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Species and local contribution to beta diversity: Baseline conditions of Ubatumirim Bay ichthyofauna

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“Biological diversity is the key to the maintenance of the world as we know it... Eliminate one species, and another increases to take its place. Eliminate a great many species, and the local ecosystem starts to decay.”

Edward O. Wilson

RESUMO

Dividir uma comunidade em grupos permite entender melhor como as espécies são distribuídas de uma forma mais replicável, mas também é importante quantificar a importância desses grupos e espécies. A partição da diversidade beta torna isso possível, por meio da medição da contribuição das espécies para a diversidade beta (SCBD) e da contribuição local para a diversidade beta (LCBD), tornando viável não apenas investigar a importância das espécies para o ambiente, mas também medir o grau de singularidade de cada local. Por esse motivo, calculamos os valores de LCBD e SCBD relacionados a assembeia de peixes marinhos da Baía de Ubatumirim, com o objetivo de entender como diferentes grupos de habitat contribuem para a diversidade beta e buscando relacionar a singularidade de cada local de amostragem às suas características. A ictiofauna foi amostrada com rede de arrasto, em seis pontos de diferentes profundidades. As 95 espécies foram classificadas em cinco grupos de habitat, mas não houve diferença significativa de SCBD entre os grupos. Enquanto isso, a Ilha das Couves apresentou uma maior contribuição local para a diversidade beta quando comparada com os outros locais amostrados, e uma regressão beta encontrou uma relação significativa dos valores de LCBD com a diminuição do diâmetro médio do sedimento. Além disso, nossos achados demonstram que os padrões para SCBD foram semelhantes aos da literatura. No entanto, o LCBD apresentou relação positiva com a riqueza funcional, não havendo relação significativa com a riqueza de espécies, diferente do que é comum em outros estudos, mas um padrão que tem sido observado em ambientes marinhos. No geral, notamos que a Ilha das Couves abriga uma composição única de peixes, provavelmente com uma maior complexidade ambiental, atuando como um filtro ambiental. O perfil de diversidade apresentado funciona como uma ferramenta de conservação, apoiando a gestão e permitindo testar futuramente a eficácia da Área de Proteção Ambiental Marinha.

Palavras-chave: Filtro ambiental. riqueza funcional. grupos de habitat. Área Marinha Protegida. Ilha das Couves.

ABSTRACT

Species and local contribution to beta diversity: Baseline conditions of Ubatumirim Bay ichthyofauna

Dividing a community into groups enables us to better understand how species are distributed in a more replicable way, but it is also important to quantify how significant those groups and species are. Partitioning beta diversity makes this possible, through measuring the species contribution to beta diversity (SCBD) and the local contribution to beta diversity (LCBD), making it viable to not only investigate species importance to the environment, but as well to measure the degree of uniqueness for each site. For this reason, we calculated the LCBD and SCBD values related to the marine fish assemblage of Ubatumirim Bay, aiming to understand how different habitat groups contribute to beta diversity and to relate the uniqueness of each sampling site to their characteristics. The ichthyofauna was sampled using a shrimp trawl, at six points of different depths. The 95 species were classified into five habitat groups, but there was no significant difference of SCBD between groups. Meanwhile, Couves Island presented a higher local contribution to beta diversity when compared to the other sampled sites, and a beta regression found a significant relation of LCBD values with the decrease of the mean sediment diameter. Furthermore, our findings demonstrate that the patterns for SCBD were similar to those in the literature. However, LCBD showed a positive relationship with functional richness, and there was no significant relationship with species richness, different from what is common in other studies, but a pattern that has been seen in marine environments. Overall, we noticed that Couves Island harbors a unique composition of fishes, probably holding a greater environmental complexity, acting as an environmental filter. The presented diversity profile work as a conservation tool, supporting the management and allowing future testing of the effectiveness of the Marine Environmental Protection Area.

Keywords: Environmental filtering. functional richness. habitat groups. Marine Protected Area. Couves Island.

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CW	Coastal Water
LCBD	Local contribution to beta diversity
RDA	Redundancy Analysis
SCBD	Species contribution to beta diversity
VIF	Variance inflation factor

SUMÁRIO

1. Introduction

Grouping species is something that has been done for a long time in ecological studies, allowing us to better answer ecological questions related to the influence of ecosystem processes on community structure (KORŇAN and KROPRIL, 2014; MALATERRE *et al.*, 2019). Additionally, grouping species makes it easy to communicate with non-specialists and decision makers about the effects of environmental management, using an ecological block instead of looking only at the species level. Consequently, species groups can be a versatile tool for conservation, to predict ecological changes and to measure the degree of anthropic impacts (SIMBERLOFF and DAYAN, 1991; WILSON, 1999; BENOIT *et al.*, 2021).

Also, relevant to applied ecology and conservation is the concept of beta diversity, the component of total diversity that reflects the strength of compositional differences between local communities (SOCOLAR *et al.*, 2016). To better understand the processes behind variation of regional diversity, beta diversity can be decomposed in different manners, such as the components of alpha and gamma diversity (JOST, 2007) or the components of species turnover and species addition (BASELGA, 2010; LEGENDRE 2014). Legendre and Cáceres (2013) followed a different approach, in which beta diversity is understood as a variance component that can be decomposed additively into the local contribution to beta diversity (LCBD) as well as into the species contribution to beta diversity (SCBD). LCBD measures the degree of uniqueness of each sample unit, whereas SCBD measures the degree of contribution of each species from the community to total beta diversity.

