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Estado de conservação das populações de budiões ao longo da costa brasileira

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Estado de conservação das populações de budiões ao longo da costa brasileira

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Orientador: Prof. Dr. Carlos Werner Hackradt

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Resumo

Áreas Marinhas Protegidas (AMPs) são áreas onde a pesca é controlada ou proibida, sendo uma ferramenta com o objetivo de recuperar populações ameaçadas pela sobrepesca e para a conservação da biodiversidade. No Brasil, os efeitos das AMPs são pouco compreendidos, pois há poucos estudos que avaliam sua eficácia, mesmo abrigando grupos-chave, como os budiões, espécies endêmicas e ameaçadas pela pesca predatória. O objetivo deste trabalho foi avaliar o papel de diferentes tipos de manejo em AMPs na recuperação de populações de cinco espécies de budiões: *Scarus trispinosus*, *Scarus zelindae*, *Sparisoma amplum*, *Sparisoma axillare* and *Sparsioma frondosum*. Esperávamos que as AMPs de proteção integral influenciassem no crescimento da abundância e biomassa dessas espécies. Seis AMPs ao longo da costa foram amostradas entre janeiro e fevereiro de 2021, usando censos visuais para acessar a abundância, biomassa e tamanho dos budiões, bem como caracterizar seus habitats. Os resultados mostraram que as AMPs de proteção integral aumentaram a abundância e a biomassa das espécies de budiões, mostrando que elas se beneficiam da proteção. As categorias de Uso Sustentável apresentam baixa abundância e biomassa de espécies de budiões semelhantes à zonas não protegidas. Os resultados sugerem que medidas adicionais são necessárias para conservar efetivamente algumas espécies que ainda estão ameaçadas mesmo dentro de áreas protegidas e garantir que elas estarão aqui no futuro.

Palavras-chave: peixe-papagaio, Scarini, Áreas Marinhas Protegidas, efeito da proteção

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Conservation status of parrotfish populations along the brazilian coast

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ABSTRACT: In Marine Protected Areas (MPAs) fishing is controlled or forbidden as a tool for population recovey and biodiversity conservation. In Brazil, the effects of MPAs are poorly understood, since there are few studies that evaluate their effectiveness, even though they harbor key groups, like endemic parrotfishes that are threatened by overfishing. The aim of this work was to evaluate the role of different types of management MPAs in recovering populations of five parrotfish species: *Scarus trispinosus*, *Scarus zelindae*, *Sparisoma amplum*, *Sparisoma axillare* and *Sparsioma frondosum*. We expected that MPAs of Fully protection would increased abundance and biomass of these species. Six MPAs along the coast were sampled between January and February of 2021, using visual censuses to access the abundance, biomass and size of parrotfishes, as well as characterizing their habitats. The results showed that Fully Protected MPAs increased the abundance and biomass of parrotfish species, showing that they benefit from protection. Categories of Multiple use present low abundance and biomass of parrotfish species, similar to not protected zones. The findings suggest that

additional measures are needed to effectively conserve some species that are still under threat even within protected areas, to garantee that they will be there in the future.

KEY WORDS: parrotfish, Scarini, Marine Protected Areas, protection effect

INTRODUCTION

Brazilian parrotfishes are threatened by overfishing (Bender et al. 2014, Roos et al. 2016, Pinheiro et al. 2021), and different from another locals around the world, where parrotfishes species face multiple legislations (e.g. Caribbean islands), there it is a single nation to management the fisheries on their endemic parrotfishes species (Ferreira et al. 2004, Floeter et al. 2005, Morais et al. 2017, Hoey et al. 2018, Pinheiro et al. 2021, de Queiroz-Véras et al. 2023). Therefore, little is known about the status of parrotfish populations in Brazil, wich has 7491km of coastline, due to lack of systematic fishing monitoring and does not assess their parrotfish stocks (Pinheiro et al. 2021).

They perform various important ecological processes and are important for brazilian coral reefs (Lellys et al. 2019), such as in aport of biomass, like *Scarus trispinosus* in sites along the coast (Francini-Filho and Moura 2008a, b, Bonaldo et al. 2006, Francini-Filho et al. 2010, Bruce et al. 2012, Giglio et al. 2020). The absence of these species can have disastrous consequences for reef ecosystems (Duffy 2003), as they help maintain the resilience of reefs (Mumby et al. 2006, Hughes et al. 2007). Also, these species can influence the diversity of fish assemblages in different communities (Bellwood et al. 2012).

Worldwide, the decline of large predatory fish populations, such as groupers, snappers, redfish, and tunas (Freire & Pauly 2010, Freitas et al. 2018), driven by increased fishing efforts, has led to a shift in fishing towards large herbivores, making them more vulnerable (Pauly et al. 1998, Duffy 2003). This has drastically impacted parrotfish populations, including Brazilian parrotfish populations, as evidenced by the decline in their biomass (Bender et al. 2014, Bonaldo et al. 2017, Roos et al. 2020a, de Queiroz-Véras et al. 2023). According to the Official List of Endangered Species, some of the Brazilian parrotfish species are threatened by overfishing (Ministerio do Meio Ambiente, Decree No. 445 of 2014). These species are: *Scarus trispinosus* (Endangered: EN), *Scarus zelindae* (Vulnerable: VU), *Sparisoma axillare* (VU), *Sparisoma* *frondosum* (VU), and *Sparisoma rocha* (VU). Recently, the species list was updated, and *Sparisoma amplum* remained excluded from the Decree No. 148 of 2022. However, this species was included in the Parrotfish Recovery Plan (Freitas 2016) due to its similar biological characteristics to the other species and being targeted by fishing activities along the Brazilian coast, as it can reach large sizes (Xavier 2015) and has been classified as Near Threatened (NT) in the Red Book of Threatened Brazilian Fauna (Brasil 2018). Due to the lack of fishing landing monitoring along the coast, it is not possible to confirm compliance with the regulations established in these legislations (Pinheiro et al. 2021).

Marine Protected Areas (MPAs), where fishing is controlled or completely prohibited, when well-planned, are considered an effective tool for conserving biodiversity, maintaining ecosystem functions, providing services, and managing fisheries in reef environments (Cinner et al. 2012, Hackradt et al. 2014, Williams & Graham 2019). There are few studies that evaluate the effectiveness of MPAs considering their managements strategies in the Brazilian coast (Ferreira et al. 2004, Floeter et al. 2006, Floeter et al. 2005, Ferreira et al. 2022).

We assessed the abundance, biomass and size class distribution of five species of parrotfish (*Scarus trispinosus*, *Sc. zelindae*, *Sparisoma amplum*, *Sp. axillare* and *Sp. frondosum*) in different management strategies in six MPAs along the Brazilian coast. We expected that MPAs of Fully protection would increased abundance and biomass of parrotfish species (Francini-Filho and Moura 2008a), and others of Multiple use would show lower abundance and biomass (Francini-Filho and Moura 2008a, b, Bender et al. 2014).

1. MATERIALS AND METHODS

2.1 Sampling sites

The study was carried out in six sites along the Brazilian coast spanning more than 2000km of coastline (Fig. 1). In each site, areas within Marine Protected Areas (MPAs) with different management strategies and adjacent areas where fishing is allowed were sampled: Recife de Corais Environmental Protection Area (APARC), Costa dos Corais Environmental Protection Area (APACC), Recife de Fora Municipal Marine Park

(RFMMP), Abrolhos National Marine Park (ABNMP), Setiba Environmental Protection Area (APASE) and Arraial do Cabo Reserve Extractive (ACREX). The Brazilian National System of Conservation Units of Nature was established by law in 2000 and categorizes MPAs in two groups, Fully Protected and Multiple use. MPAs Fully Protected investigated, equivalent for IUCN were Category II: National Park, and for Multiple Use were Category V: Marine protected landscape and Category VI: Protected are with sustainable use of natural resources (Table 1).

Table 1. Characteristic of Marine Protected Areas (MPA) studied along Brazilian coast. Management Category according to their management intent: no-take areas, extractive reserves and multiple use. IUCN Category equivalent to SNUC, Area: area of MPA (hectares), No-take: areas where fisheries and tourism are forbidden (hectares), Distance: Distance of the coast in kilometers, Year: Year of establishment, Controled by: institution responsible for supervision inside MPA boundaries. Please refer to Fig. 1 for the geographic location of MPAs.

MPA*	**Management Category**	**IUCN Category**	**MPA size**	**No-take**	**Distance**	**Year**	**Controled by**
A. APARC	Multiple use	Marine protected landscape (V)	136.000	631	5	2001	IDEMA[1]
B. APACC	Multiple use	Marine protected landscape (V)	400.000	5.546	-	1997	ICMBio, MMA[2]
C. RFMMP	No-take	National park (II)	1.190	200	1.3	1997	SMMA[3]
D. ABNMP	No-take	National park (II)	80.200	Guarita island	50	1983	ICMBio, MMA[2]
E. APASE	Multiple use	Marine protected landscape (V)	12.960	3	11	1998	IEMA[4]
F. ACREX	Extractive reserve	Protected area with sustainable use of natural resources (VI)	0.05	670	-	1997	ICMBio, MMA[2]

[1]Sustainable Development and Environmental Institute of Rio Grande do Norte[1], [2]Biodiversity Conservation Chico Mendes Institute, Environmental Ministry, [3]Municipal Secretary of Environment of Porto Seguro, Bahia (SMMA), [4]Environmental and Hidric Resources Institute of Espirito Santo state (IEMA).

