COMPOSITION AND SEASONAL VARIATION OF CAPITELLIDAE FROM BALNEÁRIO CAMBORIÚ, SANTA CATARINA, BRAZIL

COMPOSIÇÃO E VARIAÇÃO SAZONAL DE CAPITELLIDAE DE BALNEÁRIO CAMBORIÚ, SANTA CATARINA, BRASIL

Mayara Beltrao[1,2]; Natalia Joana Rebello da Cunha[1]; Fernando Luiz Diehl[1]

Artigo recebido em: 22/05/2023 e aceito para publicação em: 19/08/2023.
DOI: http://doi.org/10.14295/holos.v23i2.12494

Abstract: The objective of this study was to provide information about the structure and composition of the Capitellidae family in Balneário Camboriú, as well as evaluate its space-time variations. Four sampling campaigns were carried out at 16 stations, distributed in the Camboriú River and Balneário Camboriú Bay. A total of 1,769 ind.m² were collected and identified into five taxa: *Capitella* sp.; *Capitella* cf. *nonatoi*; *Heteromastus* sp., *Heteromastus similis* and *Mediomastus* cf. *californiensis*. The most abundant taxon was M. californiensis, showing the highest number of individuals during autumn, followed by *Capitella* cf. *nonatoi* in the summer. The distribution of *M. californiensis* was more related to the opportunistic habit of the species than to seasonality, while *Capitella cf. nonatoi* distribution was related to the high concentration of organic matter from the Camboriú River, which may be the result of residents and tourists visiting the city in the summer. These results denote the Capitellidae family bioindicator potential for anthropogenic disturbances.

Keywords: Capitella. Mediomastus. Heteromastus. Polychaeta.

Resumo: O objetivo deste estudo foi fornecer informações sobre a estrutura e composição da família Capitellidae em Balneário Camboriú, bem como avaliar suas variações espaço-temporais. Quatro campanhas de amostragem foram realizadas em 16 estações, distribuídas no Rio Camboriú e na Baía de Balneário Camboriú. Um total de 1.769 ind.m² foram coletados e identificados em cinco taxa: *Capitella* sp.; *Capitella* cf. *nonatoi; Heteromastus* sp., *Heteromastus similis* e *Mediomastus* cf. *californiensis*. O táxon mais abundante foi *M. californiensis*, apresentando o maior número de indivíduos durante o outono, seguido por *Capitella* cf. *nonatoi* no verão. A distribuição de M. *californiensis* esteve mais relacionada ao hábito oportunista da espécie do que à sazonalidade, enquanto *Capitella* cf. *nonatoi* foi relacionada à alta concentração de matéria orgânica do rio Camboriú, que pode ser resultado de moradores e turistas que visitam a cidade no verão. Esses resultados denotam o potencial bioindicador da família Capitellidae para distúrbios antrópicos.

Palavras-chave: Capitella. Mediomastus. Heteromastus. Polychaeta.

1 INTRODUCTION

The phylum Annelida, that traditionally was classified into Clitellata and Polychaeta,

[1] Acquaplan Tecnologia e Consultoria Ambiental. E-mails:(mbeltrao@outlook.com, nataliacunha@edu.univali.br, diehl@acquaplan.net)
[2] Universidade do Vale do Itajaí (Univali). Escola Politécnica. Itajaí, SC.

constitute an often dominant group within benthic communities (Struck *et al.,* 2011). This classification has undergone major changes due to recent molecular analyses, which evidence that other groups, such as Sipuncula, Myzostomida, Vestimentifera, Pogonophora, and Echiura, hitherto considered distinct phylum, present annelids affinities (Rouse; Fauchald, 1997). The current range of accepted nominal species of annelids according to Capa & Hutchings (2021) review is around 20,000, despite the WoRMS database (2023) citing 25,720 valid species. The discrepancy in the total number is mainly because to the fact that many genera and families require synonyms and taxonomic revision, and the number of complex species has increased because of the use of molecular analyses (Capa; Hutchings, 2021).

Annelida forms a highly diversified, cosmopolitan, and ecologically relevant group, reasons why they have been used as an object of study in different areas of science. In environmental assessments, they are applied in ecotoxicological tests (Sultan; Pei, 2023), biomarkers (Zhang *et al*., 2023) and as bioindicators of environmental quality (DEAN 2008; Capa; Hutchings, 2021). These invertebrates have great potential in detecting anthropogenic disturbances in benthos due to their high abundance, direct relationship with the substrate, and sedentary habit (Hartini, 2022). Assigning a specific species as a bioindicator of a deteriorated environment presents challenges, since each geographical region exhibits unique responses to unfavorable environmental conditions (Dean, 2008).

The feedback resulting from the environmental disturbances experienced by these organisms can range from changes in reproduction, growth, mortality, and dominance of species that are resistant to environmental changes (Pocklington; Wells, 1992). The increase in abundance, or density, of some annelid families can be interpreted in light of the impoverishment of the community, induced by the impact of an altered environment (Dean, 2001; Blake *et al.,* 2009; García-Garza, 2021). Therefore, the most effective way to evaluate an environment is to compare the distribution of community parameters, such as diversity, abundance, dominance, and biomass (Pearson; Rosenberg, 1978). In most polluted areas, the benthic community is not diverse, Tubificida, Spionidae, and Capitellidae are among the greatest tolerant organisms to stress associated with low oxygen and organic pollution (Tsutsumi, 1990; Méndez, 2021).

The Capitellidae family has been reported in marine and estuarine sediments polluted with organic material, often being referred to as bioindicators (Martin; Bastida, 2006; Umehara *et al*., 2019; Méndez, 2022). The capitellids constitute one of the most important families in the unconsolidated substrate and they can become very numerous.

Its distribution ranges from the intertidal zone to the bottom of the sea, usually living buried in sand or mud and fed by ingesting organic matter adhered to the sediment (González *et al*., 2021).

According to the Annelida Polychaeta Species catalog, in Brazil the Capitellidae family is distributed in 15 genera and approximately 30 species (Amaral *et al.,* 2012), however, recent molecular analyses have led to significant changes in these values. As an example, the specie *Capitella capitata* (Fabricius, 1780) has been widely identified around the world, including Brazil, however its distribution is probably restricted to the Arctic and subarctic areas (Blake, 2009). The *Capitella capitata* species complex consists of at least 50 sibling species (Méndez, 2022), and based on morphological and molecular analyzes (mtDNA sequences), Silva *et al*., (2017) revealed the existence of four new species of *Capitella* in Brazil. Species in the *Capitella* complex have a physiological demand to inhabit organically enriched bottoms (Grassle; Grassle, 1976; Tsutsumi, 1990). This theory is widely accepted and supported by several studies that have demonstrated, for at least seven decades, the abundance of capitellids in naturally and polluted enriched environments as a result of urbanization (Kitamori; Kobe, 1959; Pearson; Rosenberg, 1978; Amaral *et al.*, 1998; Rizzo; Amaral, 2001; Ourives *et al*., 2011; Laurino, 2017; Méndez, 2021).

