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Research Article

Distribution, relative abundance and diversity of deep-sea species at São Pedro and São Paulo Archipelago, Brazil

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ABSTRACT. The goal of the present study is to investigate vertical distribution, relative abundance and diversity of deep-sea species caught using baited traps at São Pedro and São Paulo Archipelago (SPSPA). The surveys were carried out between January 2012 and June 2014 at depths ranging from 170 to 700 m, comprising 53 hauls. Five species of crustaceans, ten of fishes and three of mollusks were caught. The deep-sea geryonid crab *Chaceon gordonae* was the most abundant species, followed by the Gadiform (Moridae) fish *Physiculus* sp. The results showed a clear bathymetric stratification, with some species being restricted to shallower layers (170-300 m) and others showing a wider distribution (200-700 m). Several factors can influence the vertical distribution of these species, including oceanographic and biological characteristics. In the future, more studies should be conducted in order to elucidate the interaction between distribution, relative abundance and diversity with various elements that make up the dynamics of this complex ecosystem.

Keywords: *Chaceon gordonae, Physiculus* sp., bottom traps, oceanic islands, Mid-Atlantic Ridge, Equatorial Atlantic Ocean.

Distribución, abundancia relativa y diversidad de especies de aguas profundas en el Archipiélago de São Pedro y São Paulo, Brasil

RESUMEN. El objetivo del presente estudio es analizar la distribución vertical, abundancia relativa y diversidad de las especies de profundidad capturadas con trampas cebadas en el Archipiélago de São Pedro y São Paulo. Las operaciones de pesca se realizaron entre enero 2012 y junio de 2014, en profundidades de 170 a 700 m, totalizando 53 lances. Se capturaron cinco especies de crustáceos, diez de peces y tres de moluscos. El cangrejo geriónido de aguas profundas *Chaceon gordonae* fue la especie más abundante, seguido por el pez gadiforme (Moridae), *Physiculus* sp. Los resultados obtenidos mostraron una clara estratificación batimétrica, con especies restringidas en las capas menos profundas (170-300 m) y otros con amplia distribución vertical (200-700 m). Existen varios factores que pueden influir en la distribución vertical de estas especies, incluyendo las características oceanográficas y biológicas. En el futuro, se requiere efectuar más estudios para comprender la interacción entre la distribución, abundancia relativa y diversidad de las especies de profundidad de este complejo ecosistema.

Palabras clave: *Chaceon gordonae*, *Physiculus* sp., trampas de fondo, islas oceánicas, Cordillera Meso-Atlántica, Océano Atlántico Ecuatorial.

INTRODUCTION

São Pedro and São Paulo Archipelago (SPSPA) is a small and isolated group of rocky islands at the Equatorial Atlantic Ocean (0°55’10”N, 29°20’33”W), between the African and the American continents. It is located about 1,010 km from the Brazilian coast (Lubbock & Edwards, 1981), as part of the Mid-Atlantic Ridge, being influenced by a complex system of surface and subsurface currents, and by the Intertropical Convergence Zone (ICZ) (Travassos *et al.*, 1999; Sichel *et al.*, 2008).

Studies conducted at SPSPA, since the first scientific station was installed in 1998, have generated a significant amount of information on this complex marine ecosystem, contributing not only to a better

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understanding of its dynamics, but of the functioning of oceanic insular ecosystems worldwide (Vaske-Jr. *et al.*, 2006; Leite *et al.*, 2008; Motoki *et al.*, 2010; Lima *et al.*, 2011; Melo *et al.*, 2012; Vieira *et al.*, 2012; Branco *et al.*, 2013; Viana *et al.*, 2013).

With regard to fish diversity, for instance, 108 species have already been identified, some of them endemic to the Archipelago (Viana *et al.*, 2009, Vaske-Jr. *et al.*, 2010), such as *Stegastes sanctipauli* (Lubbock & Edwards, 1981), *Prognathodes obliquus* (Lubbock & Edwards, 1981), *Enneanectes smithi* (Lubbock & Edwards, 1981), *Anthias salmopunctatus* (Lubbock & Edwards, 1981), and *Emblemariopsis* sp. (Lubbock & Edwards, 1981; Feitoza *et al.*, 2003; Vaske-Jr. *et al.*, 2005; Floeter *et al.*, 2008). Studies on benthic invertebrates, on the other hand, have suggested a vertical stratification of communities, an aspect that acquires particular importance when the steep relief of SPSPA is taken into account, emphasizing its ecological importance and fragility (Sichel *et al.*, 2008; Viana *et al.*, 2009). Several other researches have focused on many other species, from zooplankton to crabs *Grapsus grapsus* and *Chaceon gordonae*, and lobster *Panulirus echinatus* (Pinheiro *et al.*, 2003; Freire *et al.*, 2011; Melo *et al.*, 2012; Ferreira *et al.*, 2016), as well as mollusks, including 48 taxa, 26 new occurrences to the area, and 19 new species for science (Leite *et al.*, 2008; Lima *et al.*, 2011).

