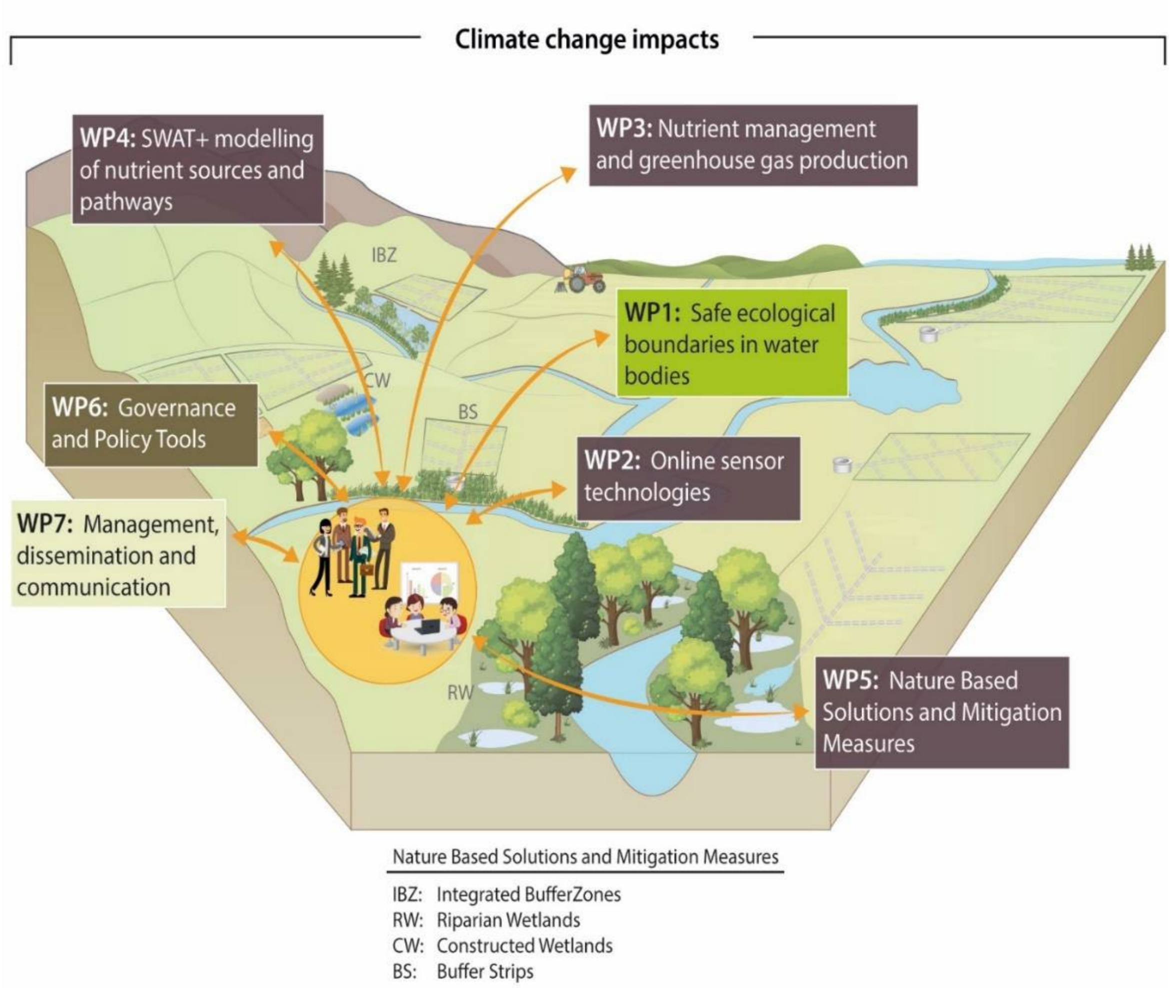
Policy brief D1.4: Safe nutrient boundaries and climate change impacts on algae.



Authors: Anne Lyche Solheim and Jan-Erik Thrane, Norsk institutt for vannforskning (NIVA), Økernveien 94, Oslo 0579, Norway.

Key messages:

- **Safe nutrient boundaries compatible with good ecological status for algae have been estimated for many types of lowland rivers and lakes in Nordic and Central Europe**
- **Current national nutrient boundaries are mostly in line with these estimates but are a lot higher in Polish rivers, indicating the need for further validation with the existing ECOSTAT tool using data covering the whole nutrient gradient**
- **Climate change causing increased temperature was found to have negative impact on the ecological conditions for algae in stratified lakes**
- **River basin managers are advised to consider more stringent nutrient boundaries and/or more nutrient reduction measures to mitigate climate-driven risks to freshwater biota.**

Boundary concentrations for phosphorus and nitrogen set by EU-countries and Norway are required by the EU Water Framework Directive (WFD) to support good ecological status for freshwater biota in European lakes and rivers. However, these boundaries vary by more than an order of magnitude within comparable waterbody types, raising concerns that some of these boundaries may not ensure good ecological status.