The urbanization of coastal zones results in a series of effects on environmental quality, such as erosion (Iskander, 2021), eutrophication (Herren *et al.*, 2021), loss of biodiversity (Scherner *et al.*, 2013), and influence on the composition of biological communities (Pagliosa; Barbosa, 2006; Momota; Hosokawa, 2021). The city of Balneário Camboriú, considered one of the main tourist destinations in southern Brazil, is subject to the highest rates of urban growth in the Santa Catarina State. In addition to its growing population, Balneário Camboriú has increased by up to 10 times the number of residents during the summer season (PMBC, 2023). In this context, the present research aimed to study the Capitellidae community from Balneário Camboriú and determine the spatial-temporal variation in the structure and composition, in order contribute to the knowledge of capitellids that occur in the region. So, in the future, it could be used as a baseline for taxonomic and ecologic studies, as well as in management plans due to their bioindicator potential for anthropogenic disturbances.

2 MATERIALS AND METHODS

2.1 Study area

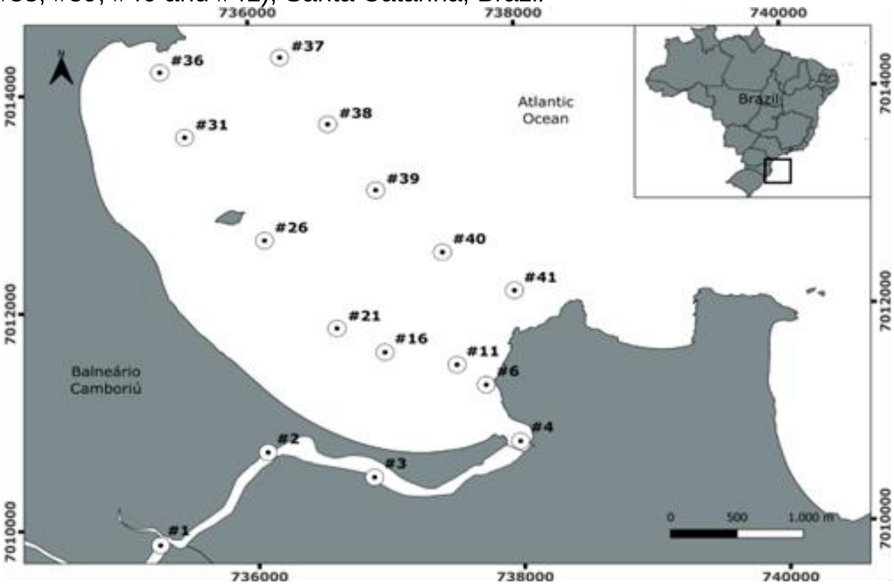
Balneário Camboriú city is located on the north-central coast (orientation NW – SE) of the State of Santa Catarina, southern Brazil. The central beach is approximately 6 km long, and it is delimited by headlands. To the north, it borders the Marambaia River, and to the south, the Camboriú River (Schettini *et al.*, 1996; Klein *et al.* 2002).

2.2 Sampling analyses

To collect the organisms, four sampling campaigns were carried out, covering an entire seasonal cycle. The summer campaign was performed in 2016, spring in 2017, and winter and autumn in 2018. Sixteen sampling stations were delimited, of which five were located in the Camboriú River at 1 – 2 meters deep (#1, #2, #3, #4, #6), and 11 were divided into two transects parallel to the shoreline (transect A= #11, #16, # 21, #26, #31 and #36, at 5 – 6 meters deep; transect B= #37, #38, #39, #40 and #41, at 9 – 11 meters deep) (Figure 1). At each point the collections were taken in triplicate with the assistance of a van Veen dredge (area of 0.022 m^2). In the laboratory, the samples were fixed in 4% formaldehyde, washed in a 0.5 mm sieve, preserved in 70% alcohol, and identified at the lowest possible taxonomic level.

At each sampling station, salinity, and dissolved oxygen parameters were collected by the Horiba multiparameter probe and a sample for granulometric analysis by van Veen dredge. The determination of granulometric fractions was performed using the sieving technique, as suggested by Suguio (1973), while the determination of the organic matter followed the method proposed by Dean (1974).

Figure 1 - Location map of the sampling stations in the Camboriú River (#1, #2, #3, #4, #6) and Balneário Camboriú shoreline (transect A = #11, #16, #21, #26, #31, #36; transect B = #37, #38, #39, #40 and #41), Santa Catarina, Brazil



2.3 Statistical analyses

To analyze the spatial-temporal variation of abiotic characteristics, a Principal Component Analysis (PCA) was applied, considering as variables the percentages of medium sand, fine sand, very fine sand, clay, silt, organic matter, dissolved oxygen, and salinity. These variables were selected because they exhibited a representative effect on variation and did not show collinearity (Legendre; Legendre, 1998; Clarke; Warwick, 2001).

The structure of the macrofauna community was analyzed according to species richness and density. Multivariate permutation analyses of variance using distance matrices (PERMANOVA) was applied to test spatiotemporal effects on the macrofauna community (Anderson, 2001; Mcardle; Anderson, 2001). Statistical significance was established at p= 0.05.

The relationships between the faunal distribution and environmental variables were investigated using restricted redundancy analysis (RDA) (Legendre; Legendre, 1998). For the analysis, was used the log-transformed fauna matrix (x+1) and the same environmental data defined in the PCA. All analyses were conducted using the Past Statistical software version 4.03 (Hammer *et al.*, 2001). As for the sedimentological characterization, the granulometry statistical data were obtained through the SysGran® 3.0 software and processed in the JAMOVI software ® 2.2.5.

3 RESULTS AND DISCUSSION

3.1 Abiotics

Based on the analysis of samples collected during a complete seasonal cycle, the Camboriú River and the Balneário Camboriú shoreline were characterized mainly by fine sand, very fine sand, and silt (Table 1). Similar results were found in sedimentological studies carried out by Klein & Menezes (2001). In transect B, stations #37, #38, and #39 were characterized by silt in all seasonal periods evaluated, except in autumn, which had the highest concentration of very fine sand, and stations #40 and #41, located south of the Bay, exhibited fine sand. In the Camboriú River, there was a predominance of very fine sand and silt facies. As for the organic matter, the highest values were observed during the summer, mainly at station #3, located in the river. Dissolved oxygen concentration values ranged from 1.74 to 8.02 and salinity from 8.7 to 34.5. The lowest values of these environmental parameters were observed in the stations located on the Camboriú river, while the stations collected in transects A and B exhibited the highest values.

