ELSEVIER

Journal of Experimental Marine Biology and Ecology 338 (2006) 164 – 178

Journal of EXPERIMENTAL MARINE BIOLOGY AND ECOLOGY

www.elsevier.com/locate/jembe

Experiments testing the use of waste material in estuaries as habitat for subtidal organisms

M.G. Chapman *, B.G. Clynick

Centre for Research on Ecological Impacts of Coastal Cities, Marine Ecology Laboratories A11, University of Sydney, NSW 2006, Australia

Accepted 14 June 2006

Abstract

In addition to producing extensive coastal infrastructure, urbanized estuaries are also often littered with large amounts of waste material. This can be used as habitat by fish and benthic plants and animals. Apart from studies of colonization of artificial reefs, which are usually deployed specifically to enhance populations of fish or to replace degraded habitat, there have been few studies that have specifically examined the use of waste material as habitat. Neither have previous studies compared different types of waste material that one characteristically finds in urbanized estuaries, nor the use of small patches of habitat typically created by waste. Spatial comparisons of species found on previously dumped artificial material may be confounded by the fact that different types of waste may be dumped in different places, or may be of different age. This study built small patch reefs of three different types of widespread waste material (tyres, wood or metal) and compared colonization of these over 19 months to colonization of patch reefs of similar age and size made from natural sandstone. Algal assemblages were similar among the different types of reefs, with all showing more cover and diversity on horizontal surfaces. Invertebrates similarly showed few differences among reefs, although there was greater diversity, primarily due to bryozoans, on the vertical surfaces of wooden reefs. Fish rapidly colonized and used all reefs, with cryptic species showing no differences among types of reefs. Schooling species were, however, more common on all of the waste reefs than on the natural sandstone reefs. Small patches of waste material dumped in estuaries can therefore provide useable habitat for a wide range of estuarine organisms and may form a valuable resource if natural habitats continue to be degraded or lost. Although we are not advocating that rubbish simply be discarded into estuaries with the excuse that it provides habitat, removal of existing rubbish should be considered in terms of multiple changes and disturbances to the environment.

Keywords: Artificial reefs; Benthos; Colonization; Environmental impact; Estuaries; Experimental; Fish; Management; Restoration

1. Introduction

Many marine organisms can persist in urbanized waterways where natural habitat is extensively replaced or augmented by urban structures (Able et al., 1999; Attrill et al., 1999; Connell and Glasby, 1999; Glasby and Connell, 1999; Thompson et al., 2002; Chapman et al., in press). In particular, the large array of hard surfaces supplied by artificial structures such as marinas, jetties and seawalls provide substrata for many intertidal and subtidal benthic organisms (e.g. Connell and Glasby, 1999; Glasby, 1999a; Glasby and Connell, 1999; Chapman and Bulleri, 2003; Bulleri and Chapman, 2004; Bulleri et al., 2005). Fish are also commonly associated with infrastructure, such as wharves and marinas (Bohnsack and Sutherland, 1985; Hair and Bell, 1982; Rilov and Benayahu, 2000). Recent research has focused on understanding the role of artificial habitats in maintaining biodiversity in urban environments (Savard et al., 2000; Bulleri, 2005; Sandström et al.,

* Corresponding author. Tel: +61 2 9351 4778; fax: +61 2 9351 6713.
E-mail address: gee@bio.usyd.edu.au (M.G. Chapman).

0022-0981/$ - see front matter © 2006 Published by Elsevier B.V.
doi:10.1016/j.jembe.2006.06.018

2006). Ecologists and environmental managers need to consider the value of artificial structures as habitat in order to make ecologically sensitive decisions about managing urbanized estuaries.

