Reef Fish in the Vitória-Trindade Seamount Chain of the Southwestern Atlantic: Biogeographical Corridors and Impact of Fishing

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Abstract

This paper aimed to study the community structure of large reef fish off the central coast of Brazil by defining the spatial distribution patterns of 34 species in the outer shelf (50 to 100 m) between 13 and 22ºS, including sea banks, seamounts and the Trindade Island, seeking further to interpret these patterns in light of biogeographic knowledge. In addition, this study attempted to estimate the impact of fishing on the community in different regions using mean weight and size distribution data. The data were obtained in four exploratory fishing surveys of demersal resources employing a bottom longline with steel wire under the aegis of the REVIZEE Program between 1996 and 1998. The numerical abundances were standardised in catch-per-unit-effort (CPUE) in number, and species matrices per station were subjected to detrended correspondence analysis (DCA) and cluster analysis. Reef fauna in the southwestern Atlantic can be divided, in its continental margin, into a tropical component and a subtropical component from latitude 19ºS, which corresponds to the Southern limit of the Abrolhos Bank. North of 19ºS, four distribution patterns were identified (North, Abrolhos, Banks and Trindade). The similarity between the last three enabled the definition of an "Abrolhos-Trindade faunal complex". Evidence of the impact of commercial fishing on the structure of reef communities was found through differences in the sizes of species studied, which may have occurred differently in each one of the regions of the Abrolhos-Trindade complex. The results also reinforce the importance of the need for conservation measures in these areas.

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Introduction

Fish are important components of coral reefs, rocky reefs and calcareous algae ecosystems in coastal areas of the outer continental shelf. Because of the position of many species in the trophic chain, the structure of their communities, presence or abundance can represent important indicators of the health of these environments.

Since the mid 1990's, many studies have been published about structure of communities in the southwest Atlantic, allowing the elucidation of its species composition (Floeter & Gasparini, 2000; Pinheiro et al., 2015), biogeography (Floeter et al., 2001; Joyeux et al., 2001), speciation patterns (Rocha, 2003) and trophic patterns (Ferreira et al., 2004). This study revealed a highly diverse fauna, with a high level of endemism, although with many similarities to Caribbean region. Considerations about speciation mechanisms suggest that the mouth of the Amazon River does not necessarily represent an effective barrier against the dispersion of reef species (Rocha, 2003).

Despite having provided relevant information about the reef ichthyofauna in the region, the cited studies used methodologies that were not totally standardised among sampling points because it, partially, considered faunistic surveys in the published literature. In general, the sampling methodology was underwater diving, which restricts sampling to a reduced depth range. As a consequence, this technique tends to undersample species of large size, because they are more agile swimmers or because their abundance is greatly reduced in coastal areas due to commercial fishing. This results in the communities of Brazilian reef fish, in depths greater than 30m, being largely unknown (Feitoza et al., 2005). Finally, the existence of samples from a few isolated points in the study area, separated by hundreds or thousands of kilometres, without representativeness of the seamount chains, limits conclusions about dispersion patterns.

In fact, the available literature attests to the scarcity of information about the reef fauna of sea banks and islands (Joyeux et al., 2001) and that the deep-sea areas are the last refuge of commercially exploited large-sized reef fish (family Serranidae and Lutjanidae) (Coleman et. al. 2000; Feitoza et al., 2005; Olavo et al., 2011).

The Program for Assessing the Sustainable Potential of Living Resources of the Economic Exclusive Zone (REVIZEE), carried out from 1995 to 2005, aimed to survey the sustainable potentials for catches of fisheries resources along the Brazilian EEZ (Costa et al., 2005a). On the central coast, between Salvador (13^{o}S) and São Tomé Cape (22^{o}S), including the islands of Trindade and Martin Vaz, several exploratory activities of fishing stocks were carried out (Martins et al., 2005a; Costa et al., 2005b; Olavo et al., 2005a), along with the assessment of stocks and the dynamics of regional reef fisheries (Martins et al., 2005b; Costa et al., 2005c; Olavo et al., 2005b; Klippel et al., 2005a, b, c). The results indicated the low potential of exploiting new living resources and that the current reef resources on the shelf were close to, or exceeding their limit of exploitation. In addition, a more recent diagnostic of fisheries indicated large growth in the longline fishing fleet, suggesting an even more critical situation for the management of these stocks (Martins & Doxsey, 2006).

Despite a clear conclusion about the depletion of reef resources, the assessments were restricted to a few species because of the limitations for application of the available methods only to single species and populations. Little is known about the impact at the community level, its extension and its spatial variation.

A multispecies approach has been cited as an important tool to study fishing impacts (Botsford et al., 1997). In this context, the adoption of communities as management units, rather than stocks composed of only one species, has been proposed (Brown et al., 1996). The lack of parameters that allow the establishment of a multispecies management strategy in the current state of depletion of explored reef resources on the Brazilian central coast indicates the need for studies to understand the structure of communities and their spatial and temporal variations. Among other management options, the adoption of marine protection areas or reserves has been suggested as a viable solution for the management and conservation of reef fish (Russ, 2001; Brasil, 2007).

