

Eco-engineering and restoration of coastal habitats in Australia



A shellfish reef breakwater for erosion control at Portarlington, Port Phillip Bay (Image: Ralph Roob)

> Globally, coastal habitats that include saltmarsh, mangroves, seagrass, shellfish and coral reefs have suffered significant declines.

> This decline in coastal habitats results in a loss of important ecosystem services, such as biodiversity provision, water purification, carbon filtration and coastal defence.

> Nature-based coastal defence is the creation or restoration of coastal habitats through hybrid and soft ecological engineering to recover shoreline protection services along with other ecosystem services.

Nature-based coastal defence is also referred to as ‘nature-based features’ or ‘living shorelines’ in the United States, or ‘building with nature’ in Europe.

Climate change is increasing the risk of erosion and flooding through drivers that include accelerating sea level rise, changing wave climate, and potentially more frequent storm events. Coupled with this changing climate is an increase in global population along the coast, which will increase exposure of people to existing and future coastal hazards. Climate change and coastal urbanisation is therefore driving

an increased need for investment in coastal defence infrastructure to protect coastal assets.

Artificial structures, such as seawalls and breakwaters, are commonly used for coastal protection. These coastal defence structures result in a loss of native biodiversity as they replace natural shorelines with a lower-quality habitat for marine species. In addition to the ecological impacts, these structures are non-adaptive as they must be

rebuilt, upgraded and maintained in response to a changing climate at a significant economic cost.

Researchers at the National Centre for Coasts and Climate (NCCC) in the Earth Systems and Climate Change Hub are working on ways to develop more sustainable and adaptive methods to protect the coast through applying nature-based solutions to build more climate resilient coastal communities.

Developing a nature-based coastal defence strategy in Australia

In some parts of Europe and the United States, nature-based coastal defence is increasingly being used in a variety of environmental conditions. For instance, in Chesapeake Bay, Virginia and Maryland, USA, soft (e.g., restored saltmarsh) and hybrid (e.g., saltmarsh with rock sills) eco-engineering techniques are used in low- to mid-energy wave conditions, respectively. Sand nourishment is used in the Netherlands to preserve beaches and dunes for protection in higher energy wave conditions. These nature-based techniques are supported by state and national policies.

Despite international precedence for the development of nature-based solutions as a cost-effective and sustainable approach to shoreline protection from erosion and flooding, they are not widely used in Australia, except for beach nourishment.

Key to their wider implementation is: (1) improved scientific knowledge; (2) effective governance; and (3) socio-economic acceptance.

We are working towards achieving this through the implementation of on-ground case studies to inform coastal management and government policy.



Oyster reef living shoreline using bagged shell in Virginia, US.

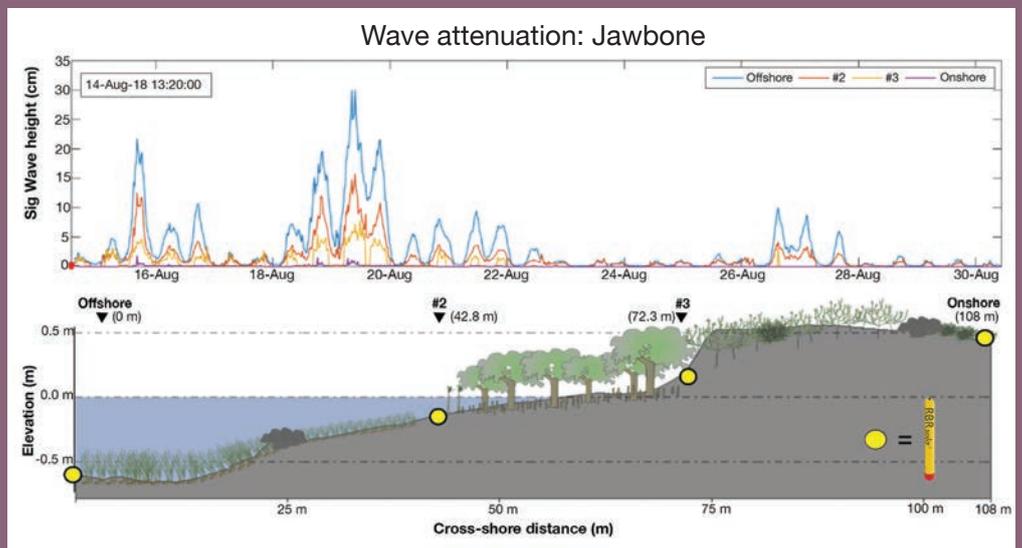


Examples of nature-based coastal defence. Soft ecological engineering techniques use natural elements only, such as the planting of saltmarsh (left image) or dune plants (right image). Hybrid ecological engineering techniques use a combination of hard and natural elements, such as rock sills in front of saltmarsh (middle image) or mangroves.

The role of natural habitats in coastal defence

Coastal vegetation, including seagrasses, mangroves and saltmarshes, can alter water flow and reduce waves through their three-dimensional structure. However, there is limited information about the extent of coastal protection provided by these habitats in temperate regions such as Victoria.

