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Carbon and nutrient recycling in coastal sediments respond disproportionally to increasing organic matter inputs

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Sediment regulates aquatic ecosystem functioning by sequestering organic matter and recycling key nutrients (e.g., Fe, P). Understanding their feedback mechanisms to the rapidly changing coastal waters is important to project the trajectories of the ecosystem. In this study, we use a lagoon system (Pinqing Lagoon, China) to demonstrate that human input can alter the sediment biogeochemistry, but sediment's feedback to the water column is non-linear. Due to the large nutrient and organic matter inflows from rivers, the coastal sediments, for example, in a harbor, have organic carbon sedimentation doubling that of the central lagoon (only 2 km apart). Consequently, sediments in the harbor consume O_2 four times faster, leading to shallower oxygen penetration. Such shallow O_2 penetration further amplifies the difference in the coupled C-Fe-S-P cycles: it allows disproportionally more "fresh" organic matter to be buried into the anoxic zone, increases the reactivity of Fe oxides, and simulates higher Fe and SO_4^{2-} reduction. More H_2S is produced to precipitate Fe^{2+} as FeS_x, resulting in less formation of P-binding Fe oxides. These effects, all together, lead to the dramatic increases in effluxes of key nutrients P and Fe: sediments in the harbor recycle > 30 times more P and > 1000 times more Fe compared to the central lagoon, providing positive feedback to the production of organic matter in the water column. Moreover, the reduction of Fe oxides can remobilize the Fe-associated organic matter and decrease the efficiency of long-term carbon sequestration. In summary, our findings demonstrate that the control of organic matter input on sediment carbon and nutrient recycling is non-linear via a series of positive feedback, and thus coastal oceans can be more sensitive to environmental changes than we previously thought.