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Research Article

The first continuous plankton sampling by VOR (Towed Oceanographic Vehicle) in southeastern and southern Brazil waters

Márcio Silva Tamanaha[1], Dyegho Moraes Costa-Gama Cunha[1] & Charrid Resgalla Junior[1]
[1]Centro de Ciências Tecnologica da Terra e do Mar (CTTMar)
Universidade do Vale do Itajaí, Itajaí, Santa Catarina, Brazil
Corresponding author: Márcio Silva Tamanaha (marcio.tamanaha@univali.br)

ABSTRACT: Plankton sampling with the Continuous Plankton Sampling survey has been conducted since 1938 in the Northern Atlantic Ocean and North Sea, where in both cases historical records have documented climate change. Plankton sampling with the VOR (Towed Oceanographic Vehicle) on industrial fishing boats was performed in May-June of 2013 off the southeastern and southern coasts of Brazil (between 23º00`S-44º21`W and 31º15`S-50º06`W). The speed of VOR towing onboard the fishing vessels was 8-10 knots to 10-12 m of depth. The size of mesh silk used was 250-270 µm. The total of taxa is 73 phytoplankton, 26 zooplankton, 10 protozooplankton (Ciliophora) and ichityoplankton (fish eggs) were recorded. The dominant phytoplankton groups detected were diatoms and dinoflagellates, although cyanobacteria were also abundant in the southeast region. The zooplankton with a size class of less than 2 mm was the most frequent. A positive correlation was observed between herbivorous zooplankton and phytoplankton in the coastal waters.

Keywords: continental shelf, ship of opportunity, VOR, plankton, Brazil.

Primer muestreo continuo de plancton con VOR (Vehículo Oceanográfico Remolcado) en aguas del sureste y sur de Brasil

RESUMEN: El muestreo de plancton con el Continuous Plankton Recorder (CPR) se ha efectuado desde el año 1938 en el Océano Atlántico Norte y Mar del Norte, donde en ambos casos el registro histórico ha documentado el cambio climático. El muestreo de plancton con el VOR (Vehículo Oceanográfico de Remolque), empleado por la flota pesquera industrial se efectuó en mayo-junio de 2013 en la costa sur y sureste de Brasil (23º00`S-44º21`W y 31º15`S-50º06`W). La velocidad de arrastre del VOR, utilizada por las embarcaciones pesqueras fue de 8-10 nudos a 10-12 m de profundidad, utilizando un tamaño de red de 250-270 µm. Se registró un total de 73 taxa de fitoplancton, 26 de zooplancton, 10 de protozoarios e ictioplancton (huevos de peces). Los grupos dominantes de fitoplancton fueron diatomeas y dinoflagelados, aunque las cianobacterias fueron también abundantes en la región sudeste. El zooplancton con un tamaño de clase <2 mm fue el más frecuente. Se observó una correlación positiva entre el zooplancton herbívoro y fitoplancton en aguas costeras.

Palabras clave: plataforma continental, barco de oportunidad, VOR, plancton, Brasil.

INTRODUCTION

Study of marine plankton using the CPR (Continuous Plankton Recorder) began in the North Sea in 1938 (Lucas, 1941), with the methods being later standardized, in 1960 (Colebrook, 1960). Since then, the methodology has not been significantly changed. The majority of studies have focused on the North Atlantic, North Sea and North Pacific (Warner & Hays, 1994; John *et al.*, 2002; Lindley & Batten, 2002; Batten *et al.*, 2003a; Richardson *et al.*, 2006; Head & Pepin, 2010a, 2010b). In the southern hemisphere, sampling began in 2001 (Hosie *et al.*, 2003; Hunt & Hosie, 2003) with emphasis on describing the variation of plankton between the Australian (60º to 160ºE and 48ºS) coastal and oceanic zone. In the last decades, studies have been

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conducted using historical data of CPR in relation to climate change (Edwards *et al.*, 2001; Head & Pepin, 2010a), and phenology of the plankton (Edwards & Richardson, 2004).

Different lines of research associated with the planktonic community can be conducted through the use of Continuous Plankton Sampling (CPS), which facilitates obtaining data in regions which until then, had not been studied on the same spatial-temporal scale. For the Brazilian coast, the studies of plankton were always based on sampling with traditional sampling methods, using plankton nets and bottles (Alvarino, 1980; Moser & Gianesella-Galvão, 1997), involving different regions of the coast in the north (Araujo & Ribeiro, 2005), northeast (Klein, 1977; Gomes *et al.*, 1989), southeastern (Muxagata & Montú, 1999), and southern (Resgalla Jr. *et al.*, 2001; Resgalla Jr., 2011), and in all cases, the samplings were conducted by scientific cruises, with limited duration and geographical coverage.

The opportunity to obtain oceanographic data continuously, using the VOR (Towed Oceanographic Vehicle - from the Portuguese Veículo Oceanográfico de Reboque) developed by Faccin *et al.* (2014), used in different fishing boats of the industrial fleet (opportunity vessels), offers new perspectives for the knowledge of planktonic groups on the Brazilian continental shelf. Associated with this, the use of fishing boats means that the oceanographic parameters can be easily collected in marine areas of greater economic interest and ecological importance. This study therefore presents the initial results obtained by continuous plankton sampling with the use of the VOR, towed by vessels of the industrial fishing fleet in the southeastern and southern regions of Brazil. The aim this study is to assessment plankton community distribution through continuous plankton monitoring by VOR in different Brazilian Coastal Zone and yours relationship with local hydrological characteristics.

