Lakes Tour

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Overview

- What is the Lakes Tour?
- What do we measure?
- Have there been long term changes?
- How did the different lakes compare in 2021?



Lakes Tour

- Five yearly survey of 20 major lakes and tarns in the English Lake District
- Lakes range in area from 0.03 (Elterwater) – 8.9 km² (Ullswater)
- Lakes range in max depth from 7 (Elterwater) – 76 m (Wastwater)
- Lakes range in water residence time from 9 (Rydal Water) – 350 days (Ullswater/ Wastwater)
- Started in 1984, with consistent methods used since 1991
- Provides a 'snap shot' of the lake condition in four seasons
- Covid lockdowns imposed numerous problems with sampling, particularly in winter 2021, therefore samples were taken in winter 2022 to ensure continuity of the annual cycle



(based on Knudsen, 1954)



Field sampling

- Standardised sampling across all sites
- Water column profile of temperature and oxygen
- Secchi depth (water transparency)
- Integrated water sample of the 0 5m or 0 -7m water column
- Samples collected for analysis physico-chemical determinands, biomass and community composition of phytoplankton community, eDNA
- Vertical haul of crustacean zooplankton







Laboratory analysis

- Samples returned to UKCEH Lancaster for analysis
- Chemical analysis of:
 - Major anions and cations
 - Nutrients
 - pH
 - Chlorophyll *a* (algal biomass)
- Microscopy analysis of:
 - Phytoplankton community
 - Zooplankton community











Long term changes - phosphorous

Soluble reactive phosphorus



- Decline in TP since peak in 1995, but overall trend for whole series not significant
- Average concentration ~10 12µg/l since 2010
- Variability across sites declines, stationary or slight increases



 Most sites show convergence to low concentrations – plateau in overall average concentration since 2005 (1.3 – 1.5µg/l)





Long term changes – dissolved nitrogen

250

150

100

20

0

Ammonium-N µg/I



- Overall, significant decline in NO₃-N concentrations over time
- Lots of variability across sites
- Average concentration in 2021 314.7µg/l

- Overall, no significant change in NH₄-N concentrations
- Most sites around LoD for the method
- Some sites (Elterwater, Rydal) have ۲ had relatively high values



Long term changes – algal biomass and transparency

Secchi depth m

9

ŝ

0



- No overall change in algal biomass across lakes over the whole time series – though concentrations in 2021 (5.8µg/l) almost halved compared to 2005 (peak – 9.9µg/l)
- Declines occurred at some sites, other very little change

- No overall change in transparency
- Large variations across lakes clearest ones show large declines in transparency, but little change for more turbid sites



Long term changes – algal biomass and transparency





Long term changes – algal biomass and phosphorus



- Algal biomass and total phosphorus concentration significantly related (for a number of reasons)
- This relationship appears to be changing over time – slope of the regression <1 in 1991 and >1.1 in 2021 – more algae per unit P



Overview of the weather in 2021/22



Soluble reactive phosphorus





Dissolved inorganic nitrogen



Phytoplankton biomass



Conclusions

- Lakes Tour has been collecting data on 20 major lakes and tarns in the English Lake District for ~40 years
- Long term decline in nitrate concentrations across lakes, some indications of declines in other variables, but inter-lake and inter-year variability adds complexity
- Changes in relationship between phosphorus and algal biomass and algal biomass and transparency over time
- SRP concentrations generally low, below levels limiting algal growth, seasonal peaks could be indicative of internal/external nutrient sources
- Dissolved nitrogen concentrations vary across lakes, with seasonality in ammonium concentrations potentially related to internal nutrient supply and N drawdown, potentially resulting in co- or N limitation of algal biomass
- Phytoplankton biomass strongly seasonal peaks generally in spring and/ or summer, particularly high concentrations in Blelham Tarn, Elterwater and Esthwaite Water during 2021

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