Arquivos de Ciências do Mar

TOURISM IMPACT ON REEF FLATS IN PORTO DE GALINHAS BEACH, PERNAMBUCO, BRAZIL

Impacto do turismo nos recifes da Praia de Porto de Galinhas, Pernambuco, Brasil

Juliana Imenis Barradas[1], Fernanda Duarte Amaral[2], Malva Isabel Hernández[3], Manuel Jesus Flores-Montes[4], Andrea Quirino Steiner[5]

ABSTRACT

Approximately 60% of coral reefs are currently threatened by several natural and anthropogenic impacts. One of the fastest growing industries in the world and a great producer of organic waste, tourism can have negative impacts on biodiversity and on the functioning of reef ecosystems. This study aimed to find possible anthropogenic impacts related to tourism in reef environments of northeastern of Brazil (Porto de Galinhas Beach, Pernambuco). Water samples were collected for salinity, pH, dissolved inorganic nutrients (ammonium, nitrite, nitrate, phosphate, and silicate), and chlorophyll a analyses during the high and low-season tourism calendar. A greater concentration of ammonium, nitrate, and phosphate was verified during the high tourist season, whereas nitrite, silicate, and chlorophyll a were highest during low tourist season. Trampling and other recreational activities harmful to reefs were also observed in the area.

Keywords: *tourism, nutrients, anthropogenic impacts, Porto de Galinhas Beach.*

RESUMO

Atualmente, cerca de 60% dos recifes de coral estão ameaçados devido a impactos naturais e antropogênicos diversos. Um dos setores empresariais que cresce mais rapidamente no mundo e que produz uma grande quantidade de resíduos orgânicos, o turismo pode trazer impactos negativos na biodiversidade e funcionamento dos ecossistemas recifais. Esse estudo objetivou encontrar possíveis impactos antropogênicos relacionados ao turismo nos ambientes recifais de uma praia do nordeste brasileiro (Porto de Galinhas, Pernambuco). Amostras de água foram coletadas para análises de salinidade, pH, nutrientes inorgânicos dissolvidos (amônia, nitrito, nitrato, fosfato, e silicato) e clorofila a durante a alta e baixa estação turística. Uma maior concentração de amônia, nitrato e fosfato foi verificada durante a alta estação, enquanto o nitrito, silicato e clorofila a tiveram valores mais altos durante a baixa estação. Pisoteio dos recifes e outras atividades de lazer nocivas aos recifes também foram observadas no local.

Palavras-chaves: *turismo, nutrientes, impactos antropogênicos, Praia de Porto de Galinhas.*

[1] Bolsista CAPES - mestrado em Ciências Biológicas. Universidade Federal da Paraíba. Cidade Universitária s/n, CEP 58059-900, João Pessoa – PB,Brazil E-mail : julianaimenis@yahoo.com.br

[2] Departamento de Biologia, Laboratório de Ambientes Recifais. Universidade Federal Rural de Pernambuco, Recife – PE, Brazil

[3] Departamento de Ecologia e Zoologia, Universidade Federal de Santa Catarina, Florianópolis –SC, Brazil

[4] Departamento de Oceanografia, Universidade Federal de Pernambuco, Recife – PE, Brazil

[5] Associação Pernambucana de Defesa da Natureza – Pernambuco, Brazil

INTRODUCTION

Due to their proximity to big cities and their easy access, reef environments have been heavily affected by human influence (Castro & Pires, 2001) and are destroyed by the very same economic activities they sustain (Wilkinson, 1992; Richmond, 1993). They also receive pollutants by urban, agricultural, and industrial rejects. The presence of tourists and the changes caused to the environment in order to receive them are great threats to marine ecosystems. For example, in the central and southeast Pacific Islands, the removal of corals, sand, and mangroves for construction damages lagoons and reef flats next to big cities; in addition, the roads, airports, and hotels built in these areas negatively impact these environments (Salvat, 2002) and modify the natural overall landscape. Trampling and overfishing are other problems that damage these delicate ecosystems, as observed in Hawaii (Brainard *et al*., 2002).

