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Nitrogen cycling in the North Sea and exchange with the North Atlantic – a model study

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Recently there has been a vivid debate about the role shelf areas are playing within the global marine cycles of carbon, nitrogen and other elements. This is true also for the Northwest-European Shelf. With respect to nitrogen some authors suggested that shelves act as source of nitrogen for the open ocean, others argued contrarily: due to strong onwelling of dissolved inorganic nitrogen and its effective transformation into inert dinitrogen the shelves are likely a sink for the marine nitrogen.

We applied the 3-dimensional biogeochemical model ECOHAM to the Northwest European Shelf (47° 41‘ – 63° 53’ N, 15° 5’ W – 13° 55’ E) for the years 1993 – 1996. Nitrogen budgets were calculated for the years 1995 and 1996 for the inner shelf region, the North Sea (511,725 km^2).

The mid-nineties were chosen because they exhibit a shift from a very high North Atlantic Oscillation Index (NAOI) in winter, 1994/95, to an extremely low one in winter, 1995/96, with noticeable consequences for the North Sea system: e.g., during the first half of 1996, the observed mean SST was about 1° C lower than in 1995. Decreased precipitation over the drainage area of the continental rivers led to a reduction in the total riverine nitrogen load to the North Sea from 76 Gmol N yr^{-1} in 1995 to 52 Gmol N yr^{-1} in 1996. In addition to these high loadings (additionally, by atmospheric deposition 27 Gmol N yr^{-1} of inorganic nitrogen were supplied), the North Sea imported from the adjacent seas a net amount of 28 and 13 Gmol yr^{-1} of total nitrogen, in 1995 and 1996, respectively.

As the main sink for nitrogen, we identified the coupled benthic nitrifica-

tion/denitrification, due to which 118 and 119 Gmol N yr^{-1} of molecular nitrogen were released into the atmosphere in these years, respectively. Considerable amounts of allochthonous organic nitrogen, imported across the northern boundary, were transformed to inorganic nitrogen, part of which was also denitrified, the rest being exported as DIN to the North Atlantic (or stored in the North Sea itself).

Conclusively, according to our model results the answer to the question ‘Is the North Sea a source or a sink of nitrogen for the adjacent North Atlantic?’ is: during the simulation period it was a net source of dissolved inorganic nitrogen, but a highly variable one.