Impact of change in climate and policy from 1988 to 2007 on environmental and microbial variables at the time series station Boknis Eck, Baltic Sea.

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Supplementary materials

The period before political system change in 1989 was not covered by our data. Therefore we could not ascertain whether an improvement or a trend break in the environmental conditions at the time series station and in the Baltic Sea occurred already before our investigation started. Here we add some arguments derived from the relevant literature which show that conditions improved most strongly in the years following political system change in the southern and eastern border states. This process was supported by ongoing efforts for better water managemnt in the other border states.

The Baltic Sea water has a turnover time (residence time) of about 25 years - short enough that improvements of water quality in the catchment area could come into effect in the adjacent sea area. Water in the Baltic Sea is supplied by the North Sea, ground water, rivers and precipitation. North Sea surface water intruding into the deep layers of the Baltic Sea is not much cleaner than Baltic Sea water itself, but river water, the main component in the Baltic Sea water budget, is comparatively much more polluted. To understand the contribution of rivers to eutrophication of the sea one has to consider waste water purification and use of fertilizer on land - and this is a matter of policy. It has to be noted that all the big rivers enter the Baltic Sea in the southern and eastern Border States. Progress in the infrastructure in these countries therefore impacts directly on water quality of the semi-enclosed Baltic Sea. We hope that the references (2 Tables, 5 Figures) are relevant for supporting our interpretation of the results of this study.

The Figures 17a and 17 b show that strongest reductions of nitrogen and phosphorus inputs from point sources and agriculture within the Baltic Sea catchment area occurred in the south-eastern Border States after change in policy. Reference: Figures 17 and 18 in HELCOM (2005).

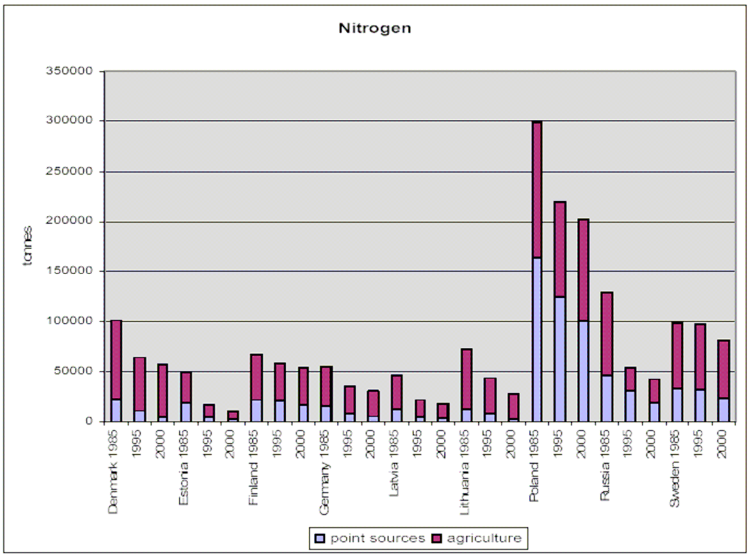

Fig. 17a: Nitrogen inputs from point sources and agriculture within the Baltic Sea catchment area by HELCOM countries in 1985 and in 2000. Reference: Fig. 17 in HELCOM (2005). Source: Hagebro, C. 2004. Agricultural impact on the water environment. HELCOM Presentation.

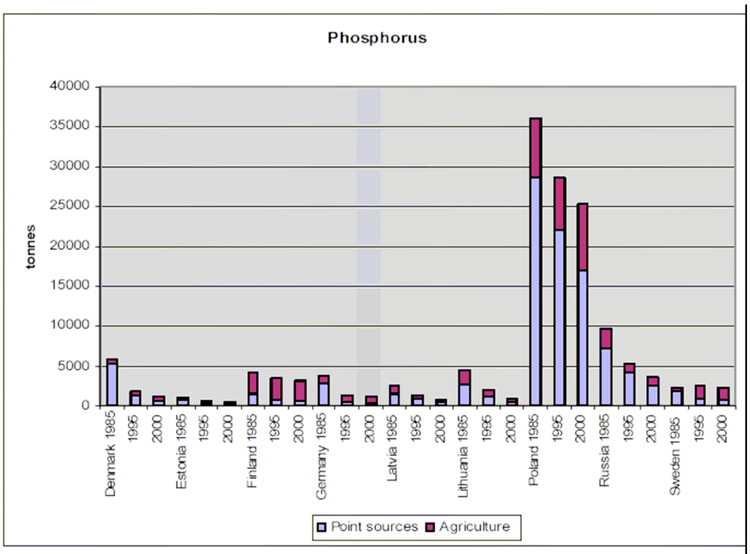

Fig. 17b: Phosphorus inputs from point sources and agriculture within the Baltic Sea catchment area by HELCOM countries in 1985 and in 2000. Reference: Fig. 18 in HELCOM (2005). Source: Hagebro, C. 2004. Agricultural impact on the water environment. HELCOM Presentation.