The two first axes of the PCA explained 69.82% of the variation among samples, the first component was responsible for 47.60% of the variation and the second explained 22.22% (Figure 2). Overall, the ordination of samples evidenced a separation of stations following a depth gradient. Samples collected in transect B, located farther from the coast, were associated with higher concentrations of silt, clay, and percentage of organic matter, except those collected during the autumn campaign. Stations of transect A were associated with positive coordinates resulting from higher concentrations of dissolved oxygen, salinity, and very fine sand, while the samples obtained from the Camboriú River were associated with negative coordinates of these variables.

Figure 2 - Biplot of Principal Component Analysis (PCA). Geometric figures symbolize the sampling stations: (▲), Camboriú River; (●), transect A stations and; (□), transect B stations. Colors describe seasonal periods: orange, magenta, brown, and green represent summer, spring, autumn, and winter, respectively. Vectors represent the percentages of the variables: S.medium, medium sand; S.fine, fine sand; S.v.fine, very fine sand; Clay; Silte; %OM, percentage of organic matter; do, dissolved oxygen and; sal, salinity

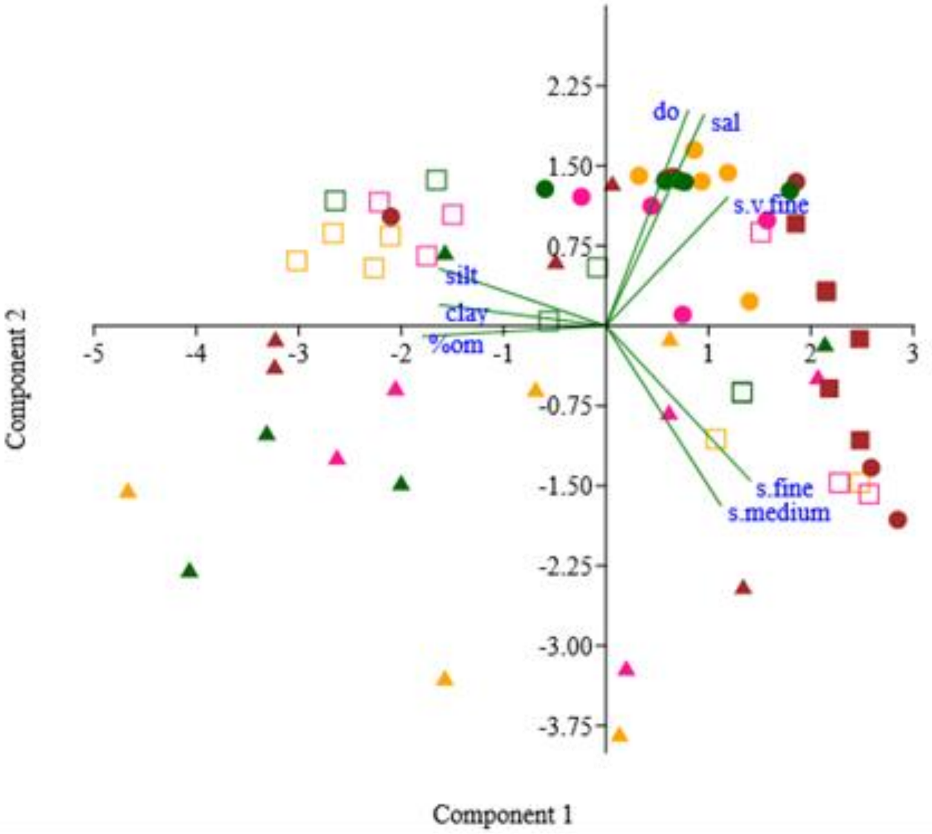


Table 1 - Sediment characteristics and classification. M, medium sand; F, fine sand; VF, very fine sand; %OM, percentage of organic matter; O, dissolved oxygen and S, salinity

	Station	Sand			Silt	Clay	%OM	O	S		Station	Sand			Silt	Clay	%OM	O	S
		M	F	VF								M	F	VF					
summer	#1	13,93	21,99	27,81	7,15	5,60	2,15	3,79	8,7	spring	#1	12,08	32,09	15,24	16,87	7,61	2,32	2,74	21,6
	#2	3,66	20,06	15,64	22,06	18,11	4,96	2,18	11,6		#2	0,72	5,60	7,75	63,07	22,23	7,67	3,02	24,2
	#3	0,13	0,70	2,35	77,10	19,61	21,91	2,61	21,4		#3	0,61	5,99	16,14	50,02	27,06	7,19	4,18	26,5
	#4	0,34	9,10	50,12	25,45	14,76	4,71	3,64	26,2		#4	2,25	28,05	46,29	15,58	4,42	1,77	4,25	28,5
	#6	3,58	8,44	70,46	10,75	6,25	3,03	4,76	28,4		#6	6,59	48,72	33,08	4,75	0,00	0,57	6,38	34,9
	#11	0,65	3,22	84,18	6,30	5,35	2,08	6,84	32,1		#11	0,16	20,44	71,39	7,88	0,00	0,58	6,08	35,1
	#16	0,73	5,62	65,46	24,90	3,01	1,91	7,83	32,4		#16	1,10	8,43	49,16	31,38	8,93	1,24	6,45	34,6
	#21	1,85	4,66	67,53	20,55	3,25	1,88	7,05	33,1		#21	0,68	5,51	58,29	22,63	12,55	1,53	6,75	34,6
	#26	5,96	22,63	54,80	11,94	3,74	1,86	6,24	33,7		#26	5,75	1,48	3,12	1,62	0,00	1,80	6,45	34,9
	#31	0,60	1,04	59,87	33,32	4,30	2,53	6,68	33,4		#31	0,57	2,18	32,65	43,38	7,99	2,68	6,55	34,9
	#36	0,06	0,08	2,12	55,04	42,65	14,41	5,85	33,1		#36	3,59	16,96	66,49	9,86	1,70	1,65	6,66	34,5
	#37	0,05	0,07	1,51	62,33	36,02	11,71	6,37	33,5		#37	0,12	0,26	1,94	61,60	36,03	8,75	6,85	34,8
	#38	1,69	2,25	7,49	48,92	38,15	10,90	7,17	32		#38	1,76	1,13	10,81	50,82	34,62	6,18	6,78	34,9
	#39	2,17	3,70	4,11	46,68	42,50	11,40	6,55	32,4		#39	3,25	3,63	3,69	42,99	45,47	7,93	6,59	34,6
	#40	13,90	35,84	12,02	13,75	18,13	3,56	6,79	32,6		#40	16,35	52,44	16,77	9,55	0,00	1,80	6,56	34,8
	#41	11,74	66,87	17,72	0,30	0,00	1,51	6,6	33,9		#41	13,57	65,72	15,60	2,50	0,00	0,91	6,47	34,8
	Station	Sand			Silt	Clay	%OM	O	S		Station	Sand			Silt	Clay	%OM	O	S
		M	F	VF								M	F	VF					
autumn	#1	0,04	0,31	2,78	9,35	87,50	13,33	6,5	24	winter	#1	0,02	0,09	1,35	57,16	41,36	11,89	1,74	16,5
	#2	0,04	0,87	5,29	10,77	83,02	13,42	5,64	24,4		#2	0,05	0,91	2,75	52,40	43,74	10,30	5,45	16,2
	#3	8,21	56,98	24,83	8,25	0,00	1,42	4,49	24,3		#3	0,14	8,82	21,46	46,46	23,09	4,99	3,18	20
	#4	0,63	17,40	32,95	12,38	36,52	7,12	7	31,2		#4	1,10	3,39	10,42	42,79	38,87	6,07	6,92	30,7
	#6	1,32	1,89	56,85	12,22	26,75	5,32	6,91	34,1		#6	7,94	45,66	31,72	6,45	0,00	0,91	7,85	33,1
	#11	0,42	2,09	68,25	24,25	4,89	1,82	6,41	33,9		#11	1,22	23,96	65,81	7,52	0,00	0,78	8,02	32,9
	#16	0,62	0,81	6,69	51,86	39,64	9,37	6,71	34,4		#16	0,64	6,01	56,70	33,53	2,69	1,15	7,03	32,9
	#21	13,53	61,47	22,83	0,85	0,00	1,42	6,84	34,3		#21	1,65	7,55	54,73	32,14	2,96	1,22	7,4	33,1
	#26	19,93	53,61	16,04	0,11	0,00	0,18	6,8	34,2		#26	0,67	6,81	62,05	26,92	3,06	1,20	7,01	32,8
	#31	1,45	11,89	85,87	0,45	0,00	0,78	6,8	34,2		#31	0,36	0,98	30,97	47,24	15,54	3,23	7,07	32,9
	#36	2,48	16,35	79,75	0,47	0,00	0,87	6,29	34,6		#36	0,03	0,07	0,86	45,09	53,90	12,48	7,71	32,4
	#37	3,21	60,45	36,16	0,15	0,00	0,22	6,13	33,8		#37	0,20	0,42	10,93	61,22	27,08	6,73	7,6	33,1
	#38	17,11	32,77	42,11	1,41	0,00	0,62	6,23	34,2		#38	4,72	14,38	20,83	44,56	14,27	2,61	7,05	33,2
	#39	12,75	27,38	56,30	0,40	0,00	0,50	7,1	34,3		#39	10,23	7,20	7,30	36,76	30,38	5,55	7,18	32,8
	#40	0,18	53,54	45,48	0,76	0,00	0,23	7,14	34,3		#40	10,80	39,61	20,91	11,04	13,80	3,25	7,12	33,2
	#41	3,37	41,33	53,31	0,23	0,00	0,72	6,98	34,5		#41	10,80	39,61	20,91	11,04	13,80	3,25	7,14	33,1

