ICP Waters

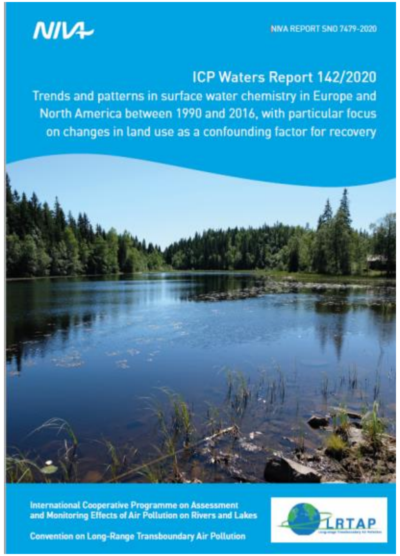
International Cooperative Programme on Assessment and Monitoring Effects of Air Pollution on Rivers and Lakes

1. Status report ICP Waters

- Recent, ongoing, planned activities
- Work plan 2022-2023
- Task Force meeting 2021

2. Presentation on 1000-lake survey

Recent and ongoing reports



- ICP Waters report 142/2020: Trends in surface water chemistry
- Ongoing: nitrogen – trends and biological responses
  - Input to work on critical empirical loads for nitrogen
- Planned for 2022: biological responses to recovery

2020-2021 Nitrogen report

1 Trends and spatial patterns

Large spatial variation in trends

- Explained by different climate, land cover and different N deposition history?

Trends in organic nitrogen and C/N ratio of organic matter

Spatial patterns and N retention capacity

2 Biological responses to N

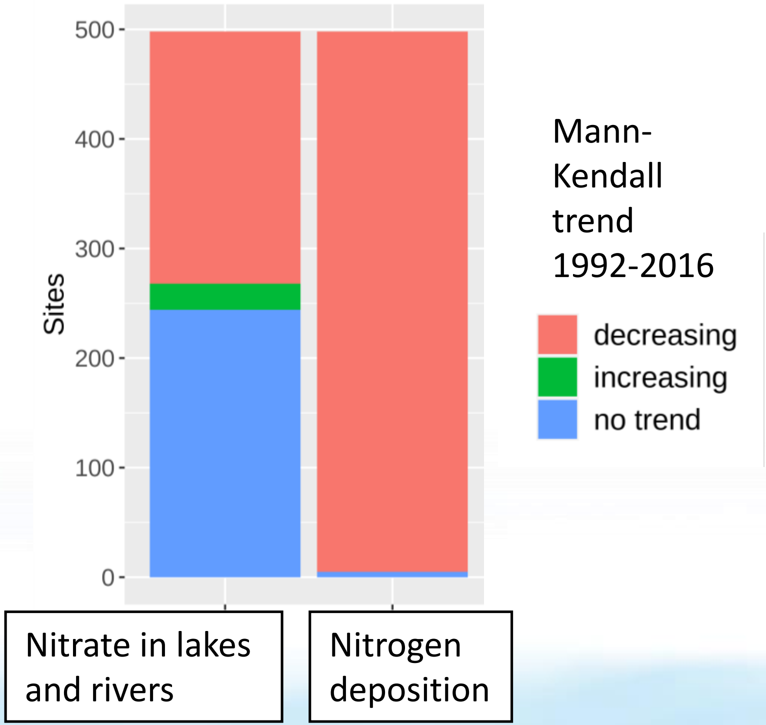
Analysis of existing datasets

- Seasonal variations in indicators of N-limitation in Norwegian rivers
- Phytoplankton, nitrogen in water and N deposition in Nordic lake dataset

Literature review

- Update of ICP Waters report 101/2010
- Basis for contributions to the revision of the empirical critical loads

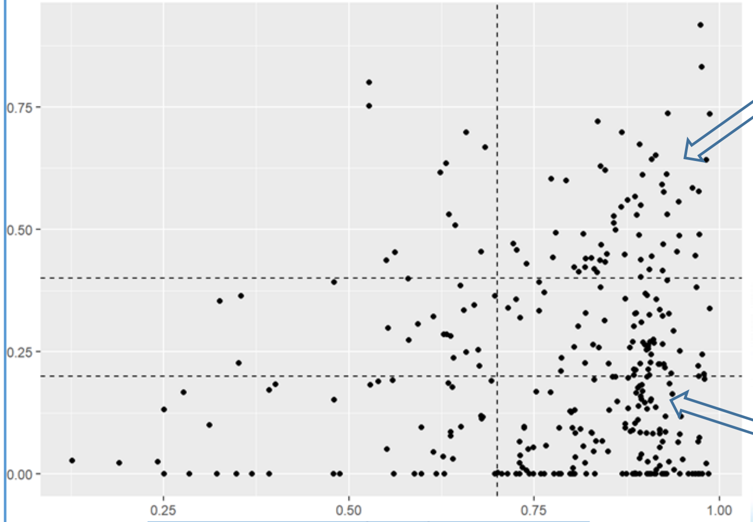
Nitrogen trends



- Nitrogen deposition declines significantly
- Nitrate in surface waters does not show a simple response to deposition
  - Climate and land cover all determine how surface waters react to changing N deposition

What separates sites with little/strong effect of N deposition on NO_3 trends?

