

EROSION HOTSPOTS AND BAR DYNAMICS ON THE DANISH WESTCOAST

Nikolai Heath Sørensen, Danish Coastal Authority, nihes@kyst.dk
 Per Sørensen, Danish Coastal Authority, ps@kyst.dk

INTRODUCTION

Focused local beach and dune erosion hamper coastal safety in certain vulnerable areas. Erosion hotspots are observed as 300-500 m stretches of coastline with greater levels of erosion than adjoining coastlines (Figure 1). Two erosion hotspots, with different wave climates, are observed and analysed to better understand their controlling mechanisms. Forecasting erosion hotspots' location and behaviour could be valuable for coastal safety in these areas.



Figure 1 - Location of, and drone image from Tversted (red) and Ndr. Thorsminde Tange (yellow).

METHODOLOGY

Two erosion hotspots are identified, one on the mid Danish west coast (Ndr. Thorsminde Tange) and one on a north-facing beach in northern Jutland (Tversted). A rip current system and an erosion hotspot is identified and monitored for 43 days, at Ndr. Thorsminde Tange, via averaged time-lapse images (Figure 2 top), thermal infrared images (TIR) (Figure 2 bottom), photogrammetric surface models, bathymetric surveys and satellite images.

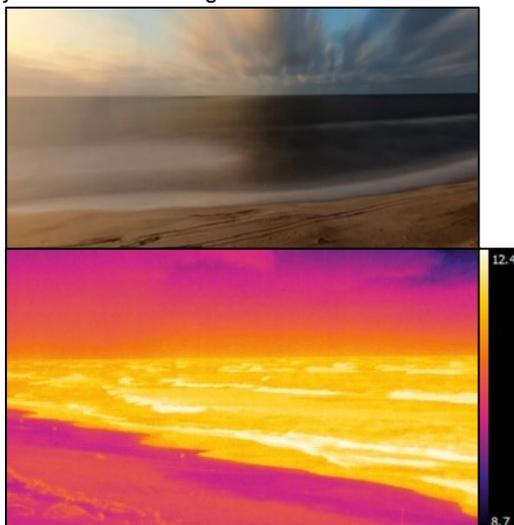


Figure 2 - Top: averaged image. Bottom: TIR image (°C).

Besides the in situ monitoring, a coupled MIKE 21/3 integrated spectral wave and hydrodynamic model is set up to simulate nearshore currents, water levels, and wave heights over the 43-day period on an initial and a final measured bathymetry, respectively.

An erosion hotspot is also identified at Tversted where film and imagery from handheld camera, camera mounted to a drill-digger and drone are available at a high-energy event. Historical coastal profiles and satellite images are analysed to better understand the coastal evolution in the area.

RESULTS, DISCUSSION AND CONCLUSIONS

The coastal undulation in lee of the rip channel at Ndr. Thorsminde Tange and the rip channel itself is found to migrate north, more or less, simultaneously. The bar system seems to control the location of the erosion hotspot, and the offshore wave height is well correlated ($R^2=0.74$) with the simulated rip current's off shore velocity (U -velocity). The rip system migration is related to the alongshore wave energy flux (P_0) and it is evident that the system migrates north when P_0 is directed northward for consecutive days.

The dimensionless fall velocity (Ω) is often applied to describe and categorise the nearshore morphology into beach types. A time series of Ω indicates that the beach type is dominantly *intermediate* throughout the 43-day monitoring period. A Ω parameter considering a response lag by a 10 day averaged Ω previous to an observed beach type describes the beach type more accurately than the instantaneous Ω . The integrated coupled MIKE 21/3 model simulates greater water levels at the beach, stronger seaward flowing currents (Figure 3) and larger waves in, and in lee of the rip channel compared to neighbouring coastlines.

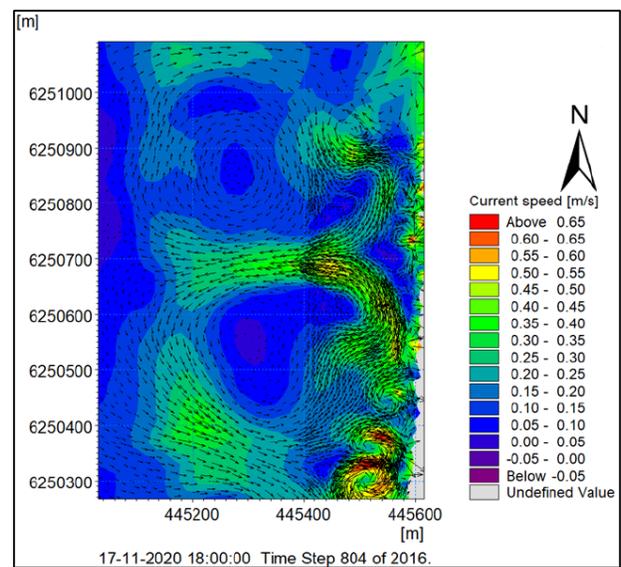


Figure 3 - Simulated rip current under the following hydrodynamic conditions: $H_{m0}=2.4$ m, $T_p=7.7$ s, $Dir=257^\circ$ N.

The observed and simulated erosion hotspot at Ndr. Thorsminde Tange is a mega cusp embayment in lee of a rip channel that migrates in the direction of P_0 and displaces with varying levels of wave energy.

Besides rip current systems, erosion hotspots can also be a consequence of migrating alongshore sandwaves and/or migrating seabed sandwaves. Alongshore- and seabed sandwaves can exist when the incident wave angle is towards $0/180^\circ$ relative to shore, which is the case at Tversted. Shore orthogonal seabed sandwave crests and troughs could possibly cultivate beach salients and embayments, respectively. The wavelength of the seabed sandwaves are similar to the extend of the erosion hotspot, which calls for further analysis. Several meters of dune erosion was observed within a few hours at a high-energy event in the trough of the alongshore sandwave at Tversted (see Figure 4).



Figure 4 - Photo of a dune after sand dune landslide. The fallen measuring rod was placed on top of the dune two hours prior to the photo.

The two examined erosion hotspots are possibly initiated by different mechanisms. The erosion hotspot on Ndr. Thorsminde Tange is caused by rip channels and alongshore sandwaves whereas the erosion hotspot at Tversted might be a consequence of shore-orthogonal orientated, migrating seabed sandwaves. It is nevertheless most likely that both erosion hotspots migrate in the direction of P_0 .