FULL PAPER

The influence of multiple factors upon reef fish abundance and species richness in a tropical coral complex

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Abstract The present study was conducted on Tamandaré reefs, northeast Brazil and aimed to analyse the importance of different factors (e.g. tourism activity, fishing activity, coral abundance and algal abundance) on reef fish abundance and species richness. Two distinct reef areas (*A ver o mar* and *Caieiras*) with different levels of influence were studied. A total of 8239 reef fish individuals were registered, including 59 species. Site 1 (*A ver o mar*) presented higher reef fish abundance and richness, with dominance of roving herbivores (29.9 %) and mobile invertebrate feeders (28.7 %). In contrast, at Site 2 (*Caieiras*) territorial herbivores (40.9 %) predominated, followed by mobile invertebrate feeders (24.6 %). Concerning the benthic community, at Site 1 macroalgae were recorded as the main category (49.3 %); however, Site 2 was dominated by calcareous algae (36.0 %). The most important variable explaining more than 90 % of variance on reef fish abundance and species richness was macroalgae abundance, followed by fishing activity. Phase shifts on coral reefs are evident, resulting in the replacement of coral by macroalgae and greatly influencing reef fish communities. In this context, it is important to understand the burden of the factors that affect reef fish communities and, therefore, influence the extinction vulnerability of coral reef fishes.

Introduction

Coral reefs harbor an unparalleled diversity of fish species (Reaka-Kudla 1997). Many factors can influence the abundance, spatial and geographic distribution of reef fishes, including biotic processes such as competition, predation and recruitment (Sale 1978; Warner and Chesson 1985; Munday et al. 2001), as well as abiotic factors including depth and exposure (Pinheiro et al. 2013). Historical disturbance events such as hurricanes and tsunamis also play an important role on the structure of reef fishes communities (Adjeroud et al. 1998). Futhermore, habitat composition appears to be a key environmental factor structuring many reef fish assemblages (Jones and Syms 1998; Depczynski and Bellwood 2005). Despite the fact that a large number of studies analysed reef fish community and biotic-abiotic factors, few of them correlated the importance level and interrelationship of these factors with regard to reef fish abundance and species richness.

Brazilian coral reefs belong to a distinct biogeographic province (Floeter et al. 2008) separated from the Caribbean Sea by mostly semi-permeable geographic barriers (Rocha 2003). Despite the relatively small area of Brazilian reefs (< 5 % of the total area of western Atlantic Ocean reefs) they support around 500 reef fish species and are responsible for a high index of endemism that range from 25 %

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on Oceanic Island to around 10 % on the coast (Moura and Sazima 2000; Floeter et al. 2008).

Effects caused by human recreational activities on coastal ecosystems have already demonstrated clear impacts on fish and coral communities (Milazzo et al. 2006; Ilarri et al. 2008). Furthermore, supplementary feeding activity proved to dramatically change reef fish assemblages on tropical coral reefs (Feitosa et al. 2012). An increase in abundance of some particular species (i.e. omnivores) has been observed as fishes converge towards focal food sources. As a consequence, the trophic structure of the fish community changes and patterns of daily and seasonal movement are disrupted (Feitosa et al. 2012). Therefore, artificial fish feeding activity will directly affect natural processes, such as competition and recruitment, in the reef fish community.

Fishing on corals reefs is important in human communities and contributes to the sustenance of millions of people globally (Jennings and Polunin 1996; Jackson et al. 2001). Despite the social and economic importance of reef fisheries, the intensity of fishing is such that trophic webs are reduced in size and structure with a corresponding reduction in fish community complexity (Pauly et al. 1998). These effects have been observed in Northeastern Brazil, as well (Freire and Pauly 2010). Floeter et al. (2006) analysed the correlation between fishing impacts and protected areas on Brazilian reef fishes and observed that highly targeted species (e.g. top predators and large herbivores) were significantly more abundant and larger in body size within sites with a higher degree of protection.

