

Cumbrian Lakes Research Forum 2026

Reconstructing 300 years of metal mining impacts on microbes in lake sediments

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Metal pollution in freshwaters

Over 1,500 km of waterways in England are affected by pollution from abandoned mines

- Water draining abandoned mines carries metals such as copper, zinc, and lead into rivers and lakes
- Metals are toxic to aquatic life and persist for centuries
- Understanding long-term impacts guides regulation and restoration



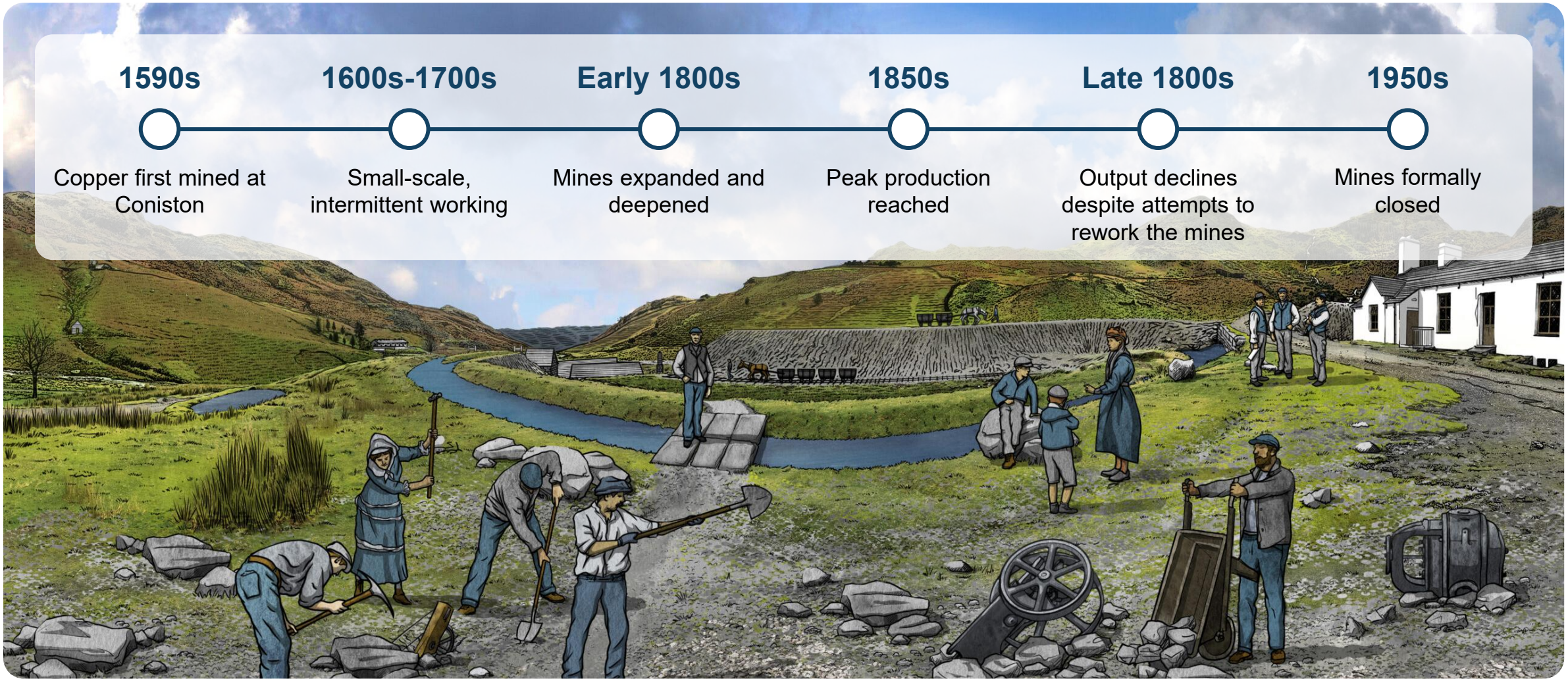




Environment Agency (2025) Abandoned metal mines in England: baseline length of rivers and estuaries polluted by harmful metals
https://www.gov.uk/government/publications/metal-mine-water-pollution-investigations-in-the-river-wear-catchment/; https://www.bgs.ac.uk/news/collaboration-progress-and-emerging-themes-in-mine-water-heating-cooling-and-storage/

