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Influence of Aquatic Vegetation Flexibility on In-Canopy Wave Hydrodynamics

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Seagrass meadows are recognised as being valuable assets to coastal fringe environments, with the ability to protect and stabilise coastlines, provide marine habitats, and contribute to blue carbon storage. These benefits are known to be strongly influenced by local hydrodynamic forcing, including waves and currents, which can have direct impacts on the local vegetation properties and sediment mobility. Wave hydrodynamics within vegetation canopies have previously been investigated through experimental research. However, the vast majority of such studies have used rigid stems, with few studies introducing flexibility as a variable. This research aims to fill this gap in understanding and advance the knowledge concerning the influence of flexural rigidity of vegetation on local wave hydrodynamics, within and above a surrogate seagrass canopy, and in turn improve the understanding of associated feedback effects within the broader ecosystem.

Experiments were conducted in a 20m long, 0.45m wide hinged-paddle wave flume dominated by progressive waves, with a working water depth of 0.7m. A surrogate seagrass canopy, 7.5m long and 0.45m wide, was inserted into the working section of the flume. In total eight different submerged canopies were tested, involving four different blade flexibilities (Semi-Rigid, Low-Flexibility, Moderate-Flexibility, and High-Flexibility) at two canopy densities (142 and 566 shoots m^2). For each canopy, four regular wave conditions were tested with a constant period of 1.25s and varying wave height (5cm, 10cm, 15cm, and 20cm). A two component Laser-Doppler Anemometer (LDA), placed in the centre of each canopy, provided high-resolution non-intrusive velocity profile measurements within and above the canopy. This approach allowed assessment of the effect of vegetation flexibility on vortex penetration into the canopy, and the flow and turbulence structure within the canopy. In addition, twin-wire resistive wave-gauges were used to quantify wave attenuation associated with different vegetation flexibility and canopy density.

This research provides, for the first time, a systematic study into the effects of vegetation flexibility on wave-induced flow and turbulence structure within seagrass canopies, which is difficult to measure in the field. The paper will present insights and detailed hydrodynamic data from this study and highlight how the results can be used to improve parametrizations for wave attenuation, vegetation drag and models for in-canopy flow velocities, which can be applied in large-scale coastal morphodynamic models.