All species surveys conducted in SPSPA to date, however, have concentrated in shallow waters, less than 250 m deep, so that current knowledge about deep-sea fauna of this important island ecosystem is still almost absent (Viana *et al.*, 2012a). This work, therefore, intended to undertake an investigation on the spatial distribution, relative abundance, and diversity of deep-sea species caught in SPSPA, using baited traps, in order to expand the present knowledge on the structure of insular community, including the influence of oceanographic processes in their distribution and abundance.

MATERIALS AND METHODS

Eight scientific expeditions were conducted around São Pedro and São Paulo Archipelago, with "Transmar I" fishing boat, between January 2012 and June 2014. Fifty three fishing sets (hauls) were done between 29.3135º-29.3760ºW, 0.9014º-0.9329ºN (Fig. 1), using three baited bottom traps with 40 mm mesh size, in depths ranging from 170 to 700 m, and a mean immersion time of 13.5 h (ranging from 6 to 27 h). Bottom traps were made of stain less steel structure with 8 mm diameter, in three different sizes: Trap 1- rectangular trap with 2.0x0.90x0.90 m and 0.30 m diameter bucket-entry; Trap 2- rectangular trap with 2.0x0.60x0.60 m and 0.15 m diameter bucket-entry; and Trap 3- conical trap with 1.00 m diameter x 0.60 m height. The dimensions of the traps were based on a previous deep-sea survey performed by the REVIZEE Program off Northeast Brazil (Oliveira *et al.*, 2014).

The relative abundance of species caught was estimated by the catch per unit effort (CPUE) in number of individuals caught per haul and trap (Olivera *et al.*, 2014). For the analysis of vertical distribution, the CPUE by species was calculated by 100 m strata. The relative abundance was also compared between two areas: West Seamount and SPSPA. Differences in CPUE between depths, area and day time (day and night) were tested for species with more than 10 individuals caught and for taxonomic groups (crustaceans and fishes). Five hauls that remained immersed between 24 and 27 h were discarded from analysis. Statistical analysis consisted on application of a normality test Shapiro-Wilk, followed by Bartlett Test for homogeneity of variances. After the heteroscedasticity of data was confirmed, a non-parametric analysis for comparison of medians was used (Wilcoxon and Kruskal-Wallis). Statistical analysis were made using R Program (R Development Core Team, 2007), with 95% confident level ($P < 0.05$).

Counts in number of individuals were used to estimate mean abundance, number of species and species richness index, Margalef (d'), Shannon-Wiener (H') diversity index, and Pielou's evenness index (J') per haul, depth strata, area and for major assemblages, resulting in a specific classification and ordination. Cluster analysis were calculated by means of the Bray-Curtis index to inspect similarities between taxonomic composition for each haul in terms of relative abundance (CPUE). Data were log (x+1) transformed and then assemblages characteristics were studied by multi-dimensional scaling (MDS) ordination followed by ANOSIM (Analysis of Similarities), a non-parametric permutation procedure that tests hypotheses about sample (haul) similarity (Clarke, 1993). Groupings were then tested by SIMPER (Similarity Percentage Analysis) to identify the principal contributor species (Gotelli & Ellison, 2004). Multivariate analysis was performed with the help of the PRIMER (Plymouth Routines Multivariate Ecological Research) statistical package, version 6.1.13 (Clarke & Gorley, 2006).