* Acronyms of MPA names are in accordance with SNUC (2000): Environmental Protection Area (APA), Municipal Park (MMP), National Park (NMP) and Extractive Reserve (RESEX)

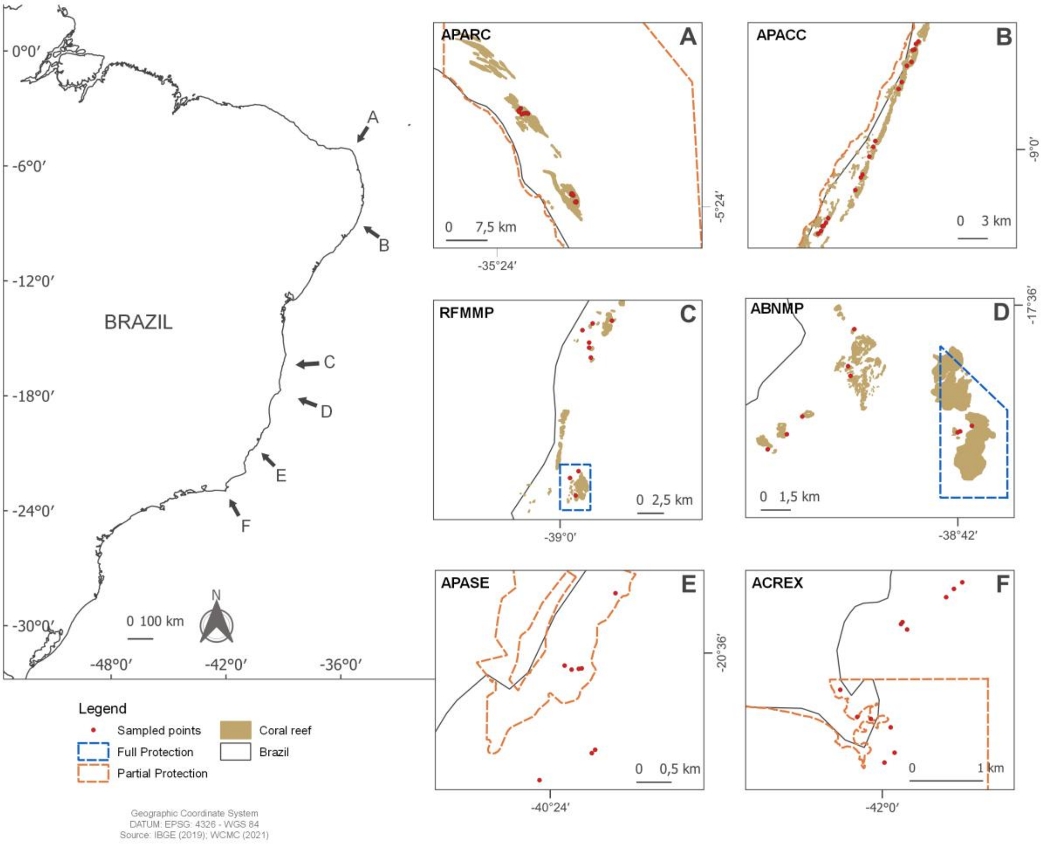

Fig. 1. Map of the Brazilian coast showing the six sites where surveys were conducted. A: Recife de Corais Environmental Protection Area (APARC); B: Costa dos Corais Environmental Protection Area (APACC); Recife de Fora Municipal Marine Park (RFMMP); Abrolhos National Marine Park (ABNMP); Setiba Environmental Protection Area (APASE); and Marine Extractive Reserve of Arraial do Cabo (ACREX). Sampled ploints are the sectors (red dots). Delimitation of MPAs boundaries and Protection Level: Full Protection (blue dashes) and Partial Protection (orange dashes).

2.3 Sampling design

We established a sampling design to evaluate the effectiveness of six MPAs in protecting parrotfish with different management strategies, where in each MPA, zones were selected being: Protected zones (P), Partially Protected zones (PP) and Not Protected (NP) zones. For two MPAs, due their extension, we added a factor called Locality, and in each, two zones were established like mentioned before. In each zone, sectors (S: random factor) were arranged, where a total of 448 visual censuses were conducted (Fig. 1).

In APARC, an orthogonal design was aplied, considering two Localities (2 levels). In each Locality, two zones were sampled, being one Protected (P) and one Partially

Protected (PP), in the first Locality we sampled eight and in second five sectors (Fig. 1A). Due to its size and specific characteristics, an orthogonal design was also used in three different Localities in APACC (Fig. 1B), and in each Locality were established two zones (P vs. PP). The first Locality were sampled 8 sectors, and second and final Locality 6 sectors each. Especifically in APARC and APACC, the PP zones were inside the MPA boundaries, but are open-acess areas. The design was unbalanced for RFMMP and ABNMP (*Beyond*-BACI, Underwood 1994), and three zones were established in each local, being the MPA the Protected zone and the other two Not Protected zones, with 3 sectors each zone (Fig. 1C, D). In APASE were sampled three zones, being the no-take zone Protected, the multiple use area within the MPA being Partially Protected (PP), and Not Protected in adjacent areas, with three sectors in each zone (except for PP, where two sectors were sampled). And finally in ACREX were sampled two zones, being the zone inside the MPA considerer PP, given the Multiple use characteristcs, and the NP zone in adjacent unprotected areas, with six sectors each.

2.4 Accessing parrotfish populations

The data were collected by SCUBA diving visual underwater censuses on transects with an area of 100m² (20x5m) adapted from the Reef Check Brasil methodology (Brasil 2018) throughout January and February 2021. A previously trained diver stretches a measuring tape to mark the transect path and moves at a constant speed (Lincoln Smith 1988, 1989) identifying fish species, estimating individual abundance in a geometric scale (1; 2-5; 6-10; 11-30; 31-50; 51-100; 101-200; 201-500; >500) and estimate their total size in two-centimeter size classes to reduce the error and standardize the estimations between observers (Hackradt et al. 2011). After that, size classes distribution of 10 centimeters were created to evaluate the number of individuals observed in each class (juveniles, adults, and terminal phases). Biomass was calculated using weight-length relationships available in the literature (Robins and Ray 1986, Moura et al. 2001).

2.5 Environmental variables

Environmental variables were accessed to identify how they influence the distribution of these populations and differentiate the zones sampled in each MPA and adjacent areas. Some environmental variables were sampled, like: depth; habitat complexity was assessed with reef inclination (INCLI) and habitat roughness (ROUGH); heterogeinety was evaluated with percentage of sand, reef, rubble (RUBBL) and seagrass (SEAGR). Depht was acessed with dive computer in meters; INCLI in visual scale of degrees of inclination of the reef (0º, 15º, 30º 45º, 60º, 90º); roughness was visually estimated in categories from 1 to 5, with 1 being low and 5 being high (Gratwicke & Speight 2005); heterogeinety was a visual estimative of percentage (%) on habitat characteristics mentioned before.

Benthic communities was assessed through substrate coverage census using the PIT (Point Intercept Transect) method were the benthic community is sampled only at fixed intervals and without measuring its size, simplifying the sampling and increasing efficiency (Hill & Wilkinson 2004, Facon et al. 2016). We used 50cm intervals (Hodgson 1999; Brazil 2018), totaling 40 points along the transect. The observed organisms were: Encrusting Coralline Algae (ECA), Articulated Coralline Algae (ACA), Macroalgae (MC), Algae Turf (AT), Soft Coral (SC), Branched Soft Coral (BSC), Hard Coral (HC), Sea Urchins (SU) and Sponges (SP).

2.6 Data analysis

We evaluated the correlation between environmental variables using the Spearman correlation coefficient (r), whose values can vary between -1 (inverse relationships) and +1. Values indicate the magnitude of the correlation between the variables, which can be classified as “weak” ($0.1 < | r | < 0.39$), “moderate” ($0.39 < | r | < 0.69$) or “strong” ($0.70 < | r | < 1.00$) (Burnham and Anderson 2004). When two predictors showed strong correlation, the most explanatory variable was selected using published literature of habitat preferences of parrotfishes (Bonaldo et al. 2014) and then was used in the Principal Component Analysis (PCA) (Table S1 to S6). We used a PCA for each site separetly, to evaluate the similarity between zones (P x PP x NP), to summarize the data and identify directions along the variation using the ‘vegan’ package (Oksanen et al. 2008).

Data analysis was conducted to understand the differences in abundance, biomass, and size of parrotfish between zones in each MPAs studied, therefore, a Permutation analysis of variance (PERMANOVA) was performed using the software Primer v.6.1.15 with the Permanova v.1.0.5 extension, using 9999 permutations and a significance level of $p<0.05$. Abundance, biomass, and size (Univariate and Multivariate: species composition) data were used to assess the potential response to different types of protection under parrotfish species.