MATERIALS AND METHODS

Study area

The Continental Shelf of the South Atlantic (Southwestern Atlantic Shelf - SWAS) comprises the southern and southeastern regions of Brazil involving the Southern Brazilian Bight (SBB - ~22°00-28°30'S) and Southern Subtropical Shelf (SSS - ~28°30-33°75'S) (Piola *et al.*, 2000; Lopes *et al.*, 2006; Palma *et al.*, 2008). The prevalent water masses in the SBB are Tropical Water (TW - T ºC >18.5 and S >36.4) of the Brazil Current on the surface, South Atlantic Central Water (SACW- T <20ºC and S <36.4) in the subsurface (200-500 m), and Coastal Water (CW) (50 m) influenced by different river inflows to the Brazilian coastal zone. In the SSS, the Falkland Current is also present, especially in the colder months, together with the Subantartic Water mixed with the Rio de La Plata, forming the La Plata Front (Piola *et al.*, 2000; Palma *et al.*, 2008).

Sampling and data acquisition

The VOR (Faccin *et al.*, 2014) operates with a silk mesh (250 and 270 µm), at trawling depths between 10 and 12 m and speeds between 8 and 10 knots (15-18,5 km h^{-1}). Sampling was conducted from May-June 2013 on industrial fishing fleet in the region of Itajaí (southern Brazil). Two trawlers were used: the Mtanos Seif operates with purse-seine fishing targeting *Sardinella brasiliensis* and the Nicassio da Costa operates with simple trawling targeting *Umbrina canosai* and *Prionotus punctatus*. The trawls (transects) were performed on the continental shelf of the southeastern and southern regions of Brazil, between the states of Rio de Janeiro and Rio Grande do Sul (Table 1, Fig. 1). In all the trips, the VOR was operated by scientific observers on board, with the aid of the crew.

After each trawl, the mesh of the plankton collection unit (K7) was rewound and wrapped in plastic bags containing 4% formaldehyde buffered with Potassium and Sodium tetraborate. The trawl courses were determined using GPS Archer software Navicomputer®, and the data on sea surface temperature between the areas sampled were obtained from satellite data from the NASA website for the same periods (http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=ocean_month).

Plankton analysis

In the laboratory, the meshes were sectioned every 5 nautical miles. Different analysis methods were used for the phytoplankton, protozooplancton and zooplankton, according to Batten *et al.*, (2003b) and Richardson *et al.* (2006). Qualitative and quantitative analyses of the phytoplankton were performed under a CPR microscope (platinum glass - 150x200 mm). At least 30 counting fields were used, with cross-sectional identification with 625x magnification and a field area to mesh area ratio 1/8000. The protozooplankton and zooplankton <2 mm were analysed by scanning with 65x magnification, and a field area to mesh area ratio of 1/50. After the work with the phytoplankton and the protozooplankton, zooplankton >2 mm were removed from filter mesh, counted and identified in a Bogorov chamber in their totality. All groups were identified to the lowest possible taxon; for the zooplankton, there was a prevalence of copepods.

Table 1. Details of VOR transects conducted during fishing vessels cruises in May and June 2013.

Transect	Vessel (fishing boats)	Sampling period	Latitud (S)	Longitud (E)	Distance (nautical miles)
SSB1	*Mtanos Seif*	May 02, 2013	23.00-24.56	44.21-44.55	30.00
SSB2	*Mtanos Seif*	May 03, 2013	24.56-25.31	47.03-47.31	40.00
SSB3	*Mtanos Seif*	May 03, 2013	26.24-26.25	48.26-47.58	20.00
SSB4	*Nicássio Costa*	June 18, 2013	27.03-27.17	48.22-47.57	25.00
SSS1	*Nicássio Costa*	June 28, 2013	30.45-30.26	49.47-49.13	20.00
SSS2	*Nicássio Costa*	June 28, 2013	31.15-31.32	49.59-50.06	35.00