One of the methods for exploratory fishing surveys during the REVIZEE Program was bottom longline (Martins et al., 2005a). Although the surveys were targeted to species of the continental slope (100 to 500 m depth), the longline was cast above the continental shelf (between 50 and 100 m) to collect data about bathymetric distribution of important resources in shallower waters. The use of this information allowed the compilation of data about species composition, relative abundance and spatial distribution of large-sized reef fish at depths greater than 50 m. This contributed to the complementation of information about biogeographical patterns and faunistic composition in the region. The collection of biometric data enabled the evaluation of the impact of commercial fishing on community structure.

This study sought to fill in some gaps in knowledge regarding fauna and the structure of reef fish communities in the southwest Atlantic by: 1) defining spatial distribution patterns of large-sized reef fish in the outer shelf (50 to 100 m) between 13 and 22ºS including sea banks, seamounts, and the Trindade Island; 2) analyse the spatial patterns and interpret them in light of biogeographical knowledge; 3) discuss possible dispersion patterns; 4) estimate the impact of fishing on the community in different regions using mean weight and size distribution data.

Materials and Methods

Study area

The study area lies in what is known as the central region of the Brazilian coast, which spans from Salvador to São Tomé Cape, including the islands of Trindade and Martin Vaz, and is delimited from 13 to 22ºS (Figure 1).

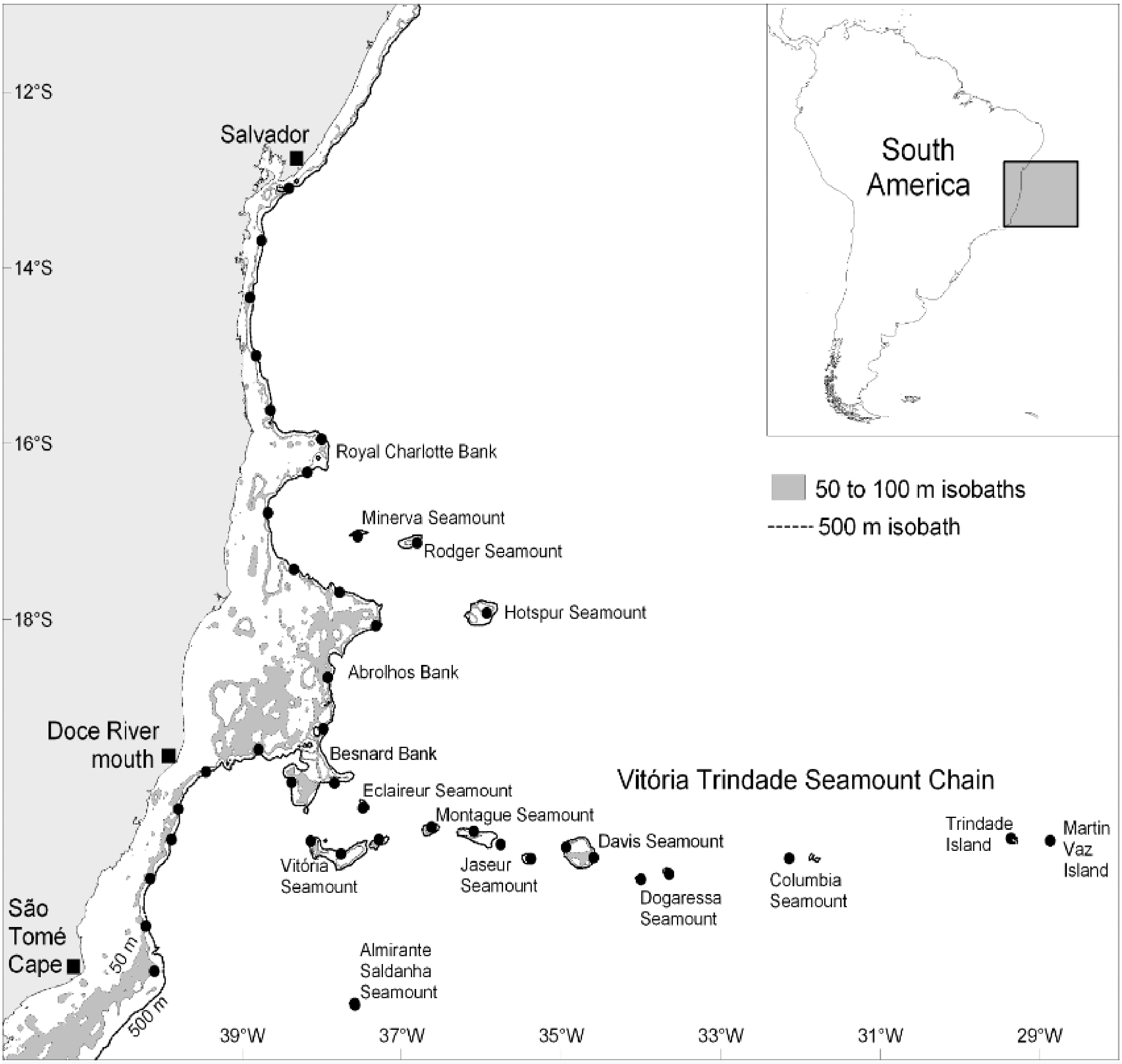

Figure 1. Map of the Brazilian central coast showing the distribution of the sampling points of bottom longline fishing surveys on four cruises, the catch areas for fishes used in this study (50 to 100 m), the delineation of the continental margin (500 m isobath) and the location of the main features of underwater morphology are highlighted.Bathimetric data according to the database of Smith and Sandwell (1997).

