UNIVERSIDADE FEDERAL DE PERNAMBUCO
Departamento de Oceanografia

TROPICAL OCEANOGRAPHY ONLINE

ISSN: 1679-3013
D.O.I.: 10.5914/to.2011.0057

INFLUENCE OF THE INDUSTRIAL PORT COMPLEX OF SUAPE (WESTERN TROPICAL ATLANTIC) ON THE BIODIVERSITY AND BIOMASS OF PHAEOPHYCEAE

Thiago Nogueira de Vasconcelos **REIS**[1*]

Nathalia Cristina **GUIMARÃES-BARROS**[1]

Edson Regis Tavares Pessoa Pinho de **VASCONCELOS**[1]

Adilma de Lourdes Montenegro **COCENTINO**[1]

Mutue Toyota **FUJII**[2]

Recebido em: 25/10/2011
Aceito em: 21/02/2012

ABSTRACT

The main objective of the present study was to know the diversity and biomass spatial distribution of Phaeophyceae in the reef region of the Suape Port Industrial Complex (Pernambuco, Brazil). The studied material was collected in 6 (six) sampling stations, in two steps, the first between 1996 and 1999 and other on January e July of 2009 (dry and Rainy season respectively) demarcated according to the topography and distance from the port. In the laboratory, samples were sorted and fixed in formalin 4%, neutralized with borax. The taxonomic identification was based on the observation of external and internal morphology. 27 taxa belonging to 4 orders (Ectocarpales, Scytosiphonales, Dictyotales and Fucales) and five families (Chnoosporaceae, Ectocarpaceae, Scytosiphonaceae, Cystoseiraceae and Sargassaceae). Through the similarity analysis it was observed two distinct groups depending on the proximity of the port, this data were supported by permanova. The biomass of Phaeophyceae species varied from 0.001 ± 0.01 (rainy season) to 77.410 ± 3.87 g. m^{-2} (dry season). The species of *Sargassum* genus were most abundant in the area. The Phaeophyceae diversity at Suape was low, and increased with the distance from the Port and decreased during the rainy season. The area can be considered resilient because, despite of the existing impacts, species of Phaeophyceae were well represented in the area, which indicates a great capacity of the ecosystem of recovery after 30 years of the Port installation.

Keywords: Macroalgae, Phaeophyceae, reef, Suape, Brazil.

RESUMO

Esta pesquisa teve como objetivo principal conhecer a diversidade e distribuição espacial da biomassa de Phaeophyceae nos recifes da região portuária de Suape (Pernambuco, Brasil). O material estudado foi coletado em 6 (seis) estações fixas, em duas etapas, uma entre 1996 e 1999 e outra nos meses de Janeiro e julho de 2009 (período seco e chuvoso respectivamente), demarcadas em função da topografia e distância do Porto. No laboratório, as amostras foram triadas e fixadas em formol a 4%, neutralizadas com bórax. A identificação taxonômica baseou-se na observação da morfologia externa e interna. Foi observada, ainda, a distribuição espacial das espécies nas faixas de maré e a associação com outras algas. Foram identificados 27 táxons pertencentes a 5 ordens (Ectocarpales, Scytosiphonales, Dictyotales e Fucales) e a 6 famílias (Chnoosporaceae, Ectocarpaceae, Scytosiphonaceae, Dictyotaceae e Sargassaceae). Através da análise de similaridade foi possível observar dois grupos

1. Departamento de Oceanografia, Universidade Federal de Pernambuco, Av. Arquitetura, s/n, Cidade Universitária, 50.670-901 Recife, PE, Brazil.

2. Instituto de Botânica de São Paulo, Seção de Ficologia, Av, Miguel Estéfano, 3687, 04301-902 São Paulo, SP, Brazil.

*e-mail: reistnv@gmail.com

distintos em função da proximidade do Porto, esses dados também foram corroborados pela Permanova. A biomassa das espécies de Phaeophyceae variou de 0.001 ± 0.01 (rainy season) to 77.410 ± 3.87 g. m^{-2} (dry season), sendo a maior contribuição para essa biomassa o peso das espécies de *Sargassum*. A diversidade de Phaeophyceae da região foi baixa, e diminuiu com a proximidade do porto e com o período chuvoso. A área pode ser considerada resiliente pois apesar dos impactos existentes, as espécies de Phaeophyceae estão bem representadas, o que indica uma grande capacidade de recuperação do ecossistema, tendo em vista mais de 30 anos de implantação do Porto.

Palavras-chave: Macroalgas, Phaeophyceae, recifes, complexo portuário, Suape.

INTRODUCTION

The Industrial Port Complex of Suape is the most complete industrial and the greatest center of investments of Northeastern Brazilian . It is located between the cities of Ipojuca and Cabo de Santo Agostinho, in the state of Pernambuco, Southwestern Tropical Atlantic, with an area of 140 km^2 and 13,500 hectares in extension, divided into port, industrial, administrative, ecological and cultural preservation zones. This complex began to be designed between 1973 and 1976, with the establishment of a Master Plan for its building. Currently the port complex receives an investment of US$ 17 billions, with more than a hundred operating companies, with 35 in installation process. Among these companies are an oil refinery, three petrochemical plants and the largest shipyard in the southern hemisphere (SUAPE - Complexo Industrial Portuário, 2011)

Although there are no data on the seaweeds, the studies conducted in the estuarine complex that houses the port showed that the community was formed by euryhaline organisms and the region was under the influence of two rivers: Massangana and Tatuoca (MELO FILHO, 1977). After the port's implementation, impacts such as landfills, dredging and constructions have changed the area's geomorphology, hydrodynamics and biota (NEUMANN-LEITÃO; GUSMÃO; NASCIMENTO-VIEIRA, 1992; NEUMANN et al., 1998) including changes in the course of rivers, with the area becoming dominated by marine waters (MELO FILHO, 1977, LIMA, 1978, LIMA; COSTA, 1978, CAVALCANTI et al., 1980, CONDEPE, 1983, RAMOS-PORTO; LIMA, 1983, NEUMANN-LEITÃO, 1986, FERNANDES, 1990, 1992).

