Modelling the long-term dynamics of nutrients and phytoplankton in the Gulf of Riga

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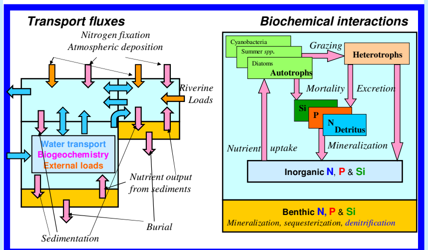
Long-term (1973 – 2000) dynamics of NO_3, NH_4, PO_4, SiO_4 and phytoplankton in the Gulf of Riga were simulated with a biogeochemical box model (Savchuk, 2002).

Because of the limited water exchange with the Baltic Proper, the Gulf of Riga maintains nutrient and phytoplankton dynamics different from those of the Baltic Proper.

Marine monitoring observations in the Gulf are available from 1973 to present. They document long-term changes in winter NO_3 and PO_4 pools. After a period of increase from 1973 – 1990, NO_3 concentrations started to decrease, while the PO_4 pool stabilized on a high level.

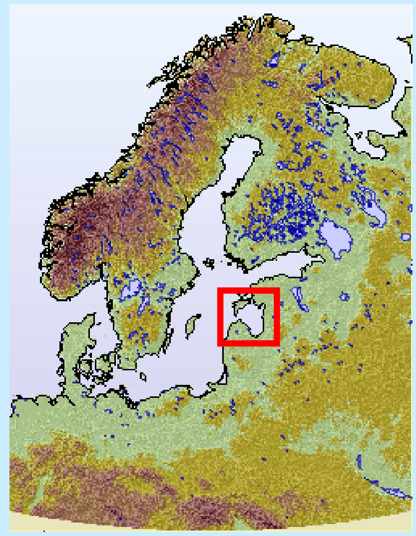
These well documented nutrient dynamics in a semi-enclosed water body subject to variable anthropogenic impact make the Gulf an interesting test case for our understanding of eutrophication in the Baltic Sea.

3-box model of the Gulf or Riga



1973 – 2000 Marine monitoring data
External N, P, Si inputs

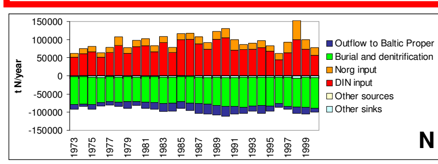
Numerical routine (simulated annealing) for parameter calibration

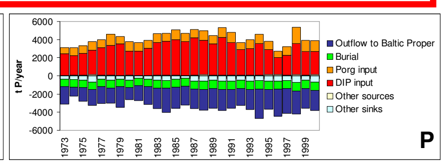


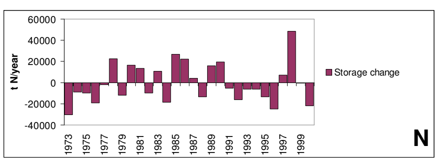
Driving the Gulf of Riga nutrient trends – long term N and P budgets

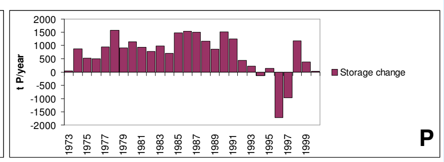
Differences between inputs and outputs led to changes in nutrient storage in the Gulf. Storage changes occurred in the water column, causing the observed nutrient trends, and temporally also in the sediments.

After 1990, nutrient inputs decreased both for P and N. Because of the large denitrification sink, the N pool declined immediately, while for P, which is removed mainly by export to the Baltic Proper, decreases in storage occurred only during low input and high outflow to the Baltic Proper in 1996/1997.

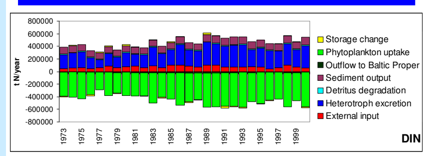






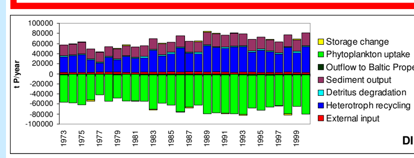


Simulated water column DIN and DIP budgets

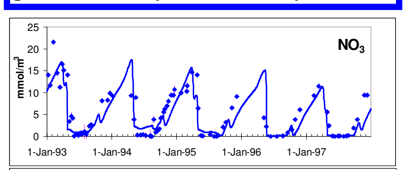


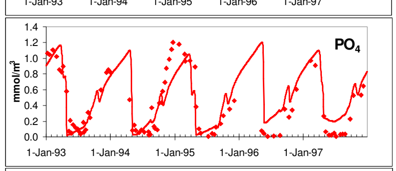
Recycling, mainly due to heterotroph excretion, dominated DIN and DIP fluxes in the Gulf.

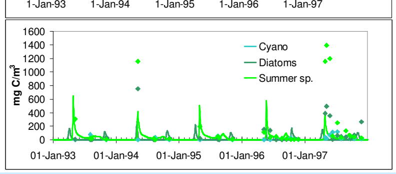
Changes in storage were small compared to the total nutrient turnover, making long term nutrient trends difficult to simulate.



Simulated seasonal dynamics (selected parameters and years, surface layer)







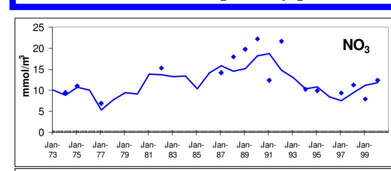
Model performance

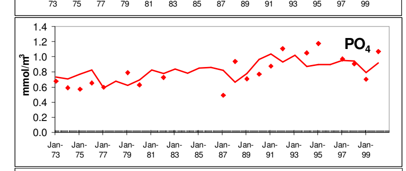
After parameter calibration, the model represented both the seasonal dynamics of nutrients and phytoplankton, as well as the long-term changes of NO_3 and PO_4 pools in the Gulf of Riga.

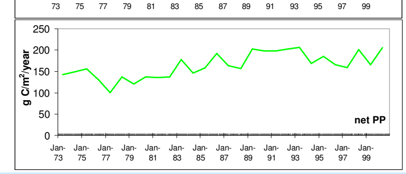
Simulation of the long-term nutrient trends proved to be sensitive to the choice of parameters. Since during calibration many (49) parameters were adjusted simultaneously, different parameter sets could result in similar nutrient trends and nutrient fluxes.

No data are available to document long-term changes in primary production in the Gulf. The model suggests an increase of net primary production from app. 150 g C m^{-2} $year^{-1}$ in 1973 to app. 200 g C m^{-2} $year^{-1}$ in 1990. Afterwards, primary production stabilized.

Simulated trends in winter nutrient concentrations and net primary production







References

Map: www.grida.no, **Biogeochemical model:** Savchuk O.P. (2002) Nutrient biogeochemical cycles in the Gulf of Riga: scaling up field studies with a mathematical model. *Journal of Marine Systems* 32, 253-280, **Numerical methods:** Press W.H., Teukolsky S.A., Vetterling W.T. & Flannery B.P. (1992) *Numerical recipes in FORTRAN 77: The art of scientific computing*. Cambridge University Press.

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