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Macrobenthic diversity reaction to human impacts on Maceió coral reefs, Alagoas, Brazil

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Abstract. Brazilian coral reefs have many endemic species. In the state of Alagoas, coral reefs are abundant, but different human impacts occur when the reefs are located in urban settings. This study compared the diversity of macrobenthic organisms on five coral reefs on the urban coast of the city of Maceió, which are subject to different human impacts. Semi-quantitative estimates of the abundance of live specimens at each station on these reefs consisted of visual records obtained during five full low-tide periods from 2005 to 2007. Fifty taxa of macrobenthic organisms were analyzed, using cluster analysis (UPGMA, Bray-Curtis). The Jatiúca (50 species) and Ponta Verde (50 species) coral reefs were similar, with 0.2 for cluster analysis; both sites are impacted only by harvesters of seafood. The Pajuçara (48 species) and Amores (47 species) coral reefs were similar, with 0.4 and 0.5, respectively; human impacts at these sites also include boat anchoring. Piscina Natural coral reef had the fewest macrobenthic species (13), with 0.7 for cluster analysis; human impacts on this reef include tourist activities and boat anchoring. These results call for stricter control of human impacts on coral reefs situated on the urban coast, and demonstrate that macrobenthic organisms can be useful indicators for monitoring coral reefs.

Key words: Brazilian reefs, invertebrate reefs, urban reefs, human impacts

Introduction

The Atlantic region is divided into four reef provinces; the Brazilian province is quite distinct because of its small number of coral species. Many of these species are endemic (Veron 1995), and are thus important for reef conservation. The first reports on coral reefs from Brazilian coast were by Laborel (1965, 1969a, b), who characterized scleractinian corals and hydrocoral zonation for different reefs along this coast. He also mentioned the impacts by many lime kilns, locally called "caieira," which exploited coral to obtain whitewash to correct the soil pH for sugarcane agriculture. The northeast coast of Brazil has the largest concentration of reef ecosystems, starting from the Manuel Luiz Banks in the state of Maranhão (Amaral et al. 2007) to the Abrolhos area on the south coast of the state of Bahia (Hetzel and Castro 1994). On the Abrolhos reefs, the species diversity and zonation patterns of hermatypic corals on two fringing reefs was studied by Pitombo et al. (1988), and the colonization and growth of crustose coralline algae were characterized by Figueiredo (1997). Castro and Pires (2001) noted that relatively little information exists about Brazilian coral reefs. Shallow-water scleractinian corals and Zoanthidea from the Coroa Grande reefs in the state of Pernambuco were characterized by Neves et al. (2002) and those from Itacolomi reefs in southern Bahia were characterized by Castro et al. (2006), who demonstrated differences in cover composition and species abundance along the northeast coast of Brazil. The marine sponge fauna of the Pernambuco coast is similar to that of other areas on the northeastern Brazilian coast, according to Muricy and Moraes (1998).

Belém et al. (1986) described environmental problems on coral reefs along the Brazilian coast, and called attention to some of the human impacts. Some reef ecosystems are being degraded by tourism in several areas, where there is a high intensity of activities because of the large flow of people and the lack of adequate planning. The environmental impacts caused by human activities on reef ecosystems were studied in the Abrolhos area (Coutinho et al. 1993, Leão et al. 1994, Leão 1996) and Fernando de Noronha island (Maida et

al. 1995), demonstrating that environmental degradation was linked to uncontrolled tourist activities.

On the coast of the state of Alagoas, environmental aspects and a general characterization of coral reefs, including faunal diversity, were presented by Sovierzoski and Correia (1995). Coral reefs are abundant on the Alagoas coast, and in some areas, fringing reefs are located near the beach line where the top of the reef platform is exposed during low tides. On these reefs, different human impacts occur, principally at urban sites, which are often visited by hundreds of people including local seafood harvesters and tourists, and are also used for boat anchoring (Correia and Sovierzoski 2005). The composition of the fauna associated with the different phytal areas was studied by Santos and Correia (1994, 1995, 2001), who demonstrated the great diversity of invertebrate species. On the Alagoas reefs, some information about species diversity and ecological aspects were described for the phylum Porifera (Sarmento and Corrreia 2002; Cedro et al. 2007). The first record of a living catenicellid bryozoan in the Atlantic Ocean was given by Vieira et al. (2007), from coral reefs on the Maceió coast.