Tourism is one of the fastest growing industries in the world, including underwater tourism. Due to their beauty, coral reefs and other reef environments attract hundreds of thousands of tourists and account for a substantial portion of the gross domestic product (GNP) in several countries, such as those of the Caribbean. Nevertheless, unplanned tourism can bring about serious damage to these ecosystems (Bryant *et al*., 1998).

Such is the case of southern Pernambuco's reef environments, a state in northeastern Brazil whose marine ecosystems suffer heavily from the impact of human activities. Although it is a problem that dates far back, preliminary observations to create the Costa dos Corais Environmental Protection Area – EPA (*Área de Proteção Ambiental Costa dos Corais*) were only carried out in the 1990's, when reefs were found in poor condition near the larger cities. Unfortunately, when the Costa dos Corais Environmental Protected Area was officially created in 1997, the neighboring reef environments of Porto de Galinhas Beach were not included, despite their important coral fauna and the threats to them – only recently this possibility is being discussed.

Nevertheless, years after this protection area was implemented, another study (Steiner *et al*., 2006) identified several tourism-related problems that threaten the EPA's reef environments: unplanned seaside urban settings, construction of roads and highways to access new tourism-directed enterprises and real estate, changes in the natural landscape (including mangrove deforestation and river transfers), lack of appropriate sanitation and waste management infrastructure to receive tourists in the high season, air and water pollution from several sources, and direct damage to reefs due to anchoring and trampling.

Like in other regions in Brazil and around the world, tourism has helped promote a large portion of local development in the studied area. Having been repeatedly elected one of the most beautiful beaches in Brazil, tourism has been growing fast in Porto de Galinhas over the past fifteen years. This has created many employment opportunities for the local and bordering population and,thus, tourism has become the main source of jobs and income in the area. However, the lack of planning and organization has generated several problems related to soil use and occupation and the exploitation of the natural resources; this has in turn resulted in ecosystem degradation, especially that of reefs and mangroves.

Nearly 60,000 people arrive at Porto de Galinhas Beach each month during high season and approximately 69% visit the reef formations by walking, snorkeling or scuba diving (MMA/SECTMA/CPRH, 2003). Reef degradation by trampling has been described since 1977 (Woodland & Hooper, 1977) and can limit coral and calcified hydroid presence through physical damage, often causing colony death and overgrowth of other organisms. Trampling also increases sedimentation rates (clogging polyps) and decreases water transparency (affecting zooxanthellae photosynthesis). For the studied area, Barradas *et al*. (2010) observed a higher percentage of bare areas in Porto de Galinhas where people are taken by boat to walk on the reef and practice snorkeling.

In addition to trampling, diving activities can also be very harmful to reef environments – especially when carried out by inexperienced people. This happens due to the damage brought about by hands, the diver's body itself, and the diving equipment and paddle (Epstein *et al*., 1999; Rouphael & Inglis, 2001). Several studies have related diving practices to damages promoted to reef environments *e.g*, Rogers & McLain Sullo, 1988; Davis & Tisdell, 1995; Allison, 1996; Rouphael & Inglis, 1997; Rouphael & Inglis, 2001; Tratalos & Austin, 2001; Zakai & Chadwick-Furman, 2002). At Porto de Galinhas beach, approximately 1,200 people practice scuba diving each month, and many others practice snorkeling.

Thus, the aim of this study was to relate tourism activities to anthropogenic impacts in the reef environment of Porto de Galinhas Beach by quantifying abiotic conditions, and identifying and describing human activities in the area.

MATERIAL AND METHODS

Porto de Galinhas Beach is located on the southern coast of Pernambuco State (northeastern Brazil), 64 km from its capital city, along which 900-meter long reef formations can be found next to the shore. It has a humid tropical climate with rainy and dry seasons, and a 24ºC mean temperature (CPRH, 2001).

