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# COMMENT

## The introduction of artificial structures on marine soft- and hard-bottoms: ecological implications of epibiota

Artificial structures, such as seawalls, breakwaters, jetties, pontoons and pier pilings are becoming ubiquitous features of landscape in shallow coastal waters of urbanized areas. Nonetheless, few published studies have focused on their ecology and little effort has been devoted to determine how the various objectives (economic, social and ecological) involved in their introduction into natural systems can be reconciled.

These structures provide suitable substrata for a variety of epibenthic organisms, including macroalgae, invertebrates and fish (Bohnsack & Sutherland 1985; Connell & Glasby 1999; Davis *et al*. 2002; Bacchiocchi & Airoldi 2003; Chapman & Bulleri 2003; Bulleri & Chapman 2004). Since their primary objective is not to attract particular target species, there is, in general, no a priori expectation as to which assemblages should or should not become established on the new surfaces. The ecological value and implications for biodiversity of these epibenthic assemblages (at local and regional scales) depend on the type of natural habitat(s) mostly affected. Specifically, they will vary between the case in which artificial structures are deployed on hard-bottoms or soft-bottoms. Distinguishing between the two scenarios could, therefore, be key to avoiding the misinterpretation of the value of epibiota occurring on artificial structures by decision-makers and stakeholders.

Independently from the amount of habitat lost, when artificial structures are deployed on hard-bottoms, the extent to which they resemble adjacent natural rocky habitats can be assessed by comparing the assemblages they support (Connell & Glasby 1999; Chapman & Bulleri 2003; Bulleri & Chapman 2004). Promoting the establishment of assemblages that are as similar as possible to those occurring on adjacent natural rocky substrata could be effective at reducing the impacts of these structures. Indeed, if artificial structures support assemblages and ecological processes similar to those of adjacent rocky shores, despite the visual impact, there would be little evidence of real loss or fragmentation of natural habitats.

In contrast, when artificial structures are deployed in soft-bottoms that lack natural hard substrata, there is no natural reference condition for the epibiota. Hence, the occurrence of hard-bottom assemblages within sandy or muddy areas is influenced more by public or economic objectives than scientific criteria (i.e. minimizing changes to patterns of distribution of organisms). Depending on the local context, we could wish to enhance the establishment of particular taxa, because they can be harvested for food (for example mussels, oysters, crabs), are of interest for recreational fishing or more attractive and charismatic than soft-bottom species. Alternatively, we may wish to prevent the colonization of artificial structures by certain species that are detrimental to economic and recreational activities (for example algal wrack).

Although social and economic demands are legitimate components of the sustainable development of coastal areas, they should be reconciled with the need to reduce environmental impacts. Claiming that artificial structures, by attracting new species, can enhance local biodiversity is a pitfall to be avoided. The validity of increases in diversity of species and complexity of processes is context-dependent and is not necessarily desirable (Connell & Glasby 1999; Challinor 2003). The attraction of a suite of hard-bottom taxa within a sandy area, unless specifically planned (for example for rehabilitation of impoverished areas, compensation for loss of habitat, conservation of endangered species), does not mitigate *per se* the impacts of the introduction of the artificial structures. Furthermore, if, on the one hand, the introduction of artificial structures can enhance the amenity value of a stretch of shore (for example for diving, snorkelling, fishing), it can, on the other, contribute to the decline of barriers isolating distinct regions, by enabling dispersal of larvae and propagules beyond the limits set by the availability of natural rocky substrata. Preventing epibiota from colonizing artificial structures introduced to soft-bottoms would be effective in preserving natural patterns of biodiversity, but that is obviously unfeasible. Our efforts could, therefore, be directed at minimizing the changes to patterns of distribution of organisms. For instance, enabling the development of assemblages similar to those occurring on the closest natural rocky reefs (Edwards & Smith 2005) could contribute to reducing alterations of biodiversity, although unlikely to mitigate the changes to assemblages living in nearby sediments. It could do this in at least two different ways. Firstly, artificial structures would not alter patterns of distribution of hard-bottom species, at least at the larger (regional) spatial scales. Secondly, artificial structures could function as surrogates of natural rocky habitats, thereby not constituting habitats of their own, with 'artificial' patterns and processes. Carr and Hixon (1997) have stressed the importance of comparing assemblages between natural and artificial reefs, but, in their case, this was aimed at assessing the performance of artificial reefs in relation to the objectives for which they were built (such as provision of habitat for target species), rather than reducing alterations to biodiversity.

Depending on the local context, an environmental impact assessment (EIA) can be required for coastal infrastructures such as those targeted in the present paper (for example, in Europe, those listed under Annexes I and II of the EC Directive 85/337/EEC, as emended by EC Directive 97/11/EC). Efforts to detect the ecological impacts of artificial structures have been, however, mostly directed toward pre-existing assemblages of organisms (such as those living on the surface and inside the matrix of sediments; Davis *et al*. 1982; Ambrose & Anderson 1990), whilst little consideration has been given to the epibiota developing on the new surfaces. At present, the need to achieve the specific objectives of the coastal development for which the structure is built generally determines the design and engineering of the structure, such as the nature of the substratum, size and shape of modules (blocks, boulders, poles) and their spatial arrangement. The response of the associated epibenthic assemblages to alternative options should, instead, be considered a key issue in the planning and design of these structures. Until recently, research efforts targeting the design of artificial reefs and their functioning as natural habitats have been confined to the field of habitat/ecosystem restoration, in order to mitigate the effects of intense fishing on overexploited commercial species (Ambrose 1994; Carr & Hixon 1997), or to enhance the general biodiversity of impoverished areas

(Carter *et al*. 1985). These could be extended to the mitigation of the impact of artificial structures built for other purposes (such as coastal development and protection). Following predictions of global climate change, such as increased frequency and intensity of storms and rise in sea level (Carter & Draper 1988; Cabanes *et al*. 2001), the use of artificial structures as a tool for coastal defence is set to increase further. Understanding the mechanisms regulating patterns of abundance and distribution of organisms in artificial habitats will enable the improvement of their design, so that they will mimic more closely natural rocky habitats. Achieving this goal could contribute to preserving patterns of biodiversity at local and regional scales.

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