MORPHODYNAMICS OF SANDY BEACHES IN LOW ENERGY, NON-TIDAL ENVIRONMENTS

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INTRODUCTION

Sandy foreshores play an important role in flood risk reduction in areas near seacoasts, estuaries and lakes. They dissipate wave energy and thereby reduce the impact of storms on the hinterland (Vuik et al., 2016). The morphodynamics of sandy foreshores or beaches in lakes, known as low-energy, non-tidal environments, have not been studied as extensively as open coasts. The goal of this research is to understand the relation between hydrodynamics and morphology on sandy lake beaches.

In the Dutch lakes “Markermeer” and “Ijsselmeer” (respectively 700 km^2 and 1133 km^2, depth ~4m), sandy foreshores have been implemented, first as a pilot study and later as full-scale reinforcement of the Houtribdijk and as protection of newly constructed marsh islands (“Marker Wadden”) (Fig. 1). These innovative projects offer the opportunity to study the morphological development of these foreshores. In the pilot study at the Houtribdijk and at the Marker Wadden, bathymetric measurements have shown a distinct cross-shore profile, with a nearly horizontal platform (Fig. 2). A study into low-energy foreshores around the world with similar platforms, including the Marker Wadden beaches, concluded that higher wave energy and/or sediment mobility results in wider and deeper platforms (Ton et al., 2019). In this study, we research whether the elevation of the subaqueous platform is related to the depth of closure, where wave-induced sediment transport is close to zero, as defined by Hallermeier (1980).

Figure 1 – Location reinforcement Houtribdijk and Marker Wadden (source: Rijkswaterstaat)

METHODS

At Pilot Houtribdijk and Marker Wadden, hydrodynamics and morphology have been monitored. Morphological characteristics, such as the average platform elevation over time, are compared to the depth of closure:

$$d_s = 2.28 H_{s,12h} - 68.5 \frac{H_{s,12h}^2}{g T_{p,12h}^2},$$

where Hs,12h (m) and Tp,12h (s) are the nearshore significant wave height that is exceeded for 12 hours per year and its associated wave period, and g is the gravitational acceleration (m/s2).

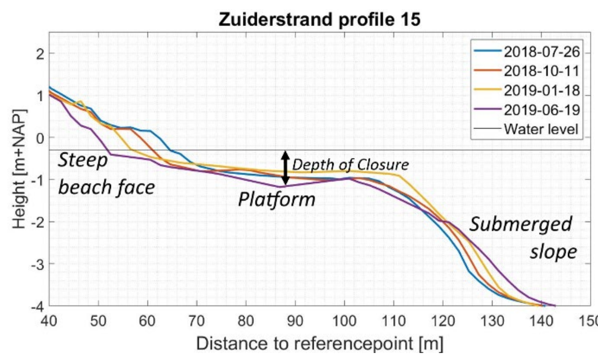

Figure 2 - Cross-shore profiles at “Zuiderstrand”, Marker Wadden, the Netherlands

RESULTS AND CONCLUSIONS

At all four study sites, a horizontal platform evolved of which the elevation stabilizes over time. We conclude that the eventual elevation of these platforms is indeed located at the depth of closure.

This study offers insights into the dynamics of sandy beaches in low-energy, non-tidal environments, such as lakes, hence enables future design and implementation for purposes such as shoreline protection, wave energy dissipation for flood risk reduction or recreation.

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