UNIVERSIDADE FEDERAL DE PERNAMBUCO
Centro de Tecnologia e Geociências
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RESÍDUOS SÓLIDOS BENTÔNICOS EM AMBIENTES RECIFAIS DE PERNAMBUCO E NA ABORDAGEM DAS OPERADORAS DE MERGULHO

Orientadora: Dra. Monica Ferreira da Costa

Recife, fevereiro 2009

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Dissertação apresentada ao Programa de Pós-Graduação em Oceanografia do Centro de Tecnologia e Geociências da Universidade Federal de Pernambuco como requisito parcial para obtenção do grau de Mestre em Oceanografia.

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Dissertação de mestrado apresentada e aprovada em 12 de fevereiro de 2009.

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SUMÁRIO

RESUMO

Resíduos sólidos marinhos bentônicos são aqueles resíduos que se depositam no fundo dos oceanos. Estudos sobre esse tipo de poluente ainda são escassos em todo o mundo, tanto estudos de quali-quantificação quanto sobre a compreensão de como os atores sociais ligados ao meio marinho se comportam em relação a esse problema. Para tanto, o presente estudo teve como objetivos quali-quantificar os resíduos sólidos bentônicos em dois tipos de ambientes recifais da costa de Pernambuco, Brasil (um recife semi-submerso exposto a um alto grau de urbanização e exploração turística, localizado na praia da Boa Viagem, Recife; e um recife costeiro submerso em uma região pouco urbanizada e com pouca atividade turística, localizado em frente à foz do Rio Goiana, norte do estado). Outro objetivo foi avaliar a abordagem de escolas e operadoras de mergulho de Pernambuco em relação à poluição marinha, principalmente aquela gerada por resíduos sólidos. Em 28 amostragens realizadas no recife semi-submerso da Boa Viagem, um total de 11.261 resíduos foi observado, sendo a maioria plástico. Resíduos presos no recife, areia ou macroalgas são diferentes daqueles observados livres sobre o recife. A praia adjacente foi considerada como a principal fonte de resíduos para o recife estudado. No recife submerso próximo à foz do Rio Goiana foram amostrados 27 transectos, nos quais nenhum resíduo sólido submerso foi observado. Foram identificadas áreas com potencial para reter resíduos. Foram realizadas entrevistas com proprietários ou funcionários de 14 escolas/operadoras de mergulho. Foram observados diferentes comportamentos em relação à prevenção e remediação da poluição por resíduos sólidos. Através do presente estudo ficou evidenciado a necessidade de expandir os estudos sobre resíduos sólidos marinhos na costa do Brasil, incluindo também outros ambientes além das praias. Recifes costeiros submersos e semi-submersos devem ser incluídos também nos planos de limpeza e gerenciamento de poluição marinha. Estudos em locais ainda sob baixo impacto antrópico também devem ser ampliados, para haver dados de base para trabalhos futuros. Os atores sociais envolvidos diretamente com o ambiente marinho, dentre eles as escolas/operadoras de mergulho, precisam entender melhor o seu papel nas mudanças que devem ser feitas, passando de passivos a ativos nos processos de gerenciamento do ambiente costeiro.

Palavras-chave: resíduo sólido marinho, mergulho, beachrock, recife costeiro, plástico.

ABSTRACT

Benthic marine debris are those debris deposited on the bottom of the oceans. Studies of this type of pollutant are still scarce all over the world, both about the quali-quantification, as well as about the understanding of how social actors linked to the marine environment are behaving on this issue. Thus, this study aimed to quali-quantify the benthic marine debris in two different reef environments of the Pernambuco coast, Brazil (a semi-submerged reef exposed to a high degree of urbanization and tourism, located on the Boa Viagem Beach, Recife, and; a submerged reef in a coastal region with little urban and tourist activity, located in front of the Goiana River estuary, north of the state). Another objective was to evaluate the approach of dive schools and operators of Pernambuco State in relation to marine pollution, mainly the one generated by marine debris. In 28 surveying occasions of the semi-submerged reef of Boa Viagem, a total of 11 261 debris was observed, mostly plastics. Debris trapped on the reef, sand or macroalgae are different from those observed loose on the reef. The adjacent beach was identified as the main source of debris to the studied reef. In the submerged reef near the Goiana River estuary, 27 transects were sampled and no benthic marine debris was observed. Areas with potential to retain benthic marine debris were identified. It was realized interviews with owners or employees of 14 dive schools/operators. We observed different behaviors in relation to the prevention and remediation of pollution from marine debris. Through this study it was evident the need to expand the studies about marine debris on the coast of Brazil, also including other environments besides beaches. Coastal reefs should also be included in plans for cleaning and management of marine pollution. Studies in places still under low anthropic impact should also be expanded, so there would be baseline data for future works. The social actors directly involved with the marine environment, among them dive schools/operators, need to better understand their role in changes that have to be made, passing from passive to active in the processes of management of the coastal environment.

Keywords: marine debris, scuba dive, beachrock, coastal reef, plastic.

INTRODUÇÃO

Resíduos sólidos são todos os materiais oriundos das atividades humanas que perderam seu valor ou função e foram descartados, além de objetos perdidos. Através de rios, usuários de praia e/ou descarte direto no mar por navios e plataformas de petróleo, os resíduos sólidos irão contaminar e poluir os oceanos e os ambientes costeiros, passando então a ser denominados de resíduos sólidos marinhos. Quando depositados no fundo dos oceanos, os resíduos sólidos marinhos são chamados de resíduos bentônicos.

A maioria dos estudos sobre resíduos sólidos marinhos tem sido realizada em praias, no entanto também é preciso entender como esses resíduos se distribuem e se comportam em outros ambientes costeiros e marinhos. Trabalhos de revisão apontam que foram realizados 38 estudos em praias da América do Sul e região do Caribe (Ivar do Sul & Costa, 2007[1]), enquanto apenas 26 pesquisas sobre resíduos sólidos marinhos no fundo dos oceanos foram realizados no mundo todo (Spengler & Costa, 2008[2]).

Todos os materiais descartados inapropriadamente possuem um elevado potencial de gerar danos ao meio ambiente e aos seres que o habitam e utilizam, incluindo o ser humano. No caso dos resíduos sólidos marinhos, existem diversos estudos sobre seu impacto sobre a fauna marinha (Laist, 1997[3]; Chiappone, 2005[4]), bem como sobre os efeitos deletérios sobre a economia de uma região turística (Balance et al., 2000[5]). No entanto, as perdas econômicas são sempre baseadas em ambientes praiais, não havendo, de nosso conhecimento, estudos que abordem os efeitos dos resíduos sólidos bentônicos nas atividades humanas.

Recifes, naturais e artificiais, são importantes ambientes costeiros, tanto para os organismos marinhos quanto para a indústria do turismo. Recifes naturais podem ser formados por organismos coloniais que constroem exoesqueletos de carbonato

[1] Ivar do Sul, J.A. & Costa, M.F. 2007. Marine debris review for Latin América and the Wider Caribbean Region: From the 1970s until now, and where do w ego from here? Marine Pollution Bulletin 54: 1087-1104.

[2] Spengler, A. & Costa, M.F. 2008. Methods applied in the studies of benthic marine debris. Marine Pollution Bulletin 56: 226-230.

[3] Laist, D.W. 1997. Impacts of Marine debris: Entanglement of marine life in Marine Debris including a comprehensive list of species with entanglement and ingestion records. In: Coe, J.M. & Rogers, D.B. (Eds.). Marine Debris: sources, impacts and solutions. Springer-Verlag, Nova York, p. 99 139.

[4] Chiappone, M., Dienes, H., Swanson, D.W. & Miller, S.L. 2005. Impacts of lost fishing gear on coral reef sessile invertebrates in the Florida Keys National Marine Sanctuary. Biological Conservation 121: 221-230.

[5] Ballance, A., Ryan, P.G. & Turpie, J.K., 2000. How much is a clean beach worth? The impact of litter on beach users in Cape Peninsula, South Africa. South African Journal of Science 96: 210-213.

de cálcio ou por algas calcárias. Na região nordeste do Brasil, os "beachrocks" ou recifes de arenito (estruturas formadas pela cimentação de sedimentos marinhos da zona intertidal por carbonato de cálcio) são muito importantes, pois possuem função ecológica e social similar aos recifes de coral (agregando organismos e atraindo turistas) além de servir como base para o crescimento de organismos construtores de recifes. Já recifes artificiais incluem diversas estruturas colocadas no fundo dos oceanos que atuam como agregadores de organismos marinhos, desde plataformas de petróleo, blocos de concreto a navios naufragados, propositalmente ou não.

O estado de Pernambuco beneficia-se muito dos ambientes recifais costeiros, como, por exemplo, pela proteção da costa que eles oferecem, pela biodiversidade e pesca, além de benefícios para a indústria do turismo. Os "beachrocks" presentes nas praias rurais e urbanas, dentre elas a Praia da Boa Viagem, são considerados como um grande atrativo aos turistas, pois, além da beleza cênica, formam piscinas naturais durante a maré baixa. Já os ambientes recifais submersos atraem um grande número de turistas interessados na prática do mergulho livre e autônomo recreativo. Além dos diversos recifes costeiros, existem mais de 60 naufrágios (tanto históricos quanto propositais) em Pernambuco. Dessa forma, fica clara a dependência do turismo no estado aos ambientes recifais naturais e artificiais. No entanto, existe uma grande lacuna em relação a estudos que abordem a poluição marinha gerada por resíduos sólidos marinhos bentônicos em locais de grande potencial turístico e ecológico no estado. Estudos sobre o valor dos ambientes submersos para a indústria do turismo, bem como sobre o impacto econômico gerado pela poluição marinha também são necessários.

Além de estudos para quantificar e qualificar resíduos sólidos marinhos, também é preciso compreender como os atores sociais relacionados ao ambiente marinho se comportam em relação aos problemas de poluição marinha, principalmente aquela gerada por resíduos sólidos. Ator social pode ser definido como pessoa, grupo ou organização social que participa em programas ou iniciativas de gerenciamento, seja na forma de residente, explorador, administrador, regulador, utilizador, ou valorizador de um determinado ambiente[6].

Escolas e operadoras de mergulho são as responsáveis pela exploração de ambientes recifais e naufrágios, logo todas as pessoas envolvidas nessa atividade têm como interesse comum a preservação do meio ambiente marinho. Por isso, faz-se necessário envolver as escolas/operadoras de mergulho na conservação do meio

[6] Kay, R. & Alder, J. 1999. Coastal planning and management. E & FN Spon, Londres, 375p.

ambiente. A mobilização das pessoas diretamente relacionadas e interessadas no problema auxilia na definição dos mesmos e na forma como devem ser tratados, fortalecendo sua participação no processo de gerenciamento (Marroni & Asmus, 2005[7]).

Objetivo geral

O objetivo geral do presente estudo foi verificar a contaminação por resíduos sólidos marinhos em dois tipos de ambientes recifais costeiros no litoral de Pernambuco, incluindo também a visão e o comportamento das escolas e operadoras de mergulho frente ao problema.

Objetivos específicos

1. Quali-quantificar os resíduos sólidos bentônicos em um ambiente recifal semi-submerso em uma área intensamente explorada por usuários de praia (locais e turistas);
2. Quali-quantificar os resíduos sólidos bentônicos em um ambiente recifal submerso com potencial para ser explorado pelas escolas/operadoras de mergulho;
3. Avaliar a abordagem sobre poluição marinha dada nos cursos de formação de mergulhadores autônomos na Região Metropolitana do Recife-PE, litoral sul de Pernambuco e Fernando de Noronha, para que se possa sugerir melhores formas de envolver as escolas e operadoras de mergulho no processo de redução da poluição marinha, através de uma maior mobilização e conscientização.

O presente trabalho está dividido em três capítulos, cada um abordando um dos objetivos específicos acima propostos. Conclusões e sugestões gerais, relativas ao objetivo do trabalho, encontram-se após o terceiro capítulo.

[7] Marroni, E.V. & Asmus, M.L. 2005. Gerenciamento costeiro: uma proposta para o fortalecimento comunitário na gestão ambiental. Editora USEB, Pelotas, 149p.

MARINE DEBRIS AT A SEMI-SUBMERGED REEF ENVIRONMENT: TRANSITION OR DEPOSITION?

Abstract

Beachrocks are reefs parallel to the coastline and form an important transitional environment between the ocean and the beach. This kind of environment has not been included in studies of marine debris so far. The aim of the present study was to verify the contamination of a beachrock at an urban beach, and to compare the results quali-quantitatively with the ones found on the beach itself trying to elucidate whether the contamination comes from the beach, from the ocean, or both. A beachrock on Boa Viagem Beach (Recife, Brazil) was surveyed in 28 days during very low tide events in 2007 and 2008. A total of 11 261 marine debris items were found, mainly plastic (84.8%). Marine debris trapped by the beachrock, sand or macroalgae differed quantitatively from those found loose on the beachrock, which indicates that they have different patterns of deposition and residence time in this environment. The beach was considered as the main source of marine debris that contaminate the beachrock, which was indicated by the great amount of plastic cups and spoons on the beachrock (items characteristics of beach users). The beachrocks of Boa Viagem Beach are contaminated by marine debris, and therefore should be included in clean ups, preventive and corrective actions about marine debris contamination.

Keywords: beachrock, urban beach, plastics, beach users, Boa Viagem Beach.

1. Introduction

Beachrocks are geological features formed by calcium carbonate-cemented sediments, as a result of lithification at the beach's intertidal and spray zones (Vieira & De Ros, 2006). Presently they are found parallel to the coastline as narrow, linear ridges (Chaves-Guerra et al., 2005), marking the present sea level. Therefore, beachrocks can also be found submerged on the continental shelf and emerse on land, and according to some authors, marking past sea level positions (Kelletat,

2006). Since beachrocks are situated in the surf zone, they are a transitional environment between the ocean and the beach.

These features can be found mainly at tropical and sub-tropical zones, although they can be observed in temperate regions as well (Calvet et al., 2003; Vieria & De Ros, 2006). On the Brazilian east coast beachrocks occur from the north of Ceará State to the south of Bahia State, covering approximately 2 000 km (Branner, 1904; Chaves-Guerra & Sial, 2003; Caldas et al., 2006). On the Pernambuco State coast, beachrocks sometimes reach 10 km long and are formed mainly by quartz particles, containing also carbonate shells, algae and coral fragments (Dominguez et al., 1990) cemented together.

The first description of the beachrocks located in Pernambuco was given by Charles Darwin in 1841 (Maida & Ferreira, 1997). Since then a few studies have been conducted on this environment, mainly focused on the geological aspects (Calvet et al., 2003; Chaves-Guerra et al., 2005; Vieira & De Ros, 2006). However, there is a lack of information, especially about the ecological importance of the beachrocks to marine ecology and its transitional role between the ocean and the beach. Beachrocks are important substrata for benthic organisms, and many of the coral and algal reefs in the region use them as a first settlement. On a coast with very little rocky shores, these features are the main responsible habitat for the space available for hard bottoms benthic and demersal fauna and flora which are not necessarily coral reef-related.

Beachrocks are special features in the sense that they help to support a multi-million coastal tourism industry, once they are scenery attractive and form pools at low tide. Because of this, ecological and social impact of human activities can arise in these environments. In the past, these impacts included mining for building materials and crowning for protection of the port. At present threats are mainly stamping, and land reclamation. The contamination by marine debris, especially plastics, is also an easily detectable problem. Spengler and Costa (2008) have recently reviewed the status of submerged marine debris research and found no works on semi-submerged reefs.

