HABITAT DEVELOPMENT ALONG A HIGHLY URBANISED FORESHORE

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Abstract

The introduction of foreshore armouring, such as seawall structures, transforms the nature of the intertidal environment, replacing biologically diverse natural foreshore habitats with featureless, species poor artificial structures. This alteration away from natural intertidal systems results in reduced marine species diversity and abundance.

Utilising intertidal enhancement research and the 2009 NSW Office of Environment and Heritage released Environmentally Friendly Seawall Guide; Kogarah City Council has developed a number of foreshore habitat enhancement projects to supplement existing foreshore areas and improve biodiversity.

Dover Park East foreshore, Kogarah Bay, NSW was a major Council enhancement project completed in July 2012. This project involved the removal of the existing low habitat seawall, and construction of an environmentally friendly seawall focused on emulating the habitat variation present on a natural rocky foreshore. This innovative seawall includes constructed rockpools at varying intertidal levels and lower foreshore gradients to develop a habitat range for intertidal organisms present on natural foreshores. Since its' construction in July 2012, over twenty five species of aquatic flora and fauna have progressively established themselves along the Dover Park foreshore. This is a major increase in biodiversity from the seven species identified along the foreshore prior to habitat enhancement.

Due to the structural integrity of most seawalls within the Kogarah local government area, Council's capacity to perform intertidal habitat development relies on the enhancement of existing seawalls or waiting for a seawall to require reconstruction. The aims of these projects are to create diverse intertidal habitats allowing the migration of organisms along the Georges River, improving intertidal biodiversity throughout the estuarine environment.

Impacts of Seawalls

The progressive urbanisation and transformation of marine and estuarine shorelines in response to commercial, residential and infrastructure demands, has resulted in extensive modification of natural foreshores. Seawalls are the least complex of armouring structures due to their typically smooth vertical design. Seawalls support fewer taxa than natural rocky shorelines as the seawalls are designed and built using engineering, heritage, aesthetic and financial criteria. As such these walls lack habitats found on natural shores they have replaced (Bachiocchi & Airoldi 2003; Chapman 2003; Chapman & Bulleri 2003; Bulleri & Chapman, 2004; Bulleri et al. 2004; Bulleri 2005; Bulleri & Chapman 2010; Goff 2010). A lack of habitat heterogeneity and complexity associated with slope, rugosity, crevices, overhangs and pooling alters natural processes including recruitment, colonization, survival, population densities, fecundity and species interaction, resulting in fewer native intertidal animals and plants (Branch 1986; Farrell 1988; Farrell 1991; Chapman & Bulleri 2003; Bulleri et al. 2004; Goff 2010).

Intertidal surface area is another difference between seawalls and natural foreshores (Little & Kitching 1996; Raffaelli & Hawkins 1996; Goff, 2010). In NSW, vertical seawalls have a compressed intertidal area (1-2m) in comparison to naturally sloping shores (>10m) (Bulleri et al. 2004; Moreira et al. 2006; Jackson et al. 2008; Chapman 2009; Bulleri & Chapman 2010). This truncation of intertidal habitat changes the interactions between organisms (Jackson et al. 2008; Ivesa et al. 2010; Klein et al. 2011).

A consequence of the structural variation between natural and armoured foreshore is that, the ecological assemblage of constructed foreshores differs to that along natural foreshores. Recent research has focused on these differences, identifying that although seawalls may provide habitat for some species, larger mobile intertidal species are more greatly impacted than sessile species, while those that are able to inhabit these areas may be genetically less diverse, and have lower growth and fecundity rates (Thompson et. al. 2002; Chapman 2003; Chapman & Blockley 2009; Bulleri & Chapman 2010; Browne & Chapman 2011). The expansion of urbanized foreshores has further ecological consequence through the disruption of population connectivity while developing migration corridors for invasive species, subsequently changing the intra- or interspecific interactions of intertidal organisms (Bulleri & Airoldi 2005; Ivesa et al. 2010; Browne & Chapman 2011).

The ecological complexity of foreshores will subsequently decline if existing natural foreshores continue to be urbanised and if improvements are not made to existing foreshore armouring structures.

Better Habitats on Seawalls

As identified, the key differences between armoured seawalls and natural foreshores include the slope (seawalls are vertical; rocky shores contain multiple slopes) and microhabitat availability (seawalls have very little; rocky shores contain many different types). This strong association between intertidal organism recruitment, survival, or dispersal and the complexity of foreshore topography has been researched (e.g. Chapman & Underwood 1994; Bulleri et al 2004; Ivesa et al 2011) resulting in the utilisation of “ecological engineering” to re-introduce complex foreshore habitats (Chapman 2003; Moreira et al. 2006; Chapman & Blockey 2009; Browne & Chapman 2011; Chapman & Underwood 2011).

