Latin American Journal of Aquatic Research, 51(1): 133-144, 2023
DOI: 10.3856/vol51-issue1-fulltext-2925

Research Article

Surf-zone fish assemblage structure and its diel variability in an ocean beach of Espírito Santo (Central Brazilian coast)

Riguel Feltrin Contente[1,2], Camila Marion[3], João Victor Silva[4], Marcelo Soeth[2]
Mario Vinicius Lopes Condini[4], Lorena Lopes Almeida[4]
Henry Louis Spach[5] & Mauricio Hostim-Silva[4]
[1]Instituto Federal de Educação, Ciência e Tecnologia do Pará, Campus Marabá Industrial
Marabá, PA, Brazil
[2]Universidade Federal do Paraná, Programa de Pós-Graduação em Sistemas Costeiros e Oceânicos
Pontal do Paraná, PR, Brazil
[3]Instituto Federal de Educação, Ciência e Tecnologia do Pará, Campus Parauapebas
Parauapebas, PA, Brazil
[4]Universidade Federal do Espírito Santo (UFES/CEUNES), Laboratório de Ecologia de Peixes Marinhos
São Mateus, ES, Brazil
[5]Universidade Federal do Paraná, Centro de Estudos do Mar, Laboratório de Ecologia de Peixes
Pontal do Paraná, PR, Brazil
Corresponding author: Ríguel Feltrin Contente (riguel.contente@gmail.com)

ABSTRACT. We characterized the surf-zone fish assemblage structure of an ocean beach on the central coast of Brazil (Guriri Beach, Espírito Santo) and assessed its diel variability. Like the entire Espírito Santo coast, Guriri Beach was also affected by ore tailings from the Fundão dam, which collapsed on November 5, 2015. Monthly samplings were carried out before the dam collapse along a year cycle (May 2013-April 2014), during the day and night in the neap tide, using a beach seine. A total of 2217 specimens were caught (1017 during the day and 1200 at night), distributed in 36 fish species and 20 families. Juveniles of the kingcroaker *Menticirrhus* spp., great pompano *Trachinotus goodei*, Florida pompano *Trachinotus carolinus*, littlescale threadfin *Polydactylus oligodon*, and Atlantic sabretooth anchovy *Lycengraulis grossidens* dominated the fish fauna, accounting for 84% of the total capture. The fish assemblage structure changed irregularly between day and night throughout the year. *P. oligodon* and *Menticirrhus* spp. were more abundant at night, whereas *T. carolinus* and *L. grossidens* were more abundant during the day. In most cases, no significant change was detected in fish abundance and richness between the day and night; when significant differences were detected, abundance and richness were higher at night. Our findings could support a monitoring program of the local surf-zone fish fauna and serve as before-impact data, allowing more accurate quantification of the ore tailings' impacts on the local fish biodiversity.

Keywords: fish assemblage; nocturnal ecology; sandy beach; Fundão dam failure; Mariana

INTRODUCTION

Sandy beaches are historically one of the most impacted coastal ecosystems by human activities (fishing, recreation, buildings; Defeo et al. 2009) and, in the last years, they have been reduced due to sea level rise mediated by climate change (Vousdoukas et al. 2020). Despite multiple and persistent impacts, basic information on ocean beach biodiversity to support conservation efforts still needs to be improved, especially in the tropics (Defeo et al. 2009, Miloslavich et al. 2011, Olds et al. 2017).

Corresponding editor: Alejandra Volpedo

Ocean beaches are habitats for different fish species adapted to live in the highly hydrodynamic environment of the surf zone. A large part of the surf-zone fish assemblages is composed of juveniles of high-value fishing species (e.g. pampos and croackers) that experience comparatively higher growth rates by using abundant stocks of planktonic and benthic prey of the surf zone. Therefore, surf zones are key and strategic habitats in both ecological and economic terms (Defeo et al. 2009, Olds et al. 2017, Torre et al. 2017, Santos et al. 2019).

Surf zones of ocean beaches are very energetic, changing according to day-to-night succession, tide, moon phases, and seasons. The diel variability of these habitats may drive diel onshore-offshore movement in fishes as a response to their endogenous rhythms, the presence of predators, surf-zone hydrodynamics, light intensity, and food availability (Reebs 2002, Barreiros et al. 2005, Gaelzer & Zalmon 2008, Félix-Hackradt et al. 2010, Olds et al. 2017, Torre et al. 2017). Such processes may determine day-night changes in the abundance and composition of surf fish species (Olds et al. 2017). Although such diel processes are well-known, most surf fish ecology studies continue to focus heavily on daytime sampling (Torre et al. 2017; see Table S1 in Olds et al. 2017). This generalized bias has neglected the potential particularities of the fish assemblage structure during nighttime (Torre et al. 2017, Gaston 2019).

In the last 20 years, a large body of studies has been conducted aiming to provide basic ecological data on the fish assemblage structure (i.e. species composition and abundance) in surf zones of ocean beaches along the Brazilian coast (Olds et al. 2017). Reviewing the global literature on fish ecology from the surf zones of ocean beaches, Olds et al. (2017) ranked Brazil second in number of ecological studies. Despite this advance, the fish fauna of many tropical ocean beaches of Brazil remains poorly characterized. That is the case of the south of Brazilian east coast, an approximately 500 km shoreline spanning from the southern coast of Bahia to Cabo de São Tomé (northern coast of Rio de Janeiro) that contains several ocean beaches. The area also deserves particular attention because its biodiversity was dramatically affected by the collapse of the Fundão mine tailings dam (Condini et al. 2021). This dam, located in the upper reaches of the Doce River catchment, collapsed on November 5, 2015, releasing 50 million m^3 of iron ore tailings into the Atlantic Ocean. A detailed monitoring program conducted since the collapse (Bianchini et al. 2020a,b) revealed that the mine-tailings plume has spread over an extensive area. The affected area comprises the entire coast of Espírito Santo, the southern coast of Bahia (including the Abrolhos National Park), and the northern coast of Rio de Janeiro, affecting different ecosystems, including ocean beaches (Sánchez et al. 2018, Bianchini et al. 2020a,b).

In this study, we described the surf-zone fish assemblage structure of an ocean beach on the northern coast of Espírito Santo (the Guriri Beach) and assessed its day-night variability. Since this study was conducted before the dam's collapse, the present findings are very important. They can be used in future studies as a control reference to more accurately assess the impact on fish communities in the local surf zones.

MATERIALS AND METHODS

Study area

The study was conducted at Guriri Beach, an 8 km-long ocean beach located in the city of São Matheus on the northern coast of Espírito Santo, southeastern coast of Brazil (Figs. 1a,c). This beach is on Guriri Island, delimited between the São Matheus River estuary and the Atlantic Ocean (Fig. 1c). The area is under the domain of the Brazil Current that moves southward. It transports two water masses: Topical Water and South Atlantic Central Water. Coastal Water is another water mass nearer the coast and consists of a mixture between low-salinity continental discharge waters and Topical Water. In the region, the current moves predominantly southward, but gravity waves and cold fronts may change the direction of the current towards the north (Castro 2014, Bianchini et al. 2020b).

