

Spatial distribution of bivalve mollusc assemblages in the upwelling ecosystem of the continental shelf of Cabo Frio, Rio de Janeiro, Brazil

Abilio Soares-Gomes¹ & Flavio da Costa Fernandes²

¹ Departamento de Biologia Marinha, Universidade Federal Fluminense. Caixa Postal 100.644, 24001-970 Niterói, Rio de Janeiro, Brasil.

² Instituto de Estudos do Mar Almirante Paulo Moreira. Rua Kioto 253, Praia dos Anjos, 28930-000 Arraial do Cabo, Rio de Janeiro, Brasil.

ABSTRACT. Bivalve mollusks of the continental shelf of Cabo Frio upwelling ecosystem were sampled monthly from February 1986 to February 1987 along a 30 to 60 m depth gradient. *Macra petiti* Orbigny, 1846, and *Tellina gibber* Ihering, 1907 were constant species in 30 m; *Nucula puelcha* Orbigny, 1846, *Adrana patagonica* Orbigny, 1846, *T. petiti*, *T. gibber*, and *Corbula patagonica* Orbigny, 1846 in 45 m; and *N. puelcha*, *T. gibber*, *C. patagonica*, and *C. caribaea* in 60 m. The number of rare species was similar along the depth gradient, ranging from six to ten species. The number of common species was higher in 60 m than in 30 m. Some species showed a continuous distribution but changed the frequency and abundance along the bathymetric gradient. The mean density was higher in 45-60 m than in 30 m, ranging from 15.6 ind.m⁻², in 30 m, to 68.1 ind.m⁻², in 60 m. There was no seasonal change in density nor in the taxocene structure during the studied period. On the other hand, the bivalve assemblage was spatially structured along the depth gradient, showing consistent changes from 30 to 60 m depths. Diversity and richness also follow this distribution pattern.

KEY WORDS. Benthic associations, community ecology, macrobenthos, soft-bottom, sublittoral.

RESUMO. Distribuição espacial das associações de moluscos bivalves na plataforma continental do ecossistema da ressurgência de Cabo Frio, Rio de Janeiro, Brasil. Os moluscos bivalves da plataforma continental do ecossistema da ressurgência do Cabo Frio foram amostrados mensalmente de fevereiro de 1986 a fevereiro de 1987, entre 30 a 60 m de profundidade. *Macra petiti* e *Tellina gibber* Ihering, 1907 foram espécies constantes a 30 m; *Nucula puelcha* Orbigny, 1846, *Adrana patagonica* Orbigny, 1846, *T. petiti*, *T. gibber* e *Corbula patagonica* Orbigny, 1846 a 45 m; e *N. puelcha*, *T. gibber*, *C. patagonica* e *C. caribaea* a 60 m. O número de espécies raras foi similar nas diferentes profundidades, variando entre seis a dez espécies. O número de espécies comuns foi maior a 60 m que a 30 m. Algumas espécies apresentaram distribuição contínua porém, com variação na frequência e abundância ao longo do gradiente batimétrico. A densidade média foi maior a 45-60 m do que a 30 m., variando entre 15,6 ind.m⁻² (30 m) a 68,1 ind.m⁻² (60 m). Não foram observadas mudanças sazonais na densidade ou na estrutura da associação de bivalves durante o período estudado. Por outro lado, a taxocenose mostrou-se estruturada ao longo do gradiente batimétrico, mostrando mudanças consistentes de 30 para 60 m de profundidade.

PALAVRAS CHAVE. Associações bentônicas, ecologia de comunidades, macrobentos, sublitoral, sedimentos não-consolidados.

Cabo Frio is situated on the coast of Rio de Janeiro State, central southeastern Brazil (23°S, 42°W). In this portion of the Brazilian coast three water masses are present: the coastal water, the tropical water of the Brazil Current, and the South Atlantic Central Water (SACW). The main oceanographic feature of the region is the SACW upwelling, driven by local topography and north-northeast wind (EMILSON 1961).