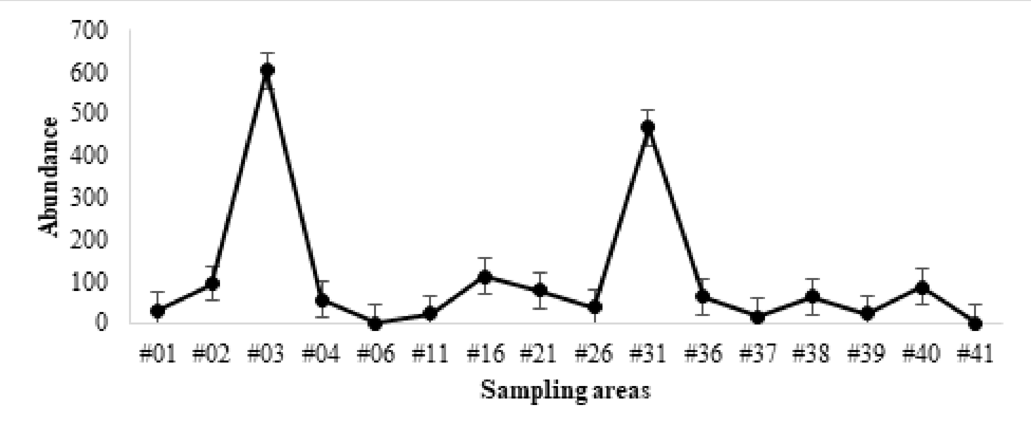
3.2 Biotic

The Capitellidae family was classified into five distinct taxa: *Capitella* sp. Blainville, 1828; *Capitella* cf. *nonatoi* Silva & Amaral, 2017, *Heteromastus* sp. Eisig, 1887, *Heteromastus similis* Southern, 1921 and *Mediomastus* cf. *californiensis,* Hartman, 1944. The taxa found in the present study are among the eight species previously recorded in the Santa Catarina state, except the species *Capitella nonatoi*, which was previously described as *Capitella capitata* (Fabricius, 1780). However, in Balneário Camboriú there was only the record of *Mediomastus californiensis* (Almeida *et al.*, 2012; Amaral *et al.*, 2012; Pagliosa *et al.*, 2012).

The density of capitellids totaled 1,769 ind.m², in general, the highest densities occurred in Camboriú River stations, mainly at #3 ($N\overline{x}$ = 603 ind.m²), as well as, in transect

A, especially at #31 ($N\overline{x}$ =468.25 ind.m²) (Figure 3). A similar density observed in Sechura Bay, in Peru, where were collected 1,886 ind.m² (Yupanqui *et al.*, 2007). This result was superior when compared to the density of Trapandé/SP Bay, which presented approximately 170 ind.m² (Souza *et al.*, 2013). In Lagoa dos Patos/RS Bay, the density of capitellids found was around 6,000 ind.m² (Soares *et al.*, 2016), a value considerably higher than that found in this study.

