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Interactive comment on "Observations of the effect of emergent vegetation on sediment resuspension under unidirectional currents and waves" *by* R. O. Tinoco and G. Coco

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Response to Anonymous Referee #2 comments on "Observations of the effect of emergent vegetation on sediment resuspension under unidirectional currents and waves"

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General comments:

The authors present laboratory measurements of the effects of emergent vegetation under conditions with currents and waves. Although the presented results are interesting, the manuscript lacks a thorough link between the velocity profile to bed shear stress, to erosion, to suspension. The common mechanisms do not hold under the governing conditions because the shape of the velocity profile is no longer logarithmic. The connection between measured data and physics needs to be improved. Unfortunately the experiments show artefacts such as lateral waves of the water surface and reflection of waves at the end of the flume.

The authors gratefully thank the reviewer for the constructive comments, and they will be considered to improve the manuscript. In general, no velocity profiles were recorded. Only velocities at a single elevation over the bed were acquired. The concern with flow artifacts is being addressed, as we show the agreement between the expected and observed lateral standing waves appearing at specific velocity ranges. While the lateral standing motions must be considered when dealing with laboratory experiments, we are aware they are not likely to be relevant in the field. We would modify the original version to address all the raised concerns as indicated in detail below:

More detailed comments (not in order of importance):

- Abstract needs to be improved and extended. Start with second sentence.
We would modify the abstract as suggested by the reviewer, to provide a better overview of the goals and content of the manuscript. It would read:

"We present results from a series of laboratory experiments on a wave and current flume, where synchronous velocity and concentration measurements were acquired within arrays of rigid cylinders, representative of emergent vegetation and benthic communities, under different flow conditions. The density of an array of rigid cylinders protruding through a sandy bed affects the velocity field, sediment motion and resuspension thresholds when subjected to both unidirectional currents and regular waves. We compare the measured resuspension thresholds against predictions of sediment motion on non-obstructed flows over sandy beds. The results show that even if flow speeds are significantly reduced within the array, the coherent flow structures and turbulence generated within the array can enhance sediment resuspension depending on the population density. "

- p603 lines 20-25: add references, also the scarse ones
We now refer the reader to the works of van Rijn 2007 for references on thresholds on

flat beds, and the work of Eckman 1981, for studies on sediment resuspension under unidirectional flows in the presence of underwater obstructions.

- p604-606: long list of equations is included without informing the reader about relevance, physical meaning, and ranges of application of the equations. In the presented equations the velocity profile is assumed to be logarithmic, which is not the case under the governing conditions. The theory presented here is not used and not compared to data.

The reviewer makes good points:

A) We are aware of the fundamental differences between non-obstructed and obstructed flows, but since one of the goals of this manuscript, now included in the abstract, is to investigate the effects of the arrays of cylinders on the onset of sediment resuspension, we consider very important to compare against the non-populated case. We would also like to include a comparison with theoretical critical velocity values for sediment resuspension in obstructed flows, but to our knowledge, no such equations, similar to the ones for flat beds, are available. We must consider as well that large scale numerical models use flat bed relationships to calculate sediment motion, thus the relevance of our contribution a a first step to incorporate the effects of aquatic vegetation, as modeled in this case by rigid emergent cylinders, into future models.

B) We have decided to include the equations to make it easier for the reader to compare theoretical predictions against our measured values, without having to look for the full derivations themselves, while providing the references to do so. We would modify the manuscript to address the reviewer concerns, so that the manuscript would read:

"We present herein a few of the existing criteria describing critical velocities and critical bed shear-stress for sediment motion, as well as critical velocities for resuspension applicable to our investigated case. While those refer to non-populated beds, they will offer a good starting point for comparison against the results from populated cases, allowing us to investigate the impact of the added physical processes within a patch of vegetation."

C) In the Results section, we compare the theoretical values calculated with the presented equations (shown in Table 4) against the measured values (shown in Table 3).

- p605 line 9: the word 'critical' is missing
We will make the correction to point out we refer to the critical velocity.
- p605 line 10: equation not valid here
The equations are included and used to compare the non-obstructed case, in which they are valid, against the case with arrays of rigid cylinders, for which we are aware there are fundamental differences in the velocity profiles.

- p605 line 11: not Kolmogorov but Von Karman
The mistake will be fixed in a revised version of the manuscript.

- p607 lines 9-17: do previous studies cover only 'currents' (not waves)? If so, please stress you are the first to cover the interaction between vegetation and waves.
We would modify the manuscript to include:

"In the case of waves, to the authors knowledge, there are no experimental works on determination of sediment resuspension thresholds in the presence of arrays of rigid cylinders."

- p609 lines 8-13: what about the wave reflections (p 610, line 26)? what is done

to prevent these reflections?
The flume counts with a passive wave absorber at the end of the flume.

- p609 lines 16-19: describe the bedforms, explain scour and bedforms
A revised version would be modified to make it more clear, reading:

"For each density, the series was stopped once scour became noticeable (Figures 3 and 4). Once sand starts accumulating behind the cylinders and bedforms start to appear within the array, vortices are generated in the now perturbed bed, enhancing resuspension as compared to a flat bed case. Once such a state is reached, since we are past the threshold values sought, the series can be stopped."

- p610 lines 10-20: what is the source of it?
We will add a sentence to clarify it, stating: "As the shredding frequency of the cylinders approaches a natural frequency of the flume, the corresponding standing wave appears (see Tinoco and Cowen, 2013)."

- p612 line 5: x velocities are not damped due to mass conservation
As pointed out by Nepf 1999, 2012, under the same forcing, because of the additional resistance offered by the vegetation, velocity within vegetated channels is less than in unvegetated channels.

- p612 lines 22-23: what is 'fully developed' here? - please include velocity profiles
Unfortunately, no velocity profiles were measured for this contribution.

- conclusion section: too superficial. Discuss the effects of dissipation and turbulence, as well as the effect of turbulence on suspension.
The effects of cylinder-generated turbulent kinetic energy enhancing sediment re-

suspension are included in the manuscript and in the conclusions. We do agree that analysis of the tke budget would be an important contribution and should be considered for future experiments.

- p615 lines 1-2: boundary layer and bed shear stress change as well

We will modify the manuscript to read: "the cylinder wakes enhance scour, changes the bed shear stresses, and the increased turbulence levels within the array effectively enhance resuspension".

- figure 5: at which elevation have these velocities been measured?

We will modify the caption to state that the measurements were taken at 5cm above the bed as indicated in the text.

- figure 6: k^(1/2)/U should be more or less constant for n = 0. Caption: delete "increase in"

The caption will me modified to avoid misunderstandings.

- figure 7 seems to be dominated by artefacts

Indeed, Figure 7 is intended to show the observed byproduct, the lateral standing waves generated by the cylinders under certain ranges with unidirectional flows, that a) can be theoretically predicted and b) also contribute to enhance resuspension, although quantification of its relevance is still to be determined.

- figure 8: discuss damping, energy loss

We address the issue as:

"While wave dissipation is not the main focus of our work, the effect of the array at dissipating the incoming waves is evident, with reductions of more than 50% of the approaching wave height for the densest cases (Fig. 8). With energy being dissipated as the wave advances through the array, the bottom shear stresses also decrease, reducing resuspension in favour of sediment deposition. Figures 9 and 10 show the up- and downstream edges of the array before and after a series of 50 waves. Scour and bedforms are clearly present at the upstream section, whereas the downstream area shows little, if any, bed disruptions. This behaviour is contrary to the one observed for currents, where the array effectively slows down the flow, yielding smaller velocities at the upstream section than at the downstream exit."