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Threshold organic nutrient levels for harmful algal events in some European coastal waters.

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Executive Summary

The occurrence of harmful cyanobacterial blooms in the Baltic Sea were compared to concentrations of dissolved organic nutrients, as approximated by the difference between total nutrients and dissolved inorganic nutrients at a central station in the Baltic Sea. Nutrient data from 0-10 meters deep were averaged. Harmful bloom occurrence was estimated as maximum area of cyanobacterial floating layers, as observed by satellite. For the studied period (1981 – 1995) no significant correlations between yearly average organic nutrients and bloom occurrence was found. Partly, this is due to the low variation in yearly averaged organic nutrient concentration. Data from other years and other areas outside of the Nordic countries are currently under investigation for further analysis.

1. Introduction

Harmful Algal Blooms (HABs) are algal blooms that interfere with human activities or are a threat to ecosystem productivity or diversity. There is substantial scientific evidence that the frequency and magnitude of this kind of blooms has increased during the last few decades. There is also substantial evidence that this increase coincided with the anthropogenic increase in nutrient input in the environment, and that there is a causal relationship of phytoplankton growth and nutrient loads. However, efforts to correlate the concentrations of nutrients to the occurrence of HABs in marine coastal waters have so far failed.

The overall objective of this workpackage is to search for relationships between nutrient concentrations or loads on one hand, and harmful algal effects on the other hand. Other parts of the project deal with the relation between algal biomass and nutrient concentrations.

Direct and indirect utilization of organic nutrients on algal blooms and harmful algal blooms has been studied in the laboratory, mesocosms and, to a lesser extent in the field e.g. (Doblin et al. 1999) (Carlsson & Granéli 1998, Stolte et al. 2002). Therefore, organic nutrients must be taken into account in eutrophication-related processes. Especially dinoflagellates, some of which classed as harmful algal species, have shown to take up even large and complex organic molecules (Legrand 1998).

There is thus a reason to study the effects of organic nutrients on phytoplankton blooms, and harmful algal blooms in particular. A practical problem is that dissolved organic nitrogen and phosphorus is not often measured routinely in monitoring programmes. Often, total nitrogen and phosphorus, and dissolved inorganic forms of nitrogen and phosphorus are measured. We have therefore decided as a first approach to use the difference between total and dissolved inorganic nutrients as a proxy for dissolved organic nutrients. It may be clear that this value is an overestimation of the concentration of dissolved organic nutrients, because part of the total nitrogen and phosphorus is enclosed or attached to particulate material.

2. Methodology

As a first approach, linear regression analysis was used to study the correlation of organic nutrient concentration and the occurrence of harmful algal events. The analysis was only performed for the Baltic Sea proper. This choice is made on the basis of available nutrient data and their overlap with available HAE data at this stage of the project. When other nutrient data are available for comparison with HAE data, this analysis will be extended to other areas.

The nutrient data available for the Baltic Proper were downloaded from a public database (SHARK) webaddress: http://www.smhi.se/oceanografi/oce_info_data/shark/home_order_sv.html.

Data from 0–10 meter from the station BY15 were used as being representative for the open Baltic Sea. The concentration of dissolved organic phosphorus was approximated by “TP - PO₄” and dissolved organic nitrogen as “TN – (NH₄ + NO₂ + NO₃)”. The average of all available data for 0, 5 and 10 m depth were used for the analysis.

Data on Harmful algal events from 1982 – 1994 were obtained as the maximum yearly expansion of cyanobacterial floating layers (scums) as observed from satellite. Data on total area covered by accumulations of cyanobacteria, corrected for sampling frequency, were kindly provided by Mati Kahru. The methodology is published in Kahru (1997).

3. Results

3.1. The Baltic Sea Proper

3.1.1. Time trends

Data on dissolved organic nutrients were available from 1975 for nitrogen and from 1968 for phosphorus. Long term trends of in the surface waters of the Baltic Sea proper show a slight increasing trend for dissolved organic nitrogen, and a less clear trend of dissolved organic phosphorus (Figure 3-1)..

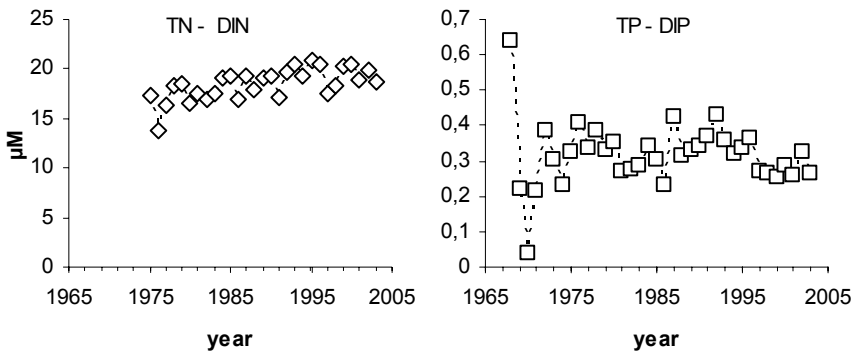


Figure 3-1 Long term time-trend for yearly averaged surface concentrations (0-10 m) of TN-DIN (left panel) and TP-DIP (right panel)

Yearly averaged dissolved organic nitrogen, as approximated by TN – DIN increased slightly from about 17 μM to 20 μM over the period that is considered in this study (1981 – 1995).