Figure 3 - Density fluctuation (ind.m², $\overline{x}$ ± SD, n= 3) of capitellides at sampling stations in Camboriú River (#1, #2, #3, #4, #6) and Balneário Camboriú shoreline (transect A = #11, #16, #21, #26, #31 and #36; transect B = #37, #38, #39, #40 and #41)

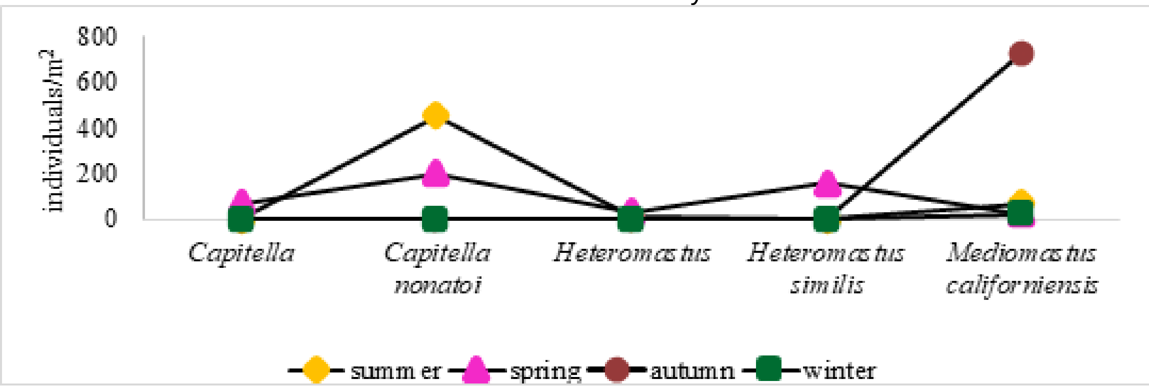


The PERMANOVA test showed significant differences in the composition of taxa in relation to the sampled areas, seasonality, as well as the interaction of these factors (Table 2). The most abundant and frequent taxon was *Mediomastus* cf. *californiensis*, showing the highest number of individuals during autumn (N= 730 ind.m²) (Figure 4). The specie *Capitella* cf. *nonatoi* was the second most abundant taxon, showing 650 ind.m² in the summer period. This species was recorded only during the summer and spring, as well as *Heteromastus* sp. The *Capitella* sp. and *Heteromastus similis* showed the lowest frequency, being recorded exclusively sampling in spring.

Table 2 - Two-way crossed PERMANOVA multivariate analysis on the abundance of capitelid taxa. Sq, sum of squares; gl, degrees of freedom; Mq, mean of squares; F, value of F by permutation; p, p-values based on over 9,000 permutations. Significant P-values (P < 0.05) are shown in bold

Two-way PERMANOVA					
Source	Sq	gl	Mq	F	p
Area	31.487	15	0.20991	16.329	**0.0152**
Seasonality	17.393	3	0.57976	45.099	**0.0006**
Interaction	86.684	45	0.19263	14.985	**0.0065**
Residual	16.455	128	0.12855		
Total	30.011	191			

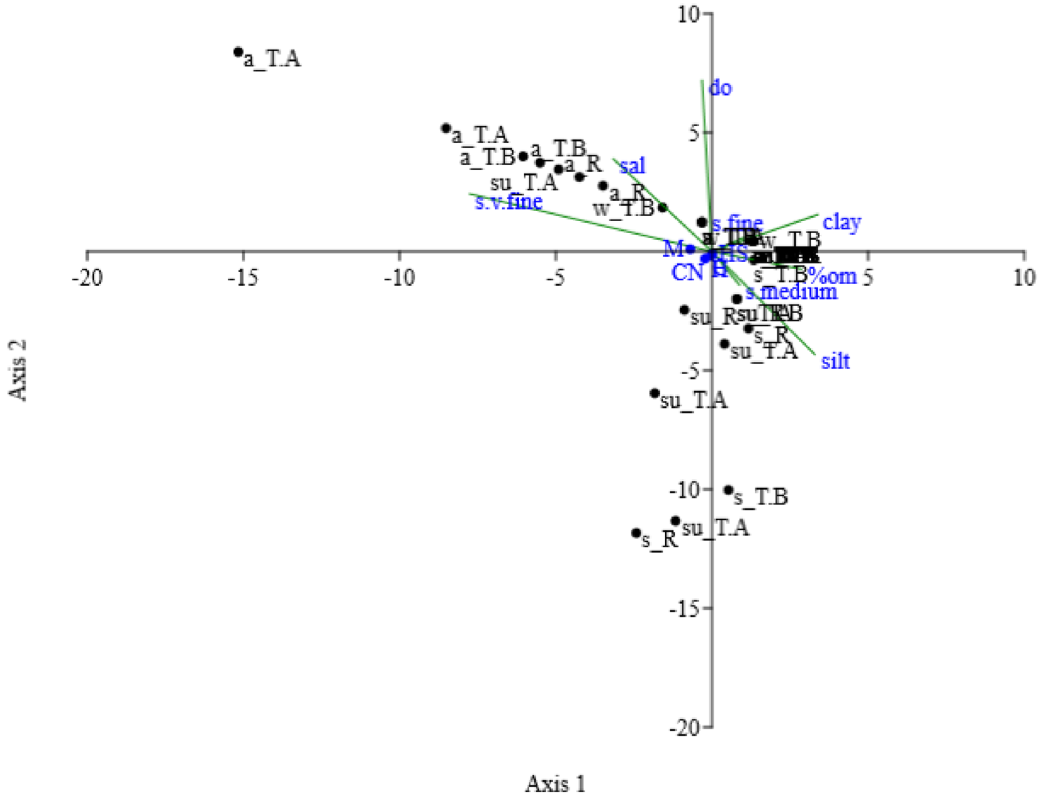
Figure 4 - Seasonal fluctuation of *Capitella* sp., *Capitella* cf. *nonatoi, Heteromastus* sp., *Heteromastus similis* and *Mediomastus* cf. *californiensis* density



The results of the redundancy analysis allowed the extraction and interpretation of two factor axes, which together explained 9.66% of the variation in the abundance data of benthic macroinvertebrates. There was a tendency of the species *Mediomastus* cf. *californiensis,* as well as most of the acquired samples, except those collected in the summer, to be associated with the first axis, which was strongly influenced by the negative coordinate resulting from the highest concentrations of very fine sand and by the positive clay coordinate. Most of the samples collected during the summer, and the species *Capitella* cf. *nonatoi*, were associated with the second axis, which was strongly influenced by the negative coordinates resulting from higher concentrations of dissolved oxygen and salinity, and the positive coordinate of silt and organic matter (Figure 5).

The dynamics of the genus *Capitella* is characterized by a rapid response to the environment, thus the association of these organisms in organically enriched environments has come to be considered a reflection of their life history (Tsutsumi, 1990). In the present study, the high density of *Capitella* cf. *nonatoi* were found at station #3, located in Camboriú River, which exhibited the highest concentrations of organic matter. This water body drains a hydrographic basin of approximately 200 km², comprising the municipalities of Camboriú and Balneário Camboriú. The river is substantially influenced by human activities developed in the region, mainly agriculture and livestock, and is utilized as an access route to berths and marinas (Schettini *et al.*, 1996; Klein *et al.*, 2002). The low-density values of capitelids recorded at stations #1 and #2, also located on the river, can be attributed to low salinity. These stations were sampled upstream, and the Capitellidae family is composed of euryhaline species (Subramanian *et al.*, 2021) generally distributed from the intertidal zone to the deep sea (González *et al.*, 2021). The Camboriú River, as well as others located close to urban centers (Strokal *et al.*, 2021), have the highest water quality close to the source, and it decreases dramatically towards the mouth as a reflection of low concentrations of dissolved oxygen and high concentrations of nutrients, mainly phosphate and ammonia (SDS, 2017). This change occurs especially as a result of effluent release with large concentrations of organic matter from urbanized areas (Oliveira *et al.*, 2021), which contribute to changing the physicochemical characteristics of the environment (Brito *et al.*, 2020).