This methodology makes it practicable to create a profile of community variation inside a certain region, aiming to find priority sites in terms of community composition, an essential step towards conservation, since the distribution of species and variations in the composition of an assemblage can be directly affected by local extinctions and anthropic effects such as habitat loss (SANTOS *et al.*, 2021). Realized that is important to know these communities before a determined impact or ecological change, local contribution to beta diversity values can be an awesome instrument, given that high LCBD measurements usually indicate places that have an unusual species combination, with elevated conservation value, or even a degraded environment, which must be restored as soon as possible, allowing us to protect sites with a contrasting community in a regional aspect (HILL *et al.*, 2021). Meanwhile, SCBD can present high values especially if the species shows large variations in abundance between locations (LEGENDRE and CÁCERES, 2013), and these values can be visualized within each group if added.

Therefore, this approach enables the delimiting not only of sample places heterogeneity but also the species and groups importance in a regional aspect, with several studies that seek to understand the precursors of LCBD and SCBD in freshwater environments (LOPES *et al.*, 2014; KONG *et al.*, 2017), forests (QIAO *et al.*, 2015; TAN *et al.*, 2019; SANTOS *et al.*, 2021), among others (SILVA *et al.*, 2018; HILL *et al.*, 2021), but there are still few who seek to understand the patterns found for SCBD and LCBD in the marine environment (CIONEK *et al.*, 2022), which raises the need for more studies aiming to understand these patterns that consider different ecosystems and regions. For that reason, we sought to measure the values of LCBD and SCBD related to the ichthyofauna of Ubatumirim Bay, in order to define a profile prior to the region transformation in a Marine Protected Area, allowing future comparisons to understand the environmental protection effectiveness and providing more comparisons of SCBD and LCBD patterns in distinct marine environments.

2. Methodology

2.1. Study area and sampling

The study was carried out in Ubatumirim Bay (23º20' – 23º26'S e 44º50' – 44º56'W), part of the city of Ubatuba, north coast of São Paulo state. The Bay is formed by several small islands, with Couves Island being the largest of them. The islands of the region constitute Marine Protected Areas (state law 149/69 and 13,426/79), presenting unique terrestrial and marine ecosystems. The ichthyofauna was sampled by trawling once every season of 2000, using a shrimp trawl equipped with two double-rig nets (mesh size 20 and 15 mm in the cod end). In each season six transects of different depths were sampled, one site close and parallel to Ubatumirim beach (2 m), two sites close to rocky shores, one sheltered (5 m) and the other exposed (7 m), two exposed sites parallel to the mainland (10 m and 15 m) and one sites on Couves Island (16 m) (Figure 1). In each transect a 30-minute haul was performed.

Bottom salinity and bottom temperature were sampled every time in each transect using a Nansen bottle, and measured with a refractometer and thermometer, depths were measured with an echo sounder coupled with a GPS. Sediment samples were collected by transect with a Van Veen type sediment catcher, covering a bottom area of 0.06 m^2, from which the values of mean sediment diameter (phi) were calculated. Procedures for sediment analysis followed Håkanson and Jansson (1983) and Tucker (1988).

The fish were fixed in 10% formalin and identified at species level according to the specialized literature (FIGUEIREDO and MENEZES, 1978; MENEZES and FIGUEIREDO 1980, 1985; CERVIGÓN *et al.*, 1992). Specimens were deposited in the fish collection of the Laboratory of Zoology at the University of Taubaté (IAM/CCILZU).

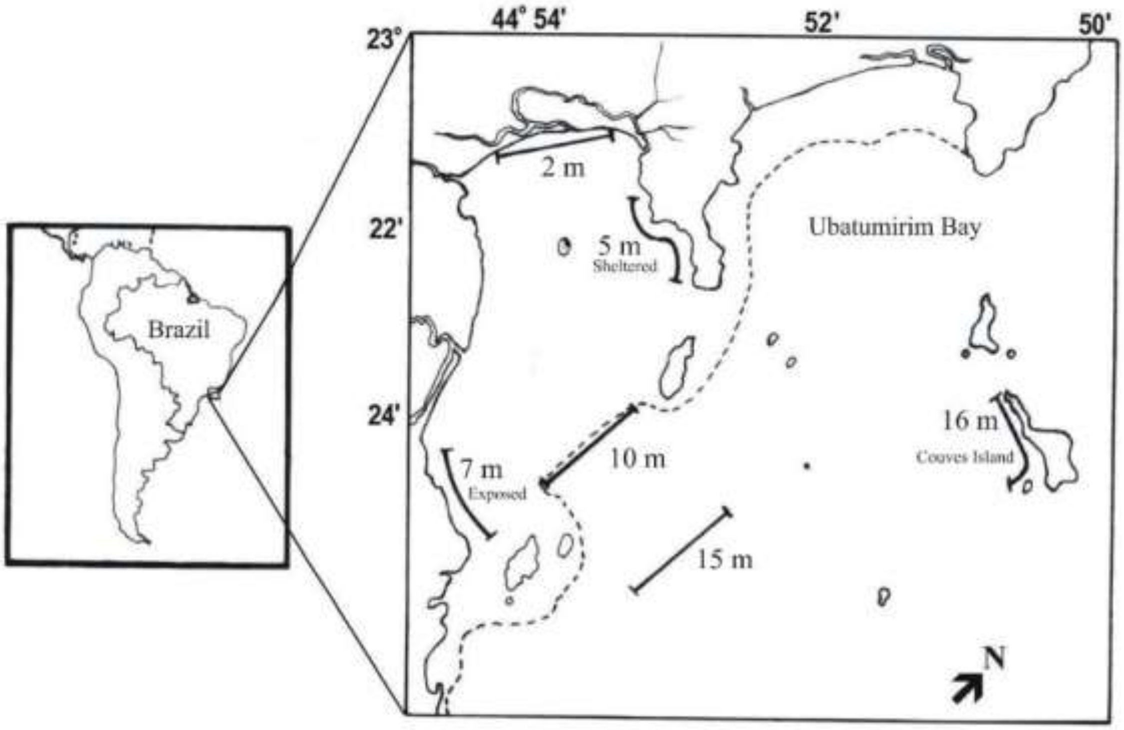

Figure 1**.** Map of the studied area in Ubatumirim Bay with the marking of the six sampling points and their respective depths.
Source: Authors.

