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### Restoration potential for subtidal shellfish populations in the Dutch Wadden Sea using hard substrates

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#### Abstract

Despite the official status as nature reserve, epibenthic shellfish populations have severely declined from the Wadden Sea over the last decades. The decline is thought to be caused by a combination of overharvesting, habitat destruction, heat waves, and diseases. Given the importance of epibenthic shellfish populations as ecosystem engineers, the loss of shellfish beds reduces habitat diversity and ecosystem services provided by these shellfish communities. In order to enhance the natural values and habitat diversity in the Wadden Sea, it is important to restore shellfish beds and their associated ecosystems. Previous research has identified some vital processes determining restoration success of intertidal oyster and mussel beds. Specifically, a lack of suitable attachment substrate and high predation pressure were shown to cause critical thresholds hampering natural re-establishment in intertidal shellfish beds. Providing complex structures that provide suitable surface for attachment while reducing predation pressure on shellfish may be a promising restoration approach. Although the ecosystems of the intertidal and subtidal Wadden Sea are tightly interconnected, not much is known about the critical factors for restoration of subtidal shellfish beds. This study therefore examines the potential of restoring shellfish beds in the subtidal Wadden Sea, with a focus on reef building oyster and mussel populations. In a first exploratory field experiment, six different types of natural or biodegradable settlement substrates for shellfish recruitment are tested and compared in both the Eastern and Western Wadden Sea. Additionally, the role of differences in substrate complexity in recruitment of shellfish is evaluated using 3D printed structures with varying standardised habitat complexity. Differences in settlement success between the types of substrates are evaluated, to decide which show the highest potential for scaling-up to larger scale restoration projects in order to contribute to science-based management decisions.

#### Keywords

Restoration, Shellfish, Wadden Sea, Settlement substrate