Wave-Induced Suspended Sand Transport Around Ripples in the Near Shore Zone

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Motivation and Background

- Sediment transport in coastal zones modifies continuously the boundary between the land and the water.
- To predict the dimensions of the cross-shore sea bed profile evolution, accurate spatial and temporal measurement of sediment load is strongly needed.

Figure 1

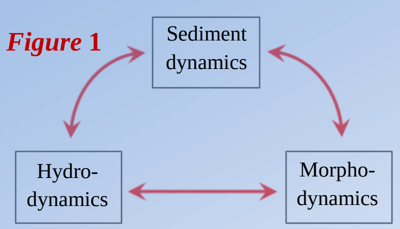


Figure 1 Interactive relations between sediment dynamics (suspended load and bed load), hydrodynamics (waves and currents) and morphodynamics (rippled bed and plane bed).

Research Facility and Test Conditions

Wave flume

- 300 m long, 5m wide and 7m deep (*Figure 2*)

Waves

- Regular waves: H = 0.8–1.2 m T = 5 s (*Figure 3*)
- JONSWAP-spectra: H_s = 0.8–1.2 m T_p = 5 s (*Figure 4*)

Bed material

- Sand layer: 0.80 m (*Figure 2*)
- Grain size: $d_{10} \approx 125$ µm; $d_{50} \approx 242$ µm; $d_{90} \approx 470$ µm
- Uniformity factor, $U=d_{60}/d_{10}$ = 2.64

Water depth

- h = 3.20 m (*Figure 2*)

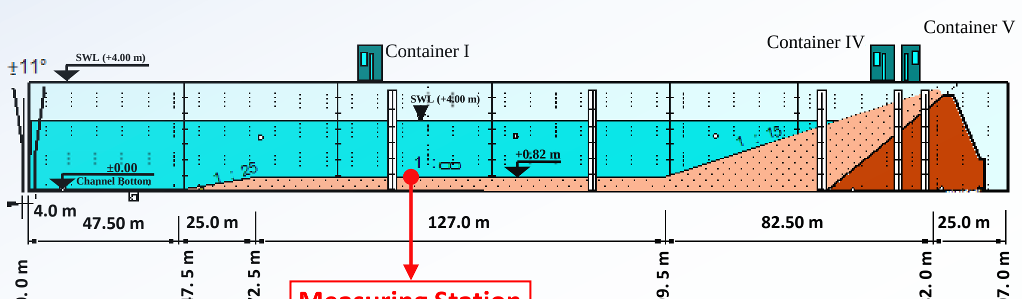


Figure 2

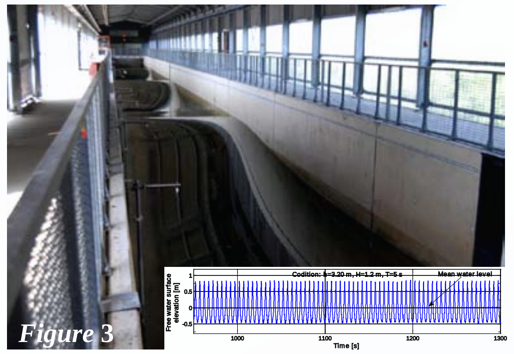


Figure 3

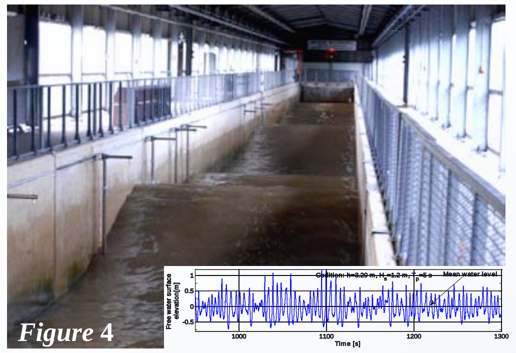


Figure 4

Experimental Setup and Instrumentation

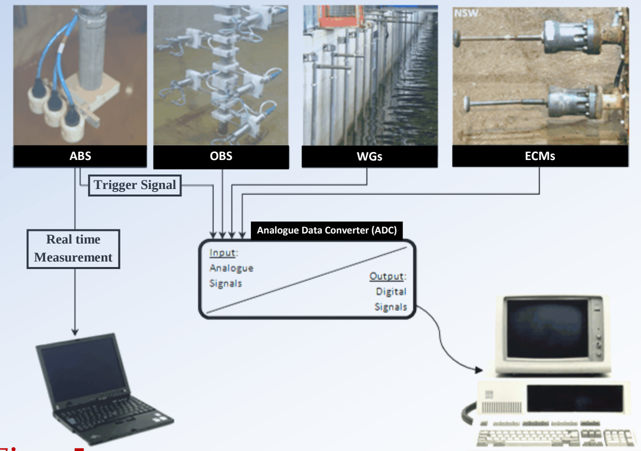


Figure 5

Measurement Devices

- Acoustic Backscatter Sensors (ABS)
- Optical Sensors (OBS)
- Transverse Suction System (TSS)
- Electromagnetic Current Meters (ECMs)
- Wave Gauges (WGs)

Figure 5 All probes used in the tests and their connection to the GWK-data acquisition system.

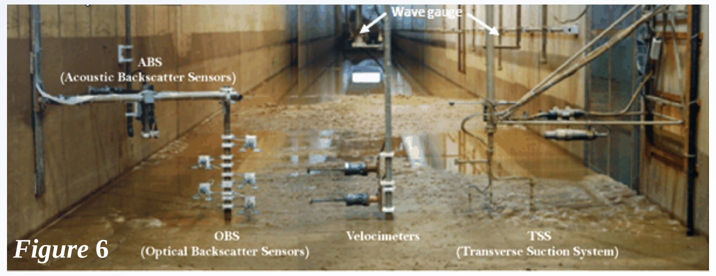


Figure 6

Figure 6 Fixed instrumentation frame in the measuring station used to measure the temporal and spatial distribution of Suspended Sediment Concentration (SSC), simultaneous oscillatory flow velocity and the free water surface elevation.