In the current context of global warming, which causes coral bleaching, and coastal development, that causes sedimentation and eutrophication on coral reefs (Hughes et al. 2003; Hoegh-Guldberg et al. 2007), predicting the risk of species extinction due to habitat degradation is one of the most challenging and urgent tasks (Munday 2000; Thomas et al. 2004; Graham et al. 2011). Much effort has been applied towards understanding this subject, yet it has not been addressed as to how abiotic and biotic factors are interrelated and that both exert a considerable influence upon reef fish abundance and species richness. Therefore, this study attempted to analyze the importance of multifactors (e.g. macroalgae abundance, fishing activity, tourism activity and coral abundance and diversity) upon the reef fish community of a tropical reef complex in northeast Brazil. We tested the hypothesis that in areas with low diversity of complex branching coral species, such as the Brazilian reefs, macroalgae abundance could be the critical factor influencing reef fish abundance and species richness.

Materials and methods

Study area. The reef complex analysed is within the limits of the "Costa dos Corais" Marine Protected Area (MPA "Costa dos Corais") that encompasses 135 km of coastline in Pernambuco State of northeast Brazil. The "Costa dos Corais" MPA was the first Brazilian federal conservation area that included coastal reefs and is the largest multiple-use MPA in the country, encompassing an area of 41,3563 ha (Maida and Ferreira 1997). The area presents a tropical climate with an intercalary regime of rainy (October to May) and dry (May to September) seasons with maximum temperatures of 26 and 30 °C, respectively (Maida and Ferreira 1997). The tropical coral reef ecosystem in the Pernambuco State, municipality of Tamandaré was selected as the sampling area (Fig. 1). Site 1 (*A ver o mar*) is located north of the Formoso River; the area is characterized as having shallow reefs (depth range of

Fig. 1 Coral reefs of the Tamandaré reef complex, northeast Brazil highlighting the two study sites Site 1 (*A ver o mar*) and Site 2 (*Caieiras*)

4 m). Algae beds composed primarily of macroalgae of the genera *Sargassum, Caulerpa, Udotea, Neomeris, Padina, Gracilaria* and *Dictyota,* encrusting coralline algae, *Halimeda opuntia*, are abundant in the area. Site 2 (*Caieiras*) is the area south to the Formoso River and has less tourism, however, supports more artisanal fishing activities. The depth range is similar to Site 1; however, the diversity and abundance of macroalgae are smaller.

Fish and benthos community data. Underwater visual census (UVC) was performed every 15 days during a period of six months between November 2012 and April 2013. A total of 48 belt transects (20 × 2 m) were performed at each site. Fishes were then grouped into seven major trophic categories based on the main diet of species to search for general patterns that were adapted from Ferreira et al. (2004). These were: Territorial Herbivores (TERH); Roving Herbivores (ROVH); Invertebrate feeders (INV); Carnivores (CAR); Piscivores (PIS); Planktivores (PLK) and Omnivores (OMN) (see Table 1). Inclusion of species in these categories was based on the available information from the literature (e.g. Randall 1967; Ferreira et al. 2004).

The benthos community analysis was determined using the point-intercept method (Meese and Tomich 1992) in which the intercept point was spaced every 0.5 m along a 20 m long transect. The established categories were: Hard Coral (HC), Soft Coral (SC), Sponge Indicator of sewage pollution (SP), Other (OT), Nutrient indicator algae (NIA), Bare Rock (RC), Recently killed coral (RKC), Silt Indication of sedimentation (SI), Sand (SD), Rubble (RB), Calcareous algae (CA) and Macroalgae (MA).

Tourism activity and fishing intensity data collection. Tourism activity data at both sites were collected by monitoring tourist activities daily over a six-month period. During the low tide period (approximately four hours), the total number of visitors was counted per day and per reef site during the study. An estimate of tourism activity was then categorized as low, medium and high and the data examined with univariate regression tree (URT) analysis.

To estimate fishing intensity, fishermen and boat drivers were interviewed during the present study at both study sites. Interviewees were asked about the number of days per month they used both sites. Fishing intensity was categorized also as low, medium and high for each site. The data were examined using univariate regression tree analysis.

Statistical analyses. Differences in abundance and species richness between sites were tested using the chi-square test routine in Statistica 10 (StatSoft Inc. 2011).

