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Adaptive cycles of a phyto-zooplankton community under human pressure

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Human activities, such as global warming and nutrient pollution, are posing significant threats to the ecological interactions and biodiversity in aquatic environments [1]. The German Bight, a highly dynamic coastal region of the North Sea, has been subject to considerable warming and nutrient fluctuations over recent decades. These changes have had profound impacts on the plankton communities in this area, leading to a swift reorganization of both phyto- [2] and zooplankton functional structures [3].

While the effects of these changes on individual phyto- and zooplankton levels have been well-documented, our understanding of how plankton interactions respond to these environmental stressors remains limited. In this study, we hypothesize that the synergy of warming and nutrient limitation will alter plankton network interactions, resulting in a shift towards consumers being controlled by resources.

We approach this hypothesis from the perspective of Gunderson and Holling's adaptive cycle metaphor [4]. The metaphor describes ecosystem development as alternating phases of stability and reorganization, being shaped by three systemic properties: the system's potential available for future change, the connectedness among its internal variables, and its resilience in the light of perturbations.

For the quantification of the adaptive cycle, we use a method developed by zu Castell and Schrenk [5,6]. Based on the most comprehensive timeseries available in marine environments, we infer a dynamic network of information transfer, which allows us to study the evolving interaction pattern between phyto-and zooplankton. We discuss this pattern in the context of the adaptive cycle phases and alternative measures of system resilience.

To our knowledge, our study is the first to provide a holistic analysis of plankton network interactions in marine environments, considering both phyto- and zooplankton species. This approach offers a deeper understanding of how human-induced impacts affect the foundation of marine food webs.

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