Björn Carlsons
ÖSTERSJÖPRIS

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"Coastal filter function under Environmental Stress"

Coastal areas worldwide are under high utilization pressure and are additionally threatened by climate change (storms, high temperatures, declining oxygen concentrations). Eutrophication in particular leads to strong changes of the entire habitat including organic matter deposition and oxygen decline in sediments. A comprehensive in-depth understanding of microbial processes is these habitats is urgently needed, especially in shallow waters. The coastal filter concept is helpful in this context and distinguishes between rapid nutrient bypassing and transformation processes and those acting on time scales larger than the residence time of water (retention and removal processes). However, investigations in shallow waters and sediments are extremely difficult due to the high physical dynamics, strong wave impact, that require close cooperation across disciplinary boundaries.

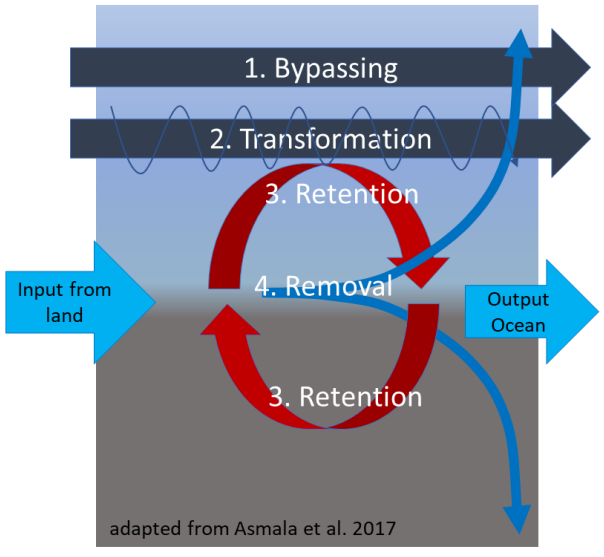


Figure 1 Coastal filter concept after Asmala et al. 2017, where 1 and 2 act on short time scales of physical advection and 3 and 4 on time scales longer than the residence time:

1. Bypassing: N-compounds unaltered transported to the ocean
2. Transformation: changes of chemical composition (assimilation, nitrification, DNRA) while transported to the ocean
3. Retention: processes slowing down nutrient flow (degradation or sinking of OM)
4. Removal: permanent like denitrification and burial in sediments

How microbial processes of the nitrogen cycle are influenced by water-sediment interaction was investigated in this project lasting from 2023- 2025. Rate measurements in the field, deployments of a lander and laboratory experiments were performed near the Leibniz Institute of Baltic Sea Research Warnemünde, IOW (Figure 2, photos below). We pursued the goal to quantify microbial processes in sandy sediments over an annual cycle. We studied the interaction of microbial rates with near-bottom currents to better understand the removal (denitrification, conversion of nitrate to N_2 gas) and retention (DNRA, conversion of nitrate to ammonium) processes.

Organic rich and muddy sediments were long thought to be the only environments providing suitable conditions for high denitrification rates while permeable and low organic matter sandy sites experience low rates. However, in the past two decades the importance of N-cycling in permeable sands was recognized and more closely investigated. Results from these studies suggest a highly dynamic environment with variable rates and a suboxic microenvronment playing a decisive role. Since 58 % - 70 % of the continental shelf globally is covered by permeable sands a correct estimation of their contribution to the global marine nitrogen removal is crucial to understand the global N-budget of coastal oceans.

