

LARGE SCALE EXPERIMENTAL INVESTIGATION ON WAVES-VEGETATION INTERACTION

Stratigaki Vasiliki¹, Eleonora Manca² and Peter Troch¹

¹ Department of Civil Engineering, Ghent University, Technologiepark 904, 9052 Zwijnaarde, Belgium

E-mail: vasiliki.stratigaki@ugent.be; peter.troch@ugent.be

² National Oceanography Centre, Southampton, UK

E-mail: e.manca@noc.soton.ac.uk

In their natural environment, seagrasses are exposed to wind-driven currents, waves and wave-driven currents. The effects of marine/estuarine submerged vegetation on unidirectional flows has been studied at a variety of scales in the field (Neumeier and Ciavola, 2004; Prager and Halley, 1999) and in laboratory flumes (Dubi, 1995; Ciraolo *et al.*, 2006), while much less is known about the interaction between seagrass and waves. Wave attenuation due to vegetation and flow conditions over and within vegetation fields have been experimentally (Fonseca and Cahalan, 1992; Ota *et al.*, 2004; Augustin *et al.*, 2009) and numerically (Li and Yan, 2007; Suzuki and Dijkstra, 2007) examined.

In this work, experiments using artificial vegetation have been conducted at full scale, simulating *Posidonia oceanica*, a seagrass species endemic to the Mediterranean Sea included in the Barcelona convention list of protected species. This marine plant forms large underwater meadows which are considered to be of high importance to the environmental conservation of the region that is occupied, supporting a highly biodiverse habitat and protecting from coastal erosion. Those seagrass meadows are distributed in shallow areas from the surface to a depth of 30-40m in clear conditions, colonising sandy substrata, rocky shores and old matte reefs.

The research was carried out in the CIEM wave flume at UPC (Universitat Politècnica de Catalunya) in Barcelona, Spain. Objectives of the experiments were the measurement of wave attenuation, transmission and energy dissipation over artificial *Posidonia oceanica* in intermediate and shallow waters. The effects of submergence ratio hs/D (hs =height of seagrass, D =water depth) and seagrass density (number of stems per square meter, stems.m⁻²) on the above characteristics were investigated. A meadow with a total length of 10.7m was constructed by polypropylene artificial plants, selected for the most similar physical properties to real *Posidonia oceanica* leaves (Folkard, 2005). Each plant was modeled by four stripes: two stripes 55cm long and two stripes 35cm long. Two different seagrass densities, which represented densities of *P. oceanica* found in nature, and two shoot arrangements, were produced: 360 and 180 stems.m⁻² in staggered and non-staggered configuration, respectively.

Experiments with regular waves, taking measurements of wave height at different locations along the meadow (seaward, front, middle, end and shoreward of *P. oceanica* field), indicate attenuation of waves along the meadow for various wave conditions and three different submergence ratios hs/D (0.500, 0.423 and 0.323) as discussed in Stratigaki *et al.* (2009; 2010a; 2010b), while results for irregular waves are presented in Manca *et al.* (2010).

Results from spectral wave propagation over vegetation have been analyzed in the present study. Bradley and Houser (2009) found that the rate of spectral wave energy dissipation by a mixed seagrass bed under low energy conditions is frequency-dependent, and Lowe *et al.* (2007) found that, within a rigid canopy exposed to irregular waves, the flow attenuation varies among the different wave components. Here, spectral analysis was performed for estimating wave height attenuation and wave induced velocities and for determining the effects of seagrass density, submergence ratio on wave characteristics along the meadow.

Acknowledgements

The study was conducted within the frame of Hydralab III 022441 (RII3) EU project. Pleasant cooperation with the laboratory staff and the participants of the Hydralab project is very much appreciated.

The first author would like to acknowledge her Ph.D. funding grant of the Research Foundation Flanders, Belgium [Fonds voor Wetenschappelijk Onderzoek Vlaanderen, (FWO)].

References

Augustin L.N., J.L. Irish and P. Lynett. 2009. Laboratory and numerical studies of wave damping by emergent and near emergent wetland vegetation. Coastal Eng. 56:332-340.

- Bradley K. and C. Houser. 2009. Relative velocity of seagrass blades: implications for wave attenuation in low-energy environments. *J. Geophys. Res.* 114.
- Ciraolo G., G. Ferreri and G. La Loggia. 2006. Flow resistance of *Posidonia oceanica* in shallow water. *Journal of Hydraulic Research* 44:189-202.
- Dubi A. 1995 Damping of water waves by submerged vegetation: A case study on *Laminaria hyperborean*. PhD thesis, University of Trondheim, Norway.
- Folkard Andrew M. 2005. Hydrodynamics of model *Posidonia oceanica* patches in shallow water, *Limnol. Oceanogr.* 50(5):1592-1600.
- Fonseca M.S. and J. Cahalan. 1992. A preliminary evaluation of wave attenuation by four species of seagrass. *Estuarine Coastal and Shelf Science* 35:577-592.
- Li C.W. and K. Yan. 2007. Numerical investigation of wave-current-vegetation interaction. *Journal of Hydraulic Eng.* 133(7):794-803.
- Lowe R.J., J.L. Falter, J.R. Koseff, S.G. Monismith and M.J. Atkinson. 2007. Spectral wave flow attenuation within submerged canopies: implications for wave energy dissipation. *J. Geophys. Res.* 112.
- Manca E., V. Stratigaki and P. Prinos. 2010. Large scale experiments on spectral wave propagation over *Posidonia oceanica* seagrass. *Proc. of 6th International Symposium on Environmental Hydraulics* 1: 463-469. Athens, Greece.
- Neumeier U. and P. Ciavola. 2004. Flow resistance and associated sedimentary processes in a *Spartina maritima* salt-marsh. *Journal of Coastal Research* 20:435-447.
- Ota, T., N. Kobayashi and J. Kirby. 2004. Wave and current interaction with vegetation. *Proc. of Coastal Eng.* 2004:508-520.
- Prager E.J. and R.B. Halley. 1999. The influence of seagrass on shell layers and Florida Bay mudbanks. *Journal of Coastal Research* 15:1151-1162.
- Stratigaki V., E. Manca, P. Prinos, I. Losada, J. Lara, M. Sclavo, I. Caceres and A. Sanchez-Arcilla. 2009. Large scale experiments on wave propagation over *Posidonia oceanica*. *Proc. of 33rd IAHR Congress*. Vancouver, Canada. ISBN: 978-94-90365-01-1.
- Stratigaki V., E. Manca and P. Prinos. 2010a. Effects of *Posidonia oceanica* meadow on wave propagation: Large-scale experiments. *Proc. of 4th International Short Conference/Course on Applied Coastal Research*. Barcelona, Spain:230-240, ISBN 978-88-6093-069-9.
- Stratigaki V., E. Manca, P. Prinos, I. Losada, J. Lara, M. Sclavo, C.L. Amos, I. Caceres and A. Sanchez-Arcilla. 2010b. Large scale experiments on wave propagation over *Posidonia oceanica*. *Journal of Hydraulic Research*, IAHR (submitted for publication).
- Suzuki T. and J. Dijkstra. 2007. Wave propagation over strongly varying topography: cliffs and vegetation. *Proc. of 32nd IAHR Congress*, Venice, Italy (CD-ROM).