Therefore, it is important to determine safe nutrient boundaries that are compatible with good ecological status for biological quality elements, such as algae in lakes and rivers, which are particularly sensitive to nutrient pollution.

Using datasets across three Nordic countries and across three Central European and Baltic countries (Figure 1) and a regression method recommended by the WFD-ECOSTAT working group, safe nutrient boundaries have been estimated for several common types of lowland lakes and rivers in the Nordic and Central regions of Europe.

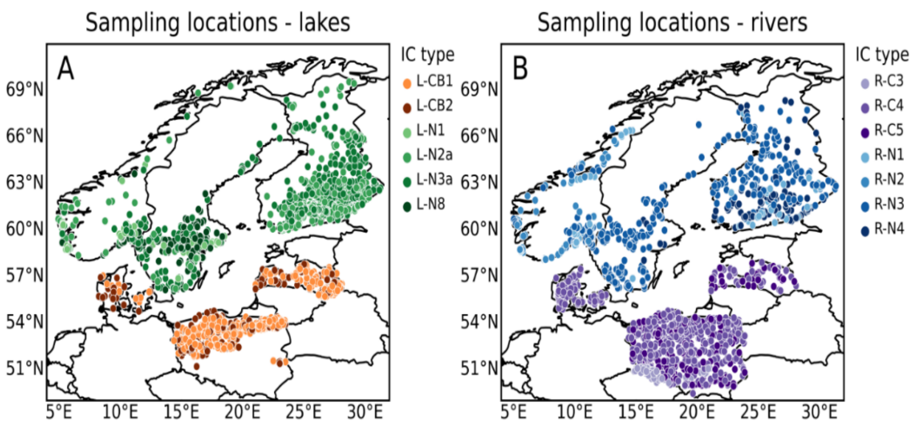


Figure 1. *Sampling locations for lakes (A) and rivers (B) with the point colours representing the different IC types.*

The results show that the national nutrient boundaries are in line with the new estimated boundaries for most of the countries and types (Figures 2 and 3). However, some of the national boundaries exceed the upper 95% confidence limit of the estimated boundaries, primarily in Polish rivers and may not ensure good ecological status if used as management targets. Thus, these national boundaries need further validation using existing tools. Some Finnish boundaries also exceed this limit but that may be due to higher concentrations of humic substances.

