

Setting safe ecological boundaries for nutrients for rivers and lakes in the Nordic and Central-Baltic regions

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NORDBALT
ECOSAFE

Coordinated by Aarhus University
Work package led by NIVA

NIVA

Background and objective

- The EU Water Framework Directive (WFD) requires that all lakes and rivers should achieve *good* ecological status based on **biological indicators**, which is defined as slight deviation from natural (reference) conditions
- Concentrations of nutrients (**phosphorus and nitrogen**) are used as supporting elements
- The WFD requires the nutrient boundaries to support **good status for the biology**

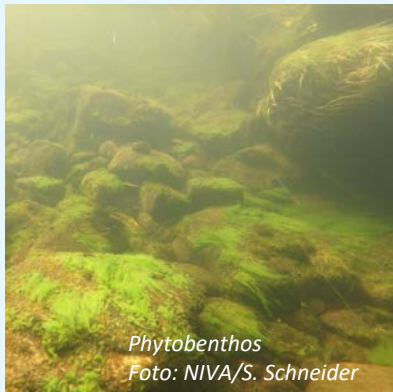
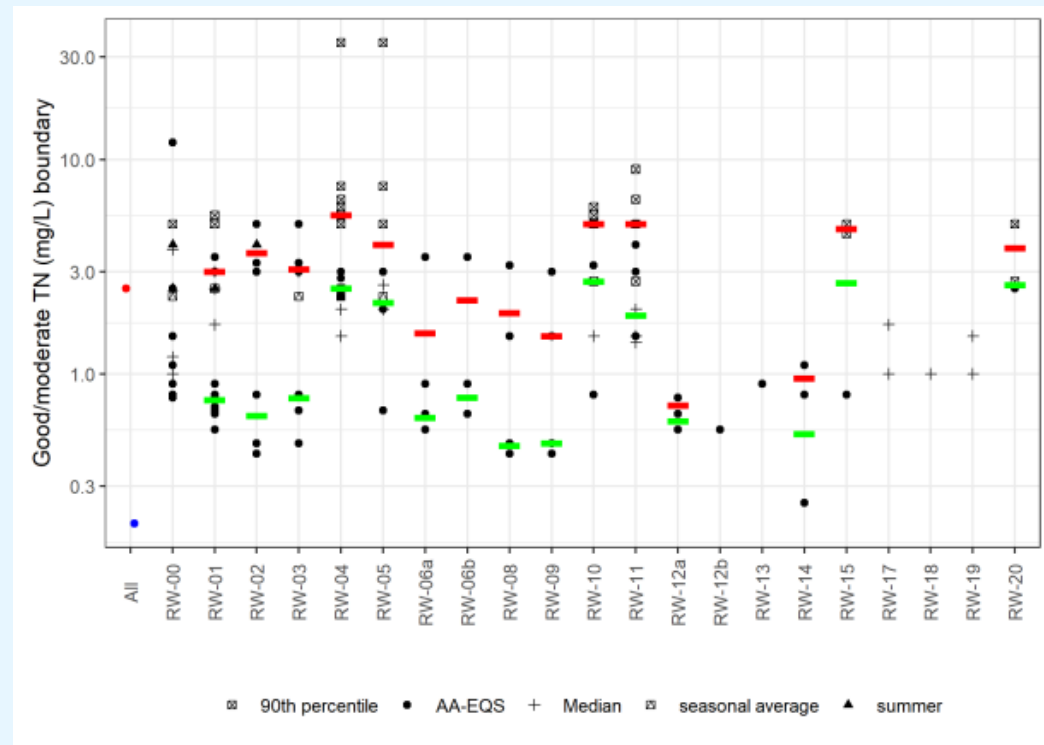
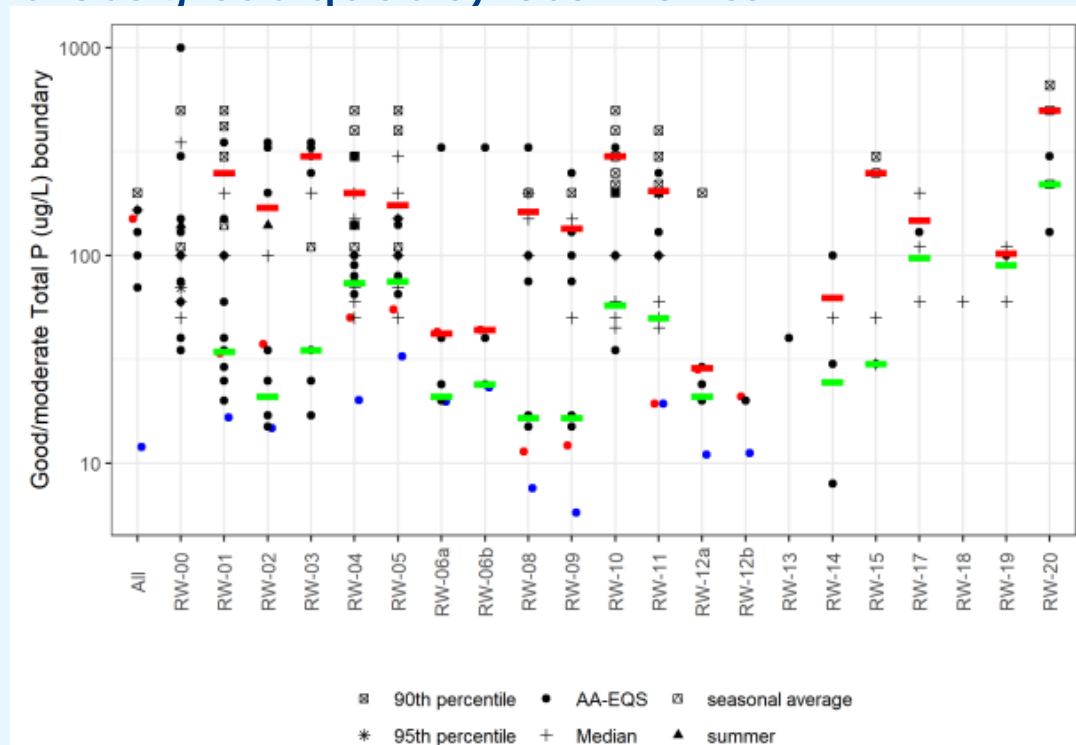


