Eco-engineering of artificial coastal structures to reduce their impact on the surrounding environment

Urbane

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Front page image: Fish-tailed rock rubble groyne at West Shore, near Llandudno, North Wales

Eco-engineering of hard defence structures is advisable due to their potential adverse impacts on the natural environment

The construction of hard coastal defence structures such as breakwaters, groynes and seawalls may have multiple, negative impacts on the native environment:

1) *The addition of an artificial hard-substrata habitat to a soft-sedimentary environment.*

Rocky habitats support very different communities compared to soft sedimentary environments and may have been fully absent in the area before the construction of the defence structure. Also, the artificial hard structure may differ greatly to natural, rocky shores. The species assemblages that colonise artificial structures may thus be very different to both, soft sedimentary environments and natural rocky shores.

A natural, diverse boulder shore on the Isle of Man (left) compared to an artificial defence structure, a boulder breakwater at Rhos on Sea, Wales (right). The artificial defence structures supports very few species

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Further negative impacts include:

2) *Changes in the hydrodynamic regime in the soft-sedimentary environment from exposed to more sheltered conditions*

A change from exposed to sheltered conditions results in shifts in grain size distribution, particularly on the landward side of the defence structure. Fine sandy habitats will support very different species assemblages to coarse habitats. The construction of defence structures thus often changes infaunal species composition adjacent to the structure, due to changes in hydrodynamics. During the URBANE project, surveys along several studies have confirmed such impacts on infaunal community assemblages.

Sheltered - Landward

Exposed - Seaward

The landward sides of defence structures tend to accumulate fine sediments, whilst the seaward sides are usually characterised by an accumulation of coarse sediments.

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Further negative impacts include:

3) The accumulation of detrital material

Material produced by the fouling organisms that are growing on the hard structures and/or re-direction of detrital material produced elsewhere may accumulate on the soft sediment surrounding the structure. These accumulations rot, smell and can lead to large numbers of flies, negatively impacting the amenity value if the adjacent shoreline.

Detrital material such as macroalgae tend to accumulate around defence structures. This may negatively impact the infaunal communities underneath.

4) The facilitation of the introduction and spread of invasive non-native species

Hard structures can act as stepping stones for species that are not native to the surrounding environment and may have profound effects on the native biota.

Undaria pinnatifida

Crassostrea gigas

Sargassum muticum

Non-native species may proliferate on or in close proximity to the defence structures

Possibilities of eco-engineering of hard defence structure to minimise impacts on the surrounding communities

Changes in the design of coastal defence structures to reduce negative impacts on native communities are possible in an ecological and cost-effective manner:

1) Increase the porosity of the defence structure

This may reduce the changes in hydrodynamics and allow more natural flow conditions behind the structure, which in turn may lower impacts on the soft sediment communities. Of course, this option needs optimisation as more porous structures will also attenuate wave action to a lesser extent.

Plymouth Breakwater (Photo J. Jackson).

A boulder groyne

Possibilities of eco-engineering of hard defence structure to minimise impacts on the surrounding communities

Changes in the design of coastal defence structures to reduce negative impacts on native communities are possible in an ecological and cost-effective manner:

2) Use a combination of "soft" and "hard" engineering solutions

Soft engineering may provide an ecological solution in some areas. These include saltmarshes or biogenic reefs (e.g. oyster and mussel beds, or beds of reef-building tube worms). They may offer important coastal protection services as they break waves, retain sediment and reduce erosion in coastal areas. They may cement together semi-mobile cobbles and boulders.

Such soft engineering options may not be able to solely fulfil full coastal protection, but may in places be a suitable addition to hard structures. A combination may be the preferred coastal defence scheme, which would reduce impacts on soft sedimentary habitats by increasing shore stability and decreasing wave action.

The honeycomb worm Sabellaria alveolata may aid in coastal protection through the reduction of wave action and retain sediment in coastal areas.

Possibilities of eco-engineering of hard defence structure to minimise impacts on the surrounding communities

Changes in the design of coastal defence structures to reduce negative impacts on native communities are possible in an ecological and cost-effective manner:

3) *Add microhabitats for grazing molluscs to help reduce algal cover and detritus production*

When the defence schemes include hard defence structures, it is desirable to increase surface rugosity and microhabitat availability of the construction material. Pools, pits and crevices are often used as nursery areas by grazing molluscs that help to rapidly reduce algal cover, which in turn will decrease detritus production. This results in other secondary positive effects as it makes structures less slippery and therefore safer for amenity use. More information on how microhabitats can be incorporated during or after the construction phase can be found in the hard-structure illustrated guide (Firth et al. 2012).

Small pits are easily colonised by grazing molluscs such as the periwinkle Littorina saxatilis (left). Grazers may reduce algal cover and resultant detrital material on hard structures and their abundance can be easily enhanced through the provision of microhabitats. Pits can be drilled in breakwater blocks as in case of the Plymouth Breakwater (right) and will be colonised by many species (middle).

Possibilities of eco-engineering of hard defence structure to minimise impacts on the surrounding communities

Changes in the design of coastal defence structures to reduce negative impacts on native communities are possible in an ecological and cost-effective manner:

4) Enhancement of native species diversity to prevent proliferation of non-native species

Non-native algae and other opportunistic species often colonise breakwaters and the disturbed surrounding communities. Resistance of a community towards the invasion by non-native species can be increased if the colonisation of native species is encouraged. Again, this can be done through the incorporation of natural microhabitats. Similarly, reducing disturbance due to poorly planned or unnecessary maintenance activities would also reduce the likelihood of colonisation by non-native species. Gardening of native target species is another means to prevent the establishment of non-native species, as space on the structure would be pre-emptied by targeted species.

Native species typical for rocky shore communities (fucoids, mussels, limpets, barnacles etc.) may colonise the defence structure and thus prevent the establishment of non-native species.