The climate of the region is super-humid tropical hot. The annual rainfall ranges between 1000 and 1250 mm, exhibiting dry and mild winters and rainy summers with high temperatures. Winds from the east-northeast and southeast quadrants influence the area. East-northeast winds prevail most of the year, while the southeast winds are associated with the polar masses coming from the south. In the Guriri Beach, waves vary from 0.6 to 0.9 m high with periods of 5 to 6.5 s (Albino 1999). The mean water temperature is 25.5 ± 2 (standard deviation, SD), ranging from 21.6ºC in July (winter) to 30ºC in February (summer). The mean salinity is 35.6 ± 1.5 (SD), ranging from 32 in December (summer) to 37 in May (winter). The tide regime is semidiurnal and micro-tidal.

The Guriri Beach is about 65 km north of the mouth of the Doce River and, as the full extension of the coast of the Espirito Santo, it was affected by the Fundão dam mud plume (Fig. 1d).

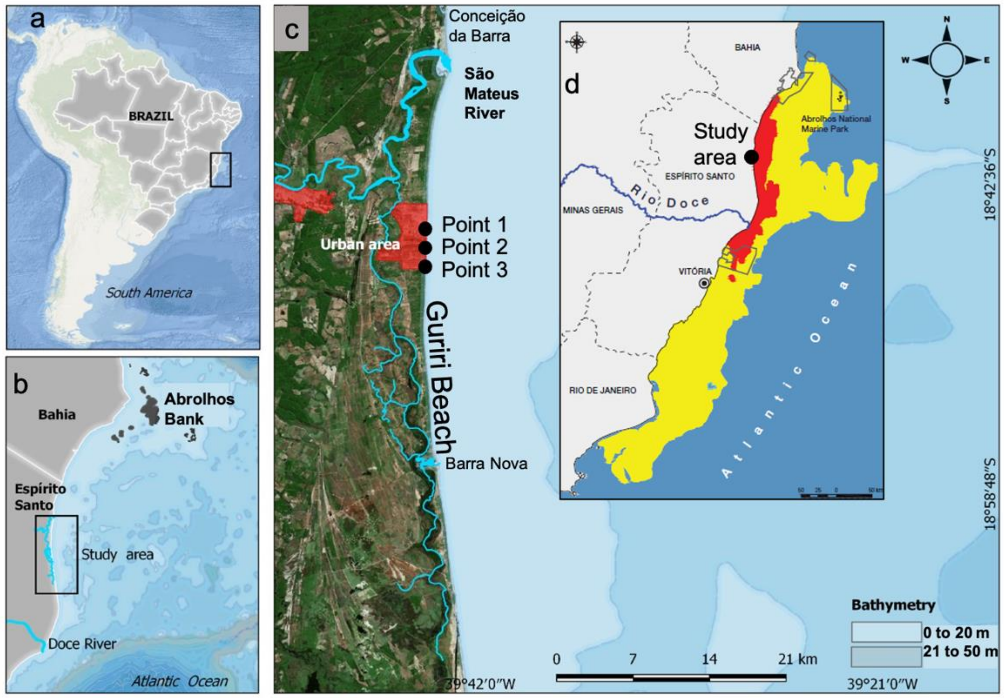

Figure 1. a) Location of the study area in Brazil and South America and, in detail b), the northern coast of Espírito Santo, highlighting the mouth of the Doce River and the Abrolhos Bank, c) municipality of São Matheus, the São Matheus River, and the study area with the three sampling sites (points 1, 2, and 3) in the Guriri Beach, which is delimited between Conceição da Barra and Barra Nova. The north side of the study area is the buffer area of the Abrolhos National Park, and d) as captured by satellite imagery, the maximum observed reach of the surface plume from the Fundão dam disaster was December 3, 2015 - February 3, 2017. Red: high-concentration plume obtained from visual interpretation of satellite imagery; yellow: low-concentration plume obtained from visual interpretation of satellite imagery. Figure 1d source: Sánchez et al. (2018).

The monitoring program of the impacts of the plume on the marine ecosystems and biodiversity has revealed that most of the mud reached, and was deposited, ahead and south of the Doce River mouth. However, gravity waves and cold fronts also moved the plume northward. Such forcings, along with other physical processes (mesoscale process, mixing, and tides), determined an onshore movement and a spreading of the plume over the northern coast of Espírito Santo as far as Abrolhos (Fig. 1d) (Bianchini et al. 2020b). Therefore, a high-magnitude environmental impact was set regionally, causing several ecological changes, especially those related to the effects of the contaminated mud. For the northern coast (the study area), the sand-beach sediment and benthos are contaminated by high concentrations of heavy metals (e.g. Cr, Hg, and Pb), affecting the benthos assemblage structure (Bianchini et al. 2020b). Some remarkable impacts, when considering the area under the plume's influence as a whole, include high concentrations of dissolved iron driving blooms of phytoplankton of opportunistic green algae; reduction of ecologically important diatoms, disrupting local energetic fluxes and trophic web; reduced zooplankton reproductive rates and fish larvae viability due to heavy metals; abnormal incidence of non-viable fish eggs and fish larvae with malformation; fish larvae assemblages shifting to species more resistant to disturbance; and mud-affected environmental variables such as turbidity and dissolved oxygen driving changes in demersal fish species composition (Bianchini et al. 2020b).

Sampling and analysis design

Fish sampling took place monthly between May 2013 and April 2014, during neap tide in low tide at three different sites at a distance of 300 m apart. In each survey at each daily period (day: 07:00-12:00 h; night: 18:00-00:00 h), three 30-m-hauls were performed perpendicular to the coastline in each site. Fish were sampled using a beach seine (2.1 m high and 15 m wide with a 5 mm between-knots mesh). Fishes were identified in the laboratory using identification keys

(Figueiredo & Menezes, 1978, 1980, 2000; Menezes & Figueiredo 1980, 1985). Fishes caught were packed in plastic bags and preserved in ice for later processing. Due to difficulty in determining the species for *Mugil* juveniles, all *Mugil* juveniles were grouped into *Mugil* spp.

For each species, indicators of abundance, occurrence, and size were calculated. To estimate the mean density of the species, a swept area of 450 m^2 was estimated for each haul. This area value consisted of the width of the net (15 m) multiplied by the distance of the area trawled (30 m). The density was estimated as the number of individuals of a given species divided by the hauled area. The mean density was estimated as the density of a species in each haul averaged by all hauls. The total number of individuals was calculated as the total number of individuals of a species. The total number of individuals and mean density were calculated by both day periods. Frequency of occurrence (%FO) was calculated as the number of occurrences of a given species divided by the total number of hauls (n = 210). Relative abundance (%RA) was determined as the number of individuals of a given species divided by the total of individuals of all species. The relative importance index (%*I*) was also calculated to identify the most important species in the assemblage by combining abundance and occurrence. The index was defined as $I_i = (\%FO_i \times \%RA_i) / \sum (FO_i \times RA_i) \times 100$, where i = 1, 2, n = species (Kawakami & Vazzoler 1980). The Shannon-Weaver diversity (H) and Pielou equitability index (J) were calculated based on the total sample. The mean total length by species was calculated and compared with the estimated first maturation length, or the total length, available in the literature to determine if most of the sampled population was adult or juvenile.