Beachrocks are a very interesting environment, since they are semi-submerged reefs, which undergo completely different environmental situations at low and high tide. Therefore, different depositional and "eroding" marine debris processes occur. These environments have not yet been approached by those who worked on the adjacent beaches (Silva et al., 2008b; Silva-Cavalcanti et al., 2009).

The beach is envisaged as the final destination for the debris (as sediments often do). However, there could be transmission of marine debris (and sediments) between the beach to the adjacent marine environments, and vice-versa. Thus, if there is connectivity between the beach and the beachrock the quali-quantification of marine debris in these two environments would be able to demonstrate the transmissions that occur between them.

The aims of the present study were to determine the main characteristics of the marine debris found on a beachrock at an urban beach and to compare the contamination by marine debris found on the beachrocks with the one found on the strandline on the adjacent beach.

2. Methodology

2.1 Study area

Boa Viagem is an urban beach, situated at Recife City (Pernambuco State capital). The beach is approximately 8 km long, being the beachrock a constant feature, present in about 50% of its lenght (Figure 1). The beachrock of Boa Viagem is a single alignment, which has fragmented and buried portions. This beach is intensely used by the local population, attracting also tourists from Brazil and other countries (Silva et al., 2008a). Boa Viagem's neighborhood is densely populated, having a great number of buildings, shops, kiosks, showers and lifeguard posts (Costa et al., in press).

Climate in the region presents two marked seasons, depending on rainfall. The dry season lasts from September to February (historic mean monthly rainfall of 87.5 ± 40.51 mm), while the rainy one starts in March and ends in August (historic mean monthly rainfall of 288.17 ± 66.76 mm).

The beachrock is not continuous along the beach, having stretches ranging from a few meters to approximately one kilometer. During high tide the beachrock becomes completely covered by water, getting exposed only when the tide recedes.

There are three surfaces within the beachrocks: the fore-reef, reef flat and the back-reef. The fore-reef corresponds to the outside of the beachrocks, which receives the direct impact from waves. The reef flat is approximately smooth, whose roughness varies according to the hardness of the rock and its covering by marine organisms, such as algae and sea urchins (Branner, 1904). The back-reef is the inside wall of the beachrocks, which is abrupt and irregular, presenting ledges and

caves. Depending on the beach morphodynamics and tidal amplitude, a lagoon is formed between the beachrock and the beach at low tide. The lagoon presents an average width of 20 m (0 - 50 m) and depth of 1 m (0 - 2.5 m).

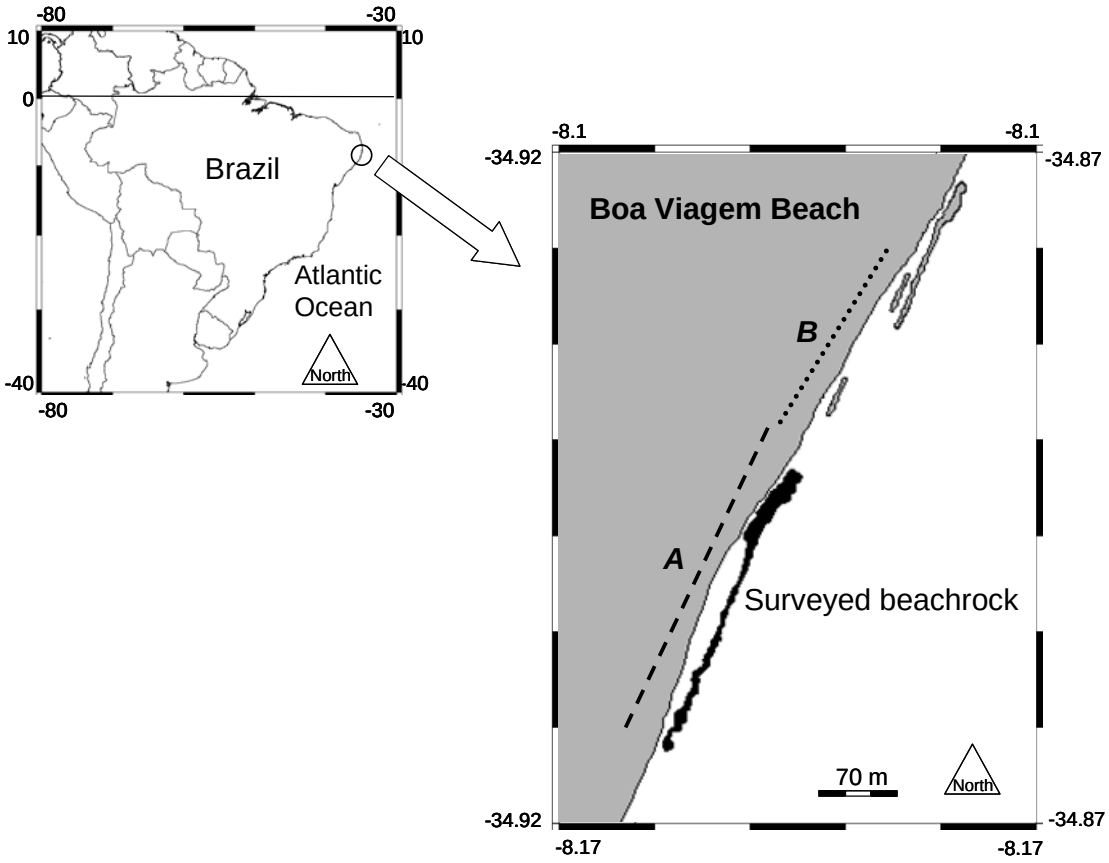

Figure 1: Location of the study area. A and B correspond to the two transects surveyed on the strandline.

2.2 Sampling and data analysis

The surveys were made at the lowest possible spring tides (0.0 or 0.1 m) to guarantee maximum reef exposure in terms of area and time. Each sampling effort took 1 to 2 h to complete. The 820 m long central reef of Boa Viagem was surveyed in 28 occasions along 2007 (10 samples) and 2008 (18 samples). Days were chosen based on the tide, and covered different beach use situations (weekday and weekends) as well as meteorological and seasonal conditions (Table 1). This section of beachrock was selected to be surveyed since it is the most continuous one, which allows walking the whole stretch along the top of the beachrock. It was chosen to survey the whole stretch of the beachrock instead of delimitating transects or sampling quadrats, because the debris tend to accumulate in certain places. It would

be necessary a great number of transects/quadrats in order to have a significant sampling of the beachrock, an effort equivalent of surveying the entire stretch.

The reef was surveyed by two observers at a time, who walked only once from north to south of the reef. No distinction was made among the three different surfaces (flat top of the reef; on the inside and outside) and the marine debris contaminating the reef environment were noted including these three different surfaces. The debris were logged into different categories and if the item was loose or trapped by the reef, sand or macroalgae. There were 14 debris categories in total: plastic fragments; plastic cups; plastic bags and packaging; plastic spoons; metal; wood and other natural materials; paper; polystyrene; nylon; rubber; foam; wax; glass/ceramics and cloth. Due to the limited time of the survey, items that did not easily fit in one of the field log existing categories were registered separately. Later at the laboratory these items were classed accordingly. Plastic items were further sub-dived according to their use (packaging, bags, cup).

The strandline was also surveyed in 18 coincident days in 2008. Two transects along the most recent strandline were covered, one in front of the beachrock (A) and the other where there was no beachrock (B) (Figure 1). Both transects have similar use pattern (Silva et al., 2008a). According to the beach states determined by Wright and Short (1984), transect A has a reflective tendency, while transect B tends to a dissipative beach. Both transects are in an area of sedimentary equilibrium (Gregório, 2004). The transects were simultaneously surveyed by different observers, from north to south, before the beach was cleaned by the municipal cleaning services. The observers were previously trained to obtained consistency in the method (Silva-Cavalcanti et al, 2009) and they also switch transects in each sampling date to avoid bias. Only the marine debris larger than 3 cm were counted and classified in the same 14 categories considered for the marine debris at the beachrock. Another category, organic matter, was also used to classify food, dead animals, flowers, etc. found on the beach. Due to length difference between transects A and B, the results were standardized as items.m^{-1}.

The diversity of the marine debris found on the beachrock (total, loose and trapped items) and on the strandline (total, transects A and B) was determined by the Shannon-Wiener index (base e).

Prior to all tests, it was verified that the data did not present a normal distribution. It was chosen not to apply any transformation, therefore non-parametric analysis were conducted.

In order to verify if there are significant differences ($p<0.05$) between the quantity and diversity of debris loose and trapped by the beachrock a non-parametric Mann-Whitney test was used. The same analysis was applied to verify if the quantity and diversity of debris on transect A and transect B were significantly different.

To verify the similarity between the beachrock and the beach, it was used a Analysis of Similarity (ANOSIM) applied to a Bray-Curtis similarity matrix. To determine the contribution of each variable to the dissimilarity between the groups (loose marine debris on the beachrock, trapped debris on the beachrock, marine debris counted along transect A and debris along transect B of the strandline) it was used the Analysis of Similarity Percentage (SIMPER). To represent the differences between the groups it was used a Multi-Dimensional Scaling analysis (MDS). For these analysis of comparisons, it was used only the data collect during 2008 (18 surveys of both the beachrock and the beach).

3. Results

3.1 Beachrock

Along the 28 days surveyed, a total of 11 261 items were counted, presenting a mean of 388 ± 297 items. The average quantity of items per meter (items.m^{-1}) was 0.47 ± 0.36. Plastics represent 84.8% of all encountered debris, followed by nylon (4.8%) and wood and other natural material (3.5%). When considering the different categories of plastic, plastic fragments was the most representative (5 359 items, 47.6%), followed by plastic cups (1 998 items, 17.7%) and plastic bags and packaging (1 924 items, 17.1%).

Regarding the marine debris loose on the reef, 8 440 items were counted (mean 291 ± 289 items), which is 75% of the marine debris found on the beachrock. Plastic fragments was the most representative category (60.8%), followed by plastic cups (21.1%), plastic bags and packaging (3.7%) and nylon (3.5%). As for the debris trapped by the reef, sand or macroalgae a total of 2 821 items were counted (mean value of 97 ± 54 items), representing 25% of the marine debris counted on the beachrock. The category with most trapped items was plastic bags and packaging (57%), followed by nylon (8.9%), plastic fragments (8.2%) and plastic cups (7.8%) (Figure 2).

The diversity of total marine debris on the beachrock along the 28 days varied from 0.7 to 2.59 nits (H' 1.85 ± 0.43 nits). Even though the diversity of the

debris trapped by the reef, sand or macroalgae and debris loose on the reef showed lower mean diversity values than the diversity of loose items (1.38 ± 0.44 and 1.64 ± 0.51 nits, respectively) this difference occurred randomly, according to the non significant result of the Mann-Whitney test (p=0.067).

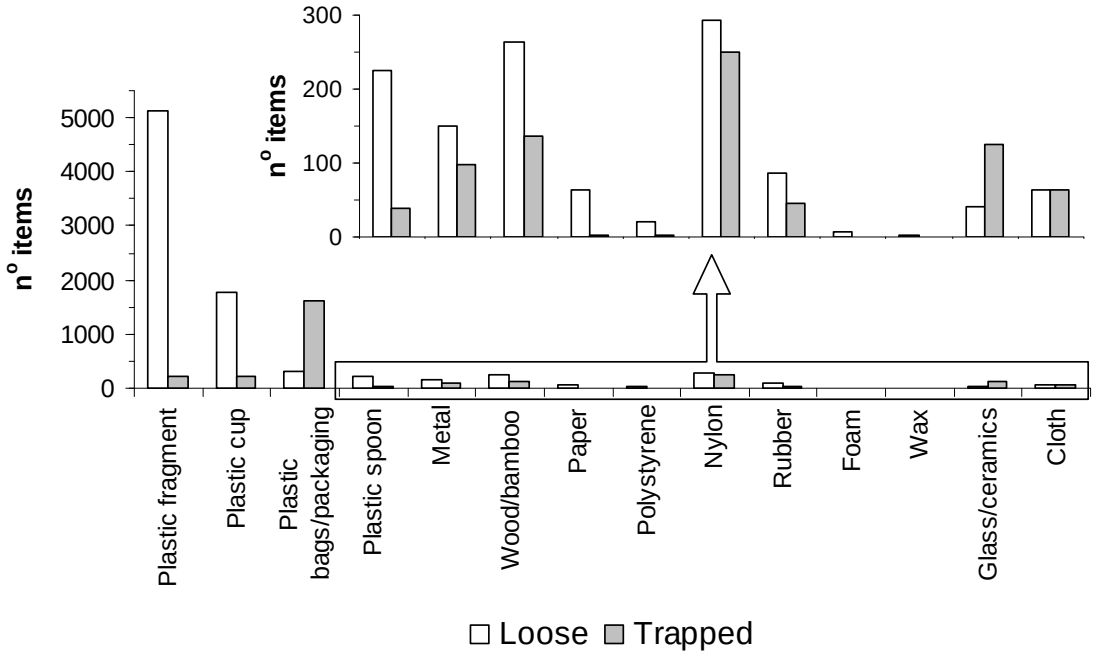

Figure 2: Number of marine debris per category found loose and trapped by the beachrock, sand or macroalgae on the surveyed beachrock of the Boa Viagem Beach.

Table 1: Information about sampling dates, selected according to the tide (0.0 or 0.1)

	Date	**Field observations** (rain, wind, overcast, algae, etc.)	**Number of people per 100 m per weekday** (Silva et al., 2008a)
2007	April 17th, Tue	Overcast	22.6
	April 19th, Thu	Overcast, rough sea, macroalgae deposited on the reef	44
	May 16th, Wed	Murky water	26.4
	May 17th, Thu	Sunny day	44
	May 18th, Fri	Murky water	62.4
	June 14th, Thu	Murky water, sand deposited on the reef	44
	June 16th, Sat	Sunny day	155
	September 27th, Thu	Murky water, gaps filled with sand, strong wind	44
	September 28th, Fri	Murky water, gaps filled with sand, strong wind, reef covered by attached macroalgae	62.4
	October 26th, Fri	Reef covered by attached macroalgae, some residues were covered by tar, murky water, macroalgae well developed on the sand bottom	62.4
2008	April 6th, Sun	Gaps filled with sand, many attached macroalgae, great quantity of sea urchins	607.8
	April 7th, Mon	Gaps filled with less sand, but with many macroalgae	0
	April 8th, Tue	Sunny day	22.6
	May 5th, Mon	Sunny day	0
	May 6th, Tue	Murky water, fish observed inside a trapped plastic packaging	22.6
	May 7th, Wed	Sea urchin with a liner attached to it	26.4

2008	June 4th, Wed	Sand on top of the beachrock and inside the gaps, rain during the survey, last 15 m completely exposed	26.4
	June 5th, Thu	Gaps filled with sand, angling lead weights found inside an octopus's hole	44
	June 6th, Fri	Sunny day	62.4
	July 3rd, Thu	Sunny day	44
	July 4th, Fri	First portion of the beachrock covered by sand, murky water, large pool between the beachrock and the beach	62.4
	July 5th, Sat	Rain during the survey, last portion of the beachrock covered by sand	155
	August 1st, Fri	Sunny day, weak south wind, it was not observed marine debris floating on the sea	62.4
	August 3rd, Sun	Sand on top of the beachrock, last portion of the beachrock covered by sand, beachrock densely covered by attached macroalgae	607.8
	August 29th, Fri	Beachrock densely covered by attached macroalgae, first and last portions of the beachrock covered by sand, shallow lagoon between the beachrock and beach	62.4
	August 30th, Sat	Sunny day	155
	September 1st, Mon	Strong east wind	0
	September 28th, Sun	Beachrock with many macroalgae and sea urchin, it was not observed marine debris floating on the sea, many people fishing on the top of the beachrock	607.8
	September 29th, Mon	Weak wind, it was not observed marine debris floating on the sea, macroalgae still covered large areas of the beachrock but are smaller in size	0

The result of the Mann-Whitney test showed a significant difference (p=0.0001) between the quantity of marine debris loose and trapped by the beachrock (Figure 3).

