EFFECT OF DOCKS ON MACROPHYTOBENTHIC COMMUNITY: A CASE STUDY IN ESTUARY

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INTRODUCTION

The unplanned occupation of the landscape is an evident and growing global phenomenon. With most of the population inhabiting the coastal areas (11), it is crucial to investigate the consequences of their urbanization. Among the many sources of impact from human activities, the urban construction-in its various configurations - is promptly evidenced by the artificial substrates proliferation in coastal cities.

On the other hand, millions of people live in areas adjacent to estuarine systems due to the fishing availability and safe navigation (24). Direct consequence of this fact is the construction of artificial structures on the margins, such as docks and piers, to facilitate local access. Although the degradation of habitat has been a major focus of research (for a review see 17), little attention has been given on the role of artificial structures as habitat for marine organisms (see 10; 5).

Structure of habitat is crucial in the composition and structure of many communities (e.g.19; 4). It is plausible, therefore, to expect that the introduction of new substrates and habitats can lead to an increase in the abundance or diversity of species in a certain area. However, other abiotic changes associated with this, can cause indirect effects which may be unfavorable for some organisms. The shade caused by artificial structures, for example, can interfere on the function of primary producers (3). Dominant in the primary production of many coastal environments (1), the macroalgae may also act as indicator of environmental quality (15). In this context, the investigation of macrophytobenthic assemblages directly exposed to urbanization is relevant in the assessment of impacts on aquatic systems.

OBJECTIVES

The hypothesis of alteration on shore as a source of impact was tested through a mensurative experiment conducted with the macrophytobenthic community from an estuarine system. Specifically, we investigated whether the presence of docks affects the solar radiation and which are the consequences for richness and biomass of the macroalgae assemblage of rocky substrate.

MATERIAL AND METHODS

Study area
Canal da Barra da Lagoa is a natural channel of 2.8 km in length, which belongs to the estuarine - lagoon complex of Lagoa da Conceição (22). It is situated in the eastern coast of the Santa Catarina Island, SC, Brazil (27 ^{0} 34 S, 48 ^{0} 25 W) and it connects the Conceição Lagoon to the Barra da Lagoa Beach. It presents an intense urbanization process, evidenced by the presence of houses, docks and other buildings throughout its extension.

Sample design and data collection
A sampling campaign was conducted in March 2009. Three sections of the channel (inner, intermediate and mouth) were sampled covering all its length. In each section, the areas under two docks and two control areas - a similar uncovered area at the same margin of the channel, far enough to avoid edge effect - were randomly sampled. At each sampling site, three replicates were collected, totalizing 36 samples.

Radiation measures were performed using portable radiometer in the control areas and under the docks. The macroalgae sampling was conducted only on rocky substrates, by scraping, using squares of 20 x 20 cm to define the sample area. Substrates sampled were selected to represent angles with similar position in relation to the sun. The species collected were fixed in 4% formalin/sea water and subsequently identified until the lowest reliable taxonomic level. For determination of biomass, samples were kept in oven at 60 ^{0} C for 48 hours and then weighed using a precision balance scale.

Data analysis

The dry biomass were evaluated with multivariate analysis (MDS) using the similarity index of Bray - Curtis. ANOSIM was used to evaluate the similarity between the sampling sites. In order to verify the difference of biotic variables and radiation between treatments, we utilized the Student - t Test. One - way ANOVA was performed to test the significance of differences in the macroalgal assemblage among sections of the channel.

RESULTS AND DISCUSSION

27 seaweed species were identified, of which Rhodophyta was the most frequent phylum (13 species), followed by Chlorophyta (8 species), Heterokonthophyta (5 species) and Cyanophyta (1 species). *Ulva lactuca*(70.3%),*Gymnogongrus* sp (29.5%)and *Chondracanthus acicularis* (29.0%) were the most frequent species throughout the channel.