The classification of rivers with regard to orthophosphate in Mecklenburg-Vorpommern, a federal state in the eastern part of Germany, before and after political system change is shown on Fig. 18. It can be seen that substantial improvement of quality of river water started and continued progressively after system change.

Reference: Abb. 1-1 in „Klassifizierung der Fließgewässer hinsichtlich Orthophosphat“, in „Ministerium für Landwirtschaft, Umwelt und Verbraucherschutz Mecklenburg-Vorpommern“ (2008). Within this web page: „Kommunale Abwasserbeseitigung in Mecklenburg-Vorpommern - Lagebericht 2011 - Bericht gemäß Richtlinie 91/271/EWG“.

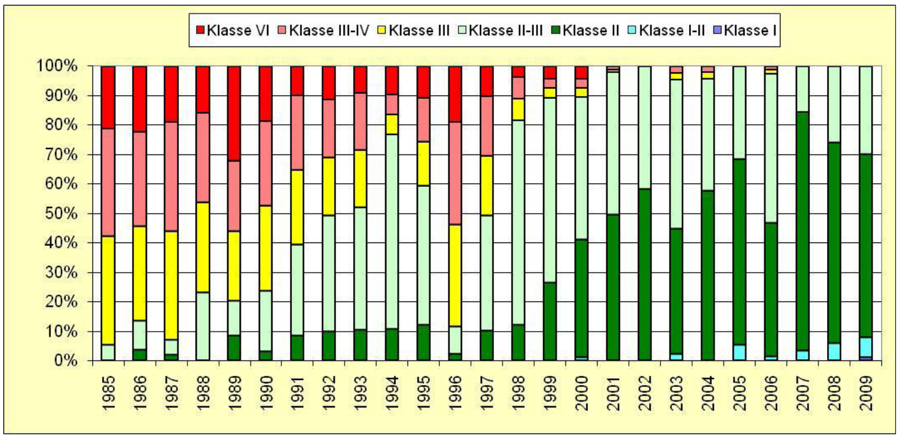

Fig. 18: Classification of rivers with respect to orthophosphate. Reference: Abb. 1-1 in Ministerium für Landwirtschaft, Umwelt und Verbraucherschutz Mecklenburg-Vorpommern, 2008: Abwasserbeseitigung. http://www.regierung-mv.de/cms2/Regierungsportal_prod/Regierungsportal/de/lm/Themen/Wasser/Abwasserbeseitigung/index.jsp

The long-term change of the nitrogen surplus (indicator of agricultural pollution impact, the difference between all nutrient inputs and outputs on agricultural land) of the field balance on arable land is shown on Fig. 19, separately for the four Federal States located in the German Baltic Sea catchment area. “These nitrogen surpluses have decreased by 40% (in Schleswig-Holstein) to 50% (in Mecklenburg Western-Pomerania, Brandenburg and Saxony) since its peak in 1987. For the Federal States Schleswig-Holstein and Mecklenburg-Vorpommern, which represent the main part of Germany of the Baltic Sea catchment, a similar development for the nitrogen surplus in the agricultural areas could be observed up to the end of the eighties.“ Reference: Figure 1, page 38, in HELCOM (2003).

Within this document it says: “Since 1990 this development is quite different. Caused by the political and economic changes in Mecklenburg-Vorpommern and in the other Federal States of the former GDR the nitrogen surplus decreased dramatically mainly because of reduction of livestock and lower application rates of mineral fertilizers. Since

1993 the nitrogen surplus is increasing again up to a level of 60 kgN/(ha•a) at the end of 90's. In Schleswig Holstein a more continuous decrease from 130 to 95 kgN/(ha•a) can be observed over the whole decade."

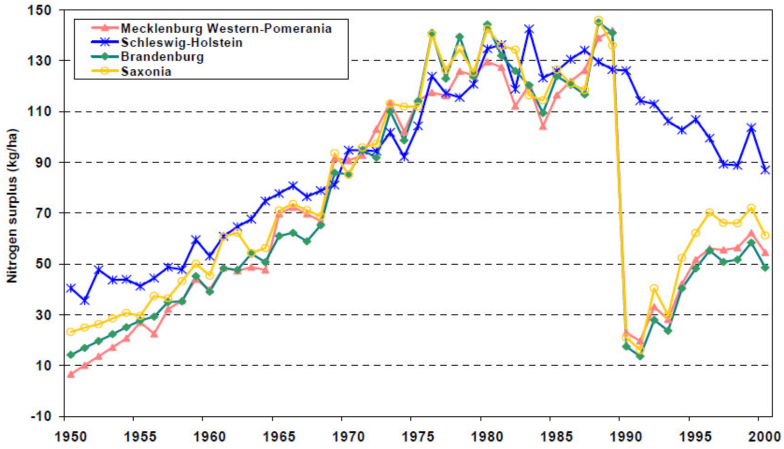

Fig. 19: Development of Nitrogen surpluses of farmland (surface balance) in the Baltic Sea area from 1950 to 2000. Nitrogen surplus (kg/ha), Mecklenburg Western-Pomerania, Schleswig-Holstein, Brandenburg, Saxonia. Reference: Fig. 1 in HELCOM (2003).