Figure 5 - Ordering diagram of the first two axes of the Redundancy Analysis for the environmental descriptors and benthic macroinvertebrates. su, summer; s, spring; a, autumn; w, winter; R, Camboriú River; _T.A, transect A stations; _T.B, transect B stations; S.médium, medium sand; S.fine, fine sand; S.v.fine, very fine sand; Clay; Silte; %OM, percentage of organic matter; do, dissolved oxygen; sal, salinity; C, *Capitella* sp.; Cn, *Capitella* cf. *nonatoi*; H, *Heteromastus* sp.; Hs, *Heteromastus similis*; M, *Mediomastus cf. californiensis*



Station #31 had the second-highest density and was mainly dominated by *Mediomastus* cf. *californiensis*. The species was associated with very fine sand and exhibited the highest density values in autumn, being unrepresentative in the other seasons. Brasil & Silva (2000) evaluating the distribution of polychaetes in Rio de Janeiro, found a relationship between the presence of *M. californiensis*, very fine sand, and the concentration of organic matter. Unlike this result, Hartman (1944) and Niki *et al*. (2006) associated the presence of *M. californiensis* with fine sand.

Several studies point *M. californiensis* as the dominant species (Swartz *et al.*, 1986; Dean, 1996; Park *et al.*, 2000). The species is described as opportunistic and has an r-type reproduction strategy, which generates large populations in a short period (Santos; Simon, 1980). When analyzing the trophic structure of Calcasieu Estuary macrofauna, Gaston & Nasci (1988) observed the highest number of *M. californiensis* occurring during the winter, however, these values exhibited considerable spatio-temporal variation. The authors indicate that fluctuations in abundance were little related to density-dependent variables, such as competition, predation, and larval-adult interactions. The study suggests that the variations are mainly due to the changeability of the area where the traffic of ships and maintenance dredging takes place.

The community of capitellids found in the Camboriú River reflects the influence of organic matter concentrations on benthic organisms. This result denotes the contribution of effluents generated by residents and tourists in the summer, the season when the city has the highest population density. Due to the low or absence of a relationship found between the genera *Heteromastus* with the explanatory variables, it is suggested to carry out further evaluations focused on the biology and ecology of these taxa.

4 ACKNOWLEDGMENTS

The authors would like to thank the Acquaplan group for the support.

REFERENCES

ALMEIDA, T. C. M.; VIVAN, J.; PESSER, B. H.; LANA, P.C. Polychaetes of the north-central Santa Catarina state, Brazil. **Check List**, v. 8, n. 2, p. 204-206, 2012. https://doi.org/10.15560/8.2.204.

AMARAL, A. C. Z.; MORGADO, E. H.; SALVADOR, L. B. Polychaetes as bioindicators of organic pollution on the beaches of São Paulo. **Revista Brasileira de Biologia**, v. 58, n. 2, p. 307-316, 1998.

AMARAL, A. C. Z.; NALLIN, S. A. H.; STEINER, T. M.; FORRONI, T. O.; GOMES, D. F. **Catálogo das espécies de Annelida Polychaeta do Brasil**, 141 pp. UNICAMP, Campinas, 2012. Available in: http://www2.ib.unicamp.br/projbiota/bentos_marinho/prod_cien/tex to_poli.pdf. Accessed in: May 02, 2023.

ANDERSON, M. J. Permutation tests for univariate or multivariate analysis of variance and regression. **Canadian Journal of Fisheries and Aquatic Sciences**, v. 58, p. 626-639, 2001. https://doi.org/10.1139/f01-004

BLAKE J. A.; GRASSLE, J. P.; ECKELBARGER, K. J. *Capitella teleta*, a new species designation for the opportunistic and experimental *Capitella* sp. I, with a review of the literature for confirmed records. **Zoosymposia**, v. 2, p. 25-53, 2009. https://doi.org/10.11646/zoosymposia.2.1.6.

BRASIL, A. C. S.; SILVA, S. H. G. Spatial distribution of Polychaeta. **Bulletin of Marine Science**, v. 67, n. 1, p. 103-112, 2000.

BRITO, F. S. L.; PIMENTEL, B. A.; VILHENA, J. C.; ROSÁRIO, K. K. L.; MORAIS, M. S.; CRUZ, R. H. R.; CORRÊA, V. L. S. Comportamento das variáveis físico-químicas da água do lago Bolonha-Belém-PA. **Brazilian Journal of Development**, v. 6, n. 1, p. 1738-1757, 2020. https://doi.org/10.34117/bjdv6n1-120

CAPA, M.; HUTCHINGS, P. Annelid diversity: historical overview and future perspectives. **Diversity**, v. 13, n. 3, p. 129, 2021. https://doi.org/10.3390/d13030129.

CLARKE, K.; WARWICK, R. **Change in marine communities:** an approach to statistical analysis and interpretation. Marine Laboratory, Plymouth, 144p. 2001.

DEAN, W. Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: Comparison with other methods. **Journal of Sedimentary Petrology**, v. 44, p. 242-248, 1974. https://doi.org/10.1306/74D729D2-2B21-11D7-8648000102C1865D

DEAN, H. K. Subtidal benthic polychaetes (Annelida) of the Gulf of Nicoya, Costa Rica. **Revista de Biología Tropical**, v. 44, n. 3, p. 69-80, 1996.

DEAN, H. K. Capitellidae (Annelida: Polychaeta) from the Pacific Coast of Costa Rica. **Revista de Biologia Tropical**, v. 49, n. 2, p. 69-84, 2001.

DEAN, H. K.The use of polychaetes (Annelida) as indicator species of marine pollution: a review. **Revista de Biologia Tropical,** v. 56, n. 4, p. 11-38, 2008.

GARCÍA-GARZA, M. E. Capitellidae Grube 1862. In: León-González JA, JR Bastida-Zavala, LF Carrera-Parra, ME García-Garza, SI Salazar-Vallejo, V Solís-Weiss & MA Tovar-Hernández (eds). **Anélidos marinos de México y América Tropical**, pp. 135-152. Universidad Autónoma de Nuevo León, Monterrey, 2021.

GASTON, G. R.; NASCI, J. C. Trophic structure of macrobenthic communities in the Calcasieu Estuary, Louisiana. **Estuaries**, v. 11, n. 3. P. 201-211, 1988. https://doi.org/10.2307/1351973

GONZÁLEZ, J. A. L.; ZAVALA, J. R. B.; PARRA, L. F. C.; GARCÍA, G. M. E.; SERGIO, I. S. V.; HERNÁNDEZ, W. V. S.; TOVAR, M. A. **Anélidos marinos de México y América tropical**, Universidad Autónoma de Nuevo León, Monterrey, Nuevo León, 2021.

