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ScienceDirect
Marine Environmental Research 63 (2007) 429–444
MARINE ENVIRONMENTAL RESEARCH
www.elsevier.com/locate/marenvrev

Biogeochemical processes and nutrient cycling within an artificial reef off Southern Portugal

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Received 5 December 2005; received in revised form 4 December 2006; accepted 5 December 2006

Abstract

This study (2002/2004) examines the effect of artificial reef (AR) structures off the southern coast of Portugal on biogeochemical process and nutrient cycling. Organic and inorganic carbon, nitrogen, phosphorus and chlorophyll *a* were determined monthly in sediment cores and settled particles for a two-year period. Ammonium, nitrates, phosphates, silicates, total organic nitrogen and phosphorus, chlorophyll *a* and phaeopigments were also determined monthly in water samples within AR and control sites. Results of the two-year study showed that: (i) there was a significant exponential fit between organic carbon and chlorophyll *a* ($r^2 = 0.91$; $p < 0.01$) in reef sediment suggesting an increase of benthic productivity; (ii) organic carbon and nitrogen content in settled particles within AR environment was about four times higher two years after reef deployment; (iii) nutrients and chlorophyll *a* in the water column were higher at AR than control site. Two years after AR deployment, dissolved organic and inorganic compounds in near bottom water were 30–60% higher, emphasizing benthic remineralization processes at AR's organically rich sediment. Marked chemical changes in the ecosystem were observed during the two-year study period, reinforcing the importance of these structures for sandy coastal areas rehabilitation through trophic chain pull-out.

Keywords: Artificial reefs; Benthic remineralization; Biogeochemical process; Nutrients; Temporal changes

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doi:10.1016/j.marenvres.2006.12.001

1. Introduction

In recent years, great strides have been made in the understanding of artificial habitat ecology, although many questions regarding their performance and environmental impacts remain unanswered (Carr and Hixon, 1997). One of the reasons for the poor understanding of AR ecology is the lack of knowledge of their effect on the surrounding natural environment (Sheng, 2000; Svane and Peterson, 2001), which is a fairly new area of AR research. Scientific literature in this field is scarce and commercial technological applications have not been developed (Antsulevich, 1994). In Portugal, research regarding these systems has been mainly focused on ichthyological fauna, especially on commercial species (Santos and Monteiro, 1997, 1998; Santos et al., 2002, 2005) and benthic communities (Boaventura et al., 2006; Moura et al., 2004, 2006).

Reef structures, by providing protection for marine species, can result in marine system biomass enhancement (Santos and Monteiro, 1997, 1998; Godoy et al., 2002) with associated changes in local productivity (Grossman et al., 1997; Pickering and Whitmarsh, 1997). As a result of biomass enhancement sediment becomes more active in the process of nutrient regeneration providing a nutritional source for other forms within the ecosystem (Rizzo, 1990), or being exported by water movements increasing the general productivity of neighbouring areas. Furthermore, planktivorous fish species can induce nutrient production in the water column, excreting substantial amounts of ammonium, urea and depositing organic material, which is then incorporated into the reef food web. This process implies the increase of productivity and diversity on a local scale by increasing biotic and abiotic habitat complexity (Ambrose and Anderson, 1990), promoting biological colonization and species richness in many ecological niches and food webs (Relini et al., 1994).

In productive ecosystems the biogeochemical processes are extremely complex due to the interactions with the sediments and the benthic–pelagic competition of primary producers (Fourqurean et al., 1993). In the case of nitrogen, sediments are a source as well as a major sink in the cycling of this element regulating its concentration and thus, the productivity of coastal marine systems (Lohse et al., 1993). Phosphorus is an essential nutrient for the growth of marine phytoplankton and has been suggested as the limiting factor for ocean primary production (Howarth et al., 1995). Most of P-removal from the water column takes place through sedimentation of organic matter (Berner et al., 1993). Consequently, it is of prime importance to know the fate of the phosphorous in organic matter upon reaching the sediment (Slomp, 1997).

In the present study a survey was carried out during a two-year period in order to better understand AR's biogeochemical processes, the chemical composition of settled particles and nutrient cycling. The main goal of this study was to evaluate the trophic chain pull-out promoted by the deployment of concrete blocks on a sandy coastal area through organic matter deposition, benthic remineralization and local productivity.

2. Methodology

2.1. Study site

The location of the study area was approximately 2.5–4.0 km off Faro (Algarve, Southern Portugal) on a flat sandy bottom (Fig. 1). These sediments range from coarse sand