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Diatom assemblages from a turbid coastal plain estuary: Río de la Plata (South America)

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Abstract

The Río de la Plata is located on the East coast of South America and is a shallow, large-scale, turbid coastal plain estuary that covers an approximate area of 35,000 km^2. Despite the socio-economic importance of the Río de la Plata, studies related to the biological aspects of this ecosystem are scarce, particularly in the freshwater tidal zone. The objective of this study was to explore the diatom composition and distribution of density, biomass and empty frustules along the fluvial–mixohaline axis. Furthermore it was to analyze the spatial succession of diatom assemblages and the environmental variables during an extensive sampling carried out during spring 2001. Two replicate sub-surface water samples were collected at 29 sites for quantitative analysis of phytoplankton. The greatest number of species, mainly pennate taxa, were observed in the freshwater tidal zone. The average density of the diatoms was 59 cells ml^{-1}. Chains or filaments of centric diatoms were frequent and dominant in the samples along the fluvial–mixohaline axis. The carbon content of the diatoms increased downstream, with an average value of 2.5 $\mu g\,C\,l^{-1}$ in the freshwater tidal zone and 4.4 $\mu g\,C\,l^{-1}$ in the mixohaline zone. Diatoms supplied 65% of the total phytoplankton carbon content in the freshwater tidal zone and reached 17% in the mixohaline zone. Canonical Correspondence Analysis (CCA) allowed us to identify two species assemblages in the Río de la Plata differentiated mainly by salinity, pH and silicate gradients. In our study species exclusive to brackish waters were not identified, but some freshwater and marine taxa with wide ranges of salinity tolerance were observed.

Keywords: Diatoms; Phytoplankton; Diversity; Spatial succession; Environmental gradients; Río de la Plata; Argentina

1. Introduction

The physical and chemical dynamics and the ecology of shallow estuarine areas are strongly influenced by the runoff of freshwater from the land and the exchange of water with the adjacent open sea (Flindt et al., 1999).

Pronounced gradients in environmental habitat properties characterize estuaries and influence the composition and dynamics of estuarine phytoplankton communities (Smayda, 1983). Estuaries are particularly susceptible to anthropogenic impact because of their hydrodynamics and proximity to massive human settlements. Their integrity is currently under risk worldwide (Kiddon et al., 2003).

The Río de la Plata estuary is one of the largest estuarine systems of South America. There are extensive industrial and urban areas located around the river and its estuary, mainly associated with the cities of Buenos Aires

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(Argentina) and Montevideo (Uruguay), which have about 15 million inhabitants. The estuary is also the marine access to a highly complex fluvial system that communicates with the Amazon basin. Industrial activities and urban conglomerates affect the aquatic habitat and conflict with environmental issues (Mianzan et al., 2001). Despite the socio-economic importance of the Río de la Plata, studies related to the biological aspects of this ecosystem are scarce, particularly in the freshwater tidal zone.

Diatom assemblages respond rapidly and sensitively to environmental change and can provide highly informative assessments of the biotic integrity of aquatic systems, and the causes of ecosystem impairment. The tolerance of species to environmental variation may provide an indicator that improves characterisation of environmental variability as well as providing mean, or median, environmental conditions (Stevenson and Pan, 1999).

Diatoms are frequent, and sometimes abundant, in the plankton of the Río de la Plata (Gómez and Bauer, 1997, 1998a,b, 2000; Gómez et al., 2004) and in the biofilms that cover the natural substrates of this ecosystem (Gómez et al., 2003). The diatom flora found in the freshwater tidal zone of the Río de la Plata is diverse (Tempère and Peragallo, 1907; Carbonell and Pascual, 1925; Frenguelli, 1933; Cordini, 1939; Frenguelli, 1941, 1945; Müller Melchers, 1945; Zannon, 1949; Müller Melchers, 1949, 1952, 1953a,b, 1959). However, there is no information on the factors affecting the composition and structure of diatom assemblages across the fluvial–mixohaline axis of the Río de la Plata.

The objective of this study was to explore:

(I) the diatom composition and distribution of density, biomass, and empty frustules along the fluvial–mixohaline axis.
(II) the relative abundance in relation with other phytoplanktonic groups and the spatial succession of diatom assemblages.
(III) the environmental variables that influence diatoms distribution in the Río de la Plata estuary.