The width of the continental shelf is very variable, ranging from 8 to 246 km. At 16ºS latitude, it extends up to 100 km to form the Royal Charlotte Bank, and, at 18º latitude it extends up to 200 km to form the Abrolhos Bank. The mean inclination of the continental slope is from 8 to 10 degrees, with irregular escarpments from 30 to 45 degrees on the slopes of the Royal Charlotte and Abrolhos banks (Zembruski et al., 1972).

Aside from the irregular margin of the continental shelf, two mountain chains and sea banks are noteworthy: the Vitória-Trindade Chain and the Abrolhos Chain (Figure 1). The first, located between 20 and 21ºS, includes two emerged points, the islands of Trindade and Martin Vaz. The second, between approximately 16 and 18ºS, comprises only submarine banks and seamounts. These two submarine chains extend up to 1,100 km off the continental shelf and include some banks that are relatively well isolated from one another (Martins & Coutinho, 1981).

The hydrology of the central coast of Brazil is characterised by the dominance of oligotrophic waters from the Brazil Current (Nonaka et al., 2000). The shallow waters of the Brazilian continental shelf and the immediately adjacent oceanic regions can be tropical or subtropical in their oceanographic, faunistic and floristic characteristics.

Commercial fishing is concentrated on the continental shelf (97.5% of fisheries), mainly between the region of the Abrolhos Bank, in the state of Bahia, and the mouth of the Doce River (17 to 19°S) (Figure 1). A small number of boats also explore banks farther from the shore. The catches of demersal species occur almost exclusively using a handline or small longlines in an artisanal or semi-artisanal fishing boat, which generally does not surpass 12 m in length (Costa et al., 2005b; Olavo et al., 2005b; Martins et al., 2005b).

Data collection

Four cruises were carried out between April 1996 and June 1998 aboard commercial fleet vessels (Figure 1). Although the cruises occurred at different times of the year, covered different areas of the central coast with overlap of cruises 1, 2 and 3 (replicates) and 38 sampling sites were considered as the basis for the biogeographic analysis, including all the sampling points where at least one casting was performed on a cruise. Because the fishes collected were demersal species, which rarely make extensive migrations, the seasonal variable was not analysed, and occurrence in at least one season of the year was considered sufficient to indicate general distribution patterns.

The fishing technique used is known as bottom longline. The longline used was a multifilament steel mainline. Mustad hooks were used (Tuna Circle Hook N°13/0 Qual 39960 D), circle-type and with an opening of 32 mm. The equipment was cast and collected during the day. The number of hooks cast and the bait used (mainly Argentine shortfin squid *Illex argentinus* and, occasionally, sardine *Sardinella* sp. and tuna) were recorded, along with initial and final information for latitude, longitude, hour, and depth for each set of hooks. During longline recovery, the condition of every hook was recorded: with bait, without bait, with fish, without fish and lost. Details of the characteristics of the vessels used, type of fishing and sampling strategy can be obtained in Martins et al. (2005a).

Sample processing

For each specimen captured, the taxonomic identity (to the lowest level possible), total length (mm) and total weight (g) were recorded. The catalogues of Figueiredo and Menezes (1978, 1980), Fischer (1978) and Menezes and Figueiredo (1980, 1985) were used to identify the specimens captured. Orders and families were classified according Eschmeyer (1990).

Data analysis

The depth of the sets of hooks was estimated as the mean between the initial and final depths. In order to compare the abundances between different sampling stations, the reinforcing the importance of the need for conservation measures in these areas.

index of total catch-per-unit-effort (CPUE) – total catch (in number of fish) divided by the total effort (number of hooks collected) – was used. This index was standardised by the number of individuals per 1,000 hooks (num./1,000 hooks).

During the cruises, 125 species were recorded, distributed among 16 orders and 39 families between the 19m and 1,000m isobaths. A large part of the material originated from the range between 50 and 500 m (Martins et al., 2005a). However, only 34 reef species from shallow waters (equivalent to the continental shelf) were selected for this study in order to isolate only the geographic variable in determining the distribution patterns (Table 1). Thus, the following exclusion criteria were used: 1) species that did not occur at least once at all stations; 2) species with more than 90% of occurrences in the upper continental slope; 3) epipelagic or non-exclusively reef species according to the classification of Froese and Pauly (2005).

The global biogeographical distribution patterns of species were obtained from Froese & Pauly (2005).

The determination of distribution patterns of species on the central coast of Brazil were performed based on the clustering of sampling stations in relation to species composition on factorial planes determined by the Detrended Correspondence Analysis (DCA) (Hill & Gauch, 1980). This technique was created specifically for ecological data and is recommended when the data being analysed are restricted to species abundance at different stations. The CPUE data in number form were log-transformed (Ln[x+1]).

The consistency of the groups formed was evaluated by an analysis of hierarchical agglomerative clustering using the relative Sørensen distance coefficient and the unweighted pair group method with arithmetic mean (UPGMA). The same data matrix was used for the correspondence analysis. The relative Sørensen distance index ("relativized Manhattan" in Faith et al., 1987) is the same as the Sørensen index, except for the fact that it performs a standardisation for the sums of each sampling unit, such that every sample contributes equally to the measure of distance. The advantage of using the relative Sørensen index compared to Euclidean distance, for example, is that it retains greater sensitivity in heterogeneous matrices and gives less weight to outliers (McCune & Mefford, 1999).