From 1990, the expansion of the Port of Suape demanded new studies to assess the environmental impacts at the area (BRAGA et al., 1990; VASCONCELOS-FILHO; GUEDES; SOBRINHO, 1990; NEUMANN-LEITÃO; PARANAGUÁ; VALENTIN, 1992). The seaweeds have not been addressed but the greatest effort of study was concentrated in microalgae from estuarine region (KOENING et al., 2003). The phytobenthos of Suape was studied by Magalhães et al. (2003), reporting the abundance of seagrass meadow. Reis (2007) conducted a study on the whole coast of Pernambuco, including Suape region and determined an equation for a quick and efficient abundance estimation of *Halodule wrightii* in order to minimize the destructive impacts of the samplings, reducing the effort and developing a more efficient sample design. Guimarães (2008) studied the biodiversity of marine macroalgae growing as epiphytes on *Halodule wrightii* in Suape Bay.

The macroalgae of many habitats are under threat, and until we have the real diversity scenario of a wide range of marine habitats and the factors that control it, we have little hope of conserving biodiversity or determining the impact of human activities such as ports constructions, industries implantation, mariculture, fishing and dumping of waste and pollution (ORMOND et al., 1997; KERSWELL, 2006). The knowledge of the species diversity of the region is essential for future monitoring programs and management, especially if considered that anthropogenic disturbances caused to macrophytobenthos are well studied in others countries and may be registered in different scales of biological organization (ARECES, 2001). In this context, the seaweeds from Suape Port (Pernambuco, Brazil) was investigated initially through the Phaeophyceae group, determining the composition and biomass.

MATERIAL AND METHODS

The Port and Industrial Complex of Suape, municipality of Cabo de Santo Agostinho, is located approximately 40 km to the South of the city of Recife, State of Pernambuco, Brazil. The climate is warm and humid, with average air temperatures of 26°C and rainfall of 1700 mm yr^{-1} (MAGALHÃES et al., 2003).

Initially, samples were collected in Suape reef for taxonomic studies, at six sampling stations (Fig. 1) from 1996 to 1999. Samplings were carried out manually through diving and using a metal spatula, to maintain the plants integrity.

Figura 1 – Studied area and sampling stations○) at the reef of the Port and Industrial Complex of Suape – Pernambuco (Brazil).

Secondly, samples were collected to obtain of the biomass through dry weight ($g.m^{-2}$) by species in January (dry season) and July (rainy) 2009, in three stations (1, 3 and 5) along three transects perpendicular to the reefs, with 18 replicas each one. A square of 25 x 25 cm (650 cm^2) was used according to Champman (1985), De Wreede (1985) and Reis et al. (2003). The square area was totally scraped and the samples were conditioned in plastic bags, and kept frozen at laboratory. Nutrients (NO_2, NO_3, PO_4) according to APHA (1995), Total Suspended Solids (TSS) and turbidity data were simultaneously collected in the water in 2009. The temperature and salinity were take to support the literature data.

At laboratory, samples were sorted and fixed in 4% formalin, neutralized with borax. The taxonomic identification was based on the external and internal morphology, using Zeiss microscope and stereomicroscope. Taxa identification was based on detailed morphological analyses, and taxonomical classification was done using the methods of Wynne (2005). A qualitative MDS analysis were performed based on the Sorensen (1948) index with PRIMER 5 for similarity tests among samples. To reveal which species mainly determine similarity or dissimilarity between stations, a one-way crossed SIMPER analysis was performed in PRIMER.

The Shannon diversity index (H') was applied to biomass for the estimation of community diversity (SHANNON, 1948), and the evenness was calculated according to Pielou (1969).

Differences on the biomass among the stations and seasons were examined to the studied area. Permutational analysis of multivariate variance (PERMANOVA), based on Bray–Curtis dissimilarities of square-root transformed data, was used to detect differences in assemblage structure along the assumed environmental gradients. All data were fourth-root transformed prior to the analysis to moderately down-weight the importance of species with greater biomass. The routine was applied using the PERMANOVA (ANDERSON et al., 2007). This approach allowed us to satisfactorily deal with the balanced designs and to analyze the dataset without rigorous assumptions of normality. Main tests were conducted across 2-factors - point (fixed and crossed) and transects (fixed and hierarchical in point) factor and used 9999 unrestricted permutations. Significant terms were then investigated using *a posteriori* pair wise comparisons with the PERMANOVA *t* statistic and 9999 permutations.

RESULTS

Environmental conditions

Temperature and salinity were homogeneous, varying from 26 to 30^{0}C and from 34 to 37, respectively. Turbidity tended to increase significantly during the rainy season and ranged from 1.56 (dry season) to 10.25 UNT (rainy season) (H = 3.85; p = 0,049). The total suspended solids ranged from 6.4 to 76.0 mg.L^{-1}, and showed significantly between rainy and dry season, and the highest values were recorded for the rainy season (H = 3.69; p = 0.0495). Nutrient levels were low and did not show significant differences between the seasons (Tab. 1).

Table 1 – Nutrients, Turbidity and Total Suspended Solids in three sampling stations at the Port and Industrial Complex of Suape, during the dry (January/09) and rainy (July/09) seasons.