According to VALENTIN (2001), the SACW up flow follows two stages: the first begins in mid-August/September (late aus-

tral winter), and the second mainly from September to March (austral spring-summer). The increment of biomass (0,5-6,0 mg chlorophyll L⁻¹) and primary production (2-14 mgC m⁻³ h⁻¹) due to upwelling event is low, comparing to similar systems elsewhere. In spite of this, local pelagic species composition and trophic structure change, and important fisheries species are supported by upwelling, such as sardines and squids, which use the area as recruitment and feeding grounds (COSTA & FERNANDES 1993, MATSUURA 1996). In situations of strong up-

welling, SACW advances beyond the continental slope and invades the shelf to depths of about 50-80 m. This flow of SACW over the inner shelf influences the composition and abundance of benthic and demersal fishes, bringing species typical of deep-sea habitats (NETTO & GAELZER 1991).

The effect of upwelling on benthic communities could be either positive or negative. In some circumstances, a heavy sedimentation of organic matter could induce hypoxic or anoxic conditions, leading to a benthic community with low diversity and high dominance of only a few species (ROWE 1985, TARAZONA & ARNTZ 2001). The ecology of benthic invertebrates of the Cabo Frio upwelling system is poorly studied, similar to other Brazilian continental margin benthic habitats. A multidisciplinary oceanographic project carried out by the Admiral Paulo Moreira Sea Studies Institute generated some results about the local benthic invertebrates, but only data on echinoderms and anururan crustaceans were published until now (VENTURA & FERNANDES 1995, VENTURA *et al.* 1997, DA GAMA & FERNANDES 1994). This work describes the distribution of the bivalve mollusc assemblages on the inner shelf and aims to contribute to the knowledge of the local ecosystem, as these invertebrates could represent an important link in the food chain from primary producers, such as phytoplankton and microphytobenthos, to predators, such as fishes (KAMERMANS 1992).

MATERIAL AND METHODS

Quantitative sediments samples were collected monthly from 30, 45, and 60 metres depths, from February 1986 to February 1987, using a 0,1 m² van Veen grab and a rectangular dredge. Two stations were sampled at each depth: 1-4 (30 m); 2-5 (45 m); 3-6 (60 m). Additionally, qualitative samples were taken by an otter-trawl net in order to improve the local species list, which was also improved with species that occurred as empty shells only and by species that occurred in stomach content of starfishes. A van Veen and a dredge sample unit were taken monthly in each station, and a single otter-trawl haul was done between stations located in the same depth isolines. Figure 1 shows the geographical situations of the study area and the sampling design adopted.

The macrozoobenthos was stained with rose Bengal, sieved out with 0.5 mm mesh size, and sorted under a stereomicroscope to determine the abundance of bivalve molluscs.

Data of density of each station were pooled according to austral seasons. Then, the mean density of each station were calculated and organized in a data matrix to calculate the Bray-Curtis similarity. The resultant Bray-Curtis similarity matrix was used to run the one-way analysis of similarity (ANOSIM) permutation test (CLARKE & GREEN 1988). In this case, the ANOSIM test the null hypothesis that there is no seasonal difference in the bivalve taxocene structure.

The data of van Veen and grab were pooled and mean for each station, according to the bathymetric gradient. These data were used to determine the frequency of occurrence (F)

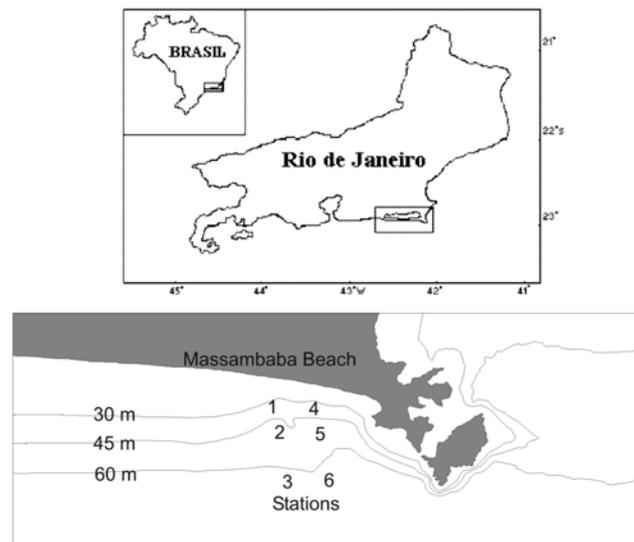


Figure 1. Geographical situation of the study area and the sampling stations.

proposed by GUILLE (1970), and depending to the value species were classified as constant ($F > 50\%$), common ($10\% \leq F \leq 50\%$), and rare ($F < 10\%$).

