ASSESSING THE INFLUENCE OF URBAN STRUCTURES ON ESTUARINE SOFT - BOTTOM BENTHIC MACROFAUNA

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INTRODUCTION

Increasing urbanization is one of the most conspicuous environment disturbances. Although harder to quantify in aquatic habitats, these impacts may affect water, sediment and benthic community interactions (see 17). Among the numerous coastal modifications, there is the building of artificial structures, such as docks and piers, to facilitate the local trade and to promote recreation sites.

The local biota can be affected by artificial structures through several manners, such as increasing shadowiness (1); attracting predators due to the shelter availability (4), which may alter trophic structure (12); altering local hydrodynamics due to the navigation, which can alter the transport of nutrients, larvae, spores and organic matter (6); and changing the erosion and sedimentation rates (19). The latter may be particularly important factor for soft bottom macrobenthic organisms, because they are non - mobile and directly related to physical - chemical characteristics of the sediment. Therefore, they respond to local effects, which make them useful as bioindicators of urbanization impacts (7). In this perspective, we inferred about urbanization pressure assessing changes on the subtidal invertebrate community on an estuarine habitat.

OBJECTIVES

In order to test the hypothesis of artificial structures impacting the subtidal of a lagoon - coastal transition system, we addressed the following questions: Does the presence of docks alter the sediment characteristics? If so, do these alterations influence on the structure of the soft - bottom benthic macrofauna assemblage?

MATERIAL AND METHODS

Study area

This study was conducted in a channel that belongs to the estuarine system of Conceição Lagoon, in the east portion of Santa Catarina Island, SC, Brazil ($27^0$34'S $48^0$24'W). The channel is 2.8 km long and connects the lagoon to the continental platform on Barra da Lagoa Beach. It is intensely urbanized and is used for recreational and fishing boats traffic, which is evidenced by the presence of several buildings and docks in its margins.

Experimental design and data sampling

We performed a mensurative experiment in March, 2009. The channel was divided in three sections (inner, intermediate and mouth), in which two docks were randomly sampled. For each dock we sampled a respective adjacent control area, i.e., an uncovered area with similar characteristics, in the same border of the channel, far enough to avoid edge effect. In each sampling site of both treatments, we collected three replicates, totalizing 36 samples of sediment and 36 of macrofauna.

Benthic macrofauna was collected from the substratum using a core of 10 cm diameter and 10 cm depth. Samples were washed on a 0.5 mm mesh sieve, fixed in 10% of buffered formalin and preserved in 70% alcohol. All individuals were separated using a microscope and identified until the lowest reliable taxonomic levels.

Sediment samples were of 200 cm3 from the 5 cm layer of the bottom. Samples were previously dried at 60^0C for 48 hours and divided in four parts. A quarter was used for granulometric analysis, the fine grains were separated from the sandy grains through a sieve of 63 μm (16). Another quarter was used to determine organic matter percentage (according to 5). Biodetritic carbonate content was determined by chemical reaction with HCl 10% using the rest of the sample.

Data analysis

We performed a bifactorial Analysis of Variance (ANOVA), testing differences among the treatments (Dock and Control) and each sampling site of channel section (Inner: 1 and 2; Intermediate: 3 and 4; Mouth: 5 and 6) for macrofauna diversity, total richness, total density, density of the six more abundant taxa (which represented 95% of total abundance), and the sediment parameters. Species diversity between treatments was calculated by Shannon's index in neperian logarithm. The homogeneity was previously assessed by Cochran test and the logarithmic or arcsine transformation was applied when necessary. The post - hoc Fisher LSD test and mean comparisons were utilized in case of significant difference, which was a probability of $p < 0.05$. In all cases, degrees of freedom were 5.

RESULTS AND DISCUSSION

Results

A total of 27 taxa was identified under the docks and in open areas. The groups Polychaeta, Oligochaeta, Bivalvia, Gastropoda, Crustacea, Nemertea, Nematoda and Anthozoa were present. Docks yielded 23 species, while control areas 16. The polychaeta *Capitella* sp., *Polydora* sp., *Neanthes succinea*, *Glycinde multidens*; the bivalvia *Anomalocardia brasiliana*; and a non - identified Tubificid oligochaeta accounted for more than 95% of all individuals.