Foto: Jan-Erik Thrane, NIVA

nEQR	Status	Level of disturbance
1.0	High	Reference conditions
0.8	Good	Slight deviation
0.6	Moderate	Moderata deviation
0.4	Poor	Major deviation
0.2	Bad	Severe deviation

Background and objective:

- Current nutrient boundaries reported with the WFD 2nd RBMPs differ by several orders of magnitude between countries for comparable water-body types
- Some of these are unlikely to support good ecological status for sensitive biological quality elements *



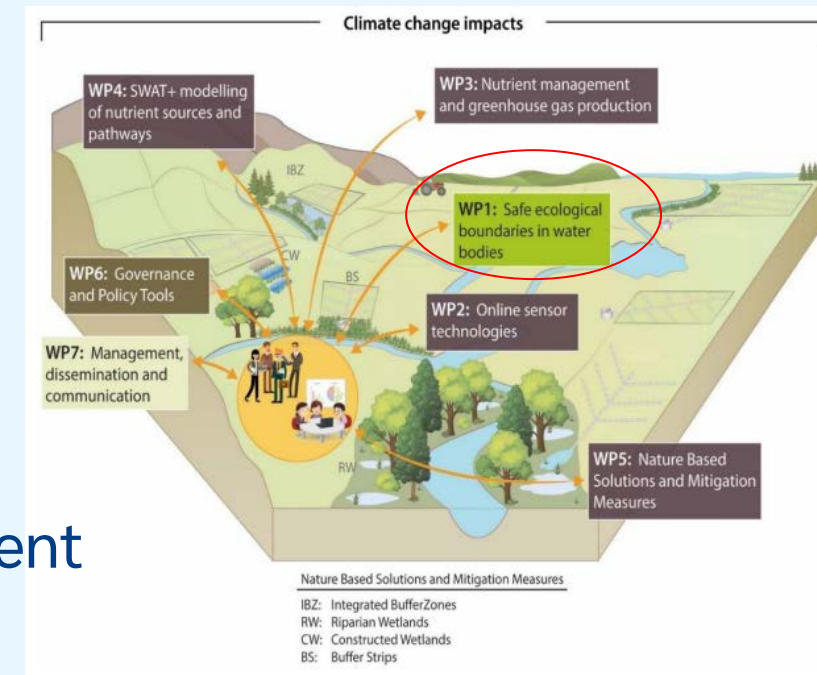
*Kelly, M., et al., 2022. Physico-chemical supporting elements in inland waters under the Water Framework Directive: a review of national standards to support good ecological status. JRC127875, EUR 31040 EN, <https://doi.org/10.2760/470539>

Main objective:

- To estimate **safe ecological boundaries** for Tot-P and Tot-N in common types of lowland rivers and lakes
- Focused on **Nordic** (Norway, Sweden and Finland) and **Baltic/Central European** (Denmark, Latvia and Poland) countries.