The mean values calculated according to the bathymetric gradient were used to analyse the spatial distribution of the bivalve taxocene. In this case, only quantitative data of van Veen were employed. Both a cluster (UPGMA method) and an ordination technique (NMDS) were performed to fourth root transformed data, using Bray-Curtis similarity, as an exploratory data analysis. The null hypothesis that there is no difference in the bivalve taxocene structure along the 30 to 60 m – depth gradient was tested by ANOSIM.

The Shannon diversity (\log_2) and Pielou evenness indexes were calculated for each station, and the null hypothesis that there is no difference in density, diversity, evenness and richness (number of species) along the depth gradient was tested by ANOVA. Prior to the analysis the data were normalised by log transformation.

Besides species collected by otter trawl net, species that are not typical soft-bottom dwellers, species with frequency of occurrence below 5% were also not considered in data analysis.

Several abiotic parameters of the sediment were measured for later try to explain the biological distribution. Granulometric fractions of the sediments (coarse sand, median sand, fine sand and silt-clay) were determined by standard dry-sieve and pipette method (SUGUIO 1973), and mean grain size and sorting coefficient were calculated according to FOLK & WARD (1957). Organic carbon, nitrogen and phosphorus were determined by titration methods, following FAO (1975) methodology. The biotrititic carbonate content (CaCO_3) was obtained by HCl 10% attack. An exploratory data analysis was performed

(Principal Component Analysis-PCA) to the log transformed normalised mean data of the abiotic variables. Data in percentages were transformed to arcsine instead of log.

Taxonomic identification was based shell features following ABBOTT (1974), RIOS (1994), and MERLANO & HEGEDUS (1994), among others.

RESULTS

The sampling devices employed collected a total of 44 species, belonging to 38 genera and 27 families (see Tab. I).

Table II show the frequency of occurrence and total abundance of the species collected by grab and dredge samples in different depths. *Mactra petiti* Orbigny, 1846 (Mactridae), and *Tellina gibber* Ihering, 1907 (Tellinidae) were constant species in 30 m; *Nucula puelcha* Orbigny, 1846 (Nuculidae), *Adrana patagonica* Orbigny, 1846 (Nuculanidae), *Tellina petitiana* Orbigny, 1846 (Tellinidae), *Tellina gibber* Ihering, 1907 (Tellinidae), and *Corbula patagonica* Orbigny, 1846 (Corbulidae) in 45 m; and *Nucula puelcha* Orbigny, 1846 (Nuculidae), *Tellina gibber* Ihering, 1907 (Tellinidae), *Corbula patagonica* Orbigny, 1846 (Corbulidae), and *Corbula caribaea* Orbigny, 1846 (Corbulidae) in 60 m. The number of rare species was similar along the depth gradient, ranging from six to ten species. The number of com-

mon species increased from 30 m (6 species) to 60 m (14 species). Some species showed a continuous distribution but changed in frequency and abundance along the bathymetric gradient. The frequency of *N. puelcha*, e.g., increased about three fold and its abundance more than 10 folds from 30 to 45-60 m. Both total species number and total abundance were higher in 45 and 60 m depths than in 30 m depth.

The mean density, determined for grab samples was higher, during the studied period, in 45 and 60 m than in 30 m, ranging from 15,6 ind.m⁻², in 30 m, to 68,1 ind.m⁻², in 60m (Fig. 2). *Tellina gibber* was the dominant species in 30 m (41,49 and 53,85%, in stations 1 and 4, respectively). In 45 m *N. puelcha* was dominant in station 2 (55,47%), and *T. gibber* in station 4 (34,96%). The abundance distribution in 60 m was more homogeneous, with the maximum dominance of 37,15% in station 6 by *N. puelcha*. There was no significant difference in the density among seasons.

According to ANOSIM test, there is no seasonal change in the taxocene structure during the studied period (Global R = -0,025; p = 55.6%). On the other hand, the cluster analysis and NMDS ordination clearly show that the taxocene was spatially structured along the depth gradient. Stations in 45 m are more closely related to 60 m stations, both in the dendrogram

Table I. List of species collected by grab, dredge, or otter-trawl. (*) Empty shells only, (**) found in the gut content of *Astropecten brasiliensis*.