R^2 of GAMM models per site



Relationship NO_3 conc and N dep (R^2)

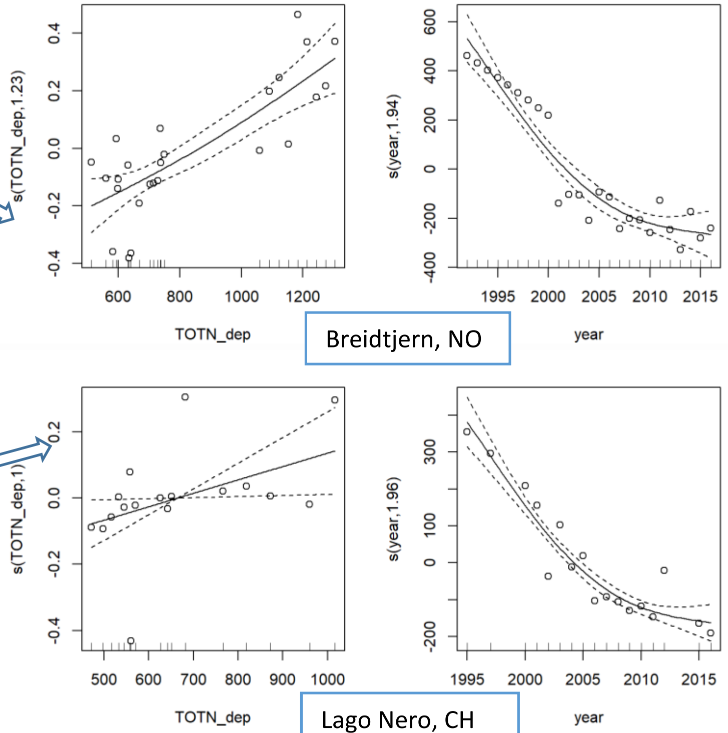
Trend in N deposition (R^2)

Strong time trend in dep and strong effect of dep on NO_3

Strong time trend in dep but small effect of dep on NO_3

NO_3 vs N dep

Dep vs time

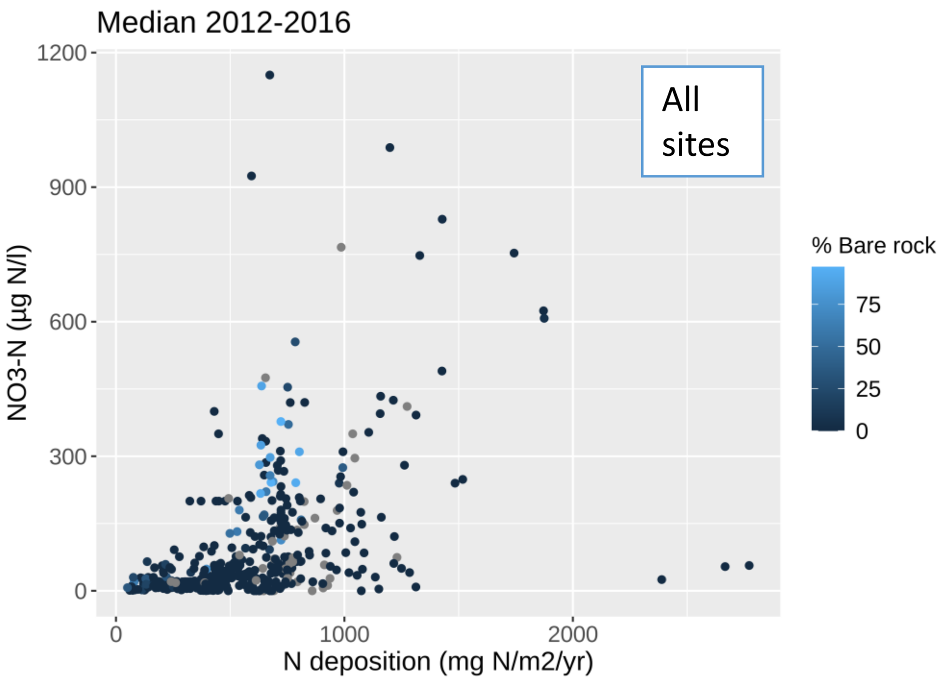


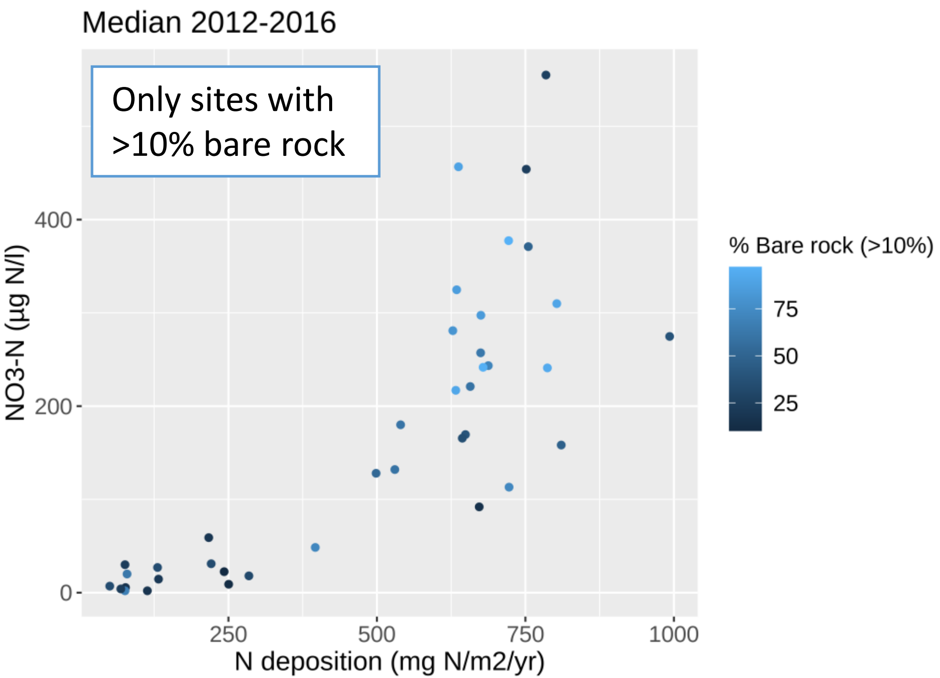
Breidtjern, NO

Lago Nero, CH

Lower N retention in mountainous sites

ICP waters sites cover a wide range in catchment characteristics (mountaint, forest, peatlands)