Secondary objective:

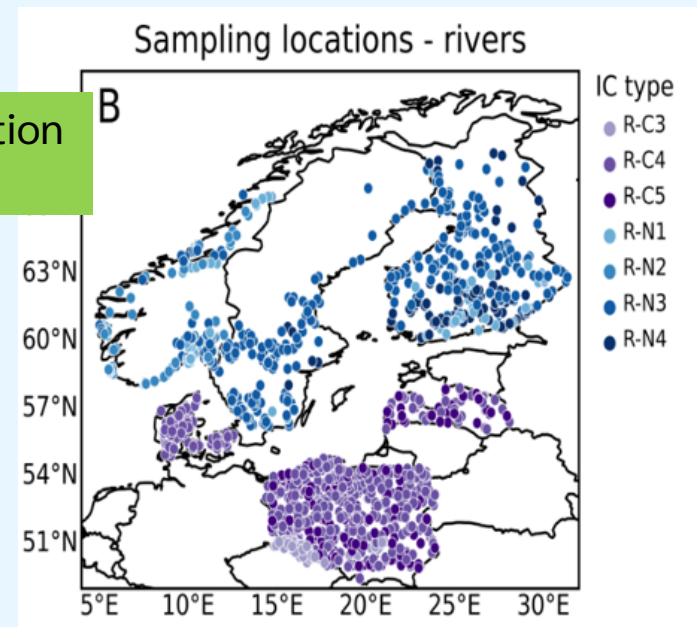
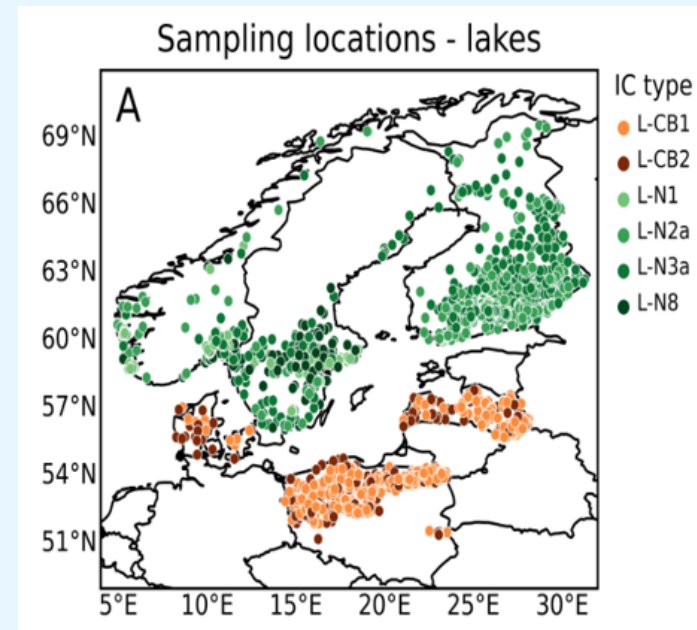
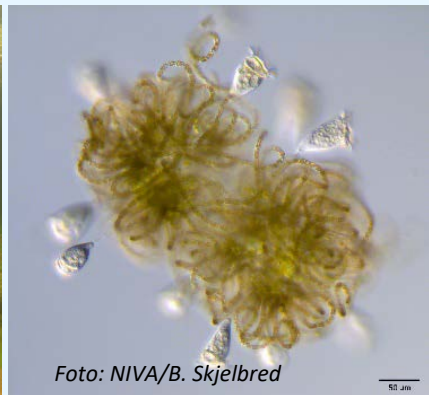
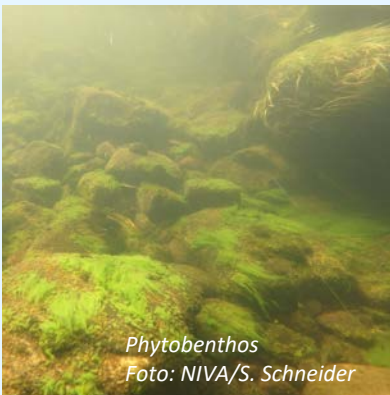
- Climate change implies **increasing temperatures, more precipitation** and more frequent **extreme events**
- Does climate change raise the need for “stricter” nutrient boundaries?



