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Is meiofauna community structure in Artificial Substrate Units a good tool to assess anthropogenic impact in estuaries?

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ABSTRACT

The applicability of estuarine meiofauna and harpacticoid copepods' communities in an artificial substrate unit (ASU) was assessed and compared to natural substrates (sediment and pneumatophores) as a tool to discern estuaries under different types of anthropogenic impacts. The ASU's replicates demonstrated a low variation of density among replicates when considering the total meiofauna and copepod species, which was reflected by a great similarity within the samples. In relation to the most abundant groups found, the ASU samples properly represented the natural substrates, even though nematodes were poor colonizers. That the ASU only showed significant differences between areas suggested that standard substrates could more efficiently detect the differences between communities and pointed toward the applicability of ASUs meiobenthic communities as useful tools for impact studies.

1. Introduction

Estuaries have great ecological and economic importance because many fish and invertebrates species with high commercial value use them as nursery, feeding and spawning grounds (Little, 2000). In addition, estuaries provide a wider variety of social benefits and constitute a source of organic material for the adjacent coastal zones (Elliott and Whitfield, 2011).

These ecosystems are characterized by high variability in the range of salinity, and they are influenced by tidal, climatic, hydrodynamic and geographic conditions (Giere, 2009). Due to these characteristics, estuarine organisms tend to be tolerant to higher physical-chemical variations and are capable of recovering from these fluctuations (Elliott and Whitfield, 2011). Thus, when evaluating the environmental quality of estuaries, it becomes difficult to distinguish the natural stress from the anthropogenic stress because the ecologic response of organisms to both would be quite similar (Elliot and Quintino, 2007). This 'problem' is recognized in the literature and is named the Paradox of Estuarine Quality (Dauvin, 2007).

Among the biological components of estuarine sediments, meiofauna play a fundamental role in the energy flow of estuaries by serving as food for a variety of predators and facilitating the biomineralization of organic material and nutrient regeneration (Coull, 1999). In addition, meiofauna have a high tolerance to changes in salinity, temperature and oxygen supply (Giere, 2009). Many environmental and biological factors contribute to meiofaunal distribution (see Blanchard, 1990; Santos et al., 1995; Alves et al., 2009; Giere, 2009), which is spatially heterogeneous, forming 'patches' (Giere, 2009).

Meiofauna can be used as a biological indicator of anthropogenic impacts due to their small size, high abundance, species richness, ubiquitous distribution, rapid generation time and direct benthic development, (Kennedy and Jacoby, 1999; Zeppilli et al., 2015), and they can detect disturbance faster than macrofauna (Giere, 2009). However, discerning human-induced stress from natural changes (described above as the Paradox of Estuarine Quality) using organisms that have a patchy distribution is a challenging task that requires higher sampling efforts to obtain reliable estimates of anthropogenic impacts.

Artificial Substrates Units (ASUs) were proposed to overcome such challenges, as they provide standardized microhabitats at different points within a spatial scale (Bishop, 2005); therefore, any difference found is not attributable to habitat features (Chapman and Underwood, 2008). Artificial substrates were used to survey benthic communities in several studies (e.g., Atilla and Fleeger, 2000; Atilla et al., 2003, 2005; Mirto and Danovaro, 2004; Rule and Smith, 2005, 2007; Russel et al., 2005; Chapman and Underwood, 2008), although few specifically considered the estuarine meiofauna (Atilla and Fleeger, 2000; Atilla et al., 2003, 2005).

Several of the ASUs already used in the study of estuarine fauna were Hester-Dendy plates (Atilla and Fleeger, 2000), pot scrubbers (Atilla and Fleeger, 2000; Atilla et al., 2003) and bottle brushes (Atilla and Fleeger, 2000; Atilla et al., 2005). There is no consensus among studies regarding

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the type of artificial substrate adopted. In addition, none of the cited studies statistically compared meiofauna communities between artificial and natural substrates.

The present study evaluated ASUs as appropriate representations of estuarine meiofauna and harpacticoid copepods, comparing the colonized ASU with natural substrates (sediment and pneumatophores). The study tested the ASU's usefulness as a tool to discern estuaries under different types and levels of anthropogenic impacts.

2. Materials and methods

2.1. Study area and experimental design

Experiments were run from the 1st to the 16th of February 2014 in two estuarine intertidal mudflats (Fig. 1) located in the Pernambuco coast (north-eastern Brazil).

The Maracaípe Estuary (sampling point on 8°32′21.42″ S and 35° 00′21.72″W) is located on the southern coast of Pernambuco. This estuary has a well-preserved mangrove vegetation far from urban centres (Araújo-Castro et al., 2009), although tourism has increased in the last several decades and is the major threat to local biodiversity (CPRH, 2006). The Santa Cruz Channel is an estuarine complex (sampling point on 7°46′11.04″S and 34°52′55.56″W) located in the northern coast of Pernambuco. It receives pollutants from different sources, such as agroindustry and wastewater discharges, and it is subjected to urban expansion and fisheries. In addition, there are historical discharges of mercury, chlorine and acid waters from sugarcane (Medeiros et al., 2001). More characteristics and summary of the main disturbance sources in these areas are resumed in Valença and Santos (2013).

A preliminary field experiment was performed in the Maracaípe Estuary to choose the artificial substrate and the period of meiofauna colonization. Three types of artificial substrates were used (pot scrubbers, bottle brushes and synthetic grass) and compared to the natural substrate (sediment and pneumatophore or anchor roots scrapes) using semi-quantitative samples. All of the artificial substrates were placed in an estuarine mudflat for meiofauna colonization and collected (with natural substrate) after 5, 9, 14 and 19 days. Data analyses showed that the synthetic grass as the artificial substrate and a 14-day colonization period better represented the major meiofauna taxonomic groups from natural substrates.

Thereafter, five synthetic grass units (each one with 50 cm^2 total area) were positioned in each estuary (Maracaípe and Santa Cruz Channel). The artificial substrates (ASUs) were fastened in contact with the sediment with a nylon rope (Fig. 2) to anchor-roots and pneumatophores of mangrove trees in five random points in each estuarine area and left for meiofauna colonization. During the experimental period, ASUs were exposed to the tidal variation, values varying from 0.0 m to 2.7 m (Santa Cruz Channel) and from 0.0 m to 2.4 m (Maracaípe) during this time. Low tides varied from 0.0 m to 0.9 m in both areas exposing ASUs to air for some hours during part of the experiment since both sampling areas were positioned at 0.5 to 0.6 m of elevation.

After 14 days, ASUs were collected, as well as samples from natural substrates: adjacent sediment (corer area 2 cm^2; sampling depth 2 cm) and pneumatophores. Therefore, five replicates of each substrate (ASU, sediment and pneumatophore) were obtained in each estuarine area (Maracaípe and Santa Cruz Channel). All of the substrates were stored in plastic pots. In the laboratory, ASUs were weighed to estimate the retained material, and then all of the samples were fixed with 4% formaldehyde. The length of each pneumatophore was measured with a ruler and the biovolume was estimated by water displacement in a 50 ml measuring cylinder in order to estimate the surface area of the pneumatophores.

2.2. Environmental descriptors

Each estuarine area was characterized in terms of the environmental conditions using the following parameters: water temperature, dissolved oxygen, redox potential (Eh) from sediment (sampling depth 2 cm), interstitial salinity, silt-clay (corer area 9.62 cm^2; sampling depth 2 cm) and organic matter fractions (corer area 9.62 cm^2;

Fig. 1. Location of studied estuarine areas (indicated by x) in Pernambuco coast, Brazil.

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