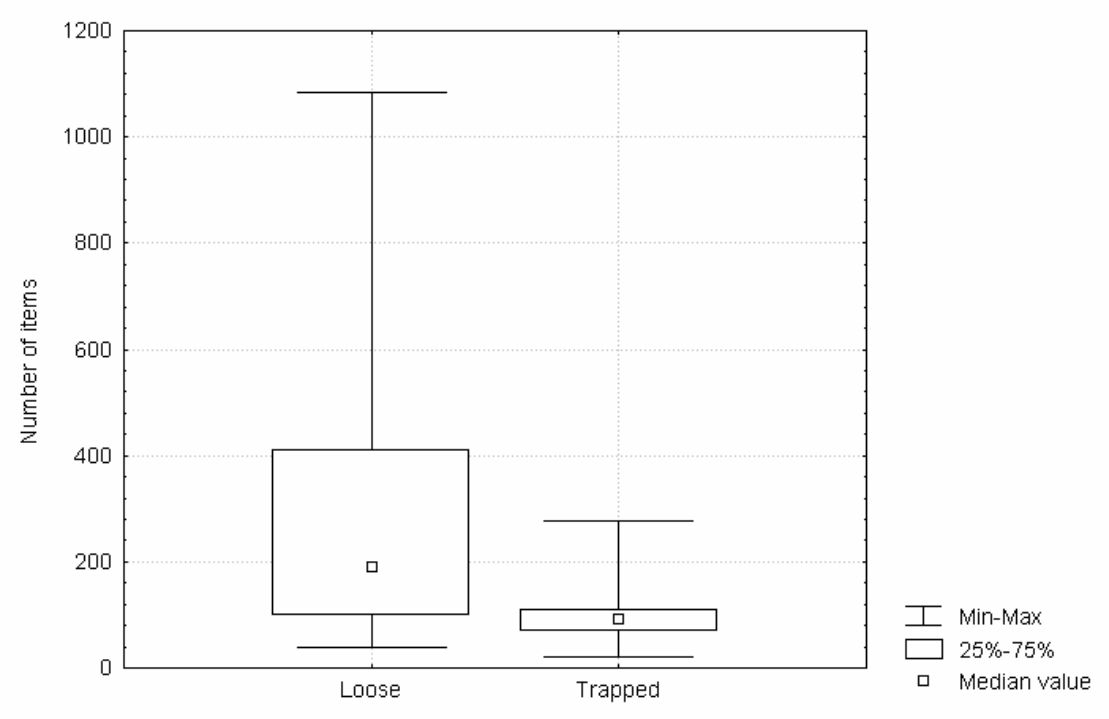

Figure 3: Representation of the difference between the quantity of loose and trapped marine debris items observed on the beachrock.

3.2 Strandline

A total of 71 502 marine debris were counted along the two transects surveyed on the strandline (in 18 days), showing an average of 5.00 ± 1.79 items.m^{-1}. The most abundant category was plastics (66.3%), followed by metal (16.0%), wood and other natural material (4.9%) and organic matter (4.6%). Along transect A (in front of the beachrock) 45 207 marine debris items were counted (2.64 ± 1.33 items.m^{-1}). Plastics corresponded to 64.6%, followed by metal (19.9%), organic matter (4.2%) and paper (3.5%). As for transect B, 26 295 marine debris items were counted (2.36 ± 0.95 items.m^{-1}). Plastics was also the most abundant category (69.2%), followed by metal (9.5%), wood and other natural material (8.1%) and organic matter (5.2%) (Figure 4).

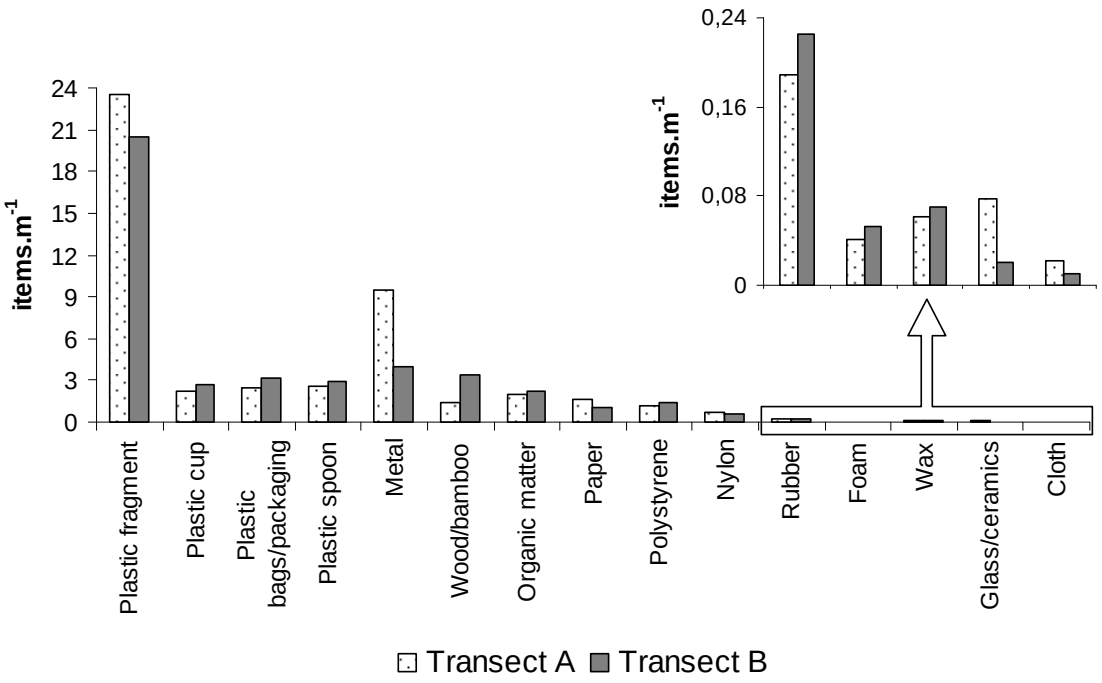

Figure 4: Number of marine debris.m^{-1} per category found on transects A and B of the strandline of the Boa Viagem Beach.

The diversity of marine debris found on the strandline varied from 2.0 to 2.67 nits (H' 2.46 ± 0.16 nits). The diversity of marine debris observed in transect A and B presented similar mean values (H' 2.38 ± 0.22 and 2.39 ± 0.17 nits, respectively).

The result of the Mann-Whitney test showed that there is no significant difference between the quantity (p=0.669) or diversity (p=0.569) of marine debris per meter of transects A and B.

3.3 Comparisons between the beachrock and the adjacent beach

When comparing the amount of items per meter, the mean quantity of marine debris found on the beachrock (0.47 ± 0.36 item.m^{-1}) correspond to only 9.4% of the mean value found for the sum of the two transects of the strandline (5.00 ± 1.79 items.m^{-1}), or 17.8% if considering only transect A. The diversity of marine debris on the beachrock (1.85 ± 0.43 nits) is also lower than the one for marine debris on the strandline (2.46 ± 0.16 and 2.38 ± 0.22 nits, for the sum of the two transects and for transect A only, respectively).

The results of the ANOSIM show that the similarities are found mainly within each group, that is, there is a clear discrimination between loose items, trapped

debris, items on transect A and debris on transect B (Table 2). The SIMPER analysis demonstrated the high percentages of dissimilarities among each group (Table 2), being plastic fragments the category with the highest contribution to the differences in all cases. The MDS plot (Figure 5) shows the segregation of the groups; the low stress value (0.07) corresponds to a good ordination.

Table 2: Results of the ANOSIM and SIMPER analysis.

	R	p	Average dissimilarity (%)
Loose items x trapped items	0.82	0.001	77.4
Loose items x transect A	0.9	0.001	85.1
Loose items x transect B	0.84	0.001	79.4
Trapped items x transect A	1	0.001	93.7
Trapped items x transect B	1	0.001	90.5
Transect A x transect B	0.17	0.003	40.5

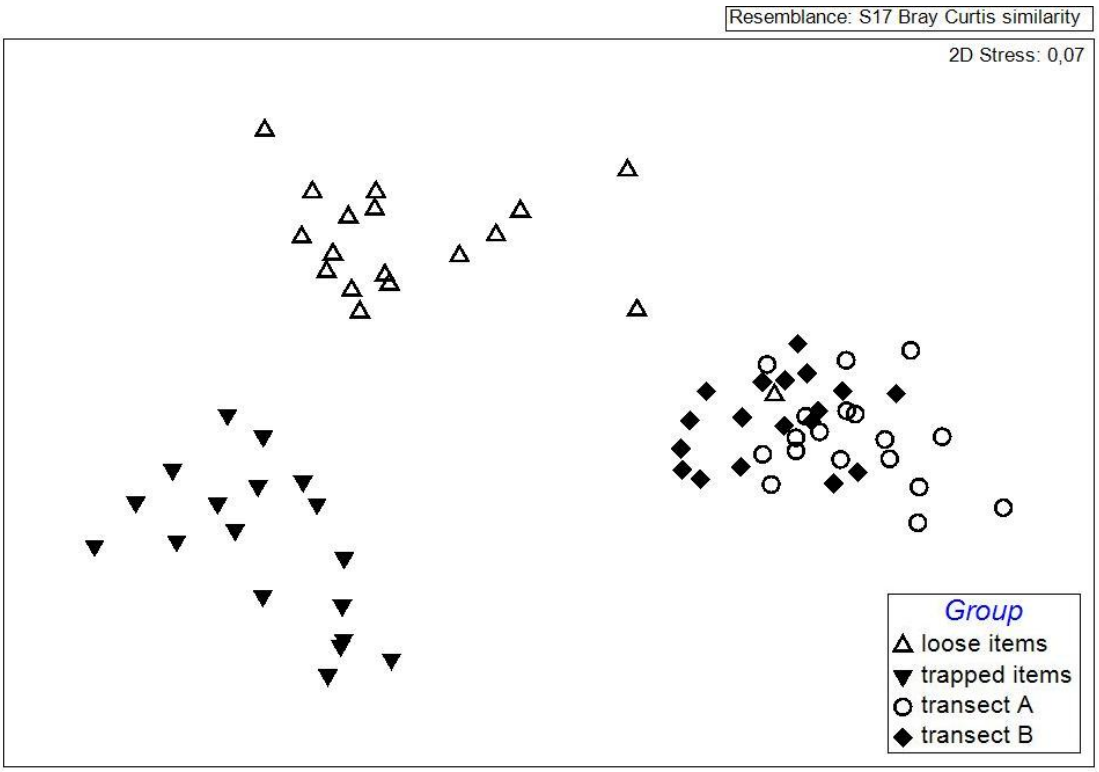

Figure 5: MDS plot of loose and trapped items found on the beachrock, items in transects A and B of the strandline of the adjacent beach.

4. Discussion

Beaches along the Brazilian Northeast coast, and particularly at Pernambuco State, have been reported to be contaminated by marine debris (Araújo & Costa, 2007; Ivar do Sul, 2008; Silva et al., 2008b; Silva-Cavalcanti et al., 2009). These debris were identified as coming from both marine and land-based sources. The results of the present study show that the beachrock of Boa Viagem Beach is also contaminated by marine debris.

The large amount of plastic items found on the beachrock corroborate with other studies that found plastic as the most common type of marine debris (Galgani et al., 2000; Ivar do Sul, 2008). This is because plastic is a very durable material, which is easily carried by the wind and ocean currents (Coe & Rogers, 1997).

The different types of marine debris suffer different patterns of transport and accumulation, thus there are differences between the quantities of loose or trapped debris by the beachrock (corroborated by the Mann-Whitney result). Plastic packaging that were commonly observed trapped by sand can be buried and thus stay on the environment indefinitely. Plastic fragments that were the most common item found loose on the beachrock can be easily transported by the wind and waves. However, the four most common marine debris found on the beachrock (plastic fragments, plastic cups, plastic bags and packaging, and nylon) were the same for trapped and loose items, only the order of importance was different. There was not even observed significant difference between the diversity of loose and trapped items. This shows that the type of marine debris that contaminate the beachrock do not vary much, a conclusion supported by the low values of marine debris diversity.

Roughness can be an important variable along the reef changing trapping capacity and type of debris deposited. It was observed, but not tested here, that the reef sampled showed three different patterns of roughness: a very rough habitat, a medium rough habitat and an almost smooth habitat. The increase in roughness of a reef was related to the constant bioerosion of sea urchins (Kilpp, 1999), as well as to the exposure during low tide and wave action. The stretch more exposed during low tide presented the highest roughness, and therefore, concentrated more debris. It was also observed that most of the plastic packaging was found trapped on the outside, which is also rougher.

Another important variable related to trapped marine debris is the macroalgae cover. The presence of macroalgae on the beachrock varies along the year; it was

noticed three macroalgae conditions: bloom with green attached macroalgae, following the rainy season; brown attached macroalgae, after the bloom period; and macroalgae only deposited on the beachrock, not attached to it. It was also observed that after storms large quantities of macroalgae are deposited on the beachrock. Plastic fragments, plastic spoons and nylon, for example, are items easily trapped by the macroalgae. Since the macroalgae is on the beachrock but not always attached to it, once the tide starts to rise and the water covers the beachrock, the action of the waves can transport the macroalgae and the debris to the ocean or to the beach. Thus, macroalgae are a very important vector of transportation of debris originated on the beach to the bottom of the ocean, and vice-versa.

As for the contamination of the beach, despite transect A be slightly more contaminated than transect B (2.64 ± 1.33 items.m^{-1} versus 2.36 ± 0.95 items.m^{-1}), the four main categories of marine debris were similar in both transects. The majority of items found on the beach can be related to beach users (metal bottle caps, straws, food scraps, plastic bottles caps). The commerce at Boa Viagem Beach is strong and varied; there are people selling from food and beverages to compact discs and handicraft. Since beach users buy things at the beach they do not feel responsible for the waste produced and believe that waste collection is included in the service (Silva et al., 2008b). The beach vendors also do not act to avoid marine debris. They only clean some places on the beach to set chairs for their clients, but the debris they collect are left in a pile next to the area they use. The majority of metal bottle caps (the item most found during the 18 days surveyed) was encountered near the areas were the beach vendors put their kiosks.

The comparison between the strandline and the beachrock shows that the strandline is more strongly contaminated by marine debris than the beachrock, and that the types of marine debris vary more on the beach than on the beachrock. As it was shown in the MDS, the beachrock and the beach are completely different environments relating to the marine debris contamination. The fact that plastic cups was the main type of debris found on the beachrock, when not considering plastic fragments which cannot be related to any specific source of pollution, indicates that the beach can be considered as the main source of marine debris to the beachrock. Plastic cups are related to beach users, as well as plastic spoons (Silva et al., 2008b). Thus, the connectivity between the beachrock and the adjacent beach can be demonstrated qualitatively, but not quantitatively (since the degree of contamination of the beachrock is considerably inferior than the beach).On the other hand, plastic

food packagings (in the case of the beachrock mainly rice, flour packaging) which was the second major category of debris found on the beachrock (excluding plastic fragment) are believed to come from rivers and possibly from ships. The net superficial circulation at Boa Viagem Beach is from north to south (Rollnic & Medeiros, 2006), which can help the wind action to bring marine debris towards the beachrock and the beach. Thus, riverine and marine sources are possible, but they have very low significant level to the contamination of the beachrock.

