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RESPONSE OF SHALLOW SEDIMENT ECOSYSTEMS TO ENVIRONMENTAL ALTERATIONS

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ABSTRACT

Shallow-water sediment systems are continuously exposed to a range of anthropogenic stressors, including increased nutrient loading, physical disturbance and toxicants. Superimposed on these local stressors are stressors related to the on-going climate change. Interacting stressors may strengthen or weaken effects of individual stressors, resulting in – often unexpected – non-additive effects. Thus, the combined effect from several simultaneous stressors in shallow-water sediment systems is the main topic of this thesis. Individual and combined stressor effects were studied on intact sediment cores placed in an outdoor flow-through facility and in the laboratory. Both functional (primary and bacterial production, community respiration, meiofaunal grazing, denitrification, nitrogen mineralization and sediment-water fluxes of oxygen and nutrients) and structural (biomass and composition of microphytobenthos and meiofauna) were studied in order to assess effects of multiple stressors.

It has been suggested that global warming can shift the trophic status of ecosystems from net autotrophy to net heterotrophy. A spring experiment (**Paper I)** showed, however, that the presence and activity of a well-developed microphytobenthic mat already in early spring sustained net autotrophy during simulated warming. The effects of increased temperature on the structure and function of the sediment systems were generally rather moderate. Consequently, it is possible that the presence and activity of microphytobenthos can buffer changes induced by seawater temperature. An autumn experiment (Paper II) suggested that warming combined with nutrient enrichment can induce shorter, intensive, heterotrophic periods that can be followed by longer autotrophic periods because initially increased mineralization induces a shortage of labile organic matter. Even though warming increased nutrient availability through increased mineralization, warming did not exacerbate the stimulatory effects of nutrient enrichment. The lack of interactive temperature-nutrient effects was mainly explained by a sustained filter function by microphytobenthos.

It has also been suggested that future warming will exacerbate the effect of toxicants. However, in **paper III** the combined effects of an antifouling compound (Cupper pyrithione) and warming resulted in antagonistic rather than synergistic effects. The two types of microalgal communities present at the end of the experiment, a typical benthic mat and a floating periphyhtic mat, were both significantly affected by the toxicant, but in opposite ways; the biomass of the benthic mat was stimulated by the toxicant, whereas the floating periphytic mat was negatively affected. Thus, autotrophic communities within the same ecosystem can respond differently. Also the nutrient status of an ecosystem can change toxicant effects. This was shown in **paper IV,** where the combination of pyrene (a polycyclic aromatic hydrocarbon) and nutrient enrichment synergistically reduced the grazing pressure of meiofauna on microphytobenthos, exerting a cascading effect on the primary producers.

In **paper V** we studied whether herbivores can mediate effects of ocean warming and acidification on microphytobenthos in a seagrass meadow, and how these effects were related to the biomass of *Zostera marina*, filamentous macroalgae and sediment-associated fauna. Analysis of variance and structural equation modeling (SEM) were used to partition net effects of warming and ocean acidification into direct and indirect effects. This statistical approach showed that the absence of stressor effects on microphytobenthos was actually a combination of direct and indirect effects mediated via grazers on filamentous macroalgae and sediment associated fauna.

Overall, the main results in my thesis is that even though changes in temperature, pH, toxin and nutrient availability, will occur in present time as well as the near future, the main function of shallow-water sediment ecosystems will be sustained given that microphytobenthos are present. My results also show that environmental alterations need to be studied together on an ecosystem level rather than on individual species level and that indirect effects always need to be taken into consideration when interpreting experimental results.

KEYWORDS

Shallow-water sediments | microphytobenthos | meiofauna | mesograzers | *Zostera marina* | multiple stressors | global warming | eutrophication | Copper pyrithione | pyrene | ocean acidification | grazing | trophic interactions | biogeochemistry | nutrient fluxes | primary production | bacterial production | structural equation modeling

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