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A NEW FORMULATION FOR VEGETATION INDUCED DAMPING UNDER WAVES AND CURRENTS BASED ON THEIR STANDING BIOMASS

MARIA MAZA[1], ISABEL GALLEGO[2]

1 Instituto de Hidráulica Ambiental de la Universidad de Cantabria, Spain, mazame@unican.es

2 Instituto de Hidráulica Ambiental de la Universidad de Cantabria, Spain, isabel.gallego@alumnos.unican.es

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1 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 wave height attenuation positively correlates with standing biomass (Maza et al., 2022) highlighting the crucial role played by this variable that can be used to estimate the ecosystem wave damping capacity without using calibration coefficients. In addition, this variable has been already characterized for many ecosystems and it can be estimated by aerial images (Doughty and Cavanaugh, 2019) and remote sensing techniques. However, this new approach has not been extended to conditions where waves and currents are simultaneously present. These conditions are very relevant to habitats like saltmarshes that are commonly affected by tidal currents or wave-induced currents flowing simultaneously with wind or swell waves. Then, to further explore this new approach based on the ecosystem standing biomass, a new set of experiments using real vegetation with contrasting morphology and biomechanical properties, and subjected to different combinations of waves and currents, 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 under the combined effect of waves and currents.

2 EXPERIMENTAL SET-UP

Experiments are run in the small flume 20.71 m long and 0.58 m wide at the Civil Engineering School 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.* (Figure 1). 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. 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 the combined action of waves and currents considering three water depths (h = 0.20, 0.30 and 0.40 m). Wave heights range from 0.08 to 0.15 m and wave period of 2 s, and current velocities range from 0.13 to 0.42 m/s. Wave heights are measured using 15 capacitive free surface gauges located along the vegetation field and velocities are measured offshore and onshore the meadow by using four Acoustic Doppler Velocimeters (ADVs). 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.

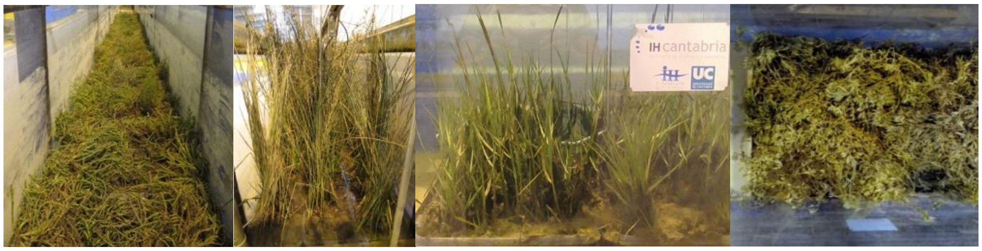

Figure 1. From left to right: Salicornia sp. Juncus sp., Spartina sp. and Halimione sp.

3 RESULTS

Wave height attenuation along the vegetation field is analyzed and Losada et al. (2017) formulation for wave hegith decay under wave and current conditions is considered to get the wave damping coefficient (β) for each test. This wave damping coefficient is obtained for the different densities and the damping coefficient obtained for bare soil tests is subtracted to wave damping coefficients found for 100 and 50% density cases to get the wave damping coefficient purely due to the vegetation effect (β_{SB}) following Maza et al. (2022). The obtained results are related to the Hydraulic Standing Biomass (HSB) defined by Maza et al. (2022) that is a function of the standing biomass of the vegetation field, the mean height of the field and the incident wave conditions (wave height, wave period and the water depth). However, to account for the combined effect of waves and currents, Thomas and Klopman (1997) nondimensional parameter relating the wave phase velocity and the current velocity is considered. Thus, the HSB is multiplied by the wave angular frequency (σ) and divided by the wave number times the current velocity ($k * Uc$). Figure 2 shows the relationship between the damping coefficients and this new parameter accounting not only for the vegetation and wave conditions, but also for the wave and current conditions.

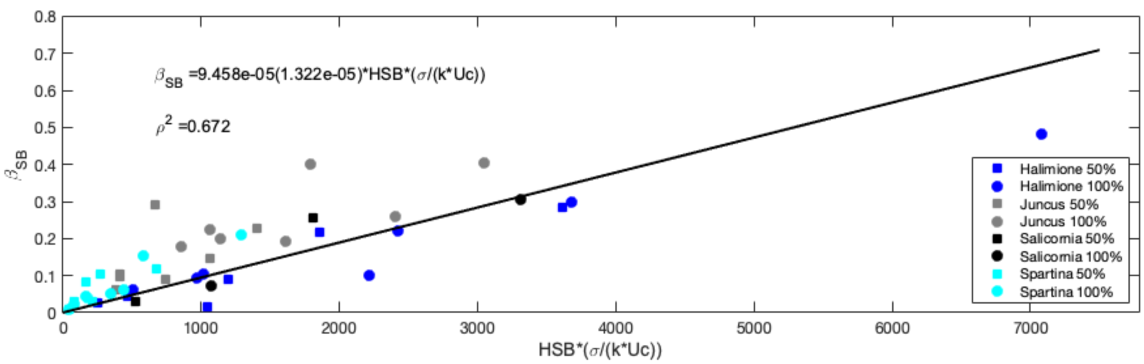

Figure 2. Obtained relationship between the wave damping coefficient found for the different vegetation species and densities and the hydraulic standing biomass multiplied by a nondimensional parameter accounting for the combined effect of waves and currents.

4 CONCLUSIONS

The obtained relationship supports the standing biomass of the ecosystem is a crucial parameter to estimate its flow energy attenuation capacity. It represents a new formulation that can be applicable to cases of colinear waves and currents flowing in the same direction and affecting a saltmarsh field.

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