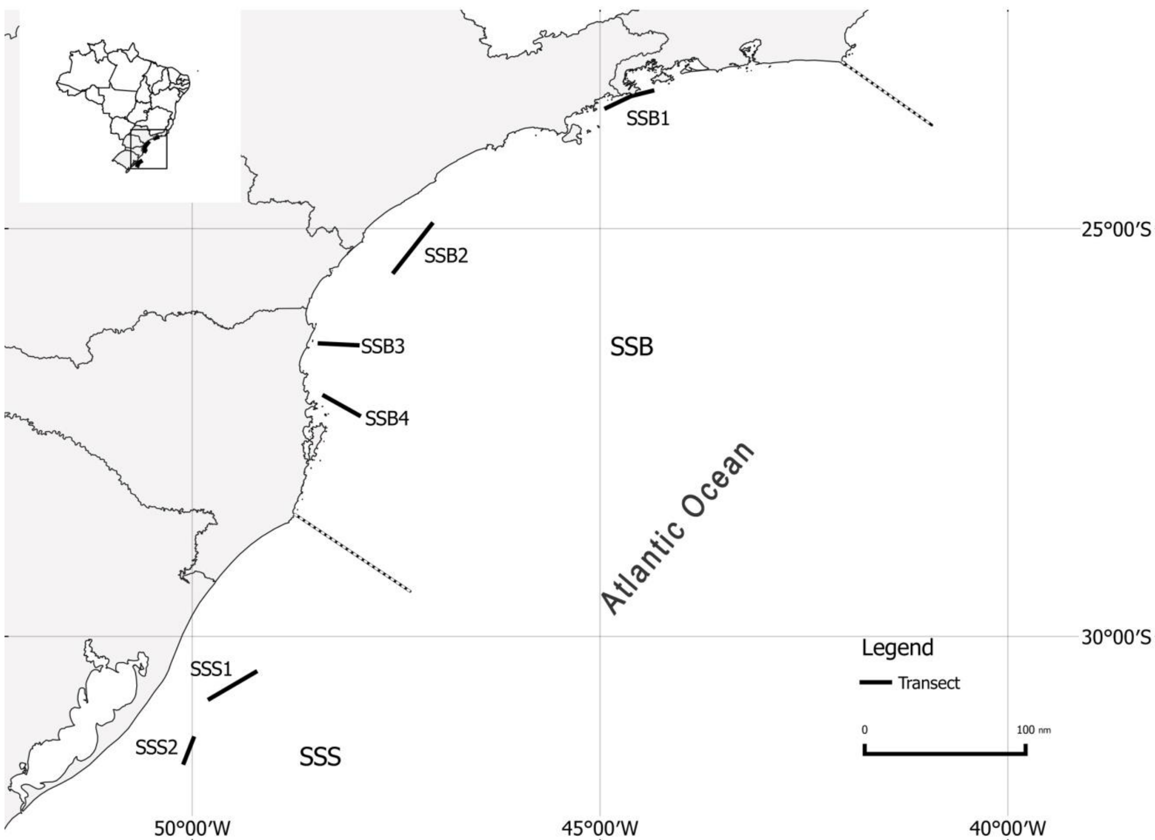

Figure 1. VOR map towing from industrial fishing boats. Highlight of the transects of the southeast and south regions of Brazil (solid line: SSB1, SSB2, SSB3, SSB4, SSS1, SSS2). Dashed line: boundary between Southern Brazilian Bight (SSB) and Southern Subtropical Shelf (SSS).

For the identification of organisms and their classification regarding to distribution in the marine environment of the Brazilian coast, the works of Cupp (1943), Desikachary (1959), Balech (1988); Balech *et al*. (1984), Round *et al.* (1990), Silva-Cunha & Eskinazi-Leça (1990), Torgan & Biancamano (1991), Hasle & Syvertsen (1997), Tomas (1997), Cardoso (1998) and Faust & Gulledge (2002) were used for the phytoplankton, and those of Rose (1933), Boltovskoy (1981, 1999), Conway *et al.* (2003), Johnson & Allen (2005) and Conway (2012a, 2012b) for the protozoo-plankton and zooplankton.

Statistical analysis

The analysis of plankton data followed the procedure described by Field *et al.* (1982) and Lindley & Williams (1994), which used a 10% higher rate of occurrence of taxa per sample. The Primer® program was used to compose a 2-dimensional scatter plot from the matrices of Bray-Curtis coefficients, were calculated for similarities between the taxa occurring within samples and the distributions of taxa between samples for each tow, by MDS (non-metric multidimensional scaling). PERMANOVA (One-way) analysis was used to test the null hypothesis that the abundance and species richness levels of a species/taxa did not differ between sample groups, and Simper analysis was used to compare the main taxa occurring within samples, and the distributions between samples for each tow. PERMANOVA data were interpreted as indicating areas with significant different plankton groupings, and the composition of different groupings. Multivariate correlation analysis (Statistic®) was used and negative/positive correlation trophic plankton community.

RESULTS

A gradient in surface temperature of the water was observed, with higher temperatures to the north (SSB1 - 23.6 to 24.5ºC), intermediate temperatures in the central region (SSB2, SSB3 and SSB4 - 21.2 to 23.4ºC) and lower temperatures to the south (SSS1 and SSS2 - 19.4 to 21.3ºC). We have identified 75 phytoplankton taxa, 26 zooplankton taxa, 10 protozooplankton taxa and fish eggs. The size of plankton is also a limitation sampling by VOR, because the size mesh and pico and nanoplankton rarely were collected, so, the community of plankton predominant is microphytoplankton (dinoflagellates, diatoms, cyanobacteria), copepods (zooplankton) and tintinnids (Ciliophora) (Table 2). The major percentage from VOR survey of phytoplankton (48%) is from coastal waters, zooplankton (48.6%) and protozooplankton (60%) from the mixture of neritic/ oceanic waters (Figs. 2-3). The result had shown that there is bottom up effect between phytoplankton and zooplankton and both of them densities tended to decrease in a north-south region (Fig. 4). For tows involving the coast and the part of ocean (transects SSB3 and SSB4), the zooplankton showed a tendency to increase in density towards the ocean. All the tows made in north-south direction were more extensive than in the east-west direction, providing greater variations in spatial distribution of the plankton.

The planktonic community showed high similarity among transects, with representation of groupings between SSB1 and SSB2, SSS1 and SSS2 and an isolated group in SSB4 (MDS coefficient of stress: 0.18) (Fig. 5). Significant differences were also observed between the transect in the north region (SSB), and higher similarity in transects located in the south region (SSS) (Pseudo-F: 5.176) (Table 3). The taxa with more significant abundance among the transect analysed are shown in Table 4. The difference for transect SSB1 in relation to the other transects is due to the high densities and predominance of the nanoplanktonic cyanobacteria *Johannesbaptistia* sp. This group was also important in transect SSB2, but with greater representation of other species (*Proboscia alata*, *Dictyocha fíbula*, *Neoceratium fusus*, *Thalassionema bacillare*) due the position of this transect, the farthest from the coast. Transect SSB3 presented high density of cyanobacteria at the beginning of the tow (*Thrichodesmium erythraeum, T. thiebautii*), followed by high density of diatoms (*Hemiaulus hauckii*) and dinoflagellates (*Prorocentrum sigmoides*), whereas that of transect SSB4 *Thalassiosira* spp. showed high density throughout the route. Transects SSB3 and SSB4 were similar due to their intermediate location, and because the tow direction was from the coast towards the ocean. Despite these differences, the distribution of phytoplankton was homogeneous for the transects located in SSB. For SSS the silicoflagellate *Octotactis octonaria* was predominant in SSS1 and SSS2.

