Sand extraction affects the functioning of benthic ecosystems

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In light of the EU mission to restore and protect our oceans by 2030, a solid understanding of how human activities affect the marine environment is imperative to ensure their sustainable management. As our natural ecosystems provide many beneficial services, it is important to understand the physicochemical and biological processes that maintain the ecosystem itself (ecosystem functions). Additionally, investigating how these ecosystem functions may change under various human pressures is therefore crucial for better informed management strategies. An example of such human pressure is marine sand extraction, which plays a vital economic role worldwide. These marine sands serve as raw materials for concrete and asphalt production and are used for beach nourishments to protect coastal areas against the effects of climate change. Despite providing important marine resources, the extraction process significantly impacts the marine environment. While previous studies explored the effects of sand extraction on the seabed structure and composition and on benthic biodiversity, the impact on carbon and nitrogen cycling, which relate to important ecosystem functions such as carbon sequestration and nutrient recycling, remains largely unknown. To address this gap, we sampled three sand extraction areas characterized by different extraction regimes in the Belgian Part of the North Sea: the Thorntonbank (continuous extraction of large sand volumes), Oostdyck (continuous extraction of small sand volumes) and Noordhinder (intermittent extraction of large sand volumes). For each area, we defined an impact and reference zone where we measured sediment, chemical and biological parameters by means of box core sampling. Nutrient and carbon fluxes over the sediment-water interface were measured by using closed-core incubations.

Our first results revealed that the mineralization processes are primarily driven by the total organic carbon (TOC) content in the sediment. No direct impact of the extraction activity (expressed in days extracted) on the mineralization processes was found. However, TOC content and extraction activity showed a weak, but significant, positive correlation ($r(28) = 0.37$, $p < 0.05$), suggesting that sand extraction may indirectly stimulate the mineralization in the sediment by increasing TOC content. Conversely, the variation in the nitrification rates (process whereby ammonia is sequentially oxidized to nitrite and nitrate) was explained by sand extraction and not by TOC content or other sediment variables. Considering that faunal activities in the sediment (particle reworking and burrow ventilation) positively influence nitrification, it is possible that sand extraction activities promote nitrification through the direct physical disturbance of the sediment as it actively brings oxygen to deeper layers.

This study is the first to investigate the impact of sand extraction on the benthic ecosystem functioning. Initial results indicate that sand extraction affects different processes in the benthic carbon and nitrogen cycles through two distinct mechanisms: either by changing sediment properties or by directly disturbing the sediment. A better understanding of how sand extraction affects essential ecosystem functions, such as nutrient cycling, carbon storage or mineralization, can support the development of new sustainable extraction practices in the future.

Keywords
Marine Sand Extraction; Human Impact; Seabed; Ecosystem Functioning; Nutrient Cycling; Carbon