ForWind – Zentrum für Windenergieforschung

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Influence of a monopile structure on multidirectional wave forces and scour development in combination with tidal current conditions

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Outline

Motivation and research objective

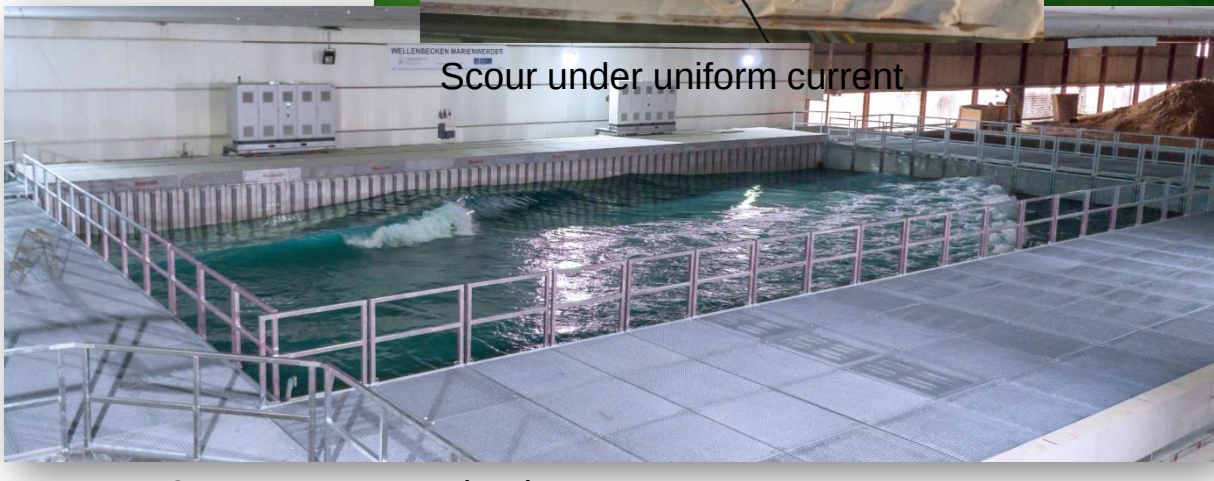
Investigations and preliminary results

- Scour
