

Nature-Enhanced Coastal Defence

Coastal urbanisation has led to a proliferation of seawalls that enclose reclaimed land and prevent coastal erosion. Biodiversity of the intertidal and shallow seas is reduced as these zones get eliminated. Increasing the height of seawalls is a common response to sea-level rise. Faced with this new long-term situation, consideration should be given to incorporating nature with coastal defence. This will improve the benefits of ecosystem services that coastal and marine biodiversity offer. It is a response that aligns with sustainable development.

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Defending the coastline against strong waves that cause erosion has conventionally been accomplished by constructing a solid wall or revetment. These hard structures commonly obliterate the intertidal zone as they provide an abrupt separation of the land that they retain and the sea on the other side. At the same time, breakwaters can be installed further offshore or extended seaward from land to reduce the full energy of waves breaking on shore. In nature, such protective functions are provided by coastal and marine habitats such as coral reef, seagrass and mangrove. This service is provided free of charge. A simple valuation of such a service is how much it would cost to construct a revetment, a necessary action if degraded habitats can no longer provide it. What is not factored in the valuation are all the other important services such as carbon sequestration, food production and nursery function that the habitats provide perpetually when adequately managed. These amount to many times more than what the revetment costs.

Coastal Biodiversity

The intertidal zone of natural shores is a highly challenging environment. Flora and fauna must adapt to the contrasting conditions as the area is subjected to cyclical high-tide submergence and low-tide exposure. Intertidal species must find ways to prevent themselves from being swept about by crashing waves of the incoming tide and also protect themselves from abrasion by tiny sand particles whizzing past in all directions. When exposed at low tide, they must prevent themselves from drying out and especially during the day, avoid heating from solar radiation. They also have to cope with marine predators at high tide and terrestrial predators at low tide. Despite these harsh conditions presented by the fluctuating tides, intertidal biodiversity flourishes because this interface between land and sea is constantly enriched with nutrients from both land and sea. At the same time, the shallow coastal waters receive abundant sunlight that drives primary productivity [Figure 1].



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Coastal Urbanisation

Conservation of coastal habitats will maximise the ecosystem benefits for people to enjoy. However rapid coastal urbanisation driven by economic expansion, population growth, poor coastal-use planning, and inadequate management of coastal habitats have resulted in the degradation of the coastal environment. Further pressure comes from the high proportion of the coastal population (living within 100km from the coast) in East Asia. The region's coastal population is above 80%, twice the world average.

The loss of coastal habitats has led to more exposed shores and coastal erosion, necessitating the construction of seawalls as a protective measure. Habitats were also buried under coastal land reclamation sites commonly armoured by seawalls. They are effective in protecting newly-formed shores from being washed away but the drastic conversion of the intertidal zone from a wide gentle-sloping shore to a narrow band of a steep solid wall effectively wiped out the potential for coastal habitats to develop. Attempts to increase biodiversity

on seawalls are limited to the restricted area of the seawall that remains submerged at low tide.

An emerging problem is the rise in sea level associated with climate change. This is a real problem especially for low-lying coastal areas and it is inevitable that coastal defence structures need to be raised sufficiently to prevent terrestrial flooding and disruption of coastal activities.

With higher seawalls becoming a common feature, it is time to consider seawalls that can also enhance coastal biodiversity. Structures on the seaward side of the seawall can be incorporated to mimic the lost intertidal area and help to re-establish habitats and biodiversity so that a return to ecosystem service provision is possible.

Just a wall or a Coastal Defence Nature zone?

Coastal biodiversity on seawalls develop best below or at the low-tide level where it is covered by water most of the time. The hard wall itself is not conducive to burrowing species common on natural intertidal

- 01 The intertidal zone supports rich biodiversity.
- 02 Seawall with a terrace.
- 03 Seawall with intertidal pools.



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shores. The limited area of this zone on walls can be increased if the wall is sloped or terraced compared to a vertical one [Figures 2, 3 & 4]. Efforts such as increasing the wall's surface rugosity can create microhabitats that favour colonisation by varied species. These interventions do improve seawall biodiversity but to a limited extent because of the restricted zone area.

To break out of this restricted zone, we need to look at how to make the upper and drier zone of the seawall, at least up to the high neap tide level, capable of supporting biodiversity. One way is to incorporate tidal pools on the

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seaward side of seawalls [Figure 5]. On natural shores, tidal pools left by the receding tide support species including fish that cannot withstand exposure. A series of tidal pools of different sizes can be constructed up the seawall such that they are fully covered by high neap tides which allow free movement of mobile species and adequate exchange of water. As the tide subsides, these pools retain water and active swimming species until the next high tide twelve hours later. These pools should be sufficiently deep to prevent heating of the trapped water during the day and they should be positioned at different heights on the seawall, similar to terraced rice paddies.

On a more ambitious scale, the size of these pools can be increased so that they function as small lagoons. Storm-water discharge with terrestrial sediment can be diverted to lagoons where mangroves can be planted. Adjacent lagoons can be used to develop seagrass or coral reef habitats. The bottom of these lagoons can be raised so that the developing habitats can keep pace with



- 04 Bringing people closer to marine life beyond seawalls.
- 05 The coral *Echinopora lamellosa* growing on a 1 x 1 m raised platform. Reached 1m diameter from 5cm diameter fragment after 3 years.



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the rate of sea-level rise. Reef restoration techniques can be applied to tidal pools and lagoons and marine biodiversity can be promoted with artificial structures such as floating rafts or tables raised off the bottom [Figure 5].

A coastal defence nature zone entails a greater encroachment of sea space as we are no longer planning a single sloped wall, but an entire area depending on how large the intertidal pools and lagoons will be. This opens up all kinds of opportunities as some of the lagoons can be designed for aquaculture use or managed fishery or to bring people closer to nature [Figure 4]. Enhancing coastal defence with nature is a response that ensures the benefit of ecosystem services. This includes additional protection external of the seawall. Most of all, the nature-enhanced coastal defence is a proactive way to address Sustainable Development Goal 14 (Life below water). 