For the protozooplankton, the predominant taxa in the southeastern region (SBB) were tintinnids (*Salpingella* sp.), which contributed to the high densities in SSB1, and zooplankton such as copepods there is high densities, as well as the presence of representatives of other groups such as Cladocera, Chaetognatha and Tunicata. In SSB2, copepods (*Paracalanus* sp., *Temora turbinata*, *Oithona* sp. and *Oncaea* sp.) and protozooplankton (*Codonellopsis*, *Salpingella* and *Dictyocysta*) had similar densities. Copepods (*Temora* and *Oncaea*) and Cladocera (*Penilia avirostris*) were the only groups observed in SSB3, and were low in number. In SSB4, copepods were predominant near the coast, while Appendicularia, Chaetognatha and Cladocera were representative in waters farther away from the coast. For the SSS region, Copepoda were the predominant group, represented by *Oithona*, *Oncaea*, *Clausocalanus* and *Centropages velificatus* in both transects of SSS1 and SSS2. Other groups of note were the Protozoa *Codonelopsis*, euphausiids, hyperiids and decapod larvae.

A positive correlation was observed between small-sized herbivorous zooplankton or those with microphagous habits (*Penilia avirostris*, *Salpingella* sp.) and the coastal phytoplankton (first axis). For other groups, such as amphipods hyperiids, euphausiids, and the copepods *Oithona* sp. and *Clausocalanus* sp., the distribution was associated with the habitats oceanic and oceanic/neritic (Fig. 6) and not with the trophic relationships.

DISCUSSION

The values for sea surface temperature showed differences between the studied regions, with a remarkable

Table 2. Classification of phytoplankton, protozooplankton and zooplankton observed in SSB (Southern Brazilian Bight) and SSS (Southern Subtropical Shelf).

Heterokontophyta	Dinophyta	Copedoda
Coscinodiscophyceae	*Ornithocercus magnificus*	*Acartia* sp.
Thalassiosira spp.	*Amphisolenia bidentata*	*Calanoides*
Skeletonema sp.	*Neoceratium fusus*	*Calanus* sp.
Cerataulina pelágica	*Neoceratium lineatum*	*Centropages velificatus*
Cerataulina dentata	*Neoceratium macroceros*	*Clausocalanus* sp.
Corethron criophilum	*Neoceratium hexacanthum*	Copepoda sp.
Dactyliosolen cf *blavyanus*	*Neoceratium pentagonum*	Copepoda (eggs)
Pseudosolenia calcar avis	*Neoceratium horridum*	Copepoda (nauplii)
Proboscia alata	*Neoceratium furca*	Copepoda (juveniles)
Rhizosolenia imbricata	*Neoceratium condelabrum*	*Labidocera* sp.
Rhizosolenia setigera	*Neoceratium trichoceros*	*Paracalanus* sp.
Rhizosolenia hebetata	*Neoceratium* sp.	*Pseudocalanus* sp.
Rhizosolenia sp.	*Neoceratium tripos*	*Undinula* cf. *vulgaris*
Bacteriastrum hyalinum	*Alexandrium fraterculus*	Calanidae
Bacteriastrum delicatulum	*Scrippsiella trochoidea*	*Temora turbinata*
Chaetoceros aequatorialis	*Podolampas palmipes*	*Temora stylifera*
Chaetoceros cf. *brevis*	*Protoperidinium claudicans*	Poecilostomatoida
Chaetoceros decipiens	*Protoperidinium elegans*	*Corycaeus* sp.
Chaetoceros diversus	*Prorocentrum* cf. *mexicanum*	Harpaticoida
Chaetoceros peruvianus	*Prorocentrum micans*	*Oithona oswaldocruzi*
Chaetoceros subtilis	*Prorocentrum gracile*	*Oithona* sp.
Chaetoceros whigamli	*Prorocentrum minimus*	*Oithona plumifera*
Chaetoceros eibenii	*Pyrocystis obtusa*	*Oncaea* sp.
Leptocylindrus danicus	Pyrocystis *lunula*	*Oncaea media*
Ditylum brighterii	Chromophyta	*Oncaea mediterranea*
Hemiaulus hauckii	Dictyochophyceae	*Microsetella* sp.
Fragilariophyceae	*Dictyocha fibula*	Branchipoda-Cladocera
Lioloma pacificum	*Dictyocha* sp	*Penilia avirostris*
Thalassionema nitzschioides	*Octotactis octonaria*	*Podon* sp.
Thalassionema bacillare	Cyanophyta	Tunicata
Climacosphenia sp.	*Synechococcus* sp.	*Appendicularia* sp.
Bacillariophyceae	*Johannesbaptistia* sp.	Chaetognatha
Naviculaceae	*Richelia intracellularis*	Tecossoma
Pleurosigma aestuarii	*Katagnymene pelágica*	Euphausidae
Cylindroteca closterium	*Trichodesmium erythraeum*	Hyperidae
Nitzschia longissima	*Trichodesmium hildebrandtii*	Decapoda
Pseudo-nitzschia - complex delicatissima	*Trichodesmium* sp.	Fish eggs
Pseudo-nitzschia - complex seriata	*Oscillatoria* sp.	
Synedra sp.	Oscillatoriales 1	
Entomoneis sp.		
Protozooplancton	*Dictyocysta* sp.	*Salpingella* cf. *acuminatoides*
Codonellopsis sp.	*Dadayiella ganymedes*	*Tintinopsis campanula*
Codonella	*Eutintinus* sp.	*Xystonellopsis gaussi*
Codonellopsis schabi	*Salpingella* sp.	

gradient from north to south. The transects of region SSB (of SSB1 SSB4) was characterized by coastal and warm continental shelf waters, or the influence of the Brazil Current, due to higher temperatures, in according to Silveira *et al*. (2000). In the south region (SSS1 and SSS2), the influence of coastal water, with the La Plata front (Piola *et al.*, 2000) may have contributed to lower temperature observed. This thermal gradient was probably a primary factor forcing the separation of the groups of transects between the regions SSB and SSS observed in the ordering analyses (MDS), differentiating the densities and groups of phytoplankton and zooplankton.

