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Coarse-grained sediment distribution in shallow water of the south-western Baltic Sea (Germany)

Henning May[1], Kerstin Schrottke[1] & Klaus Schwarzer [2]

[1]Cluster of Excellence "The Future Ocean", Institute of Geosciences, Kiel University, Germany
[2]Sedimentologie, Coastal and Continental Shelf Research, Institute of Geosciences, Kiel University, Germany

Abstract

Coarse-grained sediments like cobbles, stones and boulders commonly occur in the south-western Baltic Sea, mainly on submarine abrasion platforms in front of retreating soft-rock cliff coasts. These residual sediments seem to be an important source for the development of coarse-grained beach ridges, which play an essential role as shore protection element of the adjacent coastal lowlands. A new small-scaled, high frequency side-scan sonar (SSS) is used, to analyse large-scaled distribution pattern and characteristics of residual sediments in near-shore zones of the south-western Baltic Sea. Ground-truthing is done by scientific scuba divers. For the first time, detailed mapping of sediment distribution from the water line down to 8 m water depth were done in 2009, reflecting a broad spatial distribution of different residual sediments and sand bar systems.

1 Introduction and objectives

Cliff-coasts composed of morainic material are widespread along the south-western Baltic Sea. They alternate with coastal lowlands. At many sites, wind-induced wave impact causes cliff retreat and abrasion of the adjacent seafloor (e.g. Gurwell 1991, Schrottke 2006). Under erosion, sediment with grain-sizes ranging from clay to boulder size is supplied. Healy & Wefer (1980) assumed that residual sediments are relatively stable in position. Schrottke et al. (2006) showed that coarse-grained sediments are regularly moved on submarine abrasion platforms of the Baltic Sea, mainly in landward direction with a long-shore component. These findings match with other studies, although reflecting tidal conditions (e.g. Osborne 2005, Curtiss et al. 2009). It has been postulated, that residual sediments seem to play an important role as sediment source for the development and stability of coarse-grained beach ridges of coastal lowland (Schrottke et al. 2006). Detailed information on source to sink pathways and transport rates under different hydrodynamic conditions is still lacking, but is needed especially with respect to climate-related sea-level rise and coastal erosion. Information on spatial distribution of residual sediments in the near-shore zone is retrieved in a first step of new studies to fill these gaps.

2 Regional setting

The sites are located at the German south-western Baltic Sea coast, near the villages Schönhagen and Heiligenhafen (figure 1a-c). Each site comprises an active cliff-coast section with adjacent coastal lowlands. They are differently exposed to the main wind-wave direction with diverging fetch lengths. Tidal effects are negligible. Measurements cover areas from the water-line to about 8 m water depth.

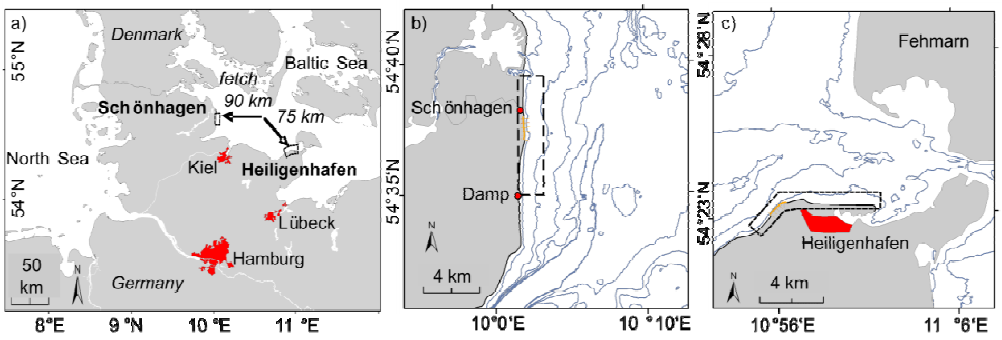

Figure 1a-c: a) Location of the study sites along the German south-western Baltic Sea, near b) Schönhagen and c) Heiligenhafen.

3 Methods

A small-scaled, dual channel, triple-frequency (260, 330, 770 kHz) SSS (Yellow Fin, Imagenex™) is used to measure even in very shallow water (< 1 m) by deployment in a fixed position from a rubber boat. The system has an across-track range resolution of 0.01 m. High frequency is used with a range of 20 m in water depths < 5 m and 40 m in water depth > 5 m. Geographical locations are given by Differential Global Positioning. A grid resolution of 10 cm is used for mosaicing (Triton IlicsTM). Ground-truthing is done by scientific scuba divers.