RESULTS

Fifty-three hauls were made around São Pedro and São Paulo Archipelago, resulting in a total effort of 142 traps and 702 h of immersion. Considering all samples together, 899 individuals were caught, distributed in five

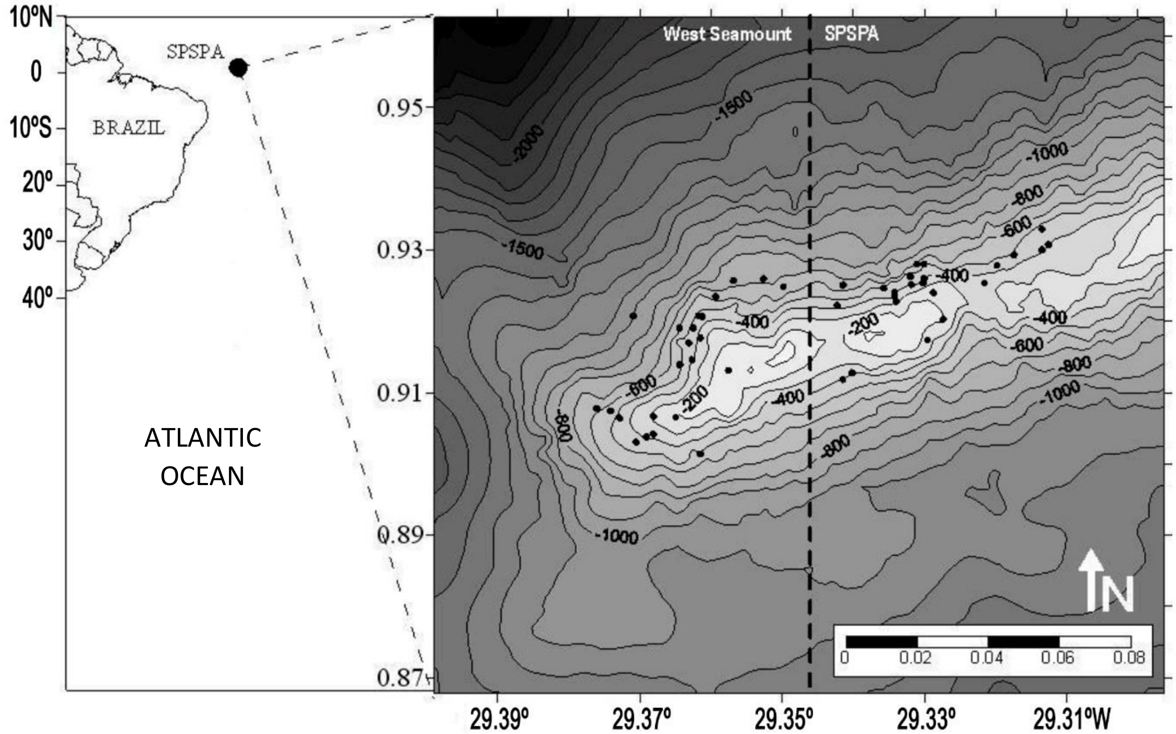

Figure 1. Hauls of bottom traps in São Pedro and São Paulo Archipelago, during January 2012 and June 2014, at depths comprising 170 to 700 m, in two distinct areas.

species of crustaceans, ten of fishes and three of mollusks. Among fish, the Congridae and Moridae families were the most representative in number of species (three and two, respectively), followed by other families represented by a single species (Macrouridae, Colocongridae, Scorpaenidae, Polimixiidae and Muraenidae). For crustaceans, all species caught were from different families (Geryonidae, Dromiidae, Homolidae, Portunidae and Nematocarcinidae). As for mollusks, *Charonia variegata* (Lamarck, 1816) was the only species identified so far. Catches in number of individuals were mainly composed by crustaceans (83.5%), followed by fishes (15.8%) and mollusks (0.7%). The deep-sea African crab (*Chaceon gordonae* Ingle, 1985) presented a high relative participation (78.2%), followed by *Physiculus* sp. (Kaup, 1858) (10.2%). Other species together responded for 11.6% of catches (Table 1).

Higher mean values of CPUE were recorded for the more abundant species (>10 individuals) and group of species in West Seamount and at night time, except for *Nematocarcinus gracilis* (Filho, 1884), which was more abundant in SPSPA area, and for *Pontinus nigropunctatus* (Günther 1868), and mollusks, which showed a higher abundance during the day (Table 1). The CPUE of grouped species, however, was not significantly difference between areas (W = 403; P = 0.345), although mean CPUE for West Seamount was higher. The same result were found in catches for group of crustaceans (W = 380; P = 0.598), for the deep-sea African crab (W = 372.5; P = 0.693), and for *Physiculus* sp. (W = 349; P = 0.992). For day time, differences not presented statistically significance (W = 175; P = 0.103), although CPUE exhibited a night time values apparently higher.