GRASSLE, J. P.; GRASSLE, J. F. Sibling species in the marine pollution indicator *Capitell*a (Polychaeta). **Science**, v. 192, p. 567-569, 1976. https://doi.org/10.1126/science.1257794

HARTINI, H. Diversity of Annelida Worm as a Bioindicator of Water Quality in Unus Estuary, Mataram Lombok. **Jurnal Biologi Tropis**, v. 22, n. 1, p. 265-270, 2022. https://doi.org/10.29303/jbt.v22i1.3262

HARTMAN, O. **Polychaetous annelids from California**: including the descriptions of two new genera and nine new species. University of Southern California Press, Los Angeles, v.7, 1944.

HAMMER, Ø.; HARPER, D.A.T.; RYAN P.D. PAST: Paleontological statistics software package for education and data analysis. **Palaeontologia Electronica**, 2001.

HERREN, L. W.; BREWTON, R. A.; WILKING, L. E.; TARNOWSKI, M. E.; VOGEL, M. A.; LAPOINTE, B. E. Septic systems drive nutrient enrichment of groundwaters and eutrophication in the urbanized Indian River Lagoon, Florida**. Marine Pollution Bulletin**, v. 17, 2021. https://doi.org/10.1016/j.marpolbul.2021.112928

ISKANDER, M. M. Stability of the Northern coast of Egypt under the effect of urbanization and climate change. **Water Science**, v. 35, n. 1, p. 1-10, 2021. https://doi.org/10.1080/11104929.2020.1864255

KITAMORI, R.; KOBE, Z. The benthic community in polluted coastal waters. IV. Kanzaki River. **Bulletin of Naikai Regional Fisheries Research Laboratory**, v.12, p. 223-226, 1959.

KLEIN, A. H. F.; BENEDET, F. L.; SCHUMACHER, D. H. Short-term beach rotation processes in distinct headland Bay beach systems. **Journal of Coastal Research**, v. 18, n. 3, p. 442-458, 2002.

KLEIN, A. H. F.; MENEZES, J. T. Beach morphodynamics and profile sequence for a headland bay coast. **Journal of Coastal Research**, p. 812-835, 2001.

LAURINO, I. R. A. Distribuição espaço-temporal de poliquetas Nereididae, Capitellidae e Spionidae em planícies lamosas no complexo portuário-estuarino de Santos (SP). Revista **Brasileira de Zoociências**, v. 18, n. 2, 2017. https://doi.org/10.34019/2596-3325.2017.v18.24609

LEGENDRE, P.; LEGENDERE, L. **Numerical ecology**. Amsterdam: Elsevier,1998. v. 2.

MARTIN, J. P.; BASTIDA, R. **Life history and production of *Capitella cf. nonatoi* (Polychaeta: Capitellidae) in Río de la Plata Estuary (Argentina)**, 2006.

MCARDLE, B. H.; ANDERSON, M. J. Fitting multivariate models to community data: a comment on distance based redundancy analysis. **Ecology**, v. 82, p. 290-297, 2001. https://doi.org/10.1890/0012-9658(2001)082[0290:FMMTCD]2.0.CO;2

MÉNDEZ, N. Assessing anthropogenic disturbance in Estero de Urías coastal lagoon through the lens of annelid distribution. **Bulletin of Marine Science**, v. 97, n. 1, p. 89-104, 2021. https://doi.org/10.5343/bms.2020.0035

MÉNDEZ, N. Effects of sediment organic matter on mortality, growth and development of the polychaetes *Capitella teleta* and *Capitella* sp.(Annelida: Capitellidae) in laboratory conditions. **Scientia Marina**, v. 86, n. 2, 2022. https://doi.org/10.3989/scimar.05208.034

MOMOTA, K.; HOSOKAWA, S. Potential impacts of marine urbanization on benthic macrofaunal diversity. **Scientific Reports**, v. 11, n. 1, p. 4028, 2021, 2021. https://doi.org/10.1038/s41598-021-83597-z

NIKI, K.; SUYAMA, N.; SUDA, Y.; MURAI, T. Relationship between distribution of *Heteromastus* , *Mediomastus* and *Notomastus* of Capitellidae of polychaete and bottom condition in the northern part of Ariake Sound. **Journal of National Fisheries University**, v. 54, n. 1, p. 7-13, 2006.

OLIVEIRA, D. C. D. S.; AZEVEDO, P. G. F. D.; CAVALCANTI, L. A. P. Processos biológicos para o tratamento de efluentes: uma revisão integrativa. **Revista Brasileira de Gestão Ambiental e Sustentabilidade**, v. 8, n. 18, p. 397-415, 2021. https://doi.org/10.21438/rbgas(2021)081826

OURIVES, T. M.; RIZZO, A. E.; BOEHS, G. Composition and spatial distribution of the benthic macrofauna in the Cachoeira River estuary, Ilhéus, Bahia, Brazil. **Revista de Biología Marina y Oceanografía**, v. 46, p. 1, p. 17-25, 2011. https://doi.org/10.4067/S0718-19572011000100003

PAGLIOSA, P. R.; BARBOSA, F. A. R. Assessing the environment–benthic fauna coupling in protected and urban areas of southern Brazil. **Biological Conservation**, v. 129, n. 3, p. 408-417, 2006. https://doi.org/10.1016/j.biocon.2005.11.008

PAGLIOSA, P. R.; DORIA, J. G.; ALVES, G. F.; ALMEIDA, T. C. M.; LORENZI, L.; NETTO, A. S.; LANA, P. C. Polychaetes from Santa Catarina State (Southern Brazil): checklist and remarks on species distribution. **Zootaxa**, n. 3486, p. 1-49, 2012. https://doi.org/10.11646/zootaxa.3486.1.1

PARK, H.; LIM, H.; HONG, J. Spatio- and temporal patterns of benthic environment and macrobenthos Community on subtidal soft-bottom in Chonsu Bay, Korea. **Korean Journal of Fisheries and Aquatic Sciences**, v. 33, n. 3, p. 262-271, 2000.

PEARSON, T. H.; ROSENBERG, R**.** Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. **Oceanography and Marine Biology**: An Annual Review, v. 16, p. 229-311, 1978.

PMBC – Prefeitura Municpal de Balneário Camboriú. Available from: https://www.bc.sc.gov.br/a-prefeitura.cfm. Accessed in: May, 2023, 19.

