Fouling Community Recruitment on an Artificial Reef in the North Coast of Rio de Janeiro State

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To investigate and to compare monthly variation of fouling community structure it was immersed 3 miles of Manguinhos beach, north coast of Rio de Janeiro (21º29'S, 41º00'W'), 36 concrete modules (Reefballs®) with plates attached monthly and removed after 30 days of submergence. To the quantification of the taxa, the external face of each panel was examined by point intersection technique. After 12 months of study, the most abundant groups in the recruitment plates were Hydrozoa (7 taxa) and Cirripedia (5 taxa). The mean richness values of taxons presented a maximum in April and May of 2002 (8 and 9 taxa, respectively). The mean Brillouin index of diversity presented the largest values in the same months (H = 1.6 to 1.8). The percentage of empty space was superior to 20% along the whole period. The dominant taxa (Balanus spp, Clytia spp, Oebela spp and Ostrea sp) alternated their cover percentage in different months following irregular patterns without defined time of recruitment.

ADDITIONAL INDEX WORDS: Colonization, seasonality, biofouling, Brazil

INTRODUCTION

The use of artificial structures to increment of the fishing activity is an old practice and broadly used about by several coastal populations of the world (Connell & Glasby, 1999). The consequences of this activity might be the increase and conservation of the marine biodiversity (Brotto, 1997; Patton and Grove, 1999) and the restoration of habitats (Pickering et al., 1998; Svane and Petersen, 2001).

Most of the benthic invertebrates have a dispersion larval phase of extreme importance for the mounting of colonization of a new environment. The larval and propagules dispersed in the plankton tend to settle as soon as they find an appropriate natural or artificial substratum (Connell and Glasby, 2001; Lindgarth, 2001).

The recruitment of benthic species will depend on the propagules and larval readiness, effects of marine currents and behavior and larval selectivity (Underwood and Fairweather, 1985). Its intensity depends on factors as production and dispersion of the larva and death rate during the dispersion and settlement (including the selection and fixation processes in the substrate). All these factors are dependent of environmental conditions (Scheffer, 2001).

The present study pretends to identify the recruitment period of the main epibenthic taxa on an artificial reef and to verify the influence of the environmental parameters pluviometric precipitation and outflow of Paraíba do Sul river in the recruitment of the species. The hypothesis to be tested is that the seasonality in the recruitment of the species is a function of the temporal variation of the above environmental parameters.

METHODS

Aiming to identify the recruitment period of the main epibenthic taxa and to investigate the influence of the environmental factors (outflow of Paraíba do Sul river and pluviometric precipitation), 36 concrete modules (Reefballs®) were immersed at 9 meters deep, 3 miles of Manguinhos beach in the north coast of Rio de Janeiro State (21º29'S, 41º00'W').

Previous studies in this region showed that salinity, pH, dissolved oxygen, nutrients and chlorophyll present temporal variations quite reduced in opposition to great pluviometric precipitation and outflow of the Paraíba do Sul river, with higher values in summer months (Godoy et al., 2002).

Daily registrations of pluviosity were obtained in the Department of Climatology of the Universidade Federal Rural do Rio de Janeiro - UFRJR (21º47S, 41º17W), Campus Dr. Leonel Miranda (Campos - RJ). The outflow of the Paraíba do Sul river (m3S) was measured biweekly in the downtown of Campos de Goytacazes (21º45S, 41º19W).

During 12 months (January of 2002 to February of 2003), four concrete plates were monthly immersed and removed after 30 days of submergence. To the quantification of the taxa, the external face of each panel was examined by point intersection technique (Sutherland, 1974). Species richness, Brillouin diversity and Simpson dominance were calculated for each sampled period (Krebs, 1989).

The influence of the environmental parameters pluviometry and outflow of the Paraíba do Sul river in the species recruitment was determined by Pearson Correlation coefficient (Zar, 1984) with monthly mean values of the environmental parameters and percentage cover of dominant taxa.

Temporal recruitment similarity was evidenced by a cluster analysis (UPGMA), with Morisita's coefficient as similarity index (Krebs, 1989).

RESULTS

Abiotic Data

Mean values of outflow and pluviometric precipitation data accumulated monthly on Paraíba do Sul river showed two seasons that characterize the area: a rainy period mainly on summer months (February/02, December/02 and January/03) and a drier one (another months). Comparing the results of the present study with precipitation and outflow data of the last 10 years (1992 to 2001), it was observed similar temporal variations; however the current values are even twice superiors to the tendency of the last years (Figure 1).

