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Tracking nutrients in the Baltic Sea food web

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Where are the nutrients from?

Eutrophied rivers discharge huge amounts of nutrients into the Baltic Sea. But they are not the only source of eutrophication.

Fixation by cyanobacteria represents a major source of nitrogen in the Baltic Sea food web. Also, direct atmospheric deposition delivers a considerable amount of dissolved inorganic nitrogen (DIN).

Does it matter where a nitrate (or phosphate) molecule enters the Baltic Sea?

A source attribution technique applied to an existing ecosystem model allows to track nitrogen and phosphorous both in space and in the food web.

It allows to answer the questions:

• What are the pathways of nutrients from different sources?
• In which fraction (DIN, PON) do the nutrient transports take place?
• Where are the final depositional areas of riverine nitrogen and phosphorous (local, basin-wide or Baltic-Sea-wide, coastal or basinal)?

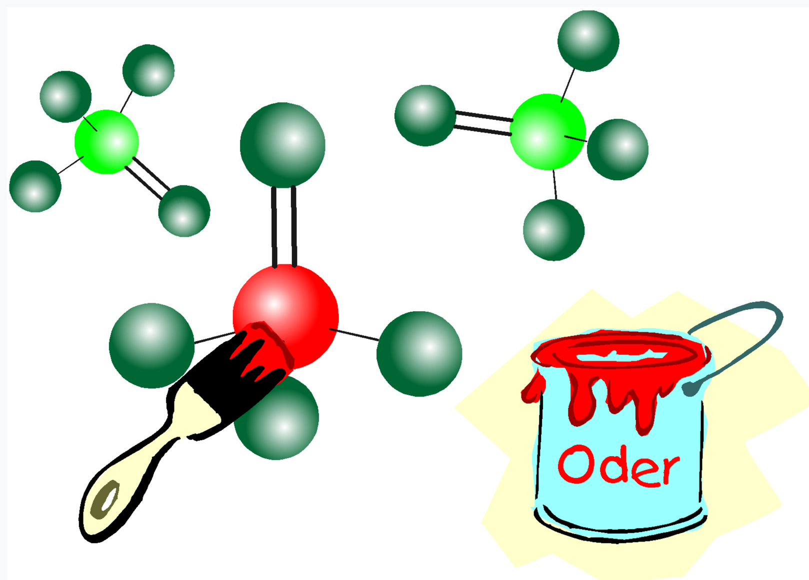

Figure 1: A marked phosphorous atom in a phosphate molecule (illustrative)

• And what are the timescales of these transports and thus the residence times of the different nutrients in the system? ■

Methods

The ecosystem model ERGOM (Neumann et. al., 2002) was extended by the possibility to mark nitrogen and phosphorous according to their source.

Nitrogen and phosphorous from the 5 rivers with the largest loads (Oder, Vistula, Njemen, Daugava, Neva) were marked, plus nitrogen from fixation by cyanobacteria.

An age attribution technique (Deleersnijder et al., 2006) allows to investigate the „age“ of a nutrient, defined as the time elapsed since it entered the Baltic Sea.

Marked N and P are not only tracked as DIN and DIP, but in the whole food web. Even after sedimentation and remineralization, the nitrogen and phosphorous atoms keep the information on their origin and their age. ■