Four stations were selected along the reef formation using a GPS (Global Positioning System): 1 – 8º30'73"S, 35º00'43"W; 2 – 8º30'34"S, 34º59'94"W; 3 – 8º30'41"S, 34º59'91"W; and 4 – 8º30'16"S, 34º59'92" W.

Water samples were collected during the low and high tourism seasons, October, 2004 and February, 2005, respectively, both in the dry season. Samples were tested for salinity, pH, dissolved nutrients (ammonium, nitrite, nitrate, phosphate, and silicate), and chlorophyll *a* analyses.

The method described by Strickland & Parsons (1972) and Grasshof *et al*. (1983), was used for the nutrient analyses and UNESCO (1973) for chlorophyll *a* analysis. The pH value was recorded using a Hanna Instrument 8417 potentiometer. Salinity was measured using the method described by Strickland & Parsons (1972). Data was analyzed between seasons using Paired Student's t test for the same stations, with Statistica® 6.0 software.

To determine which month had the greatest tourist frequency, human interferences observed in the study area were recorded during visits carried out from October, 2004 to May, 2005 and were photographed for visual evidence.

RESULTS

The human activities observed in the area were: constructions along the beach and as a likely consequence, pronounced erosion, trampling and recreational activities, boat anchoring, collection of material for decoration and aquariums, collection of reef fauna, predatory fishing, mangrove destruction and land filling, sewage discharge directly into the seawater, and great quantities of trash especially plastic. In Brazil, studies on the anthropogenic pressure on reef environments have shown damage due to commercial activities, increase in water turbidity, pollution by sewage, and overfishing *e,g*, Belém *et al*., 1986; Coutinho *et al*., 1993; Leão, 1996; Costa Jr. *et al*., (2000, 2006); Porto Neto & Marcelino, 2009, Costa *et al*., 2007 – similar to what was observed in this study.

Table I presents average values for depth, water transparency, water temperature, pH, and salinity in the four stations studied during low and high tourist season (October, 2004 and February, 2005, respectively).

Table I – Average values for depth, water transparency, water temperature, pH, and salinity in the four stations studied during the low and high tourism seasons (October, 2004 and February, 2005, respectively).

Environmental factors	Low tourism season	High tourism season
Depth	2.5 – 5.0 m	1.5 – 3.5 m
Water transparency	1.75 m	1.90 m
Water temperature	27.7 ºC	28.0 ºC
pH	8.21	8.45
Salinity	36.38	35.39

The alkaline pH values between 8.2 and 8.4 are characteristic of tropical coastal areas. Salinity showed few variations; Sassi (1991) attributes the high salinity found in the reef environment of Ponta do Seixas (Paraiba State, Northeast Brazil) to the absence of larger rivers in the area. The same is true for the area studied here. The water temperature showed few variations during the period covered, and to Perkins (1974) this homogeneity is associated with the shallow depths characteristic of tropical coastal environments.

The ammonium concentrations observed were significantly different between the two seasons, with a higher average during the high tourist season (Figure 2). No significant differences in the concentrations of nitrate and phosphate were observed between the two seasons, but both showed higher means in February (high tourist season) (Figures 3 and 4). The mean concentrations of nitrite, silicate, and chlorophyll a showed significant differences between the two seasons, with higher values during the low tourist season (Figures 5 to 7).

Nutrient concentrations found in this study are similar in value to those found by Machado *et. al*., (2007) in the same region; by Moura & Passavante (1994) at Tamandaré Beach (Pernambuco); and by Feitosa & Bastos (2007) at reef environments of Maracajaú, Rio Grande do Norte. They are all values characteristic of environments free of organic pollution.