The nitrogen budget of the Polish agriculture from 1960 to 2000: "Implications for riverine nitrogen loads to the Baltic Sea from transitional countries", is shown on Fig. 20. A clear breakdown is documented in the years after political change. Because the big streams Oder and Wisla are the most important contributors of fresh water to the Baltic Sea they contribute substantially to the state of eutrophication. Reference: Eriksson et al.(2007).

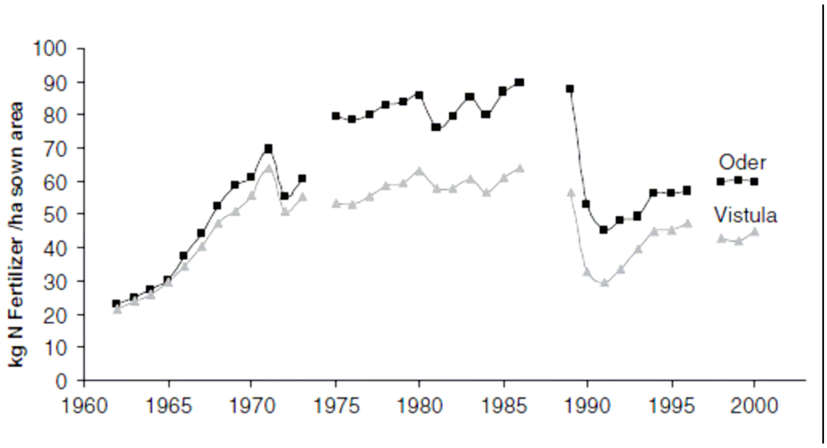

Fig. 20: The yearly consumption of nitrogenous fertilizer (kg N ha^{-1} sown area $year^{-1}$) in Oder and Vistula from 1962 to 2001. Reference: Fig. 5 in Eriksson et al. (2007).

The development of inorganic N- and P-concentrations at Boknis Eck (0-10 m water depth) before and after our study took place is shown on Fig. 21. A close look at the figure reveals that a trend brake occurred for P-sources around 1990 and for N-sources some years later probably around 2005. Reference: Bange et al. (2011).

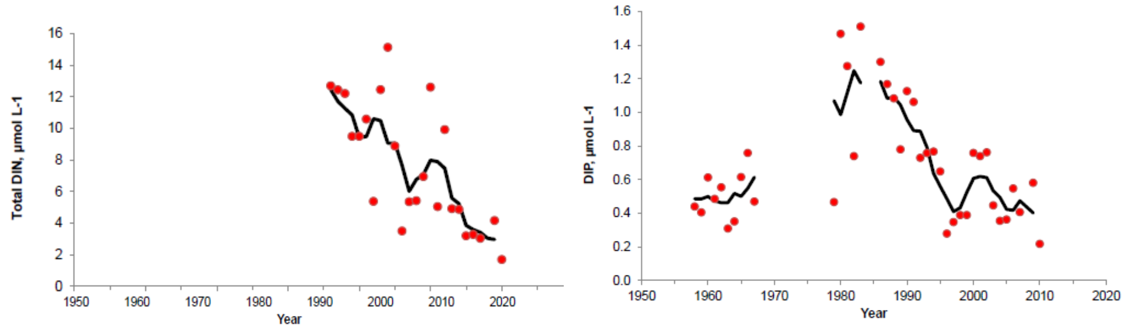

Fig. 21: Mean winter concentrations (red circles of total dissolved inorganic nitrogen (DIN, left panel) and dissolved inorganic phosphate (DIP, right panel). The black solid lines indicate 5-year moving averages. Reference: Fig. 4 in Bange et al. (2011).

In addition: Some early satellite pictures from the eastern Baltic Sea area showing chlorophyll and particle load of river plumes you can find in Horstmann et al. (1986): "The influence of river water on the south-eastern Baltic Sea as observed by Nimbus 7/CZCS imagery."

Table 4 shows clearly a strong reduction of the N and P input into the Baltic Sea immediately after political change, in this case of Poland. Reference: Table 5, p. 67 in HELCOM (2003)

Table 4: Riverine pollution load discharged to the Baltic Sea from Poland.(Load, tons/a).

Year	1988	1995	2000
Nitrogen	243.0	202.1	188.7
Phosphorus	16.7	13.1	12.3

Table 5 was composed from our own complete data set (1-25 m depth) reaching back to 1957. The phosphate concentration rose until 1988 and decreased afterwards. We assume that the slopes would be even more pronounced if the equations were calculated exclusively from the surface layer (1-2 m) because river fresh water is mainly mixed within this layer.

Table 5: Temporal change of phosphate at Boknis Eck:

Phosphate, all values in the water column from 1957 - 1988:	y = 0.000095x + 1.606
Phosphate, all values in the water column from 1986 - 1988:	y = 0.000223x + 1.109
Phosphate, all values in the water column from 1988 - 2007:	y = -0.000073x + 1.236

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