To assess the relationship between parrotfish abundance with the environmental variables, firstly to decide whether analysis apply, linear or unimodal ordination method, we calculated DCA (detrended by segments) on data, and check the length of the first DCA axis (Lepš and Šmilauer 2003). The dataset was homogeneous, so we applied a linear method, a redundancy analysis (RDA), with the package 'vegan'(Oksanen et al. 2008). Non variables had a variance inflation factor (VIF) >3, so all habitat characteristics were used in the analysis (Zuur et al. 2010). All previous analyses were performed in R version 4.0.4 (R Core Team 2015, www.r-project.org).

2. RESULTS

2.1 Habitat characteristics

In APARC, the Partial Protected zone was characterized as being more complex and deeper than the Protected, besides that, the distribution of samples of Protection factor are separeted when we observe the PCA plot (Fig. 2A). In APACC, the PCA revealed that the Protected and Partial Protected zones of APACC had similar characteristics, with a considerable overlap of samples between these areas (Fig. 2B).

In RFMMP, the Protected zone was more homogeneous in relation to Rubble and HC than the Not Protected (Fig. 2C). In ABNMP, the NP zone had higher coverage of SC and BSC, while P zone had more coverage of AT and SP (Fig. 2D). ABNMP was the only MPA that showed significant differences in the Protection factor for abundance, and also average size (Table 2, Table 4). Environmental and benthic coverage variables in RFMMP and ABNMP had the highest variance explanations of PCs (approximately 38%).

In APASE, the PP zone had more MC and Reef, while P had more Sand and BSC and in the NP zone, there was greater variation in environmental variables (Fig. 2E). In the

ACREX, there was a clear separation between samples within the PP (with a lot of Sand, Rubble, and SC) and NP, which was deeper and had more HC, MC and Seagrass (Fig. 2F).

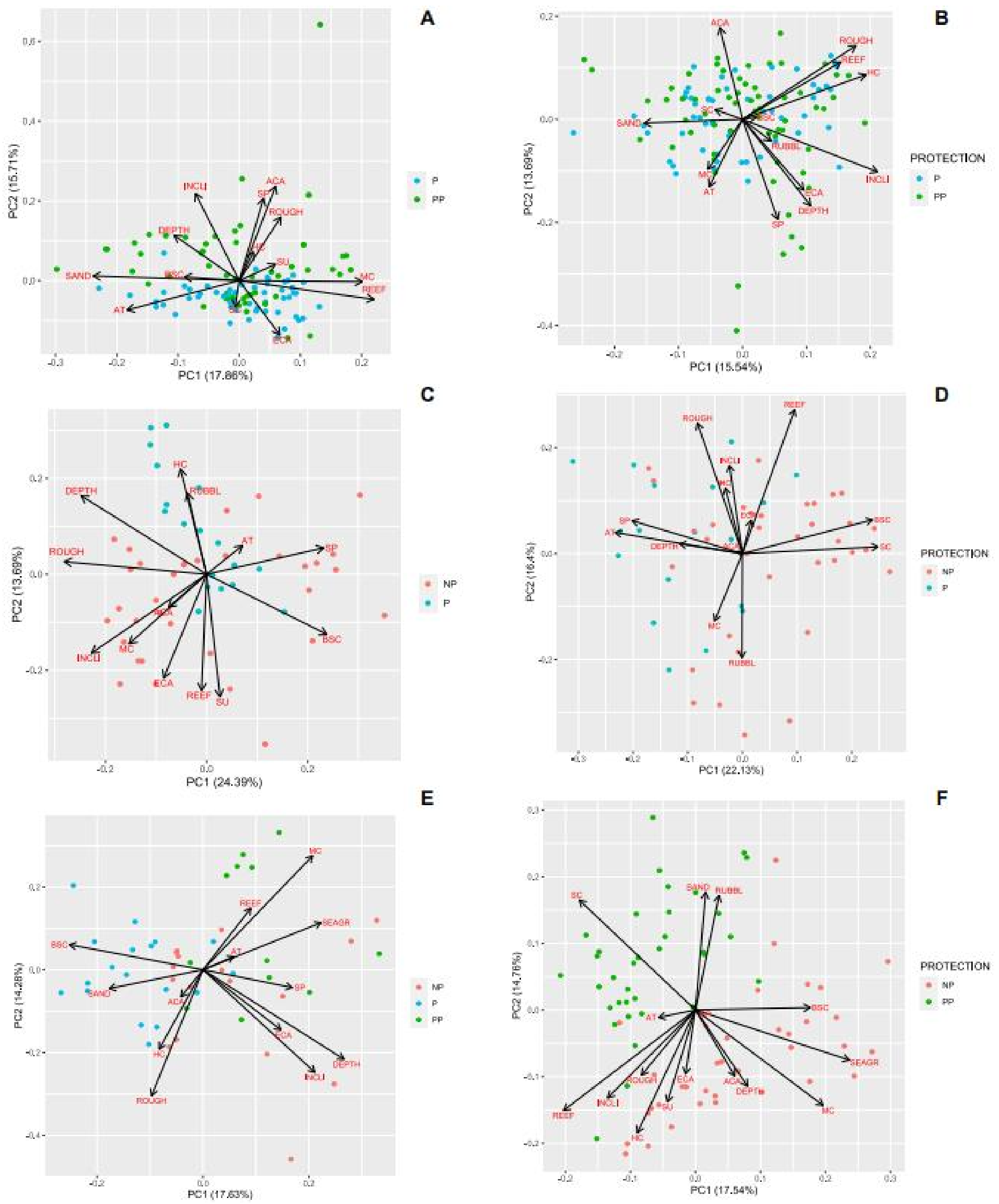

Fig. 2. Principal Component Analysis (PCA) for each site with environmental variables and benthic community. A: APARC, B: APACC, C: RFMMP, D: ABNMP, E: APASE and F: ACREX. NP: Not Protected, P: Protected and PP: Partially Protected. INCLI: Inclination, ROUGH: Roughness, RUBBL: Rubble, SEAGR: Seagrass, ECA: Encrusting Coralline Algae , ACA: Articulated Coralline Algae, MC: Macroalgae, AT: Algae Turf, SC: Soft Coral, BSC: Branched Soft Coral, HC: Hard Coral, SU: Sea Urchin and SP: Sponges.

2.2 Parrotfish abundance and biomass

In APARC, APACC, RFMMP, APASE and ACREX the abundance of parrotfish was similar between zones (Fig. 3). Only in ABNMP the average abundance of all parrotfish species was higher within the Protected area (Fig. 3D). In APASE and ACREX non individuals of *Sc. trispinosus* were observed. *Sparisoma amplum* was also not observed in LR (Fig. 3E, F). *Sp. axillare* have higher abundance in PP and NP zones (except ABNMP). Only for ABNMP was found a significant difference for abundance in the Protection factor for both univariated (F=26.75, p<0.0005), being the total abundance of parrotfishes, and multivariated (F=11.25, p<0.0005), being the parrotfish species composition (Table 2).

In APACC the mean biomass of *Scarus trispinosus* is higher in the Protected zone (Fig. 4A). Also, in ABNMP we can see that the average biomass of *Sc. trispinosus* is higher than all other species, causing the mean values of the others to be flattened (Fig. 4D). The PERMANOVA analysis with biomass of parrotfishes not showed significant values for the Protection factor (Table 3), but the results with average size of parrotfishes showed significant differences in the composition of species for ABNMP (F=4.43, p<0.005), explained by the occurrence of large individuals (>50cm, Fig. 5). APASE also showed significant diferences in the total size average of parrotfishes for Protection factor (F=9.07, 0<0.005, Table 4), where we observed for *Sparisoma axillare* large individuals in the Protected zone and for *Sp. frondosum* large individuals in the Partially Protected zone (>20cm, Fig. 5).