The present study compared the effect of human impacts on the macrobenthic diversity in the intertidal zone, for five coral reefs situated on the urban coast of Maceió city, Alagoas.

Materials and Methods

The study area is situated on the urban coast of Maceió city, capital of the state of Alagoas, northeastern Brazilian coast, where there are many coral reefs (Fig. 1).

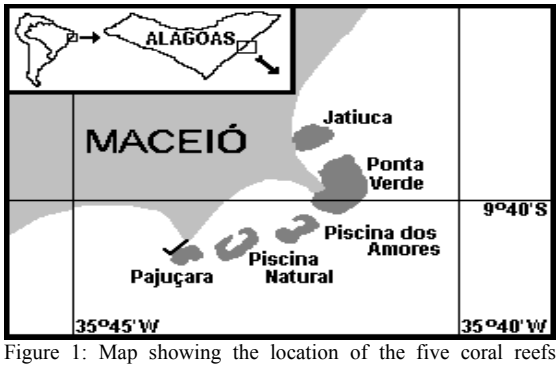

Figure 1: Map showing the location of the five coral reefs investigated on the urban coast of Maceió city, Alagoas, Brazil.

The present research was carried out in the intertidal zone on five urban coral reefs on the Maceió coast, where different human impacts occur. Some of these fringing coral reefs are located adjacent to the beachline, such as Jatiúca coral reef (9º39'38''S / 35º42'05''W), Ponta Verde coral reef (9º40'10''S / 35º41'30''W) and Pajuçara coral reef (9º42'18''S / 35º43'36''W). Two other coral reefs, Piscina dos Amores coral reef (9º41'18''S / 35º42'24''W) and Piscina Natural coral reef (9º41'48''S / 35º42'10''W), are situated at different depths in the offshore zone (Fig. 2).

All five coral reefs have the platform top exposed during low tide, where some macrobenthic organisms occur. However, the species are more concentrated in the reef pools, which are up to 2 meters deep. The reef borders have countless irregularities, with small entrances and some inlets with an accumulation of sand in the low areas, and strong wave and current action.

Semi-quantitative estimates of the abundance of live specimens on five transects, each 10 metres long, were made for the intertidal zone and in the reef pools of the five coral reefs. These estimated were based on an exhaustive compilation of visual records made during five full low-tide periods from 2005 to 2007. Fifty taxa of macrobenthic organisms were analyzed: 17 Porifera, 10 Cnidaria, 9 Echinodermata, and 14 macroalgae, because these organisms were the most common on these reefs. These macrobenthic organisms were selected because they are most common on the reef intertidal zone at Maceió coast. The macrobenthic analyses were based on the percentage cover for each species, showing the colonization intensity.

Figure 2: Aerial view of the coral reefs investigated on the urban coast of Maceió city, Alagoas, Brazil: (A) Jatiuca, (B) Ponta Verde, (C) Piscina dos Amores, (D) Piscina Natural, (E) Pajuçara.

On the urban coral reefs of Maceió, different human impacts occur: some areas are frequently visited by hundreds of people during low tide, principally in summer. The principal human

activities are local seafood harvesters, boat anchoring, and tourists, with different intensities depending on the number of people and boats per day during low tide that were transformed percentage occurrence. The Bray-Curtis index and UPGMA were measured for cluster analysis, to determine the similarity between macrobenthic organisms on the five reefs on the urban coast of Maceió city.

Results

There was an inverse relationship between the level of macrobenthic diversity and the level of human impacts at these sites. On the Jatiúca and Ponta Verde coral reefs, all of the 50 species of macrobenthic organisms were found (17 Porifera, 10 Cnidaria, 9 Echinodermata and 14 macroalgae). On the Pajuçara coral reef, 48 species were found; and 47 species were recorded for Piscina dos Amores coral reef. The Piscina Natural coral reef differed the most, with only 13 species, mostly macroalgae (Table 1).