	NO_2 µm/L		NO_3 µm/L		PO_4 µm/L		Turbity UNT		TSS mg/L	
Season	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy
E1	0.010	0.050	0.791	1.553	0.170	0.260	3.590	10.255	8.800	30.250
E3	0.020	0.030	0.977	1.372	0.140	0.130	2.135	7.050	6.400	76.000
E5	0.020	0.010	1.262	0.600	0.120	0.120	1.560	5.165	8.000	13.000
***p* value**	0.5127		0.5127		1.0000		0.0495		0.0495	

Species richness

Twenty-eight species of Phaeophyceae were identified at Suape reef area, including five orders (Dictyotales, Ectocarpales, Fucales, Scytosiphonales and Sphacelariales) and six families (Chnoosporaceae, Cystoseiraceae, Ectocarpaceae, Scytosiphonaceae, Sphacelariaceae and Sargassaceae) (Tab. 2).

Some species such as *Colpomenia sinuosa* (Roth) Derbèr & Solier, *Dictyopteris justii* J. V. Lamour., *Dictyota bartayresiana* J. V. Lamour., *D. menstrualis* (Hoyt) Schnetter, Horning & Weber-Peukert, *Lobophora variegata* (J. V. Lamouroux) Womersley ex. E. C. Oliveira, *Padina gymnospora* (Kützing) Sonder and *Spatoglossum shoroederi* (C. Agardh) Kützing. were observed only during the initial sampling (1996-1998), while *Ectocarpus* sp., *Feldmania irregularis* (kutz.) Hamel., *Hinckisia michelliae* (Harvey) P.C.Silva, *Sphacelaria rigidula* Kütz and *Dictyopteris polypodioides* (DC. In Lam. & DC.) J. V. Lamour occurred during the second sequence of sample.

Table 2 – Brown algae composition at Suape Port Complex (Pernambuco, Brazil), from 1996 to 2009.

	1996-1999	**Guimarães, 2008**	**2009**
SPECIES	Sand reef	Seagrass meadows	Sand reef
Ectocarpaceae			
Ectocarpus sp.			X
Feldmannia irregularis (Kutz.) Hamel.			X
Hinckisia michelliae (Harvey) P.C.Silva			X
Chnoosporaceae			
Chnoospora mínima (K. Hering) Papenfuss	X		X
Scytosiphonaceae			
Colpomenia sinuosa (Roth) Derbèr & Solier	X	X	
Rosenvingea sactae-crucis		X	
Sphacelariaceae			
Sphacelaria rigidula Kütz			X
Sphacelaria tribuloides Menegh.	X		X
Dictyotaceae			
Canistrocarpus cervicornis Kütz		X	X
Dictyopteris delicatula J. V. Lamouroux	X	X	X
Dictyopteris jolyana Oliveira Filho et. Furtado	X		
Dictyopteris polypodioides (DC. In Lam. & DC.) J. V. Lamour.			X
Dictyopteris justii J. V. Lamouroux	X		
Dictyota bartayresiana J. V. Lamouroux	X		
Dictyota ciliolata Sond. ex Kutz.		X	
Dictyota menstrualis (Hoyt) Schnetter, Hörnig & Weber-peukert	X	X	
Dictyota mertensii Kuetzing	X		X
Lobophora variegata (J. V. Lamouroux) Womersley ex. E. C. Oliveira	X	X	
Padina antillarum (Kütz.) Picc	X		X
Padina boergesenii Allender & Kraft	X		X
Padina gymnospora (Kützing) Sonder	X		
Padina sanctae-crucis Børgesen		X	X
Spatoglossum schoroederi Kützing	X		
Sargassaceae			
Sargassum cymosum var. *cymosum* C. Agardh	X		X
Sargassum cymosum var. *nanum* E. de Paula & E. C. Oliveira,	X		X
Sargassum polyceratium Montagne	X		X
Sargassum vulgare var. *vulgare* C. Agardh	X		X
Sargassum vulgare var. *nanum* E. de Paula	X		X

Biomass

The average biomass of the Phaeophyceae varied from 0.001 ± 0.01 (rainy season) to 77.410 ± 3.87 g. m^{-2} (dry season) with significant difference between seasons ($H = 18.35$; $p < 0.0001$). Station 5, farthest from Suape, presented higher biomass values (Fig. 2), both in the dry and rainy seasons. *Sargassum* species were very abundant in the area, and contributed on average with 89% in dry and 61% in the rainy season. However, this genus was not registered in Station 1 during the rainy season (Fig. 3). The Dictyotales species were, together with the species of *Sargassum*, the algae with the highest biomass.

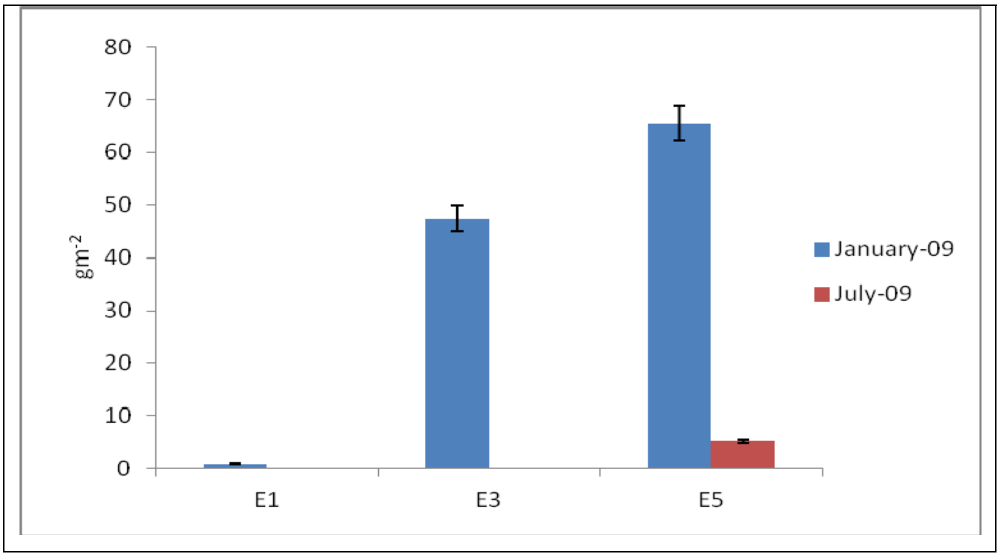

Figure 2 – Brown algae average biomass in three fixed stations at Suape Port Complex, during the dry (January/09) and rainy (July/09) seasons.