2.2. Species grouping and data analysis

Afterward, species were classified, conforming to habitat use, into five groups (Table 1), according to information available at https://www.fishbase.se/search.php (FROESE and PAULY, 2000). The total beta diversity (β_{Total}) was measured through the variance of the Hellinger transformed data table containing abundance values, with species as columns and sample units as rows (LEGENDRE and CÁCERES, 2013). To obtain the species contribution to beta diversity (SCBD) and local contribution to beta diversity (LCBD) values, the *adespatial* package was used (Dray et al., 2021). A

Kruskal-Wallis test was conducted to examine if there were significant differences of SCBD values according to the habitat use group type. Total abundance, taxonomic richness and functional richness were measured to act as predictors to LCBD values in regression, to calculate functional richness were used categorical variables, such as habitat use group and taxonomic categories and quantitative variables such as common length (FROESE and PAULY, 2000) and relative abundance of the present species. To act as predictors to SCBD values, relative abundance and number of sites occupied for each species were measured.

Beta regression was used to model SCBD and LCBD values, since the response variables can only take values from 0 to 1, assuming that the dependent variable is beta distributed. Prior to the beta regression modeling the predictors variables passed the variance inflation factor (VIF), only incorporating variables with VIF < 5. For SCBD values one regression considering relative abundance of each species and number of sites occupied was performed. For LCBD two regressions were made, one with community metrics: species richness, functional richness and relative abundance per transect, and one with environmental variables. A Redundancy Analysis (RDA) was made to explore the joint relationship of abiotic factors with habitat use groups distribution and sample units (BORCARD et al., 2018). All analyzes were performed using R (R CORE TEAM, 2022).

Table 1 - The five habitat use groups in which the fish were classified and their respective definitions, according to the FishBase website.

Groups	**Definitions**
Demersal	Live in the water column and feed on bottom organisms
Benthopelagic	Feed at the bottom, in the water column and on the surface
Pelagic-neritic	Occupy the water column close to the continent, usually in shallow water
Pelagic-oceanic	Occupy the water column in deeper waters and away from the coast
Reef-associated	Often associated with consolidated substrates, mainly coral reefs and rocky reefs

3. Results

A total of 13,055 individuals were sampled, representing 95 species, that were distributed into five different habitat groups, each one harboring the respective richness: 43 species in the demersal group, 32 in the reef-associated, nine both in the benthopelagic and pelagic-neritic and two species in the pelagic-oceanic. Subsequently, the total beta diversity was measured (β_{Total} = 0.61). The SCBD values were compared between habitat group (Figure 2) and no significant differences were found among the five habitat groups (Chi-squared = 4.69, df = 4, p = 0.31). A beta regression was performed to explore which species metric were good predictors of SCBD values (Table 2), and SCBD showed a positive relation with the total relative abundance of the species (Figure 3 A), with the same happening for the number of sites that the species occurred (Figure 3 B).