The higher values of ammonium, nitrate, and phosphate found in the high tourist season may indicate that the region is receiving a greater supply of nutrients during this period. However, the amount of rain (about 50 mm) at this time of the year was quite low (Figure 1), which means the large quantity of nutrients might not be due to the influence of rivers or coastal lixiviation. In addition, according to data from Pernambuco's State Environment and Water Resources Agency (*Agência Estadual de Meio Ambiente e Recursos Hídricos – CPRH*), the high values for fecal coliforms underscore the presence of human wastes through rivers, drain channels, and clandestine connections (CPRH, 2001). At Porto de Galinhas Beach, seawater contamination can also occur through percolation due to the sandy soil.

A high percentage of seaweed cover has also been observed in this area (Barradas *et al*., 2010) and changes in its diversity and/or biomass are seen in impacted environments and hence many species are considered pollution indicators (Hallock *et al*. 1993; Hallock, 2002; Villaça, 2002). Macroalgal blooms can occur due to higher nutrient concentrations in the water or due to decreases in the populations of herbivorous species. Van Den Hoek (1969) and Foster (1987 *apud* Coutinho *et al*., (1993) suggest that herbivory – especially that carried out by fish and sea urchins – is necessary for coral reef maintenance. Valentine & Heck (1991) suggest that the abundance of algae is kept low due to the herbivory of sea urchins, which has already been observed by Kilpp (1999) for the reefs of Tamandaré. Barradas et al., (2010) only found 2% sea urchin cover for Porto de Galinhas. The trophic level of inshore waters at Porto de Galinhas varied from mesotrophic to eutrophic and also corroborates studies by Machado *et al*. (2007) and Fonseca *et al*. (2002) for the same locality.

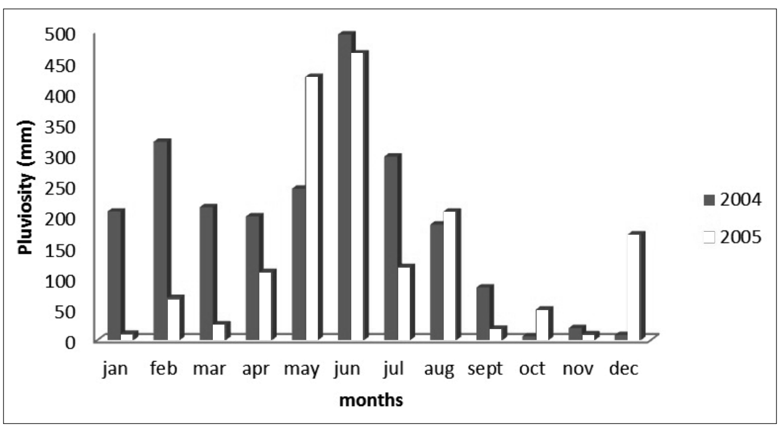

Figure 1 – Rainfall data obtained from the Porto de Galinhas Experimental Station for the years of 2004 and 2005. Source: LAMEPE/ITEP (2010) (a,b).

