

# Improved planning of coastal protection measures

by analysis of long-term transect measurements of sandy beaches on Langeoog

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## BACKGROUND

Sandy beaches of barrier island coasts are highly depend on complex natural variability in dynamics of sand transport at the island's surf zone and across tidal inlets. Since dunes are an essential part of the coastal protection system of the East Frisian Islands in the North Sea (Lower Saxony, Germany), an adequate sand supply is necessary to ensure the stability of dunes. Sand nourishments balance the natural sand supply and are also known as 'Building with Nature' (BwN) or 'Nature Based-Solutions' (NBS).



Figure 1: Location of Langeoog in the North Sea, German Bight. Picture taken at low-tide 06.08.2018 (Sentinel-2)

## MOTIVATION

A tool to forecast erosion or sedimentation of sand would lead to a next level of coastal protection and risk mitigation management. The aim is to gain enough system understanding to still provide a sufficient safety level, but also allowing natural variability and in the best case use natural forces within coastal protection. This poster presents interim results of the European Union INTERREG North Sea Region Vb project 'Building with Nature' focusing on results for Langeoog (Hillmann et al. 2018 - scan code below; WP3 BwN 2017).

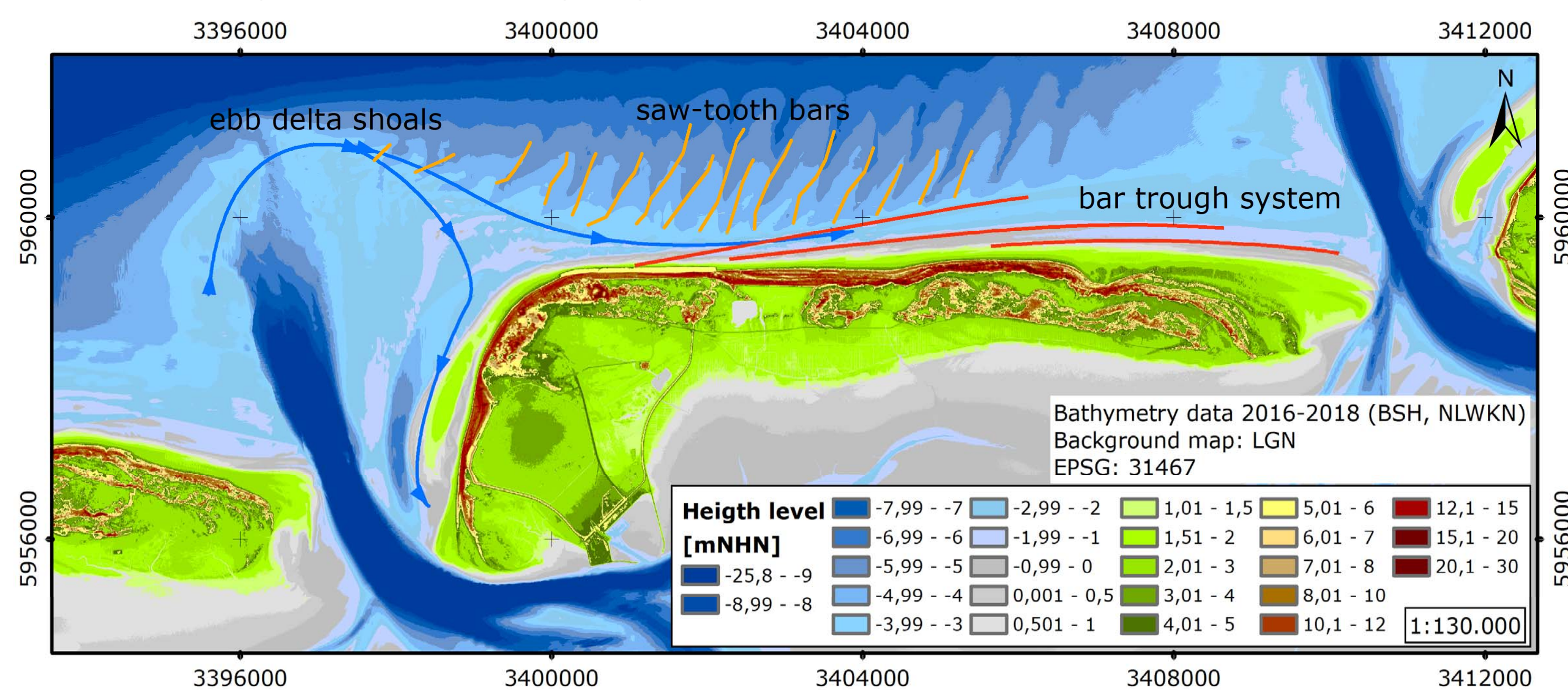


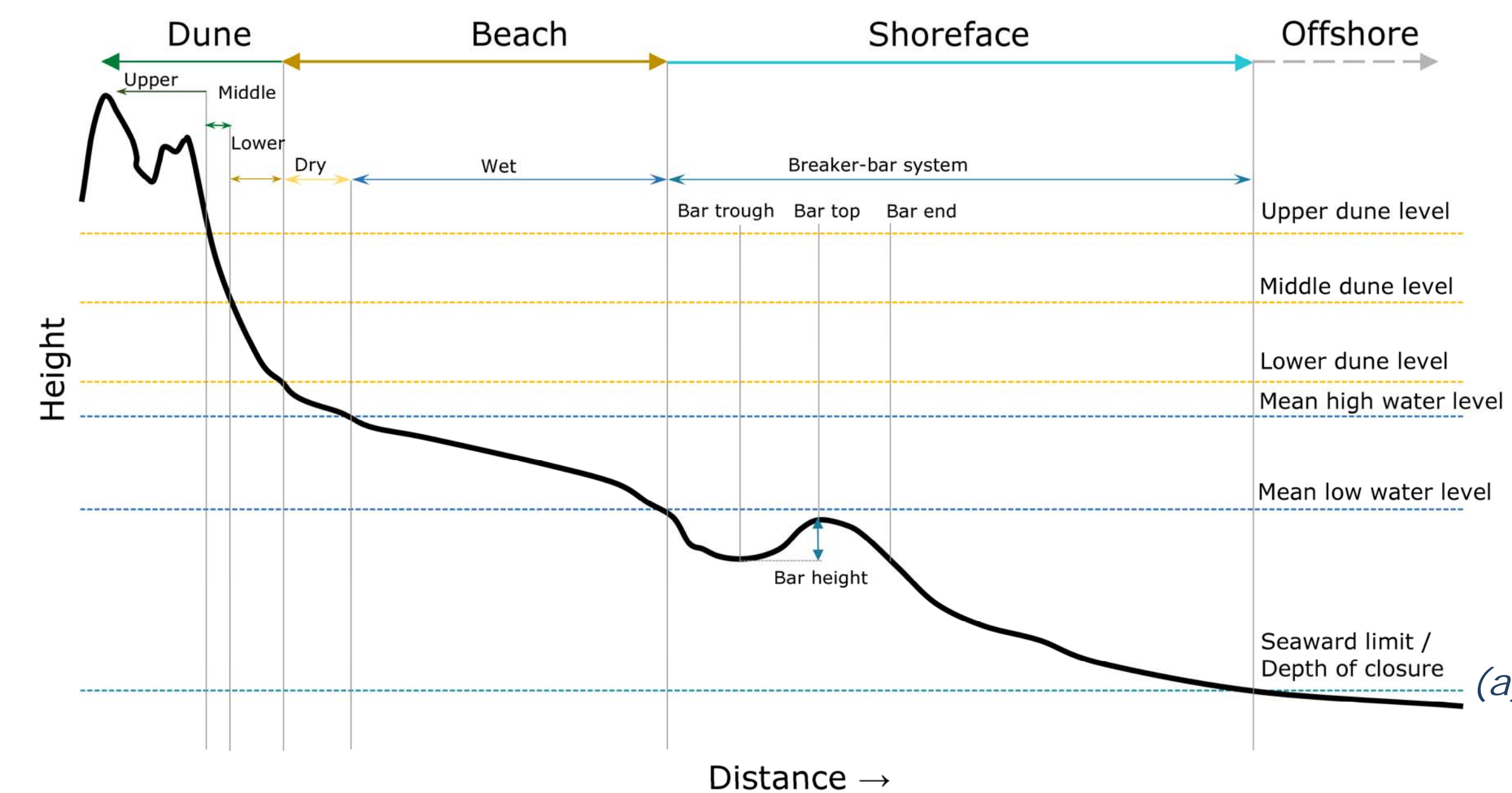
Figure 2: Bathymetry map of Langeoog. Sand is migrating from the west to east. Ebb delta shoals are formed in the tidal inlets and saw-tooth bars and bar-through systems on the seaside of the island.