2. Materials and methods

2.1. Sampling and laboratory analysis

Sampling was carried out during a twenty five days cruise (on board R./V. Holmberg at stations deeper than 5 m and on the smaller A.R.A. Cormorán vessel over

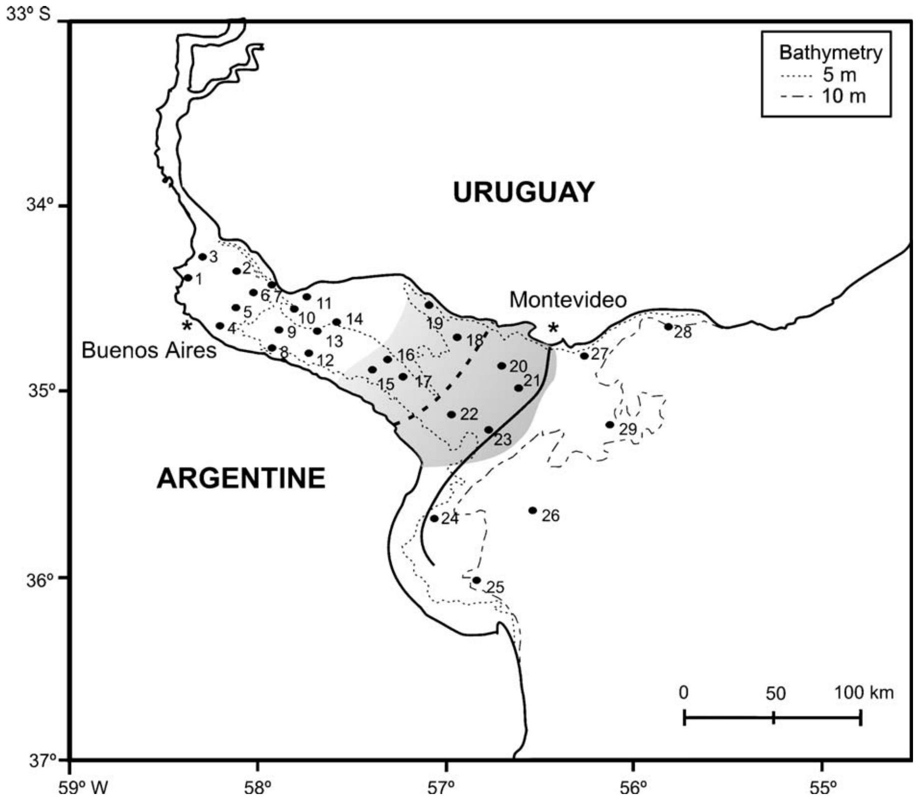

Fig. 1. Study area: sampling sites; bathymetry, maximum turbidity front (shaded area), isohaline of 0.5 PSU (dashed line) and Barra del Indio (solid line) that divides the estuary into inner (freshwater zone) and outer (mixohaline zone) areas.

Table 1
List and range of relative abundance of diatom taxa identified along the fluvial–mixohaline axis

Taxa	Acronym	1 to 7 (0–50)	8 to 14 (50–100)	15,16,19 (100–150)	17,18, 20,22,24 (150–200)	21,23,25–27 (200–250)	28,29 (250–300)
							Sites / Km
Cyclotella atomus Hustedt		---------					
Cyclotella sp.		---------					
Stephanodiscus sp.		---------					
Achnanthes inflata (Kützing) Grunow		---------					
Caloneis bacillum (Grunow) Cleve		---------					
Cymbella affinis Kützing		---------					
Eunotia formica Ehrenberg		---------					
Eunotia hexaglyphis Ehrenberg	EHEX	---------					
Eunotia praerupta Ehrenberg	EPRA	---------					
Mayamaea atomus (Kützing) Lange-Bertalot		---------					
Hippodonta capitata (Ehrenberg) Lange-Bertalot, Metzeltin et Witkowski		---------					
Navicula constans Hustedt		---------					
Navicula elmorei Patrick		---------					
Navicula erifuga Lange-Bertalot	NERI	---------					
Navicula exigua (Gregory) Grunow		---------					
Navicula notha Wallace		---------					
Navicula nyassensis O. Müller	NNYA	---------					
Navicula placentula (Ehrenberg) Kützing	NPLA	---------					
Neidium affine (Ehrenberg) Pfitzer		---------					
Neidium iridis (Ehrenberg) Cleve var. intercedens Mayer		---------					
Nitzschia commutatoides Lange-Bertalot		---------					
Nitzschia draveillensis Coste & Ricard		---------					
Nitzschia vermicularis (Kützing) Hantzsch	PMAJ	---------					
Pinnularia maior (Kützing) Rabenhorst		---------					
Pinnularia mesolepta (Ehrenberg) Smith		---------					
Pinnularia microstauron (Ehrenberg) Cleve		---------					
Eunotia pectinalis var. ondulata (Ralfs) Rabenhorst	ESLE	----------					
Encyonema silesiacum (Bleisch) Mann	NCOT	----------					
Nitzschia constricta (Kützing) Ralfs		----------					
Nitzschia filiformis (W. M. Smith) Van Heurck	NFIL	----------					
Nitzschia gracilis Hantzsch	NIGR	----------					
Nitzschia linearis (Agardh) W. Smith	NLIN		-------				
Actinoptychus senarius (Ehrenberg) Ehrenberg			-------				
Cocconeis placentula Ehrenberg			-------				
Gomphonema parvulum Kützing			-------				
Gomphonema truncatum Ehrenberg			-------				
Gyrosigma attenuatum (Kützing) Cleve			-------				
Gyrosigma scalproides (Rabenhorst) Cleve			-------				
Hantzschia amphioxys (Ehrenberg) Grunow			-------				
Navicula accomoda Hustedt			-------				
Nitzschia acicularis (Kützing) W. Smith			---------				
Nitzschia angustata Grunow			---------				
Gomphonema gracile Ehrenberg	GGRA	---------		---------			
Craticula halophila (Grunow ex Van Heurck) Mann	CHAL	---------		---------			

