacent Bransfield Strait (Kopczynska, 2008). The community is greatly dominated by centric diatoms like *Thalassiosira, Rhizosolenia, Corethron* and *Chaetoceros*, and pennate diatoms such as *Fragilariopsis, Pseudo-nitzschia* and *Fragilaria,* composed of either planktonic or benthic species (Lange *et al.*, 2007). Cells from the microphytobenthos could be resuspended in the water column through local upwelling (Brandini & Rebello, 1994; Schloss *et al.*, 2002) and advection caused by the continental ice melting (Pichlmaier *et al.*, 2004)

An important component of investigations related to the phytoplankton ecology is the correct identification of the microalgae species, allowing for the community categorization (plankton, epilithon, epiphyton, eponthic), and to estimate their role in the biomass stock available to the consumers. Regarding the phytoplankton, diatoms are responsible for most of the biomass in the Antarctic pelagic ecosystem, and a high species diversity has been usually recorded (Medlin & Priddle, 1990; Knox, 2006). A previous report (Tenenbaum *et al.*, 2011) described the structure of the phytoplankton community from Admiralty Bay, Antarctic Peninsula, also furnishing the initial results concerning the influence of benthic diatoms in the plankton system. In the present work, we provide the taxonomic analysis of diatoms belonging to the Class Bacillariophyceae ("pennate" diatoms), based on samples taken in Admiralty Bay from 2002 to 2010. In addition, we discuss the potential contribution of benthic diatoms to the plankton community.

Materials and Methods

Field sampling was carried out in the Admiralty Bay, King George Island, in eight fixed points (Figure 1) from 2002 to 2010 every December and February, also coincident with the sampling points of the Brazilian Monitoring Program. Phytoplankton was sampled using 20 µm plankton net through vertical hauls up to 30 meters depth and preserved with formaldehyde 2%.

The samples were cleaned for microscopy according to the technique of Hasle & Fryxell (1970). Permanent slides were mounted with Naphrax (refractive index = 1.74), totalizing 56 slides. Valves were measured and photographed in an Olympus BX50 light microscope. For scanning electron microscopy, small drops of cleaned samples were put in aluminum stubs, air dried and coated with gold. Observations were made using a Jeol JSM 6360 electron microscope. Data on distribution were based mainly in Scott & Thomas (2005). Diatom classification followed Medlin & Kaczmarka (2004) and Round *et al.* (1990, for orders), and frustule terminology after Ross *et al.* (1979) and Round *et al.* (1990).

Results

A total of 53 species was established, included in 30 genera (Table 1). The most representative in terms of species richness were: *Cocconeis* Ehrenberg (10 species and one variety), *Fragilariopsis* Hustedt (6 species), *Licmophora* Agardh (4 species), *Navicula* Bory (3 species) and *Gyrosigma* Hassal (3 species). Despite no quantitative evaluation has been carried out, the species *Fragilaria striatula, Achnanthes brevipes* var. *intermedia, Cocconeis antiqua, C. fasciolata, C. imperatrix, Navicula* cf. *perminuta, Gyrosigma subsalinum* and *Fragilariopsis kerguelensis* were the most abundant in the slides. Moreover, these diatoms occurred in all the sampling sites. Most of the diatoms were benthic like *Achnanthes*, *Cocconeis*, *Pseudogomphonema, Amphora, Trachyneis* and *Licmophora* (Table 1). Only *P. turgiduloides* and perhaps several species of *Gyrosigma* and *Pleurosigma* could be assigned as truly planktonic. About 25 infrageneric taxa are newly reported for Admiralty Bay (Table 1).

Discussion and Conclusion

The results in this work as well as from previous investigations confirmed a diatom flora composed of species quite similar to other coastal areas around the Antarctic (Scott & Thomas, 2005). After reviewing the few papers dealing with diatom diversity in the study area, it was found that a great number of species (25 out of the total 53 species) recorded here have not been reported in the Admiralty Bay previously (Brandini & Rebelo, 1994; Lange *et al.*, 2007; Kopczynska, 2008). On the other hand, only two species are newly recorded for the Antarctic region, namely *Pleurosigma strigosum* and *Bacillaria paxillifer*. A comprehensive reading of classic and recent literature on diatom taxonomy