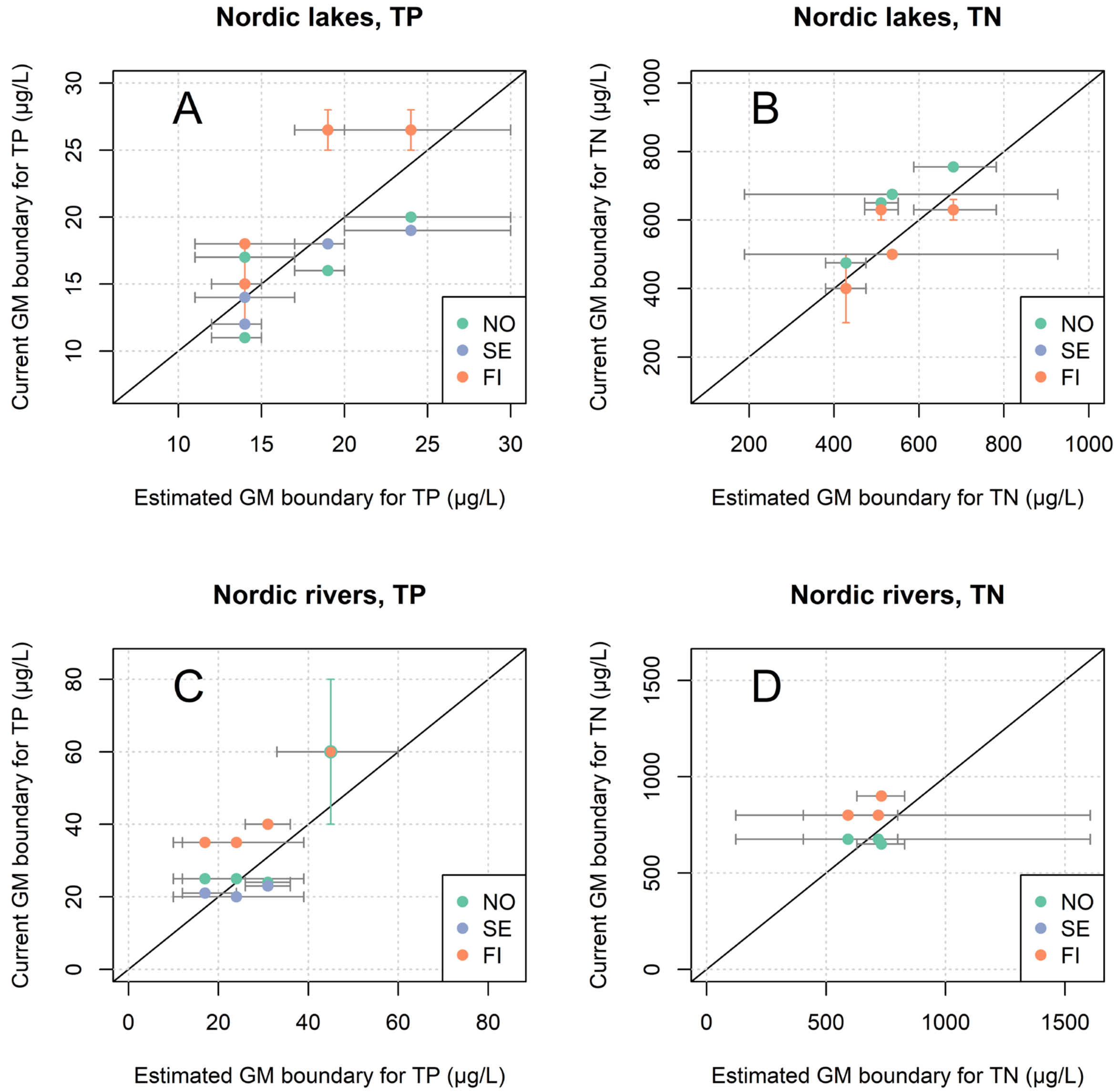


***Figure 2**. Relationship between currently used GM boundary values (y-axis) and estimated GM boundary values (x-axis) for TP (total phosphorus; µg/L) and TN (total nitrogen; µg/L) in the Nordic region. A) TP in Nordic lakes; B) TN in Nordic lakes; C) TP in Nordic rivers; and D) TN in Nordic rivers. The black line indicates the 1:1 line. Horizonal bars indicate the 95% confidence interval for the estimated boundaries from the BLR regression. Vertical bars indicate the range of current national boundaries for the IC types that may include several national types. NO = Norway; SE = Sweden; FI = Finland.*