(continued on next page)

Table 1 (*continued*)

Taxa	Acronym	1 to 7 (0–50 km)	8 to 14 (50–100 km)	15,16,19 (100–150 km)	17,18, 20,22,24 (150–200 km)	21,23,25–27 (200–250 km)	28,29 (250–300 km)
Nitzschia nana Grunow	NNAN	- -		- -			
Nitzschia palea (Kützing) W. Smith	NPAL	- -		- -			
Nitzschia paleacea Grunow	NPAE	- -		- -			
Cyclotella stelligera Cleve & Grunow	CSTE	—		- -			
Aulacoseira muzzanensis (Meister) Krammer	AMUZ			- -			
Eunotia arcus Ehrenberg				- -			
Gomphonema augur Ehrenberg				- -			
Navicula rhynchocephala Kützing				- -			
Rhopalodia brebissonii Krammer				- -			
Fragilaria capucina Desmazières				—			
Nitzschia fruticosa Hustedt	NIFT	—		—			
Tryblionella hungarica (Grunow) Mann	THUN	- -	- -	- -			
Eunotia monodon Ehrenberg	EMON	- -	—	- -			
Aulacoseira granulata (Ehrenberg) Simonsen Morphotyp*curvata*	AUGC	—	—	- -			
Nitzschia sigma (Kützing) W. Smith	NSIG	- -	- -		- -		
Navicula peregrina (Ehr.) Kützing	NPRG	- -			- -		
Nitzschia frustulum (Kützing) Grunow	NIFR	- -			- -		
Ulnaria ulna (Nitzsch.) Compère	UULN		—		- -		
Aulacoseira granulata var. angustissima f. *spiralis* (Hustedt) Czarneki & Reinke	AUGS	—	—	- -	- -		
Fragilaria heidenii Öestrup	FHEI	—	—	—	- -		
Navicula lanceolata (Agardh) Ehrenberg	NLAN		- -	- -	- -		
Stephanodiscus parvus Stoermer & Hakansson	SPAV			- -	- -		
Navicula cryptocephala Kützing					- -		
Surirella ovalis Brébisson					- -		
Eunôtia bilunaris (Ehrenberg) Mills	EBIL	- -			- -	- -	
Gyrosigma spencerii (Smith) Cleve	GSPE	- -	- -		- -	- -	
Coscinodiscus angustelineatus A. S.						- -	
Aulacoseira ambigua (Grunow) Simonsen	AAMB	━	━	━	━	- -	
Aulacoseira distans (Ehrenberg) Simonsen	AUDI	- -	—	—	—	- -	
Aulacoseira granulata (Ehrenberg) Simonsen	AUGR	━	━	—	—	—	
Aulacoseira granulata var. angustissima (Méller) Simonsen	AUGA	—	—	━	—	—	
Cyclotella striata (Kützing) Grunow	CSTR	- -	—	—	- -	- -	
Cyclotella meneghiniana Kützing	CMEN	—	—	—	—	- -	- -
Actinocyclus normanii (Ehrenberg) Simonsen	ANMN	- -	- -	—	—	- -	- -
					- -	—	- -
Chaetoceros spp.	CHSP				━	━	━
Skeletonema costatum (Greville) Cleve	SKCO					- -	- -
Chaetoceros affinis Lauder	CHAS					- -	- -
Rhizosolenia sp	RHYZ					- -	- -
Thalassiosira sp.	THAL						
Chaetoceros braevis Schut							- -
Chaetoceros subtilis Cleve							- -
Thalassiosira rotula Meunier							- -
Pleurosigma elongatum Smith							- -
No. of centric taxa		13	10	12	11	13	10
No. of pennate taxa		43	24	15	11	39	1
Centric diatoms (%)		89.3	87.8	97.4	94.7	9.1	100.0
Pennate diatoms (%)		10.7	12.2	2.6	5.3	0.7	0.0

Table 1 (*continued*)