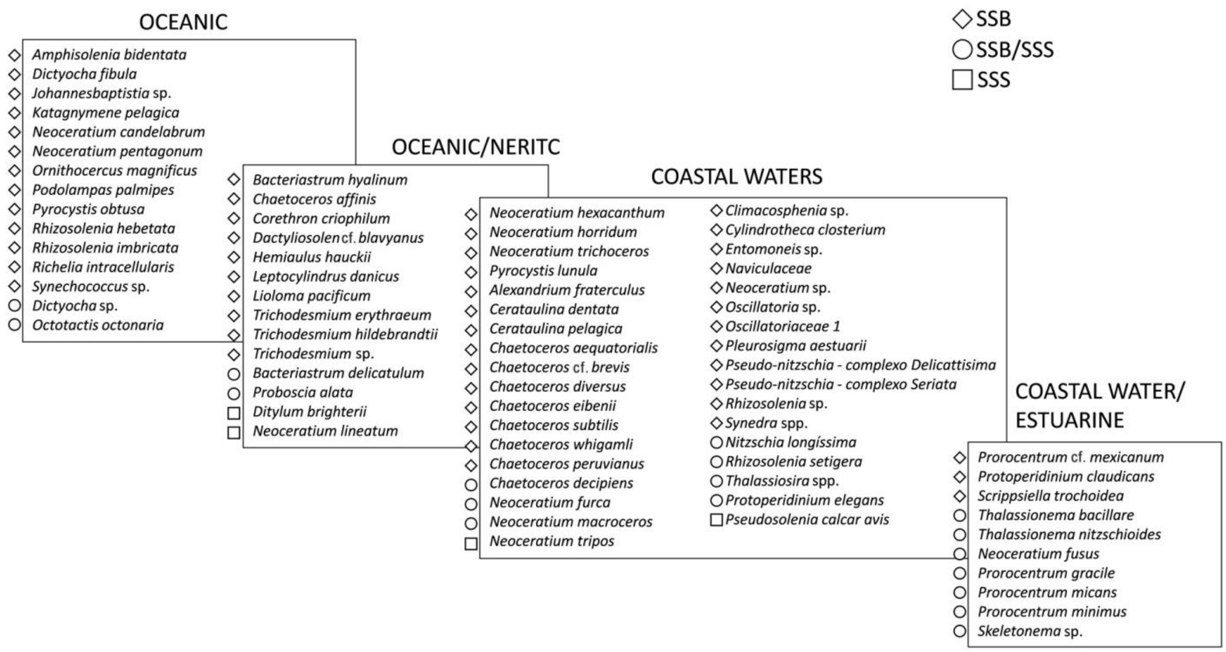

Figure 2. Classification of phytoplankton (taxonomy) according to their habitat distributions (oceanic, oceanic/neritic, coastal waters and coastal water/estuarine) and its occurrence in SSB (Southern Brazilian Bight), SSB/SSS (both region), SSS (Southern Subtropical Shelf).

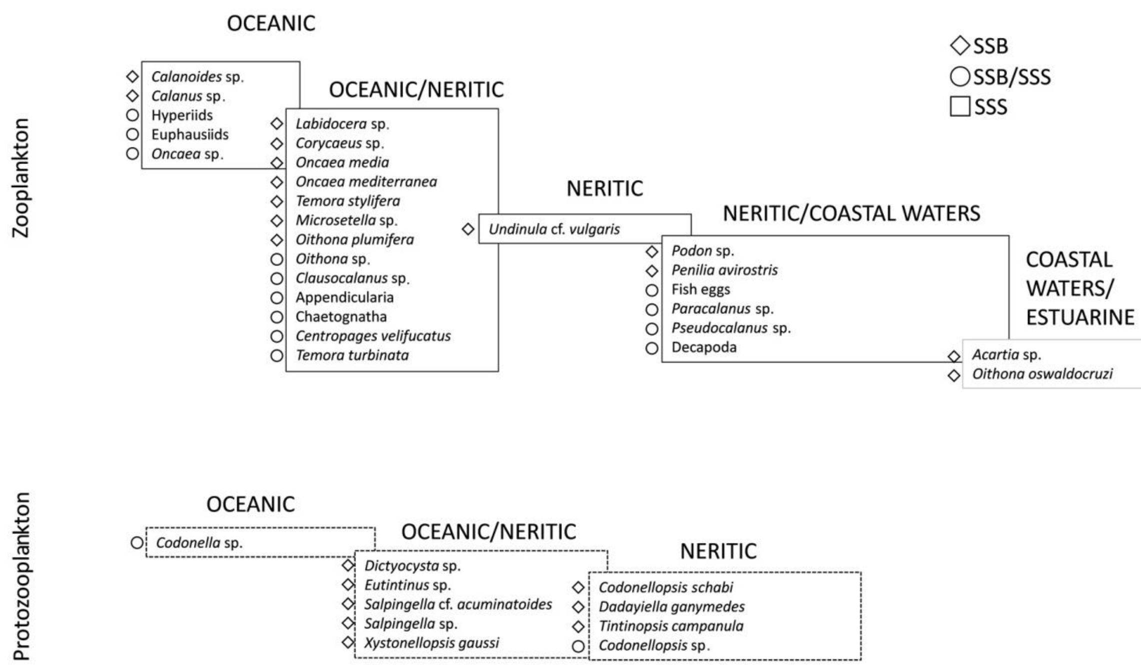

Figure 3. Classification of zooplankton, protozooplankton and other groups (taxonomy) according to habitat distributions (oceanic, oceanic/neritic, neritic, neritic/coastal waters and coastal water/estuarine) and its occurrence in SSB (Southern Brazilian Bight), SSB/SSS (both regions), SSS (Southern Subtropical Shelf).