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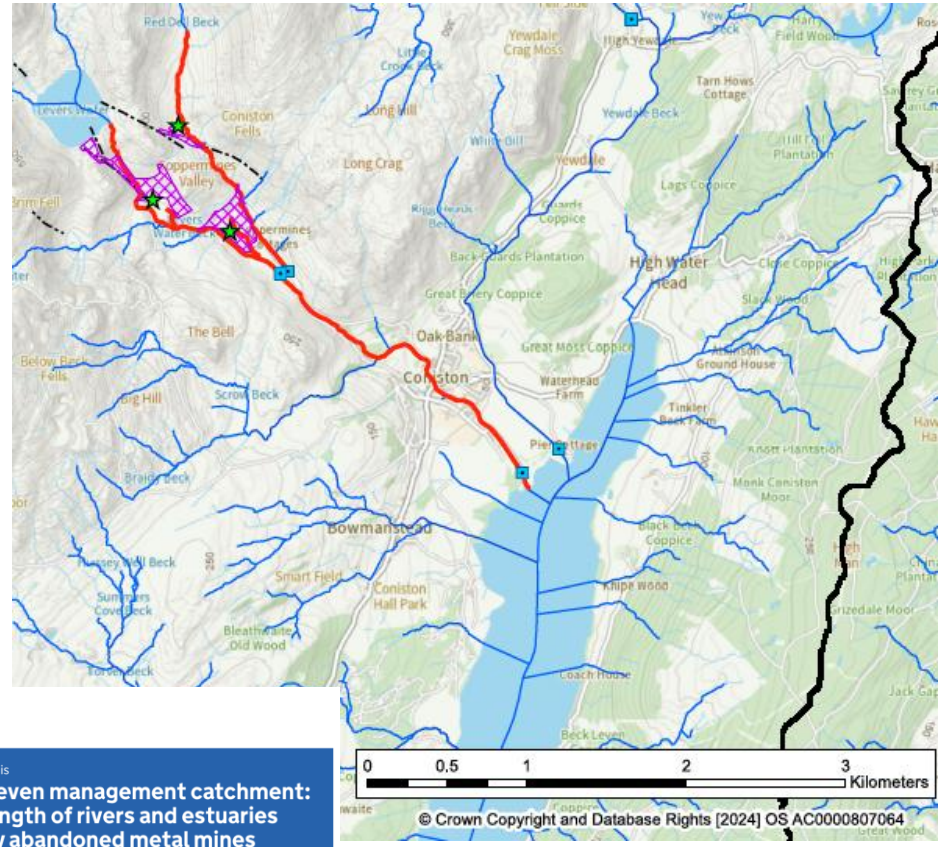
Coniston Copper Mines



Coniston Copper Project, Lake District National Park: https://lakedistrict.gov.uk/

Legacy pollution in Coniston Water

Rivers flowing into Coniston Water continue to **fail environmental quality standards** (EQS)