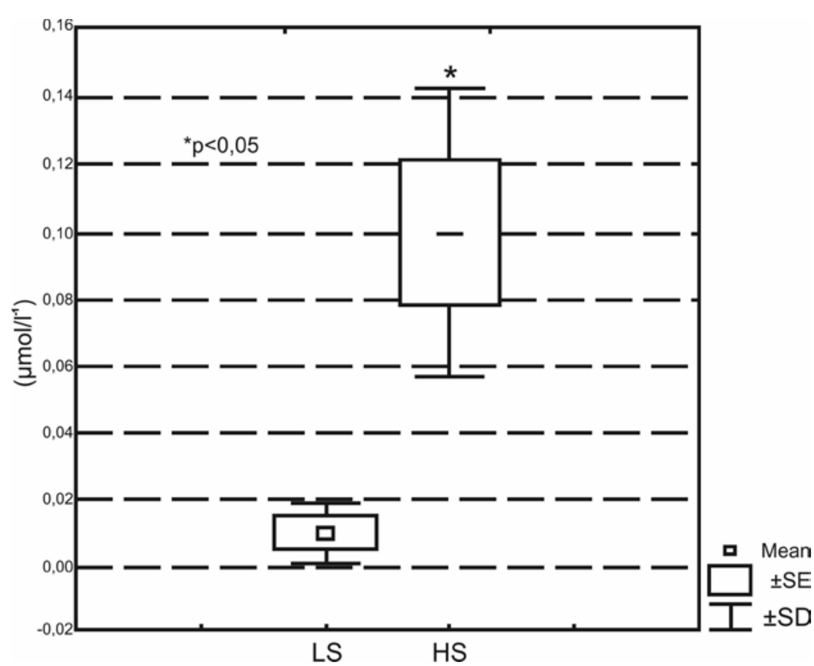

Figure 2 – Ammonium concentrations at the reef environment of Porto de Galinhas Beach (Pernambuco, Brazil) in October 2004 and February 2005 (LS – low tourist season: 0.01 µmol /l^{-1}; HS – high tourist season: 0.10±0.04 µmol /l^{-1}; values shown as Mean ±SD [t=-3.65; df=3; p<0.05]).

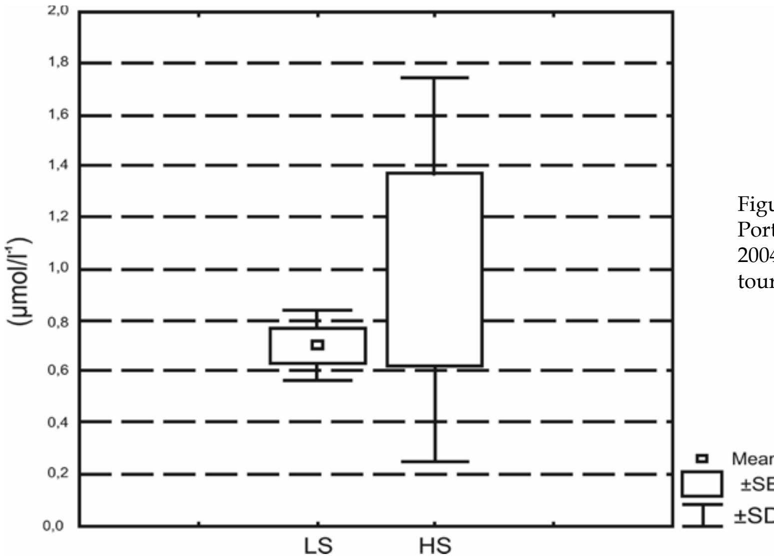

Figure 3 – Nitrate concentrations at the reef environment of Porto de Galinhas Beach (Pernambuco, Brazil) in October 2004 and February 2005 (LS – low tourist season; HS – high tourist season).

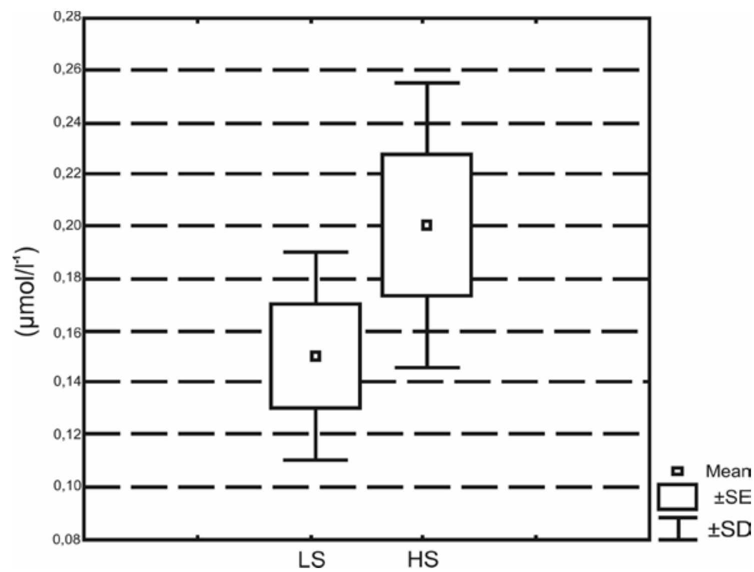

Figure 4 – Phosphate concentrations at the reef environment of Porto de Galinhas Beach (Pernambuco, Brazil) on October 2004 and February 2005 (LS – low tourist season; HS – high tourist season).