	1 to 7	8 to 14	15,16,19	17,18, 20,22,24	21,23,25–27	28,29	Sites
	0	50	100	150	200	250 300	Km
Temperature (°C)	22,1 (1,3)	20,3 (1,3)	20,3 (0,2)	19,6 (0,6)	19,3 (0,7)	19,7 (0,3)	
Salinity (ups)	0,12 (0,05)	0,09 (0,06)	0,07 (0,04)	2,5 (3,9)	10,1 (4,9)	18,0 (0,6)	
Turbidity (reflectance %)	7,0 (0,0)	7,0 (0,0)	11,0 (0,0)	9,0 (4,0)	6,6 (4,1)	4,0 (1,4)	
Suspended solids (mg l^{-1})	58,9 (24,1)	57,7 (21,2)	49,5 (26,2)	88,4 (69,5)	37,2 (32,9)	5,7 (1,1)	
pH	7,4 (0,3)	7,5 (0,1)	7,8 (0,1)	7,7 (0,2)	8,2 (0,2)	8,3 (0,1)	
DO (mg l^{-1})	6,2 (0,8)	6,1 (1,2)	7,4 (0,4)	8,0 (0,5)	8,0 (0,4)	7,5 (0,3)	
Si (μmol l^{-1})	209,1 (9,1)	209,6 (12,7)	205,3 (7,4)	98,5 (13,8)	63,1 (29,1)	37,1 (12,6)	
NO_3^-–N (μmol l^{-1})	7,3 (2,3)	11,2 (13,5)	13,4 (2,3)	19,2 (5,0)	13,9 (4,6)	0,6 (0,1)	
NH_4^+–N (μmol l^{-1})	3,4 (1,6)	4,9 (5,2)	3,6 (1,9)	3,2 (2,2)	2,6 (2,2)	3,6 (1,0)	
PO_4^{3-}–P (μmol l^{-1})	2,7 (0,8)	2,3 (1,8)	1,7 (0,7)	2,7 (1,4)	1,4 (0,5)	1,1 (0,7)	
Range of relative abundance (%)							
> 0 – 1							
>1 – 10							
>10 – 25							
>25							

Number of centric and pennate taxa and their percentage of average abundance. Mean values and standard deviation (in brackets) of physico-chemical variables.

shallower waters), in spring 2001 (November–December) in the Río de la Plata. Two replicate sub-surface water samples were collected at 29 sites for quantitative analysis of phytoplankton. For qualitative samples a 32 μm plankton net was used. The samples were fixed with Lugol's iodine and formalin (2%).

The following environmental variables were measured in the field at each site: temperature and salinity (Horiba multiparameter), dissolved oxygen (YSI sensor), and pH (Barnat Model 30 sensor). Salinity was measured using the Practical Salinity Scale. Turbidity (as % of reflectance), dissolved inorganic nutrients (Si, NH_4^+–N, NO_3^-–N, PO_4^{3-}–P) and suspended solids were derived from the PNUD/GEF Project database (PNUD/GEF RLA/99/G31, 2002).

Subsamples were used to identify the diatom species using an optical microscope, Olympus BX 50 with phase and interference contrast. Diatoms were cleaned with H_2O_2, washed thoroughly using distilled water and mounted on microscope slides with Naphrax®. Diatoms were determined according to: Ferrario (1984a,b), Frenguelli (1933, 1941, 1945), Hustedt (1930), Krammer and Lange-Bertalot (1986, 1988, 1991a,b), Krammer (1992), Patrick and Reimer (1966, 1975), Jensen and ϕjvind (1998), Prygiel and Coste (2000) and Kiselev (1969).

Phytoplankton counts were carried out according to Lund et al. (1958), with an inverted Olympus CK2 microscope at 600×, using 5 ml sedimentation chambers. The identified taxa were measured to calculate cell volumes (Hillebrand et al., 1999), which were then converted to carbon content (Menden-Deuer and Lessard, 2000). Empty frustules were also counted and their percentage in each sample was calculated.

2.2. Statistical analysis

Canonical Correspondence Analysis (CCA) was employed to explore the relationship between species composition and the environmental variables measured. In this analysis those species with a frequency greater than 7%, and with cytoplasmic contents, were included.

Those variables which did not conform to the assumption of normality were transformed: species abundance data (log $(x+1)$), temperature, pH and DO (ln), NO_3^-–N (square root), NH_4^+–N and PO_4^{3-}–P (ln $(x+1)$). Only the environmental variables with a variance inflation factor <10 were retained in the analysis (ter Braak and Verdonschot, 1995). The overall significance of the ordination, and the significance of the first axis, were tested with a Monte Carlo permutation test ($p<0.005$) using restricted permutations. Pearson coefficient was carried out with data on percentage of empty frustules, bathymetry and silicon concentration.