Data sets for setting safe ecological nutrient boundaries

- National monitoring data compiled from Nordic and Central European countries
- Concentrations of **nutrients** (Tot-P and Tot-N)
- **nEQR** (normalized ecological quality ratio)-values indicating ecological status of **biological** quality elements:
 - **phytoplankton in lakes**
 - **phytobenthos in rivers**

*Indices based on biomass and species composition
*Designed to respond to nutrients (mainly P)



Estimating safe ecological boundaries

- Binary Logistic Regression (BLR) following Phillips et al. (2024)
- New method, recommended by ECOSTAT
- nEQR expressed as a binary variable, where $> 0.6 = \textit{good}$; and $< 0.6 = \textit{not good}$ status
- BLR estimates the likelihood (p) of *good* ecological status as a function of nutrient concentration
- The **good/moderate boundary** is the nutrient concentration corresponding to a certain likelihood of good status

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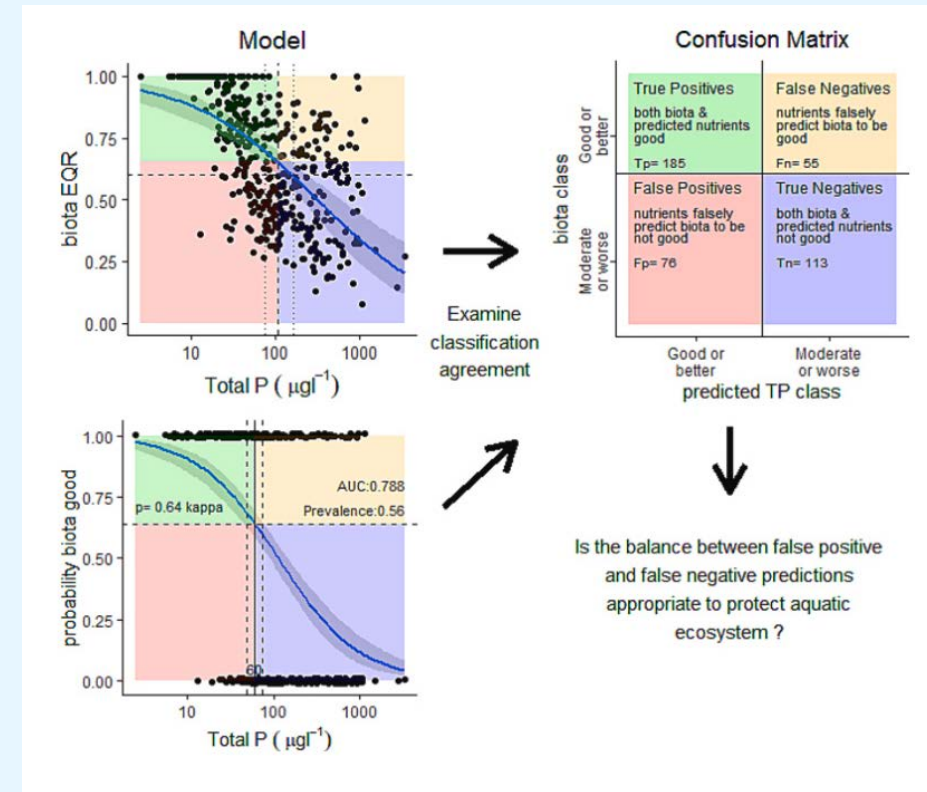