We used a species-accumulation plot to assess the sample representativeness of the local fish assemblage, using PRIMER 7 software (v.7.0.21 - PRIMER-e) (Clarke & Gorley 2006, Anderson et al. 2008). A two-way permutational multivariate analysis of variance (PERMANOVA) model (Anderson et al. 2008) was used to test the day-night effect on the fish assemblage structure. Considering "the day" as a fixed variable (two levels = night and day), "sampling month" as a random variable (12 levels = from May 2013 to Abril 2014), and each haul as a replicate (n-total = 210 hauls). We used the Bray-Curtis index to construct the similarity matrix based on each species' abundance. Before the analyses, data were square-root to reduce the effect of the most abundant fish species (Clarke & Gorley 2006). A permutational t-test was used to investigate the effect of the period of the day in each month when the interaction between the month and period of the day was significant (Anderson et al. 2008). Percentage similarity (SIMPER) was used (Clarke & Gorley 2006) to determine the species responsible for the faunal difference between day and night. The same PERMANOVA design was run on the total fish species richness (total number of species of each haul) and total abundance (total number of individuals of each haul) to investigate the diel effect on fish species richness and abundance. The euclidian distance was used to build the distance matrix (Anderson et al. 2008). The PERMANOVA+ add-on for the software PRIMER 7 (v.7.0.21) was used to run PERMANOVA.

RESULTS

Overall characteristics of assemblage

In total, 2215 fish were captured, and 34 species and 20 families were identified. Most fish were small-sized (mean = 67.5 ± 4.4 mm total length, TL) and juvenile. Kingcroaker *Menticirrhus* spp., great pompano *Trachinotus goodei*, Florida pompano *Trachinotus carolinus*, littlescale threadfin *Polydactylus oligodon*, and Atlantic sabretooth anchovy *Lycengraulis grossidens* were the most frequent species, occurring in all months. They also represented ~83% of the individuals captured. *Menticirrhus* spp., *T. carolinus*, and *T. goodie* were found in >50% of the samples, and *P. oligodon* and *L. grossidens*, in 40% of them (Table 1). In terms of abundance (number of individuals), juveniles of *Menticirrhus* spp. were the most important, representing about 29% of the individuals captured. Juveniles of *T. goodie*, *T. carolinus*, *L. grossidens*, and *P. oligodon* each accounted for 14% of the individuals captured (Table 1).

The species accumulation curve did not reach saturation (Fig. 2), suggesting that additional sampling would increase the number of species.

Diel variability of assemblage

Total fish abundance was slightly higher at night (1199 individuals) than during the day (1016). Ten species were exclusively recorded on either day (Table 1). H and J were 2.12 and 0.84, respectively.

The diel change in total abundance depended on the sampling month (P < 0.05; Table 2). The total abundance varied significantly between diel periods only in March (P < 0.05; Table 3), being higher at night (mean number of individuals = 1.7 ± 5.0) than

Table 1. Species, family, and indicators of abundance and occurrence of the fish assemblage sampled with a beach seine from May 2013 to April 2014 in Guriri Beach (east coast of Brazil). Mean dens: density of the species *i* averaged by all hauls (n = 210). Total nº ind: total number of individuals by species. The values are provided by daily period separately for density and total number. FO(%): frequency of occurrence. RA(%): relative abundance. I(%). relative importance index. I_{cum}(%): cumulative relative importance index percentage (the I value summed to the previous value). TL $(mm)_{Mean}$: mean total length by species. TL $(mm)_{Min–Max}$: total length range. Species are sorted in descending order according to (%)I-values.

Species	Family	Mean dens × 10^{-4} mm^2		Total nº ind		FO*i*	RA*i*	I*i*	I_{cum}	TL (mm)	TL (mm)
		Night	Day	Night	Day	(%)	(%)	(%)	(%)	Mean	Min–Max
Menticirrhus spp.	Sciaenidae	46.67	21.06	441	199	64.3	28.9	38.2	38.2	70.0	18-245
Trachinotus goodei	Carangidae	16.93	16.08	160	152	58.6	14.1	17.0	55.2	68.7	16-193
Trachinotus carolinus	Carangidae	11.85	20.74	112	196	51.4	13.9	14.7	69.9	44.2	16-154
Polydactylus oligodon	Polynemida	24.13	6.56	228	62	43.8	13.1	11.8	81.7	62.4	14-183
Lycengraulis grossidens	Engraulidae	7.62	22.86	72	216	43.3	13.0	11.6	93.3	72.9	12-175
Mugil sp.	Mugilidae	9.63	5.50	91	52	38.6	6.5	5.1	98.5	63.3	18-282
Atherinella blackburni	Atherinopsidae	2.86	2.01	27	19	14.3	2.1	0.6	99.1	88.3	48-128
Trachinotus falcatus	Carangidae	2.65	1.16	25	11	11.4	1.6	0.4	99.5	27.6	17-67
Chloroscombrus chrysurus	Carangidae	0.42	3.49	4	33	6.7	1.7	0.2	99.7	108.6	42-134
Anchoa lyolepis	Engraulidae	0.11	2.86	1	27	3.3	1.3	0.1	99.8	65.4	55-79
Atherinella brasiliensis	Atherinopsidae	0.63	0.95	6	9	5.7	0.7	0.1	99.8	98.9	85-117
Bagre marinus	Ariidae	0.85	0.53	8	5	5.7	0.6	0.1	99.9	113.4	82-219
Ophioscion punctatissimus	Sciaenidae	0.42	0.85	4	8	3.3	0.5	<0.1	100.0	106.1	73-148
Caranx bartholomaei	Carangidae	0.11	0.42	1	4	2.4	0.2	<0.1	100.0	78.6	40-131
Strongylura marina	Belonidae	0.42	-	4	-	1.9	0.2	<0.1	100.0	186.3	155-225
Sardinella brasiliensis	Clupeidae	-	0.74	-	7	1.0	0.3	<0.1	100.0	52.6	41-103
Oligoplites saliens	Carangidae	-	0.42	-	4	1.4	0.2	<0.1	100.0	135.3	117-162
Diapterus auratus	Gerreidae	0.32	-	3	-	1.0	0.1	<0.1	100.0	96.0	75-113
Genyatremus luteus	Haemulidae	0.32	-	3	-	1.0	0.1	<0.1	100.0	312.7	300-333
Menticirrhus martinicensis	Sciaenidae	0.11	0.11	1	1	1.0	0.1	<0.1	100.0	206.0	170-242
Stellifer sp.	Sciaenidae	0.11	0.11	1	1	1.0	0.1	<0.1	100.0	36.0	27-45
Anchovia clupeoides	Engraulidae	-	0.21	-	2	0.5	0.1	<0.1	100.0	72.0	68-76
Conodon nobilis	Haemulidae	-	0.21	-	2	0.5	0.1	<0.1	100.0	114.5	109-120
Astroscopus y-graecum	Uranoscopidae	0.11	-	1	-	0.5	<0.1	<0.1	100.0	100.0	100
Chaetodipterus faber	Ephippidae	-	0.11	-	1	0.5	<0.1	<0.1	100.0	15.0	15
Chlopsis bicolor	Chlopsidae	0.11	-	1	-	0.5	<0.1	<0.1	100.0	661.0	661
Citharichthys spilopterus	Paralichthyidae	0.11	-	1	-	0.5	<0.1	<0.1	100.0	121.0	121
Cosmocampus elucens	Syngnathidae	-	0.11	-	1	0.5	<0.1	<0.1	100.0	71.0	71
Hypanus guttata	Dasyatidae	0.11	-	1	-	0.5	<0.1	<0.1	100.0	641.0	641
Hemiramphus brasiliensis	Hemiramphidae	-	0.11	-	1	0.5	<0.1	<0.1	100.0	63.0	63
Lutjanus jocu	Haemulidae	0.11	-	1	-	0.5	<0.1	<0.1	100.0	124.0	124
Lutjanus sp.	Haemulidae	-	0.11	-	1	0.5	<0.1	<0.1	100.0	19.0	19
Paralichthys brasiliensis	Paralichthyidae	0.11	-	1	-	0.5	<0.1	<0.1	100.0	210.0	210
Selene vomer	Carangidae	-	0.11	-	1	0.5	<0.1	<0.1	100.0	69.0	69
Sphoeroides testudineus	Tetraodontidae	-	0.11	-	1	0.5	<0.1	<0.1	100.0	147.0	147
Ulaema lefroyi	Gerreidae	0.11	-	1	-	0.5	v	0.0	100.0	23.0	23