Species	Species (cont.)
<i>Abra lioica</i> (Dall, 1881)	<i>Macoma cleryana</i> (Orbigny, 1846)
<i>Adrana patagonica</i> (orbigny, 1846)	<i>Macoma tenta</i> (Say, 1834)
<i>Anadara chmnitzi</i> (Philippi, 1851)	<i>Mactra janeiroensis</i> E.A. Smith, 1915
<i>Anadara ovalis</i> (Bruguière, 1789)	<i>Mactra petiti</i> Orbigny, 1846
<i>Cardiomya perrostrata</i> (Dall, 1881)	<i>Malletia cumingii</i> (Hanley, 1860)
<i>Carditamera plata</i> (Ihering, 1907)	<i>Martesia fragilis</i> Verrill & Bush, 1890
<i>Chione pubera</i> (Bory Saint-Vincent, 1827)	<i>Musculus lateralis</i> (Say, 1822)
<i>Chlamys tehuelchus</i> (Orbigny, 1846)	<i>Myrtea lens</i> (Verrill & Smith, 1880) *
<i>Codakia pectinella</i> C.B. Adams, 1852	<i>Nucula puelcha</i> Orbigny, 1846
<i>Cooperella atlantica</i> Rehder, 1943	<i>Nuculana larranagai</i> Klappenbach & Scarabino, 1968
<i>Corbula caribaea</i> Orbigny, 1842	<i>Periploma compressa</i> Orbigny, 1846
<i>Corbula lyoni</i> Pilsbry, 1897	<i>Perna perna</i> (Linnaeus, 1758)
<i>Corbula patagonica</i> Orbigny, 1846	<i>Pitar rostratus</i> (Koch, 1844)
<i>Crassinella lunulata</i> (Conrad, 1834)	<i>Poromya cymata</i> Dall, 1889 *
<i>Crassostrea rizophorae</i> (Guilding, 1828)	<i>Raeta plicatella</i> (Lamarck, 1818) **
<i>Crenella divaricata</i> (Orbigny, 1846)	<i>Semele nuculoides</i> (Conrad, 1841)
<i>Cuspidaria brasiliensis</i> E.A. Smith, 1915 *	<i>Solemya patagonica</i> E. A. Smith, 1885
<i>Entodesma beana</i> (Orbigny, 1842)	<i>Tellina gibber</i> Ihering, 1907
<i>Ervilia concentrica</i> (Holmes, 1860)	<i>Tellina petitiana</i> Orbigny, 1846
<i>Glycymeris longior</i> (Sowerby, 1833)	<i>Thyasira croulinensis</i> Jeffreys, 1874
<i>Limaria thryptica</i> (Penna, 1971)	<i>Trachycardium muricatum</i> (Linnaeus, 1758)
<i>Limopsis antillensis</i> Dall, 1881	<i>Transenpitar americana</i> (Doello-Jurado, 1951)

Table II. Frequency of occurrence (F) and total abundance (A) – the sum of individuals during the whole sampling time – of species collected by grab and dredge on different depths.

Species	Depth					
	30 m		45 m		60 m	
	F (%)	(A)	F (%)	(A)	F (%)	(A)
<i>N. puelcha</i>	33.3	12	83.3	108	83.3	149
<i>M. cumingii</i>	5.5	2	38.9	13	44.4	36
<i>A. patagonica</i>	5.5	2	55.5	44	44.4	22
<i>N. larranagai</i>	0	0	0	0	22.2	7
<i>S. patagonica</i>	0	0	11.1	2	27.8	9
<i>A. chemnitz</i>	0	0	16.7	4	0	0
<i>L. ovalis</i>	11.1	11	22.2	39	5.5	2
<i>G. longior</i>	16.7	3	0	0	0	0
<i>L. antillensis</i>	5.5	1	0	0	0	0
<i>C. divaricata</i>	0	0	22.2	6	0	0
<i>C. tehuelchus</i>	5.5	8	33.3	39	5.5	1
<i>L. thryptica</i>	0	0	5.5	1	38.9	8
<i>C. pectinella</i>	0	0	27.8	5	0	0
<i>T. croulinensis</i>	5.5	1	0	0	44.4	8
<i>C. lunulata</i>	50.0	19	22.2	6	5.5	1
<i>C. plata</i>	0	0	0	0	5.5	1
<i>T. muricatum</i>	0	0	0	0	5.5	1
<i>M. petiti</i>	55.5	19	5.5	1	5.5	1
<i>M. janeiroensis</i>	0	0	5.5	1	16.7	3
<i>E. concentrica</i>	5.5	1	0	0	0	0
<i>T. pettitiana</i>	50.0	19	66.7	90	0	0
<i>T. gibber</i>	61.1	56	72.2	115	55.5	62
<i>M. tenta</i>	0	0	0	0	16.7	4
<i>S. nuculoides</i>	0	0	5.5	1	0	0
<i>A. lioica</i>	0	0	11.1	41	22.2	9
<i>C. pubera</i>	5.5	2	0	0	0	0
<i>T. americana</i>	16.7	4	38.9	14	0	0
<i>P. rostratus</i>	5.5	1	50.0	16	2.2	5
<i>C. atlantica</i>	0	0	0	0	11.1	3
<i>C. lyoni</i>	5.5	1	5.5	2	33.3	7
<i>C. patagonica</i>	5.5	3	61.1	101	88.9	116
<i>C. caribaea</i>	0	0	27.8	10	55.5	23
<i>P. compressa</i>	0	0	0	0	27.8	6
<i>E. beana</i>	0	0	0	0	5.5	2
<i>C. perrostrata</i>	0	0	5.5	1	11.1	4
Total Abundance		165		660		491
Total of species	18		23		25	