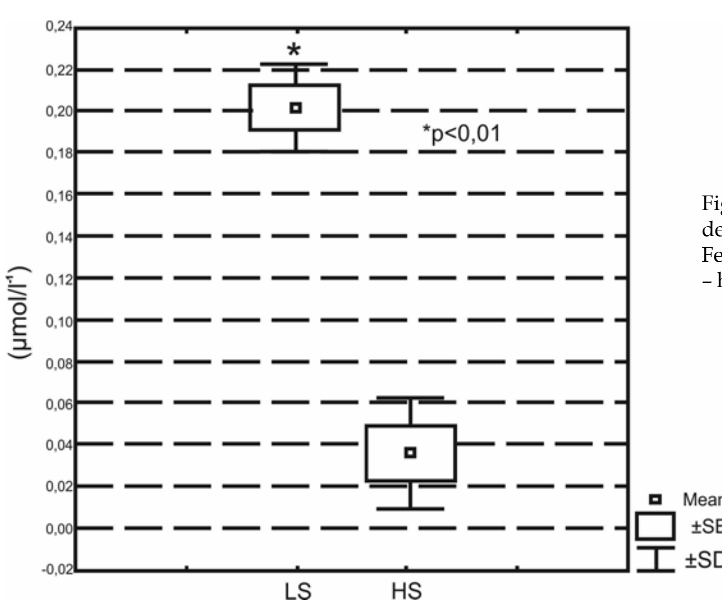

Figure 5 – Nitrite concentrations at the reef environment of Porto de Galinhas Beach (Pernambuco, Brazil) in October 2004 and February 2005 (LS – low tourist season: 0.20±0.02 µmol /l^{-1}; HS – high tourist season: 0.03±0.02 µmol /l^{-1} [$t=24.8$; $df=3$; $p<0.01$])

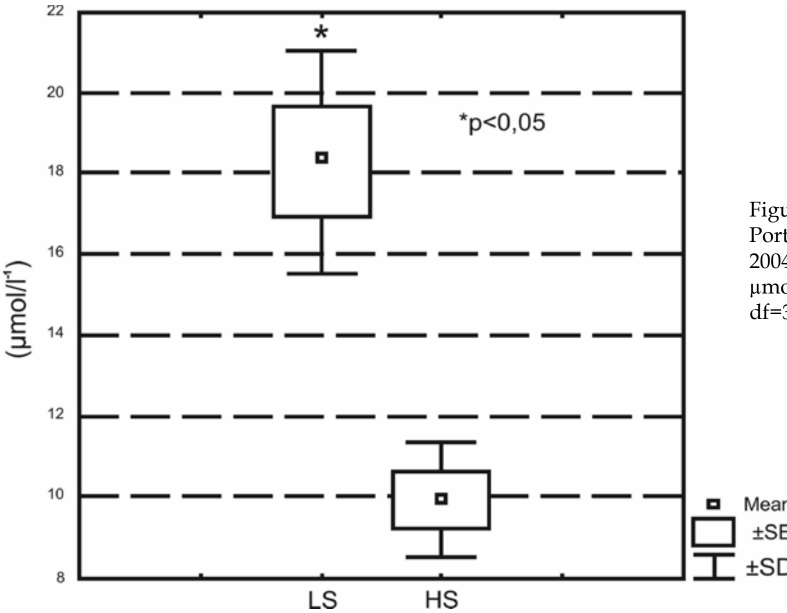

Figure 6 – Silicate concentrations at the reef environment of Porto de Galinhas Beach (Pernambuco, Brazil) in October 2004 and February 2005 (LS – low tourist season: 18±2.76 µmol /l^{-1}; HS – high tourist season: 10±1.41 µmol /l^{-1} [t=7; df=3; $p<0.01$]).