during the day (mean number of individuals = 0.5 ± 2.0. The diel variation in richness depended on the sampling month ($P < 0.05$, Table 2). In most months, there were no differences in richness between day and night ($P > 0.05$, Table 3). When significant ($P < 0.05$; Table 3), richness was always higher at night than during the day (May, day = 2.0 ± 1.2, night = 3.8 ± 1.6; September, day = 2.3 ± 1.1, night = 3.4 ± 1.0; December, day = 2.0 ± 1.0, night = 3.0 ± 1.6; March, day = 3.3 ± 1.5, night = 5.6 ± 1.3).

The diel variability of the assemblage structure depended on the sampling month ($P < 0.05$; Table 2). The assemblage varied significantly in half of the months depending on the day (Table 3). According to

Table 2. Summary of PERMANOVA results for the analysis of differences in total fish species richness and total fish abundance and for differences in fish assemblage structure between the periods of the day (day and night) in each sampling month from May 2013 to April 2014 in the Guriri Beach (east coast of Brazil). Significant results are shown in bold. df: degrees of freedom, SS: sums of squares, MS: mean squares, Pseudo-F: pseudo-F ratio, and P(perm): permutation *P*-value. P: period of the day, M: month.

Response variables	Source	df	SS	MS	Pseudo-F	P(perm)
Richness	Period (P)	1	8.06	8.06	1.36	0.2623
	Month (M)	11	206.28	18.75	8.97	**0.0001**
	P×M	11	65.13	5.92	2.83	**0.0018**
	Residuals	186	388.98	2.09		
	Total	209	663.62			
Total abundance	Period (P)	1	119.82	119.82	0.65	0.4523
	Month (M)	11	4419.20	401.74	4.98	**0.0001**
	P×M	11	2017.40	183.40	2.27	**0.0113**
	Residuals	186	15009	80.69		
	Period (P)	209	21490			
Assemblage structure	Period (P)	1	23983	23983	6.42	**0.0012**
	Month (M)	11	1,13E+05	10249	5.46	**0.0001**
	P×M	11	41184	3744	2.00	**0.0001**
	Residuals	186	3.49E+05	1876.1		
	Period (P)	209	5.27E+05			

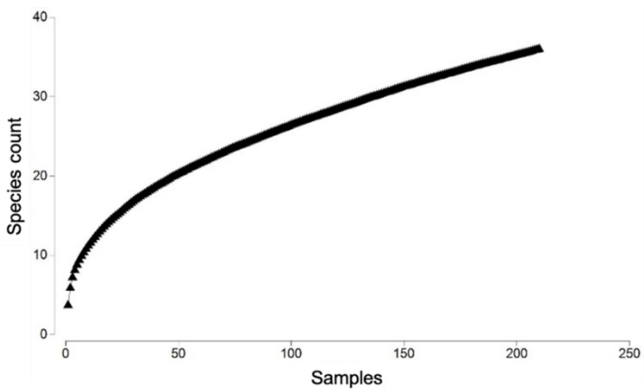

Figure 2. The cumulative species curve calculated with fish samples sampled with a beach seine from May 2013 to April 2014 in Guriri Beach (east coast of Brazil).

SIMPER results (Table 4), the fish fauna structure variation between day and night was mainly due to diel variability in the abundance of persistent species (i.e. those diagnostics to differentiate assemblages between day and night and present >50% of the significant months) and by the occasional occurrence of large groups/schools in either period of the day, Overall, the diel variability in abundance of the persistent species *P. oligodon*, *T. carolinus*, *T. goodie*, and *Menticirrhus* spp. was the main responsible for the diel variability in fish fauna structure. In most cases, *P. oligodon* and *Menticirrhus* spp. were more abundant at night, whereas *T. carolinus* and *L. grossidens* were more abundant during the day. *T. goodie* abundance varied irregularly between day and night over the months. The occasional occurrence of large schools of *Mugil* sp., *Anchoa lyolepis*, *Atherinella blackburni*, and *Chloroscombrus chrysurus* was also important to differentiate the day assemblages from the night ones.

DISCUSSION

Our study reveals that juveniles of *Menticirrhus* spp., *Trachinotus carolinus*, *T. goodie*, and *Polydactylus oligodon* dominate the surf-zone fish fauna in the Guriri Beach. The dominance of *Menticirrhus* spp., *T. carolinus*, and *T. goodie* in the surf-zone nekton is a quite common pattern in the central and southeastern coast of Brazil, with such species ranking among the top five in surf fish assemblages (Gaelzer et al. 2006, Gaelzer & Zalmon 2008, Félix-Hackradt et al. 2010, Gondolo et al. 2011, Vasconcellos et al. 2011, Del-Favero & Dias 2013, 2015 Monteiro-Neto & Prestrelo 2013, Dantas, et al. 2016, Costa et al. 2017, Santos et al. 2019). On the other hand, the great abundance of *P. oligodon* juveniles found in the Guriri Beach is not quite a common pattern for Brazilian beaches. In regional terms, *P. oligodon* has been recorded as secondary species in the São Matheus River estuary (Hostim-Silva et al. 2013) and Itaipava Beach (Andrades et al. 2014). Previous surveys revealed that *P. oligodon* is either rare (i.e. frequency of occurrence and abundance <0.1%; Godefroid et al. 2003, Araújo et al. 2008, Vasconcellos et al. 2011, Del-Favero &

Table 3. Results of *post-hoc* pair-wise contrasts (t-test permutational of PERMANOVA) of total fish species richness, total fish abundance, and assemblage structure between day and night for each month. $P_{(MC)}$: correct P-values obtained through Monte Carlo random draws from the asymptotic permutation distribution. Significant results are shown in bold.

