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Low-crested coastal defence structures as artificial habitats for marine life: Using ecological criteria in design

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Abstract

Coastal defence structures to protect sedimentary coastlines from erosion and flooding are increasingly common throughout Europe. They will become more widespread over the next 10–30 years in response to rising and stormier seas and accelerating economic development of the coastal zone. Building coastal defences results in the loss and fragmentation of sedimentary habitats and their replacement by artificial rocky habitats that become colonised by algae and marine animals. The engineering design and construction of these structures have received considerable attention. However, the ecological consequences of coastal defences have been less extensively investigated. Furthermore, due to their rapid proliferation, there is a growing need to understand the role of these man-made habitats in the coastal ecosystems in order to implement impact minimisation and/or mitigation measures.

As part of the DELOS project, targeted studies were carried out throughout Europe to assess the ecological similarity of low-crested coastal defence structures (LCS) to natural rocky shores and to investigate the influence of LCS design features on the colonising marine epibiota. LCSs can be considered as a relatively poor surrogate of natural rocky shores. Epibiotic communities were qualitatively similar to those on natural rocky shores as both habitats are regulated by the same physical and biological factors. However, there were quantitative differences in the diversity and abundance of epibiota on artificial structures. Typically, epibiotic assemblages were less diverse than rocky shore communities. Also, LCSs offered less

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structurally complex habitats for colonisation and in some locations experienced higher disturbance than natural shores. We propose several criteria that can be integrated into the design and construction of LCSs to minimise ecological impacts and allow targeted management of diversity and natural living resources.

Keywords: Coastal defences; Rocky shores; LCS design; Benthic communities; Biodiversity; Habitat complexity; Disturbance

1. Introduction

The coasts of Europe and many other parts in the world are increasingly threatened by erosion and flooding, mainly due to sea level rise and greater storminess associated with climate change (IPCC, 2001a,b; Holman et al., 2002; Hulme et al., 2002). The need for coastal protection has therefore increased, particularly in developed areas. In the south of Europe tourism and other coastal recreational activities are often an additional driver for building coastal defence structures (e.g. to enhance sandy beaches or protect marinas). As a result, an increasing number of hard defence structures have been and are being built, as a rapid and cost-effective means of coastal protection. These consist of seawalls, jetties, offshore breakwaters and rock groynes. For example, in England 23% of eroding coastlines are already modified by man-made structures (MAFF, 1994) and this proportion is certain to increase in the near future, especially on the southern and eastern coasts which are most susceptible to sea level rise.

The proliferation of coastal defences has transformed sections of naturally dynamic, erosive and depositional soft-shores coastlines into artificially static, hard-substrates. These are colonised by epibiotic organisms such as algae and sessile marine invertebrates that are commonly found on natural rocky habitats as well as providing refuges and nursery grounds for fish and crustaceans (Duffy-Anderson et al., 2003). The epibiota of man-made coastal defence structures, has received little attention (but see Moore, 1939; Southward and Orton, 1954; Hawkins et al., 1983) until the last decade or so (Johannesson and Warmoes, 1990; Hawkins and Cashmore, 1993; Connell and Glasby, 1999; Bulleri et al., 2000; Connell, 2000; Russell, 2000; Chapman, 2003), including studies of shore parallel, low crested structures (e.g. Davis et al., 2002; Bacchiocchi and Airoldi, 2003).

The overall aim of this paper is to assess the extent to which the design of shore-parallel, low crested coastal defence structures (LCS) influences the abundance and composition of colonising epibiota. Studies were made on several shore-parallel LCSs located in Spain, Italy, Denmark and UK. Our specific objectives were: 1) to compare the abundance and composition of epibiotic assemblages with natural rocky shore communities; 2) to examine at a local scale the effect of selected LCS design features such as orientation, tidal elevation, surface and habitat complexity; 3) to synthesise results from DELOS with existing knowledge on rocky shores to identify the major natural processes determining distribution, abundance and diversity of epibiota; 4) to suggest simple qualitative design rules that minimise and mitigate the ecological impacts of LCS. Thus our paper seeks to inform engineers, coastal planners and other stakeholders to enable management of diversity and natural resources and sustainable development of coasts.

This overview paper is intended to inform a non-ecological target audience and summarises a diverse array of work which is being reported in more detail elsewhere (see www.delos.unibo.it). Subsets of data have been used to illustrate specific points of interest to the general reader. Extensive referencing has been used throughout, to provide access to key literature on this complex multidisciplinary topic.

2. Material and methods

2.1. Study sites and general methodological approach

Several coastal defence schemes were investigated in Italy, Spain, UK and Denmark. In this paper we show results from studies carried out on selected sites (summarised in Table 1). Unless otherwise stated, the coastal defence schemes considered consisted of shore-parallel, low-crested structures (LCS). Epibiotic