Decreased resilience of mangroves stressed by human interference.

Intertidal mangrove forests exist in a dynamic coastal environment that is strongly influenced by anthropogenic forcing, leading to habitat fragmentation, reduced habitat quality and changing hydrodynamic and geomorphological conditions. Biophysical feedback mechanisms are essential to the resilience of mangrove ecosystems. These mechanisms facilitate sediment deposition during periods of tidal flooding and hence allow mangroves to adapt to changing environmental conditions. However, stresses induced by human interference can affect these biophysical interactions. This study addresses the impacts of two widespread human interferences with mangroves on their resilience; sediment starvation (decreased sediment influx) and coastal squeeze (ecological drowning due to sea level rise (SLR) in combination with suppressed possibilities for landward development).

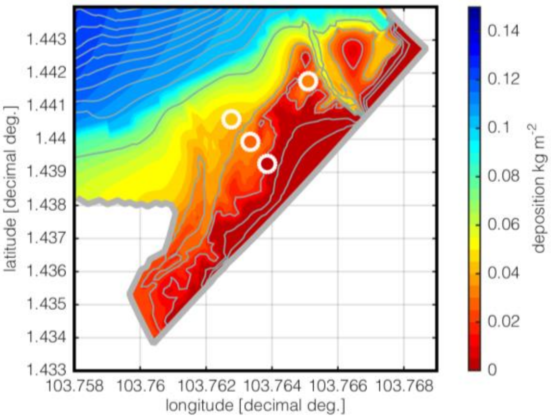

Figure 1. Modeled and measured sediment deposition in Mandai mangrove. The background shows the computed deposition of fine sediments with the model, while the fill color in the white markers shows the measured average (over all measurements) deposition of fines. The depth is shown by the gray contour lines (1 m interval) on top of the modeled deposition.

Field observations of hydrodynamics and sediment dynamics were conducted in a fringing estuarine mangrove in the Straits of Johor, located at Mandai mangrove, along the northwest shore of Singapore. An accurate depth-averaged process-based numerical model was developed in Delft3D. The model provided satisfactory approximations of flow velocities and deposition rates of fine sediments (clay and silt; <63μm) at present. The deposition rates varied between 0.00 g m^{-2} at the back of the mangrove and approximately 0.06 g m^{-2} in front of the mangrove and in the creeks (Fig. 1).

The calibrated model was used to simulate the instantaneous response of the mangrove when sediment starvation and coastal squeeze were alleviated. To reduce sediment starvation, a second open boundary, initiating tidal exchange, was imposed. The model outcomes showed increased deposition rates within the mangrove when sediment supplies were restored. Deposition at the mangrove fringe increased with almost 300% and deposition at the mangrove itself increased with at least 200% (Fig. 2.a). A reduction of coastal squeeze by extending the intertidal area landward resulted in increased flow velocities and deposition rates. More suspended sediment reached a larger extent of the mangrove and was deposited at the back and imposed basin (Fig. 2.b). A comparison between these scenarios and the current state of the mangrove showed a decrease in biophysical interaction. The human interference, contributing to sediment starvation and coastal squeeze, has evidently decreased the mangrove's resilience. More importantly, actions to reduce anthropogenic forcing could enhance sediment deposition, facilitating an increased resilience to future coastal changes such as SLR. Understanding the influence of anthropogenic forcing on mangrove resilience is essential to maintain ecosystem stability, especially along rapidly changing and urbanizing tropical shorelines.

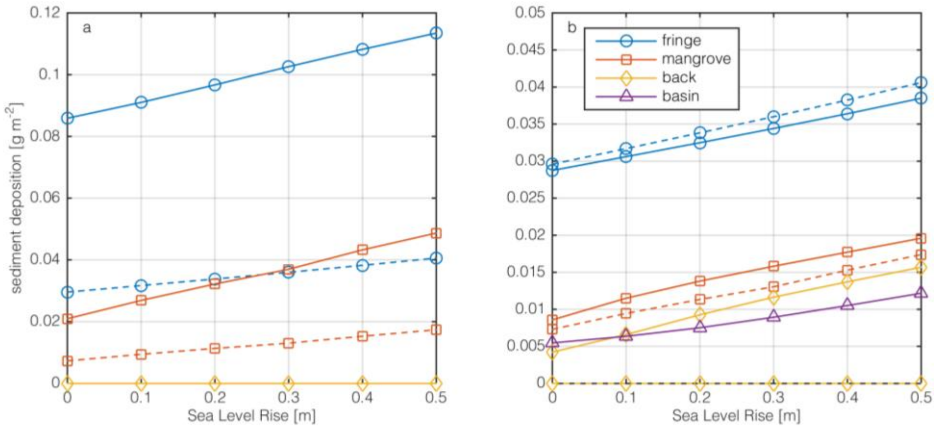

Figure 2. Deposition of fine sediments within the characteristic zones of the mangrove for the original model (dashed lines) and for the scenario's with (continuous lines). The sediment deposition in g m^{-2} is showed for (a) the scenarios with an open boundary imposed at the Johor Causeway and for (b) the scenario with an open basin at the back of the mangrove.

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