Preliminary results from six sites across Port Phillip Bay and Western Port Bay (three sites in each bay) suggest seagrasses, mangroves and saltmarshes can reduce wave height during the usual wave conditions experienced in the bay. However, in a similar study on subtidal kelp forests, we found that kelp had a negligible effect on wave attenuation.



A reduction in wave height (above) is seen as the wave passes through seagrass, mangroves and saltmarsh (below) at Jawbone Marine Sanctuary, Port Phillip Bay measured by wave sensors (yellow dots). (Data from Kelvin et al. University of Deakin/ The University of Melbourne/ Monash University).

Testing hybrid solutions in coastal protection

Sand volume – beach sector gain/loss



Effects of breakwaters seeded with mussels in retaining sand at Portarlinton, Victoria. (Data from Roob et al. The University of Melbourne/City of Greater Geelong Council).

Shellfish breakwater

We are using offshore breakwaters consisting of steel cages, filled with local rock, recycled shell and seeded with mussels to protect coastal residents in Portarlinton from persistent erosion and flooding.

Ongoing monitoring will be used to measure the success of these structures in reducing significant wave height and reducing shoreline erosion. Monitoring over the past 12 months has shown that sand has been gained behind the breakwaters, with a total net gain of 221 m³.

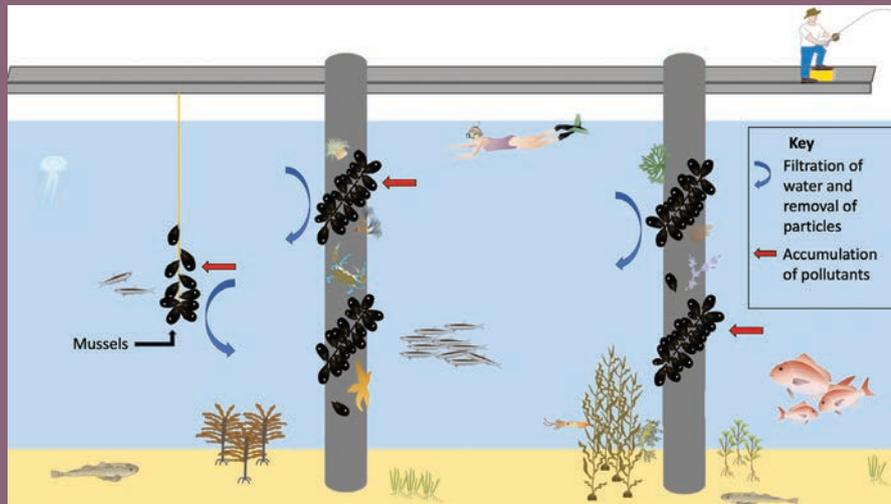
Hybrid mangroves

Custom-designed mangrove planters are being trialled in conjunction with mangrove plantings to provide erosion control in Altona, Grantville and Lang Lang in Port Phillip Bay and Western Port Bay. The mangrove planters are designed to improve the establishment of planted mangroves by reducing wave energy while the juvenile plants grow. We are monitoring these planters to measure the success of these structures in enhancing mangrove survival, reducing significant wave height and reducing shoreline erosion.



Mangrove pods for erosion control at Grantville, Victoria.

Testing hard ecological engineering



Effects of seeding mussels in improving ecological functioning of harbours. (Data from Adams et al. The University of Melbourne/Wyndham Harbour).

In heavily modified or wave exposed areas, soft and hybrid solutions for coastal protection may not be feasible. In these circumstances, hard ecological-engineering techniques can be applied to improve the ecological value of new or existing artificial structures. In this project, we are trialling a range of methods for growing mussels on pier pilings, pontoons and breakwaters in Wyndham Harbour, Port Phillip Bay. These artificial structures replace natural habitat in the bay and are hotspots for invasive species. This project will measure the effectiveness of these mussels in preventing colonisation of invasive species, and improving native biodiversity and water quality in Wyndham Harbour, Victoria.

Socio-economic considerations

Globally, there is a lot of interest in developing nature-based coastal defence approaches for coastal protection. In Victoria, surveys have demonstrated that most coastal residents have observed

flooded (77%) and eroded (68%) areas in Port Phillip and Western Port bays. A similar proportion of individuals (65-77%) think that natural vegetated habitats, hybrid approaches (mangroves with

pods and breakwaters with mussels) and artificial structures provide an important role in coastal protection. Our ongoing work is seeking to assess the cost-benefits of nature-based coastal defence relative to artificial structures for coastal protection.

Further information

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Developing nature-based coastal defence guidelines

NCCC researchers in the Earth Systems and Climate Change Hub are currently working to use current and previous knowledge to develop industry-accredited guidelines for the wider application of nature-based coastal defence in Australia. This research involves an interdisciplinary team of ecologists, engineers, social scientists, industrial designers, coastal managers and policy makers.