Univariate regression trees (URT) were used to examine the relative importance of the explanatory variables in determining the fish abundance and diversity at

two different sites (*A ver o mar* versus *Caieiras*) using Tree Plus software. Data of macroalgae abundance, fishing activity, tourism activity, and coral abundance and diversity were used as the explanatory variables for these trees. This analysis is ideal for describing meaningful patterns in complex ecological datasets being that they separate the variables in a series of binary splits (De'ath and Fabricius 2000). Additionally, both numerical and categorical variables can be inserted into the same analyses (De'ath and Fabricius 2000; De'ath 2002). For tourism activity data, daily monitoring at the two different sites was conducted during six months, also fishing activity data acquisition was based on interviews with locals (mainly boat drivers) during the research period. Intensity-level data for both tourism and fisheries classified in low, medium and high, thus, could be examined using this statistical method.

Results

A total of 8239 individual reef fish were recorded during the present study, including 59 species from 23 different families (Table 1). Reef fish abundance and species richness were higher at Site 1 compared to Site 2. Site 1 had 4858 individuals from 59 species, with a mean density of 3.26 ± 0.88 fish per 40 m^2. In contrast, Site 2 had 3381 individuals from 49 species, with a mean density of 2.04 ± 0.48 fish per 40 m^2 (Table 1). The differences in both abundance (*chi-square* = 1140.6, *d.f.* = 61) and richness (*chi-square* = 1519.1, *d.f.* = 31) between sites were significant ($P < 0.005$).

The most abundance species at Site 1 (*A ver o mar*) were *Stegastes fuscus* (mean ± s.d. = 36.2 ± 8.7), *Acanthurus bahianus* (29.7 ± 13.8), *Pempheris schomburgki* (25.4 ± 11.6), *Halichoeres poeyi* (20.7 ± 12.9) and *Abudefduf saxatilis* 15.1 ± 10.8 (Fig. 2a). The relative abundances for each of the trophic guilds were: roving herbivores (29.9 %), mobile invertebrate feeders (28.7 %), territorial herbivores (17.8 %), carnivores (7.4 %) and piscivores (1.7 %) (Fig. 2b). The most abundant species at Site 2 (*Caieiras*) were *Stegastes fuscus* (mean ± s.d. = 55.6 ± 19.5), *Abudefduf saxatilis* (11.7 ± 10.8), *Halichoeres poeyi* (9.9 ± 12.9), *Acanthurus bahianus* (9.1 ± 3.9) and *Haemulon aurolineatum* 7.5 ± 2.8 (Fig. 2a). Abundances for each of the trophic guilds were: territorial herbivores (40.9 %), mobile invertebrate feeders (24.6 %), roving herbivores (16.3 %), omnivores (8.3 %) and carnivores (4.5 %) (Fig. 2b).

At Site 1, the relative abundance of macroalgae (MA) was greater (49.3 %) compared to abundances of the other benthic categories (Fig. 3). Calcareous algae (CA) and sand (SD) also had important abundance (36.0 %