Month	t	*P*	t	$P_{(MC)}$	t	$P_{(MC)}$
	Assemblage		Abundance		Richness	
May 2013	1.911	**0.005**	2.091	0.052	2.609	**0.020**
June 2013	1.862	**0.005**	0.075	0.941	1.709	0.106
July 2013	1.312	0.173	1.481	0.160	1.484	0.149
August 2013	2.000	0.072	1.075	0.302	1.342	0.197
September 2013	1.170	0.279	1.187	0.257	2.175	**0.047**
October 2013	1.812	**0.020**	1.551	0.138	1.242	0.222
November 2013	2.000	**<0.001**	0.556	0.593	0.973	0.344
December 2013	1.000	0.082	0.471	0.647	2.138	**0.047**
January 2014	2.000	**0.021**	0.944	0.362	<0.001	1.000
February 2014	0.915	0.555	1.365	0.192	0.267	0.793
March 2014	2.000	**<0.001**	2.615	**0.017**	3.500	**0.003**
April 2014	2.000	**0.020**	0.5635	0.577	1.060	0.306

Dias 2015) or moderately frequent in field samples in southern and southeastern Brazilian beaches. The species usually accounted for less than 1% of the total individuals (Gaelzer et al. 2006, Monteiro-Neto & Prestrelo 2013). We speculate the following (not mutually exclusive) hypotheses to explain the unexpected abundance of *P. oligodon*: 1) the Guriri Beach is a typical species' nursery, i.e. it contributes disproportionately more than other locations to the recruitment of juveniles to adult populations, by providing increased food supply and reduced juvenile mortality by predation (Beck et al. 2001); 2) previous surveys were carried out only during the day (e.g. Araújo et al. 2008, Del-Favero & Dias 2015) when *Polydactilus* species appear to be less abundant in surf habitats (Gaelzer & Zalmon 2008, Dantas, et al. 2016, this study); and 3) there may have been an increased species' recruitment preceding the surveys, resulting in increased catches in our samples.

Regarding dominant taxa, the fish fauna of Guriri Beach is different from that of other beaches in Espirito Santo. For example, in the surf zone of Ilha do Frade Beach (central coast of Espírito Santo), *Lutjanus synagris*, *Archosargus rhomboidalis*, and *Eucinostomus lefroyi* were the most abundant species (Araújo et al. 2008). In Itaipava Beach (southern coast of Espírito Santo), the dominance pattern is partially different, being dominated by *Trachinotus falcatus, T. goodie, T. carolinus,* and *P. oligodon* (Andrades et al. 2014). Ilha do Frade and Itaipava beaches are moderately sheltered and have a high-to-moderate density of drift algae in the surf zone. These beaches are different from the Guriri Beach, a typical, highly-exposed ocean beach with a low density of drift algae. Such differences in environments may be the cause of such faunal differences. The estuarine areas of Barra Nova and Conceição da Barra (the closest areas to Guriri Beach that were previously sampled - Fig. 1) hold a different fauna, being dominated by *Stellifer* species and *Diapterus rhombeus*. Also, in this case, the habitat difference (estuary *vs*. ocean beach) may have determined the faunal difference.

Our results revealed that the Guriri fish assemblage changed irregularly between day and night throughout the year. When significant, the change was mostly due to diel shifts in the abundance of the dominant species, such as observed in other surf zone systems (Barreiros et al. 2005, Colombo et al. 2017). In such cases, the abundance of *T. carolinus* and *L. grossidens* were higher during the day, while that of *Menticirrhus* spp. and *P. olygodon* were higher at night, which is consistent with previous observations (Barreiros et al. 2005, Gaelzer et al. 2006, Gaelzer & Zalmon 2008, Félix-Hackradt et al. 2010). Animals have specific morphology, physiology, and behavior that enable them to explore their habitat better in a given period of the day (Reebs 2002, Gaston 2019). The higher nocturnal abundance of *P. olygodon* and *Menticirrhus* spp. may be related to adaptations to use the surf zone (likely as a feeding and shelter ground) in the dark. Both species have retinal *tapeta lucida* (Arnott et al. 1970) and larger pupil openings in the dark (personal observation). *P. olygodon* also has modified pectoral fins composed of long, independent, mobile rays that act as tactile structures, helping them to find prey within the sediment (Motomura 2004). Such traits are expected to potentialize light or prey detection. On the other hand, *T. carolinus* and *L. grossidens* have no cons-

Table 4. Output from similarity percentages (SIMPER) analysis showing the contribution of key species to the overall dissimilarity between day and night assemblage of the months in which the assemblage structure differed significantly between diel periods (see Table 3). AA: averaged abundance; AD: averaged dissimilarity; Diss/SD: dissimilarity divided by the standard deviation (SD); higher values indicate higher contribution in differentiating the assemblage amongst periods of the day; Cont(%): contribution of the species in assemblage difference; Cum(%): cumulative contribution.

Month	Species	AA (day)	AA (night)	AD	Diss/SD	Cont(%)	Cum(%)
May 2013	*Polydactylus oligodon*	0	1.36	16.53	2.03	20.84	20.84
	Mugil rubrioculus	0.29	1.43	15.49	1.55	19.53	40.37
	Trachinotus carolinus	0.68	0.87	11.46	1.03	14.45	54.82
	Trachinotus goodei	0.34	0.90	11.25	0.99	14.18	69
	Menticirrhus spp.	0.29	0.97	10.16	1.03	12.81	81.81
June 2013	*Menticirrhus* spp.	1.39	1.45	12.41	1.20	18.68	18.68
	Polydactylus oligodon	0.27	1.31	11.11	1.51	16.72	35.40
	Anchoa lyolepis	1.16	0	10.81	0.97	16.27	51.67
	Trachinotus goodei	0.92	0.76	8.40	1.08	12.64	64.30
	Trachinotus carolinus	0.60	0.76	7.23	1.09	10.89	75.19
October 2013	*Menticirrhus* spp.	1.59	0.89	10.61	1.31	20.23	20.23
	Lycengraulis grossidens	2.64	1.56	9.92	1.45	18.91	39.14
	Polydactylus oligodon	0.27	1.12	7.45	1.37	14.20	53.34
	Trachinotus carolinus	1.08	0.54	6.90	1.10	13.16	66.50
	Trachinotus goodei	0.72	0.49	5.17	1.06	9.85	76.35
November 2013	*Polydactylus oligodon*	0	1.51	16.50	1.96	21.76	21.76
	Lycengraulis grossidens	1.11	0.64	13.61	1.07	17.95	39.71
	Trachinotus carolinus	1.12	0.91	12.39	1.14	16.34	56.05
	Atherinella blackburni	0.22	0.88	9.49	0.98	12.52	68.57
	Trachinotus goodei	0.79	0.22	9.23	0.89	12.17	80.74
March 2014	*Menticirrhus* spp.	0.72	3.44	18.88	2.03	26.13	26.13
	Polydactylus oligodon	0	2.22	15.14	3.06	20.96	47.09
	Trachinotus carolinus	1.07	0.76	7.03	1.17	9.73	56.82
	Trachinotus falcatus	0.33	1.04	6.41	1.25	8.87	65.69
	Trachinotus goodei	0.65	0.71	6.38	1	8.83	74.52
April 2014	*Lycengraulis grossidens*	2.03	0.84	7.50	1.32	13.53	13.53
	Polydactylus oligodon	1.45	1.78	6.40	1.28	11.54	25.08
	Menticirrhus spp.	2.43	2.82	5.69	1.20	10.28	35.35
	Mugil rubrioculus	0.16	1.18	5.56	1.25	10.04	45.39
	Trachinotus carolinus	0.98	0	5.36	0.92	9.67	55.06
	Chloroscombrus chrysurus	1.09	0	4.93	1.03	8.90	63.96
	Trachinotus goodei	0.33	0.82	4.01	1.05	7.24	71.20

picuous traits for nocturnal foraging, thus being primarily visually oriented feeders.