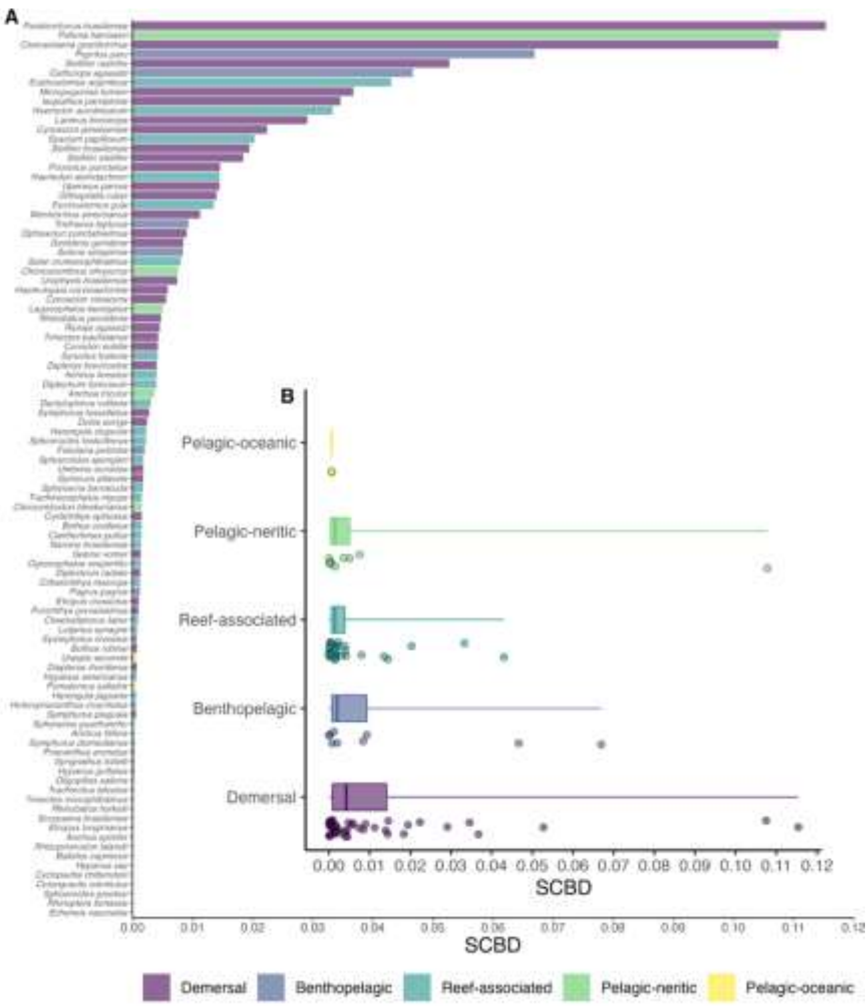

Figure 2. Barplot of the species contribution to beta diversity (SCBD), discriminating the habitat use groups of each species of the marine fish assemblage at Ubatumirim Bay (A), with the boxplot and points representing the SCBD values per group (B).
Source: Authors.

Table 2 - Beta regression results explaining species contribution to beta diversity values. N. of sites: number of sites that each species occurred. Rel. abundance: relative abundance of each species. Std. Error: standard error. p: probability associated with z. Asterisks representing significant variables.

	Estimate	Std. Error	z value	p	Pseudo R^2
Intercept	-5.750	0.172	-33.409	< 0.01	0.525
N. of sites	0.122	0.013	8.815	< 0.01*	
Rel. abundance	6.938	1.062	6.530	< 0.01*	

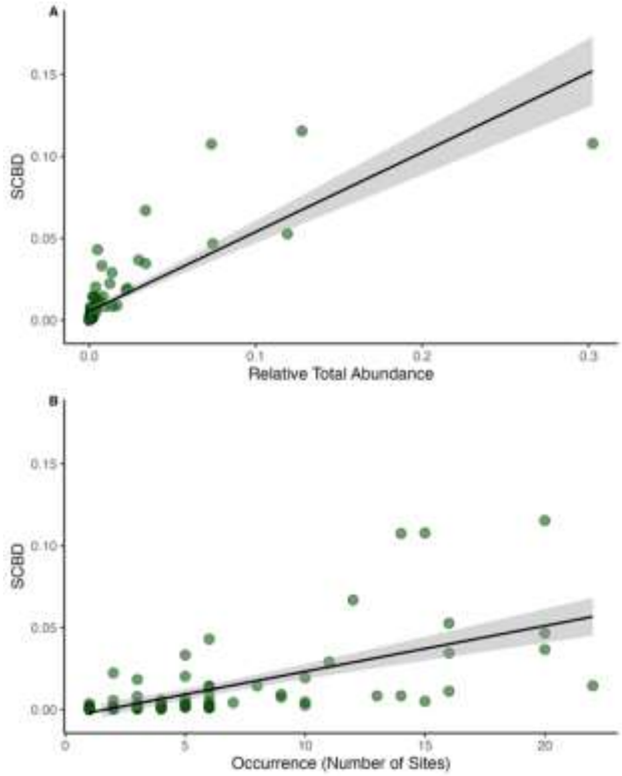

Figure 3. Relationship between species metrics: Relative total abundance (A); number of sites that each species occurred (B); with the measurements of species contribution to beta diversity (SCBD) of the sampled community at Ubatumirim Bay.

The LCBD values ranged from 0.025 to 0.075, with the beta regression model for community metrics indicating that LCBD values decreasing accordingly to functional richness (Table 3; Figure 4), but the LCBD values were average for taxonomic richness (Figure 4), since only functional richness was considered a good predictor of LCBD (Table 3). Another beta regression was performed to predict the LCBD values based on bottom salinity, bottom temperature and mean sediment diameter, with the last being considered a significant one (Table 4). The LCBD values showed a significant and negative relation with the mean sediment diameter, with the lower values of mean sediment diameter, occurring on Couves Island (16 m transect), harboring higher contributions to beta diversity (Figure 5).

Table 3 - Beta regression results explaining local contribution to beta diversity values based on community metrics. F. richness: functional richness for each sample. Rel. abundance: relative abundance for each sample. Std. Error: standard error. p: probability associated with z. Asterisks representing significant variables.

	Estimate	Std. Error	z value	p	Pseudo R^2
Intercept	-3.505	0.327	-10.700	< 0.01	0.2086
F. richness	-5.703e-05	2.747e-05	-2.076	0.037*	
Richness	0.025	0.017	1.439	0.150	
Rel. abundance	-0.193	1.844	-0.105	0.916	

