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ADAPTING METHODS FOR BED LEVEL ASSESSMENT IN AND AROUND SUBMERGED VEGETATION

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1 INTRODUCTION

Coastal vegetation has the capacity to reduce flow and orbital velocities near the bed and stabilize the sediment with its root network. As a result it has an effect on sediment dynamics which gains increasing attention as ecosystem service in coastal protection. To quantify and predict this ecosystem service, laboratory experiments with live or artificial vegetation are often conducted. During these experiments the assessment of bed level change is challenged by the presence of the vegetation. Standard optical and acoustic measurement techniques cannot obtain data below vegetation canopies. Especially for submerged flexible vegetation like seagrass, this challenge is aggravated for airborne methods that require flume drainage (e.g. terrestrial laser scanning) (Follett and Nepf, 2012). Flexible blades will spread on the ground during drainage, potentially covering meadow edges and thus excluding areas of interest from the bed level analysis. Moreover, live aquatic vegetation may be stressed by air exposure, if the facility is drained for bed level measurements. This potentially leads to different, non-natural behaviour in consecutive experiments. And finally, draining and refilling the facility is time consuming, especially as it needs to be done very carefully as not to disturb any generated bedforms. This time aspect hampers the collection of time series and thus the assessment of the development of bed level changes with airborne methods. Underwater technology like sonar and echo sounder avoid shading of areas by spread-out vegetation, but are equally not capable of obtaining data below vegetation canopies. Moreover, instruments that can obtain spatially resolved data underwater often require a minimum water depth which may exceed the water depth relevant for experiments with vegetation.

In intertidal areas (e.g. salt marshes) the challenge of obtaining bed level data below vegetation canopies is overcome by the use of a sediment-erosion-bar (SEB) (Cahoon et al., 2002). For this method a horizontal bar is installed at a fixed height above the ground and the distance between this bar and the ground is measured at defined locations along the bar and set time intervals to obtain information on the bed level change. SEBs have successfully been adapted to laboratory settings in the past (Spencer et al., 2016), but still required flume drainage. We applied this method in an undrained flume to assess sediment dynamics in and around an artificial seagrass meadow. Additionally, we tested underwater photogrammetry to obtain 3D-spatial information (e.g., 3D models) on bed level and bedforms at and near the vegetation edges. Photogrammetry has been successfully applied to obtain bedform information in the presence of seagrass stands, but to date still required the drainage of the facility (Meysick et al., 2022).

2 METHODS

A 4 m long artificial seagrass meadow (800 plants/m²) was installed across the full width of a 2.2 m wide flume (110 m long, 2 m deep). The meadow was placed on a 12 cm high sand bed in the centre of the flume with sloping ramps (~5 %) on either end to enable smooth transitions. The bed had a length of 13 m and the meadow started 5 m into the sand bed. Using a water depth of 60 cm above the sand bed, the setup was exposed to different wave spectra (JONSWAP) with significant wave height ranging from 13-22 cm. Bed level measurements were conducted prior to a wave run, and after 15, 60 and 240 minutes of wave exposure. They covered the area from 0.5 m in front of to 0.5 m behind the leading meadow edge. For the SEB measurements, a horizontal bar was placed across the flume above the still water level and 1.5 m long pins were lowered to the sediment surface through defined holes. For the underwater photogrammetry markers were installed on the flume's wall and >150 photos were taken per measurement.

3 RESULTS

The SEBs were capable of obtaining data even within the dense vegetation (Figure 1). However, positioning the pins correctly from above the water's surface proved to be time-consuming, which may lead to limitations in spatial or temporal resolution if experiments are time constrained. Moreover, we identified a trade-off between practicability and accuracy with respect to pin diameter. Given the required length of the pin to reach a fixed horizontal bar above the surface (1.5 m in our case) a small pin diameter can lead to pin flexibility which makes its positioning difficult. Additionally, small pins may sink into soft sediment more easily, resulting in vertical inaccuracies of the measurement. These effects can be reduced by a larger pin diameter. However, larger pins will also cover a larger area on the ground which will reduce the measurement accuracy on an uneven surface.

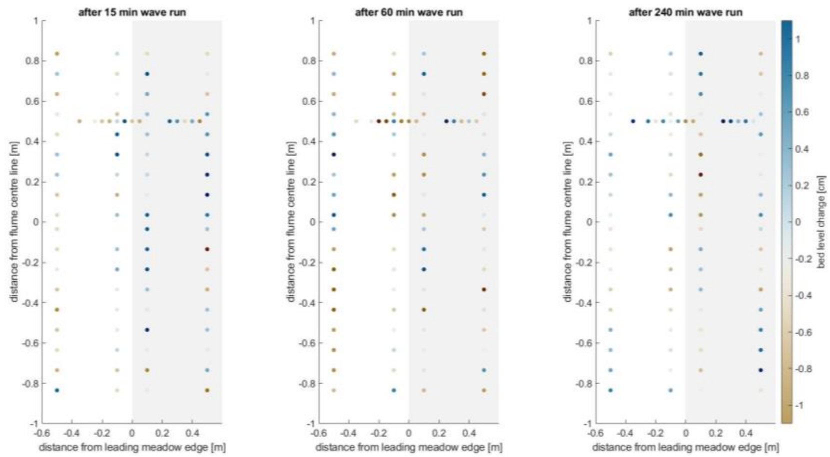

Figure 1. SEB data on bed level change induced by a wave spectrum (H_s = 13 cm, T_p = 2.6 s). The gray shaded area indicates the artificial seagrass meadow.

Underwater photogrammetry showed first promising results regarding bed level detection outside the meadow, especially when images contained some distinguishing features that enabled their stitching during the matching process. Given the laboratory setting, it is possible to provide additional markers on flume walls for instance. However, and equally to other optical methods, underwater photogrammetry failed to obtain data within the dense meadow and the results mostly depend on the visibility conditions.

4 CONCLUSIONS

Overall, both methods come with their own limitations, but have proven to be potential alternatives to existing bed level measurement techniques as they provide the opportunity to obtain time series of bed level changes in the vicinity of flexible aquatic vegetation without the need of draining the hydraulic facility. And while SEBs provide a lower spatial resolution due to their point measuring nature, they have the added benefit of the capability to acquire data within dense vegetation stands as well.

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