The establishment of the beachrock as a transitional or a final depositional place for the marine debris depends on the type of item. For plastic bags and packaging the beachrock is a depositional environment, once they get trapped by the reef, sand or macroalgae, they can be covered by sand and stay in the beachrock indeterminately. On the other hand, for plastic fragments, the beachrock is a transitional environment, since these fragments can be transported to the beach or the ocean according to the wave action. The time scale is also an important variable when determining the role of the beachrock in the marine debris' dynamics. For loose items, it can be said that the contamination of the environment is acute (short period of time), while for trapped items the contamination of the beachrock can be characterized as chronic (long period of time).

Time scale should also be considered for the contamination of the beach. In a short period of time, the beach is only a transitional place for marine debris, which arrive on the beach, deposit there, but are soon remobilize. The beach is the final depositional place only for marine debris that are deposited above the strandline.

The lagoon that is formed between the beachrock and the beach when the tide recedes is another environment that may influence the dynamics of marine debris contamination, since it also acts as a transitional place. However, this pool is not continuous, has variable width and is ephemeron, so its impact does not have the same significance and magnitude as the transitional effect of the beachrock.

4.1 Risks to humans and to the marine biota

Balance et al. (2000) found out that if a beach has more than two items of marine debris.m^{-1}, which is less than half of the amount found on Boa Viagem's strandline, 85% of tourists and residents would no longer frequent that beach. Silva et al. (2008b) verified that in certain segments of Boa Viagem Beach the amount of tourist has decreased, while in other there was a change in the kind of visitor, that is, a segment that was explored by tourist is now only used by local people. Thus, it

can be affirmed that marine debris are already affecting the tourism appeal of Boa Viagem Beach.

Besides the economic effect the marine debris are causing in Boa Viagem, there are other consequences of marine debris on this beach. The great amount of food scraps left on the beach, which are not collected by the municipal cleaning services, attract pigeons et al. These animals are vectors for transmitting diseases. In a review article on the danger of pigeons to human health, Haag-Wackernagel and Moch (2003) found 176 registered cases of disease transmission from wild pigeons to humans, including cases of transmission of bacteria, protozoa and mainly fungi.

There are other risks for human health related to marine debris on the beach. Medicine vials and bottles, syringes, condoms and needles were among the items with the highest potential to cause damages to human health. Such items were also found on the beachrock, including a plastic container with morphine.

During the surveys of the beachrock it was observed small fishes trapped inside plastic food packaging. In one occasion it was counted more than 20 5 mm angling lead weights inside an octopus's hole. A plastic liner was observed attached to a sea urchin. Researches have encountered plastic fragments in the food content of sea urchins collected from the study area (Melo, personal communication). Those are concrete examples of the threat that marine debris impose upon marine organisms of the environment.

Boa Viagem Beach is systematically cleaned by municipal services, by the use of machines and sweepers all day. However, there are problems in beach cleaning, which does not involve the collection of small items (WHO, 2003) and the machines that can bury the debris that it cannot collect.

Beachrocks are not a readily accessible environment to sample, either for scientific studies or cleaning purposes, since it requires very low tides to walk on it. It is also extremely difficult to quantify the debris, especially on the outside of the beachrock wall. The time is very limited to count the very small items and depending on the waves not all habitats are exposed, which can lead to a sub-sampling of all debris items on the beachrock. However, the results found show that the beachrock is being affected by marine debris, so it cannot be ignored the importance to include this environment on future studies and in periodical cleanup efforts. Since this is the first study known to evaluate the contamination of a beachrock by marine debris, it could be expected that similar beachrocks on the Brazilian coast (and beyond) are suffering the same problem.

5. Conclusion

Beachrocks at Boa Viagem Beach are contaminated by marine debris and this contamination is similar to that found on the beach itself. The major debris category found was plastics, in accordance with the world pattern. The amount of marine debris per meter found on the beachrock corresponds to less than 10% of items.m^{-1} observed on the beach.

The beach was considered as the main source of marine debris that contaminate the beachrock. Therefore, only a change in the behavior of the beach users would be able to diminish the problems of marine debris on the beach, and consequently on the beachrock.

Marine debris categories behave differently on the beachrock, certain categories are mainly found loose on the beachrock, while others are mainly trapped by the beachrock, sand or macroalgae. These differences will influence the time that the debris will stay on this environment and potential impacts they will have on the organisms and people.

It is very important to understand how marine debris behave on the beachrock. The type of the debris items and the time scale considered will determine if the beachrock can be considered as a final depositional place or if it is acting as a transitional deposit between the beach and the open ocean. Therefore it is necessary to further investigate the contamination of this kind of environment to better understand their role in the distribution of marine debris between the beaches and the ocean.

However, beachrocks can be no longer excluded in studies about marine debris contamination of beaches, as well as in actions of management of this problem.

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WHAT IS THE POTENTIAL CONTAMINATION BY BENTHIC MARINE DEBRIS OF THE REEFS IN AN ESTUARINE REGION OF THE BRAZILIAN NORTHEAST?

Abstract

Marine debris can be very harmful to the marine environment, as well as to human activities. The study of benthic marine debris is still incipient, especially in estuarine regions and in small scales with the use of scuba dive. The present study aimed at verifying the potential contamination by benthic marine debris in reefs and seagrass meadows adjacent to an estuarine region known to have both its shore and mangrove forests contaminated by marine debris. A total of 27 transects were deployed, covering a total area of 1 350 m^2, in depths ranging from <1 to 15 m. Areas that may potentially retain benthic marine debris were identified, but no marine debris was found. This information is extremely important as baseline data that can be used for environmental management plans and for future studies.

Keywords: coastal reefs, estuary, marine debris, baseline data, scuba dive survey.

1. Introduction

Marine debris were defined as "any manufactured or processed solid waste material that enters the marine environment from any source", either from the land or from marine activities, such as fishing (Coe & Rogers, 1997). It can cause damage to marine organisms, as entanglement, suffocation, internal injuries after ingestion and eventually death (Laist, 1997; Chiappone et al., 2005). Once on the bottom of the oceans marine debris may also be buried in the sediments or interfere with the colonization of reef environments. Other impacts of marine debris are the decrease of marine environment aesthetics (UNESCO, 1994); damages to boats (Ribic et al., 1992) and; harm to the health and security of beach users (UNESCO, 1994) and divers (Jones, 1995), especially novices, who are still learning how to adapt to the diving techniques.

The majority of the studies about marine debris are conducted on beaches. Ivar do Sul and Costa (2007) reported that from 49 studies realized in South America

and the Wider Caribbean Region, 38 sampled sandy beaches. Only two studies were carried out in estuarine regions, and a single one in a reef environment. Evaluations about benthic marine debris (the debris that accumulate on the bottom of the ocean) are also scarce throughout the world (Spengler & Costa, 2008). There is a need to exploit other marine environments regarding their contamination by marine debris. Thus, it will be possible to verify how marine debris are distributed and how they behave in different environments.

Estuaries are very important environments, since they make the transition between rivers and the ocean. They are also important for many marine organisms which depend on estuaries to reproduce, feed and grow (Beck et al., 2001).

The knowledge of the current status of coastal environment contamination by (benthic) marine debris is essential to form a base for future actions of management of this problem. Such actions would benefit the conservation of different marine environments and organisms, including reefs, fishes, marine mammals, birds and reptiles.

The aims of this study were to characterize the types of bottom to determine possible accumulation sites and to verify the marine pollution by benthic marine debris of submerged environments (reefs and seagrass meadows) adjacent to an estuary on the northeast coast of Brazil. Since the estuary is known to be polluted by marine debris, we hypothesized that the adjacent environments will also be contaminated.

2. Methodology

2.1 Study area

The Goiana River estuary is situated at the Brazilian Northeast (Figure 1). The river basin is formed by more than 15 small rivers, covering an area of 2 900 km^2. There are many human activities that may affect the river, including domestic sewage and industrial effluents; sugar-cane plantations and mills, cattle and aquaculture facilities.

There are two main seasons in the region: a rainy one (March to August) and a dry one (September to February). Tides are semi-diurnal with mean amplitude of 2 m (DHN, 2008).

The estuarine region is formed by a well preserved mangrove forest; sandy beaches; sand banks and; beachrocks, seagrass meadows, coral and algal reefs in its

lower region. The estuary is shallow and small, having a monthly average flow of approximately 10 $m^3.s^{-1}$. There are two villages in the lower part of the estuary: Acaú and Carne de Vaca. The population of Pitimbú Municipality, to which Acaú village belongs is 16 140 inhabitants, while Carne de Vaca belongs to a Municipality with 71 796 inhabitants, most of them concentrated at the head of the estuary (Goiana City) 18 km upsteam from the estuary mouth (IBGE, 2008).

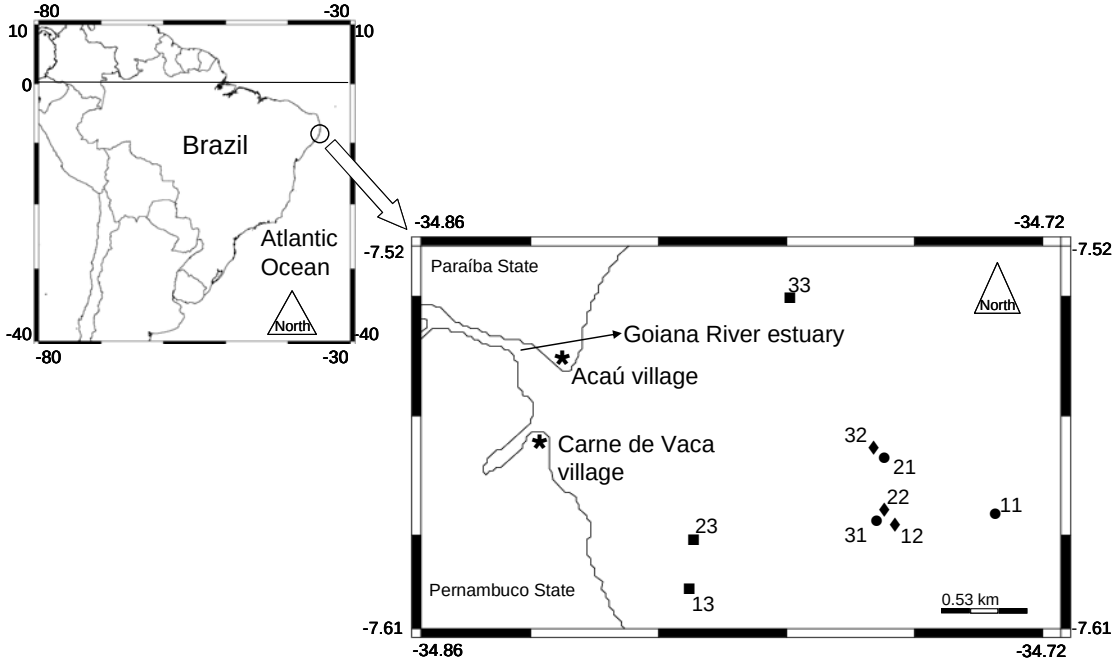

Figure 1: Location of the study area. ● Represents the deep sampling points; ♦ represents the intermediate depth; and ■ represents the shallow sampling points.

The Goiana River estuary has been studied since the late 1960's, but only recently studies concerning environmental pollution started to be developed in the region. Information on marine debris has been reported recently for the estuarine beaches (Ivar do Sul, 2008) and mangroves forests (Costa et al., 2007) in which it was suggested that marine debris are carried to the adjacent coastal region and might be deposited on the ocean floor. The fishing activity is very important in the region, and it could be also an important source of marine pollution.

The Goiana River has a typical estuarine region of the Brazilian Northeast, where a complex ecocline ranges from the wetlands within the estuarine basin to the seagrass meadows, reef and/or beachrocks and then the waters overlaying the continental shelf. Therefore, other estuaries of the Brazilian Northeast can possibly

present similar contamination patterns as the Goiana River, with the exception of estuaries subjected to a well developed tourism industry.

2.2 Sampling

The quali-quantification of the benthic marine debris was carried out during three months of summer 2008, once per month. In each field trip, random samplings were realized at three depths, ranging from <1 m to 15 m, totaling nine sampling points (Figure 1). For each field trip, sampling points 11, 21 and 31 were consider as deep (profundity varying from 12 to 15 m); 12, 22 and 32 as intermediate depth (from 6 to 8 m deep) and; sampling points 13, 23 and 33 were considered as shallow depths (from <1 to 3 m). In each field trip it was sampled one point per profundity (deep, intermediate and shallow). The distance from the sampling points to the coast varied from 2 to 8.7 km, while the distance to these points to the two closest human settlements varied from 5.3 to 9.7 km to Acaú village and from 3.9 to 9.1 km to Carne de Vaca village. The estimated visibility during the dives was approximately 5 m.

In each sampling point three random transects were deployed, each measuring 25 m long and 2 m wide (Chiappone et al. 2005). At each sampling point an area of 150 m^2 was surveyed, yielding a total area of 1 350 m^2.

The bottom type and the height of the reef ledge were noted at every 5 m along the transect. After measuring ledge height, in an area of 1 m^2 it was noted the percentage of each pre-established categories of bottom type (reef, sand and algae/seagrass) based on the literature (Nagelkerken et al. 2005; Bauer et al. 2007; Reef Check Brazil, 2008). Whenever it was not possible to separate these three categories, a combination of them was considered (reef and sand; reef and algae/seagrass; sand and algae/seagrass; and reef, sand and algae/seagrass), creating a possibility of seven categories of bottom type. The term 'reef' includes all hard substratums, like coral, algal reefs and beachrocks.

Only broad categories were used to classify the bottom type, because the objective was to know how the bottom of the area is. Each category of bottom type has a different potential to retain marine debris: reefs may hold larger debris (like derelict fishing gear) and debris that can entangle in the crevices (like bottles and cans) and; algae/seagrass may retain lighter marine debris, such as plastic bags and packaging. Sand has a low potential to hold marine debris, since they can roll away and/or be covered by the sand.

3. Results

The majority of the transects were done in areas of predominance of reef (sampling points 11, 21, 22 and 31, with mean values of 45.9%; 49.5%; 70.1% and 69.7%, respectively). In shallow depth transects, algae/seagrass was the main type of bottom (mean value of 44% in the sampling point 13; 75% in the 23 and; 63.4% in the sampling point 33). There was only one transect where sand predominated (mean value of 49.4% in sampling point 12), while in another (sampling point 32) the combination reef and algae/seagrass prevailed with 100% (Figure 2).

The most evident pattern of bottom type is observed for the shallow transects, completed bellow 4 m deep. Sampling points 13 and 23 were placed on the seagrass meadows. Sampling point 33 was placed away from the seagrass meadows, however it shows that algae/seagrass dominate the bottom of the shallow region of the study area.

The height of the reef ledge varied from 0 to 4 m for the 68 points were it was measured along 18 transects. The topography in the sampling points 13, 23 and 33 was flat. The highest average value per sampling point was found in the point 32 (1.77 ± 0.57 m), followed by sampling points 31 (1.67 ± 0.37 m) and 22 (1.54 ± 0.5 m). Sampling point 12 presented the lowest average ledge height (0.22 ± 0.19 m), followed by points 21 (0.65 ± 0.42 m) and 11 (0.77 ± 0.26 m).

A total of 27 transects were completed in the region in front of the Goiana River estuary along the three field trips. No benthic marine debris was found during the dives.

