Assessing risk of offshore windfarms towards ecosystem services.

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Offshore wind energy is widely regarded as one of the most credible sources for increasing renewable energy production. Currently, the Belgian offshore wind farms (OWFs) accommodate a total capacity of 2.26 GW and the installation of another 3.5 GW is proposed in the latest marine spatial plan. Although physical and biological impact of OWFs are frequently studied and become more and more understood, a comprehensive tool to evaluate the impact of human activities and subsequent changes in ecosystem services is lacking. Yet, all stakeholders could benefit from such a tool, as it enables intuitive evaluation of both environmental burdens and opportunities by monetizing the ecosystem services into "ecoservice capital". To this end, we propose a novel approach to assess the risks of OWFs on marine ecosystems. A set of ecosystem services were selected in collaboration with multiple key stakeholders. Ecosystem services were quantified using science-based model equations and driving parameters were selected. Environmental risk assessment (ERA) procedures were used to quantify the impact of OWFs on the ecosystem parameters, and subsequently coupled to the ecosystem services. This resulted in an evaluation of the impact and risk of changing ecoservice capital. As a first case study, waste remediation, as sediment denitrification, was selected as ecosystem service to be evaluated. Total organic matter (TOM) and fine sediment fraction quantities were found to be good proxies of waste remediation within this model. As the Belgian Continental Shelf is one of the best studied and monitored marine areas in the world and offshore wind farms are intensively monitored within this area, extensive data regarding these parameters is available and was used to construct predictive ERA models. Denitrification rates generally showed a slight increase compared to reference baseline data with a maximum increase up to 17%. However, this increase seems insignificant when accounting for natural variations of denitrification values in the studied OWFs. These results suggest that OWFs pose no to little risk towards changing the waste remediation potential of the marine environment. This proof of principal study demonstrated the use of ecosystem service evaluations in past and present ecological risk assessment procedures. However, a more complete view and evaluation using other ecosystem services needs to be conducted to provide a more holistic view of sustainable design and developments of future offshore advancements.

Keywords
Ecosystem Services; Sustainable Development; Offshore Wind Farms; Environmental Risk Assessment; Waste Remediation