Summary

This study aims to reconstruct the development of the Holocene northern barrier spit of Sylt, an island located off the southern German North Sea coast. The sedimentary architecture of this spit system was investigated through an integrated approach, using ground-penetrating radar (GPR) and sediment core data. An age assignment of stratigraphical units was obtained through radiocarbon dates. The data obtained made it possible to document the sedimentary architecture with a high resolution. This sheds new light on the sedimentary processes that influence growth and destruction of the spit and helps to sharpen predictions of future developments. The presented method provides an excellent tool for efficient, high-resolution spatial analysis of sedimentary facies and stratigraphy of sandy coastal areas in temperate climates. The models developed for the spit's sedimentary dynamics provide a framework which may also be applied for interpretation of other sedimentary successions which formed in similar settings.

A new stratigraphic model for the northern barrier spit of Sylt is presented, showing that the spit's latest Holocene development is much more complex than previously thought. Morphologically, the spit is composed of a large, recurved main spit (the „Listland") that terminates with a hooked spit geometry (the „Ellenbogen") against the northward adjacent tidal inlet. Data shows that both parts of the spit system undergo a different evolution. Increased erosion at the main spit leads to enhanced growth of the hooked spit, which therefore serves as a sediment sink for at least part of the eroded material. The data furthermore reveals that the recent shoreline of the northern spit does not reflect the orientation of the genetically built spit axis which strikes northwest – southeast. This can probably be attributed to a change of controlling factors during the development of the spit.

Whereas the southern part of the Listland consists of backbarrier sediments, overlain by washover sediments, the northern part of the spit comprises of sandy beach sediments. The welding of swash bars is shown to be the predominant process during progradational phases of the main spit system. During these periods, progradation is not restricted to a linear growth along the spit axis, but also comprises a seaward-directed component. Major erosion surfaces, which delimit progradational sediment packages, are interpreted to reflect exceptionally severe storms. Data indicates that the fossilization potential of this sedimentary succession was controlled by a positive net long-term sediment balance, and the position of the groundwater table which controlled eolian deflation. Fossil eolian deflation surfaces, preserved as erosional unconformities in different depths, indicate that the land surface of the spit is controlled by the hydrodynamic coupling of groundwater table and sea-level position. This results either in erosion – by deflation – during falling stages of the sea level, or in vertical aggradation – by trapping of windblown sand – during periods of sea-level rise.

The development of the hooked spit, the Ellenbogen, is controlled by the interplay of alongshore migrating foreshore beach-drifts under fair-weather conditions and strong erosional events, interpreted as the result of rare severe storms. These storms interrupt beach-progradation and lead to a significant retreat of the coastline. Exceptional storms may also excavate scarps in the backshore. Storm scarps play an import role in the development of the fore-dune ridges that are situated on the recent hooked spit. In contrast to the main spit of Sylt, where the sediment budget is negative, the hooked spit experienced significant beach growth during the last

Lindhorst, S., 2007. Stratigraphy and development of a Holocene barrier spit (Sylt, southern North Sea). PhD-Thesis, University of Hamburg, Germany, 164 p.

decades. This can probably be attributed to enhanced beach nourishment updrift, along the main spit, and makes the investigated hooked spit a natural laboratory to study the influence of increasing sediment supply in a system developing under the conditions of Holocene sea-level rise.

Radiocarbon dating of mollusk-shell debris makes it possible to present an age model of the late Holocene spit stratigraphy. Around 3700 BP, the initial spit reached a north-south extension comparable to the present day extension. Spit deposits are sands, and clays were deposited in the backbarrier. As a result of a sea-level lowering, erosion occurred between 3500 and 2500 BP, and an eolian deflation surface developed, nowadays located in a depth of 2 to 3 m below mean sea level. Between 2500 and 2000 BP the coast retreated, a process which was probably triggered by exceptional strong storms. Subsequently, the spit recovered by welding of swash bars. Contemporaneously, large wash-over fans formed along the lee-side of the spit. Around 2000 BP, a tidal inlet developed between the Listland and the Ellenbogen. This feature was closed before 1700 BP, due to enhanced spit progradation. Around 1300 BP at the latest, the Ellenbogen hooked spit formed. Around 1000 BP increased erosion on the western coast resulted in enhanced growth of the hooked spit. Contemporaneously, between 1700 and 1000 BP, an eolian deflation surface developed all over the Listland. This surface is nowadays buried by an up to 1.5 m thick eolian succession.

Sediment availability on the spit is an important prerequisite for spit aggradation during phases of sea-level rise. Artificial stabilization of migrating dunes and exceptionally high coastal dunes therefore reduces sediment input into the interdune valleys, impairing or even suppressing vertical spit aggradation as a natural reaction to sea-level rise in these areas. Future sea-level rise will therefore not only cause enhanced erosion on the western coast, but also the flooding of the spit by marine incursion arising from the backbarrier bay.