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The influence of riverine nitrogen on the dynamics of the North Sea oxygen minimum zone

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The mitigation of eutrophication and its concomitants, like oxygen deficiency in bottom waters, is one of the major aspects of the ecological management of coastal marine ecosystems. In the past, biogeochemical models helped to significantly improve the understanding of the interaction of the physical and biological processes driving eutrophication. Anthropogenic river input of nitrogen (N) and phosphorus (P) is the main driver for eutrophication. Nevertheless, the quantification of their influence in a specific region remains an important issue, since it is as crucial for an efficient management as it is difficult to obtain.

During the past decade, a quantitative method applicable to biogeochemical models – often referred to as 'trans-boundary nutrient transports' (TBNT) – became more and more popular in the context of marine ecosystem management. This method allows for the tracing of elements from various sources, e.g., nitrogen (N) from different rivers, throughout the whole process chain of the applied model. By this, it provides valuable information about the contributions from different sources to the overall amount and turnover of an element in different areas of the model domain. This information constitutes the basis for the quantification, evaluation and optimisation of river input reduction targets for the tributaries, which are defined in relation to their ecological consequences in the marine environment. In existing studies, the TBNT method has been applied to a variety of biogeochemical models, e.g. to quantify the atmospheric contribution to total N in the North Sea *(Troost et al., 2013)*.

This study presents a novel approach to link the TBNT method applied to N to the biological processes driving the oxygen dynamics in the bottom layer of the North Sea. For this purpose, simulations from the biogeochemical model ECOHAM (ECOlogical model HAMburg) are analysed for the years 2002 and 2010, with the focus on the southern central North Sea, the region of lowest bottom oxygen concentrations. In 2002, a year with high discharges from the European continental rivers, oxygen concentrations of less than 6 mg L^{-1} are reached in that region, while in 2010 values stay well above 7.5 mg L^{-1}. Mass balance calculations show that the remarkably lower values in 2002 are mainly caused by enhanced pelagic and benthic bacterial remineralisation during summer stratification (factor 1.55 higher than in 2010).

The TBNT analysis reveals that almost 50 % of the bacterial consumption in that region are driven by the N supply from the Atlantic. However, the large continental rivers also account for about 23 % in 2010, and even 30 % in 2002. It further shows that in 2002, remineralisation due to N originating from these rivers is about twice as high as in 2010, representing the largest relative difference among all contributors. This demonstrates the great influence of the N input from the continental rivers on the oxygen dynamics in the North Sea minimum zone, and emphasises their importance for the eutrophication management in the southern central North Sea.

References

Troost, T. A., Blaas, M., Los, F. J. (2013). The role of atmospheric deposition in the eutrophication of the North Sea: a model analysis. *Journal of Marine Systems*, 125, 101–112.