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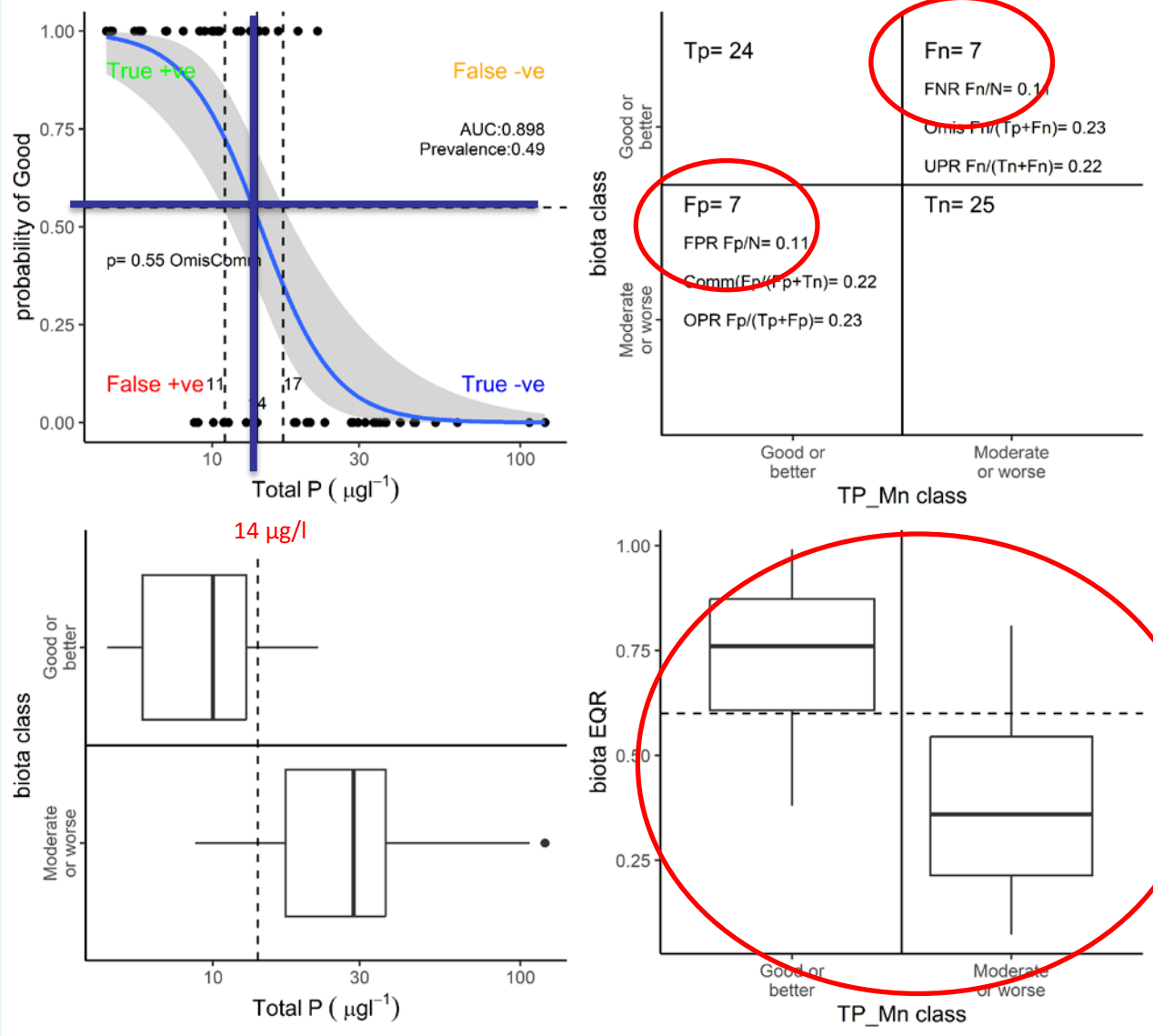
Setting nutrient boundaries to protect aquatic communities: The importance of comparing observed and predicted classifications using measures derived from a confusion matrix

Geoff Phillips^a, Heliana Teixeira^b, Martyn G. Kelly^{c,d}, Fuensanta Salas Herrero^e, Gábor Várbró^f, Anne Lyche Solheim^g, Agnieszka Kolada^h, Gary Free^e, Sandra Poikane^{a,*}



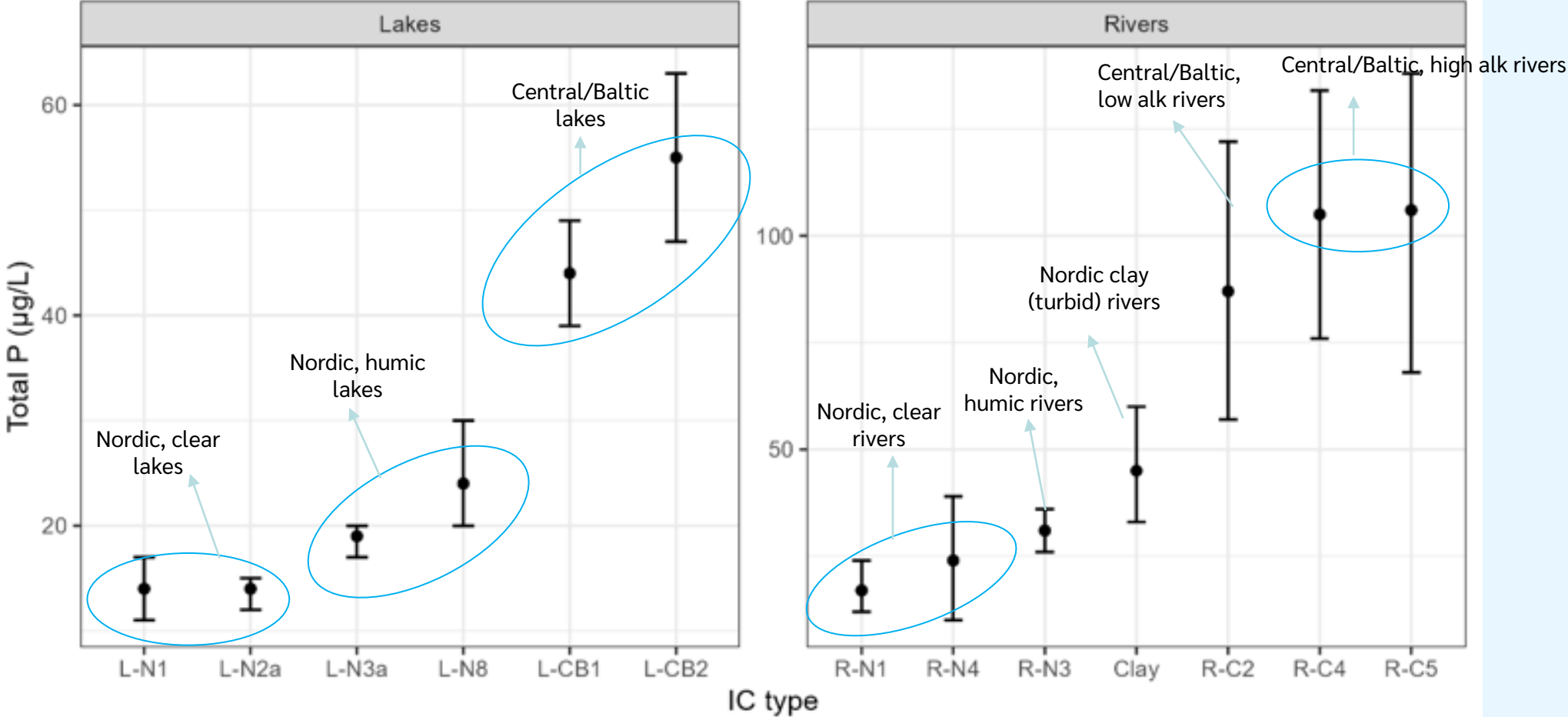
Results – example for one lake type (Nordic, clear lakes)