and in the space ordination dimensions (Fig. 3). The null hypothesis about spatial distribution, tested by ANOSIM, was rejected, indicating that the bivalve taxocene is highly structured along the depth gradient (Tab. III). The Shannon diver-

sity and richness were statistically different along the depth gradient, and were higher in 45 and 60 m than 30m (Figs 4 and 5). On the other hand, the evenness was statistically higher in 30m than in 45 and 60m (Fig. 6).

Table II. Results of ANOSIM for the null hypothesis about the spatial distribution along the depth gradient.

Global R	Significance level of sample statistic (%)	Number of permutations	Number of permuted statistics greater than or equal to global R
0.44	0.1	999	0
Groups	R Statistic	Significance Level (%)	
30-45 m	0.404	0.1	0
30-60 m	0.665	0.1	0
45-60 m	0.284	0.1	0

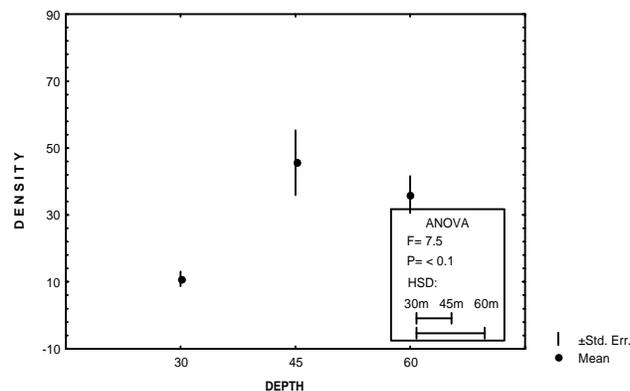


Figure 2. Plot of mean and standard error values of density on the depth gradient. The results of ANOVA and Tukey Honest Significant Difference (HSD) are shown inside the small box.

Table IV shows the means of the abiotic variables in each station. The organic content of sediment (OP, ON) was higher in 45 and 60 m stations than in 30 m, as well as the biotrititic carbonate concentration. The median sand fraction was higher at 30-45 m stations, while the fine sand fraction was higher at 60m stations. This shift in the predominance of the grain size fraction along the depth gradient is in part reflected by the mean grain size values. The sorting of sedimentary grains was higher in 30 m stations (note that the smaller the phi value, the higher the grain size!). The exploratory data analysis performed on the mean values of abiotic variables showed that the first 2 PCA axes account for 88% of the abiotic data variance. The 60 m stations (3 and 6) show a clear spatial disjunction in relation to 30-45 m stations (with exception of station 5) along the axis 1 of the PCA ordination that represent the hydrodynamic gradient (Fig. 7).