- Wave loads

3-D wave-current basin

Outlook

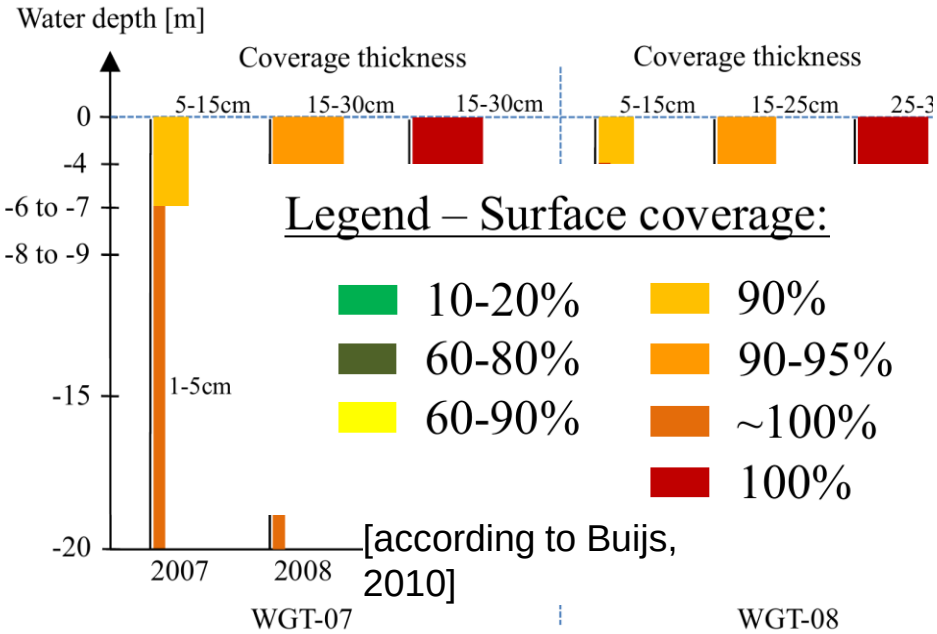
Scour under uniform current



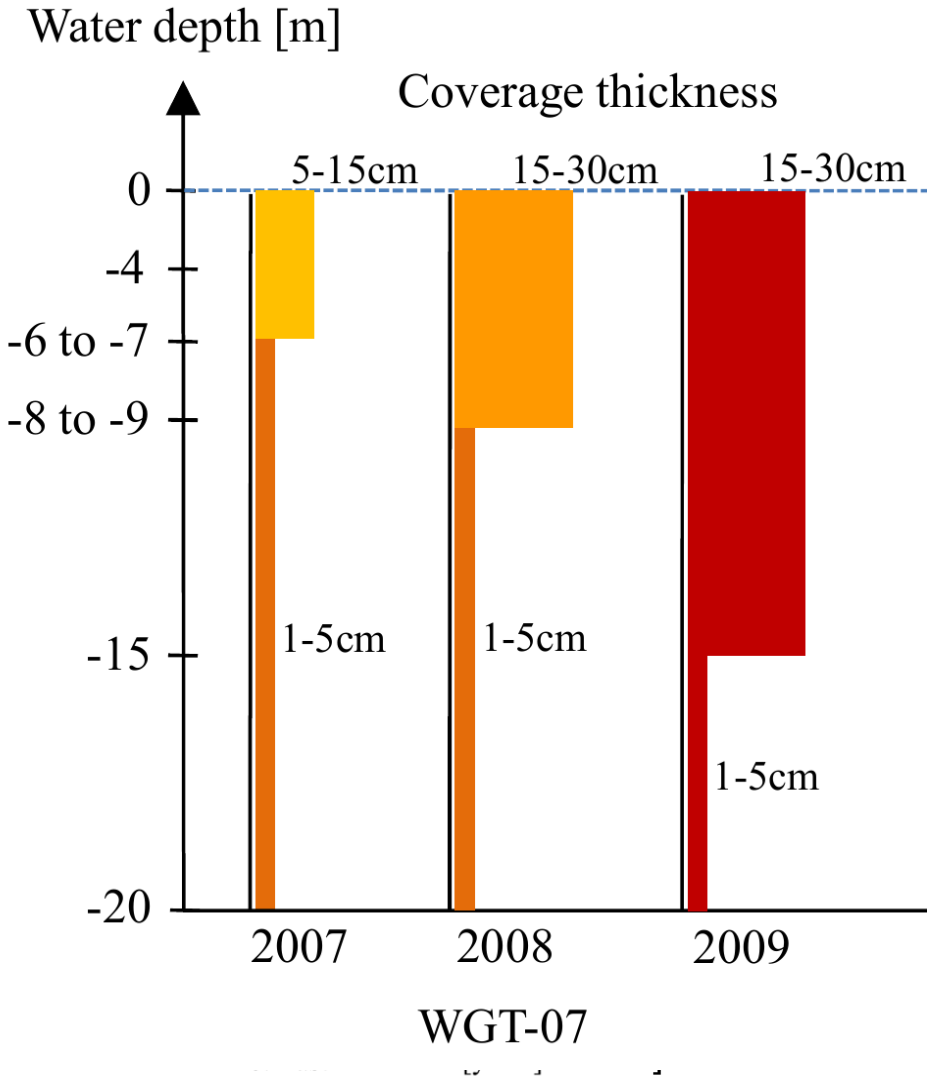
3-D wave-current basin

Motivation – Altered forces on cylinder due to marine growth

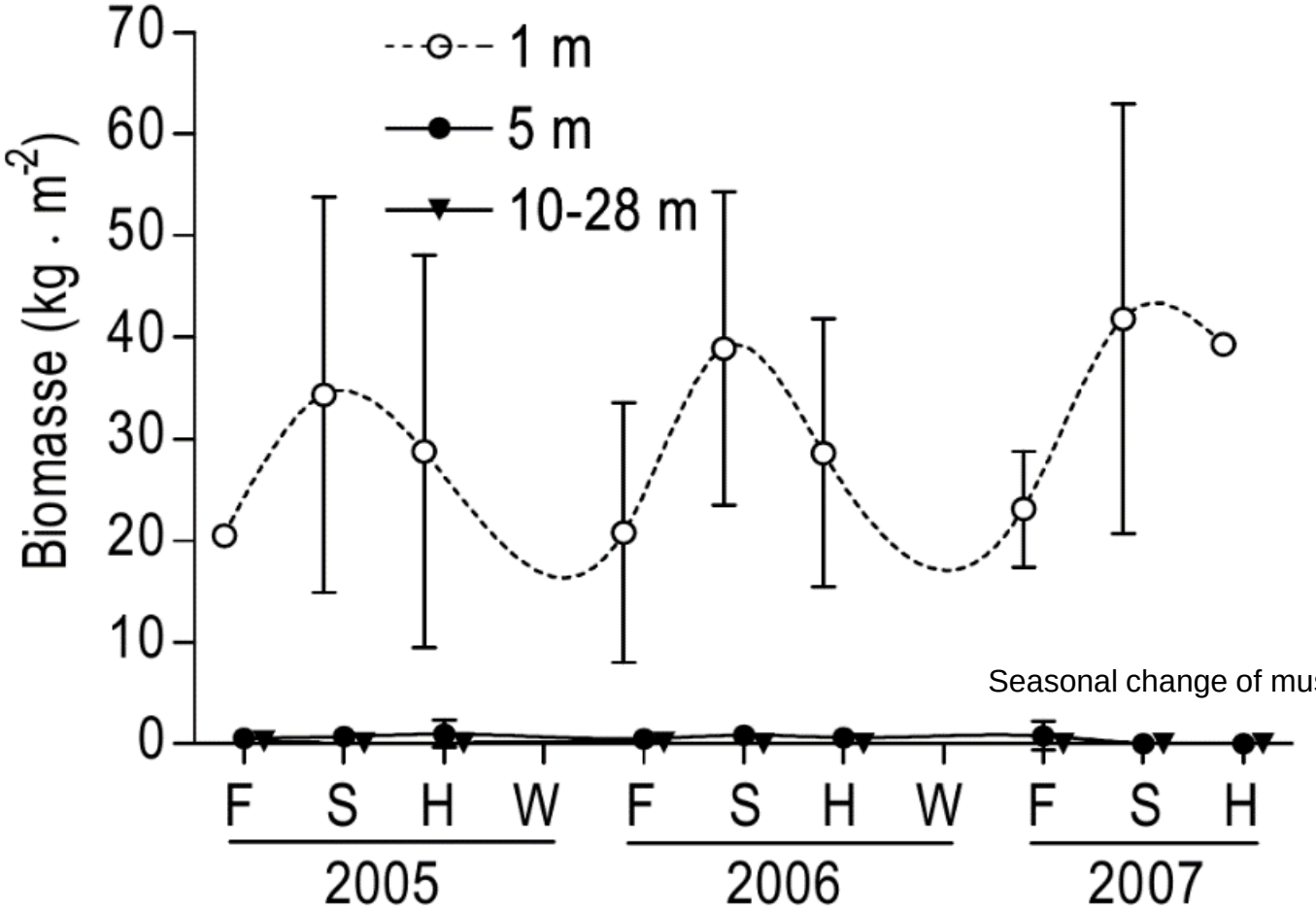
- Proceeding into greater depth
- Covering the whole surface
- D_{pile} = 4.3 m, extended to D_{rough} = 4.9
- Roughness enlarges to 0.1 m