2.3. Study area

The Río de la Plata is located on the East coast of South America between 34° 00′–36° 20′S and 55° 00′–58° 30′W. It is a shallow, large, coastal plain estuary that covers an approximate area of 35,000 km^2. It is 320 km long and its width varies from 38 km in the upper region to 230 km at the mouth. The Barra del Indio, a shallow bar across the river, divides the estuary into inner and

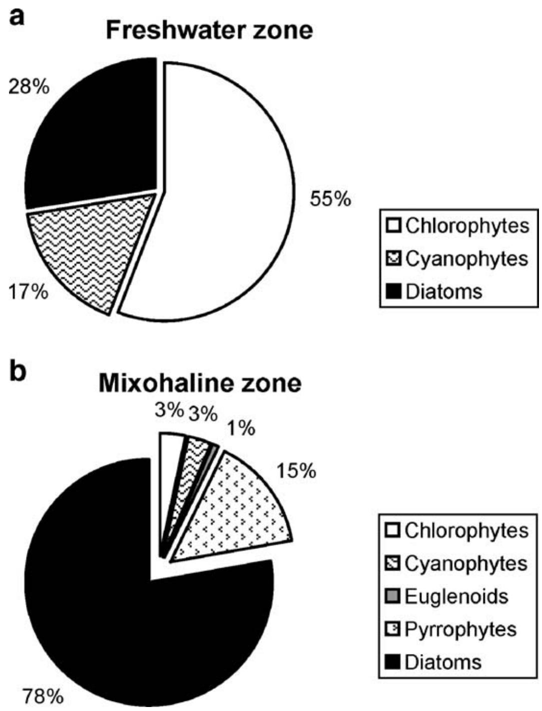

Fig. 2. Proportion of diatoms and other phytoplanktonic groups in the freshwater zone (a) and in the mixohaline zone (b).

outer areas (CARP–SHN–SOHMA, 1989) (Fig. 1). The inner region has a pluvial regime with a depth range between 1 and 5 m. The outer region is mainly mixohaline and the depth ranges between 5 and 25 m (Mianzan et al., 2001). The isohaline of 0.5 PSU is the boundary between the freshwater and mixohaline zone.

The freshwater input, coming mainly from the Paraná and Uruguay rivers, averages 20,000–25,000 m^3 s^{-1} (CARP–SHN–SOHMA, 1989) and exhibits minimal seasonal variation. The tidal waves originate on the outer shelf and enter the estuary from the Southeast, with amplitudes ranging from 30 to 100 cm. Tidal currents are typically below 45 cm s^{-1} and residence time is 46.6 days. The dynamics of the Río de la Plata estuary are controlled by the tide and wind-driven waves, and the continental runoff, but are modified by the topography and Coriolis force (Guerrero et al., 1997).

3. Results and discussion

3.1. Diatom assemblages

Chains or filaments of centric diatoms were frequent and dominant in the samples along the fluvial–mixohaline

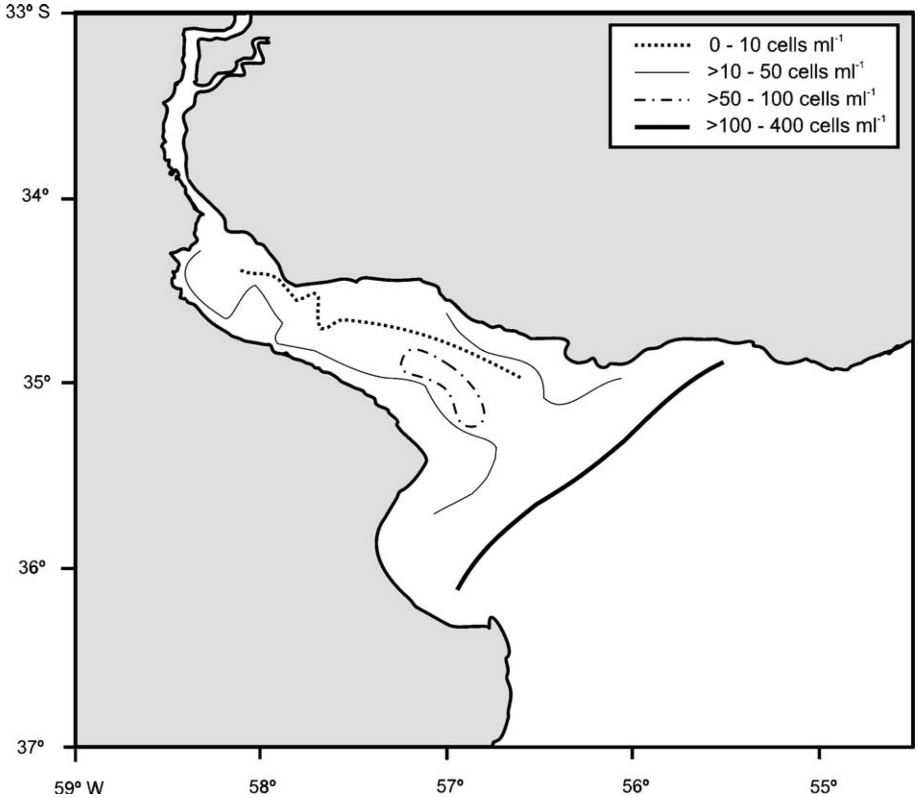

Fig. 3. Map showing the distribution of diatoms densities in the Río de la Plata.