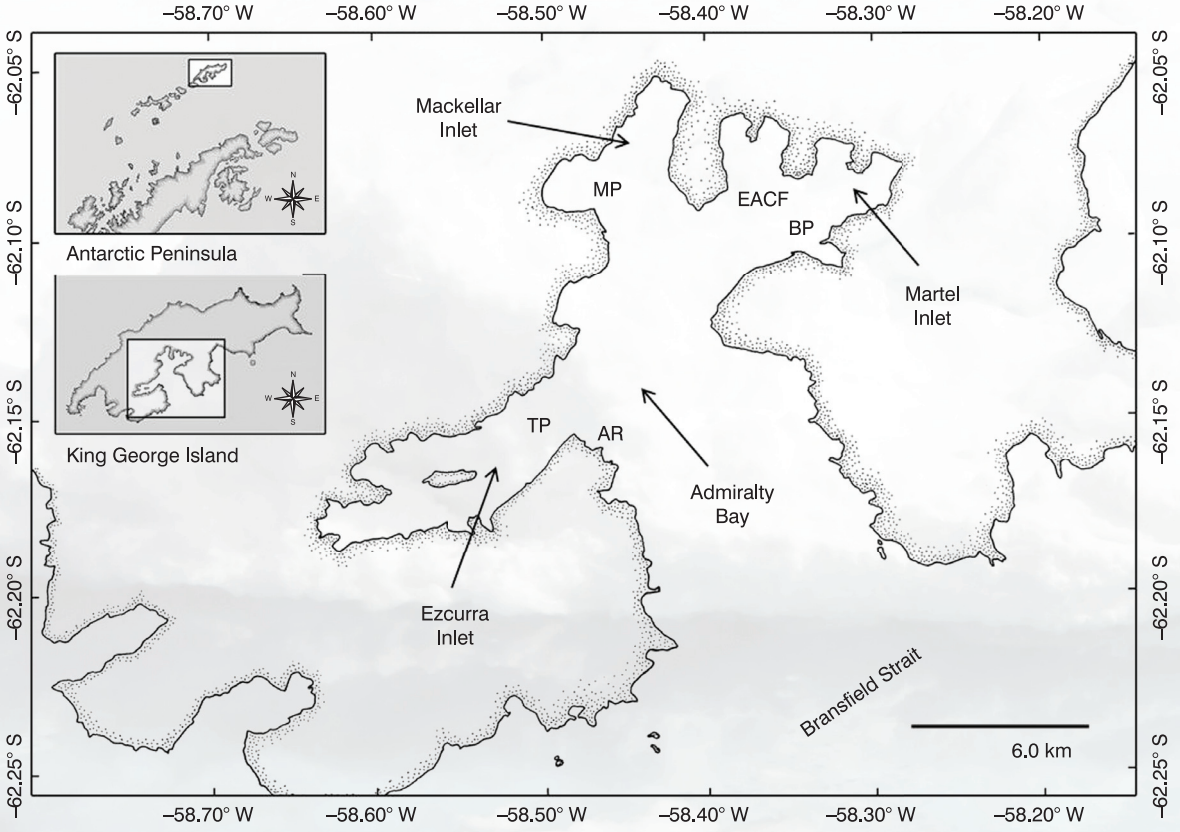

Figure 1. Study area with the position of the sampling sites in the Admiralty Bay, King George Island. Ferraz Station (EACF), Botany Point (BP), Ullman Point (UP), Machu Picchu (MP), Refugio 2 (Re2), Hennequin Point (He), Arctowski (AR), Point Thomas (PT).

Table 1. List of species and habitat preference of commonly found benthic diatoms in Admiralty Bay during the 2002-2010 monitoring program. New additions to the Admiralty Bay's diatom flora are indicated by "*".

Order Fragilariales		
Fragilaria islandica Grunow[3]		
Fragilaria striatula Lyngbye[2,4,5]	E	Ep
Licmophora antarctica Carlson*	E	
Licmophora belgicae M. Peragallo[3,4,5]	E	
Licmophora gracilis (Ehrenberg) Grunow[1,2, 3, 4,5]	E	
Licmophora luxuriosa Heiden et Kolbe*	E	
Tabulariopsis australis (M. Peragallo) Williams[3]		
Thalassionema gelida M. Peragallo*		
Thalassionema nitzschioides var. *lanceolata* (Grun.) Perag. et Perag.*		
Thalassionema nitzschioides var. *gracilis* Heiden et Kolbe*		
Order Lyrellales		
Petroneis plagiostoma (Grunow) D.G Mann*		
Order Cymbellales		
Gomphonemopsis littoralis (Hendey) Medlin*		El

E: epiphytic; Ep: eponthic; El: epilithic; P: planktonic.
[1]Ligowski (2000) in krill stomach; [2] Procopiak (2001); [3] Portinho (2003); [4]Kopczynska (2008), [5] Lange (2011)