Different intensities of human impact were recorded on the five coral reefs on the urban coast of Maceió city. All these coral reefs are usually visited by hundreds of people, such as local seafood harvesters, boat anchoring, and tourists, with differing intensities. On the Jatiúca and Ponta Verde coral reefs, few human impacts were observed, mostly seafood harvesters. On the Pajuçara and Piscina dos Amores coral reefs, human impacts were also caused by anchored boats. The Piscina Natural coral reef was subject to the highest level of tourist activities and boat anchoring, which occurs intensely year-round, principally in summer and vacation periods (Table 2).

Table 2: The intensity of human impacts on the five coral reefs investigated on the urban coast of Maceió city, Alagoas, Brazil. Legend: XXXX 100%, XXX < 75% , XX < 50% , X < 20%

	CORAL REEFS				
HUMAN IMPACTS	Jatiuca	Ponta Verde	Pajuçara	Piscina dos Amores	Piscina Natural
Seafood harvesters	XXX	XXX	XXX	XXX	XXX
Boat anchoring	X	X	XX	XX	XXXX
Tourists activities	X	X	X	XX	XXXX

Jatiúca and Ponta Verde coral reefs were more similar, with distance 0.2 in cluster analysis, where there was high diversity and low human impacts intensities were found. The Pajuçara and Piscina dos Amores coral reefs were included in the same cluster, with 0.4 and 0.5, but had fewer species and more human impacts. The greatest difference was observed on the Piscina Natural coral reef, with 0.7 for cluster analysis; there were few species, and the human impacts were caused by many different activities, as well as the presence of tourists (Fig. 3).

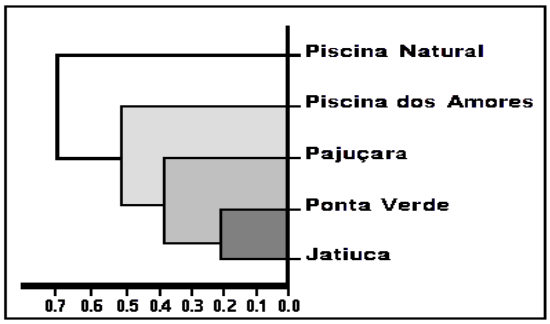

Figure 3: Cluster analyses on the five coral reefs investigated on the urban coast of Maceió city, Alagoas, Brazil.

Discussion

These results demonstrate that the diversity of macrobenthic organisms can be useful for monitoring coral reefs on the Brazilian coast, to discern the various levels of human impact. The coral reefs on the urban coast of Maceió city have many problems caused by human activities. Previous reports have described the different human impacts on coral reefs of the Brazilian coast, such as the studies of Laborel (1969a, b), who mentioned the whitewash industry, commonly referred to as "caieira", although this activity no longer exists.

However, this study indicates that there are more problems related to human impacts associated with tourist activities, which cause serious damage to the Maceió coral reefs. At all these sites, the scleractinian corals were most sensitive to different impacts among other macrobenthic organisms analyzed.

The results demonstrated differences in composition and species abundance along the northeast coast of Brazil, compared to information from Manuel Luiz Banks in the state of Maranhão (Amaral et al. 2007) and the Abrolhos area (Pitombo et al. 1988). However, on the Maceió coral reefs, the cnidarian species cited in this study are common on other coastal coral reefs in southern Pernambuco (Neves et al. 2002) and Bahia (Castro et al. 2006), as are the sponge

species on the coast of the state of Pernambuco (Muricy and Moraes 1998) and on the Maceió coast (Cedro et al. 2007).

On the impacted coral reefs, macroalgae occupy the substrate (Lirman 2001, McCook et al. 2001), because they grow faster than the invertebrate species such as corals and sponges. The evidence of this competition was found principally on the highly impacted Piscina Natural coral reef, with algae dominance and few invertebrate species.

Many other coral reefs areas along the Brazilian northeast coast have similar problems caused by human impacts (Belém et al. 1986, Coutinho et al. 1993, Maida et al. 1995). In all these reef areas, such as the Pisicna Natural coral reef, the highest impact level is caused by tourist activities, because they are visited by large numbers of people, principally during the summer vacations.