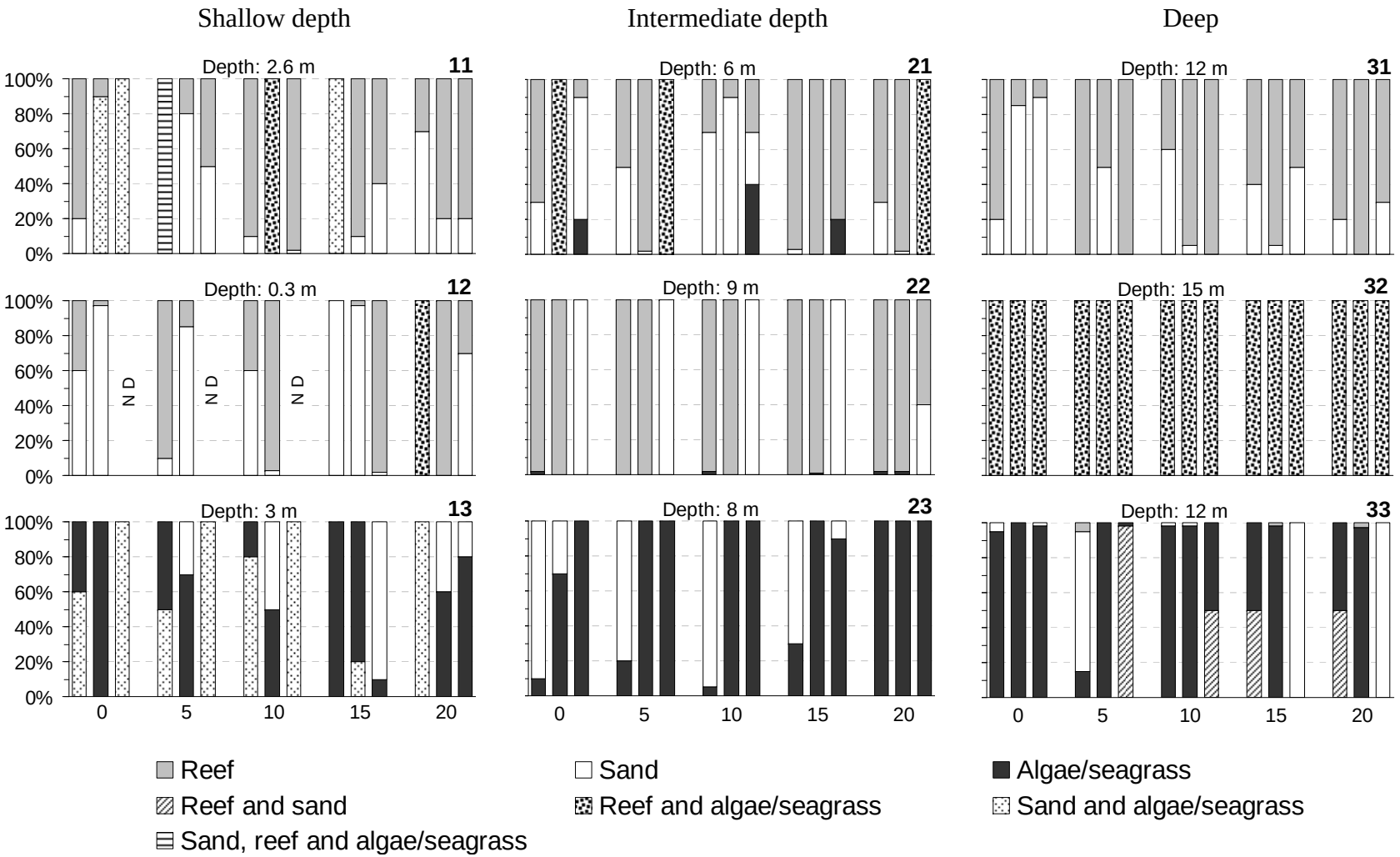

Figure 2: Percentage of bottom type for each transect at each 5 m observation. Each graph represents one sampling point. ND: no data.

4. Discussion

To our knowledge, this was the first study in South America that focus mainly on verifying the status of benthic marine debris contamination in an estuarine region in situ, that is, the direct observation of the environment. Reef environments in the Brazilian northeast coast have been monitored by the Reef Check Program for over 12 years (Reef Check Brazil, 2008). Benthic marine debris may be registered during the surveys; however, there is no published work about their benthic marine debris data. There is another study focused on benthic marine debris conducted in an estuarine region in South America, but it was done with the use of bottom trawl net at the Rio de la Plata (Acha et al., 2003). Bottom trawl net are ideal when one wants to sample a large area in a short period of time, but it can only be used on flat bottoms and there could be underestimations of small debris that pass through the mesh or that are hidden in crevices. When sampling a reef area, the most suitable method is diving (Spengler & Costa, 2008). This is why in situ observations were ideal in the study area, where the estuary is small and there are reef environments.

Even though the samplings were random, care was taken so they would always be placed close to reefs or seagrass meadows. Points 13 and 23 were placed on an area covered by algae/seagrass, while the other points were closed to reef environments. Bauer et al. (2007) found out that bottom type and local benthic characteristics, such as reef ledge height, are important for the distribution and abundance of marine debris. Since the present study was pioneer in the region, it was thought that similar depositional pattern would be found.

The reefs in the study area are potentially at risk of contamination by marine debris from both continental and marine sources; therefore they are a potential place for the deposition and accumulation of marine debris. Considering the conclusions of Bauer et al. (2007), which stated that irregular bottom and reef ledges can trap and entangle more marine debris than sparse live bottom and sand, it could be presumed that sampling point 32 offers the highest probability to retain marine debris. This can be affirmed because the three transect of this point were placed on a bottom formed by the combination of reef and algae/seagrass, and the sampling point presented the highest mean reef ledge height. Sampling points 31 and 22 also show high probabilities to hold marine debris. The sampling point that has the lowest chance to retain marine debris is point 12, once sand was the predominant bottom type and it presented the lowest mean ledge height. Sampling points 13, 23 and 33 have some

probability to have small debris retained by the seagrasses and macroalgae that predominated in the transects. However, due to the shallow depth and lack of aesthetic appeal for dive activities, it is less likely to find benthic marine debris in these points than in the other six points surveyed. The other six sampling points may attract divers, so besides marine debris that may come from the river, there is the probability of boats anchoring in the area and thus acting as another source of marine debris. The amount of marine debris has been related to the number of boats in the area (Widmer, 2003; Bauer et al., 2007).

Even though it was not found any benthic marine debris in the period sampled with the effort of 27 transects, they may be present in the reefs during the rainy season. However, there are no safe conditions to dive during this season and the visibility is too low to verify such hypothesis. Rainfall was the most important environmental variable to affect the amount of debris on estuarine beaches (Costa et al., 2007; Ivar do Sul, 2008). If more debris are carried by the river with increased river flow, it could be assumed that the probability of finding an item entangled in the reefs would be higher during this time.

Another hypothesis that may explain the absence of benthic marine debris in the study area is hydrodynamics. Marine debris are transported along the water column, and they will settle down when the energy of the water is no longer sufficient to carry them. Estuarine regions are turbulent, with fluxes of saltwater entering the river and water from the river going out, thus there may be too much energy, impeding the marine debris to deposit on the bottom. The majority of marine debris found on the estuarine beach sampled by Ivar do Sul (2008) were plastics and plastic fragments (items that tend to stay in the water column for a long period of time), which came from the river (62.3% according to her study).

Artisanal and commercial fishing are strongly present in the region; however this activity does not take place around the reefs sampled, but normally at higher depths. Spear fishing is practiced in the reefs sampled, but there are no studies about the impact of this kind of fishing considering marine debris.

The region of the Goiana River has a potential to be exploited by the tourism, especially by the dive industry, so studies in the area are essential for the establishment of plans for sustainable tourism activities. Baseline information is very important to develop management plans, and the lack of such information can complicate the assessment of environmental impacts (Smith et al., 2008).

The absence of marine debris in the reefs of the Goiana River estuary does not mean that the area is completely free of marine debris. They may not be depositing and accumulating in those specific underwater environments adjacent to the estuary, but rather being exported to coastal waters and/or to the ocean.

A point that has to be stressed is that the negative result found in the present work is a good notice for the environment; there are still places under very low impact of this type of contamination. There is a bias to publish only positive result, which in the case of marine pollution is to show that the environment is contaminated. There could be duplication of efforts and of costs when a researcher develops a study that was realized by another scientist and was not published because of the negative results (Knight, 2003).

Further studies are necessary to evaluate the contamination of benthic marine debris in the region. These researches can be concentrated in the areas where it was identified the higher potential to accumulate debris.

5. Conclusion

This first study about the potential contamination of the reefs of the Goiana River estuary showed that even though the mangrove forest and the estuarine beach are contaminated by marine debris, these debris are not being deposit in the adjacent area.

However, this does not mean that the area will be indefinitely free of benthic marine debris. Managerial plans have to be made in order to keep the area clean of benthic marine debris, including actions to avoid the contamination of the entire estuarine region.

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ENVIRONMENTAL PRACTICES AT DIVE CENTERS: STATE OF THE ART IN THE BRAZILIAN NORTHEAST

Abstract

Scuba diving is a growing activity in Brazil, following a world trend. There are studies about environmental problems caused by and affecting the dive industry, but none focusing on marine pollution. The aim of this study was to understand how dive centers from the Brazilian Northeast approach issues related to marine debris during dive classes and operations. Over 20 dive centers were approached and staff at 14 of them was interviewed. Strong and weak points of each establishment were noted. Some suggestions are made to improve the performance of dive centers in preventing marine pollution and divers' environmental education.

Keywords: Scuba dive, marine debris, marine pollution, marine conservation, Pernambuco, reefs

1. Introduction

Recreational diving is a major industry in many countries, and is considered one of the fastest growing sports in the world (WTO, 2001), with about a million people being trained every year (Davenport & Davenport, 2006). The number of active divers in the world varies from 5 to more than 28 million, according to the source (Garrod & Gössling, 2008). The Brazilian Northeast offers exceptional conditions for the practice of snorkeling and scuba dive, even though it still represents a relatively small segment of the eco-tourism and adventure market, mainly because of the high costs involved for its practice by the average Brazilian.

Scuba dive has grown significantly in Brazil with the opening of several dive schools, operators and facilities following the growing demand for adventure sports, a world wide trend. There are now sports fairs dedicated to water sports, like Rio and São Paulo Boat Shows, and to adventure sports, like the Adventure Sports Fair, held in São Paulo. This last fair has completed 10 editions in 2008, and it claims to be the largest fair of this kind of sport in South America (Adventure Sports Fair, 2008). This type of activity attracts investors and adventure sports practitioners,

helping to promote these sports in the country. The growth of these fairs in the last decade or so, together with the economic growth experienced in Brazil, is an indicative that the dive industry will continue to grow in the country.

The training of divers and most of the activities related to scuba dive in Brazil are made by the dive centers (dive schools which double as operators). They offer training courses ranging from the most basic levels to the most advanced ones. Most of the major international certifying agencies are present in Brazil. The same establishment sells equipment and accessories and organizes trips with divers, locally and abroad. Some still carry social functions by hosting private clubs and relationship centers for divers, their families and friends.

The expansion of the tourism industry related to scuba dive may be associated with socioeconomic benefits, but perhaps it is not always compatible with the protection of the marine environment (Green & Donnelly, 2003). Dive sites may undergo changes from both natural and human impacts. There could be some doubts about damages to corals health, which can be caused by storms (natural event), sewage inputs (human action), global warming (both natural and human related); but marine debris is unquestionably generated by humans only. Human daily activities produce residues that are called solid waste. Once this solid waste reaches the marine environment, either from continental or marine sources, it is labeled marine debris. When the marine debris is deposited on the ocean's floor it is then called benthic marine debris (Spengler & Costa, 2008).

There are studies about the physical damages (broken corals, disturbances in coral cover, high sedimentation rates) caused by divers to coral reefs (Rouphael & Inglis, 1997; Barker & Roberts, 2004; Hasler & Ott, 2008) and interaction with cetaceans and other marine organisms (Valentine et al., 2004), but, to our knowledge, there is no study concerning how divers impact and are impacted by marine debris and other forms of marine pollution at dive sites.

Aspects such as interesting environment and marine life, visibility, besides the financial cost of the experience are important variables considered by divers (Davis & Tisdell, 1996). Since the dive centers depend on a healthy environment to continue and increase their business, their role in preventing and reducing marine pollution aiming at environmental conservation is essential. Therefore, we must learn how dive centers face and deal with marine pollution, determining the strengths and weaknesses of their approaches. Thus, a plan of action can be established together

with the dive centers so they may assume a prominent role in the preservation of the marine environment around dive sites.

The aim of the present study was to assess the approach of dive centers based at the Northeast of Brazil (Pernambuco State), in relation to marine pollution, especially marine debris, when training divers and, later, exploiting their most valuable resource: dive sites.

2. Methodology

2.1 Study area

Pernambuco State is located on the Northeast coast of Brazil (Figure 1). It stands out in the scuba dive scenario as the "Brazilian Capital of Shipwrecks", having over 60 shipwrecks, both historical and intentional (Naufrágios do Brasil, 2008) within its reach. In addition to these various shipwrecks, there are coastal reefs that are used for the practice of diving activities. The fauna of the region collaborates to attract divers, since it includes many coral species (including endemic species), reef fishes, sharks, sea turtles and even endangered species, such as the goliath grouper (*Epinephelus itajara*) and the marine manatee (*Trichechus manatus*).

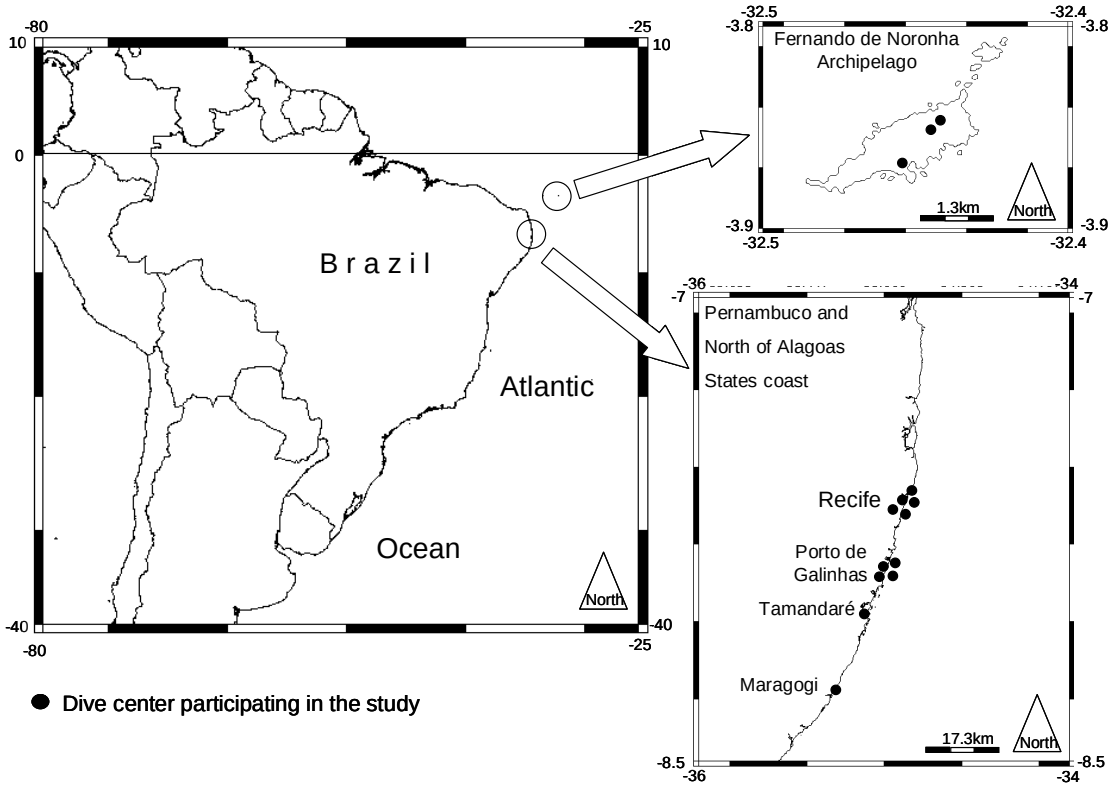

Figure 1: Location of the cities where there were dive centers interviewed.