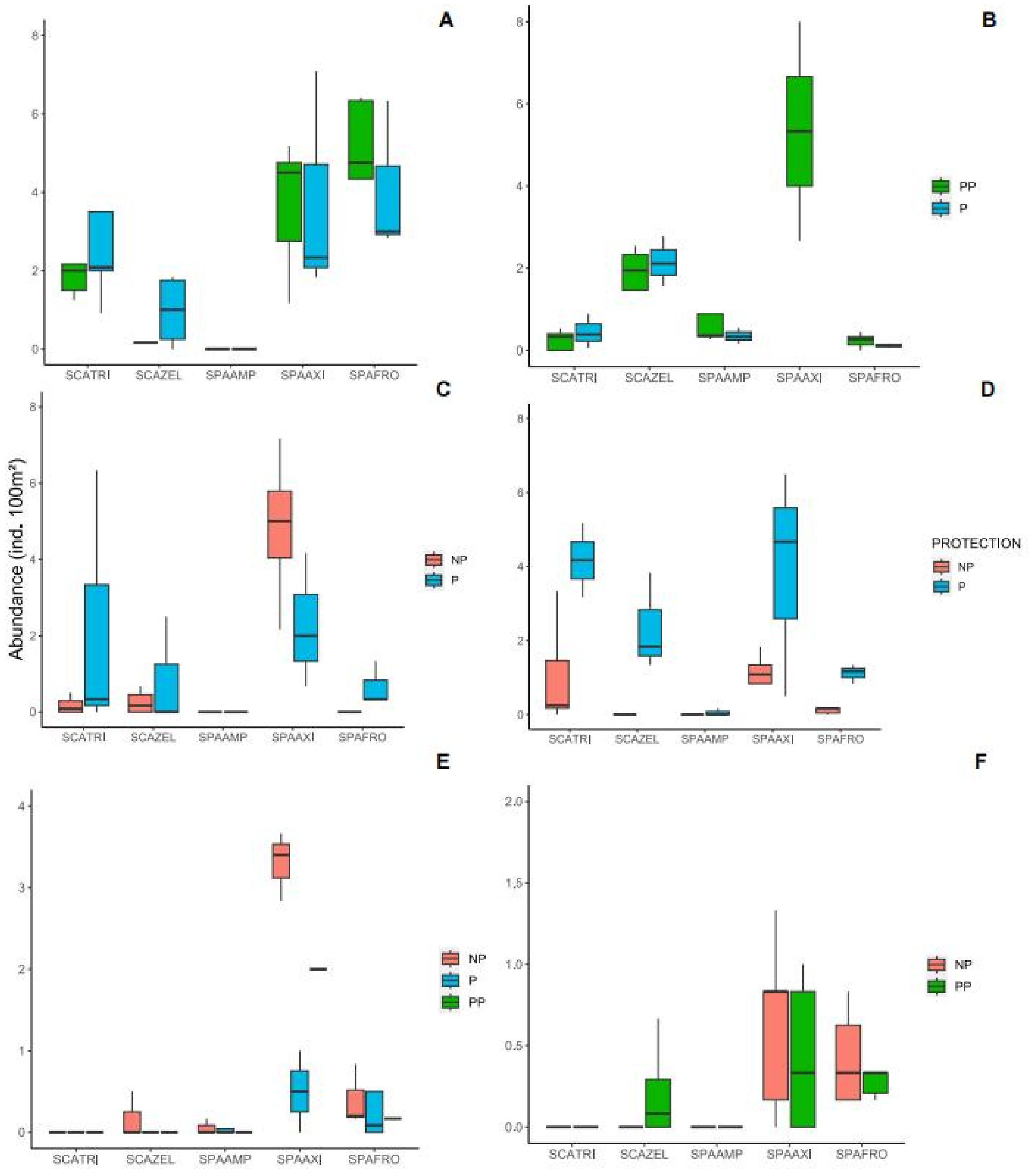

Fig. 3. Abundance (ind. 100m²) of parrotfishes species in each site with Protection factor in evidence. A: APARC, B: APACC, C: RFMMP, D: ABNMP, E: APASE and F: ACREX. NP: Not Protected (salmon), P: Protected (blue) and PP: Partially Protected (green). SCATRI: *Scarus trispinosus*, SCAZEL: *Scarus zelindae*, SPAAMP: *Sparisoma amplum*, SPAAXI: *Sparisoma axillare*, SPAFRO: *Sparisoma frondosum* and SPARAD: *Sparisoma radians*. Boxes indicate the quantiles, bars indicate mean values, different colors indicate Protection and whiskers represents the standard error. Please refer to Fig. 1 for MPAs names.

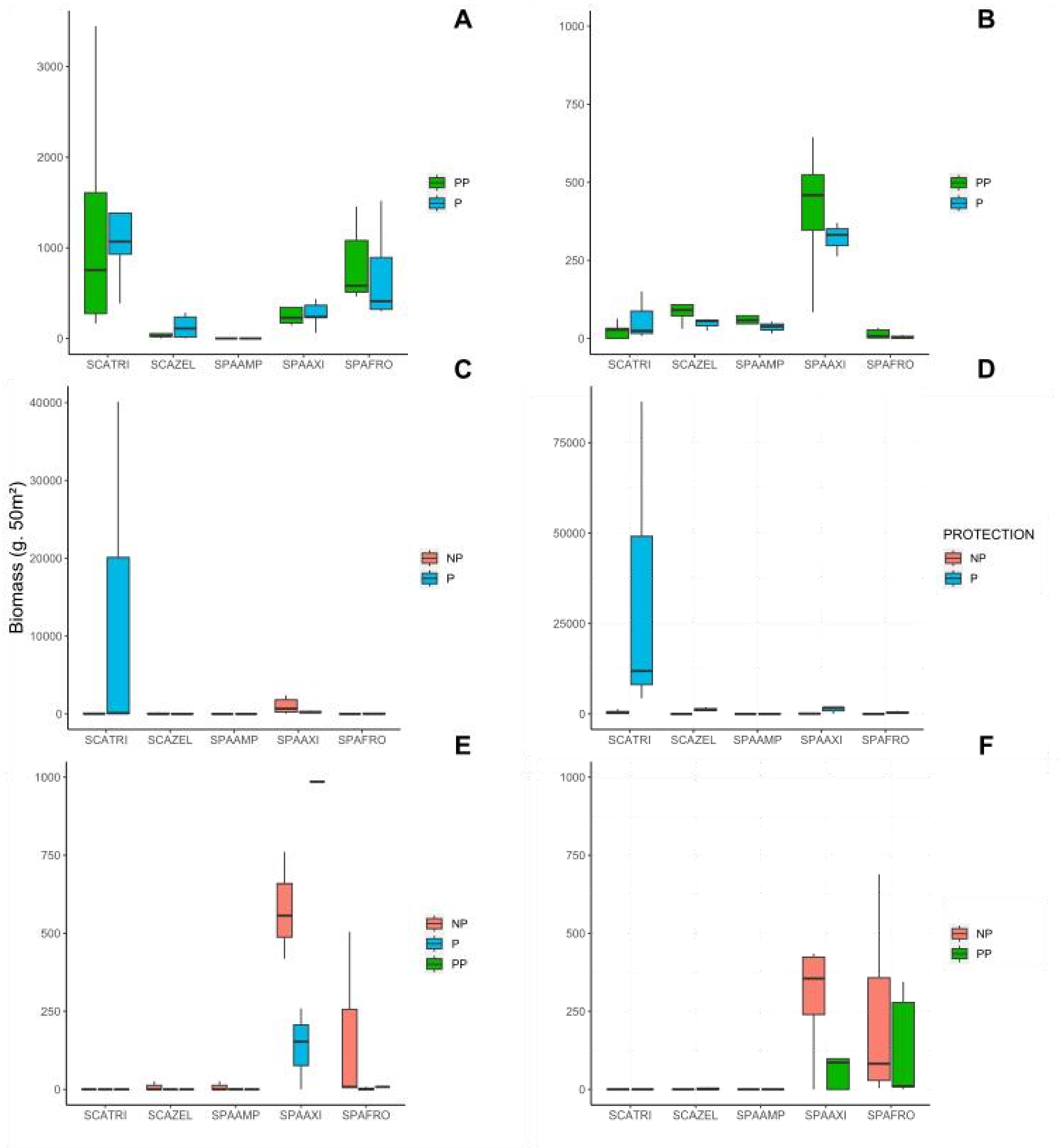

Fig. 4. Biomass (g. 100m²) of parrotfishes species in each site with Protection factor in evidence. A: APARC, B: APACC, C: RFMMP, D: ABNMP, E: APASE and F: ACREX. NP: Not Protected (salmon), P: Protected (blue) and PP: Partially Protected (green). SCATRI: *Scarus trispinosus*, SCAZEL: *Scarus zelindae*, SPAAMP: *Sparisoma amplum*, SPAAXI: *Sparisoma axillare*, SPAFRO: *Sparisoma frondosum* and SPARAD: *Sparisoma radians*. Boxes indicate the quantiles, bars indicate mean values, different colors indicate Protection and whiskers represents the standard error. Please refer to Fig. 1 for MPAs names.