The greater nocturnal fish richness and total abundance are observed in many coastal ecosystems (e.g. mangroves and coral reefs; Willis et al. 2006, Ley & Halliday 2007), and it has been attributed to many processes, such as I) greater nocturnal accessibility of fishes to prey items as many invertebrates are more actives at night; II) reduced predation rate due to lower activity of visual-oriented predators like larger fishes and seabirds; III) greater gear catchability, because, in the dark, fish may find it more difficult to see the net and escape from it; and IV) recreational activities reduced at night (Willis et al. 2006, Ley & Halliday 2007, Defeo et al. 2009, Torre et al. 2017, Gaston 2019). In most months, there was no significant difference in abundance and richness between day and night on the Guriri Beach. Such a day-night persistency, also detected in other Brazilian beaches (e.g. Barreiros et al. 2005, Gaelzer et al. 2006, Félix-Hackradt et al. 2010, Colombo et al. 2017), suggests that species and individuals remain day and night in the Guriri Beach, as a species-specific plasticity to diel variability of the habitat, food availability, and predation pressure. Alternatively, such persistency may indicate that the catchability of the gear we used was independent of the diel period. In months when differences were signi-ficant, abundance and richness were greater at night, as observed in other coastal ecosystems (Barreiros et al. 2005, Gaelzer et at. 2006, Gondolo et al. 2011).

There was inconsistency in the day and night differences in the Guriri fish assemblage structure and understanding the causes behind this inconsistency is beyond the scope of this study. Long-term studies focused on relating the fish fauna to structuring factors (e.g. wave parameters, bottom morphology, prey availability, tide regimes) would be necessary to unveil processes that drive this inconsistent pattern (Barreiros et al. 2005, Gaelzer & Zalmon 2008, Félix-Hackradt et al. 2010, Olds et al. 2017, Torre et al. 2017). Moreover, long-term studies are of great importance because effective conservation outcomes rely strongly on a solid understanding of the structuring biodiversity processes (Defeo et al. 2009, Olds et al. 2017).

A large-scale, multidisciplinary monitoring program that aimed to assess the impacts of the Fundão mine dam tailings on the marine biodiversity has been conducted since the disaster in 2015. However, this program has not been monitoring the fish assemblages of surf zones (Bianchini et al. 2020a,b, Condini et al. 2021). However, a surf fish monitoring would be necessary because the deleterious effects of mining tailings on fish are well-known (Azevedo-Santos et al. 2021), and surf zones serve as nursery and food areas for several fish species (Olds et al. 2017). Moreover, recent studies have demonstrated the negative consequences of the plume on the region's marine ichthyofauna, such as malformations in fish larval (Bonecker et al. 2019), contamination by heavy metals (Bianchini et al. 2020a,b), and niche shifts in estuarine fishes (Andrades et al. 2020). The beach macrofauna on the northern coast of Espírito Santo is critically contaminated, and its diversity and abundance are largely reduced (Bianchini et al. 2020a,b). Since macrofauna is an important food source for fish, these impacts may affect nekton through the trophic cascade (Azevedo-Santos et al. 2021). Our data also show that the Guriri Beach holds an abundant juvenile population of *P. oligodon*, *Menticirrhus* spp., and *T. carolinus*, whose adults are economically exploited by subsistence and recreational fisheries (Pinheiro & Joyeux 2007, Hostim-Silva & Soares 2013, Freire et al. 2020). The above further reinforces the importance of a local monitoring program for surf fishes.

The species accumulation curve to assess sample adequacy did not reach the asymptotic level, even though the sampling effort was high (210 samples). This suggests that an eventual continuation of sampling would detect more species. Therefore, our richness characterization should be treated cautiously. Nevertheless, it is relevant to observe that the richness of Guriri Beach is greater than that recorded in other studies using beach seines in different Brazilian ocean beaches [e.g. 22 species in the ocean sector of both Pontal do Sul Beach (Félix 2006) and Peças Island Beach (Stefanoni 2008), southern coast of Brazil; 20 species in Praia Grande Beach, southeastern coast of Brazil (Santos et al. 2019)]. However, sample adequacy in such studies was not assessed to determine an eventual undersampling. Undersampling should be common in surf-zone studies because beach seine performs poorly in ocean beaches' surf zones due to their high hydrodynamics. This poor performance determines slow net trawl speed, smaller net opening, and low fish catchability (Hahn et al. 2007).

Despite a potential richness undersampling, the dominance pattern of the most abundant species and their day/night variability is well characterized. The most abundant nekton species, in general, dominate the local ecological, energy flux, and ecosystem processes in surf habitats (Olds et al. 2017). The dominance patterns described in the present study are the only published information available for Guriri beach before the dam failure. Thus, our results could serve as a start-point (i.e. a before-impact reference point) for future local monitoring. Moreover, the results indicate that day-and-night sampling is recommended for more accurate abundance estimation of the dominant species. The monitoring could also be arranged in a monthly-based, multiyear sampling scheme and includes structuring factors of surf fish assemblage (as listed above). This strategy could determine the long-term patterns and processes that drive the local assemblage, thus helping to support more effective conservation and restoration efforts.

ACKNOWLEDGMENTS

The authors would like to thank Laboratório de Ecologia de Peixes Marinhos - LEPMAR staff for their help during fieldwork. MHS thanks the research fellowship provided by CNPq (Proc. 312278/2017-9). RFC would like to thank the Federal Institute of Pará for granting an official leave to conduct the post-doc. HLS thanks the National Council of Technological and Scientific Development (CNPq) for a PQ2 productivity fellow. We thank the anonymous referee for their constructive comments on the manuscript. The field-work was carried out with the authorization of the Brazilian Biodiversity Authorization and Information System - SISBIO (Permit 5818-1).

REFERENCES

Albino, J. 1999. Processos de sedimentação atual e morfodinâmica das praias de Bicanga a Povoação, ES. Ph.D. Thesis, Universidade de São Paulo, São Paulo.

Anderson, M.J., Gorley, R.N. & Clark, K.R. 2008. PERMANOVA + for PRIMER: guide for software and statistical methods. PRIMER-E, Plymouth.

