DIFFUSION OF A MEGA FEEDER NOURISHMENT - ASSESSING 5 YEARS OF SAND ENGINE SPREADING

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INTRODUCTION
Feeder nourishments, where sand quantities of *O* (10 million m^3) are placed locally to feed adjacent coastal stretches, are suggested nowadays as an alternative for local, smaller-scale nourishments (< 1 million m^3). These feeder nourishments rely on natural forces to spread the sediment. While processes that govern this spreading such as tidal flows, waves and wind are well known, the quantification of associated sediment transport processes remains a scientific challenge. Due to the lack of knowledge with respect to sediment spreading, no tools exist to optimize the design of feeder nourishments. The Sand Engine project that is implemented in the Netherlands in 2011 consists of 21.5 million m^3 of nourished sediment, and is the largest existing feeder nourishment (Stive et al., 2013). In this paper the morphological development of the Sand Engine mega feeder nourishment and the adjacent coastal sections is presented. The alongshore extent of the analysis is 17 km and spans a coastal cell between 2 harbor entrances (see Figure 1).

Figure 1, the Sand Engine mega nourishment placed in a 17 km alongshore coastal cell between two harbors.

METHODS
A unique dataset of 37 high-resolution topographical surveys of the total area are collected during 5 years (Roest et al., *in review*). These data are used to examine the alongshore spreading in the first five years after construction. For the analysis, the domain is sub-dived in horizontal alongshore cells in the vicinity of the Sand Engine, as well as vertical sections to analyse the response at different elevations in the coastal profile.

RESULTS
The measured volume changes in the direct vicinity of the Sand Engine are an order of magnitude larger than in the neighboring parts of the coastal cell (see Figure 2). In the center section, a net erosion of 4.2 million m^3 of sediment is measured and in the direct north and south areas a net sedimentation is measured of 1.8 million m^3 and 1.2 million m^3 respectively. The sedimentation at the north and south sides of the Sand Engine causes an increase in size of the peninsula from 2.2 to 5.8 km in 2016 in the alongshore direction. The erosion in the center of the sand engine causes a decrease in cross-shore extent from 1 km to 650 meters. The coastal areas further away from the peninsula (Figure 2, Nemo south and Nemo North) show limited sedimentation and erosion that can be directly associated with the Sand Engine.
The change in cross-shore extent and alongshore length of the peninsula are found to vary strongly with depth. The largest changes were found around the mean sea level depth contour. Correspondingly, this variability in response over depth results in different profile slope development in accretive and erosive areas. In eroding coastal sections the sub-tidal slope decreases (see Figure 3). Accretive profiles experience a profile slope increment over time. The cross-shore extent of the morphologic response shows a clear signature of the wave-driven hydrodynamics, suggesting wave forcing dominate over the effects of tidal currents and aeolian sediment transport

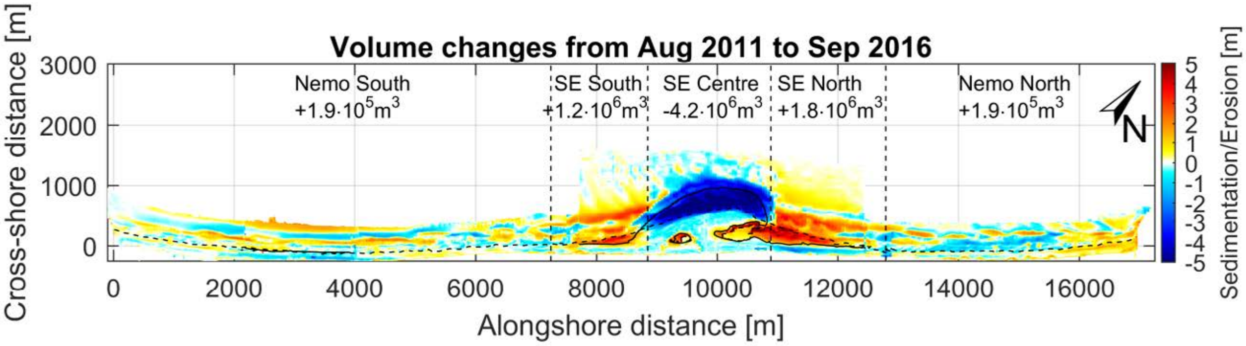

Figure 2, overview of 5 years of sedimentation and erosion in the Sand Engine coastal cell.

processes. This is in line with results of modelling studies by Luijendijk et. al. (2017).

Limited morphodynamic activity below the -8 m NAP depth contour is found which confirms earlier assessments of closure depth at this coast.

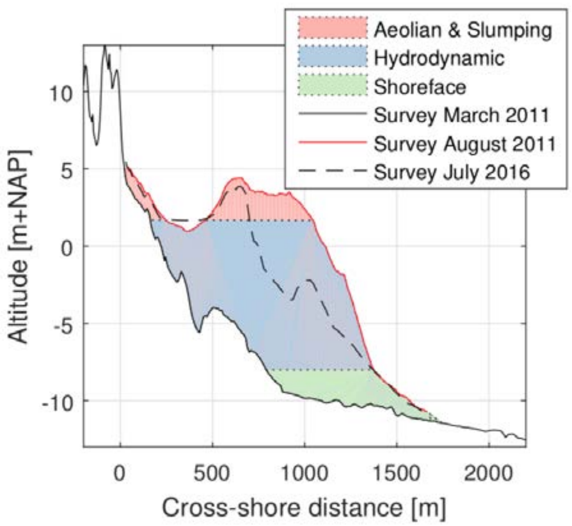

Figure 3, example of the measured net volume changes at the Sand Engine in cross-shore direction. Data is shown before the implementation, just after the implementation and after 5 years of development.

CONCLUSIONS

The analysis shows that the Sand Engine mega feeder nourishment supplies sediment to a stretch of coast that is several times the initial length of the nourishment, as the size of the Sand Engine peninsula increased from 2.2 to 5.8 km alongshore in just 5 years. The plan-form shape of the peninsula is found to gradually widen over time. The change in cross-shore extent and alongshore length is found to vary strongly with depth.

Considering the 17 km alongshore distance of the coastal cell, the measurable effect of the Sand Engine is currently confined to 5.8 km. Further spreading of the influence of the Sand Engine is expected in the coming decadal development.

Limited activity below the closure depth causes a large part of the Sand Engine's sediment to be unaffected by hydrodynamic forcing at the considered timescale of 5 years. It is unknown if and how this sediment, that is nourished at deeper water, will spread alongshore and/or cross shore in the future.

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