Biotic Data

On August/02 and September/02 it was not possible to remove the plates, due to strong storms.

After 12 months the most abundant groups in the plates were Hydrozoa (7 taxa) and Cirripedia (5 taxa), followed by Polychaeta (4 taxa), Tunicata and Ectoprocta (1 taxa each).

Taxa richness varied from 2 (October/02) to 9 (May/02), with a mean value around 5. Inferior values of diversity were registered in October/02 (H = 0.8), reflecting the dominance of
Balanus taxa and a great empty space. The largest diversity values were already observed in April and May/02 (H = 1.8 and 1.7, respectively), corresponding to a smaller dominance and a higher taxa richness (Figure 2).

The empty space area was superior to 20% along the whole period. The dominant taxa Balanus spp, Clytia spp, Obelia spp and Ostrea sp alternated their covering percentage in different months following irregular patterns without a defined period of recruitment (Figure 3).

The cluster analysis revealed two main groups. The first one was influenced by the recruitment and predominance of Balanus spp and Obelia spp. The second group was characterized by the non-recruitment of Balanus spp (Figure 4).

The Pearson analysis did not show significant correlation values between the environmental parameters (pluviometric precipitation and outflow of the Paraíba do Sul river) and the dominant taxa. However, it was reported a high correlation of the pluviometric precipitation with the percentage of empty space, which showed superior values in the rainy months (Table 1).

DISCUSSIONS

Paraíba do Sul river have an hydrographic basin of approximately 55,500 km² including São Paulo, Minas Gerais and Rio de Janeiro states (COSTA, 2003). The great area of water reception promotes an increase of the outflow at the rainy period, mainly in summer months, increasing the sedimentation and turbidity in the area.

Sedimentation and turbidity of the water are harmful to sessile organisms in settlement and recruitment processes because they interfere in the feeding and breathing processes, closing and clogging the responsible structures for these functions (PERKINS 1974; MAUGHAN, 2001). Waves and tides promote a high concentration of particulate material in suspension, which decrease the luminous energy, harming phototrophic and heterotrophic species. Besides, they promote the abrasion causing lesion in the external organic tissues or removing the organisms from the substrate (ANTHONY and FABRICIUS, 2000; MILLER, et al., 2002; PERKINS, 1974).

MAUGHAN (2001) compared the fouling community development in concrete plates under different sedimentation conditions and verified the smallest richness and diversity values in substrates subject to intense sediments. Such lower values were also observed in the present study in summer (rainy) months probably due to higher sedimentation and turbidity of the water during this period.

The well-defined seasonality of the parameters outflow of Paraíba do Sul river and pluviometric precipitation rate, with superior values from December to February did not correspond to a seasonal recruitment of the fouling organisms.

The positive correlation between pluviometric precipitation rate and the percentage of empty space in the plates suggests the rainy influence in the recruitment of the organisms. Besides, the physical stress represented by sedimentation and abrasion shows a negative influence in the larvae settlement.

The artificial reef is located in an open sea area with strong bottom currents. Besides, the plates are close to the basal substrate (about 1.0 m of the fund) resulting in a strong abrasion

Figure 1. Monthly values of mean outflow (m3S) of Paraíba do Sul river between Feb/02 and Jan/03 (present study) and between 1992 and 2001 (tendency); monthly pluviometric precipitation (mm) between Feb/02 and Jan/03 and 1992 and 2001.

Figure 2. Temporal variation of taxa richness (N); Simpson dominance (S) and Brillouin diversity (H) in the recruitment plates during the study period (mean values and standard error of four samples).

Figure 3. Monthly variation of percentage cover of the most representative taxa (mean values and standard error of four samples).
of the sand, which hinders the larvae and spores settlement. Therefore, physical factors as sedimentation, turbidity, abrasion and strong currents could explain the lower species abundance, richness and diversity in the recruitment plates in comparison to others studies on Rio de Janeiro state (ZALMON et al., 1993; SILVA, 1998; NASSAR, 1999; ZALMON and GOMES, 2003).