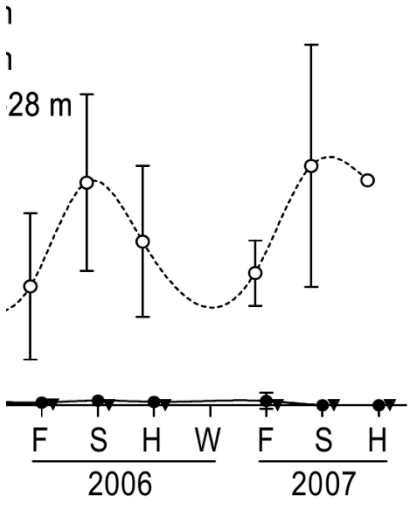


[according to Buijs, 2010]



Motivation – Altered forces on cylinder due to seasonal change





Seasonal change of mussel growth (Schröder, 2008)

Seasonal change of mussel growth (Schröder, 2008)

Motivation – Altered forces on cylinder due to short-crested waves

- Wave spreading lowers in-line forces (Ji, 2015)

- Jian (2008): Increasing forces due to short-crested waves interacting with current

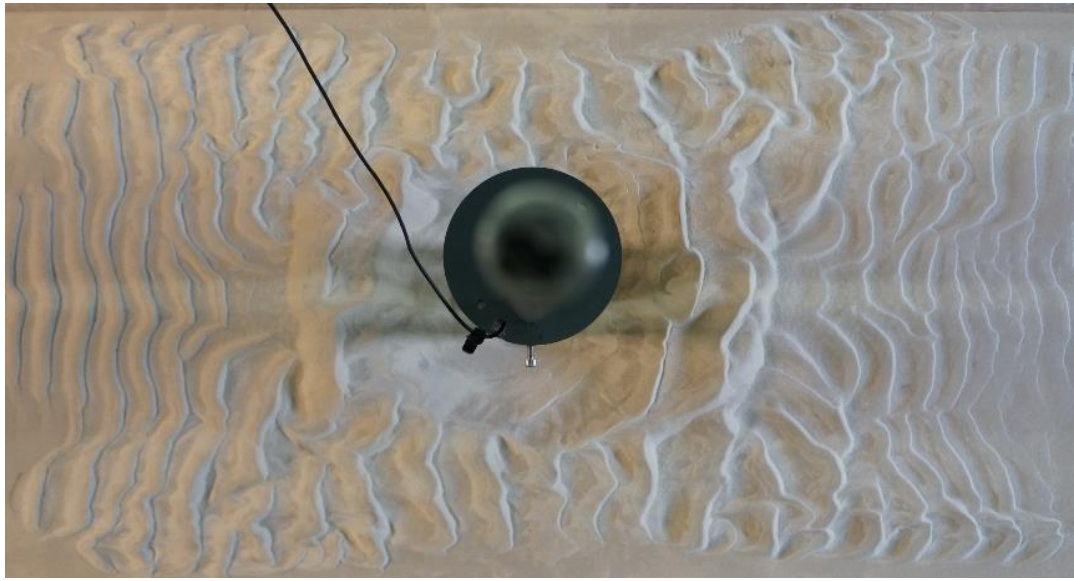
→ Comparison of long-crested and short-crested waves