Statistical comparisons among independent sets of samples were done with the Mann-Whitney *U* test. Associated probabilities of less than 5% were accepted for rejection of the null hypothesis (equal samples).

Results

Species composition and biogeography

The species selected for the study, catch in number, occurrence, total length intervals and biogeographical distribution pattern are shown in Table 1. Among the families represented, those with a greater number of species were Serranidae (10), Carangidae (7), Lutjanidae (6) and Muraenidae (5).

Biogeographical distribution patterns were clustered into latitudinal (tropical, subtropical or both) and longitudinal (western Atlantic, eastern Atlantic, both margins, circumglobal). The majority (82%) of species considered in this study is exclusively tropical, 15% occur in tropical and subtropical areas and 3% are exclusively subtropical. With respect to longitudinal distribution, the majority (52%) occurs only at the continental margin of the western Atlantic, 21% in the western Atlantic and also in distant islands, 15% at both margins of the Atlantic and 12% are circumglobal.

Table 1. Number of individuals, occurrences, length intervals and distribution pattern of 34 teleostei species captured between 50 and 100 m depth in 39 samples using a bottom longline between 1996 and 1998 in the central coast of Brazil. Orders and families according to Eschmeyer (1990). Biogeographic distribution patterns defined according to Froese e Pauly (2005). TL= total length.

Order, Family and Species	Catch (number)	Occurrences - Total (%)	TL intervals Min.- Max. (cm)	Distribution pattern*
Anguilliformes				
Muraenidae				
***Gymnothorax moringa* (Cuvier 1829)**	318	27 (69)	45 - 98	WTAI
***Gymnothorax ocellatus* Agassiz 1831**	33	4 (10)	45 - 68	WTA
***Gymnothorax polygonius* Poey 1875**	6	5 (13)	44 - 80	WTAI
***Gymnothorax* sp.**	28	9 (23)	31 - 143	
***Gymnothorax vicinus* (Castelnau 1855)**	8	5 (13)	53 - 77	WTAI
Beryciformes				
Holocentridae				
***Holocentrus ascensionis* (Osbeck 1765)**	100	20 (51)	23 - 37	TA
Perciformes				
Serranidae				
***Cephalopholis fulva* (Linnaeus 1758)**	832	31 (79)	12 - 49	WTA
***Dermatolepis inermis* (Valenciennes 1833)**	21	9 (23)	59 - 92	WTA
***Epinephelus adscensionis* (Osbeck 1765)**	7	2 (5)	33 - 52	WTAI
***Epinephelus marginatus* (Lowe 1834)**	18	2 (5)	53 - 94	SA
***Epinephelus morio* (Valenciennes 1828)**	46	11 (28)	31 - 85	WTA
***Mycteroperca bonaci* (Poey 1860)**	11	6 (15)	64 - 115	WTA
***Mycteroperca interstitialis* (Poey 1860)**	24	12 (31)	43 - 139	WTA
***Mycteroperca tigris* (Valenciennes 1833)**	4	2 (5)	75 - 126	WTA
***Mycteroperca venenosa* (Linnaeus 1758)**	10	5 (13)	59 - 87	WTA
***Paranthias furcifer* (Valenciennes 1828)**	2	2 (5)	28 - 32	WTAI
Carangidae				
***Caranx crysos* (Mitchill 1815)**	41	11 (28)	39 - 65	TSA
***Caranx latus* Agassiz 1831**	7	5 (13)	47 - 82	WTAI
***Caranx lugubris* Poey 1860**	3	2 (5)	47 - 53	CTI
***Caranx ruber* (Bloch 1793)**	6	5 (13)	39 - 59	WTA
***Seriola dumerili* (Risso 1810)**	16	10 (26)	45 - 137	CTS
***Seriola fasciata* (Bloch 1793)**	2	2 (5)	40 - 43	WTSA
***Seriola rivoliana* Valenciennes 1833**	4	4 (10)	72 - 90	CTS

Seriola rivoliana **Valenciennes 1833**	4	4 (10)	73 - 99	CTS
Lutjanidae				
Lutjanus analis **(Cuvier 1828)**	190	16 (41)	48 - 97	WTA
Lutjanus jocu **(Bloch & Schneider 1801)**	60	9 (23)	45 - 97	WTAI
Lutjanus synagris **(Linnaeus 1758)**	5	3 (8)	33 - 38	WTA
Lutjanus vivanus **(Cuvier 1828)**	49	16 (41)	42 - 75	WTA
Ocyurus chrysurus **(Bloch 1791)**	19	10 (26)	32 - 57	WTA
Rhomboplites aurorubens **(Cuvier 1829)**	14	6 (15)	24 - 50	WTA
Haemulidae				
Haemulon plumieri **(Lacepède 1801)**	16	3 (8)	25 - 36	WTA
Sparidae				
Calamus pennatula **Guichenot 1868**	4	3 (8)	34 - 44	WTA
Pagrus pagrus **(Linnaeus 1758)**	151	7 (18)	21 - 65	TSA
Tetraodontiformes				
Balistidae				
Balistes vetula **Linnaeus 1758**	245	28 (72)	28 - 97	TA
Melichthys niger **(Bloch 1786)**	2	2 (5)	27 - 44	CTI
Total	2.617	39	12 - 143	