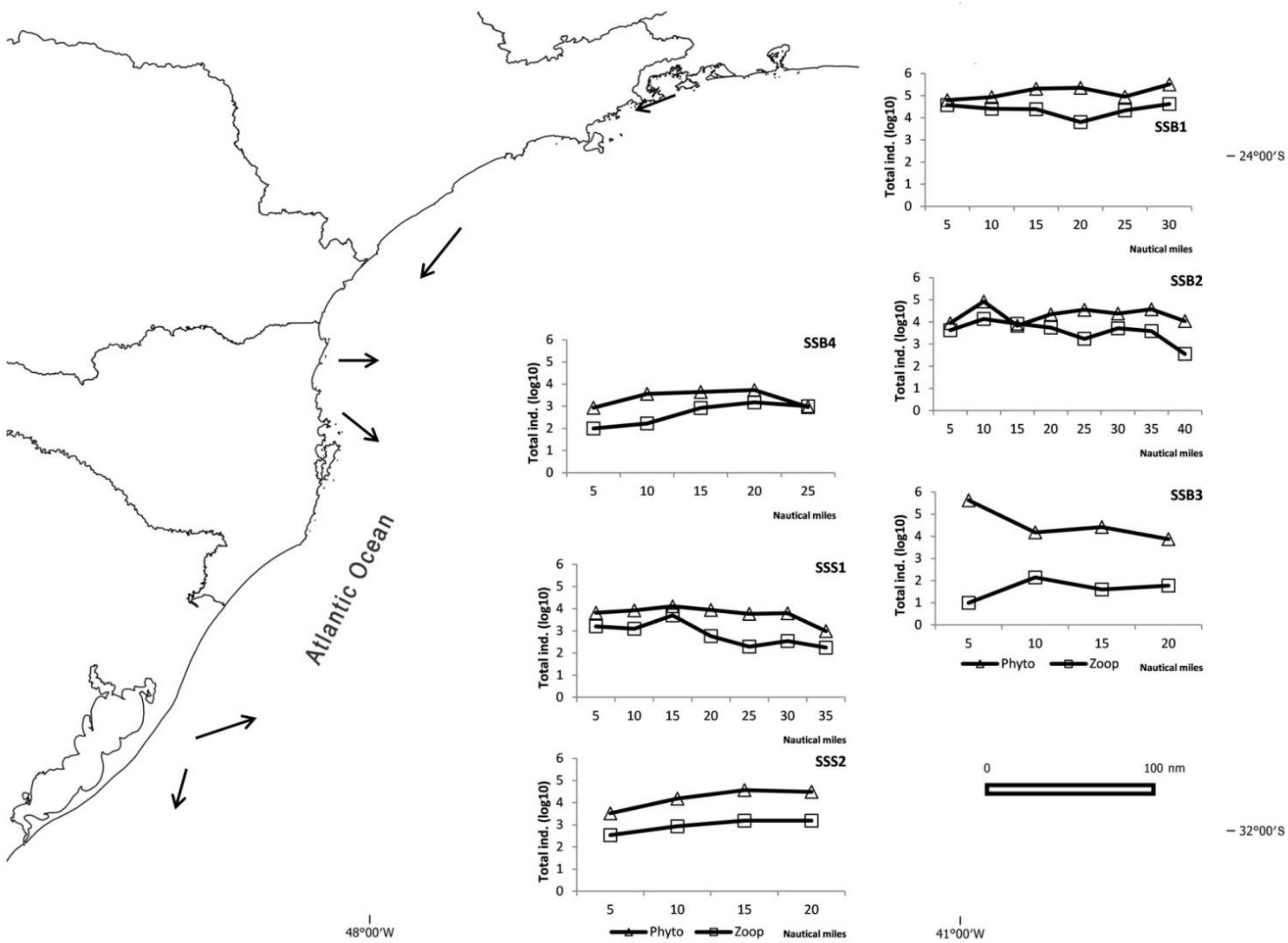

Figure 4. Total phytoplankton (log10) and zooplankton (log+1) density each 5 nm (9.26 km) between towing areas (transects: SSB1, SSB2, SSB3, SSB4, SSS1, SSS2).

For the Brazilian coastal zone, these are the first results related to the category of continuous plankton sampling with the use of VOR and microplankton was the fraction with the highest yields in the VOR tows and was also common in the North Sea and North Atlantic Ocean (Lindley & Williams, 1994; Beaugrand *et al.*, 2000; Reid *et al.*, 2003; Richardson *et al.*, 2006). Besides the presence of diatoms and dinoflagellates in transects SSB1, SSB2 and SSB3, the nanophytoplankton (*Johannesbaptistia* sp.) was observed, accompanied by *Thrichodesmium erythraeum*, *Thrichodesmium thiebautii*, which were prevalent in high density. The proximity of transects SSB1 and SSB2 to the coast may favour the occurrence of *Johannesbaptistia* sp., due to its association with an environment with higher loads of organic matter (Cohen *et al.*, 1986), which is also commonly observed in tropical environments upon presence of river inflows (Bauer *et al*,, 2008). The genus *Thrichodesmium* characterizes high productivity in the oceanic region (Gallon *et al.*, 1996) and occurs from the northeast of Brazil (Koening & Macedo, 1999) to the southeastern and southern (Brandini & Fernandes, 1996), but with low density in Subantarctic Water (Brandini, 1988).

For the transects of the arrangement farther to the south (SSB4; SSS1 and SSS2), there was observed the high densities of diatoms and silicoflagellates, which are related to a higher concentration of silicate in this region, especially during the winter, with the two largest river inputs in the south region (Río de la Plata and the Lagoa dos Patos Estuary (Piola *et al.*, 2000), in addition to the high concentration of nutrients (Rigual-Hernandez *et al.*, 2010). These phytoplanktonic groups have already been observed in the same period, associated with the cold water of Subantarctic origin (Brandini, 1998). As a result, the high prevalence of these groups is reflected in the subsequent trophic levels, as they represent the main diet of copepods common to the Brazilian coast (Lopes, 1998).