The seaweed richness and abundance in control areas were different than the areas under the docks. The patterns determined by MDS showed a significant separation between two groups: one in the presence of docks and another in control areas (ANOSIM, R = 0.313, p = 0.001). Areas under docks presented lower richness (t= - 12.2; p <0.001) and lower biomass (t= - 5.1, p <0.001) than the control areas. Moreover, in dock areas of the inner section of the channel no macroalgae was found. The same pattern was found for the average radiation (t= - 28.6, p <0.001): control areas (x = 2074.00 ± 143.53 uM/s) showed higher intensity than the areas below the docks (x = 18:27 ± 17.97 uM/s).

The macroalgal biomass differed among the three sections of the channel (F=15.7; p <0.001), and the higher biomass was found in the mouth of the channel. Although the MDS showed a trend of separation among the sections, but it was not significant (ANOSIM, R = - 0.008, p = 0.555).

Discussion

It has been demonstrated that increasing the diversity of habitats can also increase the richness of an assemblage (3; 7). However, in other cases (12; 18) the opposite can also be observed, especially when other variables are present, which is the clear case of this study. The presence of dock presented indirect consequences on the macroalgae community: a drastic decrease in biomass and richness due to the consequent decrease in light intensity. The light is considered the primary factor limiting survival and distribution of macroalgae species (6) and the most important variable affecting its canopy structure (3). The shading in marine environments sometimes is not a natural phenomenon. Several artificial structures built to facilitate the navigation in coastal environments have a great potential to increase shading of adjacent marine habitats (9).

In our study, the majority of the species found under the docks belongs to the division Rhodophyta. These species are characterized by the presence of accessory pigment phycobilins, which provides better physiological conditions to cope with low light intensity environments (14). In general, the total biomass was related to the presence of opportunistic and cosmopolitan species, such as *Ulva lactuca*(13). These characteristics are attributed not only to their tolerance to adverse conditions of the environment, but also to its great reproductive capacity (25). Many individuals of this genus grow in intertidal areas, and they are usually found in rocks, tide pools, reefs and estuarine areas, such as our study area.

The high values of macroalgae biomass in the mouth of the channel were probably due to the higher hydrodynamics in that area. In some estuaries, the tides are the main source of energy for the mixing of different water masses, the uplifting of sediments from the bottom and its transport to the estuary (21).

The presence of these structures involves other indirect impacts, which can only be observed in a larger scale. For example, shading can affect the establishment and development of entire estuarine epibiotic communities (9; 23), since that affecting the primary producers assemblages may lead to other consequences in the higher trophic levels. Furthermore, the area impacted by docks may be larger than that bounded by the shade under it. The boat traffic is a potential source of disorder, changing the hydrodynamics and altering the bottom (3). The presence of these structures on coastal areas is a sign of urbanization processes, which carries other major disturbances, such as sewage discharge and eutrophication processes which also affect macroalgae communities (20;16).

CONCLUSION

Urbanization in coastal areas has resulted in an extensive introduction of artificial structures in the marine environment. Many of them are consistently different from natural substrates in various aspects, including the material composition and intensity of shading caused. Inherent factor of human population growth, the urbanization process deserves more attention in an attempt to assess its consequences. In this context, this work can therefore confirm the hypothesis that the docks cause impacts on macroalgae community, reducing its richness and biomass due to shading caused by these structures. The mitigation of new docks impacts would therefore consider higher docks with more spacing in order to allow higher solar radiation to reach the marine substrata under them.

Anyway, public policies should consider this issue in order to regulate and avoid uncontrolled proliferation of new docks when not highly necessary.

REFERENCES

1. Alongi, D. M. Coastal ecosystem processes. New York: CRC Press. 1998.

2. Bohninggaese, K. Determinants of avian species richness at different spatial scales. *J. Biogeogr* ., 24: 49 - 60. 1997.