WTA – western tropical Atlantic

WTAI – western tropical Atlantic and oceanic islands

WTSA – western tropical and sub-tropical Atlantic

SA – subtropical Atlantic

TA – Tropical Atlantic

TSA – Tropical and subtropical Atlantic

CTI - Circumtropical island

CTS - Circumtropical and subtropical

Distribution patterns on the central coast

The Detrended correspondence analysis (DCA) showed the existence of three consistent distribution patterns of reef species on the central coast of Brazil (Figure 2A, 2B): 1) North, from Salvador (13º S) to the north of Abrolhos Bank, including the Minerva and Rodger seamounts, closer to the continental shelf; 2) South, on the continental shelf in the extreme south of the area, from the mouth of the Doce River (19º S) to the São Tomé Cape (22º S); 3) Abrolhos – Trindade Complex, encompassing the outermost stations of the Southern part of the Abrolhos and Besnard Banks, seamounts and islands farther offshore, including the Hotspur seamount to the north (18º S) and the Vitória-Trindade chain (19-20º S).

The consistency of the clusters of stations corresponding to the distinct distribution patterns of reef species was highlighted with an agglomerative cluster analysis, using the relative Sørensen coefficient and the UPGMA method (Figure 3). By 'cutting' the similarity axis at the level of the second separation of clusters, it is observed that the stations corresponding to the three distribution patterns described in Figure 2 are repeated in the dendrogram, with the stations distributed in a contiguous and clustered manner.

The representative species of each distribution pattern are shown in Table 2.

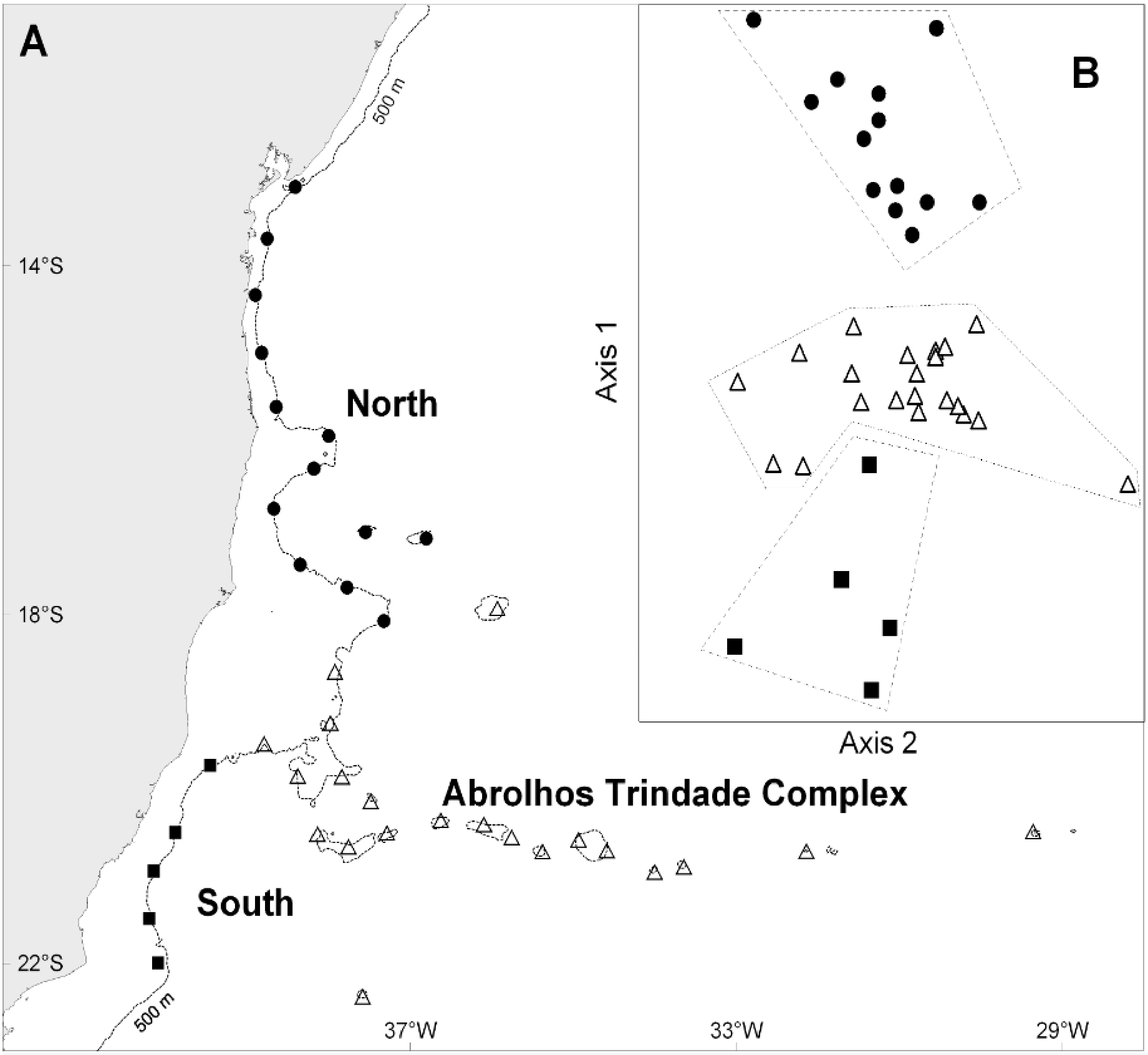

Figure 2. Map of the central coast showing symbols corresponding to sampling points divided in three geographic distribution patterns of reef fish (A) and factorial plane of the Detrended Correspondence Analysis (DCA) showing the dispersion in the main axes of the same sampling points relative to faunistic composition (B).