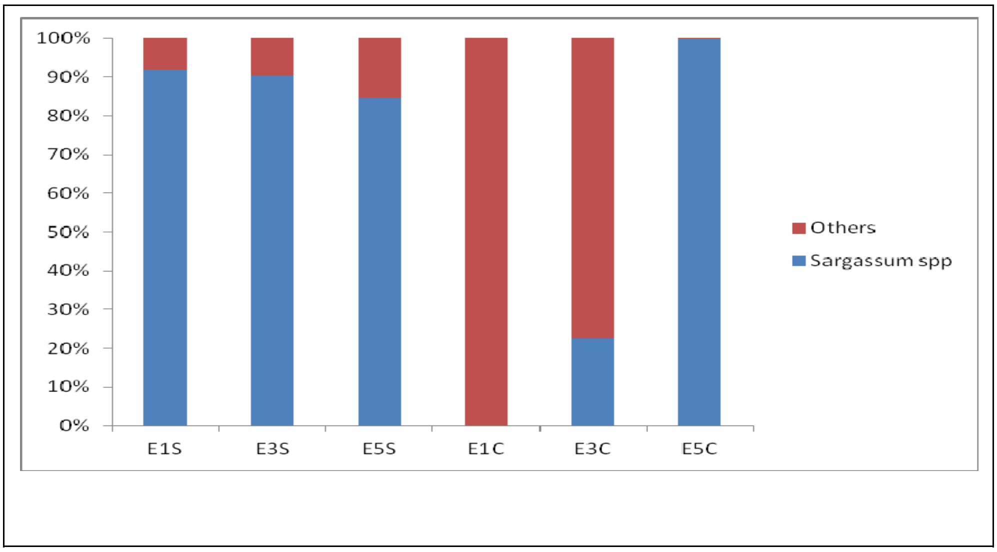

Figure 3 – *Sargassum* average biomass in relation to others brown algae in three fixed stations at Suape Port Complex, during the dry (January/09) and rainy (July/09) seasons.

Analyses

The MDS analysis Showed one group (Fig. 4). This group was formed by Stations E1S, 1, E5S, E3S e E5C , and can be observed that the stations more far from the port are currently similar to the most impacted station in the previous decade, since it is grouped with the first point of 1999. The SIMPER analyses showed how the species *Dictyopteris delicatula*;*Sargassum cymosum* var. cymosum; *Padina boergesenii*;

Chnoospora minima; *Sargassum cymosum* var. *nanum*; *Padina gymnospora*; *Padina antillarum* contributed with 91.37% to the explication of grouping.

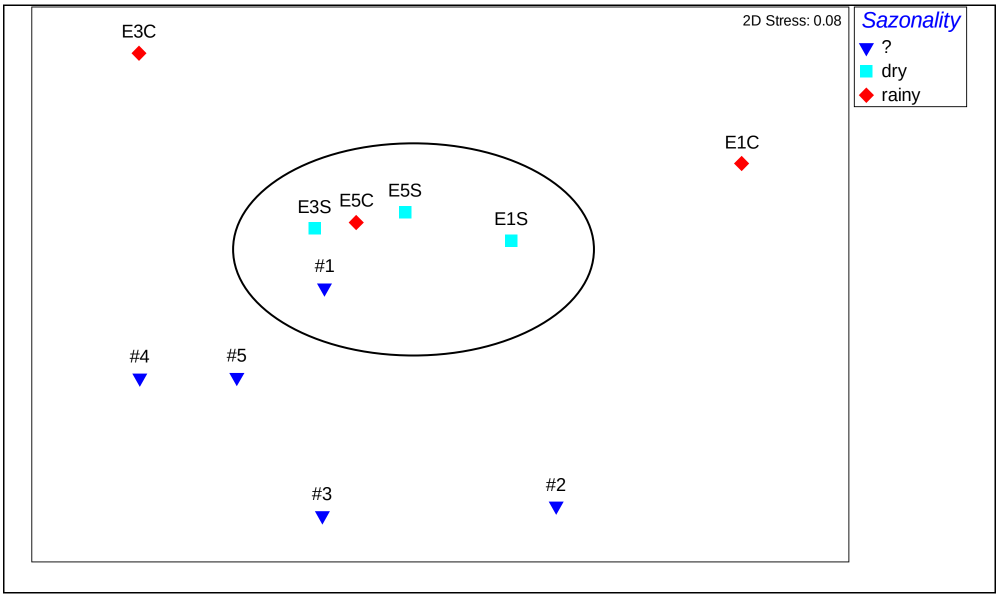

Figure 4 – Samples MDS analysis at Suape reef Port Complex – Pernambuco (Brazil). Sorensen index. Single link method. (? – mean between dry and rainy season)

The diversity of Shannon increased from Station 1 (nearer to the Port) to Station 5 (farther from the Port), and larger values of this diversity were observed in the dry period (Fig. 5). Significant differences among stations were registered only during the dry season (H = 19.76; $p < 0.001$) between Stations 1 and 5, however no difference occurred between Stations 1 and 3 and from 3 and 5, suggesting a gradual differentiation along the reef line (Tab. 3).