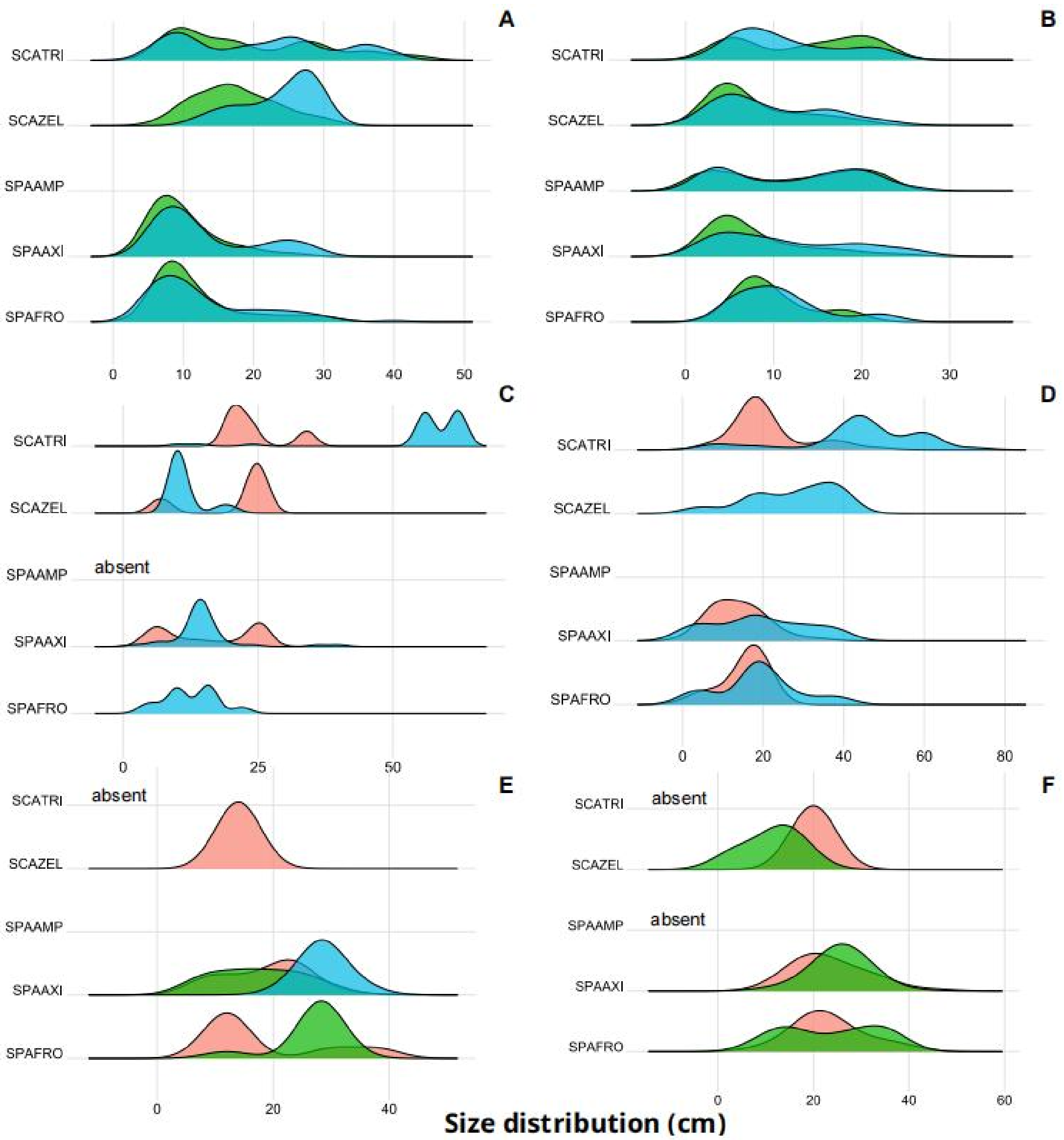

Fig. 5. Size distribution (densities) of parrotfishes species in each site with Protection factor in evidence. A: APARC, B: APACC, C: RFMMP, D: ABNMP, E: APASE and F: ACREX. NP: Not Protected (salmon), P: Protected (blue) and PP: Partially Protected (green). SCATRI: *Scarus trispinosus*, SCAZEL: *Scarus zelindae*, SPAAMP: *Sparisoma amplum*, SPAAXI: *Sparisoma axillare*, SPAFRO: *Sparisoma frondosum* and SPARAD: *Sparisoma radians*. Please refer to Fig. 1 for MPAs names.

Table 2. PERMANOVA of Univariate and Multivariate Abundance of parrotfishes for each Local: APARC, APACC, RFMMP, ABNMP, APSE and ACREX. L: Localities, SE: Sectors, DF: Degrees of Freedom and SQ: Sum of Squares. Bold cells means significant values p<0.05. Please refer to Fig. 1 for MPAs names.

Factors	DF	APARC Abundance Uni.		APARC Abundance Multi.		DF	APACC Abundance Uni.		APACC Abundance Multi.	
		Pseudo-F	P(perm)	Pseudo-F	P(perm)		Pseudo-F	P(perm)	Pseudo-F	P(perm)
LO	1	11,945	**0,0497**	2,5247	0,1366	2	4,2128	0,1018	3,4748	**0,0256**
Protection(LO)	2	0,17739	0,8478	0,96923	0,4545	4	1,2301	0,3438	1,562	0,1255
SE(Protection(LO))	14	5,2651	**0,0001**	2,6879	**0,0001**	14	1,3349	0,2033	1,1978	0,2129
Fatores	DF	RFMMP Abundance Uni.		RFMMP Abundance Multi.		DF	ABNMP Abundance Uni.		ABNMP Abundance Multi.	
		Pseudo-F	P(perm)	Pseudo-F	P(perm)		Pseudo-F	P(perm)	Pseudo-F	P(perm)
Protection	2	1,2729	0,351	2,5579	0,0695	2	26,751	**0,0001**	11,257	**0,0001**
SEC(Protection)	6	1,6697	0,1718	1,6072	0,1064	6	0,91303	0,5021	0,84066	0,6293
Fatores	DF	APASE Abundance Uni.		APASE Abundance Multi.		DF	ACREX Abundance Uni.		ACREX Abundance Multi.	
		Pseudo-F	P(perm)	Pseudo-F	P(perm)		Pseudo-F	P(perm)	Pseudo-F	P(perm)
Protection	2	3,9834	0,1056	3,4106	0,0695	1	1,8717	0,2058	1,3952	0,2725
SEC(Protection)	5	0,89982	0,4985	1,2632	0,2878	10	1,9287	0,0633	1,8531	**0,0131**

Table 3. PERMANOVA of Univariate and Multivariate Biomass of parrotfishes for each Local: APARC, APACC, RFMMP, ABNMP, APSE and ACREX. L: Localities, SE: Sectors, DF: Degrees of Freedom and SQ: Sum of Squares. Bold cells means significant values p<0.05. Please refer to Fig. 1 for MPAs names.

Factors	DF	APARC Biomass Uni.		APARC Biomass Multi.		DF	APACC Biomass Uni.		APACC Biomass Multi.	
		Pseudo-F	P(perm)	Pseudo-F	P(perm)		Pseudo-F	P(perm)	Pseudo-F	P(perm)
LO	1	0,89669	0,4755	0,27913	0,7994	2	7,0884	**0,0499**	4,2972	0,0633
Protection(LO)	2	0,4032	0,6739	1,6642	0,2055	4	0,52413	0,7244	0,55033	0,7315
SE(Protection(LO))	14	2,4284	**0,0118**	1,6559	0,0651	13	1,2508	0,2519	1,1535	0,3121
Factors	DF	RFMMP Abundance Uni.		RFMMP Abundance Multi.		DF	ABNMP Abundance Uni.		ABNMP Abundance Multi.	

		Pseudo-F	P(perm)	Pseudo-F	P(perm)		Pseudo-F	P(perm)	Pseudo-F	P(perm)
Protection	2	0,75226	0,5858	0,74171	0,5898	2	0,2898	0,762	0,26605	0,7744
SEC(Protection)	6	5,1505	**0,0018**	5,4481	**0,0012**	6	2,1549	0,0515	2,2596	**0,0464**
Factors	DF	APASE Abundance Uni.		APASE Abundance Multi.		DF	ACREX Abundance Uni.		ACREX Abundance Multi.	
		Pseudo-F	P(perm)	Pseudo-F	P(perm)		Pseudo-F	P(perm)	Pseudo-F	P(perm)
Protection	2	0,50099	0,6183	0,91594	0,4376	1	7,91E-02	0,7836	1,56E-01	0,8914
SEC(Protection)	5	1,0762	0,3887	1,0407	0,4091	10	3,1863	**0,0041**	2,1343	**0,0109**

Table 4. PERMANOVA of Univariate and Multivariate average Size of parrotfishes for each Local: APARC, APACC, RFMMP, ABNMP, APSE and ACREX. L: Localities, SE: Sectors, DF: Degrees of Freedom and SQ: Sum of Squares. Bold cells means significant values p<0.05. Please refer to Fig. 1 for MPAs names.

Factors	DF	APARC Abundance Uni.		APARC Abundance Multi.		DF	APACC Abundance Uni.		APACC Abundance Multi.	
		Pseudo-F	P(perm)	Pseudo-F	P(perm)		Pseudo-F	P(perm)	Pseudo-F	P(perm)
LO	1	5,7433	0,1402	1,6427	0,2722	2	1,6316	0,3032	2,1738	0,0623
Protection(LO)	2	0,05301	0,95	0,46924	0,838	4	0,99557	0,4453	1,5123	0,1166
SE(Protection(LO))	14	2,8532	**0,0015**	2,5147	**0,0001**	13	1,5861	0,105	1,3626	**0,0489**
Fatores	DF	RFMMP Abundance Uni.		RFMMP Abundance Multi.		DF	ABNMP Abundance Uni.		ABNMP Abundance Multi.	
		Pseudo-F	P(perm)	Pseudo-F	P(perm)		Pseudo-F	P(perm)	Pseudo-F	P(perm)
Protection	2	0,17072	0,8479	1,7133	0,1498	2	4,8393	0,055	4,4386	**0,0055**
SEC(Protection)	6	2,9933	**0,0203**	1,4592	0,1293	6	1,8889	0,1169	1,1062	0,3669
Fatores	DF	APASE Abundance Uni.		APASE Abundance Multi.		DF	ACREX Abundance Uni.		ACREX Abundance Multi.	
		Pseudo-F	P(perm)	Pseudo-F	P(perm)		Pseudo-F	P(perm)	Pseudo-F	P(perm)
Protection	2	9,0739	**0,0059**	3,914	**0,0093**	1	0,00054784	0,9818	1,8324	0,1767
SEC(Protection)	5	1,3929	0,2617	2,0671	**0,0303**	10	4,8506	**0,0001**	1,8953	**0,0174**

Scarus trispinosus was mainly associated with complex reefs with higher cover of coralline algae (ECA) and *Sparisoma frondosum* shared similar characteristics but also was associated with MC. *Sc. zelindae*, *Sp. amplum* and *Sp. axillare* were associated with similar habitat characteristics, high cover of HC and ECA. *Sparisoma radians* was associated with deeper reefs with sponges and BSC (Fig. 6).