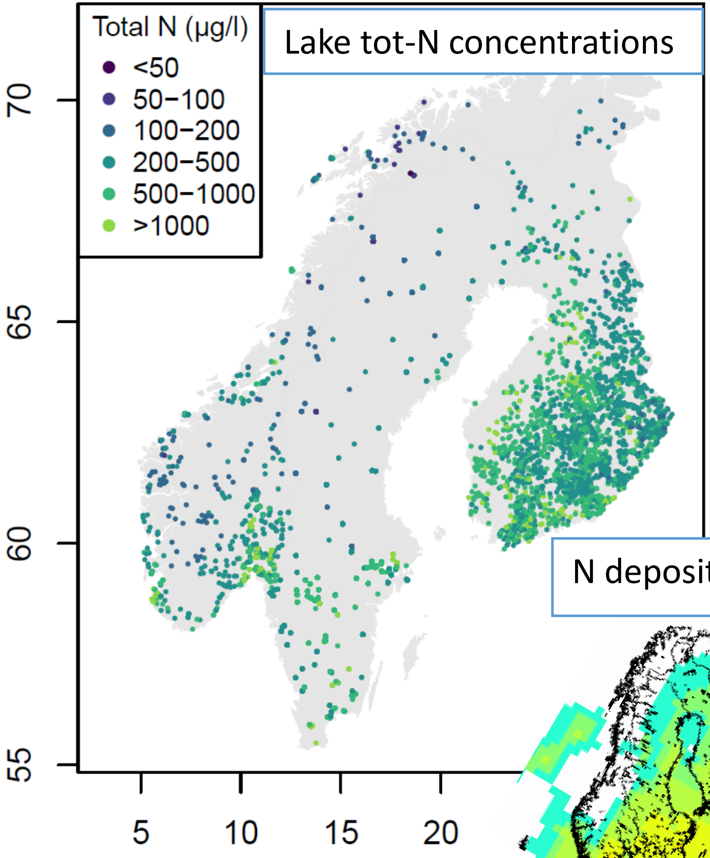


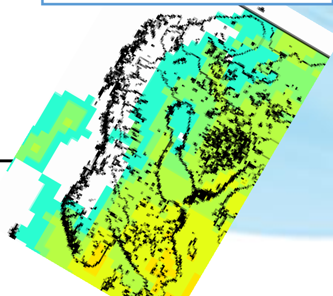
Trends – summary and way forward

- Trends
  - NO_3 mainly decreasing trends where significant
  - No clear indication of enrichment of soil N pools from CN ratios of DOM
- Spatial
  - Tendency towards higher NO_3 in sites with high N deposition and potentially low N retention
  - TOC/TON related to land cover, but may also reflect N enrichment
- Further analyses planned before TF meeting
  - Different statistical approaches and time periods
  - Data call 2020: Land cover data and time series up until 2018/19

Does nitrogen affect freshwater productivity?

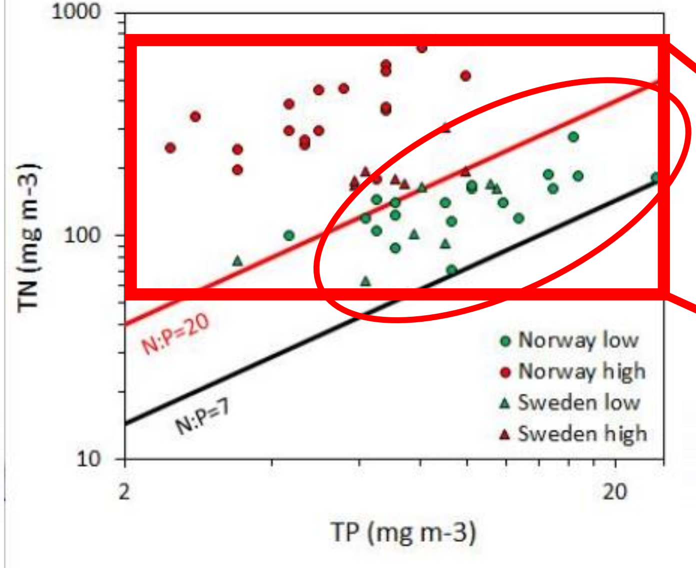
- Lake dataset from Norway, Sweden and Finland (assembled for a Nordic project on Water Framework Directive)
  - Algal productivity, water chemistry, land cover and deposition
  - Includes natural and agriculturally impacted lakes
- Availability of N relative to P as indicator of nutrient limitation



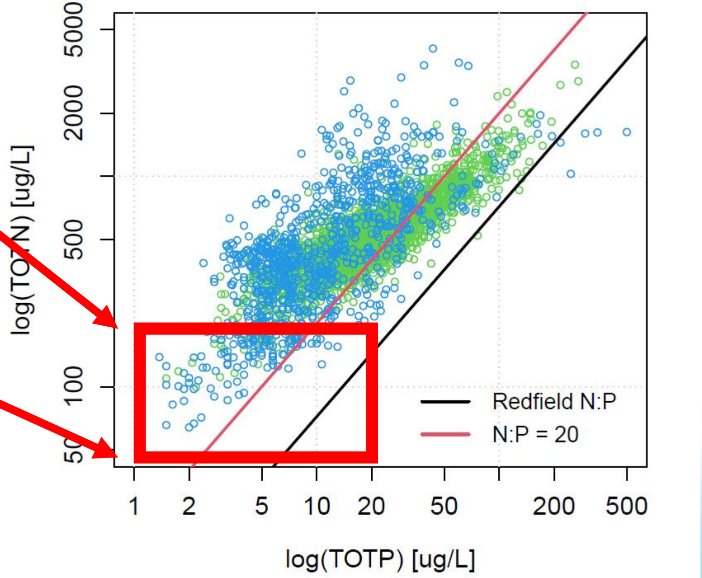


N:P < 20 in natural lakes indicates N-limitation?