Table 2. Percentage of numerical abundance in reef species catch in each geographic distribution pattern in the central coast of Brazil. The species are divided into groups according to the distribution pattern where they were most abundant in terms of percentage.

Species	Distribution pattern of greatest abundance	% of numerical abundance in the entire study area		
		North	Abrolhos Trindade Complex	South
***Gymnothorax* sp.**	North	**100**		
Mycteroperca bonaci		**100**		
Lutjanus synagris		**100**		
Mycteroperca tigris		**100**		
Paranthias furcifer		**100**		
Lutjanus jocu		**96**	4	
Lutjanus analis		**83**	7	10
Ocyurus chrysurus		**65**	35	
Mycteroperca venenosa		**53**	47	
Mycteroperca interstitialis		**45**	19	36
Rhomboplites aurorubens			100	
Caranx lugubris			100	
Caranx ruber			100	
Dermatolepis inermis			100	
Gymnothorax moringa		4	**96**	16
Melichthys niger		5	95	
Caranx crysos		3	93	4
Seriola dumerili		9	91	
Epinephelus adscensionis		10	90	
Seriola rivoliana		11	89	
Lutjanus vivanus		12	**88**	
Gymnothorax polygonius			87	13
Cephalopholis fulva		17	**83**	3
Haemulon plumieri		23	77	
Holocentrus ascensionis		7	77	16
Balistes vetula		24	71	5
Caranx latus		30	**70**	
Epinephelus morio		38	62	5
Epinephelus marginatus				**100**
Pagrus pagrus			6	**94**

Seriola fasciata	South		19	**81**
Calamus pennatula		40		**60**
Gymnothorax vicinus		6	39	**55**
Gymnothorax ocellatus			48	**52**