Table 1 Reef fish community at the two study sites

Family	Species	Trop.	A ver o mar		Caieiras	
			Total	Ind/40 m^2	Total	Ind/40 m^2
Acanthuridae	*Acanthurus bahianus*	RH	713	29.71	218	9.08
	Acanthurus chirurgus	RH	96	4.00	66	2.75
	Acanthurus coeruleus	RH	139	5.79	61	2.55
Apogonidae	*Apogon americanus*	PK	7	0.29	0	0.00
Bleniidae	*Ophioblennius trinitatis*	TH	11	0.46	20	0.83
	Scartella cristata	RH	0	0.00	1	0.04
Carangidae	*Carangoides bartholomaei*	PI	42	1.75	16	0.67
	Oligoplites saurus	CA	28	1.17	0	0.00
Chaetodontidae	*Chaetodon striatus*	SIF	66	2.75	5	0.21
Clupeidae	*Harengula clupeola*	PL	9	0.38	0	0.00
Epinephelidae	*Mycteroperca bonaci*	PI	1	0.04	0	0.00
	Cephalopholis fulva	CA	20	0.83	23	0.96
	Epinephelus adscensionis	CA	18	0.75	7	0.29
Gerreidae	*Eucinostomus lefroyi*	MIF	9	0.38	0	0.00
Gobiidae	*Coryphopterus glaucofraenum*	ONI	17	0.71	3	0.13
	Ctenogobius saepepallens	MIF	2	0.08	1	0.04
	Elacatinus figaro	MIF	1	0.04	0	0.00
Grammatidae	*Gramma brasiliensis*	PK	2	0.08	0	0.00
Haemulidae	*Anisotremus moricandi*	MIF	11	0.46	61	2.54
	Anisotremus surinamensis	MIF	1	0.04	0	0.00
	Anisotremus virginicus	MIF	31	1.29	5	0.21
	Haemulon aurolineatum	MIF	77	3.21	180	7.50
	Haemulon parra	MIF	90	3.75	8	0.33
	Haemulon plumieri	MIF	61	2.54	79	3.29
	Haemulon squamipinna	MIF	62	2.58	140	5.83
Holocentridae	*Holocentrus adscensionis*	MIF	22	0.92	8	0.33
	Myripristis jacobus	MIF	10	0.42	19	0.79
Labridae	*Bodianus rufus*	MIF	0	0.00	5	0.21
	Doratonotus megalepis	MIF	2	0.08	1	0.04
	Halichoeres brasiliensis	MIF	57	2.38	24	1.00
	Halichoeres penrosei	MIF	7	0.29	54	2.25
	Halichoeres poeyi	MIF	499	20.79	238	9.92
Labrisomidae	*Labrisomus cricota*	CA	0	0.00	1	0.04
	Labrisomus nuchipinnis	CA	18	0.75	12	0.50
	Malacoctenus delalandii	CA	3	0.13	2	0.08
	Malacoctenus sp.1	CA	3	0.13	5	0.21
Lutjanidae	*Lutjanus alexandrei*	CA	17	0.71	10	0.42
	Lutjanus jocu	CA	3	0.13	1	0.04
	Lutjanus synagris	CA	0	0.00	6	0.25
Mullidae	*Mulloidichthys martinicus*	MIF	1	0.04	0	0.00
	Pseudopeneus maculatus	MIF	60	2.50	7	0.29
	Ahlia egmontis	MIF	1	0.04	0	0.00
Pempheridae	*Pempheris schomburgkii*	PK	610	25.42	97	4.04
Pomacanthidae	*Pomacanthus paru*	OM	3	0.13	0	0.00

Table 1 continued

| Family	Species	Trop.	A ver o mar		Caieiras	
			Total	Ind/40 m^2	Total	Ind/40 m^2
Pomacentridae	*Abudefduf saxatilis*	OM	364	15.17	282	11.75
	Chromis multilineata	PK	0	0.00	24	1.00
	Microspathodon chrysurus	SIF	3	0.13	2	0.08
	Stegastes fuscus	TH	868	36.17	1332	55.50
	Stegastes variabilis	TH	174	7.25	52	2.17
Scaridae	*Scarus trispinosus*	RH	3	0.07	0	0.00
	Scarus zelindae	RH	1	0.04	5	0.21
	Sparisoma amplum	RH	5	0.21	7	0.29
	Sparisoma axillare	RH	215	8.96	134	5.58
	Sparisoma frondosum	RH	4	0.17	40	1.66
	Sparisoma radians	RH	121	5.04	15	0.63
Sciaenidae	*Odontoscion dentex*	CA	257	10.71	85	3.54
	Pareques acuminatus	MIF	1	0.04	5	0.21
Scorpaenidae	*Scorpaena plumieri*	CA	2	0.08	6	0.25
Serranidae	*Rypticus saponaceus*	CA	3	0.13	8	0.33
	Rypticus subbifrenatus	CA	1	0.04	0	0.00
Tetraodontidae	*Sphoeroides spengleri*	MIF	2	0.08	0	0.00
	Sphoeroides testudineus	MIF	4	0.17	0	0.00