Elser ea 2009: combination of monitoring and bioassays

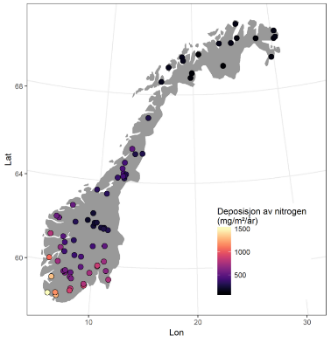


ICP Waters 2021: monitoring data Nordic countries



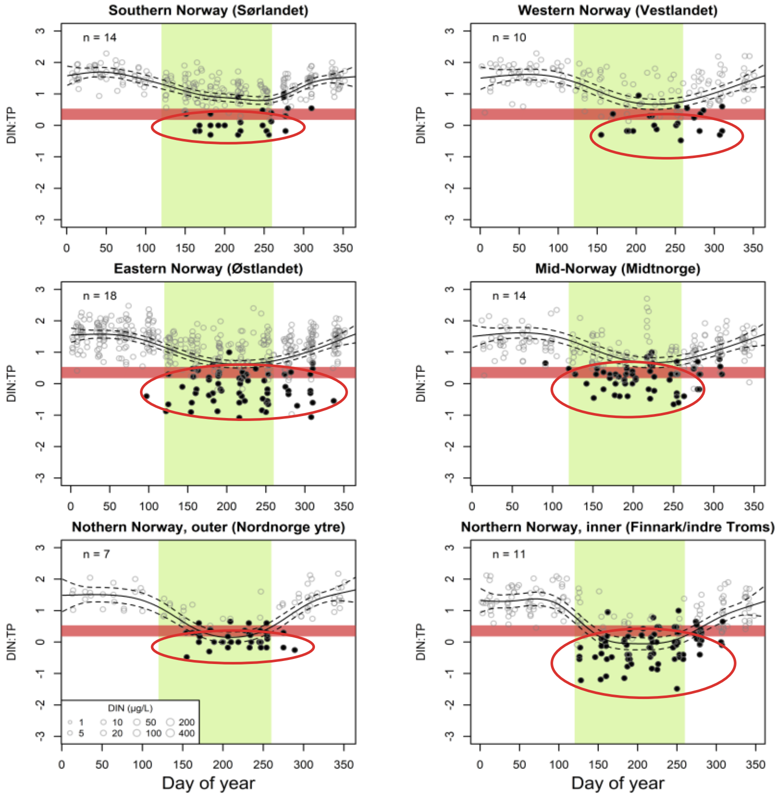
N-limitation or co-limitation in lakes with low N:P and low TP and TN

Very few lakes with low N and P concentrations and low N:P ratios



Norwegian rivers from undisturbed catchments along N deposition gradient: seasonal variation in ratio of NO_3 to total P

- Monthly sampling of water chemistry
- NO_3 to totP ratio below critical limit for N-limitation during growing season
- The lowest ratios are found in areas with low deposition (NORTH) and in regions with large areas of productive forest (EAST, MIDDLE)
    - Some data available of benthic algae (periphyton: algae growing on stones and other substrates in river)



J.E. Thrane, ICP Waters report, in prep

Next: revisit Nordic dataset, analyse algal biomass vs water chemistry and N deposition

Bergstrom et al. 2005:

Swedish lakes along N deposition gradient show *more algal biomass per unit P* where N deposition is higher

Current ICP Waters analysis on Nordic lakes: not yet tested similar to Bergstrom ea 2005

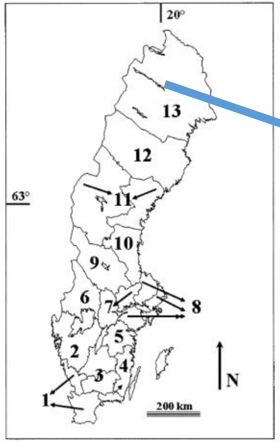
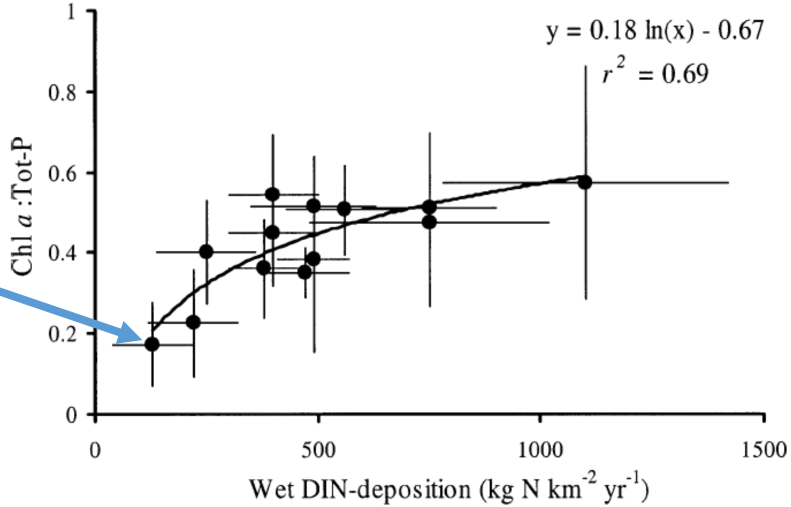
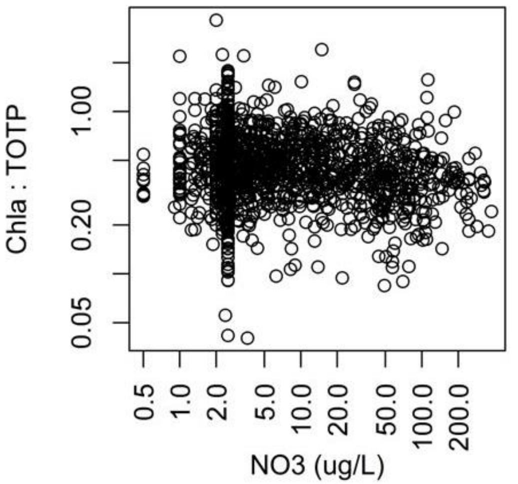


Fig. 1. The different Swedish regions used in this study.





