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Recruitment of benthic organisms onto a planned artificial reef: shifts in community structure one decade post-deployment

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Abstract

Most artificial reef (AR) studies have examined the early colonization stages of benthic communities, while only a few have monitored the development of AR communities beyond the initial successional phases and evaluated the time scale needed for such development. In addition, despite the proliferation of AR studies, comparative studies between artificial and natural reefs (NRs) are scarce. We present here the monitoring results of initial (1–2 year) and progressed (10 year) stages of the developing benthic communities of a purpose-planned AR submerged at Eilat, Israel (Red Sea), and compare them to its adjacent NR. Visual surveys of macro-invertebrates were conducted on the initial stages and coral communities were characterized at the progressed stage, using belt transects. The results demonstrate a distinct shift in species composition of the AR communities along the monitoring periods: from a soft coral dominated community, comprised mainly of *Dendronephthya hemprichi*, in initial developmental stages of up to two years post-deployment, to a community dominated by the sponge *Crella cyatophora* at year 10. Distinct differences in coral species count, living cover and diversity were found between the AR and its neighboring NR. We estimate the time frame required to develop a progressed diverse AR community to be well over a decade, even in tropical ecosystems. The factors shaping the species composition of purpose-designed ARs in a coral reef environment, including structural design, spatial orientation, depth and age, are discussed.

Keywords: Planned artificial reefs; Community shift; Coral reefs; Colonization; Biodiversity; Red Sea

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1. Introduction

The historical use of artificial reefs (ARs) in fisheries has been expanded to include control of beach erosion, mitigation of detrimental impacts on habitats, conservation of biodiversity and to test ecological theories (Baine, 2001; Seaman & Jensen, 2000). 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 & Hixon, 1997). One of the reasons for the poor understanding of the ecology of ARs is the lack of knowledge of their effect on their surrounding natural environment (Sheng, 2000; Svane & Petersen, 2001). Hence, it is of prime importance to engage in comparative studies between artificial and natural reefs (NRs) (Perkol-Finkel & Benayahu, 2004; Rilov & Benayahu, 2000; Svane & Petersen, 2001).

Unplanned ARs, such as sunken ships, oil and gas platforms and breakwaters, offer substratum for settlement of benthic invertebrates and fish. This type of AR is common worldwide and can be considered as a natural experiment in community development on ARs, accessible for monitoring (e.g., Perkol-Finkel & Benayahu, 2004; Rilov & Benayahu, 2000; Wendt, Knott, & Van Dolah, 1989). Another type of AR is that of a designed structure, pre-planned for this function, and with the advantages of being a means for creating carefully planned habitats, integrating biology and engineering (Bohnsack, Johnson, & Ambrose, 1991). Nowadays, most ARs are purpose-planned structures, built according to accepted principles of safety, durability and effectiveness (Baine, 2001; CARPG, 1998; Seaman & Jensen, 2000).

When designing ARs several factors should be taken into consideration, including type of materials (reviewed in Baine, 2001), size and orientation (e.g., Oren & Benayahu, 1997; Rilov & Benayahu, 2000), and complexity and durability (Connell & Jones, 1991). The environmental factors to be considered when positioning an AR should include geographical location, surrounding substratum, proximity to natural habitats, depth and water conditions in the area of deployment (Sheng, 2000). Furthermore, different designs of ARs may offer an array of particular environmental conditions, such as light and current regimes or sedimentation load, that may influence recruitment onto the ARs (Abelson & Denny, 1997). Only purpose-planned ARs can offer a specific design that, according to their primary goals, will produce maximum yield, making them a potential tool to examine species' response to different conditions and to test ecological theories (Bohnsack, Ecklund, & Szmant, 1997; Connell & Slatyer, 1977). The application of planned ARs for conservation and restoration of marine habitats, including coral reefs, has greatly increased over the years (Clark & Edwards, 1999; Pickering, Whitmarsh, & Jensen, 1998). However, an assessment of their performances indicates that many do not meet their goals (reviewed in Baine, 2001).

Several studies have examined early stages of colonization of ARs (Bailey-Brock, 1989; Cummings, 1994; Palmer-Zwahlen & Aseltine, 1994). These stages follow the inhibition model of succession as suggested by Connell and Slatyer (1977), in which initial settlers dominate the substratum, thus delaying the