The vast majority of zooplanktonic carcases observed in all transects were those of the copepods group (<2 mm) (*Acartia* sp., *Calanus* sp., *Centropages*

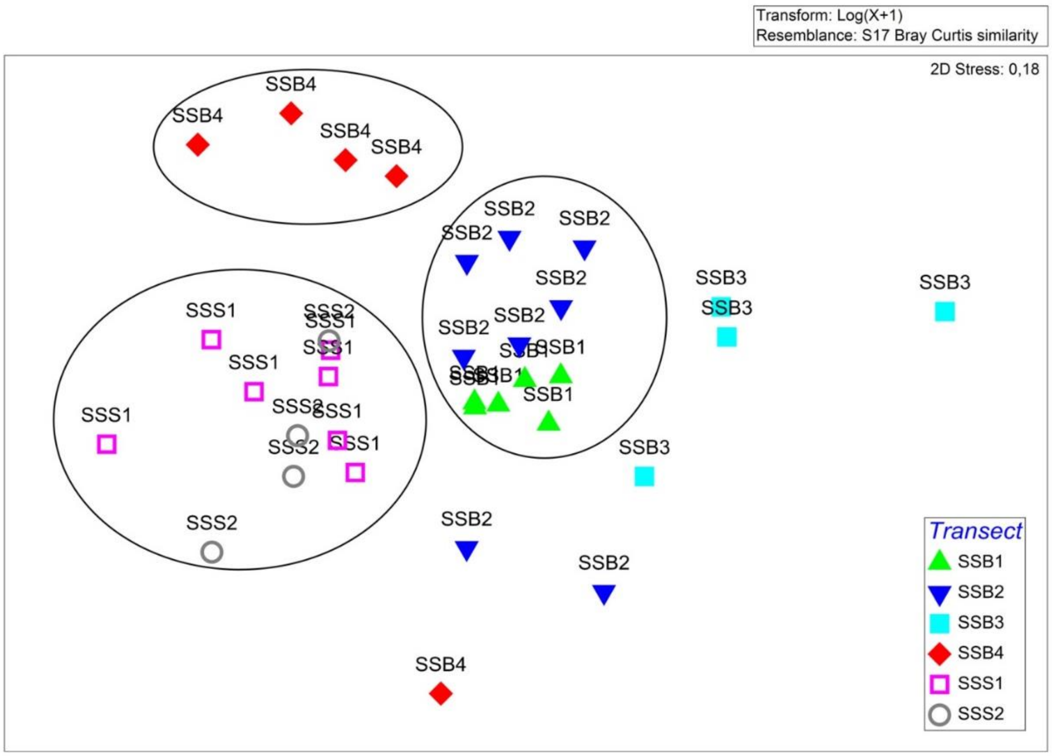

Figure 5. MDS analysis (Bray Curtis similarity - log+1; Stress: 0.18) to transects in base of phytoplankton and zooplankton densities (frequency of >10%). Sections of 5 nm to each transect (SSB1, SSB2, SSB3, SSB4, SSS1, SSS2).

Table 3. Plankton transects PERMANOVA analysis (P (perm), *non-significant difference).

P (perm)	SSB1	SSB2	SSB3	SSB4	SSS1	SSS2
SSB1	-					
SSB2	0.019	-				
SSB3	0.006	0.005	-			
SSB4	0.002	0.001	0.021	-		
SSS1	0.001	0.001	0.001	0.002	-	
SSS2	0.007	0.003	0.019	0.017	0.071 *	-
Perms: 998	Pseudo-F: 5,176		P (perm): 0.001		P(MC): 0.001	

velificatus, *Clausocalanus* sp., *Paracalanus* sp., *Pseudocalanus* sp., *Temora turbinata*, *Undinula vulgaris*, *Microsetella* sp., *Oithona* sp., *Oithona plumifera*, *Oncaea* sp., *Oncaea mediterranea*) of the shelf. The small size of dominant species is related to the Coastal Water (CW) and the mixing with Tropical Water (TW), and some species are restricted to estuaries and coastal circulation, their distribution being limited under the influence of oceanic waters (Lopes *et al.*, 2006). The greater abundance of copepods in the south region was also reported by Nunes & Resgalla Jr. (2012). Cladocera was not observed in the samples of the VOR that it only operates in a narrow depth range, which is outside the preferential distribution of the group even though Resgalla Jr. & Montú (1993) and Muxagata & Montú (1999) reported in the southern coast and southeastern Brazilian. This fact may be related to the limitation of the VOR that it only operates in a narrow depth range, which is outside the preferential distribution of the group.

The prevalence of Chaetognatha (SSB1, SSB2, SSB4, SSS1), Copepoda (*Acartia* sp., *Temora stylifera*, *Temora turbinada*, *Oithona plumifera*, *Oithona* sp., *Paracalanus* sp.) in SSB1 and Cladocera (*Penilia avirostris*) (SSB1, SSB2 and SSB3), are indicative of Coastal Water (WC) and its association with estuarine regions (Resgalla Jr. & Montú, 1993; Resgalla Jr., 2011). The genera *Paracalanus* and *Temora*, present in SSB1, are consumers of the community of phyto-plankton and microzooplankton in regions close to the coastal upwelling zone (Lopes *et al.*, 1998). Also noteworthy is the high abundance of protozooplankton, especially Ciliophora (*Codonellopsis schabi*, *Salpingella* cf. *acuminatoides*), in transects of the north region, which is the region closest to the Cabo Frio upwelling, in the State of Rio de Janeiro. This group is dominated by herbivorous, with nanoplankton being an important item in its diet (Gowing & Garrison, 1992).