The macrofauna diversity was similar in both treatments (Interaction: F=1.87; p=0.137), but total richness were higher under dock of the inner section of the channel (Interaction: F=12.58; p=0.020; Fisher: Control 2 < Dock 2). Total density were different among sampling sites and treatments (Interaction: F=1.10; p=0.002), and was higher under docks than open areas of inner section (Control 1 and 2 < Dock 1 and 2), but the opposite occurred in the rest of sections (Control 3 and 6 > Dock 3 and 6).

Sediment composition under the docks was different than in open areas, depending on the section of the channel. In the intermediate section, natural areas presented greater organic matter deposition (Interaction: F=4.02; p=0.010) and presence of fine grains (F=21.58; p <0.001), and less presence of sandy grains (Interaction: F=17.00; p <0.001), than covered areas (Control 3 and 4 > Dock 3 and 4), while the other sections presented the opposite (Control 2 and 6 < Dock 2 and 6). However, there was no difference in biodetritic carbonate percentages (Interaction: F=2.37; p=0.075).

Some species occurred in high densities according with the sediment differences along the channel. Opportunistic Polychaeta were more abundant in areas with more organic matter and fine grains (*Capitella* sp.: Interaction F=8.16; p <0.001; Control 1,2,6 < Dock 1,2,6; Control 3 > Dock 3; *N. succinea*: Interaction F=5.27; p=0.002; Control 2 < Dock 2; Control 3 > Dock 3; *Polydora* sp.: Interaction F=9.87; p <0.001; Control 2 < Dock 2). The bivalvia *A. brasiliana* was related with sediment (Interaction: F=3.70; p=0.013) but showed no clear pattern of distribution: it was more abundant in control area of inner section (Control 2 > Dock 2), where the percentage of sandy grains percentage were higher; but it was also abundant under dock of mouth section of the channel (Control 6 < Dock 6) where fine grains were higher. However, *G. multidens* (F=0.424; p=0.827) and Oligochaeta (F=0.80; p=0.561) distribution were not related with the sediment.

Discussion

Benthic communities can respond to changes in their habitats by alterations in its composition. Since the benthos, environmental conditions and human impacts intensity vary greatly depending on the studied area (e.g. 13), it is expected that the intensity of macrofauna response differs as well. In this context, previous studies that addressed potential impacts of built structures bordering aquatic systems have been suggested (11) and confirmed evident alterations in communities from affected in comparison with natural areas (e.g. 2; 8; 10). The evaluated structures in the Barra da Lagoa channel can promote physical alterations and consequent interference in the associated benthic community. However, such changes are dependent and vary in function of the channel region.

The man - made structures are probably sources of impact that are limited to the immediate nearby, as observed for the hydrodynamic changes and heavy metal concentration in the sediment (18; 15). In our studied area, local relations can be distinguished when focusing on the species details, such as the abundance of opportunistic Polychaeta related with the fine grains percentage in the intermediate section of the Barra da Lagoa channel. Given that the introduction of artificial substrates can modify the local hydrodynamics, it is expected that the sediment composition also be altered (3). Since fine grains tend to be transported first by the water flow and docks tend to decrease the hydrodynamic below it, sediment with more fine grains and organic matter percentages may be found under the covered areas. These modified habitats thus allow some organisms to occur in higher abundance, which is in accordance with the most abundant species, the opportunistic *Capittela* sp., reported worldwide as indicator of organic enrichment (9). The same subtle alteration in hydrodynamics are not visible in the extremes of the channel probably because they are exposed to greater water flow, due to the more intense tidal cycles, which are reduced in the intermediate section of the channel (14).

However, the major consequences of these non - natural structures should be seen at a larger scale. For example, Sanger *et al.*, (15) could find benthic tolerant species in more abundance in highly impacted environments, when comparing whole areas with distinct densities of docks. They also argue that structural changes caused by docks provide more complexity to the microhabitat, serving as artificial reefs and sheltering more species of small fish and crustaceans (15). Attracting more diversity of predators is, therefore, another source of impact to the benthic assemblage (4). Through another point of view, the shadowiness under the docks certainly interfere the primary producers assemblages, leading to other consequences in the higher trophic levels (e.g. 1).