→ Influence of wave-current interaction

Short-crested waves

General objectives scour investigations

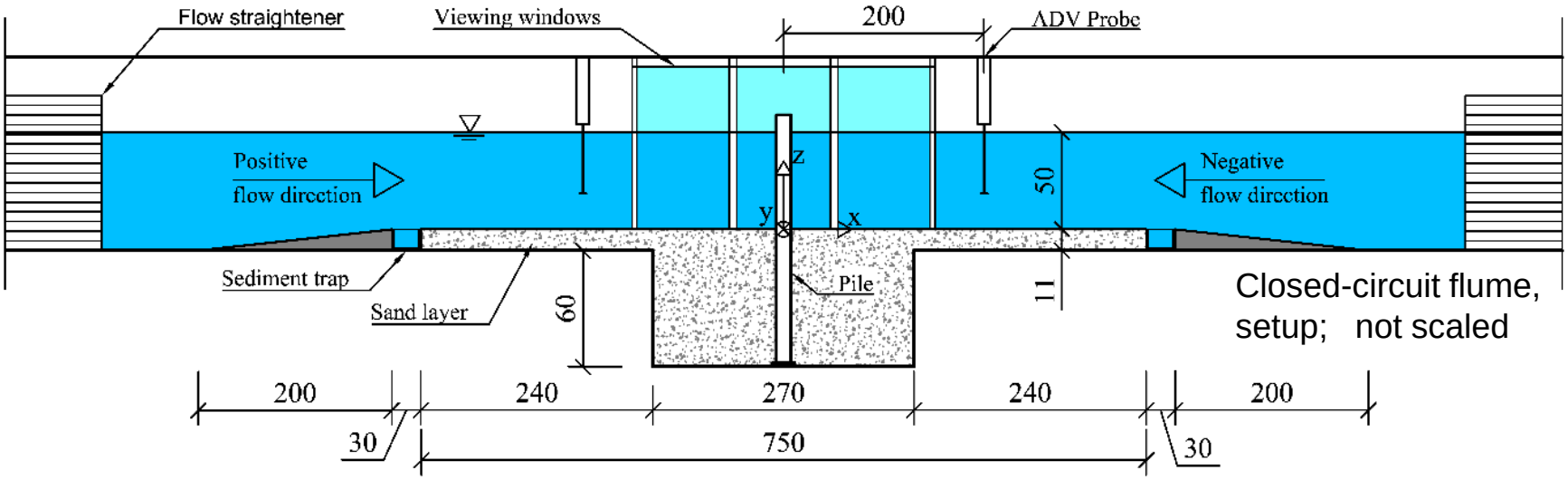
- Sea state is a combination of tidal currents and multidirectional waves
- Hydraulic model
  - Influence of tidal currents → closed-circuit flume
  - Influence of multidirectional waves and wave-current interaction → 3D wave-current basin



Sediment movement under reversing currents

Preliminary research - Scour under tidal currents

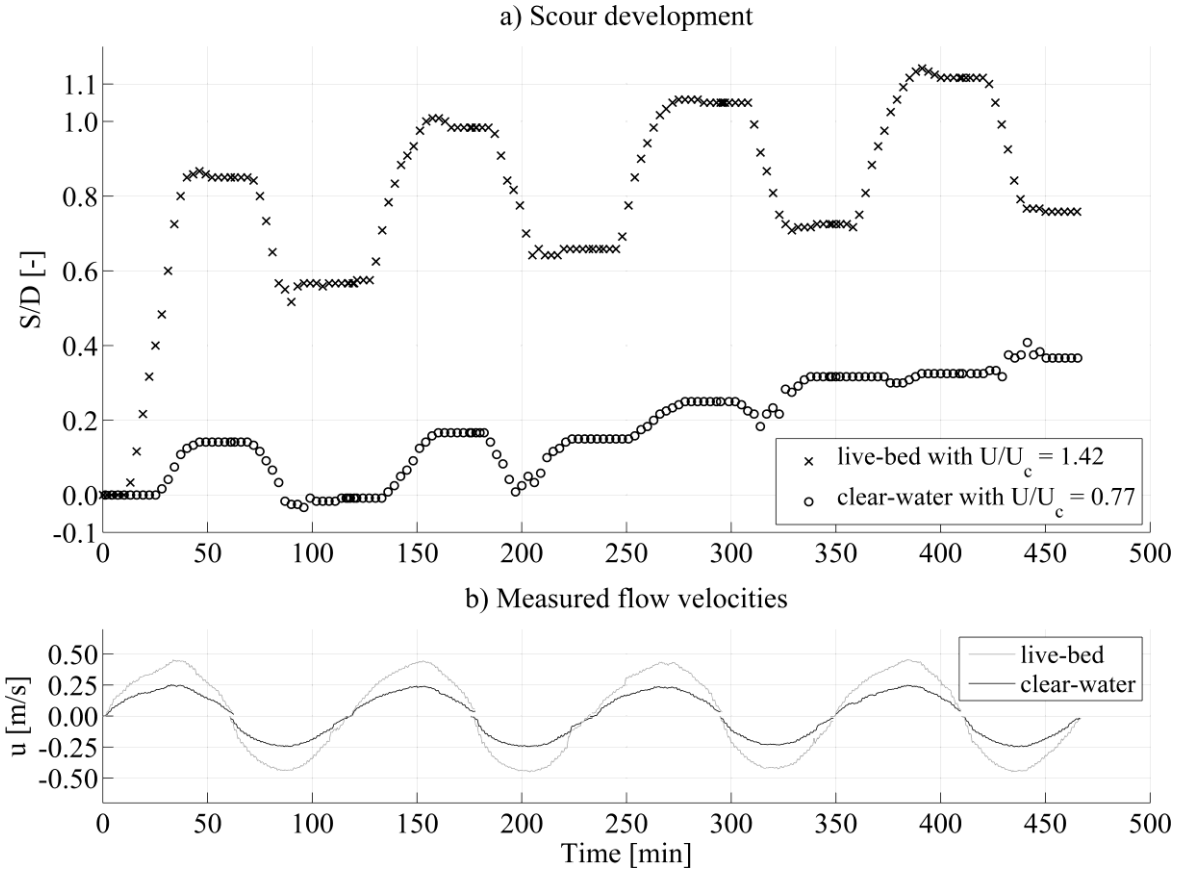
- Experimental setup – Model scale 1:40
  - Closed-circuit flume, length 60 m, width 1 m
    - driven by four pipe pumps → reverse flow
  - Transparent Monopile, D = 150 mm
  - Scour measurement by camera (inside pile, 2.5 mm scale) and laser distance sensor (carried out at a later stage)
  - ADV velocity measurements



