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Denitrification – the major nitrogen sink for the North Sea. Results from a study using the ecosystem model ECOHAM

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Benthic denitrification is known as the major sink for bioactive nitrogen in shelf and ocean margin seas. For the North Sea only some sparse measurements of denitrification rates are available, part of them with obviously too low results because of methodological reasons. To obtain a quantitative estimate of the total denitrification in the sediments of the North Sea, the 3-d coupled physical-biogeochemical model ECOHAM (version 4.2; with 2 phytoplankton and 2 zooplankton groups; 4 nutrients; 2 sinking detritus fractions) was applied to the Northwest European Shelf (47° 41‘ N – 63° 53’ N, 15° 5’ W – 13° 55’ E) for the years 2001and 2002. Nitrogen-related rates were calculated for the inner shelf region, the North Sea (511,725 km2) for both years. These years exhibit a shift from a negative North Atlantic Oscillation Index (NAOI) in winter 2001 to a positive one in winter 2002, with corresponding implications for the North Sea hydrography. The total (inorganic + organic) annual riverine nitrogen load to the North Sea amounted to 83 Gmol N yr-1 in 2001 and 85 Gmol N yr-1 in 2002.

The benthic denitrification was calculated using the empirical relationship given by Seitzinger & Giblin (1996) according to which the coupled nitrification/denitrification process in the sediments is directly proportional to the oxygen consumption which we calculated from the amount of benthic carbon remineralization.

The model yields annual denitrification rates of 77 and 79 Gmol N yr-1, respectively, for the North Sea area with a gradient from northern region to the continental coastal strip. Area-related denitrification rates reach from < 100 mmol N m-2 yr-1 in the northern North Sea to > 500 mmol N m-2 yr-1 in the inner German Bight, with a mean value of about 150 mmol N m-2 yr-1 for the whole North Sea. This value is somewhat lower than the estimate of 223 mmol N m-2 yr-1 given by Seitzinger & Giblin for the North Sea, whereas the simulated mean denitrification rates for the German Bight and for the southern North Sea (the only regions where measurements were made) amount to 265 and 220 mmol N m-2 yr-1, respectively, which is within the upper range of observational values (130-260 mmol N m-2 yr-1).

According to our model results, the benthic denitrification ‘annihilates’ an amount of nitrate which corresponds to more than the sum of riverine and atmospheric input of bioactive nitrogen to the North Sea. This, certainly, has a damping effect on the degree of eutrophication.

Taking into account the various sediment types and their different denitrification capacity should refine the regional distribution maps obtained from this study. In the next future, using a more elaborate, depth-resolved sediment module would be desirable.