ECOSYSTEM BIOMASS AS A KEY PARAMETER DETERMINING ITS COASTAL PROTECTION SERVICE

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INTRODUCTION

Estimation of the flow energy dissipation induced by an ecosystem that accounts for its characteristics (i.e. biomechanical properties, morphology, density) and the incident hydrodynamic conditions is crucial if ecosystem-based coastal protection measurements want to be implemented. Characterization of a vegetated ecosystem by measuring leaf traits, biomechanical properties of plants and the number of individuals per unit area involves a lot of effort and is case-specific. Previous studies have shown that flow energy attenuation positively correlates with standing biomass (Bouma et al., 2010; Maza et al., 2015). Standing biomass can be a unique variable defining the flow energy attenuation capacity of the ecosystem. In addition, this variable has been already characterized for many ecosystems and it can be estimated by aerial images (Doughty and Cavanaugh, 2019). Then, to further explore its relation to the induced energy attenuation on the flow, a new set of experiments using real vegetation with contrasting morphology and biomechanical properties, and subjected to different incident flow conditions, is proposed. The obtained standing biomass-attenuation relationships will help to quantify the expected coastal protection provided by different vegetated ecosystems based on their standing biomass and the flow conditions.

EXPERIMENTAL SET-UP

Experiments are run in the small flume 20.71 m long and 0.58 m wide at University of Cantabria. Four vegetation species with contrasting biomechanical properties and morphology are selected. Plants are taken from different Cantabria estuaries. The selected species are: *Spartina maritima*, *Salicornia sp.*, *Halimione sp.* and *Juncus sp*. Vegetation are taken and re-located into boxes of 0.19 x 0.29 m including a 0.10 m sediment layer to minimize the stress on the plants and to later evaluate the flow energy damping induced by the bare soil. After collecting a total of 105 boxes they are directly brought to the laboratory to introduce 94 of them between two false bottom pieces already constructed leading to a 9.05 m long meadow (Figure 1). 5 boxes are used to estimate plants biomass directly from the field, to have this measurement as control, leaving 6 extra boxes for possible contingencies. Once located into the flume, the meadow is tested under regular and random waves and waves plus current conditions considering three water depths (h = 0.20, 0.30 and 0.40 m). Wave heights range from 0.08 to 0.18 m and wave periods from 1.5 to 4 s. Waves are tested in the combination of currents, flowing in the same direction, with depth averaged velocities ranging from 0.10 to 0.5 m/s. Wave height is measured using 15 capacitive free surface gauges and velocities are measured offshore and onshore the meadow by using four Acoustic Doppler Velocimeters (ADVs).

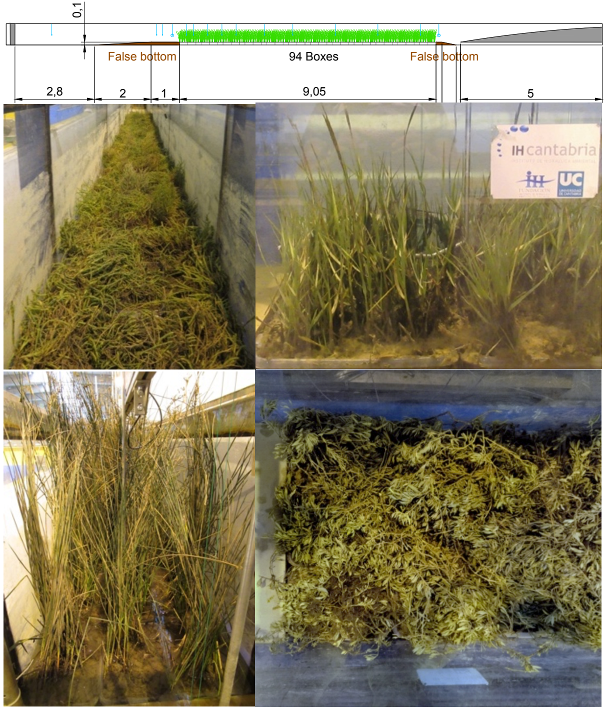

Figure 1 - Sketch of the side view of the experimental set-up including the false bottom (in brown), the vegetation (in green), the dissipation beach (in grey) and the position of free surface gauges (blue lines) and ADVs (blue circles).Bottom panels show a view of *Salicornia sp.* (top left), *Spartina sp.* (top right), *Juncus sp.* (bottom left) and *Halimione sp.* (bottom right) fields.

Three meadow conditions are considered: 100% standing biomass, which is the meadow resulting from bringing the boxes directly from the field, 50% standing biomass, after cutting vegetation from half of the boxes, and 0 standing biomass, after cutting all vegetation.

RESULTS

The wave attenuation analysis is performed by obtaining the wave damping coefficient, β, for each test. β is obtained by fitting the measured wave height along the meadow to a decay law following Dalrymple et al. (1984), Mendez and Losada (2004) and Losada et al. (2016) formulations. Figure 2 shows an example of the fitting coefficients for one of the tested regular wave conditions (H = 0.18 m, T = 1.5s and h = 0.40 m) and the three *Spartina maritima* standing biomass: 0 (S000), 50 (S050) and 100% (S100).

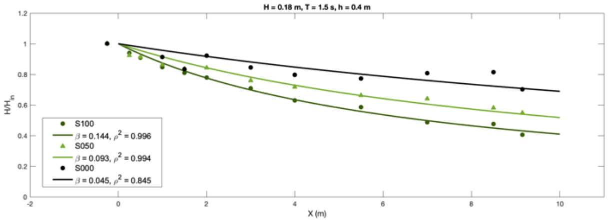

Figure 2 - Wave height evolution for H = 0.18 m, T = 1.5 s, h = 0.40 m obtained for 0, 50 and 100% of standing biomass for *Spartina maritima*.

Figure 2 shows a direct relationship between the *Spartina maritima* standing biomass and the obtained wave attenuation. This is also observed for the other tested species. However, the extremely different geometrical properties of them, lead to a strong influence of the submergence ratio (SR) in the resulting wave attenuation. SR is defined as the ratio between the vegetation height and the water depth. Then, a relationship between the obtained β and a new parameter considering both, the standing biomass and the SR is obtained. Standing biomass is obtained considering the dry weight for the four vegetation species and the two densities (100 and 50%) considered for each one of them. Then, 8 different standing biomass values are obtained. Figure 3 displays β as a function of the standing biomass times the SR for four regular wave conditions.

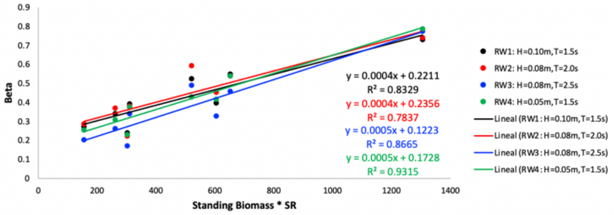

Figure 3 - Wave damping coefficient as a function of standing biomass times the submergence ratio for the four vegetation species and the two densities considered for each one of them, and four regular wave conditions.

As can be observed in Figure 3, a linear relationship is obtained between β and $StandingBiomass * SR$ for all tested wave conditions, leading to high correlation coefficients, ρ^2 >0.78. It is important to note that species with highlight different biomechanical properties and morphological traits are all fitting to the same line. This highlights the importance of the parameter $StandingBiomass * SR$ in the resultant wave attenuation.

CONCLUSIONS

The obtained relationships provide the basis for the inclusion of standing biomass as a key parameter for estimating the coastal protection provided by different saltmarsh species.

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