Trophic categories: *CA* carnivores; *MIF* Mobile invertebrate feeders; *OM* omnivores; *PI* piscivores; *PK* planktivores; *RH* roving herbivores; *SIF* sessile invertebrate feeders; *TH* territorial herbivores

and 13.2 %, respectively) compared to the remaining benthos categories. However, Site 2 presented a different trend and CA (36 %) were most abundant, followed by macroalgae (MA, 20.2 %) and bare rock (BC, 19.1 %) among the remaining categories of benthos (Fig. 3). Differences in the abundance of benthos between the two study sites were significant (*chi-square* = 318.3, *d.f.* = 11, $P < 0.005$). Moreover, coral species richness

at Site 1 was lower (three species) than at Site 2 (eight species).

Univariate regression tree analysis of correlations between reef fish abundance and species richness, and other factors featuring the best standard error (S.E.), resulted in a 4-leaf tree that explained 47.5 % of the variation (Fig. 4). The most important variable explaining more than 90 % of the differences in reef fish community among sites was

Fig. 2 Fish abundance (ind./40m^2 - standard deviation) and relative importance (%) of the trophic guilds for the two analyses sites. **a** Site 1 (*A ver o mar*) and **b** Site 2 (*Caieiras*)
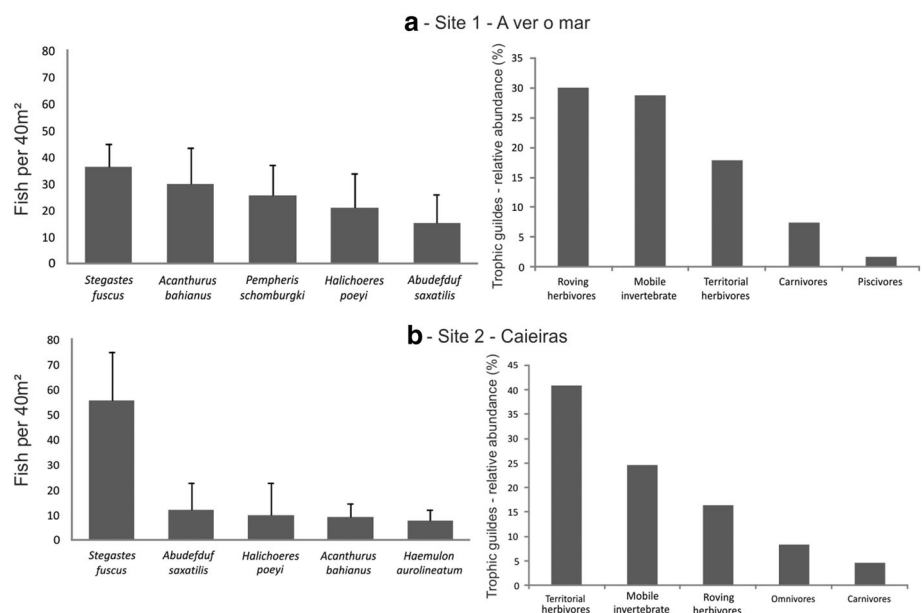
macroalgae abundance. The next split in order of importance was fishing activity, followed by tourism activity. The last representative explanatory variables were related to coral abundance and diversity (Fig. 4).

Fig. 3 Relative abundance (%) of the main benthic categories for the two study sites. Hard Coral (*HC*), Soft Coral (*SC*), Sponge Indicator of sewage pollution (*SP*), Other (*OT*), Nutrient indicator algae *(NIA)*, Bare Rock (*RC*), Recently killed coral (*RKC*), Silt Indication of sedimentation (*SI*), Sand (*SD*), Rubble (*RB*), Calcareous algae (*CA*) and Macroalgae (*MA*)

Discussion

During the present study, differences in both abundance and richness of reef fishes between the two sites were significant, and these differences are reflected in the relative importance of certain trophic guilds at each site. At Site 1, roving herbivores (30 % of total community), such as parrotfishes (*Sparisoma* spp.) and surgeonfishes (*Acanthurus* spp.), were most abundant. At Site 2, however, territorial herbivores (40 %), mainly *Stegastes fuscus*, were most important.