Nitrogen report – relation to empirical CLs

- Phosphorus is the main control of lake productivity
- Challenging to document relationships between N deposition, water chemistry and biological responses
  - Nordic lake dataset will be explored further
- Based on water chemistry: natural rivers are seasonally limited by nitrogen
  - Not further substantiated by link with biological data
  - More N limitation where N deposition is low; possible link to vegetation cover

Potential to derive critical loads for N for *type of lakes?*

- Relationships to land cover and nitrogen retention capacity?

Table A4.1 Proposed new empirical critical loads of nutrient N for fresh waters, based on this review. N deposition in kg N ha^{-1} yr^{-1}. Table numbers refer to tables in De Wit and Lindholm (2010). In *italics*, critical loads that were suggested in other reviews.

EUNIS	Description	Catchment type	Regions	Response	Critical load
C1.1	Oligotrophic soft-water lakes	Arctic	Europe, Canada, Greenland	1. Phytoplankton community shift at N deposition <1-1.5 (Table 1)	1
		Alpine, boreal	USA, Europe	1. Phytoplankton community shift at N deposition 3-5 (Table 1) 2. Higher phytoplankton productivity at N deposition < 5 (Table 3)	3-5
		Temperate, boreal	Canada, USA, UK, Scandinavia, Netherlands	1. Phytoplankton community shift at N deposition 2-9 (Table 1) 2. Higher phytoplankton productivity at N deposition < 5 (Tables 2 and 3) 3. Shift of N to P limitation of benthic algae at N deposition 2-12 (Tables 2 and 4) 4. Productivity of benthic algae increases at N deposition 2-12 (Table 4) 5. *Macrophytes: loss of key isoetid species, increase in species such as Juncus bulbosus and Sphagnum (Bobbink and Roelofs, 1995)*	5-10
		Dunes	Netherlands	1. *Increased biomass and rate of succession (Bobbink et al., 2003)*	10-20
C1.4	Dystrophic lakes	Temperate, boreal	Sweden, Canada	1. Higher phytoplankton productivity, especially at N deposition < 5 (Table 3)	3-5

Other activities ICP Waters

- Review of the Gothenburg protocol
  - Focus on observed and projected trends, suitability of current monitoring & expected new scientific findings
  - For surface waters:
    - water chemistry monitoring serves its purpose, but is under threat from reduction in funding. Increased focus on monitoring under the NEC Directive might counteract this trend. The data that are collected under the Water Framework Directive are often not suitable for targeted monitoring of air pollution effects on waters
    - Biological monitoring should be strengthened
  - New scientific findings:
    - Current analysis of impacts of nitrogen deposition on surface waters
- Mercury and the Minamata Convention
  - Input to guidance for effect-based monitoring
  - Possible collaboration with ICP IM on trends in Hg
- ICP Waters web page
  - Now with more up to date publication list for NFCs: http://www.icp-waters.no/publications/#scipap

NIVA

Workplan 2022-2023

- 2022 report on biological recovery
  - Focus on trends:
    - Regional differences
    - Potential delays in biological recovery vs chemical recovery
    - Still improvement or levelling off?
  - Policy and management implications:
    - Need for biological monitoring, description of different biological indices, dose-response relationships
  - Call for contributions just sent out:
    - Benthic invertebrate data: Update of ICP W database
    - National chapters: Biological trends/recovery across biota
- 2023
  - To be discussed at the Task Force meeting
  - Possible topics:
    - Focus on climate change effects on water chemistry
    - Joint WGE report? (Climate, biological responses..)
    - Topics emerging from the GP review process?

Task Force meeting 2021

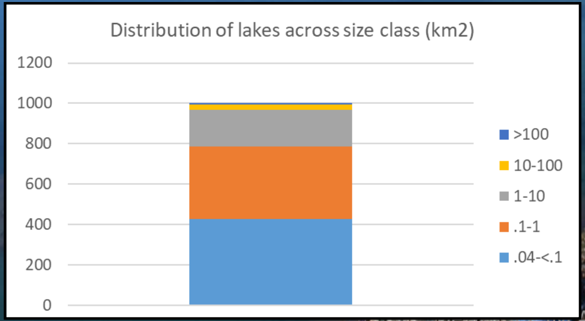
- Online: 28-29 April (afternoons)
- Again only ICP Waters
- Drop me an email if you'd like to attend

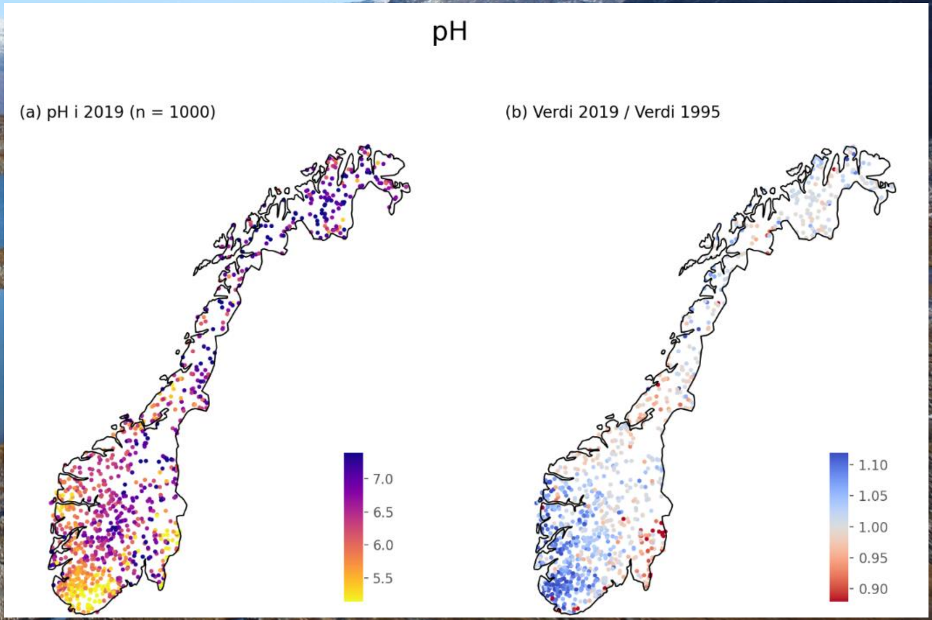
- Topics: Nitrogen, biology, trends, climate, NECD, other
- Welcome!