## STUDY SITE

East Frisian Islands are held in a fixed position in the mesotidal sector of the German North Sea coast. In this high dynamic system the islands are dominated by change in the intensity of sedimentation and erosion. Shoals and bars which migrate through the ebb-tidal delta characterize the sand supply of the islands beaches (Hayes 1979; Swart and Zimmerman 2009; Herrling and Winter 2017). This morphodynamic system is highly influenced by changes in the hydrodynamic forces and sand availability in the system. In current practice, a certain amount of variability in the sand volume of the beach and dune area is allowed and nourishments are only implemented where needed to provide a defined level of safety. In contrast to the other East Frisian Islands, Langeoog in particular has no hard coastal protection structures adjacent to its sandy beaches. Dunes are protecting areas from flooding, which cover settlements and the fresh water lens for the water supply system of the island. In 2017 and 2018 a combined beach and foreshore nourishment has been implemented on Langeoog.

## METHODS

Transect and bathymetry data covering a period of 70 years are analyzed, to find recurring migrating systems of sand transport and reveal their morphodynamic speed. First, different height levels are assigned to a morphological response - Coastal State Indicators (CSI), also for transnational comparing coastal laboratories within the BwN-project. A monitoring concept for measuring terrestrial and hydrographic data supports the current database for the ongoing BwN-project. During the monitoring period, sand samples are taken to determine the spatiotemporal grain size distribution before, during and after the nourishment. Additionally, hydrodynamic measurements in the beach area and 2.5 km offshore are carried out to give insight into the conditions in this area, comprising wave, current and water level data. Bathymetry data before and after a storm surge combined with the results of the monitoring program give input for numerical models like Xbeach to validate the model output and obtain a deeper insight in the process of beach and dune erosion.



Coastal State Indicator	Level [mNHN]	Response
Upper dune	+7	only responsive to dune erosion or human-made reinforcement
Middle dune	+5	natural dune growth can be visible (long term positive or negative sediment balance)
Lower dune	+3	variation can be the result of sand traps or of natural dune growth resulting from aeolian sand transport (short-term)
Mean high water	+1.3	active zone: available sand for hydrodynamic interaction/wave reduction
Mean low water	-1.3	