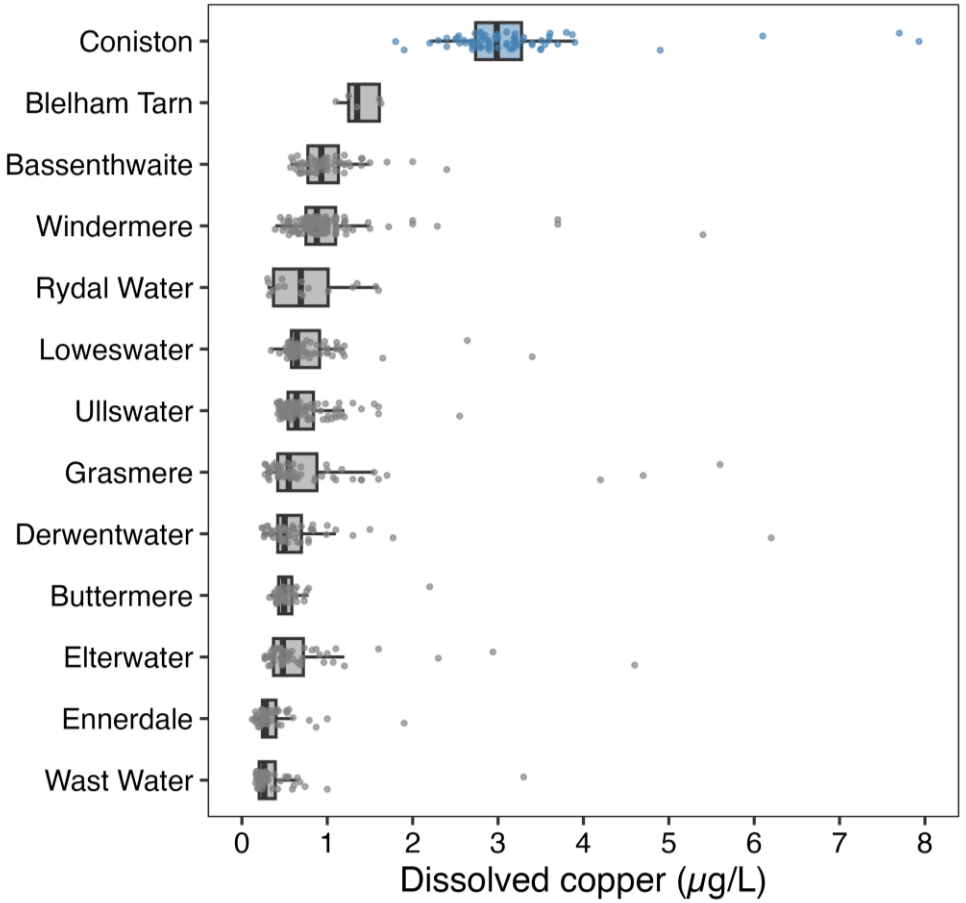
Environment Agency

Research and analysis

Kent and Leven management catchment: baseline length of rivers and estuaries polluted by abandoned metal mines

Published 12 March 2025

Copper concentrations are **3 to 6× higher** in Coniston Water than in other Cumbrian lakes