POCKLINGTON, P.; WELLS, P. Polychaetes key taxa for marine environmental quality monitoring. **Marine Pollution Bulletin**, v. 24, n. 12, p. 593-598, 1992. https://doi.org/10.1016/0025-326X(92)90278-E

RIZZO, A. E.; AMARAL, A. C. Z. Environmental variables and intertidal beach annelids of São Sebastião Channel (State of São Paulo, Brazil). **Revista de Biologia Tropical**, v. 49, n. 3, p. 849-857, 2001.

ROUSE, G. W.; FAUCHALD, K. Cladistics and Polychaetes. **Zool. Scr**., v. 26, p. 139–204, 1997. https://doi.org/10.1111/j.1463-6409.1997.tb00412.x

SANTOS, S. L.; SIMON, J. L. Response of soft-bottom benthos to annual catastrophic disturbance in a South Florida estuary. **Marine Ecology Progress Series**, v. 3, p. 347-355, 1980. https://doi.org/10.3354/meps003347

SCHERNER, F.; HORTA, P. A.; OLIVEIRA, E. C.; SIMONASSI, J. V.; HALL-SPENCER, J. M.; CHOW, F.; NUNES, J. M. C.; PEREIRA, S. M. B. Coastal urbanization leads to remarkable seaweed species loss and community shifts along the SW Atlantic. **Marine Pollution Bulletin**, v. 76, p. 106-115, 2013. https://doi.org/10.1016/j.marpolbul.2013.09.019

SCHETTINI, C. A. F.; CARVALHO, J. L. B.; JABOR, P. C**omparative hydrology and suspended matter distribution of four estuaries in Santa Catarina State–Southern Brazil.** In: Proceedings of Workshop on Comparative Studies of Temperate Coast Estuaries, p. 29-32, 1996.

SDS **-** Secretaria de Estado do Desenvolvimento Econômico Sustentável, Santa Catarina, **Plano de Recursos Hídricos da Bacia Hidrográfica do Rio Camboriú e Bacias Contíguas**, 94 pp. 2017.

SILVA, C. F.; SEIXAS, V. C.; BARROSO, R.; DI DOMENICO, M; AMARAL, A. C.; PAIVA, P. C. Demystifying the Capitella capitata complex (Annelida, Capitellidae) diversity by morphological and molecular data along the Brazilian coast. **PLoS One**, v. 12, n. 5, 2017. https://doi.org/10.1371/journal.pone.0177760

SOARES, R. B.; PEIXOTO, S.; BEMVENUTI, C.; WASIELESKY, W. J.; D'INCAO, F.; MURCIA, N.; SUITA, S. Composição e abundancia dos invertebrados bentônicos nos cercados de cultivo de *Farfantepenaeus paulensis*. In: Wasielesky Jr W & LH Poersch (eds). **Cultivo de camarões em gaiolas e cercados no Estuário da Lagoa dos Patos**, p. 174-190. Rio Grande: Editora da FURG, 2016.

SOUZA, F. M.; GILBERT, E. R.; CAMARGO, M. G.; PIEPER, W. W. The spatial distribution of the subtidal benthic macrofauna and its relationship with environmental factors using geostatistical tools: a case study in Trapandé Bay, southern Brazil. **Zoologia**, v. 30, n. 1, p. 55-65, 2013. https://doi.org/10.1590/S1984-46702013000100007

STROKAL, M.; BAI, Z.; FRANSSEN, W.; HOFSTRA, N.; KOELMANS, A. A.; LUDWIG, F.; MA, L.; VAN PUIJENBROEK, P.; SPANIER, J. E.; VERMEULEN, L. C. M.; VAN VLIET, T, H.; VAN WIJNEN, J.; KROEZE, C. Urbanization: an increasing source of multiple pollutants to rivers in the 21st century. **Npj Urban Sustain**, v. 1, n. 24, 2021. https://doi.org/10.1038/s42949-021-00026-w

STRUCK, T. C.; PAUL, N.; HILL, S.; HARTMANN, C.; HÖSEL, M.; KUBE, B.; LIEB, A.; MEYER, R.; TIEDEMANN, G. Phylogenomic analyses unravel annelid evolution. **Nature**, v. 471, p. 95-98, 2011. https://doi.org/10.1038/nature09864

SUBRAMANIAN, R.; RETNAMMA, J.; NAGARATHINAM, A.; LOGANATHAN, J.; SINGARAM, P.; CHANDRABABU, V. Seasonality of macrobenthic assemblages and the biotic environmental quality of the largest monsoonal estuary along the west coast of India. **Environmental Science and Pollution Research International**, v. 28, n. 28, p. 37262-37278, 2021. https://doi.org/10.1007/s11356-021-13144-w

SUGUIO, K. **Introdução a sedimentologia**. São Paulo: Blücher, 1973. 317 p.

SULTAN, M.; PEI, D. S. **Ecotoxicology methods of reservoir water using invertebrates.** In Reservoir Ecotoxicology (pp. 99-111). Cham: Springer International Publishing, 2023. https://doi.org/10.1007/978-3-031-26344-6_9

SWARTZ, R. C.; COLE, F. A.; SCHULTS, D. W.; DEBEN, W. A. Ecological changes in the Southern California Bight near a large sewage outfall: benthic conditions in 1980 and 1983. **Marine Ecology Progress Series**, v. 31, p. 1-13, 1986. https://doi.org/10.3354/meps031001

TSUTSUMI, H. Population persistence of *Capitella* sp. (Polychaeta; Capitellidae) on a mud flat subject to environmental disturbance by organic enrichment. **Marine Ecology Progress Series**, v. 63, p. 147-156, 1990. https://doi.org/10.3354/meps063147

UMEHARA, A.; NAKAI, S.; OKUDA, T.; OHNO, M.; NISHIJIMA, W. Benthic quality assessment using M-AMBI in the Seto Inland Sea, Japan. **Marine environmental research**, v. 148, p. 67-74, 2019. https://doi.org/10.1016/j.marenvres.2019.05.007

ZHANG, Q.; HE, Z.; WANG, J. Acute Toxicity, Oxidative Stress, Toxicity Mechanism, and Degradation Dynamics of Trifluralin in Eisenia foetide (Annelida: Lumbricidae). **Journal of Entomological Science**, v. 58, n. 1, p. 27-46, 2023. https://doi.org/10.18474/JES22-06

WoRMS Editorial Board. **World Register of Marine Species**, 2023. Available from https://www.marinespecies.org at VLIZ. Accessed 2023-05-17. doi:10.14284/170.

YUPANQUI, W.; QUIPÚZCOA, L.; MARQUINA, L.; VELAZCO, R.; ENRÍQUEZ, E.; GUTIÉRREZ, D. Composición y distribución del macrobentos en la Ensenada de Sechura, Piura, Perú. **Revista Peruana de Biología**, v. 14, n. 1, p. 75-85, 2007. https://doi.org/10.15381/rpb.v14i1.1763