The diversity and abundance of reef fishes seem to be structured by a variety of factors, such as depth (Bell 1983; Pinheiro et al. 2013), exposure (Friedlander et al. 2003), coral quality and abundance (Syms and Jones 2000) and also substratum complexity (Graham and Nash 2013). The URT analysis performed herein showed that the most important factors resulting in differences between the two sites were macroalgae abundance and fishing activity; these two factors explained 95 % of the sample variance. Although coral abundance is usually one of the most important variables driving abundance and richness of reef fishes in the Indo-Pacific (Bell and Galzin 1984) and Caribbean (Hughes 1994), the coral reef in the South Atlantic seems to be influenced primarily by macroalgae abundance. In this context, macroalgal beds (Chaves et al. 2013) and seagrass beds (Pereira et al. 2010) have been shown to be important feeding, reproduction, and resting areas for reef fishes during juvenile and adult life phases in the northeast Brazil.

Phase shifts in coral reefs ecosystems are related to overfishing, declining water quality, predation by *Acanthaster plancii*, and depletion of major functional
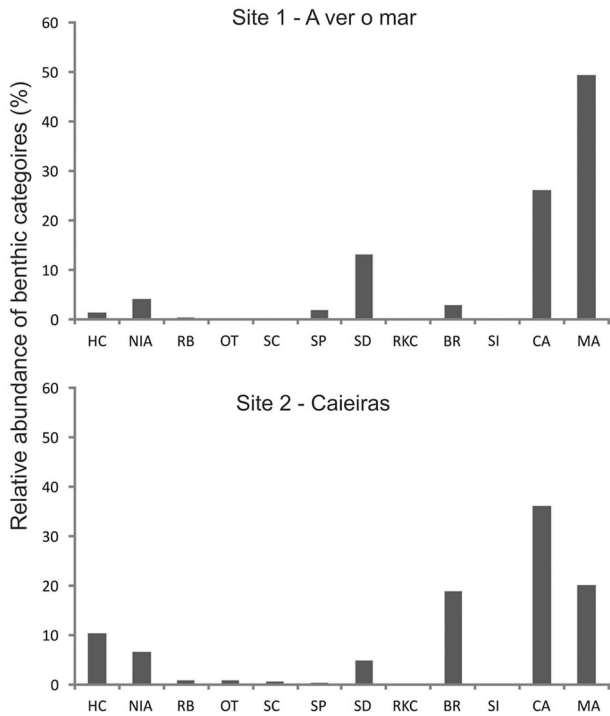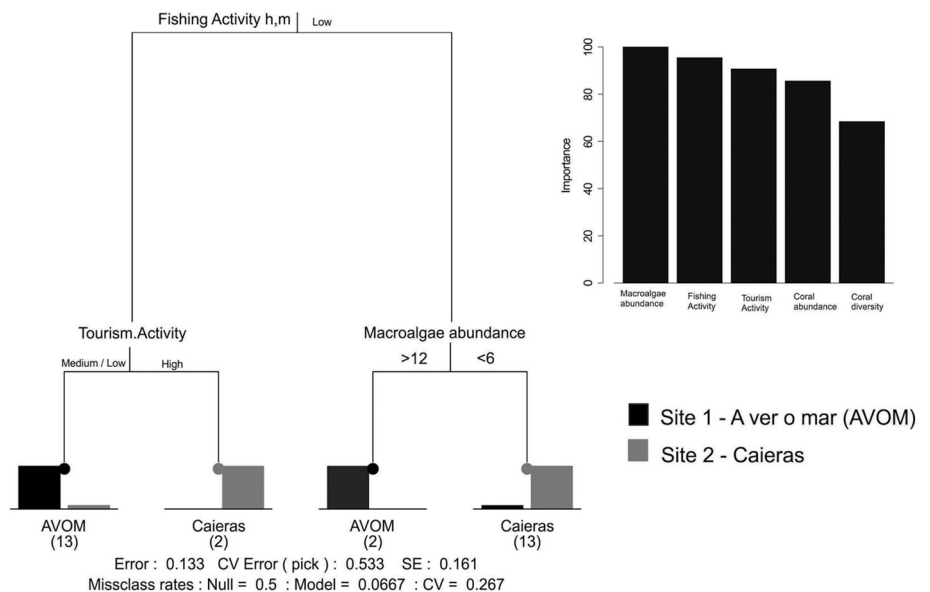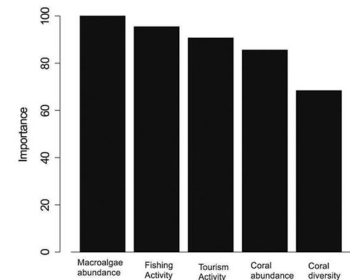

