

Offshore wind farms: sand as indispensable as wind

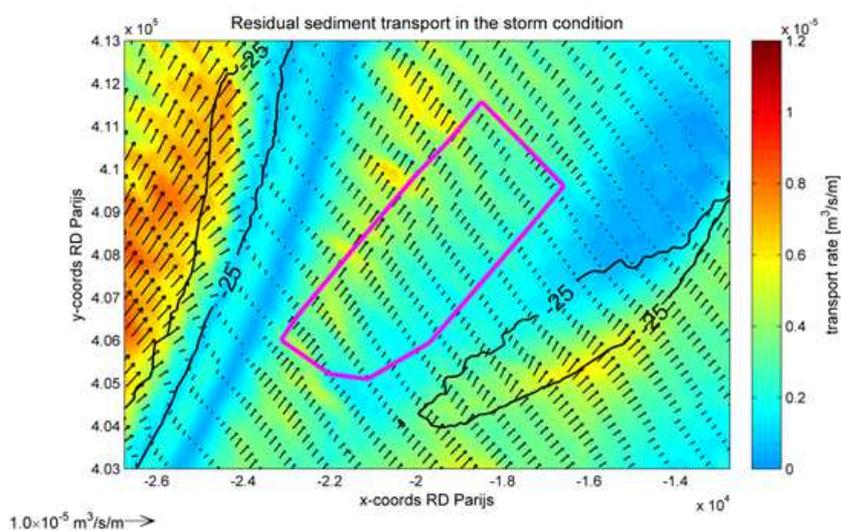
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For the energy production of offshore wind farms, wind is the main factor of interest, but during the construction and maintenance of offshore wind farms not only wind plays an important role. The impact of wind turbine foundations on the seabed, the change in local morphology and sediment transport during construction works and the operational phase plays a significant role in the design and maintenance strategy of offshore wind turbine foundations, and is also crucial to assess the environmental impact of wind farms. The construction of a wind farm often includes dredging works for levelling the seafloor at the foundation locations, for pre-trenching part of the cable route to assure sufficient burial depth during the lifetime of the project, for the creation of foundation pits (e.g. in case of gravity based foundation) and to cross navigation channels with the electrical cables. Also during the operational phase, the presence of the wind turbine foundation and the cables still can have an impact on the local seabed- and hydrodynamics e.g. in form of scour around the foundations or cables if not sufficiently buried.

These phenomena are typically studied in view of the design of the foundations, the definition of the cable trajectory and the Environmental Impact Assessment (EIA). In the framework of several Environmental Impact Assessments (EIAs), IMDC has setup numerical models that assist in estimating the expected sediment transport in the vicinity of the wind farms. These models simulate the



natural tidal currents, wave action and sediment transport in the concession areas to evaluate the natural evolution of the seabed (Rentel (IMDC, 2012), SeaStar (cf. adjacent Figure, IMDC, 2013a), Mermaid (IMDC, 2014a in prep.) and Northwester 2 (IMDC, 2014b in prep.)). Not only sediment transport in the concession areas is studied, but also the effect of dredging activities as such is assessed. Hereto IMDC performed dredging plume model studies to assess the background turbidity and suspended sediment levels due to dredging and dumping activities. The studies focus on the excess sediment dispersion caused by the activities necessary for different dredging works during the construction phase, e.g. dredging of foundation pits.



To gain insights into the evolution of the current-, wave and turbulence conditions around wind turbine foundations and the potential development of scour pits, IMDC designed a frame equipped with several measurement tools to monitor potential scour around a jacket foundation in the C-Power wind farm (cf. Figure, lowering of frame). The frame is equipped with a Scour Monitor, an ADCP (acoustic current profiler), an AWAC (acoustic wave and current profiler) and vector velocity probes. While ad-hoc multibeam measurements only provide a snapshot of the seabed at a certain time, without having information on the hydrodynamics, the frame allows continuous measuring, also during storm events of both seabed variations and hydrodynamic parameters. Especially storm data (autumn and winter period) will provide valuable information to allow better understanding of the scour phenomenon in

function of waves, currents and turbulence. The measurement campaign is set-up in a way that the collected data is sent to shore in real-time, giving the opportunity to monitor the seabed evolution and sea state conditions at any given time.