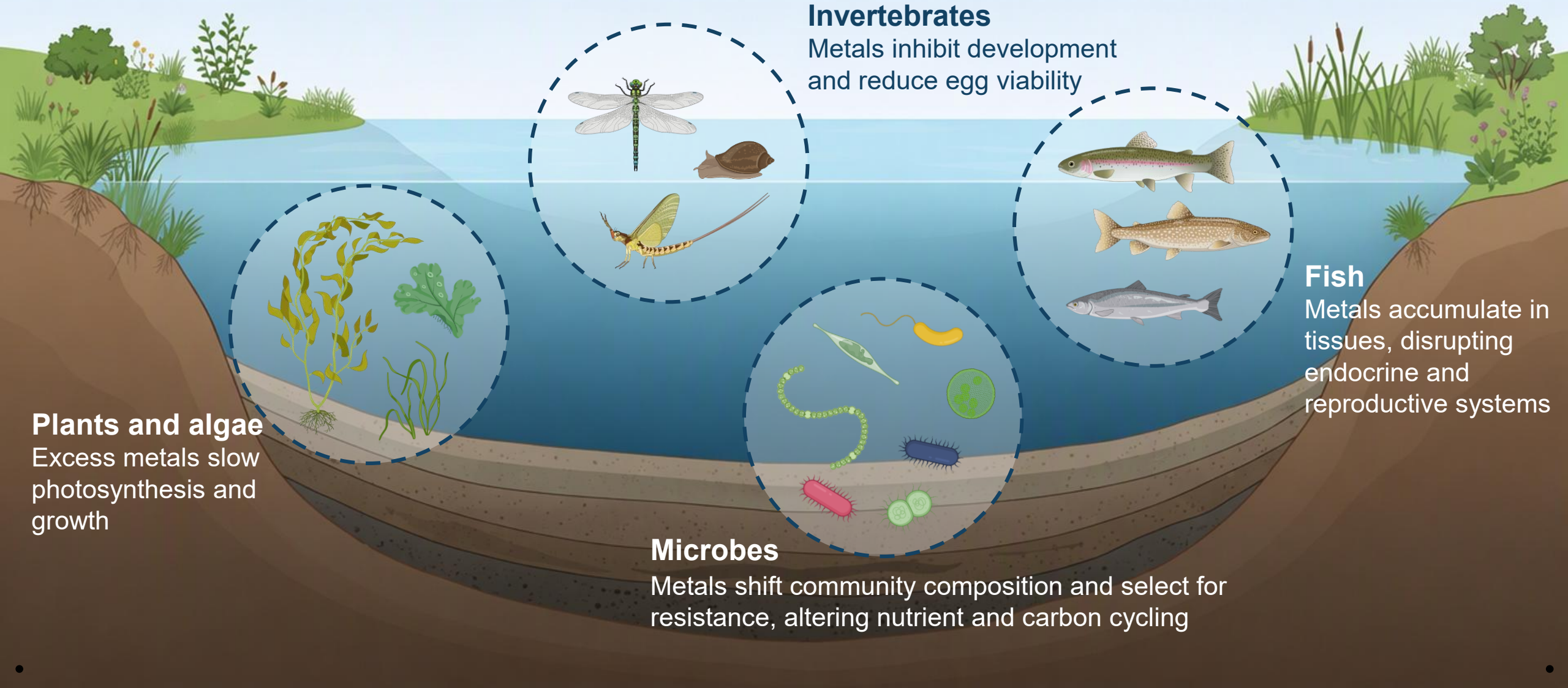


Environment Agency (2025) Kent and Leven management catchment: baseline length of rivers and estuaries polluted by abandoned metal mines

Data: UKCEH Lakes Tour & EA Water Quality Archive

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Ecological impacts of metal pollution