The CPUE values for all species together were higher between 500 and 600 m (KW = 14.465; P = 0.0245), reflecting mainly a higher abundance of crustaceans (KW = 15.178; P = 0.0189), in particular for *C. gordonae* in that strata (14.28 ind/haul/trap; KW = 17.295; P = 0.0089). The majority of fish species occurred in depths between 200 and 600 m, with a higher value of CPUE in shallow waters (170-200 m) (2.33 ind/haul/trap), although the highest CPUE for *Physiculus* sp. was obtained between 300 and 400 m (1.01 ind/haul/trap; KW = 10.312; P = 0.112). Accordingly, a higher species richness was found between 400 and 500 m, while diversity and evenness indices decreased with depth (Table 2). Crustaceans were more abundant between 400 and 500 m, except for *Bathynectes longispina* (Stimpson, 1871) that occurred only between 170 and 300 m. Only two species of crabs were caught at the deepest strata (600 to 700 m): *C. gordonae* and *N. gracilis*; together with two species of cephalopods not identified yet, and one Congridae (Fig. 2).

Table 1. Catalog composition and average values CPUE (ind/haul/trap) for the deep-sea species caught using bottom traps at São Pedro and São Paulo Archipelago.

Family	Species	n	%	CPUE				
				Total	Area		Period	
					West seamount	SPSPA	Day	Night
Crustaceans		751	83.54	5.55	6.70	4.52	3.11	6.53
Geryonidae	*Chaceon gordonae*	703	78.20	5.19	6.27	4.24	2.95	6.02
Portunidae	*Bathynectes longispina*	15	1.67	0.12	0.19	0.06	0.02	0.20
Dromiidae	*Dromia bollorei*	9	1.00	0.06	0.11	0.01	0.00	0.10
Homolidae	*Homola barbata*	1	0.11	0.01	0.00	0.01	0.00	0.01
Nematocarcinidae	*Nematocarcinus gracilis*	23	2.56	0.04	0.02	0.05	0.04	0.04
Fishes		142	15.80	1.06	1.29	0.86	0.70	1.26
Moridae	*Physiculus* sp.	92	10.23	0.71	0.91	0.54	0.33	0.92
	Laemonema barbatulum	2	0.22	0.02	0.01	0.02	0.00	0.03
Macrouridae	*Nezumia* sp.	1	0.11	0.01	0.00	0.02	0.00	0.02
Colocongridae	*Coloconger meadi*	13	1.45	0.09	0.04	0.13	0.00	0.09
Congridae	*Conger esculentus*	2	0.22	0.02	0.04	0.00	0.03	0.02
	Conger sp.	1	0.11	0.01	0.02	0.00	0.03	0.00
	Unidentified species	2	0.22	0.02	0.01	0.01	0.04	0.00
Scorpaenidae	*Pontinus nigropunctatus*	15	1.67	0.10	0.11	0.10	0.21	0.06
Polimixiidae	*Polimixia nobilis*	2	0.22	0.02	0.04	0.00	0.03	0.02
Muraenidae	*Gymnothorax* sp.	12	1.33	0.08	0.11	0.05	0.02	0.12
Mollusks		6	0.67	0.04	0.06	0.02	0.11	0.00
Ranellidae	*Charonia variegata*	1	0.11	0.01	0.00	0.01	0.00	0.00
Bivalvia	Unidentified species	1	0.11	0.01	0.00	0.01	0.00	0.33
Cephalopoda	Unidentified species	4	0.44	0.02	0.06	0.01	0.06	0.00
Total		899	100.00	6.61	7.99	5.38	3.81	7.80

Table 2. Distribution of vertical effort (trap/haul), average values CPUE (ind/haul/trap), number of species, richness (d'), diversity (D'), and evenness (j') in hauls using bottom traps at São Pedro and São Paulo Archipelago.

Parameter	Depth strata (m)					
	100-200	200-300	300-400	400-500	500-600	600-700
Effort (nº of traps)	5	15	48	39	24	13
CPUE total	4.33	1.53	4.78	4.83	15.42	8.06
CPUE crustaceans	2.00	1.27	4.13	3.96	14.28	8.06
CPUE fishes	2.33	0.27	1.31	0.87	1.13	0.00
CPUE *Chaceon gordonae*	0.00	1.20	4.04	3.73	13.43	7.94
CPUE *Physiculus* sp.	0.00	0.13	0.95	0.68	0.68	0.00
Number of species	5	5	10	9	10	3
Richness	1	1.55	1.15	1.8	1.38	0.47
Diversity	2.02	1.44	0.64	1.04	0.43	0.57
Evenness	1.61	1.14	0.51	0.83	0.34	0.61

