

# Changes in bottom shear stress, due to aggregate extraction, in the area of the Hinder Banks (Belgian Continental Shelf)

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The bottom shear stress determines sediment resuspension and erosion, deposition and bottom morphology. Bottom shear stress is influenced by a number of factors, including surface sediment structure and benthic organisms that all influence the bottom roughness. Therefore bottom shear stress is used as an indicator in the European Marine Strategy Framework Directive (MSFD), to evaluate changes linked to human activities. In the MSFD report, published by the Belgian State (2012), it is stated that human impact asks consideration when the bottom shear stress, calculated by a validated mathematical model over a spring-neap tidal cycle, increases by more than 10 %. The validation of the mathematical model however is not straightforward as measuring of bottom shear stresses is difficult and the lack of quantitative bottom stress measurements hampers a sound validation of model results.

In the framework of monitoring physical impacts of aggregate extraction on the offshore Hinder Banks, bottom mounted Acoustic Doppler Current Profilers (ADCP) were deployed to measure the current profiles currents (Van Lancker *et al.*, 2015). The near-bed current profiles have been used to calculate bottom shear stress and bottom roughness, and their associated error ranges. Data from five deployments at two stations, along the eastern and southern part of the Oosthinder, were available.

The modelling of bottom shear stress was done in an efficient way based on the different models of Soulsby (1995), Soulsby and Clarke (2005) and Malarkey and Davies (2012) so that they could be included in larger scale sediment transport models. Currents were modelled using a three-dimensional hydrodynamic model, based on the COHERENS software (Luyten, 2014), waves were calculated using an implementation of the WAM model.

Results of the validation showed, for a mean bottom shear stress of around 0.7 Pa, a bias less than - 0.09 Pa, a root-mean-square error less than 0.25 Pa and a correlation coefficient higher than 0.77 for the first two deployments along the eastern part of the Oosthinder sandbank. The results on the southern part, where the ADCP was deployed in the trough of steep dunes were less good, mainly due to strong tide-topography interactions. Overall, the results are acceptable, giving the high uncertainty associated with measurements of bottom shear stresses.

To assess the impact of aggregate extraction (about 35 million m<sup>3</sup> in 10 year time), three different scenarios of extraction were simulated. Results show that in the relatively deep waters of the Hinder Banks, the impact on the bottom shear stress remains restricted to the areas of the extraction, while the impact outside the impact areas (as defined by the Belgian State, 2012) remained limited to less than 2 %.

## References

- Belgian State, 2012. Omschrijving van de Goede Milieutoestand & vaststelling van Milieudoelen, Kaderrichtlijn Marien Strategie - Art 9 & 10, 33 pp.
- Luyten P. (Editor), 2014. COHERENS - A Coupled Hydrodynamical-Ecological Model for Regional and Shelf Seas: User Documentation. Version 2.6. RBINS Report, Operational Directorate Natural Environment, Royal Belgian Institute of Natural Sciences, Brussels, Belgium, 1554 pp.
- Malarkey J. and A.G. Davies, 2012. A simple procedure for calculating the mean and maximum bed stress under wave and current conditions for rough turbulent flow based on Soulsby and Clarke's (2005) method. *Computers & Geosciences*, 43: 101-107.
- Soulsby, 1995. Bed shear-stresses due to combined waves and currents. In: *Advances in Coastal Morphodynamics*. M.J.F. Stive, H.J. de Vriend, J. Fredsøe, L. Hamm, R.L. Soulsby, C. Teisson and J.C. Winterwerp (eds.), 4-20 to 4-23. Delft Hydraulics, The Netherlands.
- Soulsby R.L. and S. Clarke, 2005. Bed shear-stresses under combined waves and currents on smooth and rough beds. Report TR 137. HR Wallingford, Wallingford, United Kingdom, 42 pp.
- Van Lancker, V., M. Baeye, D. Evangelinos and D. Van den Eynde, 2015. Monitoring of the impact of the extraction of marine aggregates, in casu sand, in the zone of the Hinder Banks. Period 1/1 -

31/12 2014. Brussels, RBINS-OD Nature. Report MOZ4-ZAGRI/I/VVL/201502/EN/SR01, 74 pp. (+ 5 Annexes).

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