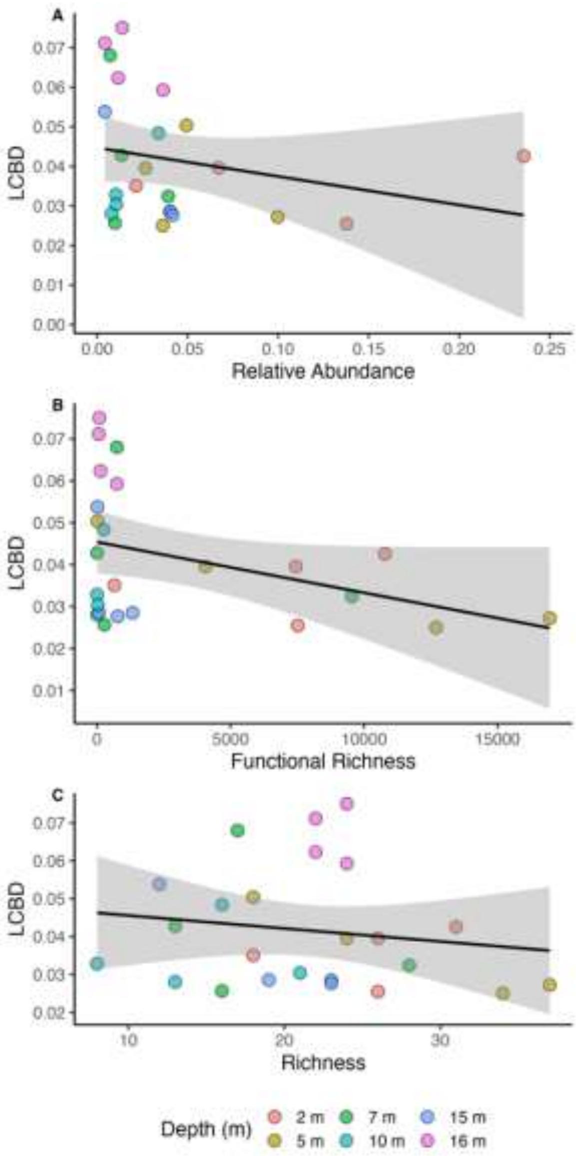

Figure 4. Relationship of the community metrics: Relative abundance (A); Functional richness (B); Richness (C); with the measurements of local contribution to beta diversity (LCBD) of the sampled units at Ubatumirim Bay.

Table 4. Beta regression results explaining local contribution to beta diversity values based on environmental variables. BT: bottom temperature. BS: bottom salinity. phi: mean sediment diameter. Std. Error: standard error. p: probability associated with z. Asterisks representing significant variables.

	Estimate	Std. Error	z value	p	Pseudo R^2
Intercept	-3.153	1.311	-2.405	0.016	0.291
BT	0.037	0.022	1.671	0.094	
BS	0.009	0.028	0.337	0.736	
phi	-0.255	0.075	-3.386	< 0.01*	

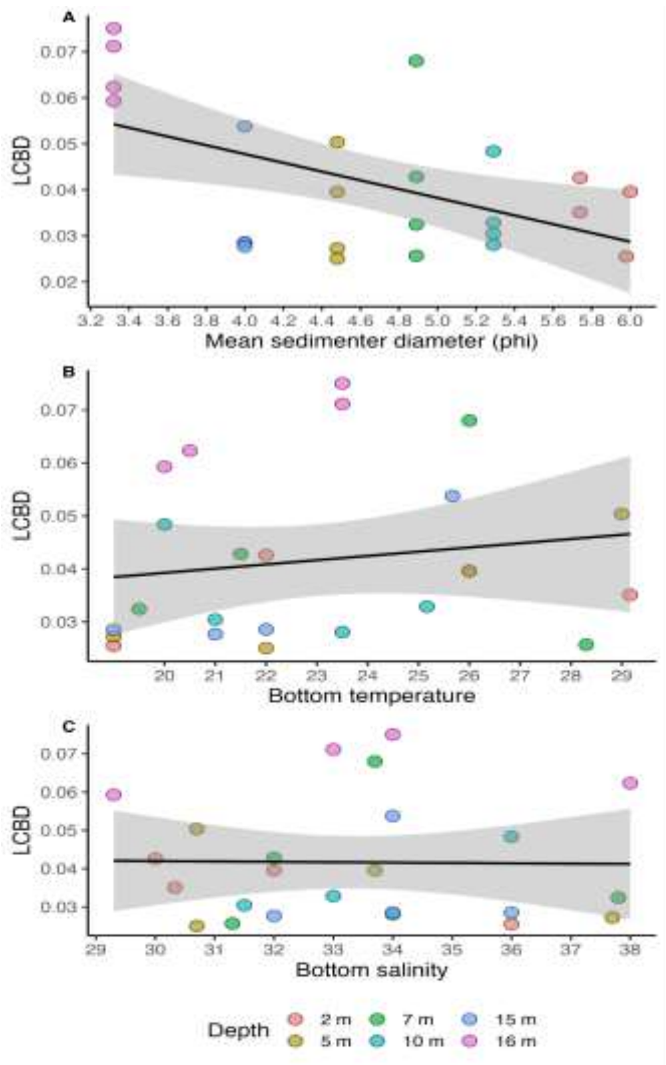

Figure 5. Relationship of the environmental variables: Mean sediment diameter (phi) (A); Bottom temperature (B); Bottom salinity (C); with the measurements of local contribution to beta diversity (LCBD) of the sampled units at Ubatumirim Bay**.**

Through a Redundancy Analysis it was possible to notice that there wasn't a clear pattern for habitat use group (Figure 6 A). The 10 species with the highest species contribution to beta diversity values are noted, with most of them associated with the demersal group (Figure 6 A). The 16 meters transect (Couves Island) was related to the decrease of the mean sediment diameter, additionally harboring the higher local contribution to beta diversity (Figure 6 B).