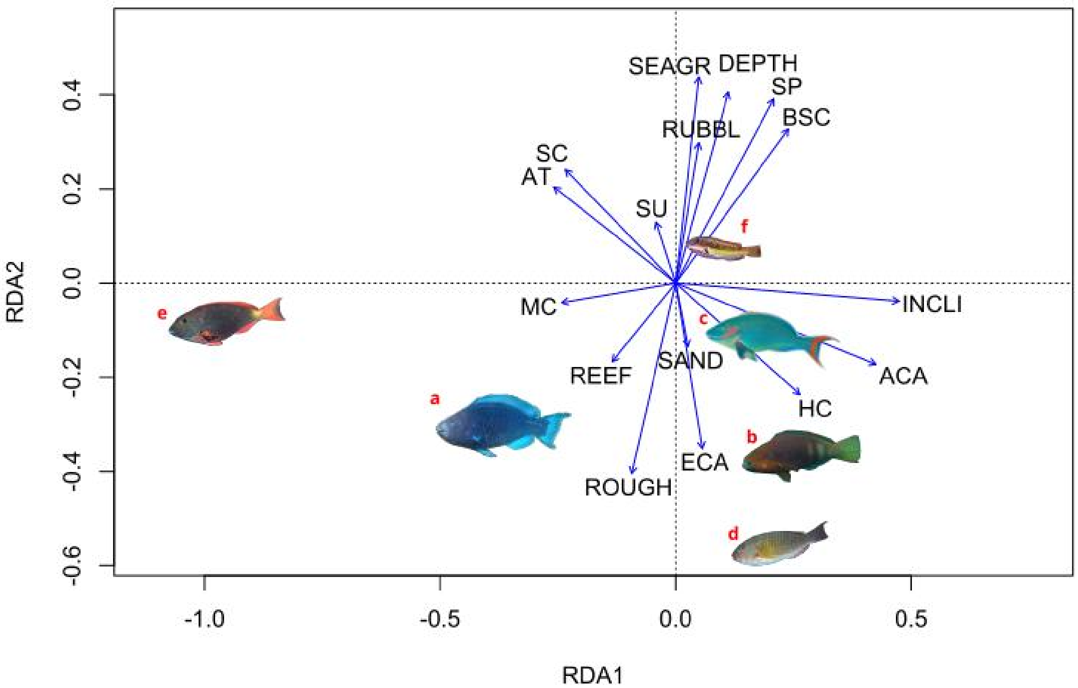

Fig. 6. RDA with abundance data for all sites together with environmental variables and benthic community. a: *Scarus trispinosus*, b: *Scarus zelindae*, c: *Sparisoma amplum*, d: *Sparisoma axillare*, e: *Sparisoma frondosum*, f: *Sparisoma radians*. INCLI: Inclination, ROUGH: Roughness, RUBBL: Rubble, SEAGR: Seagrass, ECA: Encrusting Coralline Algae , ACA: Articulated Coralline Algae, MC: Macroalgae, AT: Algae Turf, SC: Soft Coral, BSC: Branched Soft Coral, HC: Hard Coral, SU: Sea Urchin and SP: Sponges. Please refer to Fig. 1 for the names of MPAs.

3. DISCUSSION

The present study is the largest research focused on parrotfishes (in terms of extension, number of MPAs embraced and species of parrotfish sampled), evaluating the role of different Brazilian management strategies in the maintenance of endangered and endemic species. Another studies in brazilian coast also evaluated MPAs effectiveness (Ferreira et al. 2004, Floeter et al. 2005, 2006, Ferreira et al. 2022), but not focused in parrotfish threatened by overfishing (Bender et al. 2014, Roos et al. 2016, Pinheiro et al. 2021). So, why MPAs of Multiple use are not working to protectec endemic parrotfish? Here, the effect of protection was observed more significantly in the Fully Protected MPA of ABNMP. These MPA is the oldest, further from the coast and also enforced since the 80’s (Leão 1999). In these site, we have evidence that the abundance and biomass of threatened parrotfish species are higher, demonstrating that areas with fishing exclusion recover these species (Francini-Filho and Moura 2008a), results also observe in this research.

Small MPAs have been shown to be effective in increasing species richness, fish group diversity, and favoring ecological processes such as herbivory, coral cover, and higher parrotfish density and biomass (Ferreira et al. 2005, Francini-Filho and Moura 2008a,b, Bonaldo et al. 2017, Roos et al. 2020a). Evidence of spillover, when fish biomass spills over the boundaries of the protected area, demonstrated that the blue parrotfish (“budião-azul”) biomass was low before the area implementation (Francini-Filho & Moura 2008b, Harmelin-Vivien et al. 2008, Halpern et al. 2010). MPAs of Fully Protection can also play an essential role in maintaining the genetic diversity of Brazilian parrotfish (Bezerra et al. 2018). Recently was found that the overall abundance of *Sc. trispinosus* population in ABNMP has decreased over time, even within the Protected area (Roos et al. 2020a). Seagrass habitats and macroalgae banks are known to sustain high abundance of juvenile parrotfish (nursery), but lack protection and are currently in decline (Chaves et al. 2010, Roos et al. 2019, 2020a). In this research, *Scarus trispinosus* was associated with reefs with higher roughness and cover of caralline algae, and *Sparisoma frondosum* had similar relationship with *Sc. trispinosus*, but more related to MC, and these results are similar to other studies (Roos et al. 2019).

A new brazilian management strategy published in 2019 called Inverted Management Strategy (Pinheiro et al. 2021) allows threatened species to be caught in Multiple use MPAs but prohibits it in any other location. As pointed out by the authors, currently fishing occurs freely and without monitoring throughout the coast. In addition, the study suggested widespread communication and prohibition of fishing for threatened species until management plans are implemented, and only after proving the effectiveness of this strategy for parrotfishes should it be applied to other threatened species (Pinheiro et al. 2021). Freitas and colleagues (2019) point out, despite the critical state we have, for example, for *Sc. trispinosus*, we need to recognize that totally prohibiting fishing in remote locations is not effective. Research has shown that Fully Protected MPAs in Brazil take longer to show the effects of protection compared to other countries (Giakoumi et al., 2017; Goetze et al., 2021). In Bermuda, conservation measures have been implemented since 1990 that have been rapidly effective in the recovery of parrotfish populations (O'Farrel et al. 2016). Other examples of Public Policies implemented on parrotfish management and protection around the world have been implemented in Belize, Honduras, Guatemala, and Mexico (Cox et al. 2013, Cannon 2018, SEGOB 2019, Healthy Reefs 2021). Nevertheless, evidence has been found that Fully protected areas can be effective even when they are recent and surrounded by intense fishing pressure (Floeter et al., 2006; Ferreira et al., 2022).

A study conducted through interviews in the municipalities within APACC showed that the population of *Sc. trispinosus* suffered from overfishing, where fishermen noticed a decrease in the number of individuals caught as well as their biomass (Pereira et al. 2021a), which in our results the abundance of *Sc. trispinosus* is low. Study have shown population collapse of *Sc. trispinosus* in Arraial do Cabo (Bender et al. 2014), as well as suggest local functional extinction (Floeter et al. 2008), and in this study, the species was not observed. In another study, *Sp. axillare* and *Sc. zelindae* were only observed in the eastern part of Arraial do Cabo, where temperatures are higher, the reefs are shallower, and not affected by wave action as in the western part, where the phenomenon of upwelling occurs (Cordeiro et al. 2015). When we look at the results of abundance of ACREX, we can see that *Sc. zelindae* has a higher abundance in the Partially Protected area, while in the Not Protected area it is absent, and also was associated with Seagrass. Categories of Multiple use present low abundances of *Sc. trispinosus*, *Sp. amplum*, and *Sp. frondosum*, similar to Not Protected areas (Francini-Filho and Moura 2008a, b, Bender et al. 2014), and these pattern can be observed in the results, when we observe APARC, APACC, APASE and ACREX.

The species of the *Sparisoma* genus reach larger sizes and have also become a target of fishing, and their populations are at risk (Pinheiro et al. 2010, Nunes et al. 2012). *Sp.*

axillare was the only species that showed higher abundances outside the Protected areas compared to the adjacent MPAs (Francini-Filho and Moura 2008a, b). This may be related to the species habitat plasticity, which can adapt to the harsh conditions of highly fished and algae-dominated areas (Ferreira et al. 2004). In this study, it was no different, the abundance of *Sp. axillare* was also higher in the Not Protected areas, except for ABNMP. *Sp. amplum* commonly presents higher abundances in Fully Protected reserves within oceanic and coastal islands such as Fernando de Noronha, Atol das Rocas, Trindade, and Abrolhos (Rosa and Moura 1997, Gasparini and Floeter 2001, Rocha and Rosa 2001, Ferreira et al. 2004, Francini-Filho and Moura 2008a, b, Hoey et al. 2018).