axis (e.g. *Aulacoseira ambigua*, *A. granulata*, *A. granulata* var *angustissima*, in the freshwater tidal zone, and *Skeletonema costatum* in the mixohaline zone). These morphology types provides extensive light absorbing surfaces (Reynolds, 1992) and are an advantage in environments with a high concentration of suspended solids as in the Río de la Plata (Gómez et al., 2004). O'Farrell (1992), O'Farrell et al. (1998) and Reynolds and Descy (1996) reported that species of *Aulacoseira* are frequent and common in the phytoplankton of large rivers, while Muylaert and Sabbe (1999), Mallin (1994) and Rijstenbil et al. (1993) point out *Skeletonema costatum* as a common taxa in the phytoplankton of temperate estuaries. The greatest species richness, and highest number of pennate taxa, were observed in the upper zone (Table 1). The species found in this area are frequent in the Paraná and Uruguay rivers (O'Farrell, 1992; Zalocar de Domitrovic and Maidana, 1997) and in other small tributaries of the Río de la Plata (Bauer et al., 2002; Gómez and Licursi, 2001; Licursi and Gómez, 2003). According to Gómez et al. (2004) riverine specimens dominated the phytoplankton over 48% of surface of the Río de la Plata. Muylaert (1999) reported that input of allochtonous, riverine phytoplankton is an important process in the upper reaches of the freshwater tidal zone in the Schelde estuary.

In the freshwater tidal zone the phytoplankton was dominated by chlorophytes (55%) while diatoms comprised 28%. The cyanophytes reached 17%; in the Río de la Plata due to the high residence time and their connection with other eutrophic systems, this group constitutes a potential risk for the human health because of the development of harmful species as *Microcystis aeruginosa*, among others (Gómez and Bauer, 2000). In the mixohaline zone diatoms reached 78% and pyrrophytes were the subdominant group (15%) (Fig. 2). Schuchardt and Schirmer (1991), Rijstenbil et al. (1993), Mallin (1994) and Muylaert and Sabbe (1999) reported the dominance of diatoms in the mesohaline zone of temperate estuaries of the North Hemisphere.

The greatest diatoms density was observed at site 29 (372 cells ml^{-1}) and the minimum value at site 10 (3 cells ml^{-1}) (Fig. 3). The average density of diatoms in the Río de la Plata estuary was 59 cells ml^{-1}. Dominance according to algal carbon contribution to phytoplankton stock contrasts with the picture for cell counts. The carbon content of the diatoms increased downstream, with an average value of 1.9 $\mu g\ C\ l^{-1}$ in the freshwater tidal zone and 4.2 $\mu g\ C\ l^{-1}$ in the mixohaline zone. Diatoms supplied 65% of the total phytoplankton carbon content upstream (attributable mainly to *Aulacoseira ambigua*, *A. granulata*, *A. granulata* var. *angustissima* and *Cyclotella striata*). Downstream, the diatom carbon content reached 17%, being supplied principally by *Skeletonema costatum*, *Actinocyclus normanii* and *Chaetoceros* spp. (Fig. 4). Diatom biomass observed in the Río de la Plata estuary was lower than the reported for other turbid and temperate estuaries from Europe (Rijstenbil et al., 1993; Muylaert and Sabbe, 1999; Domingues et al., 2005).

3.2. Environmental variables and diatom assemblages

The maximum values of salinity, pH and dissolved oxygen occurred in the external mixohaline zone of the Río de la Plata, while the highest values of temperature and nutrients were observed in the freshwater zone (Table 1). The maximum turbidity front was located among sites 15–23.

The first two axes of the CCA accounted for 71% of the sum of all canonical eigen values and were selected for graphical representation (Fig. 5). Considering the variance in the species data, the first axis explained 32.7%, and the second 6%. This ordination allowed us to identify two species assemblages in the Río de la Plata differentiated mainly by salinity, pH and silicate gradients. The first included diatom taxa associated with low salinity, pH, and concentrations of dissolved oxygen and higher amounts of suspended solids and