DISCUSSION

Upwelling can be a continuous or a pulse phenomenon throughout the year (ROWE 1985, TARAZONA & ARNTZ 2001). In case of occurring in pulse, it is plausible to hypothesize that benthic structure community changes as a result of the dynamic of organic matter input. LEVINTON (1972) speculated that temporal variation in abundance of suspension-feeding bivalves is caused by seasonal variability in the phytoplanktonic food source,

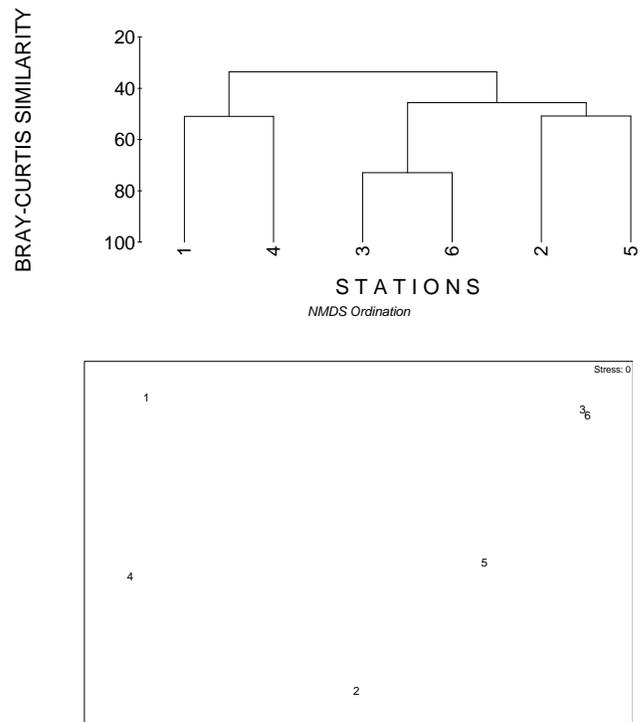
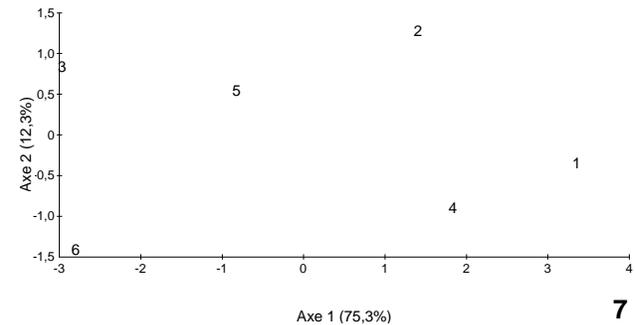
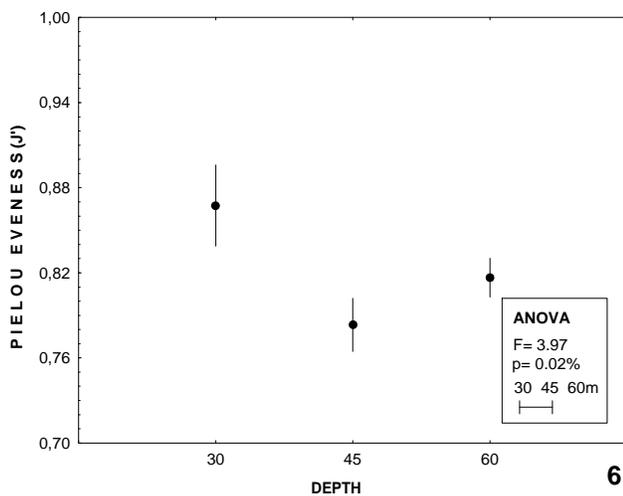
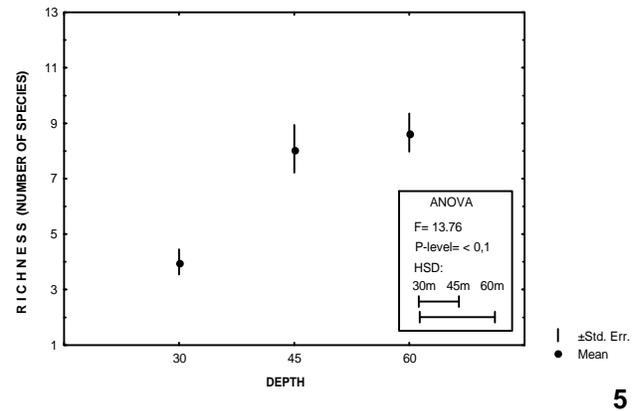
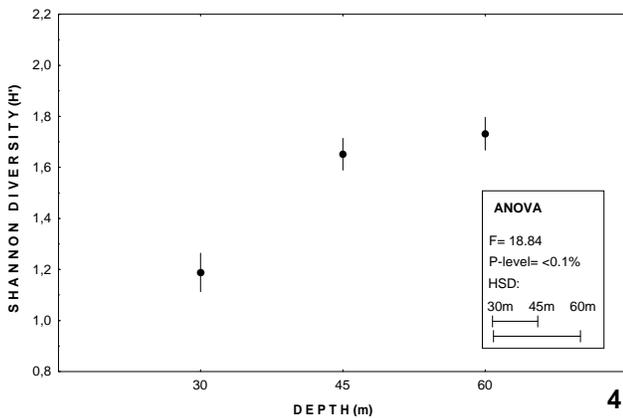