Table 1. *Continuação.*

Order Achnanthales				
Achnanthes brevipes var. *intermedia* (Kutzing) Cleve[2,4,5]		Ep	El	
Cocconeis antiqua Tempere et Brun[1,2]	E			
Cocconeis californica (Grunow) Grunow var. *californica*[2]	E			
Cocconeis californica var. *kerguelensis* Heiden[2]	E			
Cocconeis costata Gregory[1,2,4,5]	E			
Cocconeis dalmannii Al-Handal; R.-Gobin; Romero et Wulff*				
Cocconeis extravagans Janisch[2,4,5]	E			
Cocconeis fasciolata (Ehrenberg) Brown[1,4,5]	E			
Cocconeis imperatrix A.Schmidt*	E			
Cocconeis melchioroides Al-Handal, R.-Gobin, Romero et Wulff*	E			
Cocconeis orbicularis Frenguelli et Orlando[5]	E			
Cocconeis pinnata Gregory ex Greville[3]	E			
Order Naviculales				
Banquisia belgicae (Van Heurck) Paddock*		Ep		
Fallacia marnieri (Manguin) Witkowski, Lange-Bertalot et Metzeltin[2]				
Gyrosigma fasciola (Ehrenberg) Griffith et Henfrey*				
Gyrosigma subsalinum (H. Peragallo) Frenguelli et Orlando*				P?
Gyrosigma tenuissimum var. *hyperborea* (Grunow)*				P?
Navicula directa (W. Smith) Ralfs[1,2,4,5]		Ep	El	
Navicula glaciei Van Heurck[1,2,4,5]		Ep	El	
Navicula cf. *perminuta* Grunow*		Ep		
Parlibellus delognei (Van Heurck) Cox[5]		Ep	El	
Pinnularia quadratarea (A.Schmidt) Cleve[5]		Ep		
Pleurosigma strigosum W. Smith*				P
Pleurosigma cf. *eudon* (Pantocsek) var. *kerguelensis* Heiden et Kolbe*				P?
Plagiotropis paddockii Simonsen*		Ep	El	
Pseudogomphonema kamtschaticum (Grunow) Medlin[1,2,4,5]		Ep	El	
Trachyneis aspera (Ehrenberg) Cleve[2]				
Tropidoneis gaussii Heiden et Kolbe*		Ep		
Order Bacillariales				
Bacillaria paxillifer (O.F. Muller) Hendey*		Ep		
Fragilariopsis curta (Van Heurck) Hustedt*		Ep		
Fragilariopsis cylindrus (Grunow) Helmcke et Krieger[1,4,5]		Ep		
Fragilariopsis kerguelensis (O'Meara) Hustedt[1,4,5]		Ep		
Fragilariopsis obliquecostata (V. Heurck) Heiden et Kolbe[1]		Ep		
Fragilariopsis rhombica (O' Meara) Hustedt[1]		Ep		
Fragilariopsis sublinearis (Van Heurck) Heiden[1]		Ep		
Nitzschia hybrida Grunow*		Ep		
Pseudo-nitzschia turgiduloides (Hasle) Hasle*				P
Order Thalassiophysales				
Amphora marina (W. Smith) Van Heurck*			El	
Amphora proteus Gregory[3,4,5]				
Halamphora coffeaeformis (Agardh) Z. Levkov*				
Order Surirellales				
Entomoneis paludosa (W. Smith) Reimer[5]				

E: epiphytic; Ep: eponthic; El: epilithic; P: planktonic.
[1]Ligowski (2000) in krill stomach; [2] Procopiak (2001); [3] Portinho (2003); [4]Kopczynska (2008), [5] Lange (2011)

