SPATIAL EFFECTS OF ARTIFICIAL SEAGRASS PATCHES ON HYDRO- AND MORPHODYNAMICS

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INTRODUCTION

Seagrass meadows are important ecosystems which provide several ecosystem services such as attenuation of hydrodynamic forces (Paul et al 2012; Taphorn et al. 2021), stabilization of sediment and carbon sequestration. Thus, seagrass can be a part of coastal protection and plays an important ecological role, suitable to be considered as nature-based solution. Within the actual decreasing population trend of seagrass and huge losses in the 20th century (Waycott et al. 2009) many formerly dense seagrass meadows have degraded to patchy conglomerates (Reed et al. 2006) and it is presently unknown how this affects hydro- and morphodynamics and as a consequence seagrass recovery. Moreover, it is likely to have substantial consequences for seagrass recovery. As seagrass requires stable sediment, low turbidity and low to moderate hydrodynamic conditions to establish, gaps between patches may not close naturally if these conditions are not met within them.

Therefore, we investigate the hydro- and morphodynamic effects of artificial seagrass meadows in two different layouts (compact and checkerboard pattern) in hydraulic experiments. In order to determine direction dependencies, we varied the wave propagation angle. Thus, this research advances the understanding of wave-vegetation interaction in terms of patchiness and varying wave angles.

METHODS

Here, we are using artificial seagrass to investigate the hydro- and morphodynamic effects of two different degrees of patchiness. Hydraulic experiments were conducted in the 3D-wave basin of the Ludwig-Franzius-Institute in Hannover, Germany (Figure 1). A sand bed was created in the basin's sandpit, level with the surrounding concrete floor. The artificial seagrass meadows (800 plants/m²) were composed of plants with a length of 30 cm that were tied to eight frames with a size of 1m² each. Hence, the different degree of patchiness was realized by different arrangements of the frames, either in a compact (4x2 m) or in a checkerboard pattern (5x3 m in total, 8m² of plants, 7m² of gaps). The wooden frame bases were carefully buried in sand in order to model the plant-sand bed interface correctly while ensuring positional stability of the meadow at the same time. Wave transformation and morphologic processes were investigated under regular and irregular waves with varying propagating angles (45° and 90°) in order to determine direction dependencies. By the use of several wave gauges the water surface elevation was measured in front of and behind the meadow, supplemented by orbital velocity measurements with ADVs. The morphologic changes of the sand bed were measured by the use of a 3D-laserscanner prior and after the wave treatments.

Figure 1 – Experimental setup with an artificial seagrass meadow in compact layout in the 3D-wave basin

RESULTS

Despite their differing patchiness, both artificial seagrass patches led to erosion in front and deposition behind them. The changes in bathymetry of the sand bed are, however, correlated with orbital flow velocities and wave loads. Further, geometries of generated ripples differed depending on their location relative to the seagrass meadow (Figure 2). Thus, the hydraulic experiments provide essential insights into the wave-vegetation interaction in terms of patchiness and varying wave propagation angles.

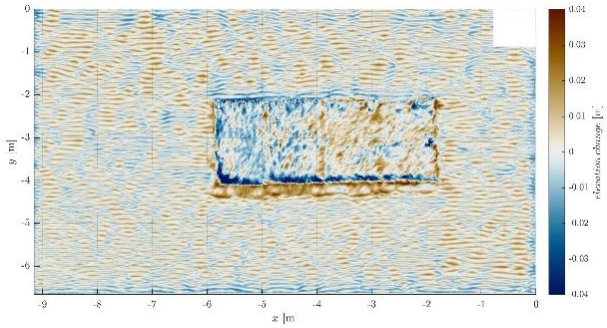

Figure 2 – Elevation change caused by a wave treatment (90°) on the compact meadow arrangement.

RELEVANCE

The results further advance the understanding of how the provision of ecosystem services relevant for coastal protection (i.e. wave attenuation and sediment stabilization) by seagrass is driven by the meadow's patchiness and layout relative to wave attack. Moreover, the results highlight the impact of meadow degradation or damage on its function as ecosystem engineer and the

potential implications for ecosystem stability and recovery. Together, both aspects are highly relevant for coastal protection and management and the study's results enable the quantitative consideration of seagrass meadows in such strategies.

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