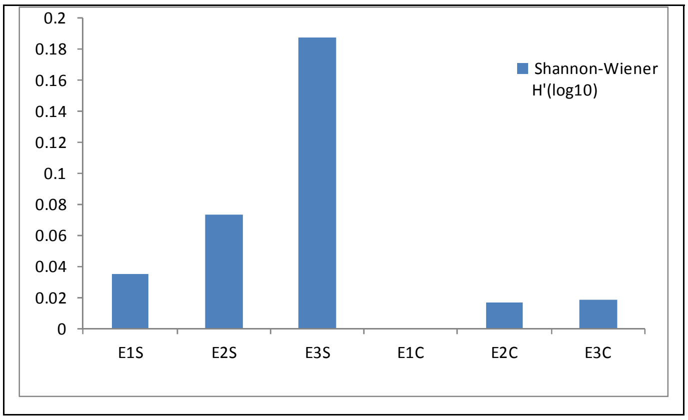

Figure 5 – Diversity and Evenness of brown algae based on biomass in three fixed stations at Suape Port Complex, during the dry (January/09) and rainy (July/09) seasons.

Table 3 – Comparison (Dunn Method) between the averages of diversity indices during the month of January 2009.

Stations	Z caulculate	Z critic	*p* value
1 x 3	2.2232	2.394	NS
1 x 5	4.4449	2.394	<0.05
3 x 5	2.2537	2.394	NS

The PERMANOVA test showed that the biomass was significantly different among the stations (Tab. 4), however no difference were registered among the transects within points.

Table 4 - Permutational analysis of variance at the Port and Industrial Complex of Suape, during the dry (January/09) and rainy (July/09) seasons.

Fator	GL	SQ	MQ	F	P (MC)
Point	2	44313.1228	22156.5614	8.1378	0.0001
Transects (points)	6	16336.0415	2722.6736	0.9209	0.5704
Residual	45	133049.7999	2956.6622		
Total	53	193698.9642			

DISCUSSION

Abiotic data did not very much, maybe the ocean influences in the region in view of the loss of supply from rivers and Massangana Tatuoca diverted at the beginning of construction of the port (NEUMANN et al., 1998). TSS and turbidity were the only factors that varied during the collection of biomass, probably for the resumption of dredging in the area between these two samples (PAGNONCELLI, 2008).

On the coast of Pernambuco State, 43 species of brown algae were recorded, corresponding to 49% of the taxa described to Brazil (COCENTINO et al., 2004). In our study, Dictyotales predominated with 60%, followed by Fucales (28%) and Scytosiphonales (11%). Pereira et al. (2002) summarizing all the macroalgae studies in Pernambuco State concluded that Phaeophyceae species were distributed in five orders and six families; and, the most representative order was Dictyotales (53%), followed by Fucales (18.5%), Ectocarpales (14%), Scytosiphonales (9%) and Sphacelariales (5%). According to Oliveira Filho (1977), Lunning (1990), Pereira (2000) and Barbosa et al. (2003), the expressive occurrence of Dictyotales indicates the tropical character of the studied flora. The species *Rosenvingea sanctae-crucis* Børgesen and *Dictyota ciliolata* Sond. ex Kutz. were registered only in literature, but were no sampled, and were recorded for the seagrass meadows (GUIMARÃES, 2008).

Studies on macroalgae from tropical reef environments, impacted by great input of nutrients, as the reef of Piedade and Boa Viagem Beachs (Pernambuco-Brazil), revealed that the division Ochrophyta is little expressive, with only one species of Dictyotales (*Dictyopteris delicatula* J. V. Lamour) (SANTOS; COCENTINO; REIS, 2006, SOUSA; COCENTINO, 2004). The authors suggested that this type of impact is the most expressive for the reduction of Phaeophyceae species richness, we observed not here, where the SST increase was the main observed impact at the Suape region.

It was possible to observe that the species of brown filamentous algae were found mainly in the biomass samplings. These species can be considered strategists for presenting a quick life cycle and development, but the quantity found was not enough to make these algae harmful to the area diversity.

Weels et al. (2007) explain that the decline in the number of species of perennial taxa, the case of some species of Phaeophyceae, is related to the natural increase in turbidity during the rainy season, and these communities are temporarily replaced by opportunistic species. As a consequence of frequent dredging in the area sampled in this study, we observed an increase in the period of dominance of these opportunistic algae, and this is perhaps the main impact on the communities observed on all organisms of region (NEUMANN et al., 1998; KOENING et al., 2001) and consequently in brown algae in the region. We can observe the replacement of some perennial species by filamentous-growth ones, as *Ectocarpus* sp., *Feldmann irregularis*, *Hinckisia michelliae*, *Sphacelaria rigidula* and *Sphacelaria tribuloides*, as a consequence of the dredging and port activities intensification.

Phaeophyceae was also well represented in others beaches of Pernambuco State (PEREIRA; LOPES, 2003). However, studies carried out in other tropical (Paraiba-Brazil, LUCENA et al., 2007, Rio de janeiro-Brazil, SZECHY; MARINO, 1991) and temperate areas (WELLS et al., 2007) registered fewer species belonging to this group when compared with this paper. This higher diversity at Suape, an area with no more than 1.5 km, is explained by the environmental heterogeneity (reefs, seagrass meadows, mangroves, etc), which, according to some authors (see GILLER, 1984), increases the number of species of this region (WELLS et al., 2007).

The values of diversity at the present study are lower than those found to macroalgae associated to seagrass (GUIMARÃES, 2008) and reef (RIBEIRO et al., 2008), both registered diversity values between 2.0 and 3.0. In recent studies, Vasconcelos et al. (2011) noted that the diversity varied according to the used method, being the biomass, used in this study, the best parameter to assess diversity. Lower diversity values were caused by *Sargassum* which accounted for almost 90% of biomass during some periods. Munoz; Pereira (2001) observed a diversity decrease during the rainy season, the same could be observed in this study.

The nutrients values were low and didn't influenced negatively Phaeophyceae abundance. It is known that impacts by excess of nutrients affect the Phaeophyceae abundance, that, under normal conditions, are abundant in tropical and subtropical seas (PAULA; OLIVEIRA FILHO, 1980), contributing with almost 50% of the biomass in the Northeastern Brazil (PEREIRA et al., 2002). The nutrients values can change in larger spatial scales (MENGE, 2000), and thus influence the seaweed cover (PEDERSEN; KRAEMER; YARISH, 2008).