Fig. 4 Univariate regression tree (URT) for the multifactors (e.g. macroalgae abundance, fishing activity, tourism activity and coral abundance and diversity) comparing the two analyses sites
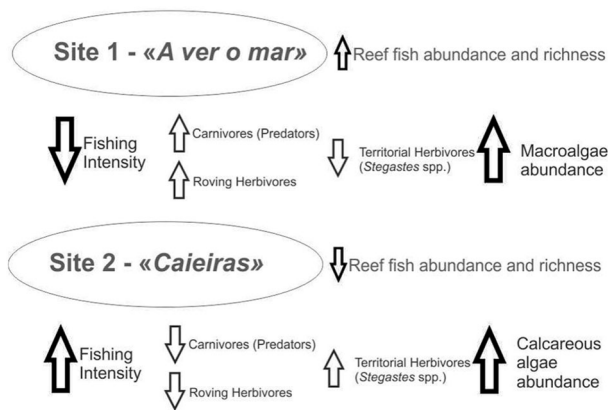
Fig. 5 Conceptual model of changes on the reef fish community according to the two most importance explanatory variables (i.e. algal abundance and fishing intensity)

groups like fishes and echinoid grazers (Hughes et al. 2007; Work et al. 2008). This change results in a high replacement of coral by macroalgae (Work et al. 2008). Brazilian coral reefs have a low diversity and abundance of branching coral species, in spite of having high abundance of the fire coral *Millepora* spp. which is an important habitat for reef fishes (Pereira et al. 2012; Leal et al. 2013). Furthermore, although in the Indo-Pacific coral abundance can be the most important factor within a reef fish community (Syms and Jones 2000), in Brazilian reef ecosystems dominated by macroalgae, algae abundance can be the most important factor contributing to reef fish abundance and diversity. For instance, in naturally algal-dominated environments, such as the rocky zones in the Mediterranean, algae are the primary source of energy and organic matter (Ballesteros 1989). Also, the structure of algal communities is an element of the substratum complexity (Wharton and Mann 1981) that influences habitat selection in fish assemblages (Patton et al. 1985). In these habitats, not only does physical complexity influence reef fish communities, but also the presence of high canopy macroalgae may greatly affect some species (Ruitton et al. 2000). Algal communities and fish assemblages are linked at two levels, the spatial which includes shelter and the trophic; i.e. food availability (Ruitton et al. 2000). Epiphytic fauna are greatly influenced by macroalgae cover (Holmlund et al. 1990; Ballesteros 1991; Sala 1997; Pereira and Jacobucci 2008), thus providing a food resource for mobile invertebrate-feeder species. Consequently, species linked to macroalgae both for shelter and feeding are likely to be influenced by its abundance and/or species composition.

Fishing activity was the second most important factor affecting reef fish community structure. At Site 2 (*Caieiras*), the area most affected by fishing activity, clear effects were observed. More than 40 % of the total

community consisted of *Stegastes fuscus* individuals, with peaks of 1.5 individuals per m^2. *Stegastes fuscus* is an endemic species from the Brazilian coast and is the most abundant damselfish species on South-Western Atlantic coastal coral reefs (Ferreira et al. 2004). This species is not a target in artisanal fishing activity and extreme abundances could feature an unbalanced reef ecosystem (Ilarri et al. 2008). Moreover, a significant reduction in the abundance of roving herbivores, mainly parrotfishes, was observed. There is growing concern that increased artisanal fishing poses a threat to coral reefs (Russ 2002). Jennings and Polunin (1996) concluded that removing just 5 % of fish biomass could significantly alter the structure of reef fish communities once top predators and roving herbivores are preferentially targeted and depleted. Particularly, vulnerable species may be threatened with local or even global extinction (Roberts and Hawkins 1999).