The climate in the region presents two main seasons, a dry one from September to February, and a rainy season from March to August. Seawater in the region is warm (≥ 25°C) all year long and presents good visibility, which can be diminished during the rainy season even though there are only small coastal rivers.

Fernando de Noronha is an archipelago formed by 21 islands situated 545 km from Recife (Pernambuco State's capital city). The majority (70%) of the archipelago is part of the Fernando de Noronha Marine National Park, which is under the control of the Chico Mendes National Institute of Biodiversity Conservation (ICMBio, Ministry of Environment), while the remaining area forms an Area of Environmental Protection, controlled by the Pernambuco State. Fernando de Noronha is the main dive destination in Brazil, attracting a large number of tourists from Brazil and abroad.

Maragogi is on the north coast of Alagoas State, which boarders with Pernambuco State. In the present study it was included in Pernambuco due to its socio-economic link with this state. The majority of local tourists in Maragogi are from Pernambuco, and the main access to the town is through Pernambuco, including tourists that come to the region by airplane.

2.2 Sampling

A preliminary survey identified 21 dive centers in Recife, Olinda, Porto de Galinhas, Tamandaré, Fernando de Noronha Archipelago and Maragogi. In order to confirm the contact information and to verify the situation of operation of these centers, an initial contact was made by letter, email or telephone, in this order of priority. The dive centers that agreed to participate in the project were visited for interviews with instructors, administrators or employees. Three other dive centers not previously listed were cited during the interviews and were also contacted.

The interview was generally realized with the owner of the dive center, and took approximately one hour to be completed. It was always applied by the same interviewer, who sometimes was accompanied by a second person. The interview was divided into six sections: identification of the dive center (12 questions); knowledge about legal instruments regulating dive activities (4 questions); training of divers (12 questions); dive operations (16 questions); solid wastes and marine debris (19 questions) and; diseases (16 questions). At the end, a table containing the 21 dive centers initially identified was shown to the interviewees in order to find out their knowledge about the local market. General comments were also noted,

including observations about the impact of the governmental incentives to the tourism industry.

The term 'regular dive center' was applied to the centers that function as a microenterprise, that follow business regulations and pays taxes. On the other hand, an 'irregular dive center' cannot be considered a microenterprise since it does not pay taxes and does not have an infrastructure to operate.

2.3 Questionnaires to novice divers

Six dive centers based at Recife and Porto de Galinhas (three that have been operating for more than 5 years and three that have been in operation for less than 5 years) were selected to apply a two steps questionnaire to their novice divers. The first step, before the course, had questions about the student's socio-demographic data, motives to do a dive course and their knowledge about environmental education (10 questions) and; the second step, answered upon their return from the first open water dive, assessed their opinion about the marine environment (9 questions). The comparisons between the two questionnaires would inform if there was any difference in the student's environmental education.

2.4 In situ observations

In order to verify the activities of the dive centers during the dive trips, four dive centers were randomly chosen, two from Recife and the other two from Fernando de Noronha. Observations were made onboard about points asked during the interview, such as diving briefings and the onboard conduct regarding solid wastes. During the dives it was also observed the presence or not of benthic marine debris.

3. Results

3.1 Interviews with dive centers

From the 24 dive centers identified, seven have shut down and three did not reply to any of our forms of contact, even though they are known to be still operating. We chose not to visit them to keep the same methodology of contact with all dive centers. From the fourteen remaining centers, five are based in Recife, four in Porto de Galinhas, three in Fernando de Noronha, one in Tamandaré and one in Maragogi (Table 1).

Table 1: Results from the first section of the interview with the dive centers that agreed to participate in the survey. Answer 4 is an estimated mean made by the interviewees. Answer 6 considers the most experienced instructors only. Answers 7 to 9 are estimates made by the interviewees. Answer 10 considers the capacity each dive center can take per dive trip.

Dive Center	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Time of operation (years)	3	21	12	1.5	8	11	< 1	4	20	13	15	20	< 1	2.5
2. Number of certifying agencies available	1	1	4	1	4	1	1	1	2	5	6	1	1	1
3. Number of formal employees	0	3	6	0	5	3	0	10	5	18	29	25	0	1
4. Number of cash-in-hand employees	5	5	2	2	3	6	4	1	2	0	3	0	2	1
5. Number of dive instructors	1	1	3	1	3	1	1	3	2	8	8	15	1	1
6. Instructor's professional experience (years)	20	16	19	2.5	8	11	9	3	30	30	10	10	15	2
7. Number of novice divers trained per year	15	300	200	100	160	45	0	150	30	*	200	400	0	140
8. Number of instructors trained per year	0	2	6	0	2	0	0	15	0	5	0	20	0	0
9. Number of dive trips per year	45	120	195	150	260	50	0	300	400	1098	1185	966	0	250
10. Number of divers per trip	2	14	17	3	18	4	6	25	6	25	24	40	4	8

* The interviewee did not know and was not able to estimate it to an acceptable degree of precision.

Twelve dive centers operate regularly in shipwrecks, which represents from 1 to 100% of their dive trips. Coastal reef environments represent a dive destination option for ten centers, making up from 40 to 100% of their dive trips. When considering only the dive centers from Recife, the main destination of the trips is to shipwrecks (91%), being *Pirapama* and *Vapor de Baixo* the most visited ones. There are usually one to six trained divers per dive instructor (or guide); however some centers are able to change this proportion according to the level of experience of the divers in the group. The time spent at each dive site varies from one to six hours, which is usually related to the number of divers and dives per trip (five centers do one dive, while the other nine do two dives per trip).

The main target public is tourists for 71.4% of the dive centers interviewed, while former local students correspond to the main public of only 28.6% of the centers.

Over 50% of the dive centers prefer to hire instructors who speak at least one other language besides Portuguese, preferably English or Spanish. There were no preferences regarding the educational level of the instructor, which varied from high school to M.Phil. in Oceanography. One dive center declared that it should be mandatory for dive instructors to have completed high school, even though it does not consider it as a top priority when hiring its instructors.

Regarding the students' educational level, all levels from coursing high school to university degree were mentioned by the centers. In Fernando de Noronha, the great majority of students had university degrees. Even though no center admitted that there is a requirement related to the educational level of the students to take a dive course, two centers said that the students need only to be literate to learn to dive. On the other hand, one center confirmed that it had two illiterate students, while another stated that it would admit an illiterate student if it was the case.

When questioned about the reasons why they think students decided to take dive classes, the most cited was that the students want to have more contact with nature and to learn about the sport. In Fernando de Noronha, another reason pointed out by the interviewees was that students become attracted to take a dive course after going on a sea try diving.

Over 70% of the dive centers said that the students had notions of environmental education prior to the classes. One of the centers affirmed that tourists have higher environmental conscience than the local people. The majority of dive centers give information about environmental education voluntarily during their

training (Table 2). The environmental education classes/comments are concentrated in the basic level of diver's training. The time spent discussing environmental issues is approximately 20 minutes as a compulsory subject, and 30 minutes to 2 hours in the voluntary model. Four dive centers complement the environmental education contents offering talks given by specialists in some marine sciences field. The ones that do not offer such opportunities demonstrated interest in doing so. However, two dive centers in Fernando de Noronha mentioned the talks given to the tourists at an environmental education center on the island as a reason not to offer their own.

Participation in research projects is also a common practice for the dive centers (Table 2). In Recife, only the newest center did not have a previous experience with a research project. Even the ones that did not participated in a research project before affirmed that it is important and that there should be more projects involving the dive industry.

Table 2: Summary of the information about environmental education, solid waste and marine debris obtained from the interviews with the dive centers. When the total absolute number of dive centers is different than 14, it is informed in parenthesis.

	Frequency of dive center	
	Absolute	%
Environmental education as a compulsory class	2	14.3
Voluntary environmental class	4	28.6
Comments about environmental education only	8	57.1
Separation of recyclable solid waste	1	7.1
Participation in research projects	9	64.3
Separation of batteries only	7	50
Disposal of old equipment as ordinary garbage	8	66.7
Observation of litter falling from the boat to the sea	11	78.6
Collection of this litter from the sea	9 (11)	81.8
Observation of benthic marine debris on coastal reefs	9 (10)	90
Observation of benthic marine debris on shipwrecks	8 (11)	72.7
Collection of benthic marine debris on diving sites	14	100
Instructions to divers about the collection of marine debris	11 (13)	84.6
Promotion/participation in clean up days	10	71.4

When questioned about legislation and norms regulating dive activities (training and operations), the opinions of the interviewees were quite different. Six centers stated that they regulate themselves through the international certifying agencies; four mentioned the Brazilian Navy, even though they also said that it does not legislate about recreational diving (one even stated that the Navy is a problem for legislation about marine-based activities); one affirmed that the Ministry of Sports regulates the activity, while two mentioned that there is only a timid relation between this Ministry and the recreational dive industry. For the dive centers of Fernando de Noronha, the Brazilian Institute of Environment and Natural Renewable Resources (IBAMA), which is under the Ministry of Environment, was pointed out by two interviewees as the responsible for the regulation of the dive activities, while the other affirmed that there is no legislation at all covering this sort of business.

Considering the ones which stated that there is no legislation, only one is against the creation of such legislation, three agree with legislation but with some restrictions, and seven are completely forward towards a legislation of the activities for recreational diving operations.

The same pattern of responses was found for the question about legislation or directives about proper environmental and citizenship conduct during diving. Seven dive centers declared that there is no legislation on this subject (out of those, four said that suggestions on personal behaviors varies according to the certifying agency); three affirmed that there is a federal legislation; two that there is a state legislation; one said that the municipality has legislation on the subject and; one stated that the third sector regulates this issue. However, most important of all, the major problem pointed out by some interviewees was the lack of monitoring of the activities. Out of the seven dive centers which declared that there is no legislation, four agree with the urgent need in the preparation of some sort of guidance document, two are against, and one is favorable, but with restrictions.

Concerning the practices of the dive centers related to solid wastes and marine debris, all of them said that there are trash cans at their operational bases and only one center does not have it onboard. However, the problem lays on the separation of recyclable solid wastes (Table 2). Four dive centers pointed out that the main reasons for them not to separate the recyclable waste is the lack of a proper collection of this kind of trash and the lack of a recycling culture. Donation to poor fishers and re-selling of wet suits, especially, are regular practices of the dive center.

As for the boat's engine oil, six centers send it to be recycled at ordinary gas stations; two have boats with a two stroke engine (the oil is burnt with the fuel); one uses it for lubrication and; the other five do not know what happens with the oil after they bleed it from their engines.

Regarding marine debris, the majority of the dive centers have found marine debris at the dive sites (Table 2). These debris are normally collected, unless, as stated by two dive centers, they are fouled or "incorporated" to the reef. The centers said that usually there are not many debris, but a major comment from the centers at Recife was that the quantity of benthic marine debris at the shipwrecks increases significantly during and immediately after the dredging of the port.

Even though clean up events are frequent (Table 2), discussions about the contamination of the dive sites by marine debris are not common, neither encouraged. One center said that it only comments about this problem depending on the clients` profile, while another center affirmed that there is too little debris so it is not necessary to mention it.

Regarding health issues, 42.8% of the dive centers have life insurance for the dive operation. Only one center demands from its employees to have vaccine against hepatitis and tetanus; one asks for their employees and students to have skin tests for mycosis before the course and another one asks for employees only to do so.

All interviewees affirmed that there is a strong seasonality in the local dive industry, related both to water quality, which varies between the rainy and dry seasons, and school holidays. The large majority of dive operations occur during summer, while during winter the activities are very scarce. Three dive centers give vacation to all employees during at least one month in winter; one changes the area of the dives and; five use this period to do maintenance works and to give more courses of divers formation (like Rescue Dive). The other five stated that their dive operations are slower, but that it does not require a change of activities. Seasonality was pointed out as the greatest difficulty for their permanence in business. The activities related to recreational diving were considered as non-profitable by the interviewees, making them to quit or have a combined activity. Some establishments cover the operational costs, but make very little profit for the owner. Some, as a mechanism for surviving the low season, offer other non-recreational diving services to ports, shipyards and consultancy groups for instance. Although this may happen under other business registration number, the service is executed by the same divers and with the same operator's equipment.

The perception about the local dive market varies among the dive centers interviewed. A couple of centers said that the activity is expanding, while others affirmed that it is saturated in the region. The majority of the interviewees were not able to list and recognize all the dive centers in business. The perception about the local market also varies according to the place. The centers from Porto de Galinhas complained about the irregular dive operations on the beach, which have began about two years ago. They said that this kind of operation has impacted the local market and that the municipality should forbid it. The complaints from the centers from Recife were about the different capacities and prices found in a market with too many players; and about the problems that affect tourism as a whole (exchange rates and air traffic issues within Brazil). The centers from Fernando de Noronha criticized the monopoly of the flying companies serving the island, which results in expensive fares.

Even though there was some divergence about the existence of governmental incentives to the tourism, and especially dive industries, the overall opinion was that it is not enough and not adequate. The interviewees stated that there should be a specific market towards the diving destinations of Pernambuco, especially about the scuba diving sites.

3.2 Questionnaires to novice divers

A total of 225 questionnaires were distributed to the six selected dive centers, but only six (2.6%) were returned after four months. Due to this low return level, the results of these questionnaires will not be discussed in this study.

3.3 In situ observations

One dive center from Recife chosen to be observed during the dive trips does not own a boat, so it depends on other dive centers to go to the sea. The other operator from Recife has one boat, while the two dive centers from Fernando de Noronha have two boats each. Snacks and beverages served in disposable plastic cups were offered in all boats, but they all had trash cans. The content of the briefings were similar from all dive centers: the crew is introduced to the divers; there are explanations about the facilities onboard and how people should behave on deck regarding safety; divers are set in pairs and; finally there are explanations about the dive procedures. Only the dive centers from Fernando de Noronha made a few comments about not touching the marine organisms. No specific information about the dive site was given by any dive center.

During the six dives realized at shipwrecks near Recife, only one plastic fragment was found. On the other hand, many construction waste (tiles, bricks, ship ladder) was observed during one dive (out of six) done in Fernando de Noronha.

4. Discussion

The number of dive centers interviewed is very representative (82.4%), so the information gathered and the perceptions of the interviewees can be extrapolated to the dive industry at Pernambuco State. Also they were the largest operators, which serve and formed the majority of divers. The receptivity of the dive centers towards the interview was quite different among them. Some people were really willing to collaborate, while others made clear that they thought the interview was a waste of time.

Currently there are 105 people formally hired to work in the dive industry sampled in this study. However, when considering also the autonomous/informal employees, the total number of people increases by 30%. More people could be employed directly by this industry, if the dive centers could fully operate throughout the whole year. A new dive center requires high investments to enter into the dive industry, and these investments do not stop once it is operating. Seasonality imposes the greatest challenge to overcome in order to stay in business, and parallel/alternative activities may be an option. However, when a dive center also works in environmental consultancy, there should be different equipments for each activity. A wet suit that is used in an environment exposed to contamination (such as port water and sewage) should not be used by dive students, since it may cause skin diseases. Other reasons for having different sets of equipment for each activity is that, during environmental consultancy jobs, equipment may suffer more damage, which can affect its aesthetics, and therefore the imagine of the dive center.

Another health issue found is that from the six dive centers that use a swimming pool for their practice lessons five do not ask their students and employees to have skin exams. They opt for adding more chlorine in the water, which can provoke allergic reactions to some people and deteriorate more quickly the dive equipment.