CONCLUSION

It is clear that the marine ecosystems along the Brazilian coast are facing significant threats due to human activities such as overfishing, pollution, and climate change (Hatje and Barros 2012, Tedesco et al. 2017, Nunes et al. 2021, Oliveira et al. 2021, Pereira et al. 2021b). However, the establishment of Marine Protected Areas (MPAs) has shown promising results in conserving marine biodiversity and mitigating the negative impacts of these threats around the world (Cinner et al. 2012, Hackradt et al. 2014, Williams and Graham 2019). Several studies have demonstrated the effectiveness of MPAs in protecting and increasing the abundance of fish species which are important for the ecological functioning of coral reefs. However, other species, such as *Scarus trispinosus*, have experienced population collapses and functional extinction, despite being protected in MPAs (Bender et al. 2014, Roos et al. 2020a, Pereira et al. 2021b, de Queiroz-Véras et al. 2023). The data revealed that Fully Protected areas have higher fish abundances and larger sizes, indicating that they are effective in providing refuge. While MPAs have proven to be effective tools in marine conservation, there is still much work to be done to ensure the long-term sustainability of marine ecosystems. However, the findings also suggest that additional measures are needed to effectively conserve some species that are still under threat even within protected areas, such as *Scarus trispinosus*, to garantee that they will be there in the future.

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Supplementary Information

Effect of protection on parrotfish species (Labridae: Scarini) along the Brazilian coast in different management strategies

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Table S1. Spearman correlation test between environmental variables and benthic community to APARC. Result: No correlation between variables.

	DEPTH	INCLI	ROUGH	SAND	REEF	ECA	ACA	MC	AT	SC	BSC	HC	SU	SP
DEPTH		0,29	0,04	0,27	-0,14	-0,20	0,05	0,07	0,25	-0,23	0,12	-0,11	0,05	0,12
INCLI	0,29		0,18	0,11	-0,28	-0,22	0,38	-0,11	0,00	-0,22	-0,02	0,18	-0,04	0,18
ROUGH	0,04	0,18		-0,14	-0,06	-0,16	0,19	0,13	-0,28	-0,03	0,03	0,19	0,20	0,16
SAND	0,27	0,11	-0,14		-0,67	-0,13	-0,14	-0,43	0,20	0,00	0,17	0,00	-0,06	-0,09
REEF	-0,14	-0,28	-0,06	-0,67		0,13	0,14	0,40	-0,16	-0,02	-0,12	-0,10	0,06	0,08
ECA	-0,20	-0,22	-0,16	-0,13	0,13		-0,18	0,05	-0,11	-0,10	-0,08	-0,11	-0,13	-0,08
ACA	0,05	0,38	0,19	-0,14	0,14	-0,18		-0,06	-0,24	-0,08	-0,03	-0,09	-0,05	0,65
MC	0,07	-0,11	0,13	-0,43	0,40	0,05	-0,06		-0,46	-0,32	-0,13	-0,04	0,14	-0,10
AT	0,25	0,00	-0,28	0,20	-0,16	-0,11	-0,24	-0,46		-0,17	0,13	-0,29	-0,17	-0,12
SC	-0,23	-0,22	-0,03	0,00	-0,02	-0,10	-0,08	-0,32	-0,17		-0,03	-0,12	0,04	0,00
BSC	0,12	-0,02	0,03	0,17	-0,12	-0,08	-0,03	-0,13	0,13	-0,03		-0,05	-0,02	-0,01
HC	-0,11	0,18	0,19	0,00	-0,10	-0,11	-0,09	-0,04	-0,29	-0,12	-0,05		0,14	-0,01
SU	0,05	-0,04	0,20	-0,06	0,06	-0,13	-0,05	0,14	-0,17	0,04	-0,02	0,14		-0,02
SP	0,12	0,18	0,16	-0,09	0,08	-0,08	0,65	-0,10	-0,12	0,00	-0,01	-0,01	-0,02	

Table S2. Spearman correlation test between environmental variables and benthic community to APACC. Result: No correlation between variables.

	DEPTH	INCLI	ROUGH	SAND	REEF	RUBBL	ECA	ACA	MC	AT	SC	BSC	HC	SP
DEPTH		0,38	0,00	-0,03	-0,13	-0,07	0,25	-0,13	-0,17	0,09	-0,19	0,07	0,03	0,25

INCLI	0,38		0,25	-0,23	0,18	0,16	0,20	-0,23	-0,02	-0,04	-0,07	0,00	0,25	0,20
ROUGH	0,00	0,25		-0,17	0,32	0,06	-0,01	0,01	-0,27	-0,09	-0,13	0,07	0,36	-0,27
SAND	-0,03	-0,23	-0,17		-0,33	-0,06	-0,19	-0,19	-0,06	-0,11	-0,10	0,00	-0,20	-0,16
REEF	-0,13	0,18	0,32	-0,33		-0,01	0,04	0,13	0,16	-0,08	0,03	-0,16	0,32	-0,05
RUBBL	-0,07	0,16	0,06	-0,06	-0,01		0,06	-0,12	0,00	-0,07	-0,03	-0,05	-0,05	0,08
ECA	0,25	0,20	-0,01	-0,19	0,04	0,06		-0,14	0,02	-0,04	-0,03	-0,01	-0,06	0,20
ACA	-0,13	-0,23	0,01	-0,19	0,13	-0,12	-0,14		-0,31	-0,28	-0,07	-0,10	-0,19	-0,14
MC	-0,17	-0,02	-0,27	-0,06	0,16	0,00	0,02	-0,31		0,08	0,04	-0,11	-0,19	0,08
AT	0,09	-0,04	-0,09	-0,11	-0,08	-0,07	-0,04	-0,28	0,08		0,06	-0,08	-0,27	0,09
SC	-0,19	-0,07	-0,13	-0,10	0,03	-0,03	-0,03	-0,07	0,04	0,06		-0,03	-0,01	-0,06
BSC	0,07	0,00	0,07	0,00	-0,16	-0,05	-0,01	-0,10	-0,11	-0,08	-0,03		0,10	-0,05
HC	0,03	0,25	0,36	-0,20	0,32	-0,05	-0,06	-0,19	-0,19	-0,27	-0,01	0,10		0,04
SP	0,25	0,20	-0,27	-0,16	-0,05	0,08	0,20	-0,14	0,08	0,09	-0,06	-0,05	0,04	

Table S3. Spearman correlation test between environmental variables and benthic community to RFMMP. Result: exclusion of SC, Sand and Seagrass.

	DEPTH	**INCLI**	**ROUGH**	**SAND**	**REEF**	**RUBBL**	**SEAGR**	**ECA**	**ACA**	**MC**	**AT**	**SC**	**BSC**	**HC**	**SU**	**SP**
DEPTH		0,31	0,62	0,26	-0,26	0,12	0,14	0,06	0,09	0,24	-0,19	-0,50	-0,51	0,21	-0,22	-0,39
INCLI	0,31		0,44	-0,28	0,24	0,19	-0,34	0,25	0,23	0,34	-0,28	-0,49	-0,31	0,00	0,17	-0,44
ROUGH	0,62	0,44		0,03	-0,04	0,09	-0,02	0,30	0,22	0,29	0,03	-0,72	-0,57	0,06	-0,11	-0,54
SAND	0,26	-0,28	0,03		-0,97	0,10	**0,88**	-0,22	-0,11	0,10	-0,05	-0,13	-0,05	-0,14	-0,03	0,20
REEF	-0,26	0,24	-0,04	**-0,97**		-0,31	**-0,86**	0,23	0,10	-0,05	-0,02	0,15	0,07	0,14	0,05	-0,20
RUBBL	0,12	0,19	0,09	0,10	-0,31		-0,06	-0,08	-0,02	-0,18	0,31	-0,12	-0,10	-0,10	-0,07	-0,10
SEAGR	0,14	-0,34	-0,02	0,88	-0,86	-0,06		-0,22	-0,04	0,11	-0,12	-0,09	-0,06	-0,06	-0,09	0,37
ACI	0,06	0,25	0,30	-0,22	0,23	-0,08	-0,22		-0,06	-0,01	0,04	-0,13	-0,08	-0,32	0,05	-0,16
ACA	0,09	0,23	0,22	-0,11	0,10	-0,02	-0,04	-0,06		-0,07	-0,03	-0,19	-0,18	-0,33	-0,09	-0,04
MC	0,24	0,34	0,29	0,10	-0,05	-0,18	0,11	-0,01	-0,07		-0,42	-0,35	-0,25	-0,19	0,18	-0,22
TF	-0,19	-0,28	0,03	-0,05	-0,02	0,31	-0,12	0,04	-0,03	-0,42		-0,10	-0,08	-0,27	0,12	0,01
CMi	-0,50	-0,49	**-0,72**	-0,13	0,15	-0,12	-0,09	-0,13	-0,19	-0,35	-0,10		0,57	-0,10	-0,03	0,44
CMr	-0,51	-0,31	-0,57	-0,05	0,07	-0,10	-0,06	-0,08	-0,18	-0,25	-0,08	0,57		-0,24	0,17	0,37
CD	0,21	0,00	0,06	-0,14	0,14	-0,10	-0,06	-0,32	-0,33	-0,19	-0,27	-0,10	-0,24		-0,26	-0,19
OU	-0,22	0,17	-0,11	-0,03	0,05	-0,07	-0,09	0,05	-0,09	0,18	0,12	-0,03	0,17	-0,26		-0,13

SP	-0,39	-0,44	-0,54	0,20	-0,20	-0,10	0,37	-0,16	-0,04	-0,22	0,01	0,44	0,37	-0,19	-0,13	

Table S4. Spearman correlation test between environmental variables and benthic community to ABNMP. Result: exclusion of Sand.