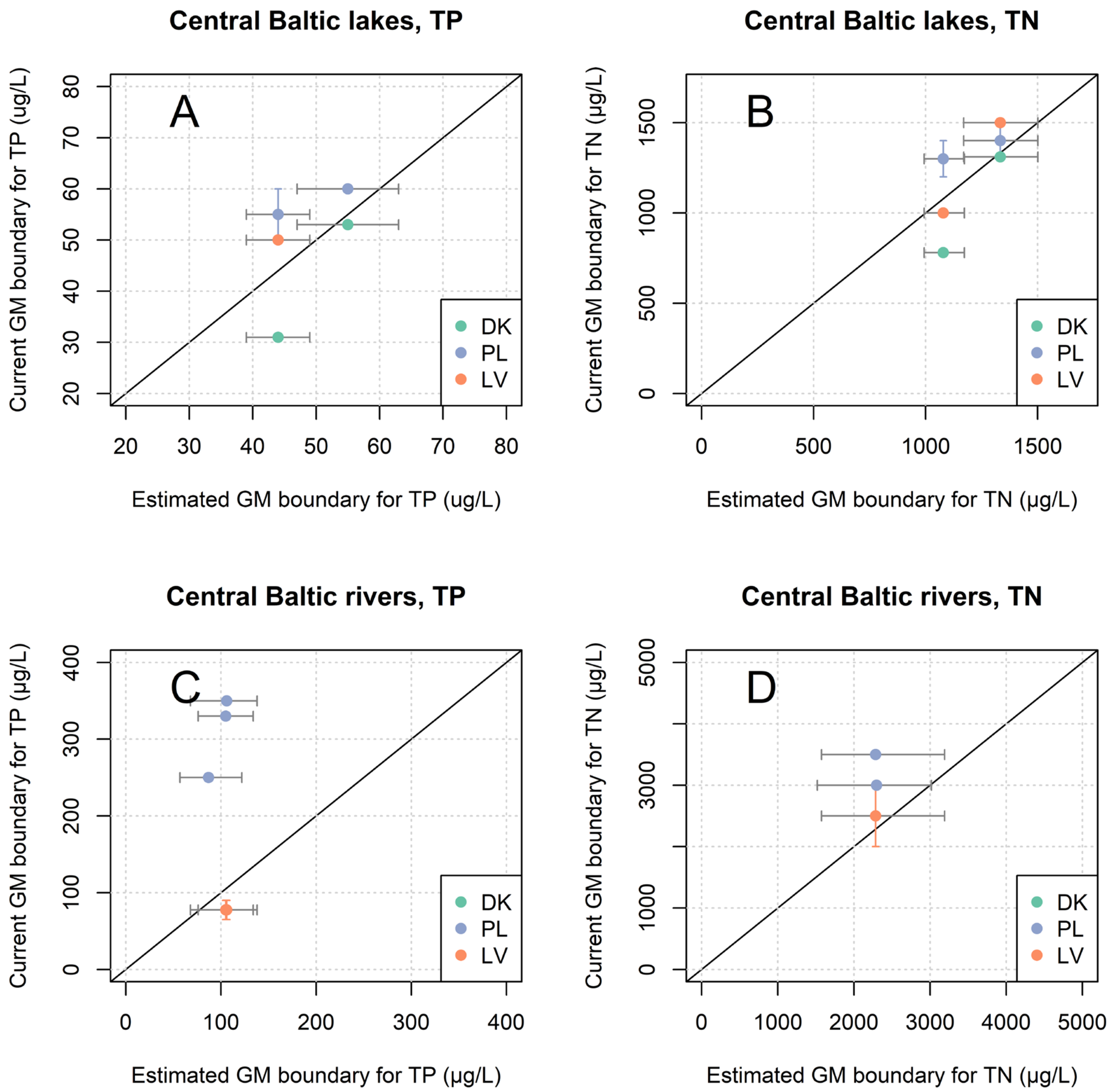


Figure 3. *Relationship between currently used GM boundary values (y-axis) and estimated GM boundary values (x-axis) for TP (total phosphorus; µg/L) and TN (total nitrogen; µg/L) in the Central-Baltic (CB) region. A) TP in CB lakes; B) TN in CB lakes; C) TP in CB rivers; and D) TN in CB rivers. The black line indicates the 1:1 line. Horizonal bars indicate the 95% confidence interval for the estimated boundaries from the BLR regression. Vertical bars indicate the range of current boundaries for the IC types that are comprised of several national types. DK = Denmark; PL = Poland; LV= Latvia.*

Climate change may cause less tolerance to nutrient pollution for algae in lakes and rivers. Therefore, the effects of temperature and precipitation on ecological status were tested on the same dataset that was used to estimate safe nutrient boundaries. The results show that the ecological status of phytoplankton was negatively related to summer air temperature in all stratified lake types. However, the effect was relatively weak compared to the clear effects of nutrients (Figure 4).

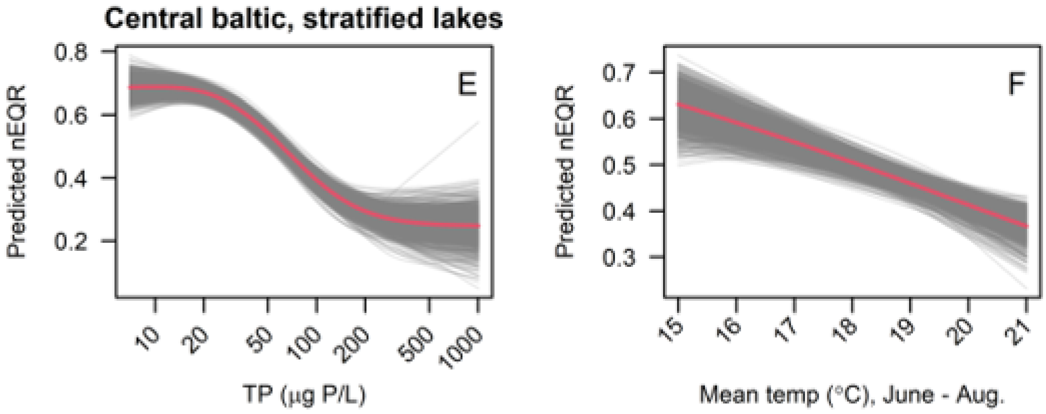


Figure 4. *Predicted effects of total phosphorus (TP, µg/L) and mean June – August temperature (°C) on phytoplankton nEQR in Central-Baltic, stratified lakes (IC type L-CB1). Faint grey lines represent predictions from 1000 model iterations, where the red line represents the mean of all predictions.*

These results suggest that climate change may reduce biological resilience to nutrient pollution, thereby increasing the risk for harmful algal blooms. Consequently, river basin managers are advised to consider more stringent nutrient boundaries and/or more measures to mitigate climate-driven risks to freshwater biota.