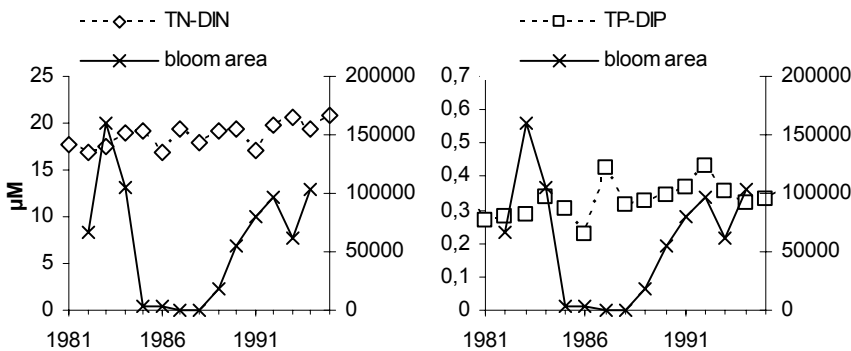


Figure 3-2 Time trends of yearly averaged surface concentrations (0-10 m) of organic nitrogen and organic phosphorus for the years 1981-1995 at BY15, together with cyanobacterial bloom area for 1982-1994.

3.1.2. Correlations of bloom surface area with organic nutrient concentrations.

Linear regression analyses revealed no significant correlations between bloom area and organic nutrient concentrations (). Also bloom area was not correlated significantly with organic nutrient

concentrations during the coming year, which was the case for inorganic phosphorus (Deliverable 3.1.2).

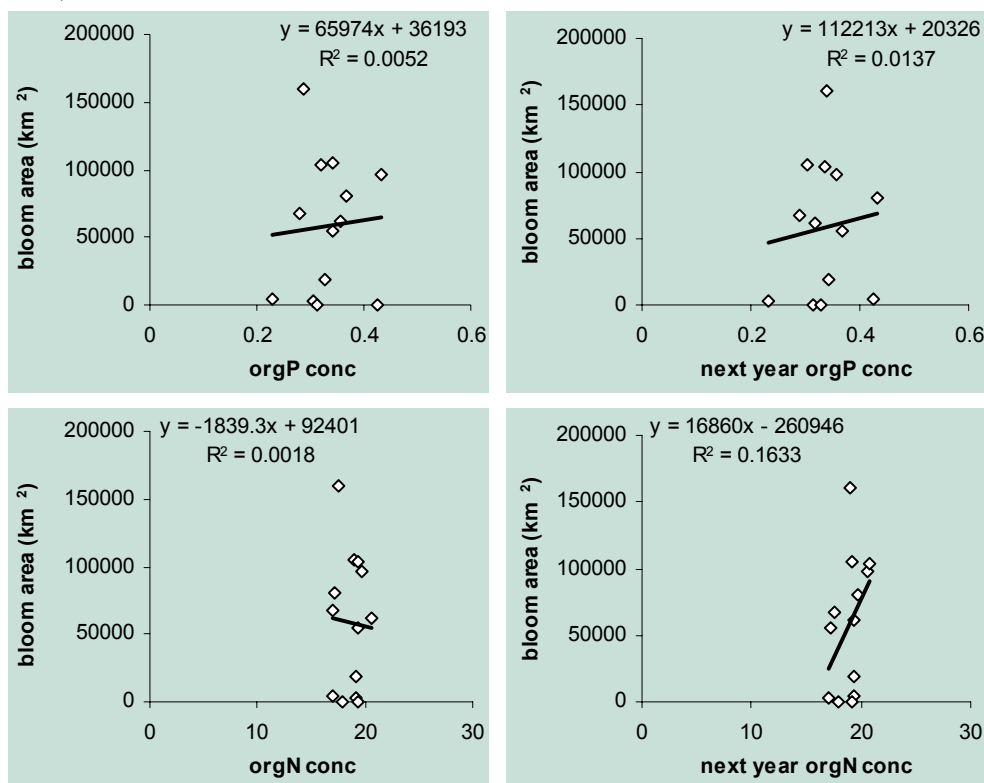


Figure 3-3 Correlations between cyanobacterial bloom area and concentrations of total surface (Jan-Dec; 0-10 m) yearly averaged organic phosphorus and nitrogen (in µM) from the same year (left panels) respectively next year (right panels). At a 0.05 level, none of the correlations is significant.

3.1.3. *Thresholds of organic nutrients for harmful algal events in the Baltic Proper*

At this stage of analysis, there is no clear threshold nutrient concentration for the occurrence of cyanobacterial floating blooms in the Baltic Proper. This may be partly due to the relatively low variation in nutrient concentrations over the considered period. Planktonic cyanobacteria, which are the main causative organisms of HABs in the Baltic Sea, are perhaps not the most probable organisms to profit from high inputs of organic nutrients. They are known as relatively strict photoautotrophs. However, indirectly, cyanobacteria may profit from enhanced concentrations of dissolved organic material. For instance, in mesocosm experiments, cyanobacteria were stimulated by the addition of high-molecular-weight dissolved organic material, most probably due to enhanced iron availability (Stolte et al, submitted). Especially nitrogen-fixing cyanobacteria have high iron requirements, and the availability of iron, possibly introduced into the Baltic Sea bound to dissolved organic material, may be a prerequisite for cyanobacterial blooms, and may in such case form a threshold for blooms. At this stage however, our data do not provide evidence that this has been the case for the period that was studied.

4. Conclusions

The correlation between organic nitrogen and phosphorus concentrations and harmful algal events was studied in the Baltic Sea. The number of data used in the analysis appeared to be limited by the availability of data on harmful algal events. Trends were studied using linear regression. No significant relationships could be observed, and therefore we can not draw any conclusions about thresholds of organic nutrients for blooms in the Baltic Sea for the studied period. If more data come available for analysis, a better answer may be given to the question if thresholds for organic nutrients exist with respect to the formation of harmful algal blooms.

5. Acknowledgements

Mati Kahru is acknowledged for the data on cyanobacterial bloom areas in the Baltic Sea.

6. References

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