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PHYSICAL EXPERIMENTS OF WAVE ATTENUATION OVER SUBMERGED SHELLFISH REEFS

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ABSTRACT

Globally and across Australia shellfish reef ecosystems have become critically endangered due to decades of overfishing, pollution and dredging (e.g., Beck et al., 2011). In response, the Australian federal government, in partnership with The Nature Conservancy, committed to restoring 60 shellfish reef ecosystems across Australia by building reefs from limestone and recycled shells scattered with juvenile oysters or mussels. Although the primary aim is to promote healthy marine ecosystems and biodiversity, there are strong indications that these restored shellfish reefs may also substantially dissipate ocean waves and provide protection against coastal flooding. Analogies have been drawn with conventional engineering structures (submerged breakwaters, e.g. Dattatri et al., 1978) as well as nearshore shellfish reefs increasingly considered as a nature-based method for coastal resilience against flooding ("living shorelines", see e.g. Morris et al., 2021). Although the currently restored reefs do present clear similarities, they also have distinct differences that raise questions to whether they can be as effective in dissipating wave energy. Observational data from laboratory or field to verify this is currently lacking.

This study aims to quantify the effectiveness of multiple parallel submerged reef structures in relatively deep water in dissipating wave energy. Experiments (1:10 scale) were carried out in a 54-m-long wave flume using 3 reef designs that vary in reef spacing, width and height, representative for shellfish reef ecosystems as recently restored and established across Australia and the US. All designs were subjected to two water depths (0.7 and 1 m on laboratory scale) and 8 (irregular) wave conditions covering 4 peak wave periods and significant wave heights ranging from 0.1 to 0.3 m (lab scale). For the cases with 0.7 m water depth, wave height reduction varied from 10 to 23%, while for the cases with 1 m water depth wave heights generally decreased slightly up to about 5%. The reefs were found to be particularly effective in reducing the largest waves within the timeseries that would have the highest potential of causing coastal impact (e.g., flooding or erosion). In addition, observations obtained with an Acoustic Doppler Velocimeter showed up to 45% reduction of near-bed orbital (*rms*) velocities, highlighting the potential for these structures to benefit seagrass restoration efforts. Overall, the results of this study show that restored shellfish reefs can reduce incident wave energy and orbital velocities considerably, in particular for relatively high waves in relatively shallow water, and have the potential to be considered in nature-based coastal defense strategies.

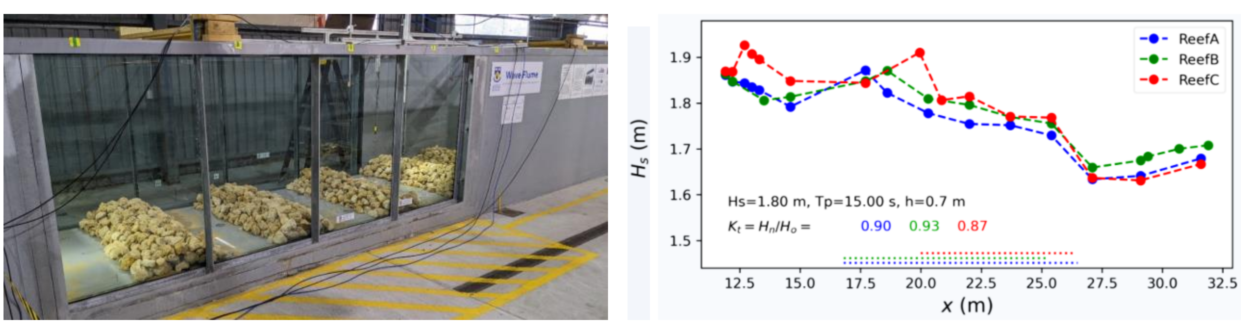

Figure 1. Photo of experimental setup with sequence of reef structures in large-scale wave flume (left panel), and example result of observed wave attenuation (prototype scale) over reef structures for three reef designs (right panel).

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