Low biomass values (4 and 65 $g.m^{-2}$) were also registered to the total macroalgae associated to the seagrass *Halodule wrightii* at Suape bay (GUIMARÃES, 2008) and this was due the muddy sand sediment, that is not adequate to the macroalgae fixation. In general, sized species as those of the genus *Sargassum*use the seagrass as substrate. In this mentioned study, Ochrophyta dominated mainly with *Canistrocarpus cervicornis* Kütz and *Dictyopteris delicatula* J. V. Lamour. This last species together with *Padina* and *Sargassum* presented higher biomasses at the Suape reef area. These genera are also responsible for the high abundance found in other coastal reefs (COSTA JR et al., 2002). Studies show that the order Dictyotales is numerically dominant, accounting for more than 90% of the biomass, however in sandstone reefs, the species within that group becomes secondary in terms of biomass values and are replaced by species of *Sargassum* (RIUL et al., 2009).

Similar results to ours were registered at other beach near to Suape area, where Phaeophyceae biomass varied from 3 to 69 $g.m^{-2}$ and *Sargassum cymosum* presented higher abundance, being lower only than the Chlorophyta *Halimeda opuntia* (PEREIRA et al., 2008). At Suape, *Sargassum* presented high biomasses during the dry season declining in the rainy one, when the suspended solids were high. There is a general tendency of *Sargassum* increase in abundance in summer, both in Brazil (VELOZO; SZECHY, 2008) and in other countries (GILLESPIE; CRITCHLEY, 1999).

The formation of distinct group, influenced by the distance from the port, suggests that the algal community area is responding to the impacts generated by the development of the industrial port complex. Although the impacts appear to be small, it is possible to observe the decrease in the number of species recorded for the area closest to the port, therefore becomes more appropriate studies necessary in order to contemplate other parameters on the more refined flora.

CONCLUSION

The variations observed in the Ochrophyta at Suape reef are related to the Port activities, mainly the continuous dredging, that increase the values of Total Suspended Solids decreasing the algae biomass. With respect to the samples MDS analysis, it was noted that stations closer to the port had a reduced number of species. Despite these impacts, it could be observed that the Ochrophyta are resilient, well represented in the area and quickly recovering from impacts. We recommend a cautious when the need arises for dredging in the region and close monitoring of the works.

AKNOWLEDGEMENTS

The authors would like to thank the Chemistry Laboratory of the Department of Oceanography of the Federal University of Pernambuco for the chemical analyses; CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior), for the financial support, through the Botanic Improvement Program; CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) for the financial support through the universal announcement of 2008. Thanks also to Professors Sigrid Neumann-Leitão, Fernando and Maria Louys Feitosa Koening, the relevant contributions during the writing of this article. Marina S. L. C. Araujo, the contributions in the translation and revision.

REFERENCES

ARECES, A. **La ficoflora intermareal como bioindicadora de calidad ambiental. Estudio de caso: El litoral habanero.** In: Alveal, k.; Antezana, T. (Eds*).* Sustentabilidad de La biodiversidade. Um problema actual, bases científico-técnicas, teorizaciones y perspectivas. Chile Concepción: Trama Impresores S.A., 2001. p. 569-589.

ANDERSON, M. PERMANOVA: **Permutational Multivariate Analysisof Variance. Departmento f Statistics**, Auckland. 2005

ANDERSON, M. J., Gorley,R.N., Clarke,K.R.,. **PERMANOVA for PRIMER**: guide to software and statistical methods. PRIMER-E, Plymouth. 2007

BARBOSA, J. P. et al., A dolabellane diterpene from the Brazilian brown alga *Dictyota pfaffii*. **Biochemical Systematics and Ecology**, n. 31, p. 1451-1453, 2003.

BRAGA, R. A. P.; MAESTRATI, P.; LINS, M. F. Impacto da implantação do complexo industrial-portuário de Suape (PE) sobre populações de moluscos comestíveis. **Anais da Sociedade nordestina de Zoologia**, n. 3, v. 3, p. 137-153. 1990.

CAVALCANTI, L. B.; COELHO, P. A., ESKINAZI-LEÇA, E.; LUNA, J. A.; MACEDO, S. J., PARANAGUÁ, M. N. **Condiciones ecologicas en el area de Suape (Pernambuco-Brasil)**. In: Seminario sobre el estudio cientifico e impacto humano en el ecossistema de manglares. Memorias... Montevideo: UNESCO, 1980. p. 243- 256.

CLARKE K.R.; WARWICK, R.M. **Change in Marine Communities**: an Approach to Statistical Analysis and Interpretation (second ed.). Plymouth: PRIMER-E Ltd., 2001. p. 859.

CONCENTINO, A. L. M.; MAGALHÃES, K. M.; PEREIRA, S. M. Estrutura do macrofitobentos marinho. In: ESKINAZI-LEÇA. E.; NEUMANN-LEITÃO, S. & COSTA. M. F. (Org.). **Oceanografia**: um cenário tropical. Recife: Bargaço, 2004. p. 391-423.

CONDEPE. (1983). **Caracterização do complexo estuarino-lagunar da área de Suape (Pernambuco - Brasil)** - Síntese ecológica. Recife, v. 1.

COSTA Jr., O. S. et al. Benthic macroalgal distribution in coastal and offshore reefs at Porto Seguro Bay, Brazilian Discovery Coast. In: International Coral Reef Symposium, 9., 2002, Bali. Proceedings... Bali, 2002. p. 499-508.

CUTRIM, M. V. J. **Distribuição das macroalgas na região entre-marés do recife da praia de Piedade, município Jaboatão dos Guararapes (Estado de Pernambuco – Brasil)**. Recife, 1990. 135fls. Dissertação (Mestrado em Botânica). Universidade Federal Rural de Pernambuco.