3. Burdick, D.M., & Short, F.T. The effects of boat docks on eelgrass beds in coastal waters of massachusetts. *Environ. Manag.*, 23: 231 - 240, 1999.
4. Connell, S.D. Urban structures as marine habitats: an experimental comparison of the composition andabundance of subtidal epibiota among pilings, pontoons and rocky reefs. *Mar. Environ. Res* ., 52: 115 - 125, 2001.
5. Connell, S.D., Glasby, T.M. Do urban structures influence local abundance and diversity of subtidal epibiota? A case study from Sidney Harbor, Australia. *Mar. Environ. Res* ., 47: 373 - 387, 1999.
6. Dennison, W.C., Orth, R.J., Moore, K.A., Stevenson, J.C., Carter,V., Kollar, S., Bergstrom, P.W., Batiuk, R.A. Assessing Water Quality with Submersed Aquatic Vegetation. *BioScience* , 43(2): 86 - 94. 1993.
7. Douglas, M., & Lake, P. S. Species richness of stream stones: An investigation of the mechanisms generating the species/area relationship. *Oikos* , 69: 387 - 396. 1994.
8. Foster, M. S. Algal succession in a *Macrocystis pyrifera* forest. *Mar. Biol.* 32: 313 - 32, 1975.
9. Glasby, T. M. Interactive effects of shading and proximity to the seafloor on the development of subtidal epibiotica assemblages. *Mar Ecol Prog Ser.* 190: 113 - 124. 1999.
10. Glasby, T.M. & Connell, S.D. Urban structures as marine habitats. *Ambio* , 28: 595 - 598, 1999.
11. Hammond A. World resources 1992 - 1993: towards sustainable development. Oxford: Oxford University Press. 1992.
12. Heck, K. L. Some determinants of the composition and abundance of motile macroinvertebrate species in tropical and temperate turtlegrass (*Thalassia testudinum*) meadows. *J. Biogeogr* ., 6: 183 - 200. 1979.
13. Ho, Y.B. *Ulva lactuca* as bioindicator of metal contamination in intertidal waters in Hong Kong Hydrobiologia 203: 73 - 81, 1990.
14. HORTA, P. A. ; OLIVEIRA, Eurico C de . MACROALGAS DEL INFRALITORAL - UN NUEVO DESAFÍO PARA EL CONOCIMIENTO DE LA BIODIVERSIDAD MARINA BRASILERA.. In: K. Alveal, T. Antezana. (Org.). Biodiversidad Algal. Concepcion: Universidad de Concepcion, 2001..
15. Levine, H. G. The use of seaweeds for monitoring coastal waters. In L. E. Shubert (Eds.), Algae as ecological indicators. New York: Academic, 1984, p. 189 - 210.
16. Liu, D., Bai, J., Song, S., Zhang J., Sun, P., Li Y., Han, G. The Impact of Sewage Discharge on the Macroalgae Community in the Yellow Sea Coastal Area around Qingdao, China. Water Air Soil Pollut: Focus,7: 683–692. 2007.
17. Lunden, C.G. and Linden, O. Coastal ecosystems: attempts to manage a threatened resource. *Ambio* 22: 468–473, 1993.
18. McGuinness, K. A., & Underwood, A. J. Habitat structure and the nature of communities on intertidal boulders. *J. Exp. Mar. Biol. Ecol* ., 104: 97 - 123. 1986.
19. Menge, B. A., & Sutherland, J. P. Species diversity gradients: Synthesis of the roles of predation, competition and environmental heterogeneity. *Am. Nat* ., 110, 351 - 369, 1976.
20. Morand, P., Briand, X. Excessive growth of macroalgae: A symptom of environmental disturbance. *Botanica Marina* . 39 (6): 491 - 516. 1996.
21. Nichols, M.N. ; Biggs,R.B. Estuaries. In: Davies, R.A. Coastal Sedimentary Environments. Edited by Richard A.Davis Jr. 77 - 186 Springer Verlag. New York, 1985, 716 p.
22. Pereira, M.L.M. Estudo da dinâmica das águas do canal da Barra da Lagoa-Florianópolis, SC. Programa de Pós Graduação em Geografia, Florianópolis, SC, UFSC. 2004, 148 p.
23. Saunders, R.J., Connell, S.D. Interactive effects of shade and surface orientation on the recruitment of spirorbid polychaetes. *Austral Ecology* 26(1): 109 - 115. 2001.
24. Shabman, L.A. & Batie, S.S. Estimating the economic value of coastal wetlands: conceptual issues and research needs. In V.S. Kenndy, Estuarine perspectives. New York: Academic Press, 1980, p. 3 - 16.
25. Smith, G. On the reproduction of some Pacific Coast species of Ulva. *Am. J. Bot* . 34: 80 - 87, 1947.