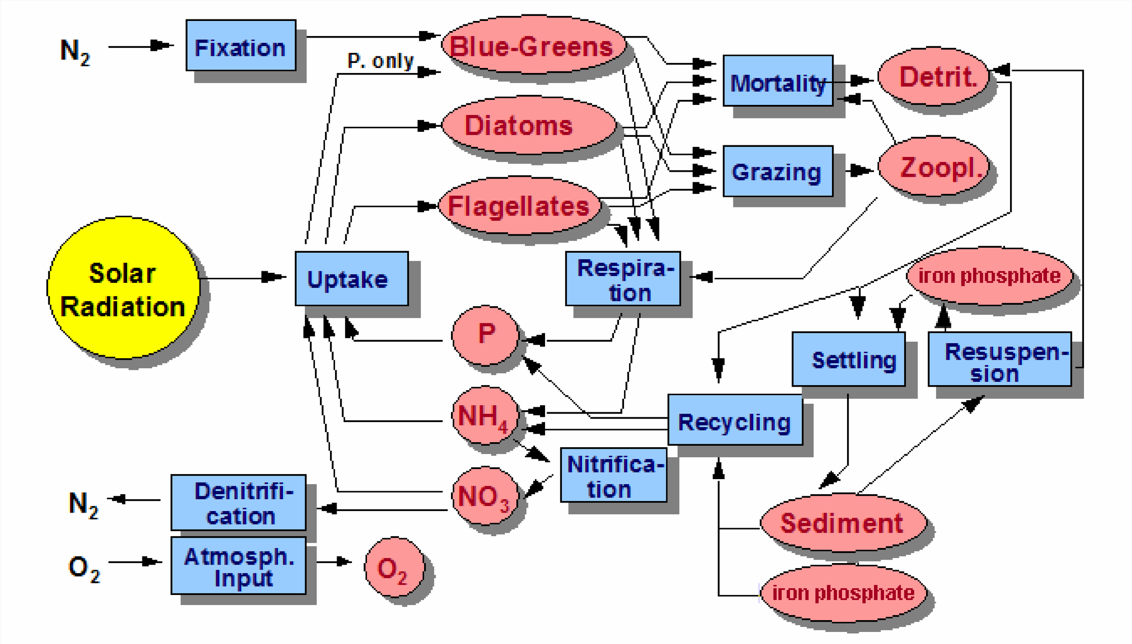

Figure 2: Schematic view of the ecosystem model ERGOM used in this study

Results

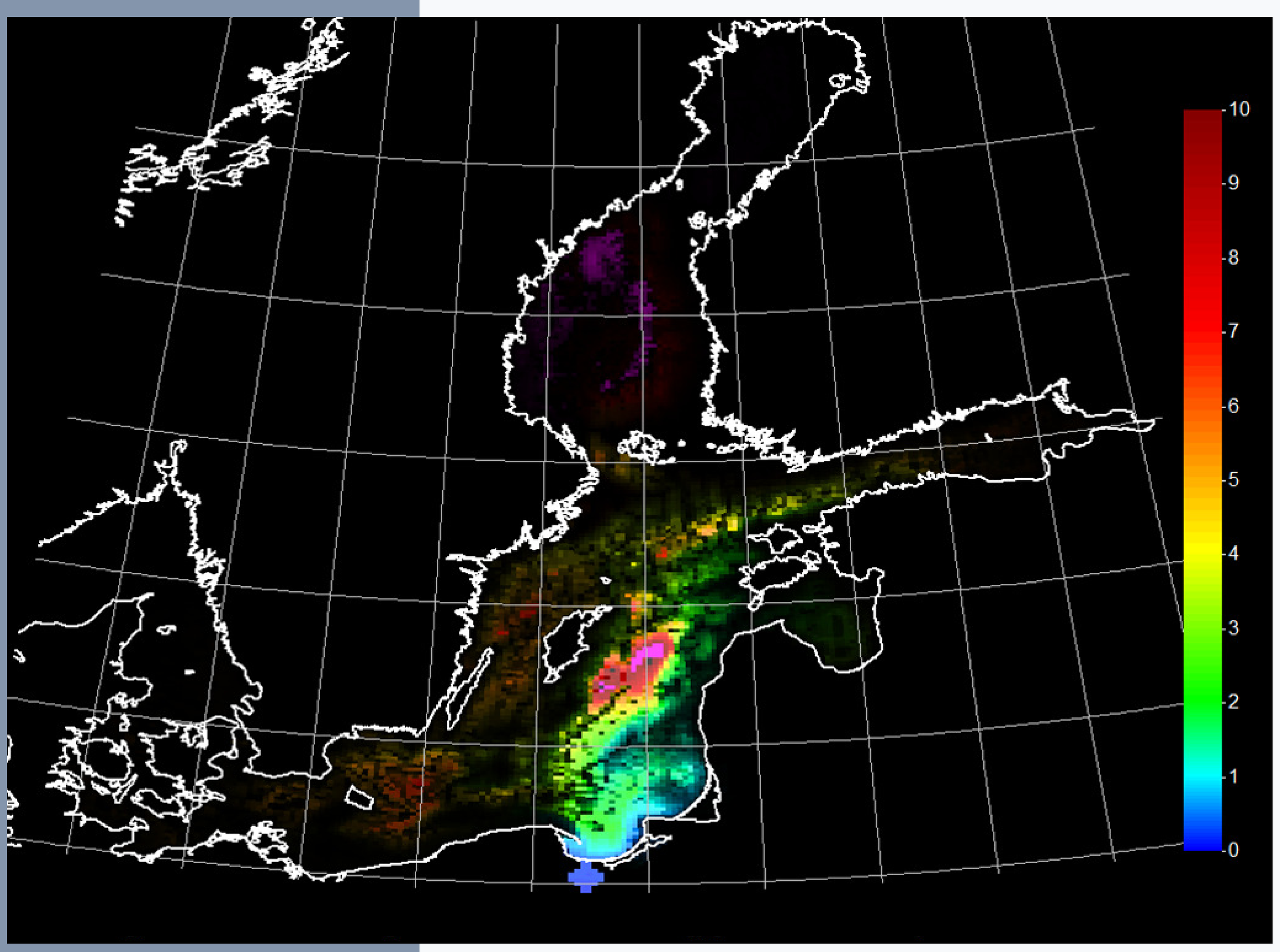

Figure 3:
Nitrogen from Vistula in the surface sediment, 1996 average.
Colors indicate time since entering the Baltic Sea (in years), intensity indicates concentration (full intensity = 50 mmolN/m²)