Abundance cluster analysis of log transformed data for taxonomic groups exhibited the presence of four groups by bathymetric gradient and area (35% Bray-Curtis similarity index) (Fig. 3). Cluster 1 (Group A) included shallow strata (average depth 341.13 m) mainly located at SPSPA area; Cluster 2 (Group B) was represented by intermediate depths (466.42 m); followed by Cluster 3 (Group D), that included deepest waters (546 m). Group C was excluded from the analysis because it included less than two samples in cluster. The MDS for deepest species presented the *R* global of 0.766 (Fig. 4), indicating that hauls in each group individually were more similar in terms of species composition than any other cluster. Differences between clusters, tested with ANOSIM, revealed that major values of *R* were near to zero, indicating individual dissimilarity from each group.

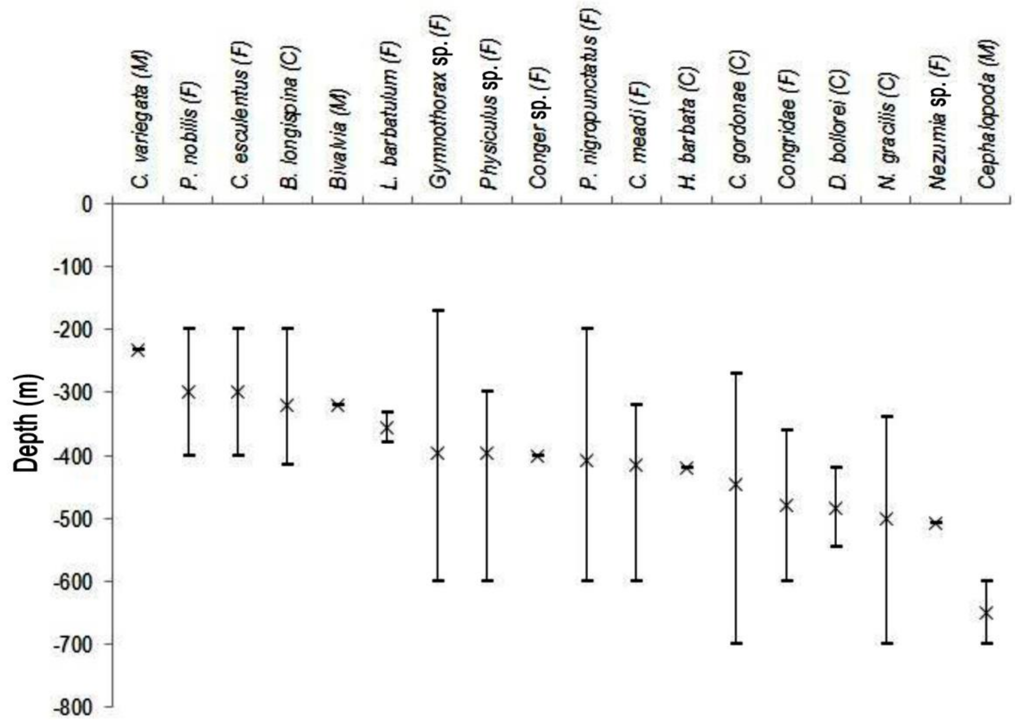

Figure 2. Bathymetric distribution of caught species during scientific surveys using bottom traps at São Pedro and São Paulo Archipelago. Points represents the average and discontinue lines indicates the amplitude observed. F: fish; C: crustacean, M: molusks.