The proposed conceptual model (Fig. 5) summarizes the relationship of the two most important explanatory variables, macroalgae abundance and fishing intensity, and the reef fish community at both sites. At Site 1, area with high reef fish abundance and species richness, fishing intensity was lower and a cascade effect ensued, in which higher macroalgae abundances could result once the abundance of territorial herbivores (i.e. *Stegastes fuscus*) could be reduced by predation. In contrast, for Site 2 fishing intensity was greater and a higher abundance of territorial herbivores was observed (up to 40 % of the community). Consequently, more calcareous algae were recorded at the benthic substratum. Furthermore, in Site 2 a higher coral abundance was observed probably because of a lower abundance of macroalgae and thus less competition for corals (McCook et al. 2001; Bruno et al. 2009). This would result also in an increase of sea urchin density, because of less fish predation, that could potentially favour coral recruitment (Coma et al. 2011). In this context, what is still unclear is the real relationship in between fishing activity and the algae/coral competition trade-off on coral reefs. Despite the fact that most of the studies conducted to date concluded that there is a positive correlation between herbivore abundance and coral cover (Edmunds and Carpenter 2001; Lirman 2001; Hughes et al. 2007), some researchers are still not convinced about this connection (McClanahan and Shafir, 1990; Carassou et al. 2013). It is important to mention that this correlation is extremely dependent on the exact ecological role of herbivore species (Hata and Kato 2004).

Tourism activity is also considered a major threat in coral reef areas, mainly in developing countries. Tourism development may affect reef systems because of the effects of construction, poor infrastructure, direct impacts from snorkelers and scuba divers, and also upon fishery stocks that may be over-exploited to meet tourist demand

(Hawkins and Roberts 1994; Gössling 2001). This situation is a particular threatening in the reef areas of northeast Brazil, which is affected currently by a high increase of tourism with lack of environmental planning. Tamandaré municipaly (site of the present study) is a classic example of this situation. This area is considered one of the most important tourist destinations in the country, and there are no regulations or restrictions on tourist activities and boat operations, both of which are currently sources of negative impacts to the reef (P. H. C. Pareira, personal observation). Specifically, it is already known that artificial feeding impacts reef fish assemblages (Feitosa et al. 2012) and that increase on the tourism activity changes fish community structure in Brazilian reefs (Ilarri et al. 2008) and elsewhere (Milazzo et al. 2002, 2005). However, in the present study tourism was not the most important factor affecting reef fish abundance and species richness patterns. These findings can be related to the fact that tourism activity is a very recent activity on the coral reefs examined in this study, although activity has increased significantly over the last five years. Therefore, it is important to suggest that impacts from tourism activity in coral reefs can be more evident in the long term, a fact that does not reduce the need for oversight of operations that must be given to this industry.

Coral reefs are in decline, with at least 30 % damaged severely and 60 % are predicted to be lost by 2030 (Hughes et al. 2003). Combined with local threats, such as fishing activity and tourism effects, reef fish communities have dramatically changed all around the world (Feitosa et al. 2012; Chong-Seng et al. 2012). Therefore, it is important to understand the factors influencing the extinction vulnerability of coral reef fishes (Graham et al. 2011; Bender et al. 2013). For example, it is already known that roving herbivores (*Sparisoma* spp.) and large predators (*Mycteroperca* spp.) are more affected by fishing activity (Floeter et al. 2006; Graham et al. 2011). Nevertheless, specialized coral-dwelling fishes (*Gobiodon* spp. and *Pomacentrus* spp.) are most affected by habitat loss caused by climate change (Munday 2000; Graham et al. 2011). In this context, and considering the high endemism of Brazilian reef fishes, a strong factor increasing extinction vulnerability (Bender et al. 2013), it is important to understand burden of factors that can affect Brazilian reef fish communities.

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