Dive centers should also consider having life insure. Diving is an adventure sport, and like any other sports it offers high risks when not performed accordingly to safety measures. However, less than half (6) of the interviewed dive centers offers life

insurance for people participating in their dive activities. In the Brazilian culture, the practice of insurance is not very common, and it is reflected in the dive centers. Life insurance has a high cost, but certainly it would benefit the dive center in the case of an accident.

People who work directly with dive operations in Pernambuco State have a perception that the marine environment, at least the dive sites, is not significantly contaminated by benthic marine debris. The routine collection of marine debris whenever found on the seabed can contribute to this perception, since it avoids accumulation of debris. During the interviews doubts emerged about the collection of debris fouled or "incorporated" to the reef. It is hard to define the limit of marine organisms attached to debris that indicate the debris should be collected or not. Yet, there are three cases when the debris should not be collected: (i) if the organism attached is endangered and it will cost more to the environment to take the organism away than leaving the debris (which is hard to perceive); (ii) if the debris is completely covered by marine organisms and; (iii) if it will represent a risk to the diver to collect the debris. Issues like this could be stressed during training of dive instructors and other operational staff with specific regional contents. All people employed by the dive industry should be familiar with the marine environment and organisms in their diving sites, as well as with issues related to the better care of the environment. This would improve the divers' environmental knowledge and behavior (Davis & Tisdell, 1996), since dive guides and instructors are the ones in direct contact with divers, therefore they are the ones who can reinforce environmental friendly attitudes (Hasler & Ott, 2008)

Even if they perceive the marine environment as free from marine debris, discussions about the problems of marine pollution should be encouraged. The specific dive site visited may not show contamination, but the problem still exists. People who drop debris in the ocean, accidentally or not, have to be reprehended. This is not a question about marine debris only; it is a matter of creating environmental consciousness.

The students' educational level varies among the dive centers, and can be assumed to be a characteristic of the majority of the diving public of each place. The fact that the majority of the dive students from the centers in Fernando de Noronha have a university degree can be related to the high costs involved in going to the island and practice dive there. People who are highly educated can be linked to well-paid jobs, thus can spend more money in diving training, equipment and travel (Garrod

& Gössling, 2008). One educational level issue raised was that one dive center admitted to have given classes to illiterate people, while another said it would admit an illiterate student. The basic diving principles require the understanding of some physical laws, which can be quite complicated for someone who cannot read. Also, to understand and use properly the diving tables one must know how to read. Therefore, it should be mandatory for every diving student to know how to read and write.

Regarding the environmental education, even though the majority (10) of the interviewees declared that the students have prior knowledge about environmental issues, these issues should be more stressed during classes. Environmental questions are a complex and unlimited subject, so the knowledge people have is not always related to the sea. If one of the main reasons for the students to take a dive class was cited as being to have more contact with the environment, they would presume to gain more knowledge on the subject. Lück (2003) pointed out that participants in dolphin tours expect and even want to receive more information about the marine environment. The author also stated that these participants can potentially change their attitudes towards the environment and even offer financial support to environmental organizations after being lectured on environmental issues. If such changes in behavior can occur after only a few hours spent onboard, dive classes that take at least 20 h could be used as an effective way to transmit environmental knowledge among the students. Educated divers have lower chances to damage the marine environment (Barker & Roberts, 2004) and themselves, and may even increase the carrying capacity of a reef environment (Shivlani & Suman, 2000). However, there is no exact answer about the duration of the lectures or comments about environmental education able to promote these positive consequences. Medio et al (1997) affirmed that environmental briefings given just before the dives are sufficient to reduce voluntary and involuntary contacts with the substrate. On the other hand, Barker and Roberts (2004) stated that the briefings do not produce any results; it is necessary an intervention underwater to decrease divers' contacts with the substrate. Environmental issues discussed during classes may be more efficient than briefings onboard, once the students are not preoccupied about the dive procedures they are going to deal with in a few minutes. Briefings onboard have to be concise, due to weather conditions, length of the trip, diver's health condition, among others. Therefore, there is no time for discussions, only simple and practical instructions can be given (Townsend, 2008).

The different answers given by the interviewees when questioned about environmental education arise some concerns. Among the 14 dive centers, two stated that classes about environmental issues are mandatory according to the dive certifying agency. If they were really mandatory, all centers should be given such classes, once their dive instructors are equally trained and receive the same material from the certifying agency. The concept of an environmental class may have been misunderstood, or it is not actually mandatory by the certifying agency. Another issue is that the concern about environmental education depends on the interests of the dive centers and their employees (Lindgreen et al., 2008). The power to certify a dive student is given by the certifying agency to the dive instructor, not to the dive center. Thus, the contents of environmental issues can be discussed superficially or in more details according to the importance the dive instructor gives to the matter.

Lindgreen et al. (2008) analyzed the educational material of the Professional Association of Diving Instructors (PADI), which is the world's largest dive organization and that is present at 71.4% of the dive centers approached during the present work. They found out that the Open Water Diver and the Advanced Open Diver Manuals are superficial related to proper environmental attitudes underwater, and that it may be an individual choice to obtain more knowledge on this subject. As for the Instructor Manual, it is said to be limited. The only direct points about marine pollution are to be discussed during the Junior Open Water course and the Project AWARE Speciality Program. This shows that certifying agencies have to understand better their role in managing the environment and be more forward towards the better care of the environment. Certifying agencies are in the top of the dive industry hierarchy (Lindgreen et al., 2008), so when they make a few changes, this will have a cascade effect.

Over 1/3 of the interviewees blamed the lack of a recycling culture and proper collection of recyclable debris for their deficiency in separating the solid waste. However, only one center showed initiatives to improve the recyclable waste knowledge among its divers, like changing disposable plastic cups for numbered plastic cups that are returned after the dive trip and can be used again. The fact that five interviewees did not know what happens with the oil of the boats they use shows some disinterest, even though they rent boats for their dive operations. In Brazil there is no marina awarded by the Blue Flag Organization (Blue Flag, 2008). This award is given based on the sewage treatment and bathing water quality, and it can be used to qualify an area and attract a more educated and with a higher environmental

consciousness public. Therefore, to know exactly what happens with the oil that is drained from the boats is a basic step to try to achieve the Blue Flag award. Besides the pollution caused by boats' engine oil, there are studies that relate the amount of benthic marine debris to the quantity of boats in the area (Widmer, 2003; Bauer et al., 2007). Since the majority of recreational diving activities in Pernambuco depend on boats to access the diving sites, it can be said that recreational diving might generate mainly two types of marine pollution: marine debris (diving gear, snacks) and oil pollution from the boat's engine. Studies about the impact of spills from the engine are absent in the scientific literature (Lindgreen et al., 2008). Dive centers are a very important stakeholder for the conservation of the marine environment, they must learn about the better destination for all the residues produced in their activities, so they can be a part in all the changes that have to be done. If there are problems about the government's actions related to waste collection, they should discuss the issues to diminish the deficiencies. Dive centers depend on a healthy environment to continue their activities, and they have great influence in their students and divers. Therefore, they should be a model of environmental care and actions, and not just blame others for not doing their part.

Dive centers should also have a better knowledge about the Brazilian laws that may influence their activity. The interviewees were confused when asked about the existence of legislation or norms regarding dive activities and proper environmental and citizenship conduct during dive activities. A series of norms was issued by the Brazilian Association of Technical Norms (ABNT) in February 2008, after the interviews were realized. There are three norms for the training and certification of autonomous divers; two for training and certification of dive instructors and one norm presents the minimum requirements for the operation of a dive center (ABNT, 2008). One of the norms (ABNT NBR ISO 24801-2:2008) establishes that a diver in level two must have knowledge about environmental education. As for the norm related to dive centers (ABNT NBR ISO 24803:2008), there is one topic about the necessity of evaluating the risks of pollution in a dive site. However, as pointed out by the interviewees, more than just having laws and norms, it is necessary to supervise their application and compliancy. As Barker and Roberts (2008) stated, divers are always under regulations, from local laws to the regulations imposed by dive centers, but they do not automatically adopt such regulations; there is a need for supervision.

The dive centers showed a willingness to participate in further research projects. However, we did not find them truly enthusiastic about this. The six dive

centers selected to apply the two-step questionnaire were visited and received the same information and instructions. The questionnaires were left with them during a period from three to seven months, during which there was constant contact to verify how many questionnaires had been filled in and if they were encountering problems to apply the questionnaires. The only dive center that returned the few questionnaires was the one from Recife that had never participated in a research project before. The reasons pointed out for the unsuccessful of this collaboration was that the instructors forgot to apply the questionnaires and that they did not have any novices' classes after they received the questionnaires. Normally the participation of dive centers in research projects involves only abatement of the diving's costs and support during the dives. This may be one of the reasons why the collaboration with dive centers involving paperwork failed. Questions rise about what is participation in a research project after all, and if dive centers need extra incentive to collaborate in research projects, like tax exemption, or gaining knowledge about how to improve their activities is enough. The answers will depend on how dive centers see their role for the development of science.

The aim of the questionnaires was to obtain information about the new divers, to know who they are, their socio-economic status, and their expectations and interests in the marine environment. Divers are an important actor in the preservation of the marine environment, and it is fundamental to know them, so they can be effectively included in environmental management plans and actions (Garrod, 2008).

One of the biggest issues observed about the dive industry in Pernambuco State is the lack of self-organization. The majority of the interviewees did not have an accurate knowledge about the local market, which is necessary in order to define if it is expanding or not, and to make decisions about new investments. There is a state association of dive centers, which is not known by everyone interviewed. Also, we detected misinformed associated members. An efficient association would help organize the local market; solve problems related to dive industry, even the more local ones and; claim for more government initiatives that will benefit the dive industry and improve co-operation, reducing the stress during low season. Dive activity in Recife is based on shipwrecks, and there are plans to expand their numbers in order to attract more fish and consequently more divers. Studies have been conducted to verify how shipwrecks (as artificial reefs) influence fish and benthic communities, and how they can damage coral reefs (Prech et al., 2001). However, to our knowledge, there is no study about how shipwrecks impact the soft bottom, which acts as a biological filter and has not yet been extensively study about the impacts shipwrecks posed on it

(Burton, 2008). Another problem related to the shipwreck dive in Recife is that the boats are anchored to the shipwrecks with a rope, so the shipwrecks are damaged by the movement of the boats at the surface, which depends on the sea roughness. The interviewees acknowledge this problem, but they said that installing a moron in each shipwreck would be too expensive and that the dive centers that do not collaborate would still benefit from its use. In this case, an efficient association would resolve the disputes between the dive centers.

As stated before, the main problem reported by the dive centers based at Porto de Galinhas was the irregular dive operators on the beach. These irregular dive centers set their equipment in tends at the beach, and offer lower prices than the regular dive market for going on a sea try diving. The informality of other economic sectors in Brazil makes the practice of these irregular dive operators not so absurd for some people who consider only the price but not the quality of the service. If the regular dive centers unite themselves, they would have more power to demand attitudes from the city, like regulations and monitoring of dive activities in the region. Again, an efficient association would make the opinion of dive centers stronger.

Tourists are the main focus of the dive industry in the region, so there should be joint actions between all the sectors that can profit from them. The fact that the dive centers give preference to dive instructors who speak other languages shows that they are worried about international tourism. However, there is not enough advertising in specialized websites about the dive sites in Pernambuco, except Fernando de Noronha that has two dive sites at the 33rd and 94th positions in a list of the 100 top dive sites (Scuba Travel, 2008). There is direct collaboration (a store or booth inside five star resorts) between dive centers with hotels and tourist agencies only in Porto de Galinhas and Maragogi, so this is an area that could be better explored among these sectors. There are also local fishermen that take tourists for short snorkeling trips at their boats who can be included in joint actions with dive centers.

There are many options for diving in Pernambuco State, from coastal reef environments to shipwrecks. However, there is a tendency to over-explore a few sites (the ones which have a better access and are not too deep, within the limits of the Open Water certification) and thus provoke cumulative impacts on the resource (Shivlani & Suman, 2000). Another point is that with the preference of some dive sites by the dive centers, divers are taken to the same places, thus the dive becomes repetitive and people can decide to dive somewhere else. Once a dive site looses its natural environment appeal, it will loose its value as a dive site, leading to economic

losses (Davis & Tisdell, 1996). With the exception of Fernando de Noronha, where there are more restricted legislation and supervision, there are no studies about the carrying capacity of the dive sites. Dive centers should act together to preserve the marine environment they depend on. They have to think more about the future and take some actions now.

4.1 Fernando de Noronha

The reality of the dive industry of Fernando de Noronha is completely different from the other dive centers at Pernambuco mainland and even in Brazil. The dive centers treat the diving activities with more professionalism, showing a higher level of organization than the other dive center interviewed at the mainland. Therefore, the dive industry of Fernando de Noronha could be used as a model for the development of the dive activities in Pernambuco and even in Brazil.

For being an archipelago and constituted of an area of environmental protection and a national marine reserve, there is very restricted legislation about diving operations in Fernando de Noronha. This was stressed by the three dive centers that act in the island. On the other hand, the archipelago is a main dive destination in Brazil, attracting a great number of tourists from Brazil and overseas. The dive centers have at least two boats and during the peak dive season (October to March) each operator makes four to six dive trips per day, with a minimum of 24 divers per boat. This could be the cause of conflicts between two main actors of the archipelago, the dive centers and the environmental agency. However, there were no complaints from the dive centers towards the ICMBio, once they have learned how to respect and cooperate with each other. Besides this great number of dive trips organized for scuba divers, there are also other trips designated for snorkeling and manta tow activities.

The number of novice divers formed in Fernando de Noronha is a little higher when comparing to the other places in Pernambuco State. One of the main reasons for this is that other dive centers from Brazil send their students to do their checkouts in Fernando de Noronha; hence these new divers are credited to the dive centers of the island. The greatest number of new dive instructors is also found in Fernando de Noronha. There is no other place in Brazil that has such intense diving activity as Fernando de Noronha, so it is a good place to become more experienced in the sport and in all activities involved in the dive trips. One of the dive centers offers a one-year contract for the instructors they form even before they finish the course.

Even though it was found a great quantity of benthic marine debris in one dive site in Fernando de Noronha, this does not represent a lack of care by the current environmental administration. The benthic marine debris was found in the region that used to be the port during World War II, so the construction material probably fell during the unloading of the boats. However, it is interesting to point out that the dive center staff did not understand those materials as being marine debris. Some of the objects were partially covered by marine organisms, so people may not distinguish them from the natural environment. Perception of environmental problems may not correspond to the real situation, but they have to be considered in environmental management (Widmer, 2003).

In 2001, it was held a workshop in Brazil to discuss national guidelines for the practices of recreational dive in conservation units. There were representatives from the federal and state environmental agencies, from the dive industry sector and from non-governmental organizations. The final document produced contains information about the impacts generated by different diving activities and suggestions about how to overcome these impacts. It is stated that the key point is to monitor the activities; there should be restrictions on the use of boats with a two-stroke engine; dive instructors and guides are responsible for divers' behavior towards the environment and; that discussions before (briefing) and after (debriefing) diving are mandatory (Augustowski & Francine, 2002). There is no specific comment about marine pollution. Even though these are only guidelines, they would be expected to be followed, especially in Fernando de Noronha, since there were representatives from its administration and two dive centers at the workshop. However, as stated above, the briefings given by the two dive centers did not contain information about proper environmental actions, how to avoid disturbances in the environment. A debriefing was also missing.