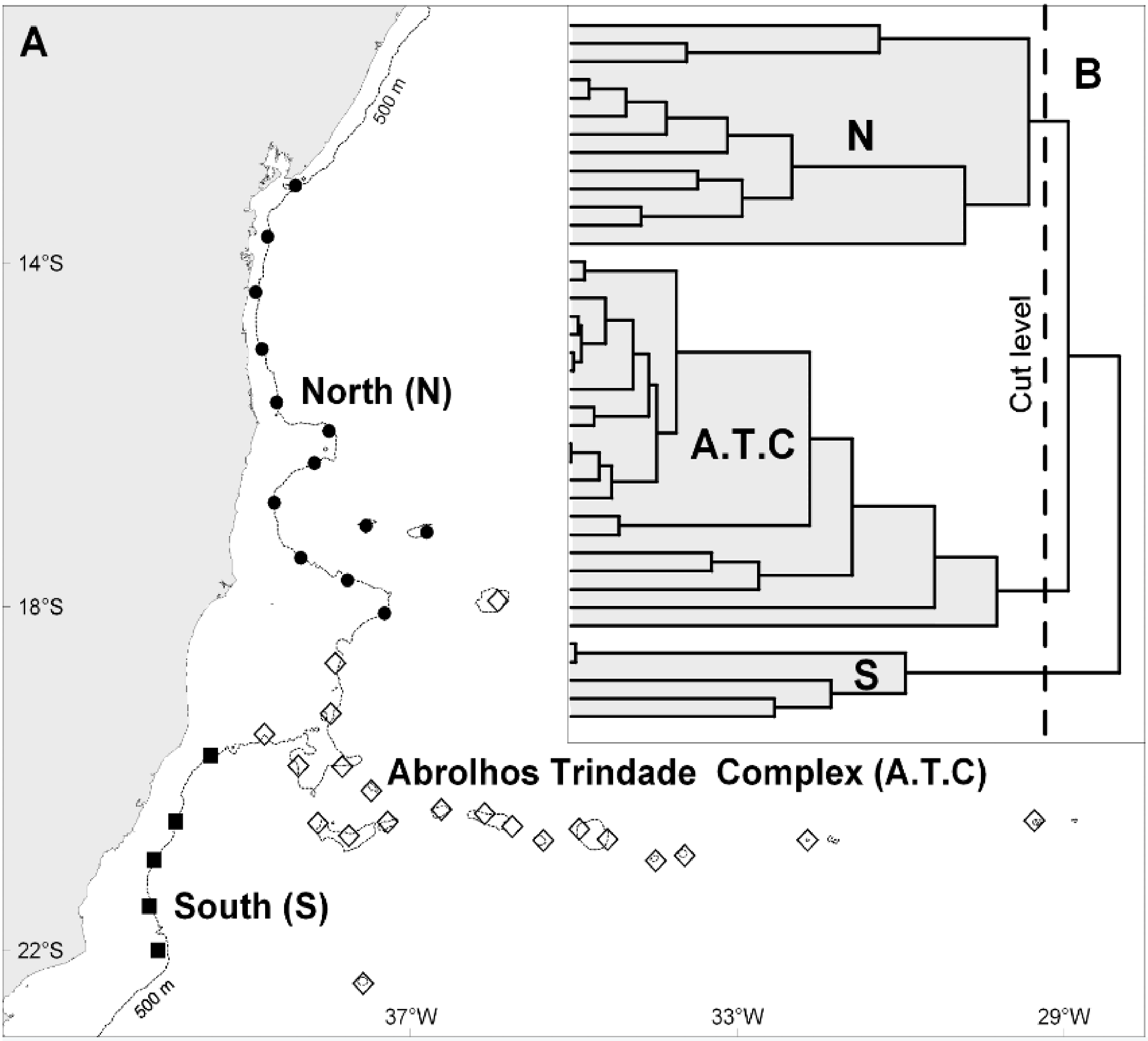

Figure 3. A – Map of the central coast showing symbols corresponding to the sampling points divided in three geographic distribution patterns of reef fish, with one of them (A.T.C.) subdivided in three geographic sub-patterns; B – Dendrogram of the cluster analysis (relative Sorensen coeffecient, unweighted pair group method with arithmetic mean - UPGMA) showing the clustering of the same sampling points in relation to the faunistic composition (B) separated by the cut-off level of the second hierarchical division.

Evidence of commercial fishing impact - size structure

Figure 4 shows size frequency distributions of the group of species in each capture area and can be grouped into three distinct patterns: 1) presence of a little pronounced mode of 30 cm and another more pronounced mode of 60 to 70 cm, identifiable in the North area, suggesting the presence of healthy populations, less affected by fishing activities; 2) the presence of a very pronounced mode of 30 cm and another little evident mode between 60 and 70 cm, identifiable in the Abrolhos Trindade Complex, indicative of populations severely affected by commercial fishing through the reduction of the proportion of larger individuals; 3) a single pronounced mode in the range of 50 cm, identifiable only in the South area. It is not possible to infer the impact of fishing because of the large faunal differences.

Because the reduction in sizes reflects the impact of commercial fishing on the community, and not only on a particular species, the areas of Abrolhos bank and seamounts exhibited the community most affected by commercial fishing, especially in the seamounts area, where the mean weights are lower and homogeneous, and the frequency of smaller individuals is more accentuated.