4 Results

Figure 2a exemplarily shows an SSS mosaic from the seafloor close to Schönhagen. The area bounded by dashed lines consists of a nearshore bar identifiable by wave-induced, cross-shore ripples. The distance between ripple crests decrease towards onshore from 95 to 10 cm. Smaller ripples appear as relatively light areas (figure 2a).

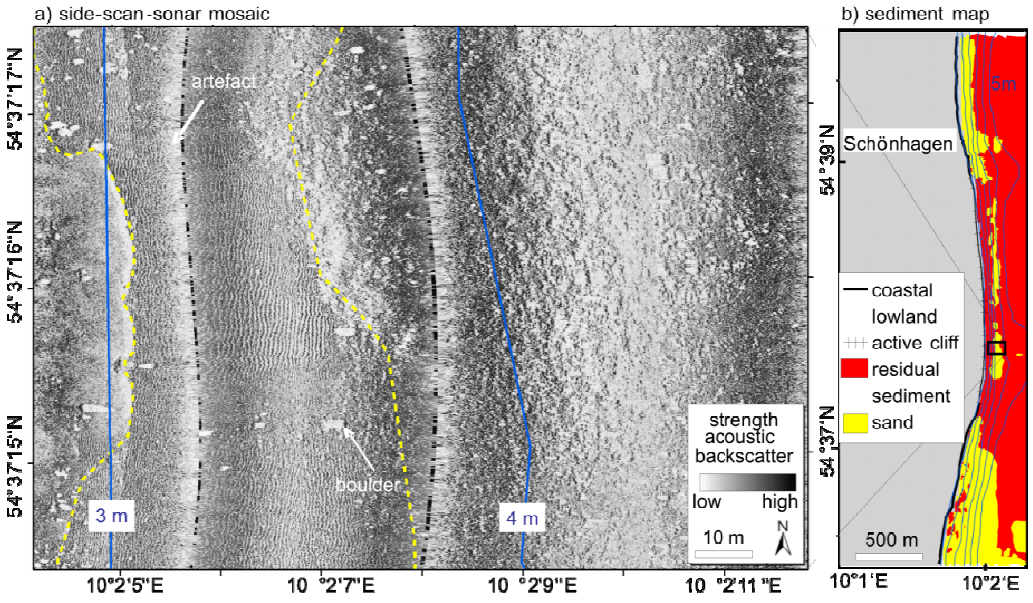

Figure 2a-b: a) Side-scan sonar mosaic from the near-shore zone of Schönhagen mapped on 23 April 2009. b) Sediment map based on SSS data.

The nearshore bar is bordered by heterogeneous sediments varying from gravel to boulder size. Boulders, which are not used as settling ground by macrophyto- and macrozoobenthos, are clearly detectable by dark spots with white acoustic shadows (figure 2a). Large areas of high backscatter indicate cobble coverage, as found eastwards of the nearshore bar. The black lines, which are surrounded by low backscatter, are allocated to device-specific artefacts. However, boulders still can be identified in these zones (figure 2a). The sediment map (figure 2b) reflects a broad, spatial distribution of residual sediments. They are particularly dominant in shallow waters in front of the cliffs and in water depths > 4m. Sandy deposits are widespread in the nearshore zones of the coastal lowlands. The nearshore bar in front of the cliff is almost rudimentary, covering residual sediments.

5 Discussion and conclusion

So far, spatial information on sediment distribution patterns in near-shore zones has been mostly based on aerial or satellite images and sediment sampling in rigid grids. Single cobbles of 10 cm in diameter could not be identified, as possible in the SSS mosaics of this new measuring device. Data of the new SSS now clearly reflect the option of detecting coarse-grained sediments and distribution patterns with high spatial coverage, especially in very shallow water, which has not been done before. In a next step, resurveys are now used to analyse coarse-grained sediment transport, combined by high resolution tracer experiments.

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Address

Prof. Dr. K. Schrottke
University of Kiel - Institute of Geosciences
Cluster of Excellence: The Future Ocean, Sea-Level Rise & Coastal Erosion
Otto-Hahn-Platz 1, 24118 Kiel, Germany

ks@gpi.uni-kiel.de