One suggestion given to reduce environmental impact caused by diving activities at conservation units was underwater trails. However, there is none underwater trail established in Fernando de Noronha. Underwater trails concentrate the damage caused by snorkelers in a constrained area. Yet, the damages can be reduced if an area is carefully chosen (deep enough to avoid contacts and away from fragile organisms), floating rest stations are placed along the trail, there is rotation between different trails and if people are well informed about the damages they can cause and how they can prevent such damages (Plathong et al., 2000).

4.2 Suggestions to improve the role of environmental care by dive centers

The following suggestions should be employed by dive centers that organize scuba dive operations, as well as for centers who do other marine related activities, such as snorkeling, manta tow and boat trips. The more collaboration among tourist dependent actors, the better for the environment.

(i) Dive centers should be more pro-active in environmental issues, promoting more discussions about environmental problems, how they can be avoided, solved or at least mitigated. The decisions about environmental educational classes should not have to be imposed by the certifying agencies; dive centers could take this action and incorporate regional issues in the discussions.

(ii) Dive centers should not wait for the local government to start a recyclable waste program; they could do their part and demand the government to take some action.

(iii) The majority of potential waste should be avoided onboard. Snacks can be removed from their package and placed in Tupperware; sandwiches can be wrapped in paper napkins; disposable plastic cups can be replaced by numbered plastic cups that are returned after the dive trip and can be used again. By doing so, the chances of accidently dropping waste in the ocean will be reduced.

(iv) The briefings should contain more information about the specific marine environment that is going to be visited, the damages that can be caused by divers and how divers can avoid causing harm to the marine environment.

(v) There should be more discussions after the dive, including topics about how to better preserve and conserve the marine environment.

(vi) Underwater trails should be established for the use of snorkels in Fernando de Noronha, Porto de Galinhas and Maragogi, following the idea of disturbing one area in the favor of conserving the majority of the environment.

5. Conclusion

Recreational diving activity is related to a healthy environment, because people want to explore the marine environment in its more natural state as possible. Therefore, dive centers depend on the good state of marine environment to continue and even expand their activities. In order to maintain a healthy environment, dive centers have to be a part in its conservation.

The role of dive centers in the conservation of the marine environment goes beyond stopping and educating about marine debris and other forms of marine

pollution. Recreational diving gives common citizens access to the marine world, promoting its close observation, possibly further understanding and consequently a strong affection to it. Everything learned during a dive course and during the dive itself can be practice by divers anywhere they go. Thus, when a person learns how to properly behave during a dive, he/she will be able to dive properly everywhere in the world, with or without having his/her dive trip organized by a dive center.

Divers are major players in the marine conservation game. The challenge ahead is to find ways to guarantee their fair-play, so the environment as well as people will be winners.

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Através do presente estudo é possível concluir que a contaminação por resíduos sólidos bentônicos é bem variável nos diferentes tipos de ambientes recifais do estado de Pernambuco. No entanto, por se tratar de um contaminante exclusivamente antrópico, qualquer quantidade de resíduo sólido no ambiente já representa um grande risco para os organismos, bem como para as pessoas.

O ambiente recifal estudado na praia da Boa Viagem (recife costeiro semi-submerso exposto a um alto grau de urbanização e exploração turística) apresentou-se contaminado por resíduos sólidos. Esta contaminação foi qualitativamente similar àquela encontrada na linha do deixa, sendo o plástico o material mais observado. A praia foi sugerida como a principal fonte de resíduos sólidos que contaminam o "beachrock" central da praia da Boa Viagem. Por se tratar do primeiro estudo sobre resíduos sólidos em um recife semi-submerso no litoral do nordeste brasileiro, fica evidente a necessidade de futuros estudos neste tipo de ambiente. Também é fundamental que esse ambiente seja incluído nas ações de limpeza de praia e de conscientização sobre os problemas dos resíduos sólidos marinhos.

Ao contrário do que o esperado, o recife estudado próximo à foz do estuário do rio Goiana (recife costeiro submerso em uma região pouco urbanizada e com pouca atividade turística) não apresentou contaminação por resíduos sólidos. A hipótese de que os resíduos sólidos marinhos encontrados na praia e no mangue seriam depositados nos recifes costeiros adjacentes foi refutada. Dessa maneira, sugere-se uma nova hipótese, a de que os resíduos seriam carreados para maiores distâncias da foz do estuário, ou para recifes mais profundos.

O fato de não ter sido encontrado nenhum resíduo sólido na área de estudo, com o esforço amostral utilizado, fornece um bom dado de base para futuros estudos sobre poluição marinha na região, que possui um alto potencial para ser explorada pela indústria do turismo, principalmente para atividades de mergulho.

As entrevistas com as escolas/operadoras de mergulho demonstraram como a preocupação com o meio ambiente é variável entre estes atores que dependem de um ambiente marinho saudável e preservado. Ficou evidenciado que a grande maioria ocupada apenas um papel de cobrar atitudes de terceiros, como culpar o governo local pela falta de coleta seletiva. No entanto, mudanças não precisam ser feitas de cima para baixo. Ao contribuir com a organização de uma coleta seletiva na comunidade onde a escola/operadora de mergulho está inserida, e disseminar conceitos e práticas

de educação ambiental, os atores sociais se tornarão ativos nas mudanças que devem ser feitas. Dessa forma, passarão a ter conhecimento prático de como é preciso agir, o que facilita as negociações com o poder público para a implantação das mudanças.

Embora tenha crescido o número de estudos sobre resíduos sólidos marinhos nos últimos anos, o conhecimento sobre esse problema é escasso no litoral brasileiro. A maioria dos estudos está localizada no litoral do Rio Grande do Sul e de Pernambuco. Devido à observação direta e de baixo custo, as praias são o ambiente costeiro mais estudado. Este foi o primeiro estudo, de nosso conhecimento, a abordar a poluição marinha por resíduos sólidos em ambientes recifais no Brasil, mostrando a necessidade de verificar o estado de contaminação de outros ambientes marinhos, como recifes submersos e semi-submersos. Todos os ambientes são de alguma forma interligados, logo é preciso saber como os resíduos se comportam em cada tipo de ambiente e como podem afetar as regiões adjacentes. Dessa forma, é possível estabelecer planos de limpeza e de gerenciamento mais completos e eficientes.

O problema dos resíduos sólidos marinhos não é apenas uma questão de limpeza pública, mas sim um amplo problema social. Resíduos sólidos atraem organismos vetores de doenças, podem causar ferimentos, além de perdas na indústria do turismo pelo detrimento à estética do local. Este tipo de poluição gera um grande problema econômico, seja pelos gastos com a limpeza de praias, com a saúde pública e/ou com ações sociais para suprir o desemprego pela queda do turismo. Assim, não basta apenas ampliar a limpeza dos ambientes, é necessário incluir todos os atores que de alguma maneira estejam envolvidos com o ambiente marinho, tanto aqueles responsáveis pela poluição quanto aqueles interessados na sua conservação, nas discussões e nas ações que devem ser tomadas para prevenir, resolver ou mitigar as questões de poluição marinha.

ANEXO

ENTREVISTA COM AS OPERADORAS

Operadora:

Nome do entrevistado:

Função do entrevistado na operadora:

Data:

Quem entrevistou:

IDENTIFICAÇÃO

1. Certificadora: ( ) PADI ( ) PDIC ( ) CMAS ( ) BSAC ( ) NAUI
( ) IANTD ( ) Outra _____

2. Tempo de atuação da operadora:

3. Participação do dono da operadora: ( ) Instrutor de mergulho
( ) Administração da empresa
( ) É uma filial de outra operadora.

4. Número de funcionários: **Formais:** **Informais:**

5. Número de instrutores:

6. Tempo de atuação dos instrutores:

7. Os instrutores são da mesma certificadora que a operadora?
( ) Sim ( ) Não

8. Caso não, qual? ( ) PADI ( ) PDIC ( ) CMAS ( ) BSAC
( ) NAUI ( ) IANTD ( ) Outra _____

9. Escolaridade dos instrutores: ( ) Ensino médio completo
( ) Ensino superior incompleto
( ) Ensino superior completo
( ) Pós-graduação

→ A: Quais são as exigências para a formação de instrutores?

10. Já participaram em outros projetos de pesquisa? ( ) Sim ( ) Não

11. Caso sim, quais?

12. O que acham da iniciativa? ( ) Acham importante
( ) Gostariam que houvesse mais parcerias
( ) É uma troca, com benefícios para ambos

REGULAMENTAÇÃO DAS ATIVIDADES DE MERGULHO

13. Existe alguma regulamentação oficial que cubra o funcionamento das operadoras de mergulho em relação aos cursos e saídas de mergulho?

( ) Federal
( ) Estadual
( ) Municipal
( ) Sociedade organizada
( ) Não existe

14. Caso não exista, são favoráveis a uma regulamentação?

( ) Sim ( ) Sim, mas com ressalvas ( ) Não

15. Existe alguma regulamentação oficial que cubra o conteúdo sobre boas práticas ambientais e de cidadania durante a prática do mergulho?

( ) Federal
( ) Estadual
( ) Municipal
( ) Sociedade organizada
( ) Não existe

16. Caso não exista, são favoráveis a uma regulamentação?

( ) Sim ( ) Não

FORMAÇÃO DE MERGULHADORES

17. Níveis que formam: ( ) Básico
( ) Avançados
( ) Especialidades
( ) Instrutor de mergulho

18. Número de alunos que formam por ano:

Registro: ( ) Sim ( ) Não

19. Número de instrutores que formam por ano:

20. Colocação dos instrutores no mercado: ( ) Na própria operadora
( ) Em outra operadora do estado
( ) Em outra operadora do país
( ) Em outra operadora no exterior
( ) Não exerce mais a atividade
( ) Desconhecem

21. Motivos para fazer o curso:

Aluno	**Instrutor**	
( )	( )	Contato com a natureza
( )	( )	Conhecer o esporte
( )	( )	Ampliar os conhecimentos sobre o mergulho
( )	( )	Atuar como profissional de mergulho
( )	( )	Outro _____

22. Escolaridade dos alunos: ( ) Ensino médio incompleto
( ) Ensino médio completo
( ) Ensino superior incompleto
( ) Ensino superior completo

➞ B: Quais são as exigências para a aceitação de alunos?

23. Os alunos têm noções de educação ambiental anterior às aulas na operadora?

( ) Sim ( ) Não

24. Existe alguma aula que enfoque principalmente a educação ambiental antes da primeira saída para o mar? ( ) Sim, obrigatória segundo a certificadora
( ) Sim, obrigatória segundo a legislação
( ) Sim, voluntária
( ) Não

25. Qual é a sua duração?

➞ C: Como é o material utilizado?

26. Essas aulas são diferenciadas para cada nível de formação?

( ) Sim ( ) Não

27. São feitas palestras por especialistas no assunto? ( ) Sim ( ) Não

28. Caso não, existe interesse para que sejam feitas por especialistas?

( ) Sim ( ) Não

MERGULHOS

29. Quantas saídas são feitas por ano?

Registro: ( ) Sim ( ) Não

30. Quantas para naufrágios (%)?

31. Quantas para ambientes costeiros (%)?

32. Número de pessoas que participam de cada saída:

33. Número de mergulhadores para cada instrutor:

34. Taxa de reincidência de mergulhadores: ( ) Baixa

( ) Média

( ) Alta

35. Quem procura mais pelos mergulhos?

( ) Ex-alunos

( ) Pessoas formadas em outras operadoras

( ) Turistas

36. Possuem seguro de vida/acidentes: ( ) Sim ( ) Não

37. Existe sazonalidade? ( ) Sim ( ) Não

38. Caso sim, quando fazem saídas?

39. Quando ficam parados?

40. O que fazem quando estão parados? ( ) Exercem outra atividade

( ) Mudam de região de operação

( ) Férias coletivas

41. Quais os naufrágios mais visitados? ( ) Areeiro

( ) Chata de Noronha

( ) Pirapama

( ) Reboque

( ) Servimar X

( ) Taurus

( ) Vapor de Baixo

( ) Outro _____

42. Quais os sítios de mergulho mais visitados?

43. Quanto tempo ficam em cada local?

44. Quantos mergulhos por saída?

RESÍDUOS

45. Existe alguma regulamentação/certificação ambiental e de segurança em relação a resíduos sólidos nas atividades de mergulho?

( ) Sim ( ) Não

46. Existem lixeiras na base? ( ) Sim ( ) Não

47. Existem lixeiras no barco? ( ) Sim ( ) Não

48. Existe coleta seletiva? ( ) Sim ( ) Não ( ) Parcial

Pilhas

49. O que fazem com o equipamento antigo de mergulho? ( ) Lixo comum
( ) Doação
( ) Revende

50. Vocês já observaram algum resíduo sólido caindo da embarcação no mar? ( ) Sim ( ) Não

51. Tentam recolhê-lo? ( ) Sim ( ) Não

52. Abordam quem cometeu a falta, caso não tenha sido acidental?
( ) Sim ( ) Não

53. Vocês vêem resíduos nos sítios de mergulho? ( ) Sim ( ) Não

54. E nos naufrágios? ( ) Sim ( ) Não

55. Recolhem esses resíduos? ( ) Sim ( ) Não

56. Caso sim, fazem de maneira rotineira? ( ) Sim ( ) Não

57. Dão instruções de segurança para os mergulhadores antes de começar o recolhimento? ( ) Sim ( ) Não

58. Existe uma data específica na qual os resíduos são recolhidos?
( ) Sim ( ) Não

59. Caso sim, quando?

60. Chamam a atenção dos alunos para o fato dos sítios estarem contaminados?
( ) Sim ( ) Não

61. Ocorre discussão sobre os esgotos e plumas de rios observados durante a saída? ( ) Sim ( ) Não

62. Caso sim, quem inicia a discussão: ( ) Alunos/Clientes
( ) Instrutores
( ) Tripulação

63. Qual o procedimento adotado com o óleo do barco? ( ) Reciclagem
( ) Jogado no lixo
( ) Desconhece

DOENÇAS

64. É exigido exame de pele para os alunos? ( ) Sim ( ) Não

65. E para os funcionários da operadora? ( ) Sim ( ) Não

66. É exigido vacina antitetânica para os alunos? ( ) Sim ( ) Não

67. E para os funcionários da operadora? ( ) Sim ( ) Não

68. É exigido vacina contra hepatite para os alunos? ( ) Sim ( ) Não

69. E para os funcionários da operadora? ( ) Sim ( ) Não

70. Após o mergulho, é observado algum tipo de irritação de pele nos alunos? ( ) Sim ( ) Não ( ) Desconhece

71. Caso sim, o que é observado? ( ) Vermelhidão

( ) Urticária

( ) Outra _____

72. E nos instrutores, é observado algum tipo de irritação de pele?

( ) Sim ( ) Não ( ) Desconhece

73. Caso sim, o que é observado? ( ) Vermelhidão

( ) Urticária

( ) Outra _____

74. Após o mergulho, é observado algum tipo de doença diarréica nos alunos? ( ) Sim ( ) Não ( ) Desconhece

75. E nos instrutores? ( ) Sim ( ) Não ( ) Desconhece

76. Após o mergulho, é observado algum tipo de verminose nos alunos?

( ) Sim ( ) Não ( ) Desconhece

77. E nos instrutores? ( ) Sim ( ) Não ( ) Desconhece

78. Houve casos de hepatite nos instrutores?

( ) Sim ( ) Não ( ) Desconhece

79. Caso sim, quantos?

TABELA DE OPERADORAS

80. Você conhece outra operadora/escola de mergulho além dessas relacionadas na tabela? ( ) Sim ( ) Não

81. Caso sim, qual?

OUTRAS PERGUNTAS

➞ D: Como é o mercado local?

➞ E: Como eram as operadoras no passado?

➞ F: Qual o impacto do incentivo ao turismo nas atividades de mergulho?