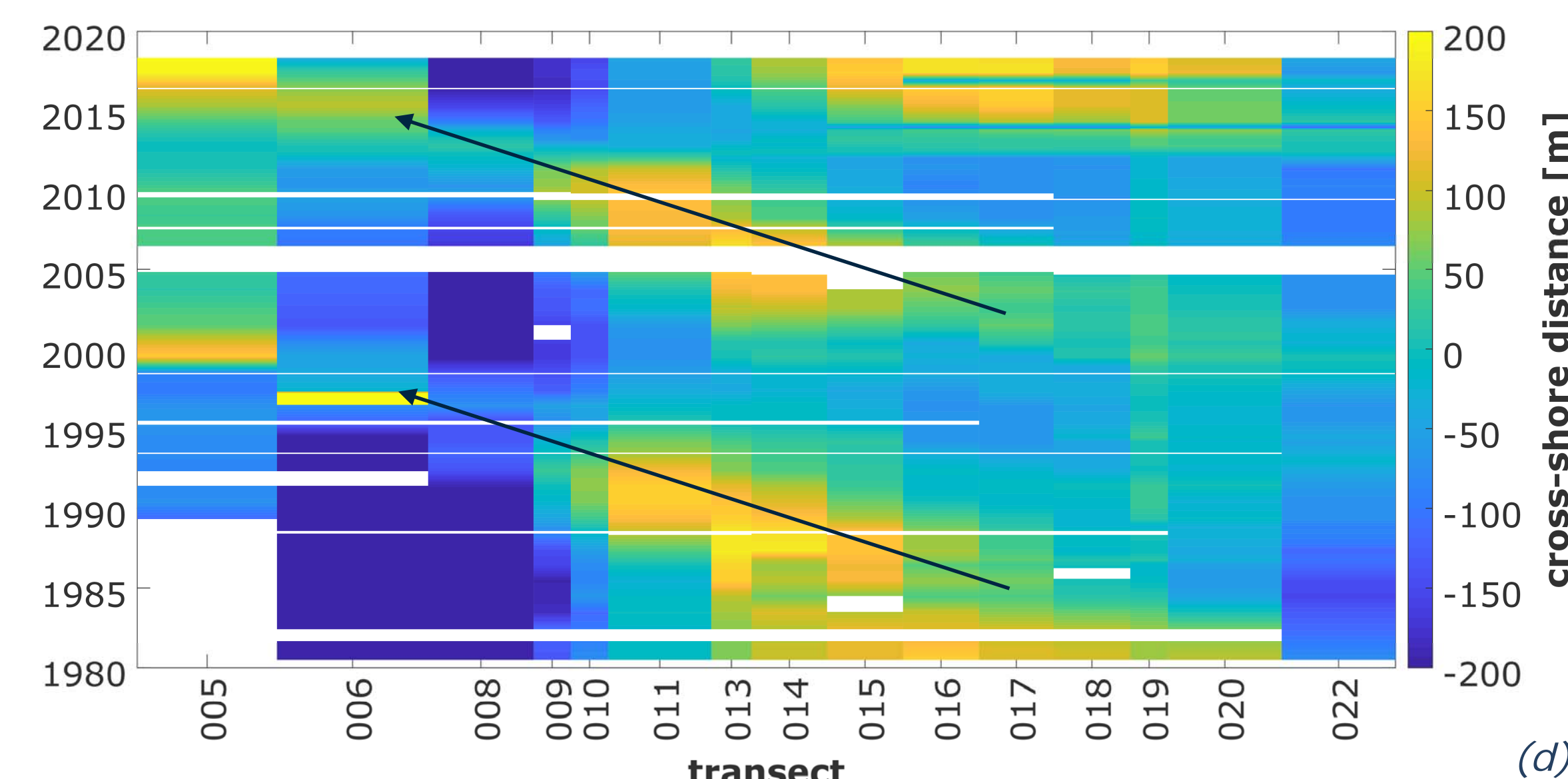


Figure 3: Analysis Process of transect measurements. Common coastal terms are defined for comparing same morphological features for different coastal areas (NLWKN 2018) (a). By linking these terms to a height level, they become a CSI for showing the response of a morphological behavior (b). Looking at one transect development (here no. 13) for these CSI, a long term behavior is visible (c). Looking at neighboring transects for the CSI mean high water (+1.3 mNHN + MKL Model 0.5 m (Sutherland 2010)) a long term behavior becomes a trend estimation (d).

## RESULTS

Within the INTERREG project 'Building with Nature' Coastal State Indicators are developed to link a measured value of the beach to a morphological response. Also different morphological systems are derived from long-term transect data for Langeoog. For those morphological systems the past behavior is evaluated. Recurring phases of erosion or accumulation are shown for the past and can be estimated for the future development.

## CONCLUSIONS AND FURTHER RESEARCH

Analysis of long-term transect data returns system understanding in the framework of coastal protection management. This leads the way to improved planning of sand nourishments regarding timing, placement and volume. The value of long-term and high resolution monitoring emphasizes the need of ongoing measurement programs to support 'Building with Nature'-Solutions and to evaluate their effectiveness. If the system is well known and natural positive behavior for coastal protection is detected to avoid unnecessary negative impacts by building hard structures, soft structures are an alternative regarding possible ecological and morphological impact. Results of the monitoring program can be analyzed further to support these findings by numerical models like Xbeach.



[Read BwN National Analysis Lower Saxony \(GER\)](#)

## REFERENCES

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NH5.7/AS4.63/CL3.10/GM11.10/OS2.12  
Natural hazards and climate change impacts  
in coastal areas (co-organized)

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