Closed-circuit flume, setup; not scaled

Scour under tidal currents

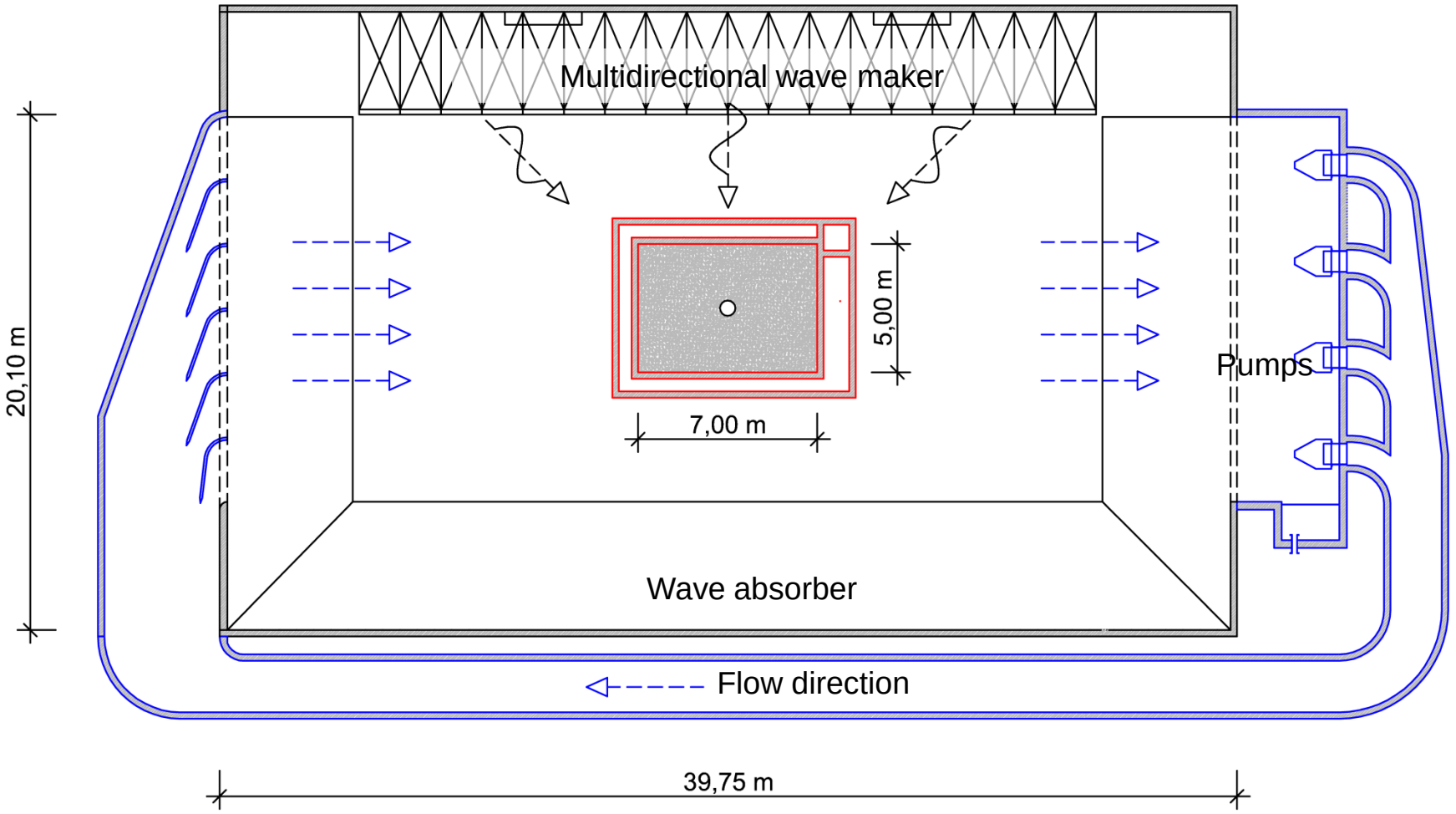
- Comparison of clear-water and live-bed conditions