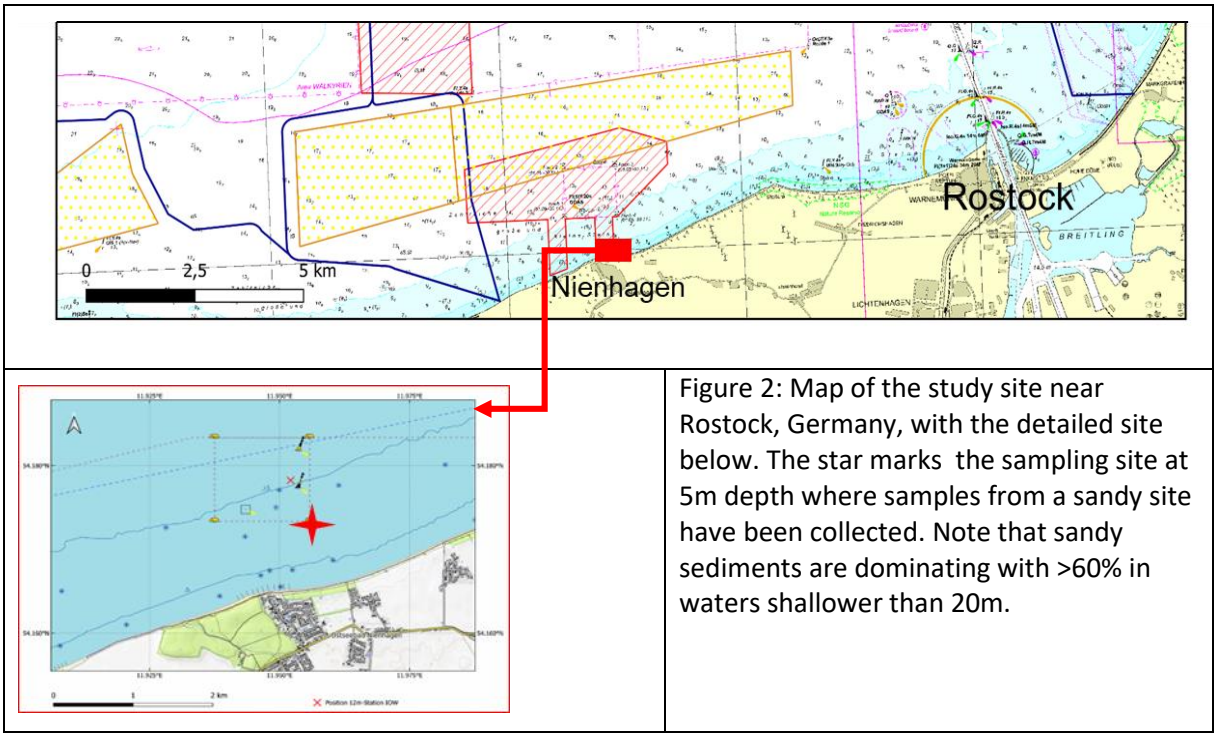


Figure 2: Map of the study site near Rostock, Germany, with the detailed site below. The star marks the sampling site at 5m depth where samples from a sandy site have been collected. Note that sandy sediments are dominating with >60% in waters shallower than 20m.

With her PhD work Kaja Gentsch started in March 2023 and examined environmental variables and denitrification and DNRA rates in the shallow coastal sediments of the southern Baltic Sea on monthly basis. The interesting and novel aspect of her thesis is the combined measurement of both rates at a sandy site. Results will add to our understanding of the fate of nitrate, since nitrate can be converted to ammonium or dinitrogen gas with the latter being unavailable to most life forms. DNRA, however, keeps the nutrient available and only recycles the nutrient without removal (Figure 3) Additionally, a benthic chamber lander was employed to characterize nutrient and oxygen fluxes at the sediment water interface. Sediment properties and pore water nutrient concentrations were characterized.

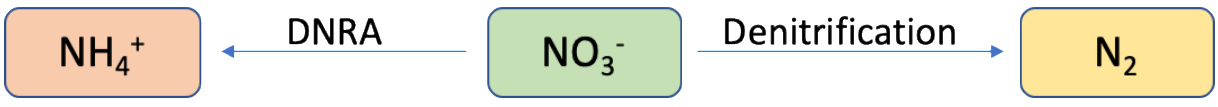
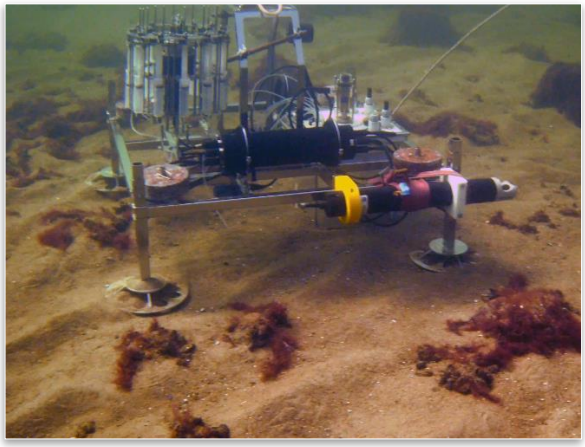
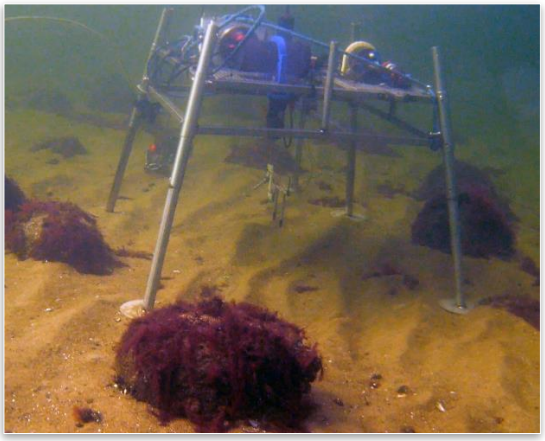


Figure 3: simplified schematic showing the two major pathways of nitrate conversion in sediments.

Preliminary data of a PhD thesis suggest that denitrification rates followed a seasonal cycle but with variable rates similar to DNRA. Potentially, DNRA may be triggered by events such as low oxygen concentrations or organic matter deposition which seem to be enhanced in later summer and autumn. In addition, light and the competition for nitrate by microphytobenthos seems to play a role, as nitrate is also taken up by primary producers. If a coastal filter works more towards retention (DNRA) than removal processes (denitrification) there is a risk of higher nutrient export from the coastal zone to the open Baltic Sea – in particular when waters become oxygen depleted. The data analysis has not yet been completed and publications are planned for the coming years. Overall, a highly exciting and timely doctoral thesis is currently in its final year and there is hope that the work can continue beyond that.





Photos of the field work with different landers under water (upper two panels), a lander being deployed and Kaja Gentsch discussing with a colleague at Tvärminne Zoological Station.