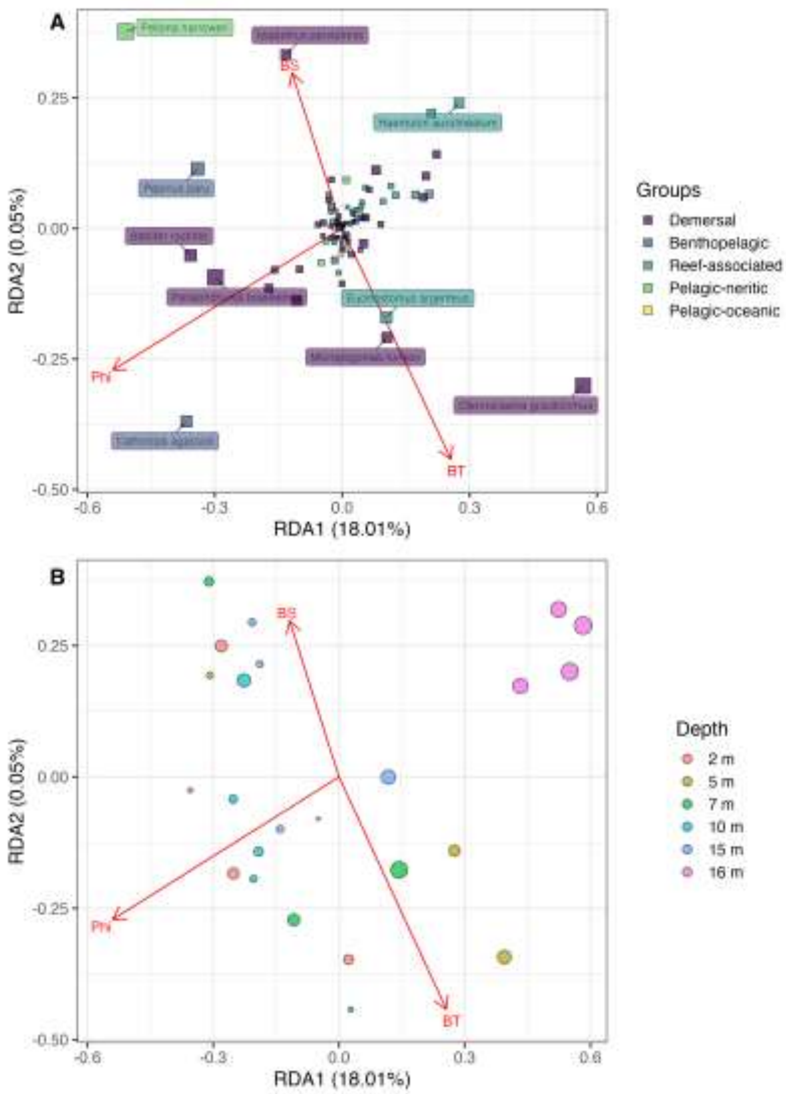

Figure 6. Redundancy Analysis (RDA) carried out to investigate the relationships of the five habitat use groups with the environmental variables (A), and the relationships of the sample units with the environmental variables (B) in the Ubatumirim Bay. The size of the squares represents the contribution to beta diversity of each species (A) and the size of the circles increases accordingly to their values of local contribution to beta diversity (B). BS: bottom salinity. BT: bottom temperature. phi: mean sediment diameter.
Source: Authors.

4. Discussion

The demersal group was the richest one in the Ubatumirim Bay, which can be related to the sampling method chosen, since trawling can present a preference to species associated to the substrate (LOWE-MCCONNELL, 1987). Despite that, there was no significant difference of SCBD values between the habitat use group. Even so, five of the ten species with the highest contribution belong to the demersal group, but more specifically to the Sciaenidae family, namely: *Paralonchurus brasiliensis* (Steindachner, 1875), *Ctenosciaena gracilicirrhus* (Metzelaar, 1919), *Stellifer rastrifer* (Jordan, 1889), *Micropogonias furnieri* (Desmarest, 1823) and *Isopisthus parvipinnis* (Cuvier, 1830). The Sciaenidae family is generally found in unconsolidated substrate and shallow water, being an important resource for fisheries on the Brazilian continental shelf and the most important family in the demersal fish community of Southeastern and Southern Brazil (MENEZES and FIGUEIREDO, 1980; SOARES and VAZZOLER, 2001), and presents a relationship between its biomass with Penaeoida shrimp biomass in the Ubatuba region, in consequence of the Coastal Water (CW) entrance, which occurs in the winter and has a high temperature and low salinity, favoring the establishment of shrimp species that are an important part of these fish diet (SOUZA *et al.*, 2008). However, as can be seen in the RDA, the distribution of the demersal group did not show a pattern of occurrence according to the expected for the CW mass.

So, digging deeper into SCBD values related to species metrics, Cionek *et al.* (2022) also found in Southern Brazil that the family Sciaenidae represented the majority of species with high values of SCBD, two of the three with the highest values, *P. brasiliensis* and *S. rastrifer*, and both are among the five species with the highest values of SCBD. SCBD in our findings. *Paralonchurus brasiliensis*, the species with the highest SCBD value, is indeed known for its wide distribution and demersal habits (ROBERT *et al.*, 2007), with the same occurring for *C. gracilicirrhus*, which has a high abundance in coastal regions of Southeastern Brazil (ARAÚJO *et al.*, 2002) and has a low commercial value, often discarded as bycatch, a characteristic that goes against the reality of most family members (POMBO *et al.*, 2013). Another species with a high SCBD value and belonging to the same family was *S. rastrifer*, also part of an abundant genus in coastal and shallow waters. Another pattern found for this beta diversity partitioning was seen for a species of the pelagic-neritic group, *Pellona harroweri* (Fowler, 1917), that was the second species with the higher value of contribution to beta diversity, since a high value of SCBD can be related to abundance oscillation (SANTOS *et al.*, 2021), a typical feature for *P. harroweri* due to the habit of forming schools, as animals that inhabit open areas count on safety in numbers (KRAUSE *et al.*, 2010).