- Next year in Riga and hopefully with ICP IM! 🤞

Repeated sampling of 1000 Norwegian lakes – 1995 and 2019 (De Wit et al., in prep)

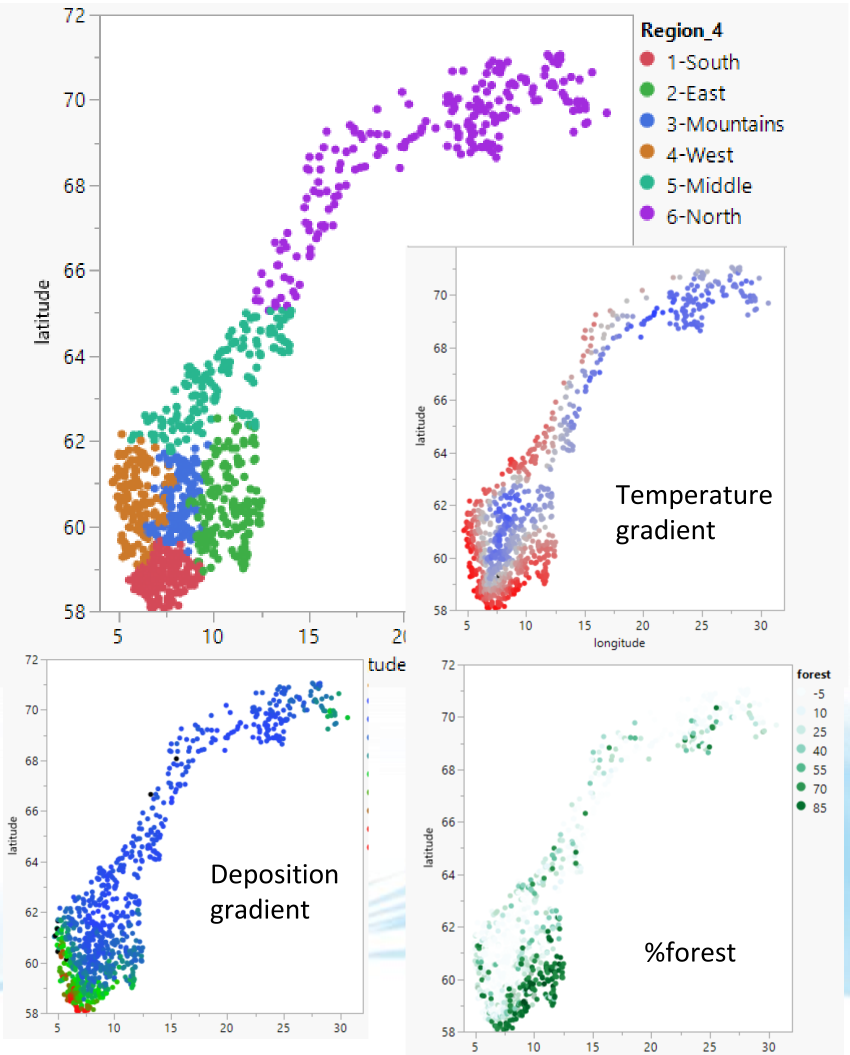
- Representative survey of lakes for Norway: 3:2:1-ratio between nr of lakes from South – Middle – Northern Norway
- Emphasis on smaller lakes and catchments
- Mostly natural lakes



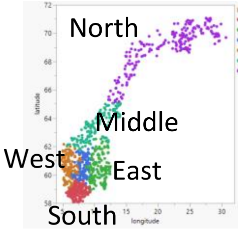


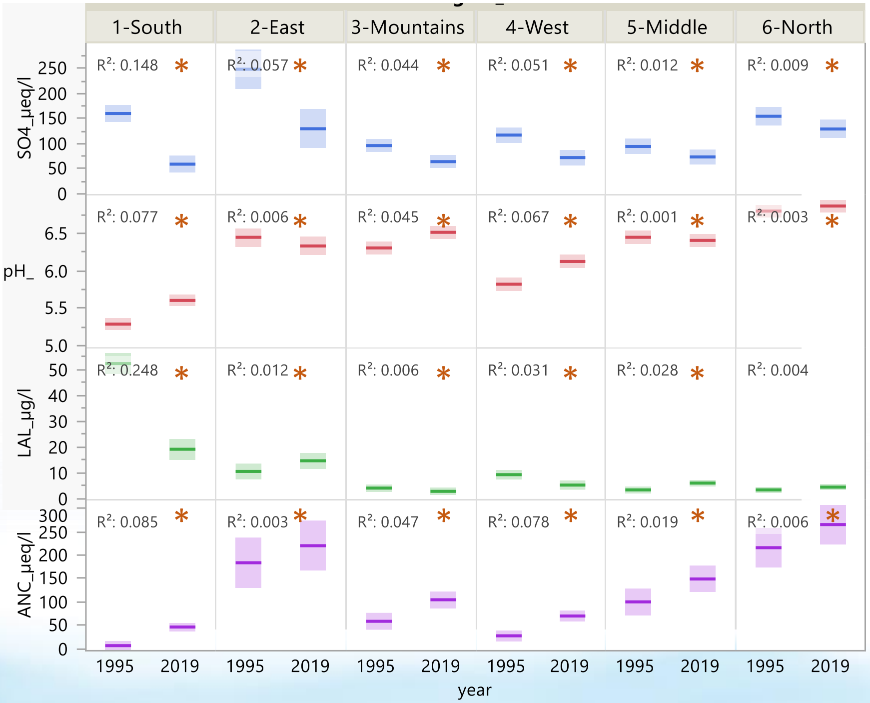
Aim: document changes in ecological status.

