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Shoreline Evolution of Mega-Nourishments: a One-Line Numerical Model Case Study for the Texas Gulf Coast

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The Upper Texas Gulf Coast is notorious for high erosion rates. In order to adequately mitigate erosion in this area, innovative solutions beyond the traditional local nourishments and flood protection schemes must be explored. As a method of reducing recurring linear nourishment costs and frequent beach disruption from nourishment activities, a mega-nourishment on the Dutch coast, the Delftland Sand Engine, has been constructed to test the feasibility of using large-scale nourishments to feed sediment material to adjacent beaches. While the benefits and drawbacks of this specific mega-nourishment pilot project are still being evaluated, the potential advantages could make this approach a viable alternative for the Texas coast where erosion rates and nourishment costs are high.

In an effort to determine the time scales necessary for adjacent beaches to experience accretive effects from a mega-nourishment along the Upper Texas Gulf Coast, a hypothetical mega-nourishment on Follets Island, Texas is numerically modeled using a modified version of the Coastline Evolution Model (CEM) with increased spatial and temporal resolution. CEM is a one-line numerical model capable of simulating wave-induced longshore sediment transport processes and associated coastline evolution. The model is calibrated using Dutch prototype data and adapted for use in the Gulf coast environment.

The hypothetical ∼14.6 million m3 mega-nourishment was a peninsula similar in shape to a Gaussian distribution ∼4 km long (alongshore) and extending 810 m (cross-shore). This size and shape was chosen because it is similar to the Sand Engine coastline after ∼1.5 years of evolution with a nearly continuous coastline, avoiding model complexities. Areas of the simulated shoreline ∼3 km away from the nourishment experienced 0.2 m of accretion after ∼13.9 years of model time while regions closer to the nourishment experienced shoreline progradation almost immediately. After 50 years of model time, the nourished feature had mostly diffused with a 60 m disparity in the maximum-minimum cross-shore extent. By this point, shore positions up to 3 km away from the edge of the original nourishment had experienced over 110 m of shoreline extension. It took a century for the nourished feature to completely diffuse into a near-straight coastline. As the Dutch Sand Engine was designed to diffuse and feed nearby beaches over the course of 25 years, results of the modeled hypothetical mega-nourishment in Texas show time scales of diffusion to be 2 to 4 times greater than those expected for the mega-nourishment on the Dutch coast. This is likely the result of a higher occurrence of high-angle (> 45 deg relative to the mean coastline normal) incident waves in the offshore wave climate of the Netherlands that slow diffusion rates in the model. Given that the modifications of CEM allow it to capture morphological behaviors of the nourished feature and shore accretion tens of kilometers away from the nourishment, the adapted model is an effective method of simulating mega-nourishments in the Texas Coast.