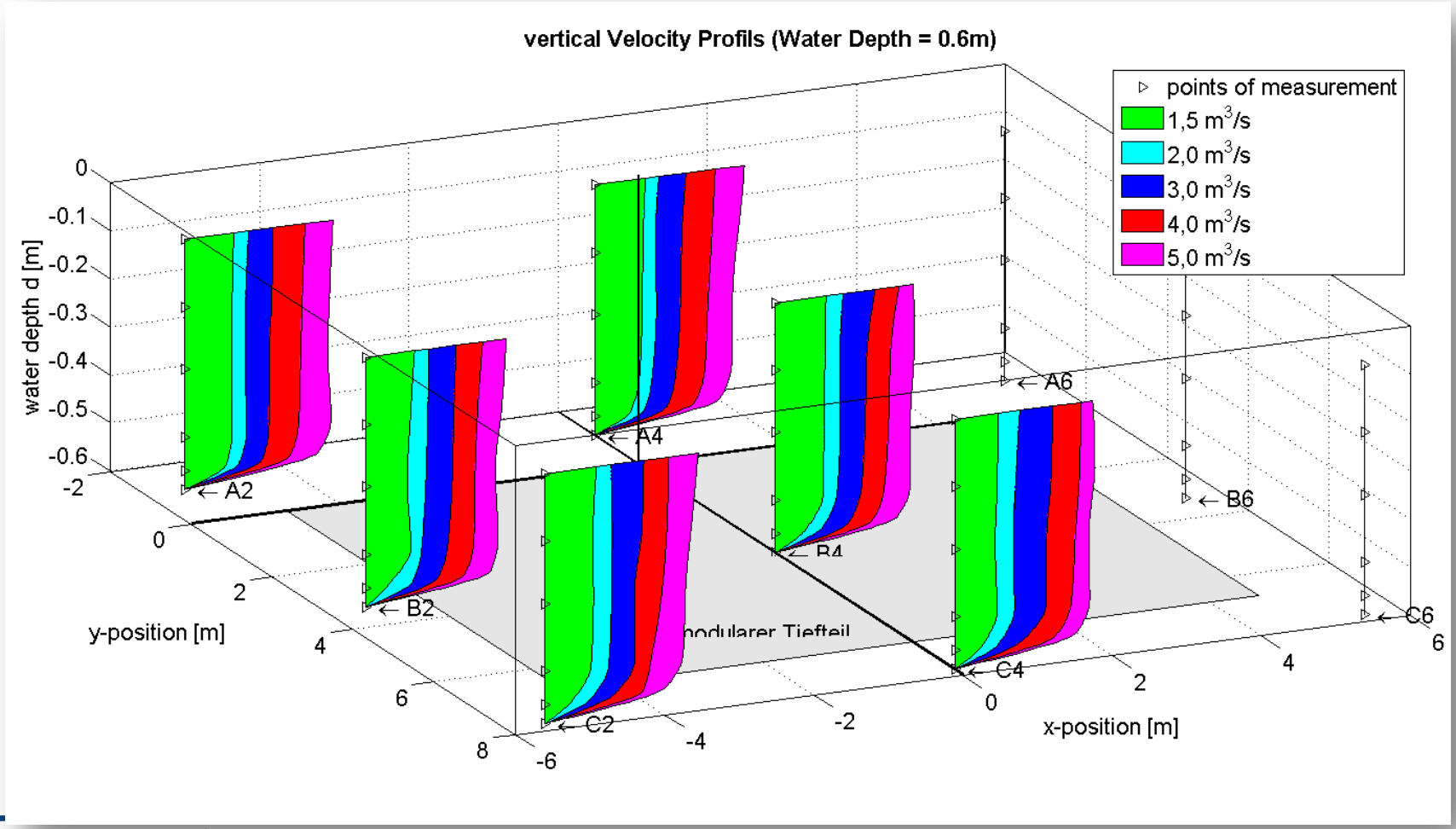
Scour development

Current flow velocities

3-D wave-current basin



Well developed velocity profiles at investigation area



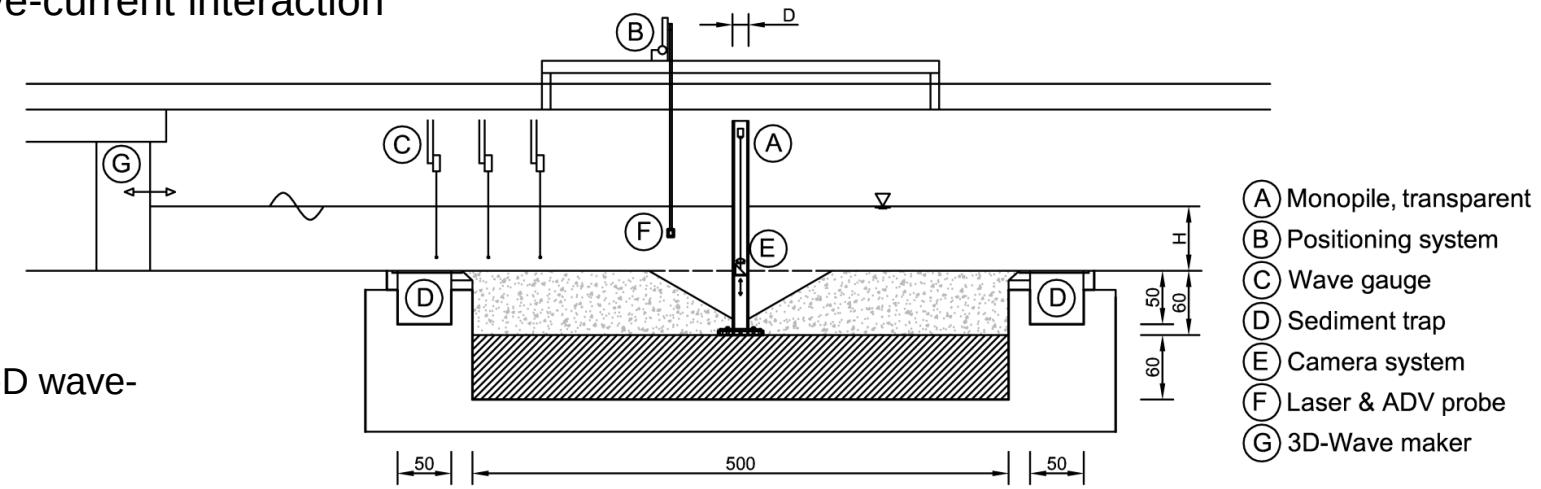
Outlook - Wave-current interaction

- Advanced dispersion relation
  - Changed wave length du to currents
  - Energy conservation leads to higher /lower wave heights

- Wave-current interaction in the 3-D wave-basin
  → waves opposing currents get higher
  → waves following currents get smaller

Outlook - Scour under multidirectional and random waves