The ecological benefits of increasing the heterogeneity and complexity of structures such as seawalls are well documented (Glasby & Connell 1999; Chapman & Bulleri 2003; Bulleri et al. 2004; Moreira et al. 2006; Jackson et al. 2008; Bulleri & Chapman 2010; Goff 2010). Seawall enhancement has been examined in recent research (Moreira et al. 2006; Moreira et al. 2007; Chapman & Blockley 2009; Chapman & Underwood 2011; Browne & Chapman 2011) suggesting that the scarcity of many mobile animals on seawalls is caused by a lack of microhabitats that retain water and provide refuge. These observations relate to the environmental stresses during low tide or inclement weather.

The most obvious “missing” habitats on many seawalls are those which provide shelter from the effects of emersion (Chapman & Blockley 2009). Intertidal rock-pools are an important feature of natural shores, providing habitat for specialist intertidal fauna and flora, but also a refuge during times of stress for many other species that also use the surrounding rock-platform. Intertidal ecological engineering research (e.g. Chapman & Blockley 2009; Chapman & Underwood 2011; Browne & Chapman 2011) suggests that intertidal seawalls may be improved by including artificial rock pools that retain water

during low tide; and constructing seawalls with gentle slopes or a combination of horizontal and vertical surfaces.

The Environmentally Friendly Seawall Guide (2009), along with research from Chapman & Blockey (2009), and Browne & Chapman (2011) represents the majority of on ground seawall habitat enhancement research projects performed within New South Wales. These projects examine the development of armouring structures as valuable habitat for species whose natural rocky habitat may have been lost during infrastructure development, or other anthropogenic disturbances. This included the construction of a vertical seawall incorporating experimental rockpools which retain water at low tide (Chapman & Blockey 2009), and the enhancement of existing seawalls through the installation of experimental pots to similarly retain water (Browne & Chapman 2011) demonstrating changes in seawall assemblages. Within a year of construction or installation, the experimental rockpool systems had a major effect on intertidal diversity by increasing the number of algae and animal species living on the new seawall or within the pot structures. Many of these newly recruited species are not found on unmodified intertidal seawalls due to habitat or immersion limitations; and therefore the re-introduction of such habitats has initiated recruitment.

Both ecologically engineered rockpool systems demonstrated improvements in foreshore biodiversity associated with the capacity for immersion at low tide. It is, however, also clear that simply providing physical structure that attempts to mimic natural habitat is, in itself, inadequate to ensure colonization by a full range of species. Chapman and Blockey (2009) identified that it was not possible to build habitats that exactly mimicked natural pools because natural foreshores are surrounded by gently sloping rock-platforms, which support many species that may use pools at times of stress. Natural pools are also not generally shaded, whereas these engineered habitats were frequently shaded due to their presence on vertical seawalls.

While these projects illustrate the benefits of water retention on constructed seawalls, the infrastructure demand for vertical seawalls, associated with the value for property, limited the ability to alter foreshore slope. Kogarah City Council had the capacity to incorporate both slope and water retention in a seawall construction project undertaken in 2012 at Dover Park East. Research is ongoing to examine the benefits of both habitat enhancements in one seawall structure.

Kogarah Foreshore

Approximately 13% of the foreshore within the Kogarah City Council (KCC), local government area (LGA) is naturally rocky shoreline. These areas present the highest intertidal biodiversity and species abundance present along the Georges River prior to urbanisation. Although the rest of the Kogarah foreshore is developed and armoured, only a small proportion (approximately 6%) of the urbanised foreshore is owned and maintained by Council. Consequently, Council's attempts to increase intertidal habitat and promote ecological improvements along the Georges River are most effective at sites owned by Council.

Due to the structural integrity of most seawalls within the KCC LGA, Council's capacity to perform intertidal habitat development relies on the enhancement of existing seawalls or waiting for a seawall to require reconstruction.

Council's recent intertidal habitat improvement program has resulted in the collaborative installation of 30 experimental pots on Sans Souci Park seawall to retain water as

introduced by Browne & Chapman (2011). An ongoing sampling program is being performed to examine the influence of this rockpool habitat introduction on the existing seawall along the Georges River. It is the belief that this engineered enhancement could serve the same function as rockpools on the adjacent natural rocky foreshore, improving local diversity through the re-introduction of specialist species that utilise pools for shelter during low tides. Habitat enhancement along the seawall at Sans Souci Park is a central focus to council's foreshore program due to its location at the mouth of the Georges River and association with Botany Bay (Map 1). The creation of a diverse intertidal habitat on the Sans Souci Seawall may result in the pelagic migration of organisms into the Georges River with establishment along the Kogarah foreshore. Observed changes include an increase in biodiversity within the mid-shore and high-shore areas. Further research is required however, prior to any seawall conclusions being drawn. KCC is committed to an ongoing sampling program to assist this outcome.