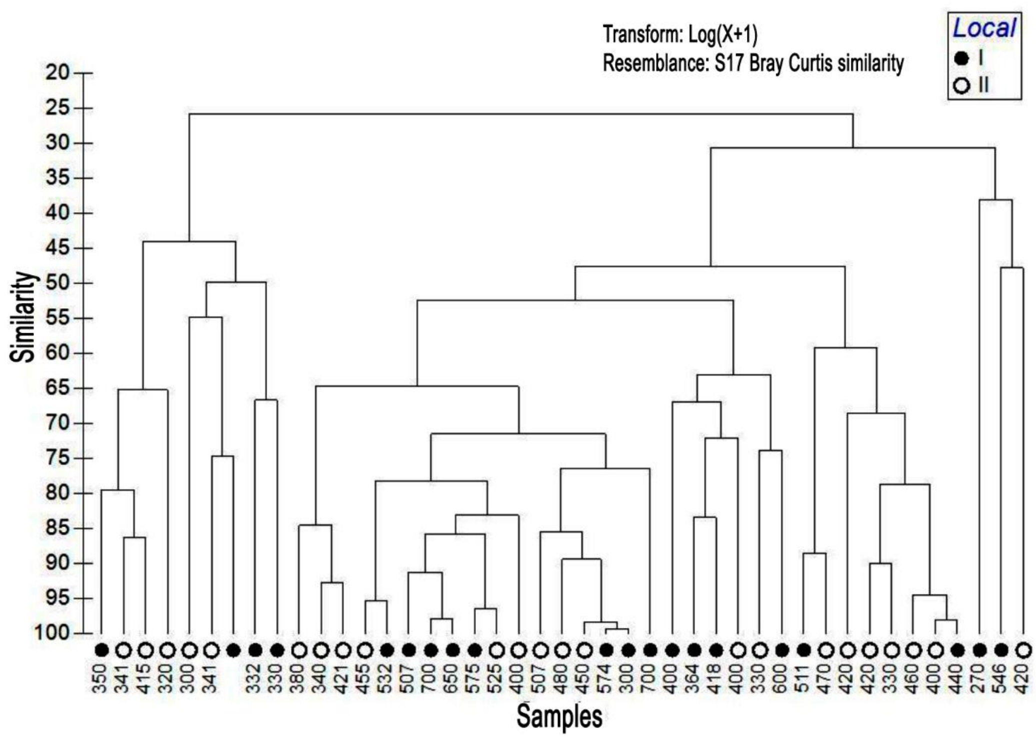

Figure 3. Cluster by depth strata in terms of abundance (ind/haul/trap) during scientific surveys using bottom traps at São Pedro and São Paulo Archipelago.

Average similarity in Group A was equal to 63.2%, mainly due to the contribution of three species: *Physiculus* sp., *C. gordonae* and *B. longispina*, with *Pshysiculus* sp. being the major contributor (66.2%).

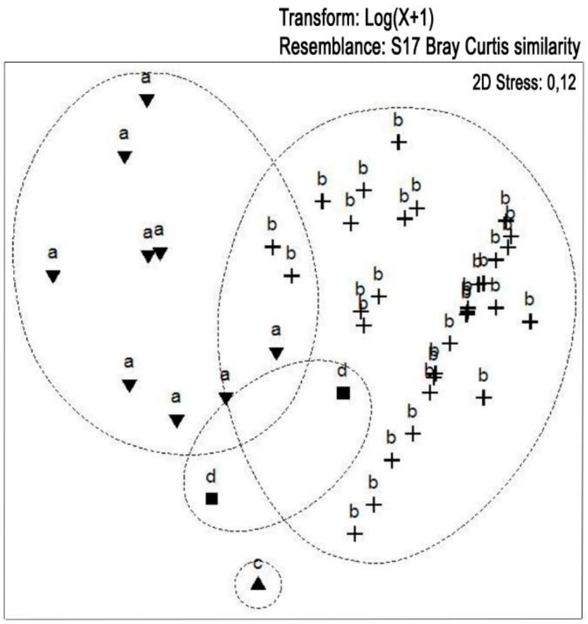

Figure 4. Multi-dimensional scaling (MDS) ordination for deep-sea species grouped by cluster analysis. The dashed lines indicate similarity levels of 35%. Global *R* = 0.766.

For Group B, average similarity was 67.6%, being composed by *C. gordonae*, *Physiculus* sp., *N. gracilis* and *Coloconger meadi* (Kanazawa 1957). *C. gordonae* was, by far, the main contributor (91.3%). Group D (average similarity 80.0%) included *C. gordonae*, *Dromia bollorei* (Forest, 1874), *Physiculus* sp. and *P. nigropunctatus*, with all these species contributing with the same percentage (25%) for group similarity. The three principal species in each group explained more than 90% of the accumulated similarity (Table 3).

SIMPER analysis confirmed the existence of three groups with high values of dissimilarity (>50%). Cluster dissimilarity between groups (A and D; B and D) were mainly because of the same species (*D. bollorei*, *P. nigropunctatus*, *Homola barbata* Fabricius, 1793, and *Gymnothorax* sp. Bloch, 1795). Differences between Group A and B were credited to *Physiculus* sp., *B. longispina*, *C. gordonae*, *C. meadi* and *N. gracilis* (Table 4).