Andrades, R., Gomes, M.P., Pereira-Filho, G.H., Souza-Filho, J.F., Albuquerque, C.Q. & Martins, A.S. 2014. The influence of allochthonous macroalgae on the fish communities of tropical sandy beaches. Estuarine Coastal and Shelf Science, 144: 75-81. doi: 10.1016/ j.ecss.2014.04.014

Andrades, R., Guabiroba, H.C, Hora, M.S.C., Martins, R.F., Rodrigues, V.L.A., Vilar, C.C., et al. 2020. Early evidences of niche shifts in estuarine fishes following one of the world's largest mining dam disasters. Marine Pollution Bulletin, 154: 111073. doi: 10.1016/ j.marpolbul.2020. 111073

Araújo, C.C.V., Rosa, D.M., Fernandes, J.M., Ripoli, L.V. & Krohling, W. 2008. Composição e estrutura da comunidade de peixes de uma praia arenosa da Ilha do Frade, Vitória, Espírito Santo. Zoológica, 98: 129-135. doi: 10.1590/S0073-47212008000100016

Arnott, H.J., Maciolek, N.J. & Nicol, J.A. 1970. Retinal tapetum lucidum: a novel reflecting system in the eye of teleosts. Science, 169: 478-480. doi: 10.1126/science.169.3944.478

Azevedo-Santos, V.M., Arcifa, M.S., Brito, M.F.G., Agostinho, A.A., Hughes, R.M., Vitule, J.L.S., et al. 2021. Negative impacts of mining on Neotropical freshwater fishes. Neotropical Ichthyology, 19: 1-25. doi: 10.1590/1982-0224-2021-0001

Barreiros, J.P., Figna, V., Hostim-Silva, M. & Santos, R.S. 2005. Diel seasonality of a shallow-water fish assemblage in a sandy beach at Canto Grande, Santa Catarina, Brazil. Journal of Coastal Research, 42: 343-347. doi: 10.2307/25737000

Beck, M., Heck Jr., K., Able, K., Childers, D., Eggleston, D., Gillanders, B., et al. 2001. The identification, conservation, and management of estuarine and marine nurseries for fish and invertebrates. BioScience, 51: 633-641. doi: 10.1641/0006-3568

Bianchini, A., Bastos, A.C., Teixeira, E.C. & Castro, E.V.R. 2020a. Relatório anual 2020 do PMBA/FEST-RRDM. Evolução espaço-temporal na qualidade ambiental e na biodiversidade no ambiente marinho. Programa de monitoramento da biodiversidade aquática da área ambiental I - Porção capixaba do Rio Doce e região marinha e costeira adjacente. Fundação Espírito-Santense de Tecnologia, Espírito Santo. [http://www.ibama.gov.br/cif/notas-tecnicas/ct-bio/relatorios-da-rede-rio-doce-mar]. Reviewed: March 15, 2022.

Bianchini, A., Bastos, A.C., Teixeira, E.C. & Castro, E.V.R. 2020b. Relatório semestral de evolução do PMBA/ FEST-RRDM. Outubro/2019-março/2020. APÊNDICE II. Programa de monitoramento da biodiversidade aquática da área ambiental I - Porção capixaba do Rio Doce e região marinha e costeira adjacente. Fundação Espírito-Santense de Tecnologia, Espírito Santo. [http://www.ibama.gov.br/cif/notas-tecnicas/ct-bio/relatorios-da-rede-rio-doce-mar]. Reviewed: March 15, 2022.

Bonecker, A.C.T., De Castro, M.S., Costa, P.G., Bianchini, A. & Bonecker, S.L.C. 2019. Larval fish assemblages of the coastal area affected by the tailings of the collapsed dam in southeast Brazil. Regional Studies in Marine Science, 32: 100848. doi: 10.1016/ j.rsma.2019.100848

Castro, B.M. 2014. Summer/winter stratification variability in the central part of the South Brazil Bight. Continental Shelf Research, 89: 15-23.

Clarke, K.R. & Gorley, R.N. 2006. User manual/tutorial. PRIMER-E, Plymouth.

Colombo, N., Manes, S., Almeida, L.L., Hostim-Silva, M., Daros, F.A. & Spach, H.L. 2017. Variação temporal na composição e estrutura da assembleia de peixes em uma praia no sul do Brasil. Brazilian Journal of Aquatic Science and Technology, 20: 33-42. doi: 10.14210/bjast.v20n2.9534

Condini, M.V., Pichler, H.A., De Oliveira-Filho, R.R., Cattani, A.P., Andrades, R., Vilar, C.C., et al. 2021. Marine fish assemblages of eastern Brazil: an update after the world's largest mining disaster and suggestions of functional groups for biomonitoring long-lasting effects. Science of the Total Environment, 807: 150987. doi: 10.1016/j.scitotenv.2021.150987

Costa, L.L., Landmann, J.G., Gaelzer, L.R. & Zalmon, I.R. 2017. Does human pressure affect the community structure of surf zone fish in sandy beaches? Continental Shelf Research, 132: 1-10. doi: 10.1016/ j.csr.2016.11.007

Dantas, N.C.F.M., Júnior, C.A.B.S., Lippi, D.L. & Feitosa, C.V. 2016. Diel variations and ecological aspects in fish assemblages of a sandy beach in the semi-arid region of northeast Brazil. Brazilian Archives of Biology and Technology, 59: e16160076. doi: 10.1590/1678-4324-2016160076

Defeo, O., Mclachlan, A., Schoeman, D.S., Schlacher, T.A., Dugan, J., Jones, A., et al. 2009. Threats to sandy beaches ecosystems: a review. Estuarine, Coastal and Shelf Science, 81: 1-12. doi: 10.1016/j.ecss.2008.09.022

Del-Favero, J.M. & Dias, J.F. 2013. Spatio-temporal variation in surf zone fish communities at Ilha do Cardoso State Park, São Paulo, Brazil. Latin American Journal of Aquatic Research, 41: 239-253. doi: 10.3856/vol41-issue2-fulltext-4

Del-Favero, J.M. & Dias, J.F. 2015. Daily and seasonal fluctuations of the fish community in the surf zone of an estuarine-coastal area of southeast Brazil. Pan-American Journal of Aquatic Sciences, 10: 141-154.

Félix, F.C. 2006. Comunidade de peixes na zona de arrebentação de praias com diferente morfodinamismo. Master Thesis, Universidade Federal do Paraná, Curitiba.

Félix-Hackradt, F.C., Spach, H.L., Moro, P.S., Pichler, H.A., Maggi, A.S., Hostim-Silva, M. & Hackradt, C.W. 2010. Diel and tidal variation in surf zone fish assemblages of a sheltered beach in southern Brazil. Latin American Journal of Aquatic Research, 38: 447-460. doi: 10.3856/vol38-issue3-fulltext-9

Figueiredo, J.L. & Menezes, N.A. 1978. Manual de peixes marinhos do sudeste do Brasil. II. Teleostei (1). Museu de Zoologia da USP, São Paulo.

Figueiredo, J.L. & Menezes, N.A. 1980. Manual de peixes marinhos do sudeste do Brasil. III. Teleostei (2). Museu de Zoologia da USP, São Paulo.