	DEPTH	**INCLI**	**COMPL**	**SAND**	**REEF**	**RUBBLE**	**ACI**	**ACA**	**MC**	**TF**	**CMi**	**CMr**	**CD**	**SP**
DEPTH		0,15	0,27	0,18	-0,25	0,17	-0,10	-0,30	-0,20	0,15	-0,18	-0,08	-0,07	0,39
INCLI	0,15		0,19	-0,15	0,23	-0,18	-0,21	-0,09	-0,08	0,07	-0,01	0,09	0,21	0,15
COMPL	0,27	0,19		-0,31	0,39	-0,22	0,26	-0,04	-0,21	0,26	-0,18	-0,02	0,20	0,28
SAND	0,18	-0,15	-0,31		-0,83	-0,07	-0,24	-0,01	0,23	0,15	-0,41	-0,39	-0,16	0,03
REEF	-0,25	0,23	0,39	**-0,83**		-0,50	0,19	0,06	-0,16	-0,10	0,32	0,32	0,23	-0,04
RUBBLE	0,17	-0,18	-0,22	-0,07	-0,50		0,04	-0,10	-0,07	-0,05	0,07	0,04	-0,16	0,02
ACI	-0,10	-0,21	0,26	-0,24	0,19	0,04		0,51	-0,20	-0,02	-0,10	0,06	-0,20	-0,05
ACA	-0,30	-0,09	-0,04	-0,01	0,06	-0,10	0,51		-0,08	0,11	-0,17	-0,13	-0,26	-0,08
MC	-0,20	-0,08	-0,21	0,23	-0,16	-0,07	-0,20	-0,08		-0,02	-0,28	-0,31	0,00	-0,10
TF	0,15	0,07	0,26	0,15	-0,10	-0,05	-0,02	0,11	-0,02		-0,60	-0,56	-0,07	0,54
CMi	-0,18	-0,01	-0,18	-0,41	0,32	0,07	-0,10	-0,17	-0,28	-0,60		0,69	-0,30	-0,35
CMr	-0,08	0,09	-0,02	-0,39	0,32	0,04	0,06	-0,13	-0,31	-0,56	0,69		-0,15	-0,42
CD	-0,07	0,21	0,20	-0,16	0,23	-0,16	-0,20	-0,26	0,00	-0,07	-0,30	-0,15		-0,13
SP	0,39	0,15	0,28	0,03	-0,04	0,02	-0,05	-0,08	-0,10	0,54	-0,35	-0,42	-0,13	

Table S5. Spearman correlation test between environmental variables and benthic community to APASE. Result: exclusion of SC and Rubble.

	DEPTH	**INCLI**	**ROUGH**	**SAND**	**REEF**	**RUBBL**	**SEAGR**	**ECA**	**ACA**	**MC**	**AT**	**SC**	**BSC**	**HC**	**SP**
DEPTH		0,38	0,13	-0,20	0,03	0,09	0,20	0,41	0,21	0,07	-0,09	-0,43	-0,40	0,00	0,19
INCLI	0,38		0,31	-0,09	-0,13	0,19	0,19	0,17	-0,18	0,02	0,17	-0,32	-0,31	0,06	0,23
ROUGH	0,13	0,31		0,17	-0,12	0,02	-0,07	-0,11	0,05	-0,42	-0,16	0,13	0,11	0,13	-0,10
SAND	-0,20	-0,09	0,17		-0,51	-0,14	-0,13	-0,11	-0,16	-0,11	-0,07	-0,05	0,02	-0,17	-0,22
REEF	0,03	-0,13	-0,12	-0,51		-0,78	0,09	0,02	0,11	0,10	0,06	0,05	-0,01	-0,05	-0,08
RUBBL	0,09	0,19	0,02	-0,14	**-0,78**		-0,11	0,06	0,00	-0,08	-0,03	0,00	0,01	0,19	0,25
SEAGR	0,20	0,19	-0,07	-0,13	0,09	-0,11		-0,06	-0,13	0,39	0,12	-0,19	-0,20	-0,16	0,06
ECA	0,41	0,17	-0,11	-0,11	0,02	0,06	-0,06		0,08	-0,02	-0,07	-0,14	-0,11	0,02	0,09

ACA	0,21	-0,18	0,05	-0,16	0,11	0,00	-0,13	0,08		-0,15	-0,23	0,20	0,17	0,00	-0,02
MC	0,07	0,02	-0,42	-0,11	0,10	-0,08	0,39	-0,02	-0,15		-0,09	-0,15	-0,14	-0,36	0,16
AT	-0,09	0,17	-0,16	-0,07	0,06	-0,03	0,12	-0,07	-0,23	-0,09		-0,26	-0,28	0,09	-0,22
SC	-0,43	-0,32	0,13	-0,05	0,05	0,00	-0,19	-0,14	0,20	-0,15	-0,26		0,97	0,13	-0,10
BSC	-0,40	-0,31	0,11	0,02	-0,01	0,01	-0,20	-0,11	0,17	-0,14	-0,28	**0,97**		0,10	-0,11
HC	0,00	0,06	0,13	-0,17	-0,05	0,19	-0,16	0,02	0,00	-0,36	0,09	0,13	0,10		-0,04
SP	0,19	0,23	-0,10	-0,22	-0,08	0,25	0,06	0,09	-0,02	0,16	-0,22	-0,10	-0,11	-0,04	

Table S6. Spearman correlation test between environmental variables and benthic community to ACREX. Result: No correlation between variables.

	DEPTH	INCLI	ROUGH	SAND	REEF	RUBBL	SEAGR	ECA	ACA	MC	AT	SC	BSC	HC	SU	SP
DEPTH		0,21	0,09	-0,02	0,02	-0,10	0,32	0,22	-0,05	0,28	0,21	-0,26	0,10	-0,03	-0,18	-0,05
INCLI	0,21		0,37	-0,09	0,31	-0,03	-0,16	0,13	0,14	-0,07	0,10	0,17	-0,27	0,34	0,09	-0,01
ROUGH	0,09	0,37		-0,04	0,34	0,05	-0,08	-0,03	0,01	-0,01	0,14	0,02	0,05	0,09	0,15	-0,05
SAND	-0,02	-0,09	-0,04		-0,30	0,33	-0,18	0,06	-0,13	-0,15	-0,04	0,04	-0,02	-0,25	-0,19	-0,03
REEF	0,02	0,31	0,34	-0,30		-0,36	-0,58	0,09	-0,03	-0,17	0,19	0,10	-0,23	0,30	0,26	0,14
RUBBL	-0,10	-0,03	0,05	0,33	-0,36		-0,10	0,00	-0,11	-0,07	-0,10	0,16	0,24	-0,16	-0,18	-0,05
SEAGR	0,32	-0,16	-0,08	-0,18	-0,58	-0,10		-0,01	0,25	0,52	-0,10	-0,41	0,32	-0,10	-0,06	-0,14
ECA	0,22	0,13	-0,03	0,06	0,09	0,00	-0,01		-0,03	0,06	0,06	-0,15	-0,10	0,32	0,00	-0,04
ACA	-0,05	0,14	0,01	-0,13	-0,03	-0,11	0,25	-0,03		0,07	-0,39	-0,14	0,20	0,27	-0,07	0,11
MC	0,28	-0,07	-0,01	-0,15	-0,17	-0,07	0,52	0,06	0,07		-0,11	-0,65	0,25	-0,06	0,11	0,05
AT	0,21	0,10	0,14	-0,04	0,19	-0,10	-0,10	0,06	-0,39	-0,11		-0,13	-0,16	-0,25	-0,06	-0,26
SC	-0,26	0,17	0,02	0,04	0,10	0,16	-0,41	-0,15	-0,14	-0,65	-0,13		-0,33	-0,10	-0,21	0,06
BSC	0,10	-0,27	0,05	-0,02	-0,23	0,24	0,32	-0,10	0,20	0,25	-0,16	-0,33		-0,19	-0,01	0,26
HC	-0,03	0,34	0,09	-0,25	0,30	-0,16	-0,10	0,32	0,27	-0,06	-0,25	-0,10	-0,19		0,22	-0,02
SU	-0,18	0,09	0,15	-0,19	0,26	-0,18	-0,06	0,00	-0,07	0,11	-0,06	-0,21	-0,01	0,22		-0,03
SP	-0,05	-0,01	-0,05	-0,03	0,14	-0,05	-0,14	-0,04	0,11	0,05	-0,26	0,06	0,26	-0,02	-0,03	