Table 3. SIMPER analysis similarity between groups. Species are listed in order of contribution in average similarity (AS) within each group. AA: average abundance, SD: standard deviation.

Species	AA	AS	Sim/SD	Contrib%	Cum.%
Group A (AS = 63.20)					
Physiculus sp.	1	41.83	3.62	66.19	66.19
Chaceon gordonae	0.67	16.12	0.81	25.51	91.7
Bathynectes longispina	0.44	5.24	0.43	8.3	100
Pontinus nigropunctatus	0.11	0	-	0	100
Laemonema barbatulum	0.11	0	-	0	100
Coloconger meadi	0.11	0	-	0	100
Bivalvia	0.11	0	-	0	100
Group B (AS = 67.59)					
Chaceon gordonae	1	61.69	2.8	91.27	91.27
Physiculus sp.	0.35	4.52	0.36	6.69	97.95
Nematocarcinus gracilis	0.16	0.91	0.15	1.35	99.3
Coloconger meadi	0.13	0.47	0.11	0.7	100
Laemonema barbatulum	0.03	0	-	0	100
Nezumia sp.	0.03	0	-	0	100
Conger esculentus	0.03	0	-	0	100
Conger sp.	3	0	-	0	100
Polymixiia nobilis	0.03	0	-	0	100
Cephalopoda	3	0	-	0	100
Group D (AS = 80.00)					
Chaceon gordonae	1	20	-	25	25
Dromia bollorei	1	20	-	25	50
Physiculus sp.	1	20	-	25	75
Pontinus nigropunctatus	1	20	-	25	100
Homola barbata	0.5	0	-	0	100
Gymnothorax sp.	0.5	0	-	0	100

Table 4. SIMPER dissimilarity between groups. Species are listed in order of contribution in average dissimilarity (AD) within each group SD: standard deviation.

Species	AD	Diss/SD	Contrib%	Cum.%
Group A & B (AD = 53.52)				
Physiculus sp.	18.02	1.19	33.67	33.67
Bathynectes longispina	9.32	0.84	17.42	51.08
Chaceon gordonae	9.3	0.63	17.38	68.46
Coloconger meadi	4.06	0.51	7.58	76.04
Nematocarcinus gracilis	3.42	0.42	6.39	82.42
Laemonema barbatulum	2.44	0.39	4.57	86.99
Pontinus nigropunctatus	2.37	0.35	4.44	91.43
Bivalvia	1.95	0.35	3.64	95.07
Cephalopoda	0.74	0.18	1.38	96.45
*Nezumia*sp	0.6	0.18	1.12	97.57
Conger esculentus	0.43	0.18	0.81	98.38
Conger sp.	0.43	0.18	0.81	99.19
Polymixiia nobilis	0.43	0.18	0.81	100
Group A & D (AD = 51.90)				
Dromia bollorei	13.71	5.05	26.41	26.41
Pontinus nigropunctatus	12.3	2.37	23.7	50.11
Homola barbata	5.92	0.96	11.4	61.51
Gymnothoraxvicinus	5.92	0.96	11.4	72.91
Bathynectes longispina	5.53	0.85	10.66	83.57
Chaceon gordonae	4.78	0.66	9.2	92.77
Laemonema barbatulum	1.25	0.34	2.41	95.18
Coloconger meadi	1.25	0.34	2.41	97.59
Bivalvia	1.25	0.34	2.41	100
Group B & D (AD = 60.09)				
Dromia bollorei	15.23	4.91	25.35	25.35
Pontinus nigropunctatus	15.23	4.91	25.35	50.69
Physiculus sp.	10.5	1.28	17.48	68.17
Homola barbata	6.46	0.98	10.76	78.93
Gymnothorax sp.	6.46	0.98	10.76	89.69
Nematocarcinus gracilis	2.23	0.43	3.71	93.4
Coloconger meadi	1.7	0.38	2.83	96.23
Cephalopoda	0.47	0.18	0.78	97.01
Laemonema barbatulum	0.41	0.18	0.68	97.69
Nezumia sp.	0.41	0.18	0.68	98.37
Conger esculentus	0.33	0.18	0.54	98.92
Conger sp.	0.33	0.18	0.54	99.46
Polymixiia nobilis	0.33	0.18	0.54	100

DISCUSSION

In Brazilian waters (northeast, southeast and south regions) few studies on deep-sea fauna have been conducted so far, particularly in oceanic islands, being, therefore, a new frontier for marine science in the country, with a potentially significant contribution for biodiversity, biotechnology and fishing. An example of this potential was found during the REVIZEE Program, which along 10 years (1995-2005), identified several fish stocks and recorded various new deep-sea species in the outer the edge of continental shelf and upper slope (40 to 500 m depth) (Perez *et al.*, 2009).

