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 phoautotrophs 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, Ligowski (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 Fragilaria, 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 (Pichlmair 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 influence of benthic diatoms in the plankton community. System in the present work, we provide the taxonomic richness were: Cocconeis Ehrenberg (10 species and one variety), Fragilaria Hustedt (6 species), Licmophora (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. fasciulata, C. imperatrix, Navicula cf. perminuta, Gyrosigma subsalinum and Fragilaria 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).

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), Fragilaria 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. fasciulata, C. imperatrix, Navicula cf. perminuta, Gyrosigma subsalinum and Fragilaria 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 & Rebello, 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

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), totaling 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).
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 ‘*’.

<table>
<thead>
<tr>
<th>Order Fragilariales</th>
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<tbody>
<tr>
<td>Fragilarioides islandica Grunow*</td>
<td>E</td>
</tr>
<tr>
<td>Fragilaria stratiu Laingbye1,2,3,5</td>
<td>Ep</td>
</tr>
<tr>
<td>Licmophora antarctica Carlson*</td>
<td>E</td>
</tr>
<tr>
<td>Licmophora belgicae M. Peragallo1,2,3,5</td>
<td>E</td>
</tr>
<tr>
<td>Licmophora gracilis (Ehrenberg) Grunow1,2,3,4,5</td>
<td>E</td>
</tr>
<tr>
<td>Licmophora luxuriosa Heiden et Kolbe*</td>
<td>E</td>
</tr>
<tr>
<td>Tabulariopsis australis (M. Peragallo) Williams3</td>
<td>E</td>
</tr>
<tr>
<td>Thalassionema gelida M. Peragallo*</td>
<td>E</td>
</tr>
<tr>
<td>Thalassionema nitzschioidea var. lanceolata (Grun.) Perag. et Perag.*</td>
<td>E</td>
</tr>
<tr>
<td>Thalassionema nitzschioidea var. gracilis Heiden et Kolbe*</td>
<td>E</td>
</tr>
</tbody>
</table>

Order Lyelliales

| Petroneis plagiostom (Grunow) D.G Mann* |            |

Order Cymbelliales

| Gomphonemopsis littoralis (Hendey) Medlin* | Ei          |

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

Order Achnanthales

Achnanthes brevipes var. intermedia (Kützing) Cleve\(^{1,4,5}\) Ep Ei
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* E
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 orbiculata Frenguelli et Orlando\(^3\) 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 subsalimum (H. Peragallo) Frenguelli et Orlando* P?
Gyrosigma tenusimum var. hyperborea (Grunow)* P?
Navicula directa (W. Smith) Ralfs\(^{1,2,4,5}\) Ep Ei
Navicula glaciei Van Heurck\(^{1,2,4,5}\) Ep Ei
Navicula cf. perminuta Grunow* Ep
Paribellus delognei (Van Heurck) Cox\(^2\) Ep Ei
Pinnularia quadratarea (A. Schmidt) Cleve\(^5\) Ep
Pleurosigma striosum W. Smith* P
Pleurosigma cf. eudon (Pantocsek) var. kerguelensis Heiden et Kolbe* P?
Plagiotropsis paddocki Simonsen* Ep Ei
Pseudogomphonema kamtschaticum (Grunow) Medi1\(^{1,2,4,5}\) Ep Ei
Trachyneis aspera (Ehrenberg) Cleve\(^2\)
Tropidoneis gaussii Heiden et Kolbe* Ep

Order Bacillariales

Bacillaria paxillifer (O.F. Muller) Hendey* Ep
Fragilaripos cysta (Van Heurck) Hustedt* Ep
Fragilaripos cylindrus (Grunow) Helmcke et Krieger\(^{4,5}\) Ep
Fragilaripos kerguelensis (O'Meara) Hustedt\(^{1,4,5}\) Ep
Fragilaripos obliquecostata (W. Heurck) Heiden et Kolbe\(^1\) Ep
Fragilaripos rhombica (O'Meara) Hustedt\(^1\) Ep
Fragilaripos sublineans (Van Heurck) Heiden Ep
Nitzschia hybrida Grunow* Ep
Pseudo-nitzschiia turgiduloides (Hasle) Hasle* P

Order Thalassiophysales

Amphora marina (W. Smith) Van Heurck* Ei
Amphora proteus Gregory\(^{1,4,5}\) Ei
Halamphora coffeiformis (Agardh) Z. Levkov*

Order Surirellales

Entomoneis paludosa (W. Smith) Reimer\(^6\)

E: epiphytic; Ep: epilithic; Ei: 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.
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.

Acknowledgements

This study first integrated the project "Implementation of a Strategy for Assessment of Environmental Impacts on Coastal Shallow Water Benthic Fauna of Admiralty Bay" (Brazilian Antarctic Program) and later the project "Marine Antarctic Biodiversity in Relation to Environmental Heterogeneity at Admiralty Bay, and adjacent areas" (International Polar Year). Those projects were funded by the Brazilian Ministry of Environment (MMA), Ministry of Science and Technology (MCT), and National Council for Research and Development (CNPq), and were also part of multidisciplinary projects inserted in the International Polar Year (IPY) and the Census of Antarctic Marine Life (CAML). This research is currently supported by the Brazilian National Institute of Science and Technology – Antarctic Environmental Research (INCT-APA, Portuguese acronym), CNPq proc. n° 574018/2008-5 and Carlos Chagas Research Support Foundation of the State of Rio de Janeiro (FAPERJ n° E-16/170.023/2008). The Center of Electron Microscope of Federal University of Paraná made available all the facilities, including the scanning electron microscope.

References


