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One-line numerical modeling of mega nourishment shoreline interactions with a terminal groin field

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Many areas of the world suffer from chronic erosion and shoreline retreat. Given the amount of coastal infrastructure vulnerable to retreating coastlines, innovative solutions beyond traditional nourishments and hardened shore defenses must be explored. One solution that may reduce linear nourishment costs and local beach disruption is the use of mega nourishments (MNs), large scale nourishment projects that act as feeder beaches distributing sediment to adjacent shores via natural transport processes. These should result in shores more natural in appearance than ones with hard coastal structures, which should improve the landscapes' natural beauty, increase the potential for recreation, and create safer environments. As many beaches suffering from chronic erosion have been reinforced by terminal groins, understanding MN interactions with terminal groin fields is a necessity if MNs are to be used as a viable risk reduction strategy. While shoreline-groin interactions on a small scale are well-documented, there are no known instances of larger scale interactions with a MN and their effects down shore.

To explore MN shoreline evolution, a modified version of the Coastline Evolution Model (CEM) is utilized. CEM is a cellular one-line model that simulates cross-shore changes in shoreline position via alongshore gradients in wave-induced sediment flux. CEM is capable of simulating coastline evolution on very large spatial (hundreds of km) and temporal (up to thousands of years) scales. This is beneficial in modeling MNs as it is expected to take decades for one to fully redistribute its sediment volume, and their effects may be observed many kilometers from the nourishment site. CEM has been calibrated using data from the Sand Engine project, a physical MN on the Dutch coast. Novel algorithms simulating terminal groin-shoreline interactions are incorporated into CEM. These algorithms account for longshore sediment transport (LST) obstruction resulting from the presence of a terminal groin and sediment bypassing a groin, both of which are calculated as fractional sediment volumes dependent on the permeability of the groin and the shoreline distance from the groin tip, respectively. Wave diffraction resulting from terminal groins is also accounted for by reducing wave height and adjusting wave angle at the point of wave breaking.

The results of several different scenarios are presented. A Gaussian MN (volume of $\sim$14 million m3) on a straight coastline is shown as a baseline scenario. An identical MN placed downdrift of a groin field is also presented to examine specific interactions between the field and the MN shoreline evolution. It is hypothesized that the groin field will obstruct updrift LST resulting in sediment buildup and a greater shoreline extension between the groins and the MN. Another scenario where a MN is constructed on top of a groin field is also presented. It is expected that the groin field will slow the MN rate of dispersal resulting in a large beach surface in the MN area for a longer amount of time than for the baseline scenario.