- Ca 1000 lakes sampled in 1995 and 2019, grouped into 6 regions
- Strong gradients in climate, land cover and deposition
  - Internally correlated
- All ‘common’ water chemistry, metals, nutrients, organic matter quality
- Possible to do ‘paired tests’, grouped by region



Recovery from acidification

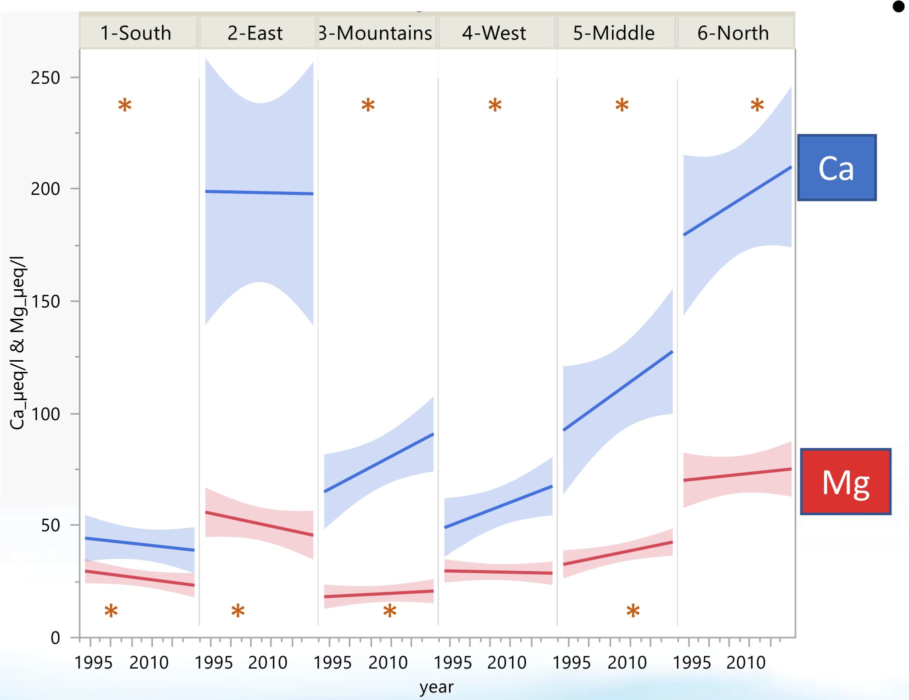




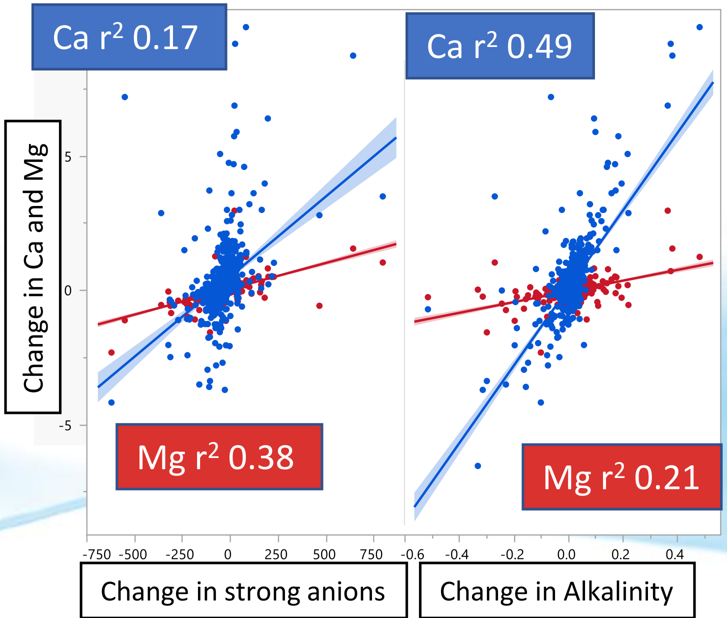
- Sulfate declines with 68% (south) to 17% (north)
- pH increases, labile Al decreases, ANC increases
  - Notable exceptions: in areas with high TOC and a high TOC increase
- Southern Norway remains strongly acidified
  - Long history of high deposition and traditionally poor in base cations

NIVA

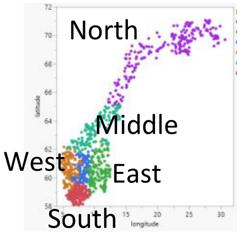
Do Ca and Mg live separate lives?



- Changes in Mg lag behind changes in Ca: very distinct increase for Ca.
  - Ca correlates best with alkalinity
  - Mg correlates best with Cl and SO4

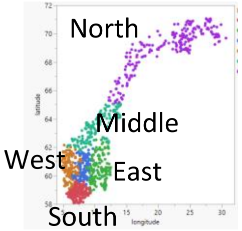


DOC & nutrient limitation

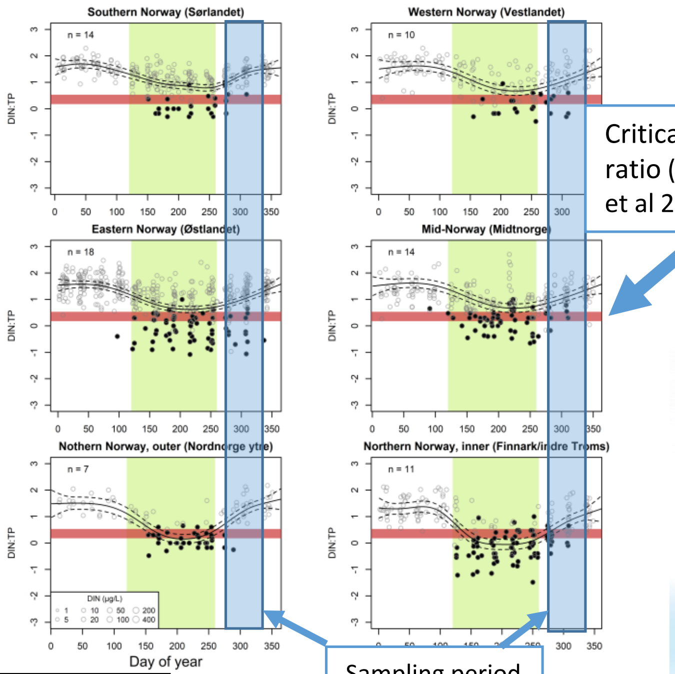


- Lakes have increased in DOC, related to reduce S deposition and increased rainfall
- NO_3 has declined almost everywhere, related to reduced N deposition and probably climate (increased terrestrial uptake, less distinct snowmelt)
- Total P shows little change
- The ratio of NO_3 to totP has decline strongly everywhere, suggesting a stronger nitrogen-limitation in lakes in areas with low N deposition
- Lakes in south more light-limited, lakes in north more nitrogen-limited
  - Tendency towards more light and nutrient limitation everywhere