Both nitrogen and phosphorous show a quick counter-clockwise alongshore advection and a slow cross-shore transport. Horizontal fluxes take place mostly as DIN and DIP transports, but also advection of resuspended sediments contributes significantly to the total transports.

Riverine nitrogen accumulates in coastal areas, while the nitrogen pool of the inner basins is supplied by atmospheric sources. Most riverine nitrogen is deposited in the vicinity of the river mouth. Contrary, **riverine phosphorous is distributed seawide**. In addition to a regional eutrophication effect, it thus contributes after sufficiently long time periods to the overall eutrophication relatively independent from its source.

Riverine nitrogen leaves the ecosystem after 1.4 years on average, mostly due to sedimentary denitrification.

The residence time of phosphorous exceeds our simulated period of 35 years.

While making up >25% of the N input to the Baltic Sea, the 5 marked rivers contribute only 16% to its total N amount. This suggests a longer residence time of nitrogen from direct atmospheric deposition. ■

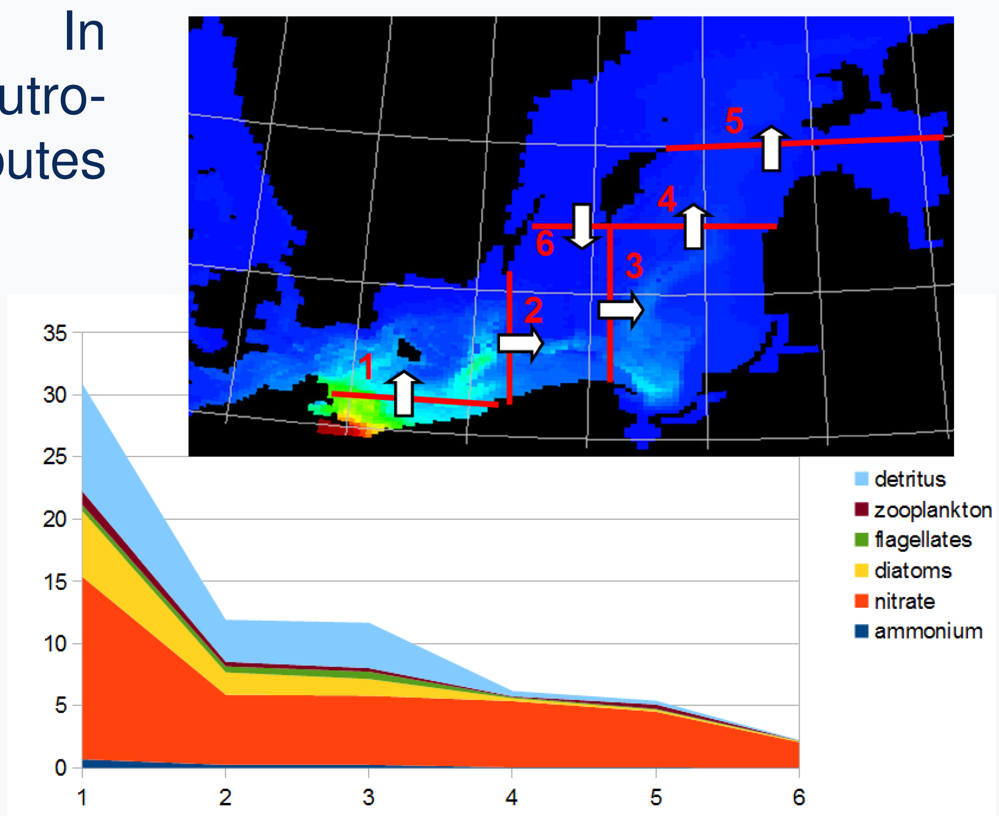

Figure 4: Nitrogen transports from Oder river over selected transects (in kt/year, 1980-1984 average).
Transports of „detritus“ take place mostly as sediment transports.

Acknowledgements

This work was supported by DFG-grant NE 617/5-1. Supercomputing power was provided by HLRN (Norddeutscher Verbund für Hoch- und Höchstleistungsrechnen).

References

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