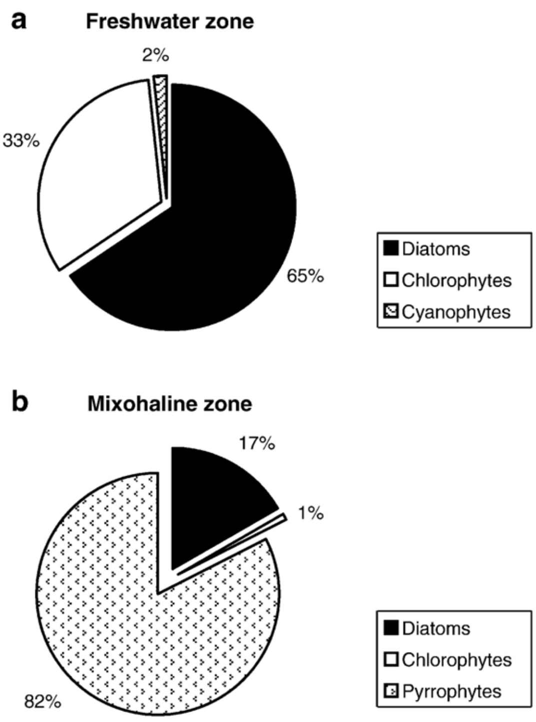

Fig. 4. Percent of the phytoplankton carbon contributed by individual phytoplankton groups in the freshwater tidal zone (a) and in the mixohaline zone (b).

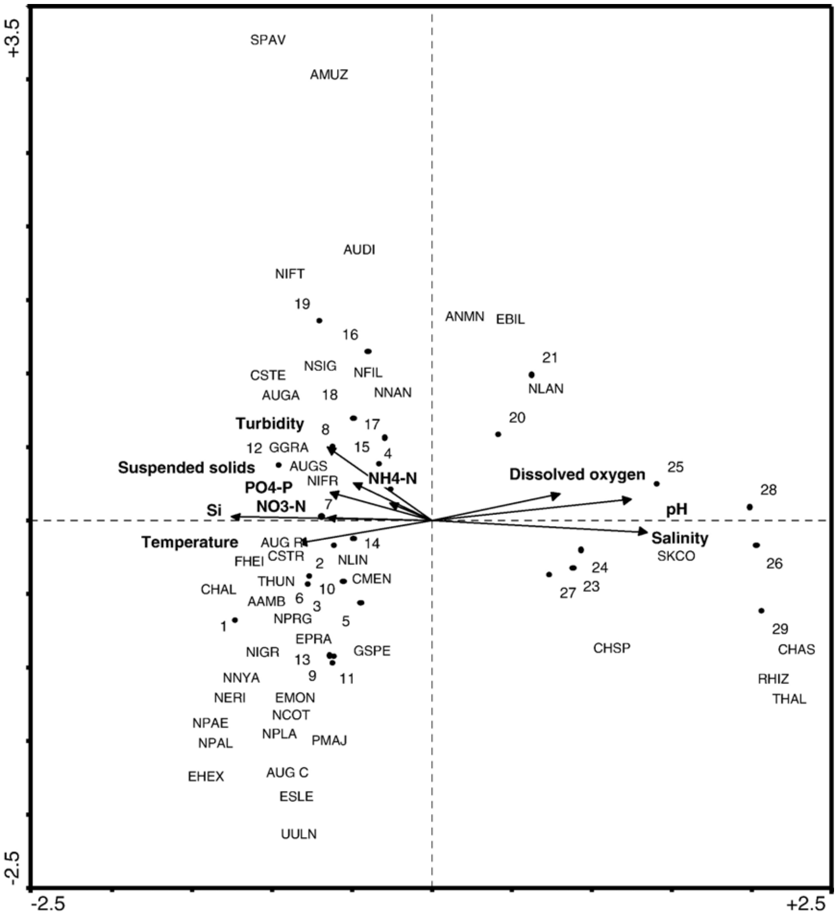

Fig. 5. Ordination diagram displaying the first two axes of the CCA constrained with environmental variables. Numbers represents sampling sites. Acronyms of species names are shown in Table 1.

nutrients (sites 1–19). In this association two groups of taxa could be recognized, one related to higher turbidity (e.g. *Stephanodiscus parvus*, *Aulacoseira granulata* var. *angustissima*, *Aulacoseira distans*, *Aulacoseira muzzanensis*, *Nitzschia nana*, *Nitzschia fruticosa*, *Gomphonema gracile*, *Aulacoseira granulata* var. *angustissima* f. *spiralis*) and the other with low turbidity (e.g. *Aulacoseira granulata*, *Cyclotella striata*, *Aulacoseira ambigua*, *Aulacoseira granulata* morphotype *curvata*, and many pennate taxa such as *Fragilaria heidenii*, *Craticula halophila*, *Navicula peregrina*, *Eunotia praerupta*, *Navicula nyassensis*, *Nitzschia paleacea*, *Ulnaria ulna* and *Encyonema silesiacum*). The second association grouped taxa that tolerate more salinity and alkalinity (sites 20–29) (e.g. *Skeletonema costatum*, *Thalassiosira* sp., *Chaetoceros affinis*, *Chaetoceros* spp. and *Rhizosolenia* sp.). This group of species is characteristic of marine environments. The transition between 7 and 8 PSU (sites 23–24), in the surface samples analysed, was the lower limit of salinity tolerance for marine taxa. In our study species exclusive to brackish waters were not identified, but some freshwater and marine taxa with wide ranges of salinity tolerance were observed. According to Carpelan (1978), all diatoms living in transitional zones between marine and freshwater should be considered as marine or freshwater taxa with different degrees of euryhalinity.