In view of the further development of the offshore wind at the Belgian Part of the North Sea, Elia Asset nv foresees in the realisation of a Belgian Offshore Grid (BOG) as a the next step in an optimisation of transporting the offshore generated energy to shore by means of a redundant system (MER BOG, IMDC 2013b). The BOG consists of the creation of at least one offshore high voltage station on the Lodewijkbank (OHVS Alpha) and the connection to land with several cables. In the near future the offshore wind farms will be able to plug into the OHVS Alpha to allow a bundled and redundant transport of their energy to shore. In EIA BOG, the OHVS Alpha is proposed as an artificial island on the Lodewijkbank.

Sediment transport and dredging activity not only relate to the foundations but also to the cable installation, since cables have to be buried over a certain depth. Hereto typically a burial risk assessment is performed that includes the assessment of the burial depth along the entire cable route. Laying offshore cables at the required depth can be achieved by several techniques, such as jetting, ploughing or trenching. When trenching is chosen, it requires dredging of trenches with a base width of about 5 m for each cable. The dredged material is than temporarily stored in a designated area and later re-used as backfill after completion of the cable laying process. If the trenching technique would be selected for laying the entire cable route stipulated in the BOG project (IMDC, 2013b), approximately 11 million m³ of sediment need to be dredged. Dump losses are estimated at around 3 million m³ of material before storing. The estimation of 30% of sediment losses during and after dredging-dumping works is based on observations on the Thornton Bank (Van den Eynde et al., 2010). During the backfill process, another 2 million m³ of material will be lost again, counted over the entire cable route. Around 0.5 million m³ of material will be permanently stored in the designated dump area. Laying these cables by applying the trenching technique would cause a temporary increase in turbidity, especially in the nearshore zone where finer material is present in the subsurface. Since this is also the area with naturally higher turbidity levels, the impact of the activities is negligible with a local but temporary disturbance of the benthos, avifauna and marine mammals.

Also for the creation of the artificial island that will support the OHVS Alpha sand extraction will be needed. The necessary sand volume for the creation of an artificial island Alpha as proposed in the EIA BOG will be about 5 million m³ (IMDC, 2013b). It comprises the creation of a flat base layer with a core of sand on top of it. Considering again dredging losses of about 30% after dumping (Van den Eynde et al., 2010)), about 7 million m³ needs to be extracted, equating a loss of about 2 million m³ of sediment. The nearby Blighbank is considered as the most suitable location, both technically and economically, for sand extraction. At the Lodewijkbank, at the location of the Alpha island (present water depth between -17 and -28 m LAT), the presence of the island will impact the local morphodynamic equilibrium and grain size distribution. The local bathymetry will here protrude above

the water surface. These morphological alterations will change the local flow patterns and as a consequence scouring of the seabed around the Alpha island is expected if no additional protection is installed.

During the dredging works for the creation of the sand base and upper core, the turbidity will locally and temporarily change. Hereto different dredging scenarios are simulated. Model results show that the background value in the region of 4 mg/l (Van den Eynde et al., 2013) will not be exceeded for more than 20% of the dredging time for a scenario with one trailing suction hopper dredger (TSHD) of 10,000 m³ (IMDC, 2013b). For a scenario with 2 TSHD of 5,000 m³, involving more frequent dredging and dumping, the background value of 4 mg/l will not be exceeded for more than 30% of the time. The dredging activity causes the highest turbidity. The dredging plume is higher in concentration but smaller in size for the scenario with 2 TSHD. The dredging plume contour is more than 1,300 m long and moves over a distance of up to 2.5 km. Compared to turbidity concentrations during natural storms, this is a small negative effect, with temporary habitat disturbance of the benthic fauna, fish and marine mammals.

In conclusion, recent monitoring results, modelling effort and ongoing measurements have shown that during the entire life cycle of offshore projects, the impact of these infrastructures (i.e. foundations, cables, island,...) on the local morphology, hydrodynamics and sediment transport should be taken into account not only for design aspects, but also when assessing the environmental impact of the projects. It is further important that these assessments are done based on a combination of modelling studies and real-life monitoring of the processes prior to the works, during the works and during the operation and maintenance period. IMDC hereto has gained experience in all of these fields and combines the knowledge to provide an integrated assessment.

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