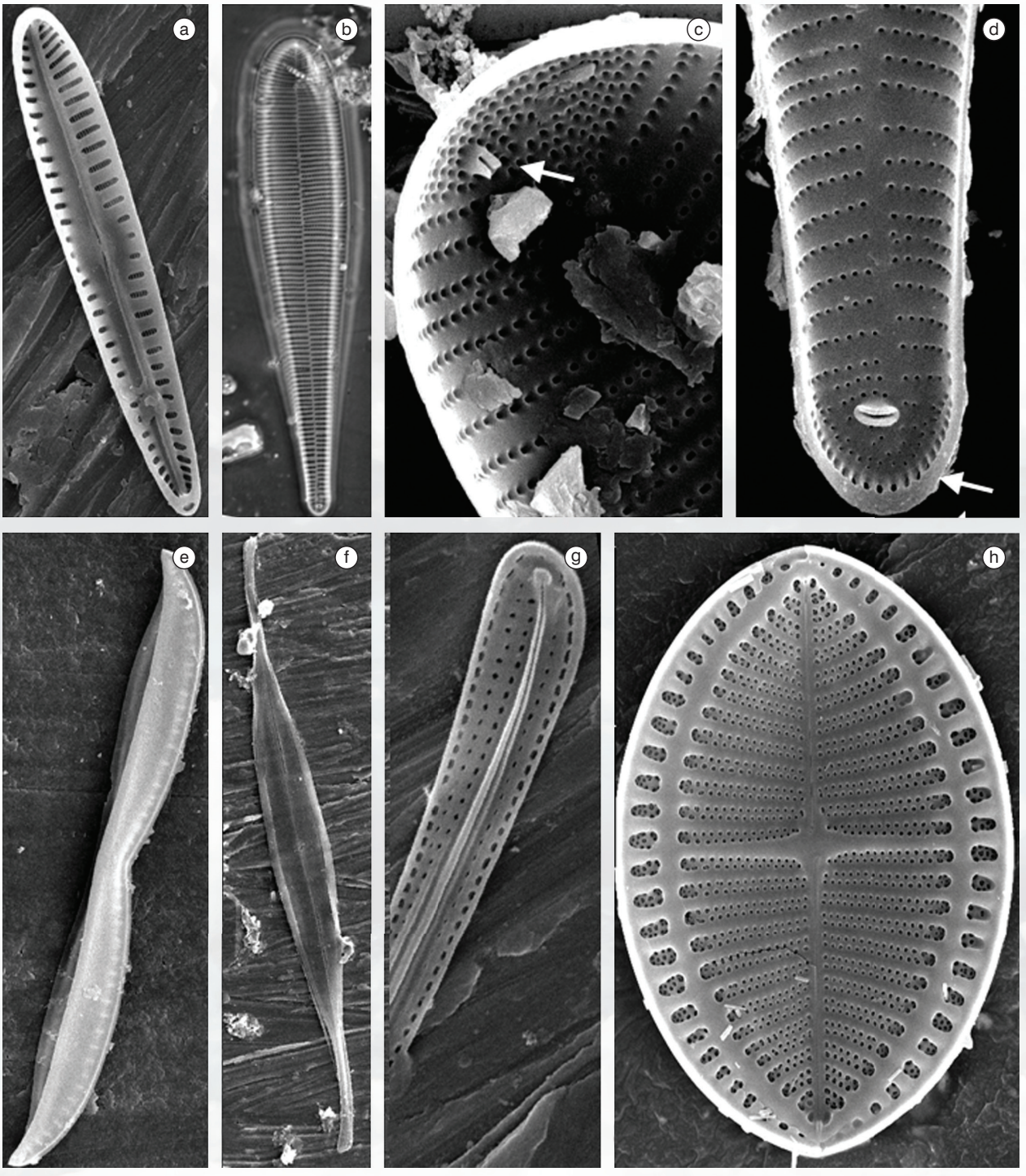

Figure 2. Some common pennate diatoms recorded in the Admiralty Bay during the 2002 - 2010 monitoring program of phytoplankton. All pictures in scanning electron microscope except for Figure 2B (light microscope). A: *Pseudogomphonema kamtschaticum*. B: *Licmophora belgicae*. C: *L. belgicae*, showing rimoportula (arrow) at the head pole. D: *L. belgicae*. Foot pole with rimoportula and multiscissurae (arrow). E: *Nitzschia hybrida*. F: *Gyrosigma fasciola*. G: *G. fasciola*. Apex showing the raphe. H: *Cocconeis imperatrix*, raphe valve.

in Antarctica has revealed that the problems regarding identification and nomenclature still exist, even after the intensification of investigations using electron microscope. In our material, some species were identified only after intense research and detailed examination of the frustule in electron microscope. Even though, two species await further confirmation, and several others presented nomenclatural uncertainties. Therefore, the need for thorough taxonomic studies in the region is clear, a gap in knowledge already claimed by Wulff *et al.* (2009). Additionally, we suggest the intensification of samplings in the benthic community aiming to investigate the microflora inhabiting different substrates like ice, rocks and macroalgae, ultimately allowing the precise determination of habitat preferences for many species, which are found in the water column as well. These studies will surely support the monitoring program of phytoplankton currently being held by the Brazilian Antarctic Program.

Most of the species recorded are benthic like *Cocconeis*, *Pseudogomphonema, Amphora, Trachyneis* and *Licmophora* (Table 1), and their presence in the water column might be the consequence of the local hydrographic dynamics, resuspending the cells from the bottom. Corroborating this hypothesis, Lange *et al.* (2007), working with quantitative samples for cell density estimates in the same sampling stations of our work, reported a significant contribution of microphytobenthic diatoms to the plankton community. Finally, in a recent review on the phytoplankton studies in Admiralty Bay, Kopczynska (2008) emphasized the potential role of benthic diatoms in the local plankton community and to the pelagic biota as a whole.

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