Invertebrates
Metals inhibit development and reduce egg viability

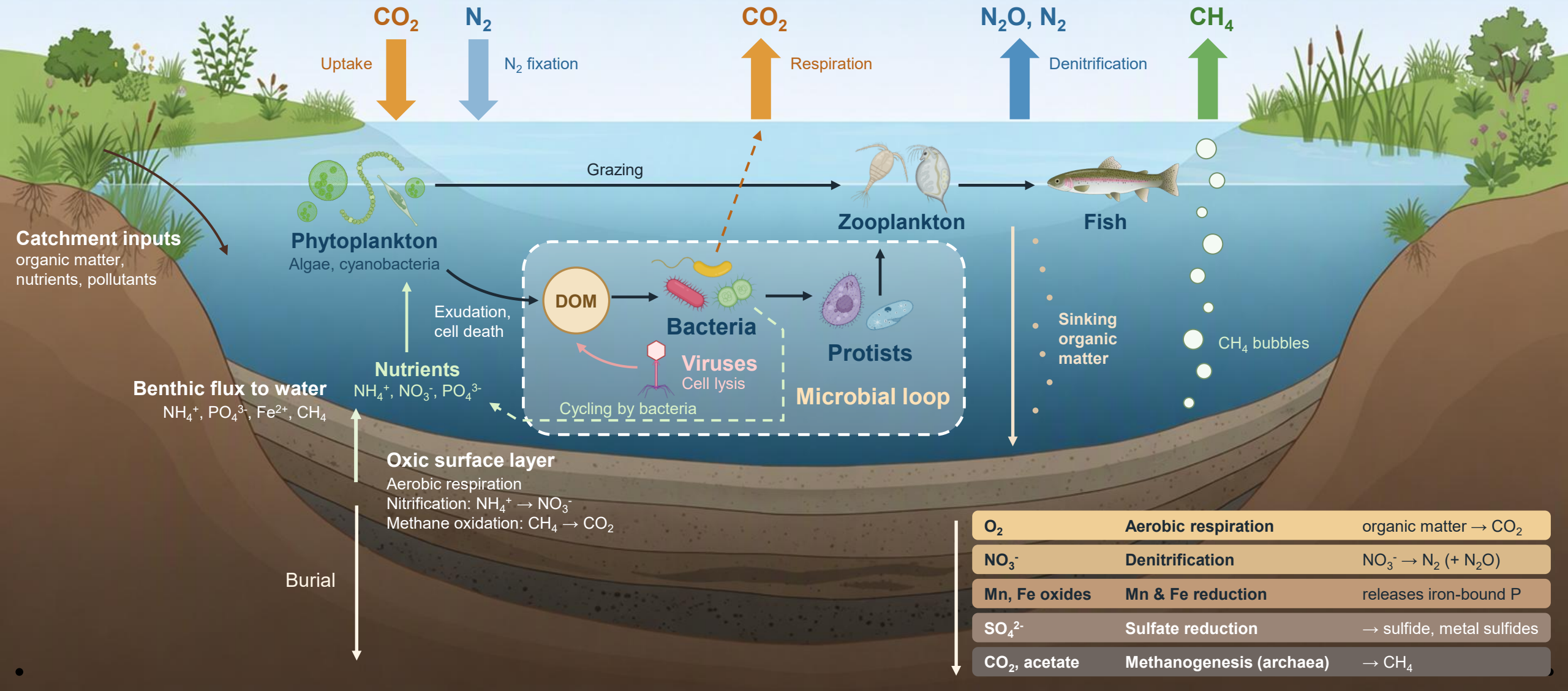
Fish
Metals accumulate in tissues, disrupting endocrine and reproductive systems

Plants and algae
Excess metals slow photosynthesis and growth

Microbes
Metals shift community composition and select for resistance, altering nutrient and carbon cycling

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Microbes drive biogeochemical cycling



O_2	**Aerobic respiration**	organic matter → CO_2
NO_3^-	**Denitrification**	$NO_3^- \rightarrow N_2$ (+ N_2O)
Mn, Fe oxides	**Mn & Fe reduction**	releases iron-bound P
SO_4^{2-}	**Sulfate reduction**	→ sulfide, metal sulfides
CO_2, acetate	**Methanogenesis (archaea)**	→ CH_4

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How has mining affected the microbes of Coniston Water?



Community

How did the taxonomic composition of the microbial community change with metal pollution?



Genes

Which genes did copper select for, such as metal resistance and stress response genes?



Nutrient cycling

Did the microbial pathways that cycle carbon and nutrients change?