De WREEDE, R. E. **Destructive (harvest) sampling**. In: LITTLER, M.M. & LITTLER, D. S. (eds.) Handbook of Phycological Methods Ecological Field Methods: Macroalgae. New York: Cambridge University Press, 1985. p. 147-160.

FERNANDES, M. L. B. **Moluscos Gastropoda do complexo estuarino lagunar de Suape, PE (sistemática e ecologia)**. Recife, 1990. 182p. Dissertação (Mestrado em Oceanografia). Universidade Federal de Pernambuco.

FERNANDES, M. L. B. Condições ecológicas da família Columbellidae (Molusca: Gastropoda) no complexo estuarino de Suape - PE. In: ENCONTRO DE ZOOLOGIA DO NORDESTE, 9., 1992, Recife. **Resumos**... Recife, 1992. p. 63.

GILLER, P.B. **Community structure ad the niche**. Chapman & Hall, London, 1984. 176p.

GILLESPIE, R. D. & CRITCHLEY, A. T. Phenology of *Sargassum* spp. (Sargassaceae, Phaeophyta) from Reunion Rocks, KwaZulu-Natal, South Africa. **Hydrobiologia**. v. 398/399: 201-210, 1999

GUIMARÃES, N. C. **Biodiversidade de Algas marinhas epífitas dos prados de Halodule wrightii na Baía de Suape, PE**. Recife, 2008. 100p. Dissertação (Mestrado em Oceanografia). Universidade federal de Pernambuco.

KERSWELL, A.P. Global biodiversity patterns of benthic marine algae. **Ecology**, v. 87, P.2479-2488, 2006.

KOENING, M. L., et al. Impacts of the construction of the Port of Suape on phytoplankton in the Ipojuca River estuary (Pernambuco-Brazil). **Brazilian Archives Biology Technology**. v.46, n.1, p. 3-81. 2003.

LIMA, D. A. O. **Projeto Suape e a vegetação**. Recife, Instituto de Desenvolvimento de. Pernambuco, 1978. 18p. (Comunicação Técnica, 2).

LIMA, D. A.; COSTA, J. T. M. (1978). **Flora e vegetação terrestres da área Programa Suape**. Recife, Instituto de Desenvolvimento de. Pernambuco, 1978. 24p. (Comunicação Técnica, 5).

LUCENA, L. A. F.; KANAGAWA, A I.; MARTINS, G. J. M.; TARGINO, C. H.; MIRANDA, G. E. C. & HORTA, P. A. Levantamento da Flora do Infralitoral do Município de Pitimbú, Litoral Sul do Estado da Paraíba, Brasil. **Revista Brasileira de Biociências**. v. 5, n.2, p. 585-587. 2007.

LÜNING, K. **Seaweeds**: their environment, biogeography and ecophysiology. New York, Wiley-Interscience. 1990. 532p.

MAGALHÃES, K. M. et al. Seagrass meadows at the Suape Port area, Pernambuco In: Congresso de Ecologia do Brasil, IV., 2003, Fortaleza. **Anais de trabalhos completos**. Fortaleza: Editora da Universidade Federal do Ceará, 2003. p. 334 – 335.

MELO FILHO, J. A. S. **Caracterização da situação atual da área Programa Suape sob o ponto de vista poluição ambiental**. Recife, CONDEPE, 1977, 15 f. (Comunicação Técnica, 1).

MENGE, B. A. *Top-down and bottom-up community regulation in marine rocky intertidal habitats.* **J. Experiments of Marine Biology and Ecology**, v. 250, p. 257-*289.* 2000.

MUNOZ, A. M. & PEREIRA, S. M. B. **Comunidades y diversidad de macroalgas em pozas intermareales de arrecifes**. In: ALVEAL, K.; ANTEZANA, T. (Org.). Sustentabilidad de la Biodiversidad - Un Problema Actual , bases científico-técnicas, teorizaciones y perspectivas. Concepción: Trama Impresores S.A., 2001. P. 315-330.

NEUMANN, V. H.; MEDEIROS, C.; PARENTE, L.; NEUMANN-LEITÃO, S. AND KOENING, M. L. Hydrodynamism, sedimentology, geomorphology and plankton changes at Suape area (Pernambuco - Brazil) after a port complex implantation. **Anais da Academia Brasileira de Ciências**, v. 70 n. 2, p. 313-323. 1998.

NEUMANN-LEITÃO, S.; GUSMÃO, L. M. O.; NASCIMENTO-VIEIRA, D. A. Zooplâncton dos estuários dos rios Massangana e Tatuoca, Suape (PE-Brasil). **Arquivos de Biologia e Tecnologia**, v. 35, n. 2, p. 341-360. 1992.

NEUMANN-LEITÃO, S.; PARANAGUÁ, M. N.; VALENTIN, J. L. (1992b). The planktonic rotifers of the estuarine lagunar complex of Suape (Pernambuco, Brazil). **Hydrobiologia**, 232:133-143.

NEUMANN-LEITÃO, S. **Sistemática e ecologia dos rotíferos (Rotatoria) planctônicos da área estuarina-lagunar de Suape - Pernambuco (Brasil)**. Recife, 1986, 261p. Dissertação (Mestrado em Oceanografia). Universidade Federal de Pernambuco.

OLIVEIRA-FILHO, E. C. **Algas Marinhas Bentônicas do Brasil**. São Paulo, 1977, 406p. Tese (Livre Docências em biociências). Universidade de São Paulo.

ORMOND. R. et al. Effectiveness of coral protection programas in the Mohamed National Park, Egyptian Red Sea, In: **International Coral Reef Symposium**, 8., 1997, Panama. Proceed..., Panama: Smithsonia Tropical Research Institute, 1997. p. 1931-1936.

PAGNONCELLI, M. **Plano Nacional de Dragagens**: Politica e atividades para dragagens. Secretaria Especial de Portos – PR, Coordenador-Geral de Planejamento Estratégico.