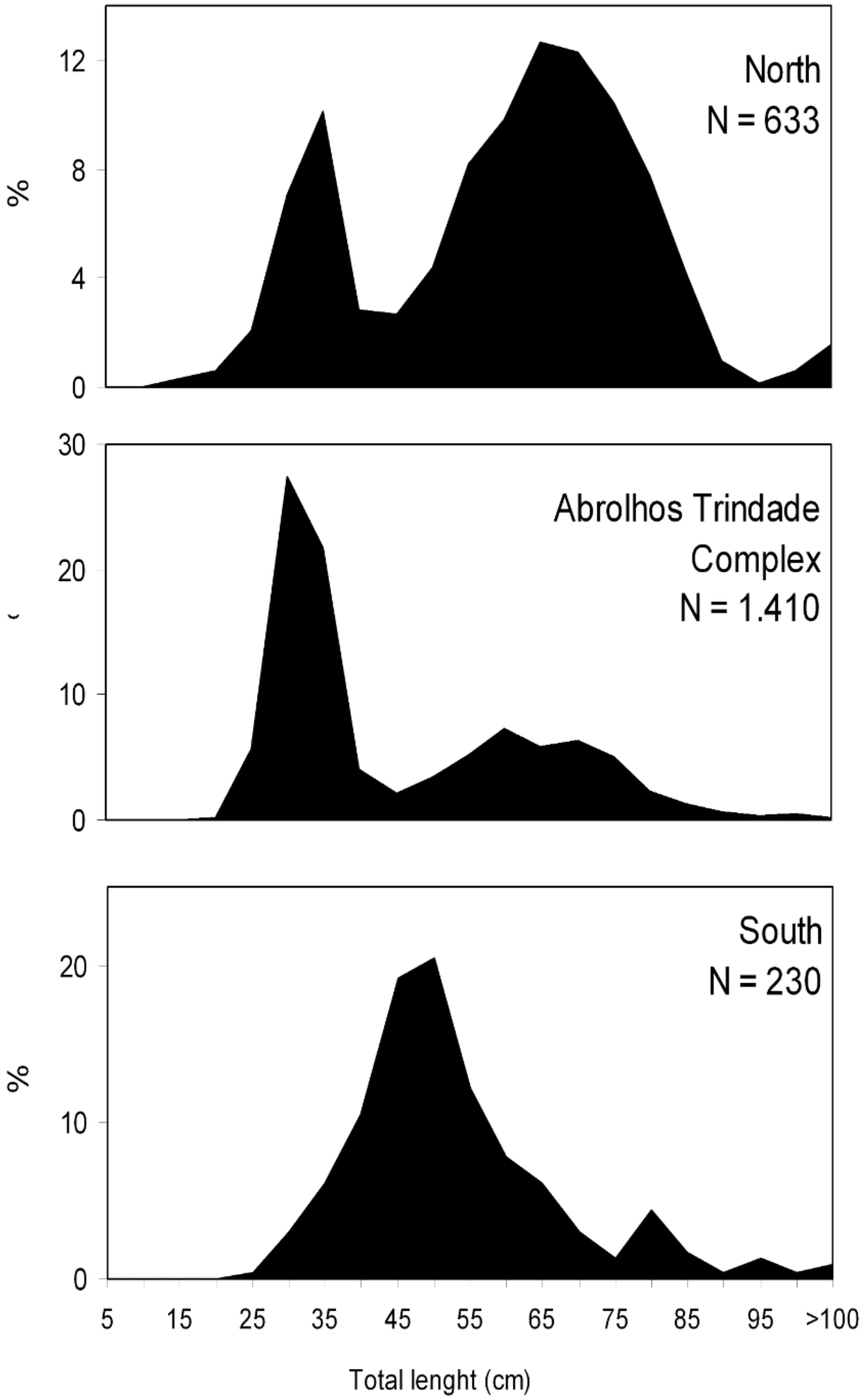

Figure 4. Size distribution of the total of fish species caught in each geographic distribution area in the central coast of Brazil.

Discussion

This study found results not addressed in previous publications (Floeter & Gasparini, 2000; Floeter et al., 2001; Gasparini

& Floeter, 2001; Joyeux et al., 2001; Rocha, 2003; Floeter et al., 2006; Feitosa et al., 2005), as it showed continuous distribution patterns of subtropical and tropical reef species on the continental margin and an extensive seamount chain. Despite the limitations and selectivity of longlining, this analysis enabled sampling top predators reef species of the outer shelf, between 50 and 100m depth. These species have been most frequently studied to date by means of SCUBA diving, generally restricted to 30 m depth (Feitoza et al., 2005).

The beginning of a possible division between subtropical and tropical fauna from the range of 19-20ºS coincides with the presence of the Abrolhos Bank and the Vitória-Trindade Chain, topographical features that form a barrier to the Brazil Current, causing physical and chemical changes in the patterns of water masses in the region (Schimid et al., 1995; Floeter et al., 2001). Aside from this, at latitudes above 22º S, relatively colder water masses commonly occur over the continental shelf, derived from upwelling of the South Atlantic Central Waters, reducing temperature (Ekau & Knoppers, 1999). The consistency of the tropical and subtropical distribution limit at a latitude of 19ºS can be confirmed by the continuous distribution of species with a higher level of indication of this distribution pattern in the direction of the southeast-south coast of Brazil, such as *Pagrus pagrus* and *Epinephelus marginatus* (Haimovici et al., 2004; Froese & Pauly, 2005; Olavo et al., 2011).

The pattern of continuous substitution of continental shelf and seamount chain species that form a faunistic complex complements the indicators surveyed in previous studies (Floeter & Gasparini, 2000; Floeter et al., 2001; Gasparini & Floeter, 2001; Joyeux et al., 2001; Feitoza et al., 2005). The results showed with greater resolution and spatial continuity that the reef fauna of Trindade Island has a great deal of similarity to the fauna of the continental shelf. The most accepted theory for this fact is that of the presence of a chain of banks and seamounts, which, because they are relatively distant from one another (between 50 and 250 km), favour the colonisation of species from more coastal areas, generally with greater diversities, in the direction of oceanic areas (Gasparini & Floeter, 2001).

The effect of reduction in the mean size of several populations by fishing is reported in the literature (Beverton & Holt, 1957; Ault & Ehrhardt, 1991). Only recently, however, did this approach begin to be applied at the suprapopulation level. It has been demonstrated that the size distributions of the whole community can also be good indicators of the state of fishing (Ault et al., 2005).

The lower sizes in Abrolhos Trindade Complex, if compared to the North and Trindade areas, indicate that there was a different impact from commercial fishing. Analyses of distribution of fleets (Martins et al., 2005b) and fishing effort (Costa et al., 2005c) partially corroborate this statement because at least the region of Abrolhos and Trindade seamount chain is located closer to the ports of origin of the main fishing fleets and is the target of more intensive fishing. The same studies indicate that the region of the seamounts is much less explored (less fishing effort) because of the large distance between the operational centres of the fishing fleets (generally greater than 200 nautical miles). Nevertheless, the exploitable area of the sea banks is significantly smaller than in the region of Abrolhos, such that a few fishing trips carried out per year over each bank would be able to have a considerable impact.

The impact on the reef fish communities reveals the fragility of these regions to opportunist fishing exploitation both by small-scale and industrial fleets. These results bring into evidence the need for regulatory measures for fisheries management and for implementation of strategies of recovery and conservation of the seamounts.

These results also support the proposal of two areas classified by the Convention on Biological Diversity as Ecologically and Biologically Significant Marine Areas (EBSA; Secretariat of the Convention on Biological Diversity, 2014) in the EBSA Region of the Wider Caribbean and Western Mid-Atlantic, called the Northeast Brazil Shelf Edge Zone (EBSA 19) and Abrolhos Bank and Vitória-Trindade Chain (EBSA 21), reinforcing the importance of the need for conservation measures in these areas.

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