The distribution of the percentage of empty frustules showed a statistically significant correlation ($p<0.05$) with the bathymetry of the Río de la Plata. The highest percentages of empty frustules (mainly of freshwater centric diatoms) was observed in samples from sites with depths <10 m, reaching more than 70% in sites 11 and 21 (Fig. 6). The Río de la Plata estuary is a shallow system and diatoms benefit from windy periods that resuspend both live cells and empty frustules. The correlation between the percentage of empty frustules and the silicon concentration was also significant ($p<0.001$). Studies of silicon (Si) cycling

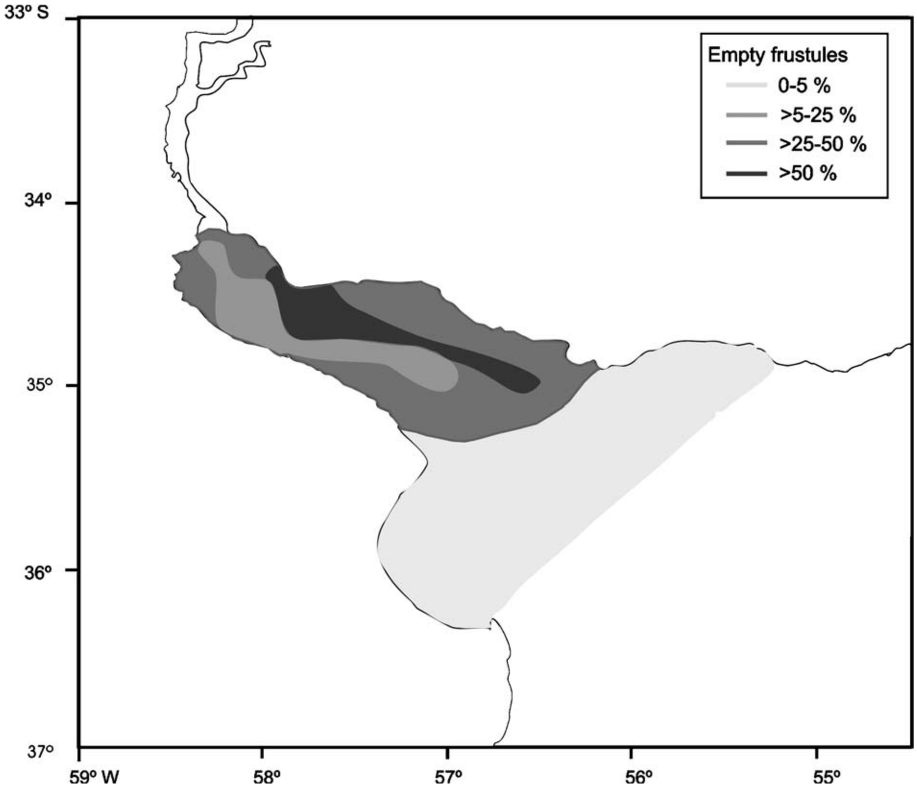

Fig. 6. Map showing the distribution of empty frustules in the Río de la Plata estuary.

in estuarine systems have emphasized the importance of terrestrial inputs, benthic fluxes and uptake and recycling of Si by diatoms (Norris and Hackney, 1999).

4. Conclusions

The greatest species richness, and highest numbers of pennate taxa, were observed in the upper zone, due to the shallow depth of this area that favours the incorporation of benthic diatoms in the water column and to the contribution of species proceeding from the main tributaries.

Two species assemblages were recognized in the Río de la Plata. The first included diatom taxa associated with low salinity, pH, and concentrations of dissolved oxygen and higher concentrations of suspended solids and nutrients. This assemblage was characterized mainly by species and varieties of the genus *Aulacoseira* arranged along a progressive change in turbidity gradient.

The second assemblage grouped taxa typical of marine environments, that tolerate more salinity and alkalinity.

In our study species exclusive to brackish waters were not identified, but some freshwater and marine taxa with wide ranges of salinity tolerance were observed. Diatoms were the dominant phytoplanktonic group in the mixohaline zone, however diatoms also supplied the greatest amount of carbon content to the ecosystem in the freshwater tidal zone.

The growing socio-economic development of Argentina and Uruguay requires the implementation of more investigations in order to improve the knowledge of diversity and ecology of the biotic communities that inhabit the Río de la Plata; this type of information will contribute toward the sustainable management of this ecosystem.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jmarsys.2006.03.002.

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