Deep large-scale sand extraction and ecological landscaping, short-term impact results from the Rotterdam harbour Maasvlakte 2 borrow pit

de Jong Maarten[*1]

[*]*Presenting author: maarten.dejong@wur.nl*

[1] *IMARES Wageningen UR, Institute for Marine Resources & Ecosystem Studies, Bevesierweg 4, 1781 AR Den Helder, The Netherlands*

The demand for marine sand in the Netherlands and worldwide continuous to rise. In the Netherlands, 24 million m^3 marine sand is used yearly for coastal nourishments and construction. Due to sea-level rise, a possible increase of annual nourishments up to 85 million m^3 is anticipated. The Dutch authorities permitted deep sand extraction, down to 20 m below the seabed, to decrease the surface area of direct impact of a 220 million m^3 sand extraction project for a 2000 hectares harbour expansion of Port of Rotterdam. To guarantee sufficient supply of marine sand in the intensively used Dutch coastal zone, the authorities continue promoting sand extraction depths over 2 m. The ecological impact of deep sand extraction, however, is still largely unknown.

This project focusses on the short-term impact of deep large-scale sand extraction and ecological landscaping on macrozoobenthos, demersal fish, sediment characteristics, bathymetry, sedimentation rates and hydrodynamics. We developed ecosystem-based design rules for future borrow pits based on insights from the short-term impact studies and baseline study resulting in the highest biodiversity and high sand extraction yield. The project is part of EcoShape Building with Nature, a public-private innovation program which is committed to the integration of infrastructure, nature and society in new or alternative forms of engineering that meet the global need for intelligent and sustainable solutions.

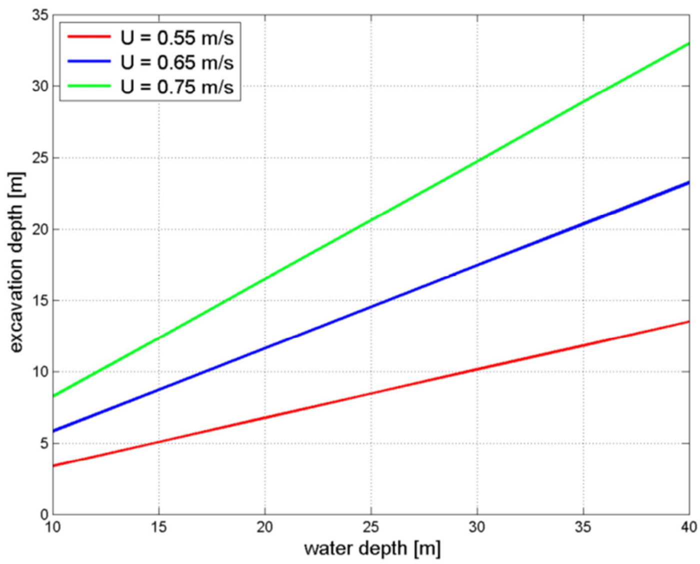
We used a boxcorer to sample macrobenthic infauna, a bottom sledge to sample macrobenthic epifauna and a 4.5 m wide commercial beam trawl to sample demersal fish. Sediment characteristics were determined from the boxcore samples, bed shear stress and near-bed salinity was calculated with a hydrodynamic model. The dredging companies collected multibeam data. Two sandbars were excavated on the seabed of the extraction site to investigate the applicability of ecosystem-based landscaped sandbars in borrow pits. The sandbar parallel to the tidal current was completed in spring 2010 with a 700 m long and 70 m wide crest at a water depth of 30 m and troughs over 45 m depth. In 2011, the second sandbar was completed with an orientation oblique to the tidal current, due to time constraints, the difference in depth between crest and trough was less pronounced.

Macrozoobenthic biomass increased fivefold in the deepest areas, species composition changed significantly and white furrow shell (*Abra alba*) became abundant. Macrozoobenthic assemblage and biomass is correlated to time after cessation of sand extraction, sediment and hydrographical characteristics. Furthermore, sediment characteristics significantly changed in 2012 in the deepest parts. We observed increased sedimentation rates in the troughs of the parallel sandbar, which presumably led to unsuccessful boxcore sampling. Demersal fish biomass increased 20-fold and fish species assemblage changed significantly, inside the borrow pit plaice (*Pleuronectes platessa*) was dominant whereas dab (*Limanda limanda*) dominated reference areas. Increased demersal fish biomass is closely linked to increased white furrow shell (*Abra alba*) biomass. Ecological landscaping sandbars influenced macrozoobenthic and demersal fish assemblage.

We observed significant differences in epifaunal and demersal fish samples in the southern trough of the parallel sandbar in 2012. Epifauna was characterised by a maximum biomass (601.36 g WW m^{-2}) with serpent star (*Ophiura ophiura*) as most abundant species whereas demersal fish biomass and species composition returned to reference levels. These changes may be related to the high sedimentation rate (0.75 m y^{-1}) or to the increase of organic matter and mud in the sediment or a combination of these factors resulting in reduced dissolved oxygen (DO) levels.

For future borrow pits, information on sediment characteristics is lacking but bed shear stress (τ) can be calculated with water depth, extraction depth and depth-averaged peak flow velocity. Based on shear stress, a distinction was made between two clusters (τ < 0.37 N m^{-2} *Abra alba*, τ > 0.40 N m^{-2} *Echinoidea* spp. – *Phoronida* sp. assemblage. This is a starting point for design options for a borrow pit, the largest biodiversity can be expected when shear stress values are around 0.4 N m^{-2}. For the Maasvlakte 2 borrow pit, extraction depth would be 12 m and a post-dredged water depth of ~32 m.

A morphological model study predicts 5 m sedimentation in 30 years, backfilling of the borrow pit may take decades or even longer. We recommend ongoing macrozoobenthic monitoring with the inclusion of sedimentation rate and oxygen measurements.



References:

Tonnon PK, Borsje B, De Jong M (2013) BwN HK2.4 Eco-morphological design of landscaped mining pits. Deltares, Delft

De Jong MF, Baptist MJ, van Hal R, De Boois I, Lindeboom HJ, Hoekstra P (2014) Impact on demersal fish of a large-scale and deep sand extraction site with ecosystem-based landscaped sandbars. Estuar Coast Shelf Sci 146:83-94

De Jong MF, Baptist MJ, Lindeboom HJ, Hoekstra P (Submitted) Relationships between macrozoobenthos and habitat characteristics in an intensively used area of the Dutch coastal zone. ICES J Mar Sci

De Jong MF, Baptist MJ, van Hal R, De Boois I, Lindeboom HJ, Hoekstra P (in prep.) Short-term impact of deep sand extraction and ecosystem-based landscaping on macrozoobenthos and sediment characteristics. Mar. bul. pol.

De Jong MF, Baptist MJ, van Hal R, De Boois I, Lindeboom HJ, Hoekstra P (in prep.) The future of deep and large-scale sand extraction in the North Sea. Mar. bul. pol.