Seasonal variation in DIN:totP ratio in natural river in Norway suggests that shift towards N-limitation in lakes could be stronger than indicated by 1000-lake survey



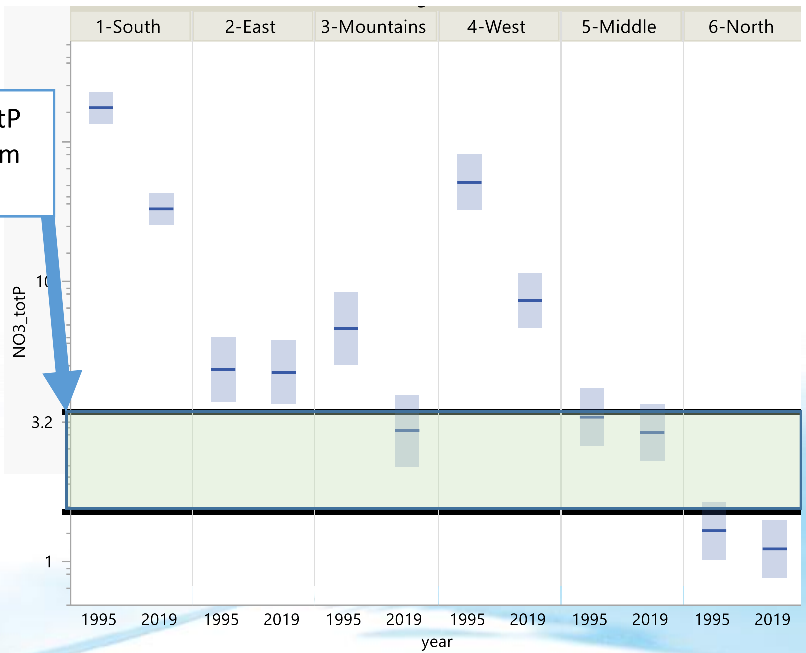
Monitoring of 'natural' rivers with monthly sampling frequency



Critical DIN:totP ratio (Bergstrom et al 2010)

Sampling period 1000-lakes

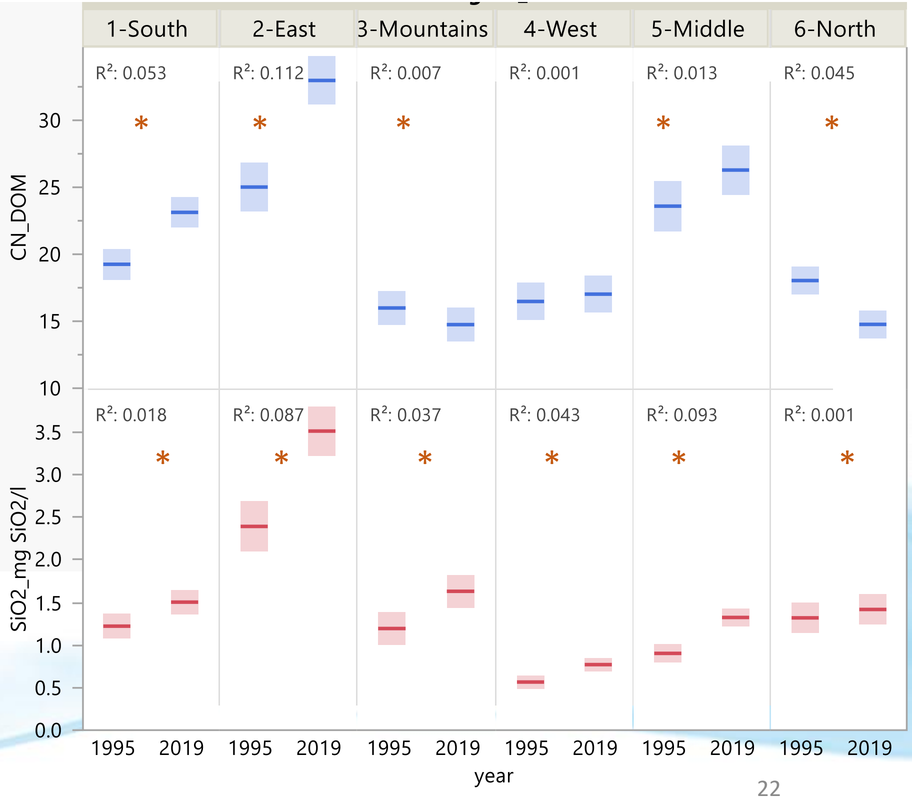
1000-lakes (post autumn-turnover samples)



J.E. Thrane&De Wit,
ICP Waters rapport in prep

Unexpected increases in SiO2 and variation in CN of DOM

- SiO_2 has increased everywhere, and appears to be tightly coupled to %forest
  - SiO_2 is biologically cycled and is also produced by mineral weathering
  - Indirect effect of climate change (CO2, hydrology?)
- CN of DOM has increased (DOM is lower in N) in areas with high forest productivity / increases in forest biomass
  - Is nitrogen being reallocated from soils to vegetation?



Conclusion

- Some expected, some unexpected changes
- Interactions between deposition and climate impacting catchment cycling appear to be very important
- Changes in CN of DOM and SiO2 could be a topic of interest for ICP IM?