In addition to the large array of built infrastructure, urbanized estuaries are often littered with large amounts of material which has been dumped, intentionally or accidentally, into the water. This "rubbish" tends to increase over time, producing complex physical structures. Not unlike larger urban developments (Attrill et al., 1999; Glasby and Connell, 1999; Chapman and Bulleri, 2003; Bulleri, 2005), dumped material, such as car-bodies and tyres, can change the structure of coastal habitats, by adding novel hard substrata, often into areas that are otherwise sandy or muddy. This has the potential to affect local assemblages of organisms that live on and around hard substrata, especially if these habitats are not utilized in the same way as are natural habitats. There is, however, little documented information about the use of this form of urbanized waste as habitat for estuarine organisms.

Although out of sight, dumped waste is nevertheless often considered a potential environmental impact and the material is frequently removed (e.g. on Clean-Up Australia Day). Removing rubbish may remove habitat and/or impose additional environmental impacts by the process of removal itself (Foster et al., 1990). Before advice can be given about whether the artificial habitat created by discarded rubbish should be left or removed, it is important to determine whether it is having an impact. For example, not all contamination is pollution; one must distinguish between the presence of a contaminant and its ecological effects (GESAMP, 1994). Similarly, if waste material provides very similar habitat to natural reefs, then a different level of justification may be needed for removing it, compared to the situation where it provides very different habitat (e.g. supports non-indigenous species, or very large abundances of only a few species).

In many parts of the world, waste material, such as tyres and car-bodies, has been used to build artificial reefs, often specifically to attract fish (e.g. Bohnsack and Sutherland, 1985; Pollard, 1989; Grossman et al., 1997). Tyres have also been used as a cheap form of construction, such as building breakwaters and retaining walls, which is justified on the grounds that it reduces waste while creating essential infrastructure. Published information on the effects of waste materials when used to create purposefully-built habitat has almost solely been focused on fish assemblages, largely because the construction of the reefs is justified in terms of fish-enhancement (Bohnsack and Sutherland, 1985; Svane and Petersen, 2001). Relatively few studies have compared different types of materials that are used to construct such habitats in terms of the epibiota that live on them. For example, in Baine's (2001) review of 249 studies of artificial reefs, only four tested for the effects of the material used to construct the reefs on the epibenthos colonizing those reefs and, generally, studies of the epibenthos have been incidental to the main focus of the fish populations. Similarly, Buckley and Hueckel (1985) examined colonization of concrete reefs by invertebrates, but they were concerned about these organisms in terms of their value as food for fish.

Many studies on artificial reefs, especially those built using unnatural material, have included concrete (e.g. Walker et al., 2002; reviewed by Baine, 2001) as the base material because its is relatively cheap and robust. In Sydney Harbour, concrete is widely used for infrastructure. The effects of concrete on subtidal epibenthos have been examined in a study of a range of artificial structures in Sydney Harbour (Connell and Glasby, 1999) and for fouling assemblages (e.g. Anderson and Underwood, 1994; Falace and Bressan, 2002). Nevertheless, most of the discarded rubbish found in Sydney Harbour is not concrete, but is composed of tyres, wood, various forms of metal and small items, such as bottles and plastic. This material is most common in disturbed parts of the harbour, particularly adjacent to wharves and associated with jetties and boating.

Previous surveys indicated that there was considerable diversity of algae and invertebrates associated with dumped material (Chapman, unpublished data) and that fish were common and diverse around wharves containing a lot of rubbish (Clynick, unpublished data). One problem that arose when trying to interpret differences among assemblages associated with previously dumped material, was the lack of data about the time when different types of rubbish had been dumped. Any differences associated with patches of different types of waste material were potentially confounded with the time available for colonization. In addition, many patches of waste material were jumbles of mixed material, making it difficult to determine which species were associated with which material. Alternatively, different types of waste had been dumped in different places, spatially confounding any comparisons of the type of waste (Hurlbert, 1984).

To evaluate the use of rubbish as habitat, assemblages living on waste material need to be compared to those on natural substrata. Despite its prevalence in some places, patches of dumped rubbish in the Harbour are generally quite small (<10 m in extent) and do not form extensive "reefs". Natural reefs, in contrast, are continuous and quite extensive. Comparing assemblages on small isolated patches of artificial habitat to