Figure 3. Dendrogram and NMDS ordination plot of van Veen abundance data.

and that these animals have evolved means of rapidly increasing their numbers in response to periods of food abundance. In periods of upwelling, the higher input of organic matter from the pelagic system could improve the benthos if this input does not lead to anoxic conditions. The Cabo Frio upwelling is a pulse event, occurring at any time of the year, although more commonly during spring and summer periods (VALENTIN 2001). During the studied period the structure of the benthos in the region did not change in time, revealing that the increment of phytoplankton biomass was not enough to shift the patterns of species dominance nor bivalve density. It could be speculated that the extra organic matter driven by upwelling was being consumed by pelagic species in the water column itself with very little being transported to the seafloor. Another possibility would



Figures 4-7. (4-6) Plot of mean and standard error values of: (4) Shannon diversity index on the depth gradient; (5) number of species (richness) on the depth gradient; (6) Pielou evenness index on the depth gradient. The results of ANOVA and Tukey Honest Significant Difference (HSD) are show inside the small box; (7) PCA ordination plot of stations based on abiotic variables.

be that the population dynamic of none of the bivalve species occurring in the area fit to the increment in food availability.

Not only temporal food availability promotes changes in biotic structure. Assemblages of more mobile species could show a faster shift in their composition in response to changes in environmental temperature. This seems to be the case for local benthic and demersal deep-sea fishes reported by NETTO & GAELZER (1991), such as the red porgy *Pagrus pagrus* (Linnaeus, 1758), the cusk-eel *Genypterus brasiliensis* (Regan, 1903), the silver hake *Merluccius hubbsi* Marine, 1933, and the anglerfish *Lophius gastrophysus* Miranda Ribeiro, 1915, that follow the intrusion of SACW over the shelf. This behaviour was also described for the crab *Portunus spinicarpus* and the snail *Zidona dufresnei* (Donovan, 1823), by PIRES-VANIN *et al.* (1995) for the coast of Ubatuba, southern of Cabo Frio. Benthic sedentary and sessile species, such as bivalve mollusks, however, are not expected to exhibit this behavior. In this case, the taxocene is more structured in time if not affected by

another environmental variable or by intrinsic factors.

In relation to the spatial distribution, the bivalve taxocene is clearly structured along the depth gradient studied. Both the exploratory data analysis (cluster and NMDS ordination) and hypothesis testing (ANOSIM) results showed a consistent shift in the taxocene structure between 30 and 60 m stations. The 45 m stations seem to be a transition zone between 30 and 60 m isobaths. This same spatial pattern was found for echinoderms by VENTURA & FERNANDES (1995) and for benthic and demersal fishes by NETTO & GAELZER (1991). Such a clear spatial pattern in a narrow depth gradient is amazing since, as FRANZ (1976) stated, "the structure of benthic communities varies in conjunction with gradual changes along environmental gradients. The resulting continuum of species distribution implies the absence of precise boundaries separating such communities, except at points where the environmental gradients steepened to form natural or habitat separation". Although there is a set of species that shift their

Table III. Mean values and standard deviation of the abiotic variables in each station. N = 12, (Ca) biodebitric carbonate, (OP) organic phosphorus, (ON) organic nitrogen, (OC) organic carbon, (CS) coarse sand, (MS) median sand, (FS) fine sand, (SC) silt-clay, (Mz) mean grain size, (Sort) sorting coefficient.