Comparative Analysis

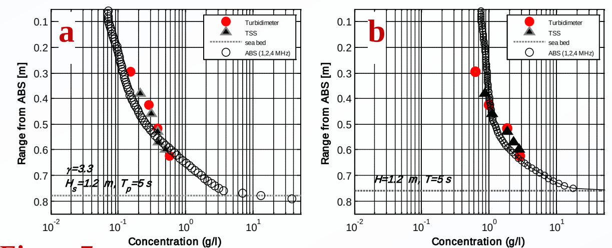


Figure 7

Figure 7 Time- and bed-averaged concentrations measured by: ABS, OBS and TSS under:
a) JONSWAP spectrum (H_s=1.2 m, T_p= 5 s, γ=3.3)
b) Regular waves (H=1.2 m, T= 5 s)

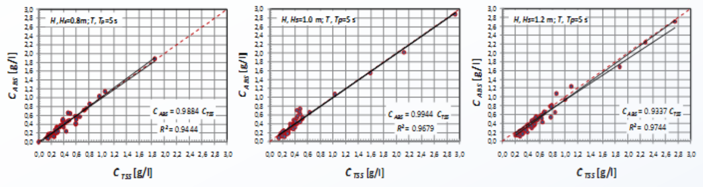
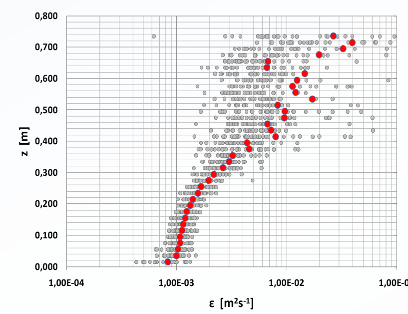


Figure 8

Figure 8 Regression plots of mean ABS concentrations against TSS concentrations at 0.14, 0.17, 0.21 and 0.37 m above the sand bed under regular and irregular waves.

Intra Wave Analysis



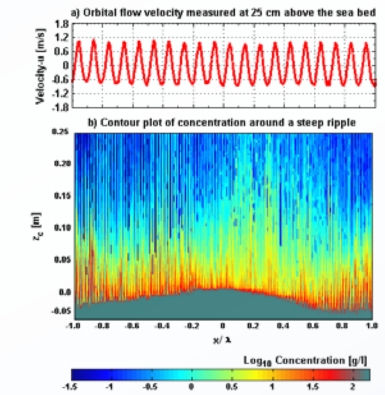


Figure 9 Sediment diffusivity profiles with height above the sea bed beneath regular waves including the averaged sediment diffusivity profile.

Figure 10 (a) Horizontal orbital flow velocity u, and (b) suspended concentration above a steep ripple beneath non-breaking waves. (H=1.0m, T=5s, h/L= 0.075)

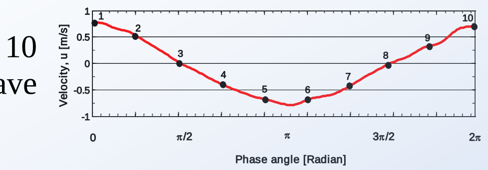


Figure 11 Wave induced horizontal orbital velocity at 10 selected phase angles of a wave cycle.

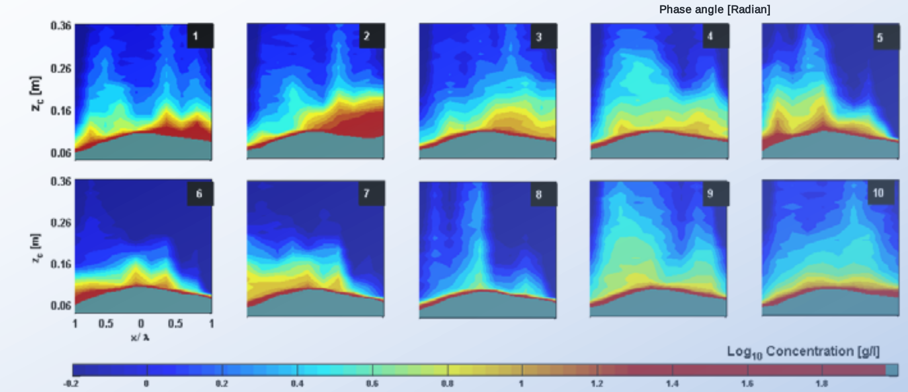


Figure 12 Sound imaging of vortex generation and suspended sediment entrainment over a ripple at the selected phases of a wave cycle depicted in *Figure 11*.

Concluding Remarks

1 Measurement and analysis of the sediment entrainment processes above rippled bed under non-breaking waves using different measuring techniques were performed.

2 It was found that the non-intrusive acoustical backscattering method (ABS) clearly represents the most appropriate device to capture the sediment entrainment event over steep ripples with sufficient temporal and spatial accuracy.

3 Results of ABS-measurement show that the generation of the coherent sediment-rich vortices at the lee side of the steep ripple crests represents the primary entrainment process of the sand particles above a steep ripple.

4 Analysis of the high resolution sound images of suspended sediment (SSC) has shown that due to the phase lag between the vortex generation and the time of the flow reversal, the net sediment flux above rippled bed is directed off-shore.