- Best overall classification accuracy at prob (good status) = 0.55
- Good/moderate boundary:
 - 14 µg/L [11 – 17 µg/L]
- Balanced rate of mis-classifications
- Good separation of biota nEQR for lakes classified as good / not good based on the Tot-P boundary



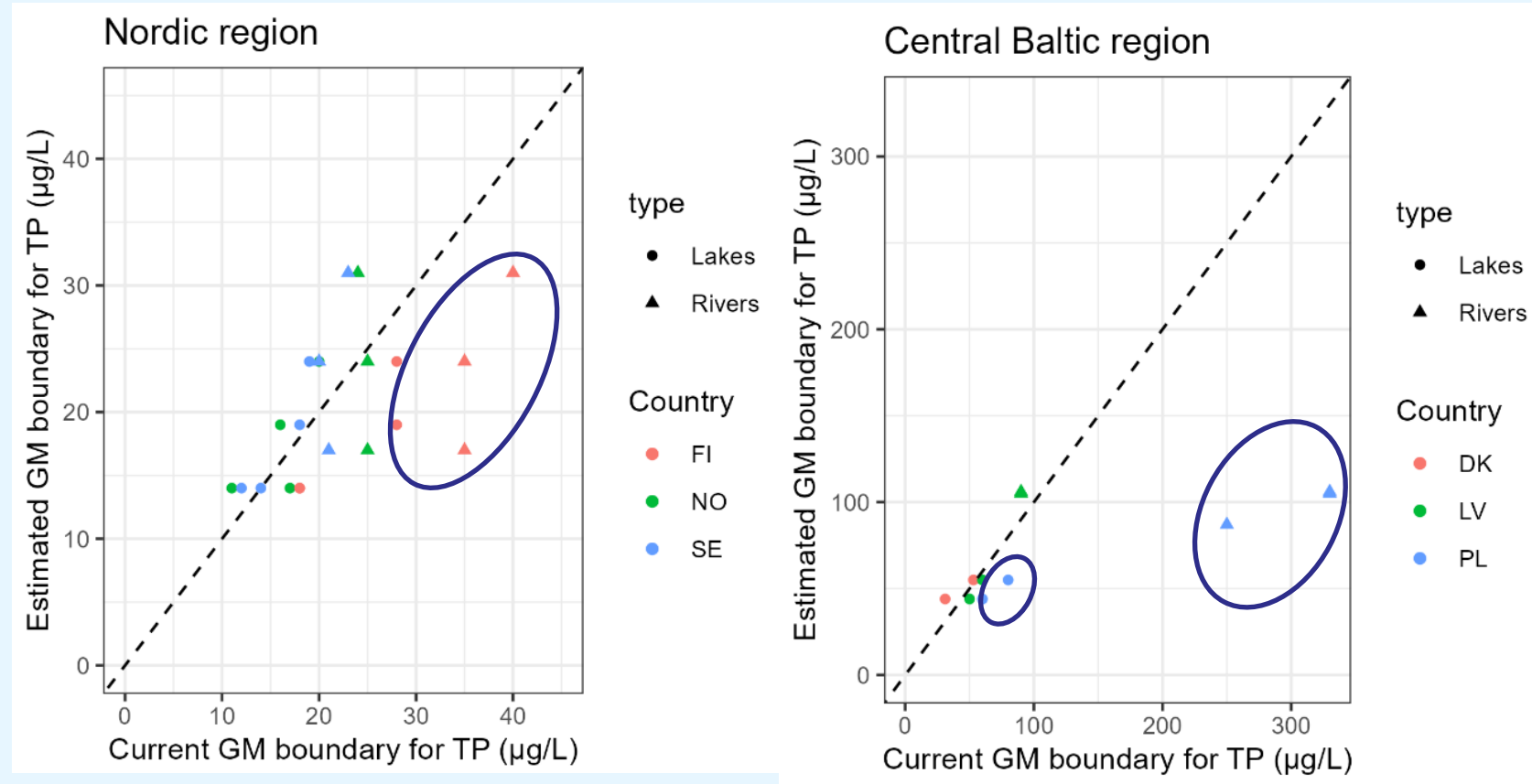
Good/moderate boundaries for Tot-P in different lake and river types

