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Title: Biophysical feedbacks between seagrasses and hydrodynamics in relation to grazing, water quality and spatial heterogeneity : consequences for sediment stability and seston trapping

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Summary

Seagrass is important to marine ecosystems, since it supports various ecosystem engineering systems, such as: nursery for marine animals, reducing hydrodynamic forces (waves and currents) and reducing water turbidity through sediment entrapment. But in spite of preserving good marine conditions through its ecosystem service, seagrass is declining globally. In Indonesia alone, seagrass loss reached 30-40% of its surface in the last 10 years. Seagrass loss was caused by the impact of biotic and abiotic factors, including significant human interventions with marine ecosystems in general (e.g.: dredging, scouring, vessel propellers). Although interactions of human interventions and seagrass do not necessarily lead to seagrass loss, they almost certainly contribute to fragmentation of seagrass meadows. Understanding how fragmented seagrass meadows interact with biotic and abiotic factors (wave and current) will help to develop hydrodynamic indicators (e.g.: turbulence, Reynold stress, volume discharge) and provide insight in how they affect fragmented seagrass growth, regrowth or further seagrass loss.

My study focused on 1) fragmented seagrass interaction with hydrodynamics and 2) fragmented seagrass interaction with nutrients. Two heterogeneous patches are used in this experiment. Heterogeneous seagrass patches are set with different density, spatial arrangement and leaf length. Gaps as a result of seagrass interaction with herbivores, humans or hydrodynamics are also simulated in this study. Different gap sizes are created to investigate hydrodynamic effects within gaps. The overall aim of my study is to explore and analyze the mechanisms of biophysical feedback that affect the stability of a seagrass bed upon fragmentation. In other words, if current, turbulence, sediment-water exchange, water-plant exchange (of CO₂ and nutrients) are all changed by the fragmentation, will this tend to promote filling up of the gaps with vegetation (i.e. return to closed bed, a positive feedback), or will it give rise to a runaway reaction (further fragmentation of the bed, ultimately leading to disappearance – this is a negative feedback, a self-reinforcing reaction). My main research questions are developed to approach this overall theme from different angles: i) How do heterogeneous patches in the seagrass bed interact with the hydrodynamic force? ii) How do the different seagrass properties (density, leaf length) and gap sizes influence flow development inside the gap? iii) How is the advective porewater exchange influenced by the presence of seagrass? and iv) How do the different hydrodynamic

factors (diffusion, flow, wave and flow induced by wave) influence porewater exchange from sediment to water column?

The results of these studies show that in controlled environments which exclude the effects of factors other than the hydrodynamic conditions, seagrass meadows have the ability to restore and re-homogenize themselves. However, a wide range of other factors may also play a role in determining whether heterogeneous patches become more or less homogeneous, such as nutrient cycling from sediment into the water column or vice versa, deposition of organic matter, erosion by waves or tidal currents, or animal grazing. I also found that exchange from the water column to the sediment porewater or vice versa (carrying nutrient), in the presence of fragmented seagrass, is governed mostly by pressure gradients due to the deceleration and acceleration caused by hydrodynamics interactions with the seagrass meadow.

This PhD thesis presents findings that elucidate the fundamental processes of seagrass–hydrodynamics interactions, which impact ecological processes such as patch and gap dynamics and advective porewater exchange. These processes are important in order to create and implement strategies for the restoration of disturbed seagrass meadows. Seagrass should be considered as one of the most important marine commodities that produce high economic value, and one that needs sustainable management in order to optimize its economic value. Further research is required to investigate causes of global seagrass decline and to establish a strategy for the restoration and conservation of seagrass ecosystems