It's clear that the more widely distributed a species and more abundant is coastal regions, more likely to hold higher values of SCBD, in addition to that, we found a positive relationship between the relative abundance and number of samples occupied by the species and the SCBD values evidenced in the beta regression. Therefore, the patterns found for SCBD values corroborate what was found in previous studies, that relative abundance is positively related to SCBD (TAN *et al.*, 2019; SANTOS *et al.*, 2021), despite the pattern that species occurring in an intermediate number of locations tend to present higher SCBD values than those distributed in almost all locations has also been found (HEINO and GRÖNROOS, 2017; CIONEK *et al.*, 2022).

Regarding the values of local contribution to beta diversity, the negative relationship between LCBD values and species richness is habitual (HEINO and GRÖNROOS, 2017; TAN *et al.*, 2019; SANTOS *et al.*, 2021), but despite being a common pattern, it is not a rule (SILVA *et al.*, 2018), since this relationship may be related to the simple fact that sites with greater taxonomic richness can present high values of contribution to beta diversity, as there is naturally a greater chance of sharing species with other sites in the region (HILL *et al.*, 2021). For example, marine environments have shown that sites with high LCBD do not necessarily represent sites with low richness, but heterogeneous points acting on the community with different environmental filters (CIONEK *et al.*, 2022). When using abundance data, Heino and Grönroos (2017) also didn't find a significant relationship between LCBD and taxonomic richness. On the other hand, functional richness also did not appear to have a significant relationship with LCBD for mammalian communities (SANTOS *et al.*, 2021), unlike our findings that the relationship between local contribution to beta diversity and functional richness is significant and negative, demonstrating that for fish assemblages in marine environments the amount of functional space filled by species in a community does not equate to a high local contribution to beta diversity.

On the other hand, considering the environmental variables as predictors of the values of LCBD, the Couves Island stood out in all samples, therefore harboring a unique ichthyofaunistic composition, which may be related to its heterogeneous characteristic acting as an environmental filter, consequently selecting different species (PELÁEZ *et al.*, 2017). The island heterogeneity can be observed by the distinct mean sediment diameter (phi), showed in the RDA and by the beta regression, which reflects a measure of structural complexity, characterized by a thicker sediment, or at least reflecting the spatial differentiation present in the region. Islands like Couves Island are known for their rocky reefs, that may be acting as an environmental filter, harboring community structures similar to coral reefs. However, the management and conservation of the former is often placed in the background, which highlights the need to better understand the occurrence of that group and the environment they occur (ROLIM *et al.*, 2017; VIEIRA *et al.*, 2021).

For that reason, the distinctiveness of Couves Island fish composition was evidenced, and that diversity profile of local contribution to beta diversity can be preserved over time if this heterogeneous environment and fauna keeps its features (PELÁEZ *et al.*, 2017). Such characteristics to be preserved seems to be provided by the island rocky reefs, filtering different species, especially from the reef-associated group, with their distinct structural complexity and sheltering reflecting on the sediment diameter.

On account of that, it's relevant that the data was sampled before the region of Ubatumirim and nearby islands, like Couves Island, were included into the Marine Environment Protection Area of São Paulo North Coast (Decree-law 66823/22). Through the contributions to beta diversity observed in the present study, it makes possible future questions that seek to understand whether the heterogeneity of the site was maintained if future surveys are made, once protected island environments can serve as a refuge for feeding and reproduction (ROLIM *et al.*, 2017). Wherefore, we present a description of the assemblage species and local contribution to beta diversity, aiming to formalize a baseline condition prior to the region transformation into a protected area and providing this knowledge for a future comparison of the beta diversity changes after the decree establishment, quantifying the effectiveness of this transition, since changes in the environmental characteristics would alter species and local contribution to beta diversity (LEGENDRE *et al.*, 2005; HEINO and GRÖNROOS, 2017), which are important tools to understand the functionality of these ecosystems, especially since the rocky reefs of these islands were classified as belonging to high environmental sensitivity but still being targeted by anthropic effects such as predatory tourism in the last years (POLETTO and BATISTA, 2008).

5. Conclusion

Understanding these patterns for SCBD and LCBD are essential for conservation and ecological knowledge, as it allows identifying which places have priority in terms of the need to protect their faunal heterogeneity. A possible relationship of LCBD values with the greater structural complexity of rocky reefs is noted, when compared to other environments in the region. Highlighting the importance of studies that seek not only the understanding of how species and sites contribute to local diversity, but also how the difference in faunal composition can be a conservation tool on a regional scale, enabling an adequate management of these places.

Such findings directly contribute to the ecological knowledge of marine fish assemblages, acting as predictors or even encouragers of the species and local characteristics conservation process. We recommend for future studies the application of a new methodology that allows the measurement of structural complexity per site. The measures presented in this work, if compared with new measures after the region transformation into part of the Marine Environmental Protection Area, will allow a better uptake of the management effectiveness and predatory tourism impact in the Ubatumirim Bay area.