In a broader view, anthropogenic activities are non - point sources of pollution and disturbance in aquatic habitats (e.g. effluent and sewage discharge, damages in riparian forest, siltation, and boat traffic). Docks presence is only part of the cumulative impacts due to the coastal urbanization. The overlap of those several different human impacts is much more disturbing for the benthic macrofauna. We suggest this synergistic effect as responsible for the variation in the benthic macrofauna composition and structure observed along the channel.

CONCLUSION

The artificial structures contribute with some level of biotic and abiotic changes, which are also influenced by the hydrodynamic and other sources of disturbance observed in the studied area. However, the proliferation of buildings in coastal areas is only a symptom of the bigger problem: the uncontrolled occupation of the landscape, which is responsible for substantial changes in the quality of environment. (We thank CAPES for financial support and Sebastião Dutra from NEMAR for helping with laboratorial analysis).

REFERENCES

1. 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.

2. Butler, A.J., Connolly, R.M. Development and long term dynamics of a fouling assemblage sessile invertebrates. *Biofouling*, 9: 187 - 209, 1996.

3. Connel, 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.

4. Davis, N., Vanblaircom, G.R., Dayton, P.K. Man - made structure on marine sediments: effects on adjacent benthic communities. *Mar. Biol.*, 70: 294 - 303, 1982.

5. Dean, W.E., Jr. Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: comparison with other methods. *J. Sediment. Petrol.* , 44: 242 - 248, 1994.

6. Fairweather, P.G. Implications of "supply - side" ecology for environmental assessment and management. *Trends Ecol. Evol.*, 6: 60 - 63, 1991.

7. Giere, O. Meiobentology: the microscope fauna in aquatic sediments. Berlin, 1993, 235p.

8. Glasby, T.M. Differences between subtidal epibiota on pier pilings and rocky reefs at marinas in Sydney, Australia. *Estuar. Coast. Shelf Sci.*, 48: 281–290, 1999.

9. Grassle, J.R., Grassle, J.P. Opportunistic life histories and genetic systems in marine Polychaetes. *J. Mar. Res.*, 32: 253 - 284, 1974.

10. Lindegarth, M. Assemblages of animal around urban structures: testing hypotheses of patterns in sediments under boat - mooring pontoons. *Mar. Environ. Res.*, 51: 289 - 300, 2001.

11. Lindegarth, M., Hoski, M. Patterns of distribution of macro - fauna in different types of estuarine, soft sediment habitats adjacent to urban and non - urban areas. *Estuar. Coast. Shelf Sci.*, 52: 237 - 247, 2001.

12. Martin, D., Bertasi, F., Colangelo, M.A., Vries, M., Frost, M., Hawkins, S.J., Macpherson, E., Moschella, P.S., Satta, M.P., Thompson, R.C., Ceccherelli, V.U. Ecological impact of coastal defence structures on sediment and mobile fauna: Evaluating and forecasting consequences of unavoidable modifications of native habitats. *Coast. Eng.*, 52: 1027 - 1051, 2005.

13. Morrisey, D.J., Howitt, L., Underwood, A.J., Stark, J.S. Spatial variation in soft - sediment benthos. *Mar. Ecol. Prog. Ser.*, 81: 197 - 204, 1992.

14. 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.

15. Sanger, D.M., Holland, A.F., Hernandez, D.L. Evaluation of the impacts of dock structures and land use on tidal creek ecosystems in South Carolina estuarine environments. *Environ. Manag.*, 33: 385 - 400, 2004.

16. Suguio, K. Introdução a sedimentologia. Edgar Blunchen, EDUSP, São Paulo, 1973, 317 p.

17. Vitousek, P.M., Mooney, H.A., Lubchenco, J., Melillo, J.M. Human domination of the Earth's ecossystems. *Science*, 277: 494 - 499, 1997.

18. Weis, J.S., Weis, P., Proctor, T. The extent of benthic impacts of CCA - treated wood structures in Atlantic coast estuaries. *Arch. Environ. Contam. Toxicol.*, 34: 313 - 322, 1998.

19. Weston, D.P. Quantitative examination of macrobenthic community changes along organic enrichment gradient. *Mar. Ecol. Prog. Ser.*, 61: 233 - 244, 1990.