Alternative nourishment methods for the Belgan coast

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The natural dynamics of the Belgian sandy coast system are severely disturbed nowadays. Coastal defense structures have changed the natural patterns for the sediment transport, which has resulted in accretion and erosion issues along the coast in agreement with the state of the world's beaches. The anticipated acceleration of the sea level rise will increase the vulnerability of the Belgian coast to extreme events.

To strengthen the safety of the coast, the Flemish government has approved the Masterplan for Coastal Safety. This Masterplan consists of a suite of measures to prevent flooding related to a 1000-year flood event. Nourishment of beaches is considered one of the most important measures to maintain and enhance coastal safety. Nowadays, beach nourishments along the Belgian coast (~annual volume 0.5 million m^3) are constructed using a traditional method: by heightening the upper and intertidal beach.

A possible alternative for creating a more resilient and dynamic Belgian coast are feedere-type mega nourishments such as the so-called Sand Engine along the Dutch coast. This innovative soft engineering intervention makes use of natural processes (i.e. waves, currents, wind) to redistribute the nourished sand across the entire coastal profile (i.e. shoreface, subaqueous and subaerial beach, and dune area) and represents a paradigm shift in coastal management.

The present study aims to quantitative predictions of the shoreline change across decadal timescales as part of an exploratory study on the potential for a mega nourishment along the Belgian coast. Using the coastline model UNIBEST-CL+ we aim to i) evaluate the alongshore sediment transport post-construction for a range of idealized mega nourishment with varying dimensions (alongshore and cross-shore extent, volume), ii) quantify the dissipation time of these mega nourishment designs, and iii) explore the sensitivity of the predicted shoreline changes and lifespan predictions to the hydrodynamic (i.e. waves and tidal currents) and sedimentologic (i.e. grain size and sediment transport formulation) conditions.

A calibration of the UNIBEST-CL+ model on data from the Mariakerke nourishment was performed first. The combined beach-shoreface nourishment had a total volume of about 1Mm^3 of sand and was constructed in early 2014. UNIBEST-CL+ simulations using daily wave observations and the Bijker sediment transport formulation showed the best agreement with the observations on cross-shore evolution and volume decay. This finding indicates that the model is capable of replicating shoreline changes following the construction of a large nourishment along the Belgian coast.

Then, thirteen idealized nourishments were designed. The nourishments had a seaward extent ranging between 150 m and 900 m with variable alongshore lengths to evaluate the effect of geometry on resultant shoreline changes. The smallest nourishment had a volume of 1 million m^3 of sand and the largest one was 30 million m^3. All nourishment designs showed a morphological reshaping from the original trapezoidal shape to a smoother bell shape during the first years post construction. As a result of the reshaping, the head of the nourishment retreated and sand was being fed to the adjacent beaches, leading here to coastal advance. A key finding is that the dissipation time scaled approximately linear with the initial nourishment volume for the same width-to-length ratio.

Simulations indicate that the volume decay of mega nourishments is much slower than predicted for the Dutch coast, primarily due to a smaller sensitivity to gradients in alongshore sediment transport. The behaviour of intertidal bars in the Belgian North Sea remains poorly understood and it requires further investigation for robust morphologic simulations. A mega nourishment makes use of nature's ecosystem services and provides a sustainable alternative to current nourishment practices allowing for a more flexible and adaptable management of the Belgian coast in response to climate change.

Keywords: Feeder-type nourishment; Sea level rise; Sediment transport; Numerical modeling