Empty space was not a limiting factor to the fouling community recruitment on the studied area. Their high percentage is probably reflecting the local physical stress. Besides, the low recruitment can also be explained by a shortage of a "larvae/spores bank" nearby. It is observed in the studied area a scarcity of hard substrate that would act as a center of larvae dispersion (propagules source). Balanids, serpulids, incrusting bryozoans, hydroids and colonial tunicates are often observed attached to drifting brown macroalgae Dycteopteris and Sargassum as the available substrate for settlement.

Original source of larvae and spores are of extreme importance as a propagules supply for the colonization of adjacent areas, carrying out an important role on population dynamics of benthic communities. The dispersion reduces the risk of local extinction and spreads larvae and propagules to other areas (LOTZE et al., 2001). STANDING (1978) studied the influence of Obelia dichotoma in the larval recruitment of Balanus in Bodega Harbour (California) and verified that the hydroid occupied the whole available area in a few weeks. The author showed the opportunistic character of Obelia (fast growth and high reproductive rate) having an inhibitory effect on Balanus. In the present study the hydroids Obelia and Clytia presented quite a similar feature with a more intense growth on free spaces and also presenting a negative correlation with Balanus.

Table 1. Pearson Correlation analysis of the percentage cover of the dominant taxa and the empty space with environmental parameters mean outflow of Paraíba do Sul river (of) and pluvimetric precipitation (pp).

<table>
<thead>
<tr>
<th>Abiotic data x taxa</th>
<th>Pearson Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>of x Balanus spp</td>
<td>0.38</td>
</tr>
<tr>
<td>of x Clytia spp</td>
<td>-0.42</td>
</tr>
<tr>
<td>of x Obelia spp</td>
<td>0.03</td>
</tr>
<tr>
<td>of x Ostrea sp</td>
<td>-0.19</td>
</tr>
<tr>
<td>of x empty space</td>
<td>0.11</td>
</tr>
<tr>
<td>pp x Balanus spp</td>
<td>-0.08</td>
</tr>
<tr>
<td>pp x Clytia spp</td>
<td>-0.20</td>
</tr>
<tr>
<td>pp x Obelia spp</td>
<td>-0.12</td>
</tr>
<tr>
<td>pp x Ostrea sp</td>
<td>-0.01</td>
</tr>
<tr>
<td>pp x empty space</td>
<td>0.46</td>
</tr>
</tbody>
</table>

A negative correlation of the most representative species abundance was registered mainly between Clytia and Balanus, showing a negative interference relation. ABSALÃO (1993) demonstrated the occurrence of chemical inhibition (allelopathy) in an epibenthic community by fishes Blemnidae and Gobiosociidae. Chemical inhibitions between fouling species occurs frequently in submerged substrate (ENGEL & PAWLK, 2000; PEREIRA et al., 2002; PISUT and PAWLK, 2002).

Connell (1985) suggests three factors that could affect the settlement and recruitment of benthic organisms: (1) a few planktonic propagules gets to arrive at the fixation place; (2) the conditions of the water adjacent to the substrate are not favorable to the settlement of the propagule and (3) the substrate is not very attractive. Probably the first and second ones have a stronger influence in the local recruitment, due to the shortage of adjacent natural substrate and the adverse conditions promoted mainly by the sedimentation, currents and abrasion. The attractive power of the substrate seemed not to be a problem to the fouling recruitment. ZALMON and GOMES (2003) working in the same area showed that artificial reefs made by concrete present good conditions for the fouling colonization.

Chlorophyll concentrations are commonly used as a model of feeding resources. Some studies suggest a positive relation among nutrients, primary productivity and benthic communities' development (BOCK and MILLER, 1995; MENGE et al., 1997; BRODEUR et al., 1999). It was registered by SOUZA (1998), CARNEIRO (1998) and GODOY et al. (2002) a low primary productivity (chlorophyll a) in the local area. Chlorophyll values are more expressive in the internal estuary of the Paraíba do Sul river (10 µg/L). Low chlorophyll concentrations reflect in lower available food for fouling organisms, which are represented mainly by suspension feeders or secondary consumers with needs of indirect primary production.

A simultaneous action of physical and biological (clorofila a) factors occurred in the studied area, which overlaps recruitment temporal patterns of the fouling species. Monthly plates reflected the available larvae in the plankton in the different months of the year, which were able to overcome stressing factors (e.g. sedimentation, turbidity, abrasion and currents), a low primary productivity and a shortage of larval source.

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LITERATURE CITED


CONNELL, J.H., 1985. The Consequences of Variation initial