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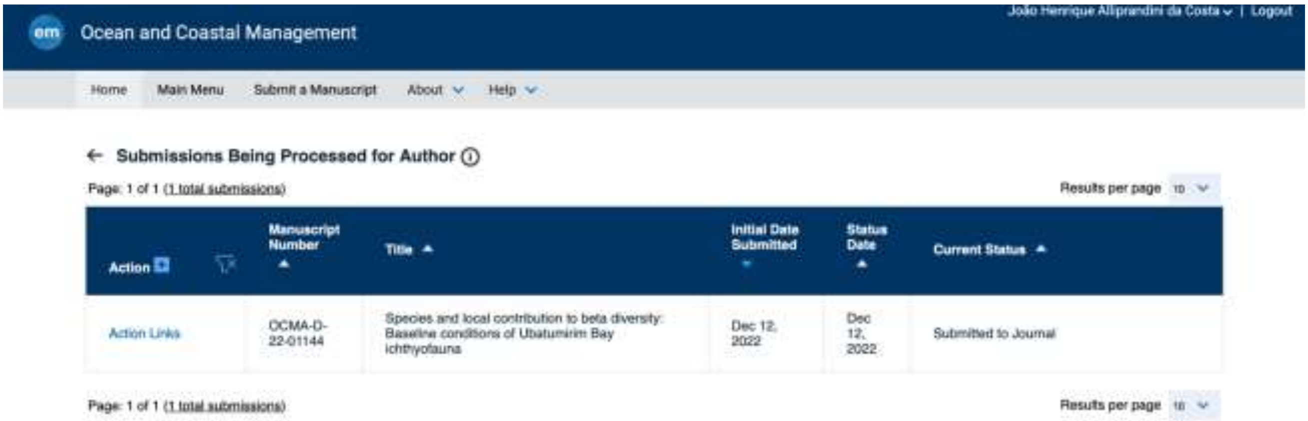

APÊNDICES

APÊNDICE A - Table com media e desvio padrão das variáveis abióticas amostradas nos seis transectos da Baía de Ubatumirim. Apresentado como: Média (Desvio padrão).

Transect	BS	BT	phi
2 m	32.08 (2.75)	24.04 (4.46)	5.86 (0.14)
5 m	33.2 (3.31)	24 (4.39)	4.48 (0)
7 m	33.7 (2.91)	23.82 (4.03)	4.89 (0)
10 m	33.62 (1.88)	22.41 (2.35)	5.29 (0)
15 m	34 (1.63)	21.91 (2.79)	4 (0)
16 m	33.57 (3.57)	21.87 (1.88)	3.31 (0)

APÊNDICE B - Table com as 95 espécies amostras na Baía de Ubatumirim e suas respectivas espécies.

Family	Species
Achiridae	
	Achirus lineatus
	Trinectes microphthalmus
	Trinectes paulistanus
Arhynchobatidae	
	Rioraja agassizi
Ariidae	
	Cathorops agassizii
	Genidens genidens
Balistidae	
	Balistes capriscus
Batrachoididae	
	Porichthys porosissimus
Bothidae	
	Bothus ocellatus
	Bothus robinsi
Carangidae	
	Chloroscombrus chrysurus
	Oligoplites saliens
	Selar crumenophthalmus
	Selene setapinnis
	Selene vomer
	Trachinotus falcatus

	Uraspis secunda
Charcharhinidae	
	Rhizoprionodon lalandii
Clupeidae	
	Harengula clupeola
	Harengula jaguana
Cyclopsettidae	
	Cyclopsetta chittendeni
	Citharichthys macrops
	Etropus crossotus
	Etropus longimanus
	Syacium papillosum
Cynoglossidae	
	Symphurus diomedianus
	Symphurus plagusia
	Symphurus tessellatus
Dactylopteridae	
	Dactylopterus volitans
Dasyatidae	
	Hypanus americanus
	Hypanus guttatus
	Hypanus say
Diodontidae	
	Cyclichthys spinosus
Echeneidae	
	Echeneis naucrates
Engraulidae	
	Anchoa filifera
	Anchoa spinifer
	Anchoa tricolor
	Cetengraulis edentulus
Ephippidae	
	Chaetodipterus faber
Fistulariidae	
	Fistularia petimba
Gerreidae	
	Diapterus rhombeus
	Eucinostomus gula
	Eucinostomus argenteus
Gymnuridae	
	Gymnura altavela
Haemulidae	
	Conodon nobilis

	Haemulon aurolineatum
	Haemulon steindachneri
	Orthopristis ruber
	Haemulopsis corvinaeformis
Lutjanidae	
	Lutjanus synagris
Monacanthidae	
	Cantherhines pullus
Mullidae	
	Upeneus parvus
Narcinidae	
	Narcine brasiliensis
Ogcocephalidae	
	Ogcocephalus vespertilio
Phycidae	
	Urophycis brasiliensis
Pomatomidae	
	Pomatomus saltatrix
Priacanthidae	
	Priacanthus arenatus
	Heteropriacanthus cruentatus
Pristigasteridae	
	Chirocentrodon bleekerianus
	Pellona harroweri
Rhinobatidae	
	Rhinobatos horkelii
	Rhinobatos percellens
Rhinopteridae	
	Rhinoptera bonasus
Sciaenidae	
	Micropogonias furnieri
	Ctenosciaena gracilicirrhus
	Cynoscion jamaicensis
	Isopisthus parvipinnis
	Larimus breviceps
	Menticirrhus americanus
	Ophioscion punctatissimus
	Paralonchurus brasiliensis
	Stellifer brasiliensis
	Stellifer rastrifer
	Stellifer stellifer
	Cynoscion virescens

	Umbrina coroides
Scorpaenidae	
	Scorpaena brasiliensis
Serranidae	
	Diplectrum formosum
	Diplectrum radiale
	Dules auriga
Serranidae	*Epinephelus niveatus*
Sparidae	
	Pagrus pagrus
Sphyraenidae	
	Sphyraena barracuda
	Sphyraena guachancho
Stromateidae	
	Peprilus paru
Syngnathidae	
	Syngnathus folletti
Synodontidae	
	Synodus foetens
	Trachinocephalus myops
Tetraodontidae	
	Lagocephalus laevigatus
	Sphoeroides spengleri
	Sphoeroides testudineus
	Sphoeroides greeleyi
Trichiuridae	
	Trichiurus lepturus
Triglidae	
	Prionotus punctatus
Trygonorrhinidae	
	Zapteryx brevirostris