PAULA, E. J.; OLIVEIRA-FILHO, E. C. Aspectos fenológicos de duas populações de Sargassum cymosum (Phaeophyta - Fucales) do litoral de São Paulo, Brasil. **Boletim de Botânica**. v.8, p. 21-39, 1980.

PEDERSEN, A.; KRAEMER, G.; YARISH, C. Seaweed of the littoral zone at Cove Island in Long Island Sound: annual variation and impact of environmental factors. **J. Appl. Phycol**. v. 20, p. 869-882. 2008.

PEREIRA, S. M. B. As Algas Bentônicas. In: BARROS, H. et al. (Org.). **Gerenciamento Participativo de Estuários e Manguezais**. Recife: Ed. Universitária da UFPE, v. 1, p. 49-65. 2000.

PEREIRA, S. M. B. et al. **Algas marinhas bentônicas do estado de Pernambuco**. In: TABARELLI, M.; SILVA, J. M. C. (Ed). Diagnóstico da Biodiversidade de Pernambuco. Recife: Ed. Massagana, Sectima. p. 97 - 124. 2002.

PEREIRA, S. M. B. et al. Caracterização estrutural das macroalgas de ambiente recifal da praia de Enseada dos Corais. In: **Congresso Brasileiro de Ficologia**, XI., 2006. Itajaí-SC. Anais de trabalho completos. Rio de Janeiro: Série Livros do Museu Nacional. 2008.p. 231-242.

PEREIRA, S. M. B.; LOPES, A. S . Distribution of Dictyotales (Phaeophyta) onto reefs of Serrambi beach (Pernambuco-Brazil). In: **Congresso de Ecologia do Brasil**, IV., 2003, Fortaleza. Anais de trabalhos completos. Fortaleza: Editora da Universidade Federal do Ceará, 2003. p. 467-468.

PIELOU, E.C. **An introduction to Mathematical Ecology**. New York: Wiley, p. 286. 1969.

RAMOS-PORTO, M. ; LIMA, J. T. Estudos dos crustáceos decápodos da baía de Suape, Pernambuco. **Anais** da Sociedade Nordestina de Zoologia, v. 1, n. 1, p. 54. 1983.

REIS, T.N.V. **Determinação de parâmetros para estimativa de abundância da angiosperma marinha** *Halodule wrightii* **ascherson, em prados do estado de Pernambuco, Brasil**. Recife, 2007. 81P. Dissertação (Mestrado em Oceanografia). Universidade Federal de Pernambuco.

REIS, R. P. et al. Efeito de fatores bióticos no crescimento de Hypnea musciformis (Rhodophyta - Gigartinales). **Acta Botanica Brasilica**. v. 17, n. 2, p. 279-286, 2003.

RIBEIRO, F. A. et al. Análise quali-quantitativa das populações algáceas de um trecho recifal na praia de Boa Viagem. **Oecologia Brasiliensis**, v. 12, p. 223-229, 2008.

RIUL, P. et al. Rhodolith Beds at the easternmost extreme of South America: Community structure of an endangered environment. **Aquatic Botany**, v. 90, p. 315-320, 2009.

SANTOS, A. A.; COCENTINO, A. L. M.; REIS, T. N. V. Macroalgas como indicadoras da qualidade ambiental da praia de Boa Viagem Pernambuco, Brasil. **Boletim Técnico Científico do CEPENE**, Tamandaré, v. 14, n. 2, p. 25-33, 2006.

SHANNON, C. E. A mathematical theory of communication. **Boll. Syst. Tech**. J., v. 27, p. 379-423, 1948.

SORENSEN, T. A method of stablishing groups of equal amplitude in plant sociology based on similar species content and its applicatin to analyses of vegetation on Danish Commons. **Biologiske Skrifter**, v.5 p. 1-34, 1948.

SOUSA, G. S.; COCENTINO, A. L. M. Macroalgas como indicadoras da qualidade ambiental. **Tropical Oceanography**, Recife, v. 32, p.1-22, 2004.

SUAPE - Complexo Industrial Portuário, 2011 <www.suape.pe.gov.br/home/index.php#>, Disponível em 05 de julho de 2011, Acessado em 5 de Julho de 2011.

SZÉCHY, M. T. M.; MARINO, M. C. Feofíceas do litoral norte do Estado do Rio de Janeiro. **Hoehnea**, São Paulo, v. 18, n. 1, p. 205-241, 1991

VASCONCELOS-FILHO, A. L.; GUEDES, D. S.; SOBRINHO, D. G. Taxonomia e ecologia da fauna ictiológica da área de Suape (Pernambuco-Brasil). **Trabalhos Oceanográficos da Universidade Federal de Pernambuco**, Recife, v. 21, p. 305-343, 1990.

VASCONCELOS, E. R. T. P. P.; REIS, T. N. de V.; GUIMARÃES-BARROS, N. C.; SOARES, L. P.; MIRANDA, G. E. C.; COCENTINO, A. L. M. Métodos de amostragem para comunidades de macroalgas marinhas em recifes de arenito. **Revista Brasileira de Engenharia de Pesca**, v. 6, n. 1, p. 17-29, 2011.

VELOSO, A. P. A.; SZÉCHY, M. T. M. Variações espaciais e temporais no desenvolvimento vegetativo e reprodutivo da macroalga *Sargassum* C. Agardh (Fucales, Phaeophyceae) - síntese do conhecimento. **Oecologia Brasiliensis**, v. 12, p. 275-290, 2008.

WELLS E., et al. The use of macroalgal species richness and composition on intertidal rocky seashores in the assessment of ecological quality under the European Water Framework Directive. **Marine pollution Bolletin**, v. 55, n.1, p.151-161, 2007

WYNNE, M. J. A checklist of benthic marine algae of the tropical and subtropical western Atlantic: second revision. **Nova Hedwigia** v. 129, p. 1–152, 2005.