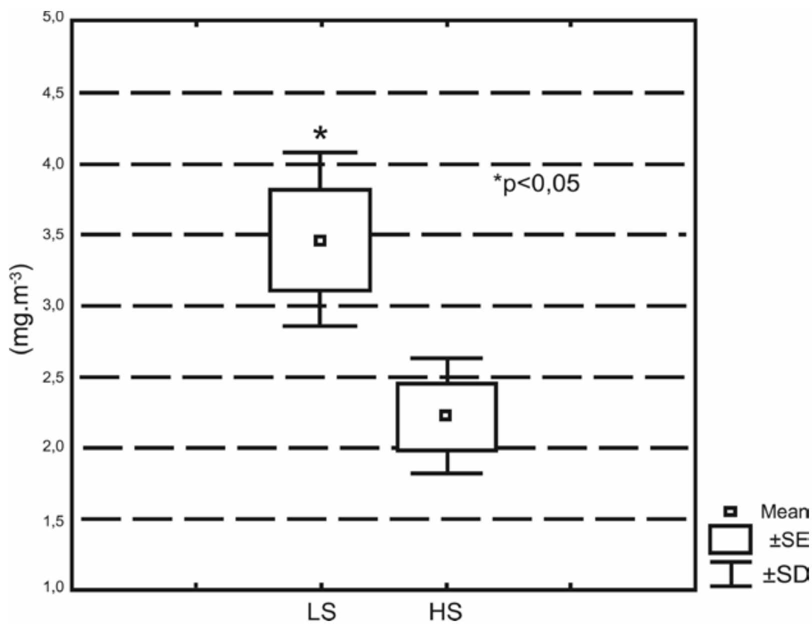

Figure 7 - Chlorophyll a concentrations at the reef environment of Porto de Galinhas Beach (Pernambuco, Brazil) in October 2004 and February 2005 (LS – low tourist season: 3.47±0.61 $mg.m^{-3}$; HS – high tourist season: 2.22±0.40 $mg.m^{-3}$ [t=8.25; dfl=2; $p<0.05$]).

CONCLUSIONS

The reef environment of Porto de Galinhas Beach has been suffering from the effects of unplanned human presence, which has become very common in scenically attractive environments such as these. Data collected here showed that tourism has negatively impacted the area and thus must be accompanied more closely by the relevant regulatory institutions. In order to minimize human anthropogenic stress a few measures could be taken, such as implementing a sewage collection and treatment system, delimiting areas for boat circulation, to constructing points for boat anchoring, to limiting the number of visitors on the reef per day, providing tourists with correct instructions on how to behave in this environment, prohibiting the collection of marine organisms and predatory fishing, to placing waste baskets along the beach, and improving garbage collection and disposal system.

It is important to note that no interferences will be effective without a good educational program, since the people who depend on the reef environment for income need to fully understand the importance of that environment in order to contribute to its conservation. Thus, it is necessary that the municipal government participate by supervising the programs implemented.

Acknowledgments - We would like to thank the chemistry laboratory of the Departamento de Oceanografia da Universidade Federal de Pernambuco for the water analysis; the CAPES – Coordenação de Aperfeiçoamento Pessoal de Nível Superior for the bursary given to the first author; PADI – Professional Association for Diving Instruction/Project Aware to have supported part of this study; Aicá Diving Center to the logistic help with diving and water collection; and the Universidade Federal da Paraíba – Departamento de Sistemática e Ecologia for the opportunity to carry out this study.

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