- › Boundaries increase with humic content and alkalinity
- › Higher boundaries and more variability in the Central European/Baltic region than in the Nordic region



Tot-P: Estimated G/M boundaries vs. current boundaries

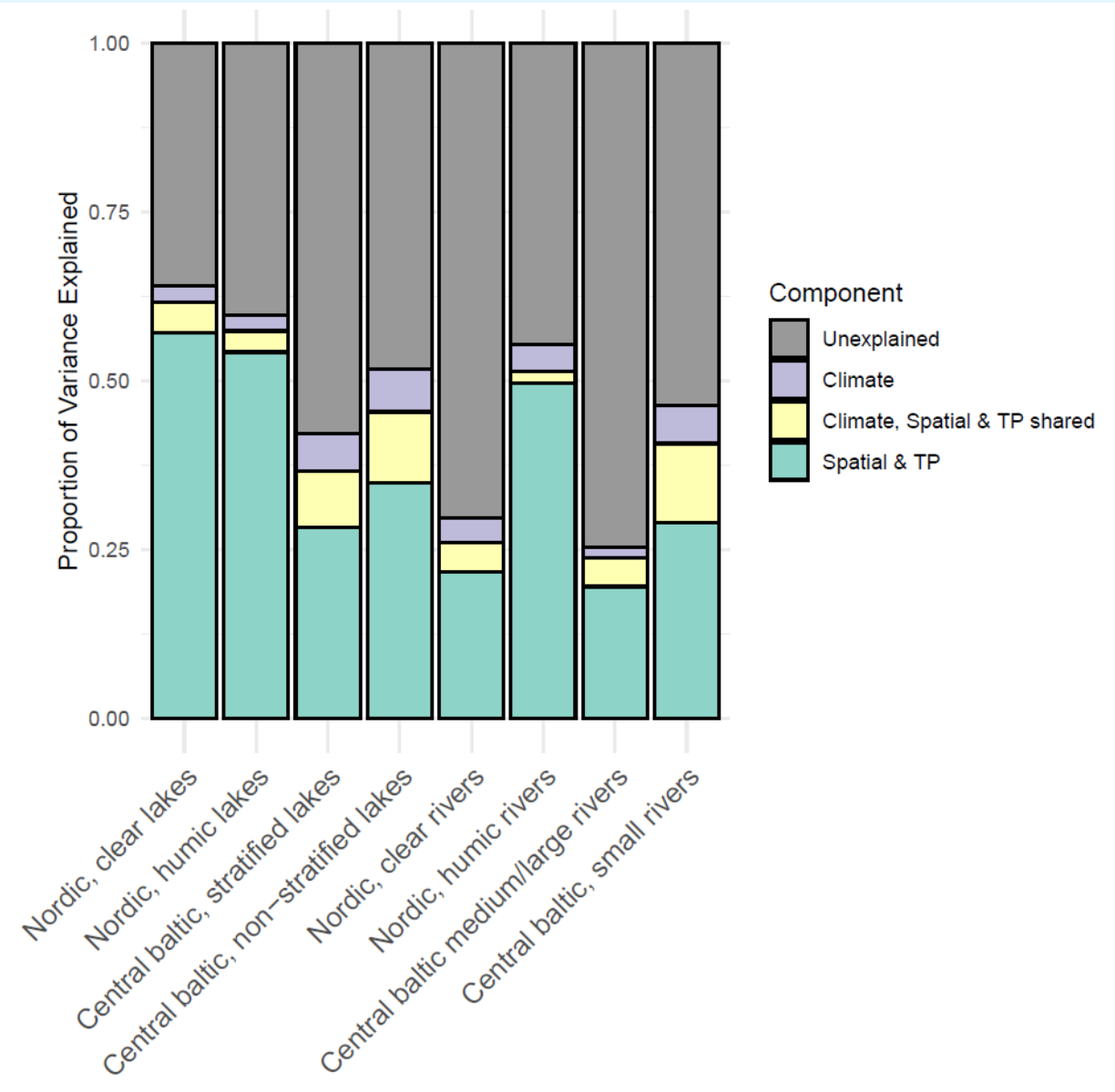
- Current boundaries are significantly higher in several
 - Finnish river and lake types
 - Polish river and lake types
- Suggests that these boundaries should be reviewed to ensure that they support good status for the biology