Dover Park East foreshore improvement is KCC's major enhancement project completed in July 2012. Dover Park East is located in Blakehurst, along the south western foreshore of Kogarah Bay (estuarine bay on the Georges River) (Map 1). The locality is subject to extensive urban development, with residential and commercial/industrial lands surrounding the foreshore. Residential developments with private boat ramps and jetties are located to the north and south of Dover Park. The park itself has extensive grassed areas with remnant bushland on the ridge away from the foreshore. The 'pre-work' foreshore consisted of a steeply sloping sandstone boulder ('rip-rap') seawall along the majority of the intertidal area with four concrete boat launching ramps (owned by Council and built in the 1970s) transecting the seawall.

Map 1. KCC seawall enhancement project locations

Quadrat sampling of intertidal ecology on the rip-rap seawall was performed as part the project's environmental impact assessment. The biodiversity of the seawall was identified in this analysis to be low, with the boulder seawall inhabited by seven invertebrate and three algal species. Although the boulder seawall provided greater habitat variation than a vertical seawall, including crevices and some slope, it lacked vertical platforms and low tide water retention as observed on natural rocky foreshores.

The Dover Park East foreshore improvement project involved the removal of the existing boulder seawall, and construction of an environmentally friendly seawall focused on emulating the habitat variation present on a natural rocky foreshore. This foreshore includes rockpools at varying intertidal levels, longer foreshore slopes, vertical platforms, boulders and crevices to develop a habitat range for all intertidal organisms originally present on Kogarah Bay natural rocky foreshores.

Three large rockpools were constructed along the foreshore, two at mid-shore tidal level (~1.0m and ~1.3m above chart datum) and one within the high tide level (~1.6m above chart datum). These pools were incorporated into a sloped loose rock seawall, with greater horizontal grade than the previous steep sloped boulder ball. The pools were constructed using large rectangular sandstone blocks which also provided horizontal surfaces within the seawall, and an industrial pond liner which enabled the retention of water at low tide. Due to the size of each pond (>2m^2) and the concern of deoxygenation and increased water temperatures during low tide emersion, the pools were constructed deeper than most natural rockpools examined. The deepest point of each rockpool is ~30cm, reducing the capacity for impacts on water quality during prolonged emersion of the foreshore. This is particularly the case for the high-shore rockpool which isn't completely immersed during all high tides. To mimic the shallow areas of rockpools, the bottom of each pool was finished with crushed sandstone with larger blocks and boulders installed to provide habitat, refuge and shallower areas. Some of the blocks had further cut outs and grooves added to provide greater refuge for fish and larger mobile invertebrate species.

Although ecological analysis of the new intertidal seawall is ongoing, and consequently results and conclusions cannot be developed, observable improvements in biodiversity have been identified. The retention of water during low tide has provided suitable habitat for Ascidians, Porifera, juvenile Fish, Algal and Invertebrate species previously not present on the Dover Park rip rap foreshore. The height differences between the mid-shore and high-shore rockpools also developed different assemblages. Sediment migration into the lower pools created a low tide aquatic habitat for crabs, worms and gudgeon fish species; while the sandstone base of the upper rockpool provided habitat for numerous juvenile fish species and other intertidal species. In total 25 species of flora and fauna were qualitatively sampled within the new seawall.

Further analysis is required prior to final conclusions being developed, however it is apparent that the construction of the new seawall has increased the biodiversity present on the intertidal foreshore of Dover Park East. These results mimic the observed improvements on the Sans Souci Park seawall, associated with the installed rockpool devices, demonstrating the influence of seawall enhancement on marine ecology. Artificial pools rely primarily on recruitment of juveniles and consequently diversity in these pools may increase over time as species recruitment and establishment occurs. These habitats will, however only sustain species in the long-term if adequate food supplies are present within the structures themselves, which may occur as they age, or they can get enough opportunities to forage on the surrounding foreshore without predation.

While restoration of the Kogarah intertidal foreshore to natural conditions is not an option in the urbanised area, council's seawall projects present a unique opportunity for cost effective ecological enhancement along a highly urbanised shoreline. Seawall enhancement could yield benefits to intertidal organisms and subsequently many recreationally significant fish species, resulting in increasing habitat, aesthetic, social, educational and cultural values of Georges River foreshore.

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