Station	Depth (m)	Ca (mg.g-1)	OP (ppt)	ON (ppt)	OC (%)	CS (%)	MS (%)	FS (%)	SC (%)	Mz (φ)	Sort (φ)
1	30	2.8 ± 1.08	157.7 ± 158.7	76.6 ± 44.70	0.23 ± 0.12	0.33 ± 0.18	94.96 ± 84.0	2.89 ± 1.54	0.08 ± 0.02	1.33 ± 0.11	0.35 ± 0.04
2	45	10.6 ± 7.30	200.7 ± 204.0	131.3 ± 143.20	0.20 ± 0.10	1.93 ± 1.10	77.31 ± 65.2	20.46 ± 18.4	0.14 ± 0.09	1.58 ± 0.46	0.62 ± 0.22
3	60	22.3 ± 12.60	359.0 ± 117.9	380.9 ± 184.00	0.48 ± 0.15	2.49 ± 1.90	21.66 ± 18.4	67.94 ± 49.7	3.76 ± 2.10	2.75 ± 0.20	0.79 ± 0.24
4	30	3.9 ± 1.31	248.2 ± 274.9	111.4 ± 87.33	0.21 ± 0.13	0.17 ± 0.09	53.30 ± 51.1	45.67 ± 38.5	0.50 ± 0.31	2.00 ± 0.08	0.44 ± 0.08
5	45	9.6 ± 3.30	449.1 ± 461.9	253.6 ± 158.70	0.22 ± 0.10	2.53 ± 1.90	41.09 ± 36.2	45.36 ± 42.1	4.33 ± 3.50	2.14 ± 0.57	0.55 ± 0.22
6	60	17.3 ± 7.20	624.5 ± 516.7	446.3 ± 82.32	0.57 ± 0.16	1.75 ± 1.10	19.84 ± 14.2	74.16 ± 58.7	2.50 ± 2.22	2.57 ± 0.43	0.57 ± 0.14

frequency and density along the gradient, the majority of species showed a continuum distribution. Only four and seven species were found exclusively on 30 and 60 m isolines, respectively. When 45 and 60 m isolines are analysed together, the list increases to 13 exclusive species. On 45m isoline there were found only four exclusive species. This fact reinforces the idea that the 45 m isoline is an ecotone zone. These results are in accordance with the concepts of communities that recognize this apparent ambiguity between continuum and discrete entities. "Communities have a spatially open structure, in which the species that coexist in a given locality may extend more or less independently into other communities" (SCHLUTER & RICKLEFS 1993).

Along the Brazilian coast, spatial distribution of bivalve assemblages related to sediment types was also found by GONÇALVES & LANA (1991), on a section of the Southeast Brazilian continental shelf, by ABSALÃO (1991), on the continental shelf off Lagoa dos Patos (Rio Grande do Sul) estuary, and by GRILLO *et al.* (1998), in a sheltered habitat of Ilha Grande (Rio de Janeiro) with tidal current influence. The bivalve assemblages seem to have a recurrent spatial distribution pattern on the Brazilian south-eastern shelf, at least on mid-shelf (> 50 m depth), on bottoms where fine grain fractions are greater. According to GONÇALVES & LANA (1991) recurrent assemblages dominated by *Corbula caribaea* Orbigny, 1846, *Macoma tenta* (Say, 1834) (Tellinidae), and *Limaria thryptica* (Penna, 1971) (Limidae) occur on these bottoms. These species also occur at Cabo Frio, but only *Corbula caribaea* could be considered typical of these bottoms.

The granulometric features in the area suggest a hydrodynamic gradient that could be conditioning the spatial distribution of the bivalve taxocene. Greater contents of organic matter and fine grains indicate that action of waves or bottom currents are less effective in 60 m depth stations. The higher values of grain sorting in shallower stations also corroborate this thought, since well-sorted sediments are typical of high-energy environments whereas more heterogeneous ones occur in low-energy areas (GRAY 1981). Specific diversity has been correlated with habitat heterogeneity among other environmental variables. Fine sediments with high silt-clay contents are well sorted and structurally homogeneous. These sediments have few potential niches and are characteristically poor in species number comparing to poorly-sorted sediments that show more structural heterogeneity (GRAY 1981). In Cabo Frio, the Shannon diversity was higher in deeper stations than in shallow ones. These higher values of diversity in deeper stations were due to the higher number of species (richness) rather than due to the evenness component of diversity, indicating a possible positive correlation between diversity and habitat heterogeneity.

CONCLUSIONS

The abundance and occurrence of bivalves mollusks seems to have no links with upwelling phenomena at Cabo Frio region as there was no seasonal change in density nor in the assemblage structure during the period studied. On the other hand,

the assemblage is spatially structured along the depth gradient, showing a consistent shift between 30 and 60 m isobaths, with the 45 m isobaths representing a transition zone. The increasing in the richness and diversity found in 60 m isobaths could be attributed to a higher spatial heterogeneity in this depth.

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