Figueiredo, J.L. & Menezes, N.A. 2000. Manual de peixes marinhos do sudeste do Brasil. VI. Teleostei (5). Museu de Zoologia da USP, São Paulo.

Freire, K.M.F., Pinto-Nascimento, F. & Rocha, G.R.A. 2020. Shore-based competitive recreational fisheries in southern Bahia, Brazil: a baseline study. Marine and Fishery Science, 33: 183-203. doi: 10.47193/mafis.3322020301103

Gaelzer, L.R. & Zalmon, I.R. 2008. Diel variation of fish community in sandy beaches of southeastern Brazil. Brazilian Journal of Oceanography, 56: 23-39.

Gaelzer, L.R. Machado, G.R., Baptista, O.R. & Zalmon, I.R. 2006. Surf-zone ichthyofauna diel variation in Arraial do Cabo, southeastern Brazil. Journal of Coastal Research, 39: 1114-1117.

Gaston, K.J. 2019. Nighttime ecology: the "Nocturnal Problem" revisited. American Naturalist, 193: 481-502. doi: 10.1086/702250

Godefroid, R.S., Spach, H.L., Schwarz-Junior, R. & Queiroz, G.M. 2003. A fauna de peixes da praia do balneário Atami, Paraná, Brasil. Atlântica, 25: 147-161. doi: 10.5088/atlântica.v25i2.2302

Gondolo, G.F., Mattox, G.M.T. & Cunningham, P.T.M. 2011. Ecological aspects of the surf-zone ichthyofauna of Itamambuca Beach, Ubatuba, SP. Biota Neotropica, 11: 183-192. doi: 10.1590/S1676-06032011000200019

Hahn, P.K.J., Bailey, R.E. & Ritchie, A. 2007. Beach seining. In: Johnson, D.H., Shrier, B.M., O'Neal, J.S., Knutzen, J.A., Augerot, X., O'Neil, T.A. & Pearsons, T.N. (Eds.). Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society in association with State of the Salmon, Bethesda, pp. 267-324.

Hostim-Silva, M. & Soares, G.S.S. 2013. Boletim estatístico da pesca do Espírito Santo - Ano 2011: programa de estatística pesqueira do Espírito Santo. Universidade Federal do Espírito Santo, 2: 56. [https://www.icmbio.gov.br/cepsul/images/stories/biblioteca/download/estatistica/es/est_2011_es_boletim_estatistico_pesca_1.pdf]. Reviewed: April 12, 2022.

Hostim-Silva, M., Lima, A.C., Damasceno, J., Sciarretta, T., Silva, J.V., Bot-Neto, R.L. et al. 2013. As assembleias de peixes dos estuários de Conceição da Barra e Barra Nova, Espírito Santo. Tropical Oceanography, 41: 132-153. doi: 10.5914/to.2013.0085

Kawakami, E. & Vazzoler, G. 1980. Método gráfico e estimativa de índice alimentar aplicado no estudo de alimentação de peixes. Boletim do Instituto Oceanográfico, 29: 205-207.

Ley, J.A. & Halliday, I.A. 2007. Diel variation in mangrove fish abundances and trophic guilds of northeastern Australian estuaries with a proposed trophodynamic model. Bulletin of Marine Science, 80: 681-720.

Menezes, N.A. & Figueiredo, J.L. 1980. Manual de peixes marinhos do sudeste do Brasil. IV. Teleostei (3). Museu de Zoologia da USP, São Paulo.

Menezes, N.A. & Figueiredo, J.L. 1985. Manual de peixes marinhos do sudeste do Brasil. V. Teleostei (4). Museu de Zoologia da USP, São Paulo.

Miloslavich, P., Klein, E., Díaz, J.M., Hernández, C.E., Bigatti, G., Campos, L., et al. 2011. Marine biodiversity in the Atlantic and Pacific coasts of South America: knowledge and gaps. Plos One, 6: e14631. doi: 10.1371/journal.pone.0014631

Monteiro-Neto, C.A. & Prestrelo, L. 2013. Comparing sampling strategies for surf-zone fish communities. Marine and Freshwater Research, 64: 102-107. doi: 10.1071/MF12070

Motomura, H. 2004. Threadfins of the world. An annotated and illustrated catalogue of polynemid species known to date. FAO species catalogue for fishery purposes 3. FAO, Rome.

Olds, A.D., Vargas-Fonseca, E., Connolly, R.M., Gilby, B.L., Huijbers, C.M., Hyndes, G.A., et al. 2017. The ecology of fish in the surf zones of ocean beaches: a global review. Fish and Fisheries, 19: 78-89. doi: 10.1111/faf.12237

Pinheiro, H.T. & Joyeux, J.C. 2007. Pescarias multiespecíficas na região da foz do Rio Doce, ES, Brasil: características, problemas e opções para um futuro sustentável. Brazilian Journal of Aquatic Science and Technology, 11: 15-23. doi: 10.14210/bjast.v11n2.p15-23

Reebs, S.G. 2002. Plasticity of diel and circadian activity rhythms in fishes. Reviews in Fish Biology and Fisheries, 12: 349-371. doi: 10.1023/A:1025371804611

Sánchez, L.E., Alger, K., Alonso, L., Barbosa, F.A.R., Brito, M.C.W., Laureano, F.V., et al. 2018. Impacts of the Fundão Dam failure. A pathway to sustainable and resilient mitigation. Rio Doce Panel Thematic Report 1. IUCN, Gland.

Santos, E.K., Grande, F.R. & Vaske-Junior, T. 2019. Seasonal evaluation of the condition factor in a surf-zone assemblage from southeastern Brazil. Boletin do Instituto de Pesca, 45: e453. doi: 10.20950/1678-2305.2019.45.3.453

Received: April 29, 2022; Accepted: December 5, 2022

Stefanoni, M.F. 2008. Ictiofauna e ecologia trófica de peixes em ambientes praiais da Ilha das Peças, Complexo Estuarino de Paranaguá, Paraná. Master Thesis, Universidade Federal do Paraná, Curitiba.

Torre, M.P., Lifavi, D.M. & Targett, T.E. 2017. Diel differences in abundance and diversity of fish species and blue crab (*Callinectes sapidus*) in the sandy beach shore zone of lower Delaware Bay. Fishery Bulletin, 115: 556-565. doi: 10.7755/FB.115.4.11

Vasconcellos, R.M., Araújo, F.G., Santos, J.N.S. & Silva, M.A. 2011. Diel seasonality in fish biodiversity in a sandy beach in southeastern Brazil. Journal of the Marine Biological Association of the United Kingdom, 91: 1337-1344. doi: 10.1017/S0025315410000652

Vousdoukas, M.I., Ranasinghe, R., Mentaschi, L., Plomaritis, T.A., Athanasiou, P., Luijendijk, A. & Feyen, L. 2020. Sandy coastlines under threat of erosion. Nature Climate Change, 10: 260-263. doi: 10.1038/s41558-020-0697-0

Willis, T.J., Badalamenti, F. & Milazzo, M. 2006. Diel variability in counts of reef fishes and its implications for monitoring. Journal of Experimental Marine Biology and Ecology, 331: 108-120. doi: 10.1016/j.jembe.2005.10.003