Table 4. The percentage contribution (%) of abundance of plankton by Simper analysis between transects SSB1, SSB2, SSB3, SSB4, SSS1 and SSS2.

Rate/Transects	SSB1	SSB2	SSB3	SSB4	SSS1	SSS2
Average similarity (%)	57.80	33.81	38.45	30.74	45.74	40.61
% Similarity each taxa						
Johannesbaptistia sp.	14.52	10.60				
Dictyocha fibula	11.67	14.14				
Proboscia alata	8.62	14.75				
Neoceratium fusus	7.84	13.02				
Chaetoceros decipiens	7.77					
Thalassionema bacillare		11.14		27.52		
Hemiaulus hauckii			38.14			
Prorocentrum sigmoides			23.24			
Corethron criophilum			10.07			
Thalassiosira spp.				55.52	18.39	
Rhizosolenia setigera					34.49	
Octotactis octonaria					19.12	29.93
Thalassionema nitzschioides						16.53
Rhizosolenia setigera						12.17
Appendicularia sp.		4.27				
Penilia avirostris		4.18				
Oithona sp.		2.77				

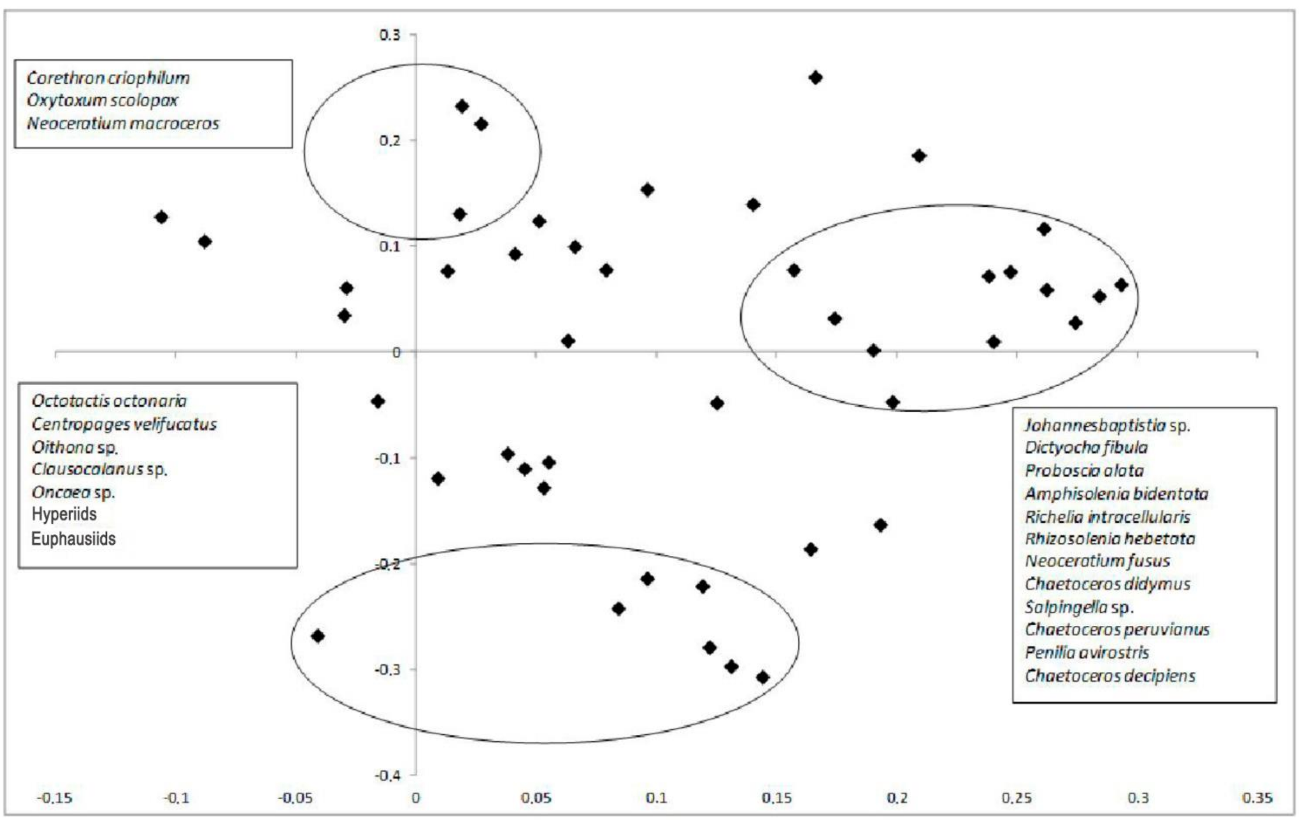

Figure 6. Multivariate correlation between phytoplankton and zooplankton density (>10%, transf. data: log).

The efficiency of Continuous Plankton Sampling has been compared with that of traditional samplers in different studies, and has proven to be robust (Batten *et al.*, 2003b; Hunt & Hoise, 2003). In different studies of plankton involving the CPR, the diversity and abundance have presented high confidence in time series analyses for monitoring climate change in the North Atlantic (Edwards *et al.*, 2010; Mcleod *et al.*, 2012). In addition, plankton is currently the only group to have been monitored continuously since the 1940s, and multi-decadal analyses have already been established, due to the quantity and robustness of the data collected by this method. In according to the data provided by the VOR, on the continental shelf of Southeastern Brazil, the planktonic community was dominated by organisms smaller than 2 mm, whose distribution has reached the South region. Estuarine and coastal waters phytoplanktonic species showed a predominance of cyanobacteria and diatoms in SSB, and silicoflagellates in SSS, while the distribution of zooplankton was characterized by small copepods in SSB and genres of larger size in SSS, but all with neritic/oceanic characteristics.

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