Deep-sea fishing usually uses trawling nets, long-line and bottom traps, with the last fishing gear being more selective and less impacting to the environment. Besides, it is also more easily adapted to irregular bottoms, being the one, therefore, chosen for this study. The first deep-sea fishing operations using bottom traps in Brazil started with the exploration of deep-sea geryonid crabs: *Chaceon notialis* and *C. ramosae* (Pezzuto *et al.*, 2006; Arana *et al.*, 2009).

All species found in this study represent new records for the region around the archipelago, with the exception of *C. gordonae* (Ferreira *et al.*, 2016), the Scorpaenidae *P. nigropunctatus* (Vaske-Jr. *et al.*, 2008) and the moray *Gymnothorax* sp., Muraenidae family (Lubbock & Edwards, 1981). These new findings represent an increase of 10% in the current list of fish species at SPSPA since the last published review (Feitoza *et al.*, 2003; Vaske-Jr. *et al.*, 2005), increasing the number of species from 108 to 118. For the crustaceans, this contribution was equal to 22%, raising from 18 to 23 species recorded in the SPSPA (Holthuis *et al.*, 1980; Lubbock & Edwards, 1981; Viana *et al.*, 2004). New records have recently reported for SPSPA (Bezerra *et al.*, 2011; Lima-Filho *et al.*, 2011; Viana *et al.*, 2012b), and others will be published for the first time (Macena & Nunes; unpublished data; Carvalho-Filho *et al.*, 2016; Ferreira *et al.*, 2016).

This study found three assemblages (groups) of deep-sea species at SPSPA divided by depth ranges, according to the cluster analysis, corroborating other studies for the same area (Edwards & Lubbock, 1983), for other oceanic islands (Edwards, 1993; Pereira-Filho *et al.*, 2011; Pinheiro *et al.*, 2011), and for the Caribbean (Paramo *et al.*, 2012). This bathymetric distribution may result from numerous elements involved in the dynamics of this complex and spatially isolated ecosystem, such as the complex equatorial current system, combined with the steep relief (Travassos *et al.*, 1999; Hekinian *et al.*, 2000; Sichel *et al.*, 2008; Vaske-Jr. *et al.*, 2012).

Species assemblage from shallow waters (Group A), composed by *B. longispina*, *Laemonema barbatulum* Goode & Bean, 1883, *Polymixiia nobilis* Lowe, 1838 and one Bivalvia, were distributed in a restricted depth strata, while two species of the Group B (*C. gordonae* and *N. gracilis*) had a wide vertical distribution (270-700 m). Some species are therefore able to perform vertical migrations, possibly for feeding and/or reproduction, reaching a greater range of bathymetric distribution (Travassos *et al.*, 1999; Clark *et al.*, 2010; Ferreira *et al.*, 2016). Two species were common in Groups A and B (*L. barbatulum* and *C. meadi*) and one in Groups A and D (*P. nigropunctatus*). The deep-sea African crab *C. gordonae* and *Physiculus* sp. attended the three assemblages confirming the ability of these species to occupy different bathymetric strata. Specie richness reached maximum indices between 400 and 500 m depth (intermediate area), and minimum in the deepest zone (600-700 m), a result similar to the one found in Gulf of Mexico (Powell & Haedrich, 2003) and other areas (Paramo *et al.*, 2012; Govindam *et al.*, 2013). Diversity and evenness indices, however, decreased with increased depths, reaching the lowest values between 500 and 600 m.

The deep-sea fauna is yet poorly studied around the world, and particularly at São Pedro and São Paulo Archipelago, where no survey beyond 250 m had been done before. The results presented here are, therefore, an important contribution for the knowledge of SPSPA biodiversity and for the understanding of the zoo-geography of deep-sea species in the Atlantic Ocean. Further research efforts are, however, needed in order to broaden the knowledge of this important island ecosystem. Considering the fragility of the species found, as well as its potentially reduced distribution and abundance, it's particularly important to obtain data through non-lethal methods (Rudershausen *et al.*, 2010; Bacheler *et al.*, 2013), including the use of BRUVs (Baited Remote Underwater Video) (Harvey *et al.*, 2009) and remotely operated vehicle (ROV).

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