- Model tests – 3-D wave-current basin
- Setup:
  - Monopile, transparent
  - Camera system, Laser Distance Sensor for scour measurement
- Test program
  - Multidirectional and random waves
  - Wave-current interaction

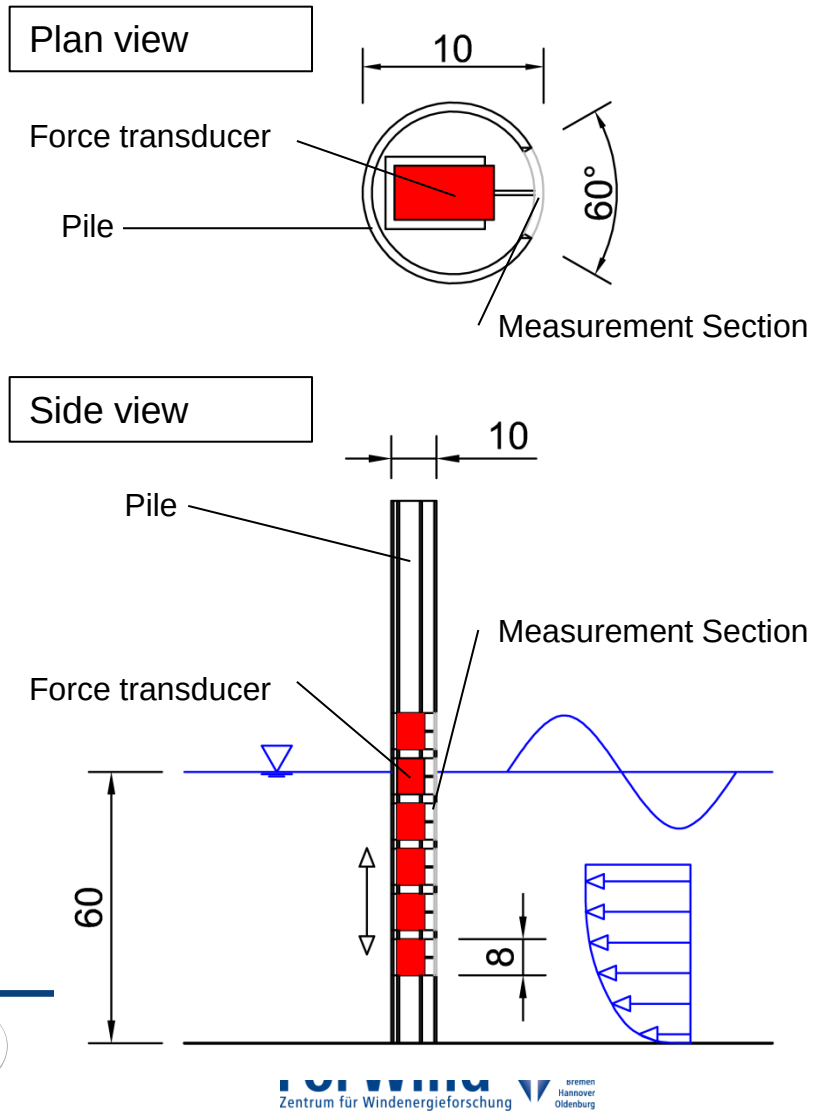


Setup in 3-D wave-bassin

Outlook - Wave forces on a vertical cylinder

Experimental set up

- Force transducer
  - → forces normal to cylinder‘s surface
- Moment transducer
  - → registrate shear forces via lever arm
- Movable measurement facilities
  - → Rotation
  - → Different heights for force transducers



