An experimental assessment of the effect of sand extraction on benthic nutrient cycling and carbon storage

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The worldwide demand for sand exceeds that of all other minerals and metals. Sand is heavily needed for concrete production and for coastal protection to combat sea level rise. Nevertheless, mining of marine sands and aggregates comes at a price, as these activities leave a large footprint on the marine environment. By trailing a dredging drag head, the seafloor is heavily disturbed and large sediment plumes are created. The impact of these activities on benthic community structures and their physical habitat (seabed morphology and sediment characteristics) in the Belgian Part of the North Sea (BPNS) has already been closely investigated. However, sand extraction may not only change community structure, but also the functional traits expressed by the community, thereby affecting ecosystem functioning and its services, such as nutrient cycling or carbon storage.

The aim of this study was to investigate the effect of marine sand extraction on sediment biogeochemical processes such as organic matter mineralization and nutrient cycling. Sand extraction areas generally harbor coarse grained, permeable sediments which are known for their fast mineralization of organic matter, fast regeneration of nutrients to the overlying water column and hence low organic carbon stocks. Therefore, it is expected that disturbance of biological and sedimentological properties of the seabed will change these important ecosystem functions. We sampled three tidal sand banks on the BPNS, characterized by different sand extraction regimes: Thornton Bank (continuous and high intensity extraction regime), Oostdyck (continuous and low intensity extraction regime) and Noordhinder (periodic and high intensity extraction regime). Prior to sampling, seabed morphology and sand extraction impact were visualized by multibeam imagery. As such, a number of replicate sampling locations could be assigned with high accuracy in similar geomorphological settings in both impacted and reference zones. At each location, undisturbed sediments were collected using a boxcore, followed by sediment core incubations to measure sediment community oxygen consumption (SCOC), nutrient fluxes across the sediment-water interface, and faunal activity. Subsamples for granulometry, permeability and organic matter were taken as well.

The continuous high extraction regime had a clear effect on the seabed morphology with obvious one to two meter deep drag head tracks cutting through the sandwaves. First results showed a lower permeability and higher sediment oxygen consumption in the impacted area compared to the reference area, although not significant due to high spatial variability. In the areas with continuous low or periodic high extraction, dredging tracks were less apparent. Here, the sediments remained permeable too, which could partly explain the limited impact of sand extraction on the measured SCOC. Together with additional results from anticipated nutrient and organic carbon analyses, we will draw more holistic conclusions on how different sand extraction regimes affect ecosystem functions and how this translates to important ecosystem services such as primary productivity, nutrient cycling and carbon storage.

Keywords: Sand extraction; Ecosystem functioning; Seabed; Biogeochemistry; Carbon; Nitrogen