These observations illustrate the need for stricter control of human activities on urban coral reefs on the Maceió coast, with monitoring activities and restricting access, specifically in the coral reef areas where tourist activities occur.

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Table 1: Macrobenthic diversity on the five coral reefs investigated on the urban coast of Maceió city, Alagoas, Brazil.
Legend: XXXX 100%, XXX < 75% , XX < 50% , X < 20% , - 0%

	TAXA	CORAL REEFS				
		Jatiuca	Ponta Verde	Piscina dos Amores	Piscina Natural	Pajuçara
	PORIFERA					
1	*Amphimedon viridis*	XXX	XXX	XX	-	XX
2	*Amphimedon compressa*	XXX	X	X	-	X
3	*Chalinula molitba*	X	XX	X	-	X
4	*Chondrilla nucula*	XXX	XXX	XX	-	XX
5	*Chondrosia collectrix*	X	XX	X	-	-
6	*Chondrosia reniformis*	X	XX	X	-	X
7	*Cinachyrella alloclada*	XX	XXX	XXX	-	XXX
8	*Cinachyrella apion*	X	X	-	-	X
9	*Cliona celata*	XX	XX	X	-	XXX
10	*Cliona varians*	XX	XX	X	-	XX
11	*Haliclona curacaoensis*	XX	XX	X	-	XX
12	*Haliclona manglaris*	XX	XX	X	-	X
13	*Haliclona melana*	XX	XX	X	-	X
14	*Niphates erecta*	XX	X	X	-	X
15	*Spirastrella hartmani*	XX	X	X	-	X
16	*Tedania ignis*	XXX	XXX	X	X	XXX
17	*Tethya maza*	X	XX	X	-	XX
	CNIDARIA					
18	*Agaricia agaricites*	XXX	XX	X	-	X
19	*Favia gravida*	XX	XXX	X	-	X
20	*Mussismilia hartii*	X	X	X	-	X
21	*Mussismilia hispida*	X	X	X	-	X
22	*Palythoa caribaeorum*	XX	XXX	X	XX	XX
23	*Palythoa variabilis*	X	XX	X	-	X
24	*Porites asteroides*	XXX	XX	X	-	X
25	*Porites branneri*	XXX	XXX	X	-	X
26	*Siderastrea stellata*	XX	XXX	XXX	-	X
27	*Zoanthus zociathus*	XXX	XXXX	X	X	XX
	ECHINODERMATA					
28	*Diadema antillarum*	XX	X	X	-	X
29	*Echinaster echinophorus*	X	X	-	-	-
30	*Echinometra lucunter*	XXXX	XXXX	XX	X	XX
31	*Eucidaris tribuloide*	XX	X	X	-	XX
32	*Lytechinus variegatus*	X	X	X	-	XXX
33	*Linckia guildingii*	XX	XX	X	-	XX
34	*Ophioneris reticulata*	X	X	X	-	X
35	*Ophioderma cinereus*	XX	X	X	-	X
36	*Ophiotrix angulata*	X	X	X	-	X
	MACROALGAE					
37	*Acanthophora* sp	X	X	-	X	X
38	*Amphiroa fragilissima*	XX	XXX	XX	X	XX
39	*Bryopsis sp*	XX	XX	X	-	XX
40	*Caulerpa mexicana*	XX	X	X	-	X
41	*Caulerpa racemosa*	XX	XX	X	X	XX
42	*Dictyosphaeria* sp	XX	XX	X	X	XX
43	*Dictyota cevicronis*	XX	XX	X	-	X
44	*Enteromorpha* sp	XX	XX	X	X	X
45	*Halimeda opuntia*	XX	XXXX	XX	X	XX
46	*Gelidiella* sp	XX	XX	X	X	X
47	*Gelidium* sp	X	XX	X	XX	X
48	*Padina* sp	XX	XX	X	-	X
49	*Sargassum cymossum*	XX	XX	X	X	XX
50	*Ulva lactuca*	X	X	X	-	XXX
	Total species	50	50	47	13	48