Summary

- Changed loads
  - Wave-current interaction
  - Marine fouling
- Scour progression changes

- 3-D wave-current basin
  - Investigating loads and scour

References

- Bruijs, M.C.M., (2010): „Survey of marine fouling on turbine support structures of the Offshore Windfarm Egmond aan Zee, June 2009“, KEMA Technical and Operational Services: Biological Fouling, OWEZ-R-112-T1-20100226, February 26 2010, Arnhem, Netherlands
- Ji, X., Liu, S., Li, J., Jia, W., (2015): „Experimental investigation of the interaction of multidirectional irregular waves with a large cylinder“ Ocean Engineering, Vol. 93, pp 64-73
- Jian, Y., Zhan, J., Zhu, Q., (2008): „Short crested wave-current forces around a large vertical circular cylinder“ European Journal of Mechanics B/Fluids, Vol. 27, pp 346-360
- Schröder, A., Gutow, L., Joschko, T.J., Krone, R. Gusky,M., Paster, M., Potthoff, M. (2008): „Benthosökologische Auswirkungen von Offshore-Windenergieparks in der Nordsee (BeoFINO II)“

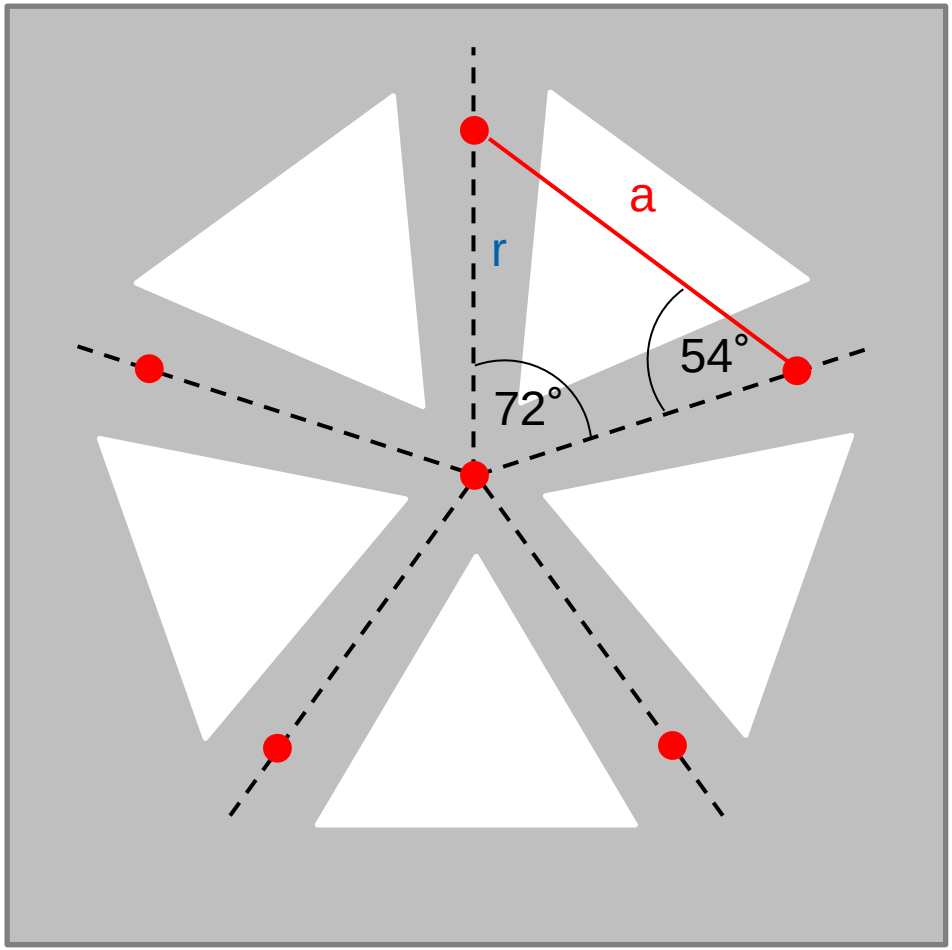
Thank you for your kind attention

Scour under multidirectional and random waves

- Influence of multidirectional sea (waves and currents) on the scour process
  - Understanding of inherent processes
  - Spatial extension, equilibrium scour depth, …
  - Effects of superimposing waves and current
  - “Backfilling”

- Effects of varying wave and current conditions (North Sea) on time scale and progression of scour with the life-time of offshore structures
  - Time scale
  - Definition of worst case conditions
  - Investigation of extreme events

Back up



- Wave gauge