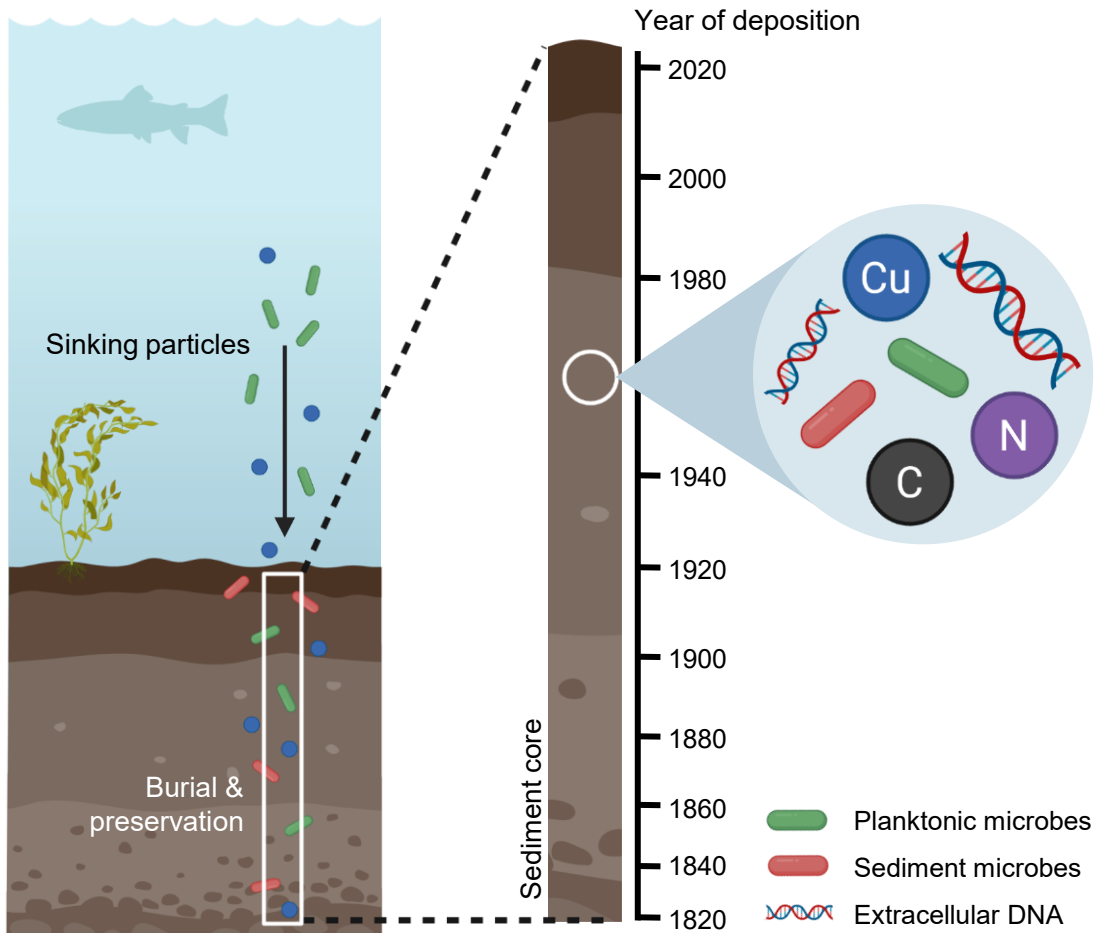


Recovery

Have the community and its functions recovered since mining ended?

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Sediments as a record of lake history



Sediment coring
- Coniston Water
- Windermere
- Loughrigg Tarn

Dating & geochemistry
- Radiometric dating
- Metal concentrations
- Organic matter, C & N content

Sedimentary DNA
- DNA extraction
- Metagenomic sequencing
- Taxonomy & functional genes

DNA from the past
Deposited from the water column, buried and preserved over time

DNA from life today
From microbes living in the sediment now

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Sedimentary copper tracks mining history



Microbial communities shift with copper



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Copper resistance genes are enriched in Coniston



Stress response peaks with copper in Coniston



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Nutrient cycling shifted during the copper peak



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Conclusions

Microbial community composition shifted with copper pollution
→ Sediments give monitoring a centuries-long baseline

Copper resistance persists while stress responses are short lived
→ Mining pollution can affect microbial communities long-term

Copper changed carbon, nutrient & metal cycling potential
→ Pollution can change how lakes function, not just who lives there

Mining has left a legacy in Coniston's microbes that lasts long after the mines closed. Sediments are important for lake monitoring, recovery, and potentially remediation.



Thank you for listening!

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