Climate effects

- 2-6% of the variation in nEQR could be uniquely attributed to climate variables (violet part of graph)
- Most of variation in nEQR was explained by Tot-P and broad spatial patterns (green part of graph)
- In line with recent research on broad climate patterns:
 - There are often climate effects, but they are variable, hard to generalize and often «system specific»*

*Soranno et al. 2025, PNAS - Analysing Climate effects on algal biomass in ~25 000 US lakes

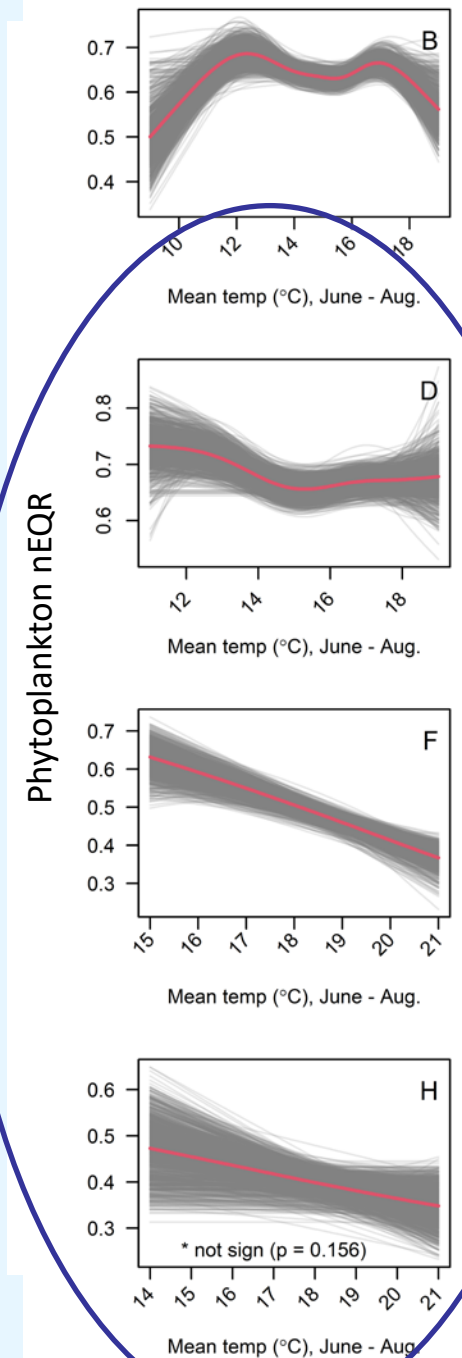


Negative temperature effect on phytoplankton nEQR

- Negative effect of mean summer temperature on phytoplankton nEQR in three out of four lake types
- Increased risk of cyanobacterial blooms in warmer years/areas?
- Higher biomass of algae with higher temperatures?
- No effects of precipitation



Cyanobacterial bloom in Norway's largest lake, Mjøsa, in 2019.



Conclusions

- › Nutrient boundaries varies a lot between countries – some are very high and might not support good status for the biology
- › The BLR method allowed nutrient boundaries for Tot-P and Tot-N to be estimated for several lowland types of rivers and lakes in the Nordic and Central/Baltic regions
- › The results are most reliable for Tot-P in lakes in the Nordic region
- › The results are very uncertain for Tot-N, especially for rivers in the Central-Baltic region
- › Current boundaries for several IC types in Finland and Poland exceed the upper 95th %-ile of the estimated boundaries – may need revision to support good ecological status
- › ECOSTAT Shiny app tool (https://shiny.freshwater-ecology.com/Tkit_NEW/) allows users to apply the BLR method to estimate safe ecological boundaries based on monitoring data
- › Climate effects on EQR-values are present, but relatively small and with varying directionality.
- › A negative effect of temperature in lakes was estimated for three of four lake types

Thanks for your attention!

