Map Impact

The Health of Windermere: A Satellite Perspective

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The Facts

It took City of Nottingham from about 1830 to recent years to grow 8 times - Windermere does this overnight in the summer!

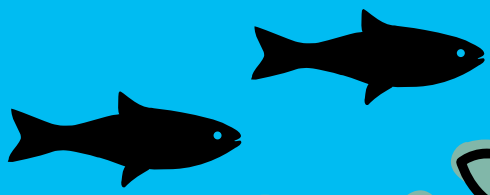
The highest ever temperature recorded in the Lake District was 32°C in 2022.

Raw sewage was dumped into Windermere for around 5,904 hours over a period of 246 days in 2022

Lake Windermere

is a glacial lake formed during the last Ice Age.

Under optimum conditions blue-green algae can achieve a growth rate in hours.



Home to many fish including the rare Arctic charr!

1,373 plant species have been recorded in the Lake District as well as 155 species of bird.

Atlantic salmon, which was also once a common Windermere species, is now on the verge of extinction.

Sources of facts: University of Kentucky, BBC Cumbria, Cumbria Wildlife Trust, The Guardian and The Global Nature Fund.

Lake Windermere is England's largest freshwater lake, with its health subject to increasing scrutiny.

Heightened local concerns have been voiced over the substantial discharge of raw sewage into the Lake's tributaries, particularly noticeable during peak tourist periods, when there is a visible increase in algal blooms, detectable in their early stages through satellite imagery.

The primary drivers of algae growth are nutrient input (mainly Phosphorus and Nitrogen), and climatic conditions. Nutrients often flow into lakes through wastewater discharge and agricultural runoff, leading to eutrophication. Increased algae is detrimental to biodiversity and human health.

To tackle the growing environmental issues at Lake Windermere, Map Impact, in collaboration with various stakeholders, have delivered a project that provides fresh perspectives and novel data sources to the study of the Lake's ecosystem.

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Rothay

Brathay

Windermere - North Basin

Trout Beck

Esthwaite Water

Cunsey Beck

Windermere - South Basin

Leven

Waste Water Treatment Works

Fed by numerous streams, the Lake supports a modest year-round residential population that dramatically swells during the tourist season.

A community engagement workshop asked:

"What are the factors that influence the Lake's Water quality?"

Stakeholder attendees pointed the project to:

01

Inadequate Infrastructure

02

Weather & Climate

03

Agriculture

Many other issues were raised in managing the catchment:

"Organisations work in silos"

"There is a selectiveness of data used for decision making"

"It's not clear who's responsible for monitoring and overall coverage"

Esthwaite Water Algal Bloom, 23 June 2022

Over 1500 Satellite images analysed

Satellite technology offers a powerful tool for monitoring algal blooms by enabling the measurement of chlorophyll concentration in water bodies from a remote perspective.

All of the results within this project have been created using remote sensing data sources, as well as some open source, publicly available data. Requests to access phosphorous (and other) data sets that would have enhanced the study were denied.

Algae alters water's colour and reflectance patterns. Satellites equipped with specialised sensors can detect these changes, allowing for the identification and monitoring of algal blooms over vast and inaccessible areas.

Windermere North Basin Algal Bloom, 12 August 2022

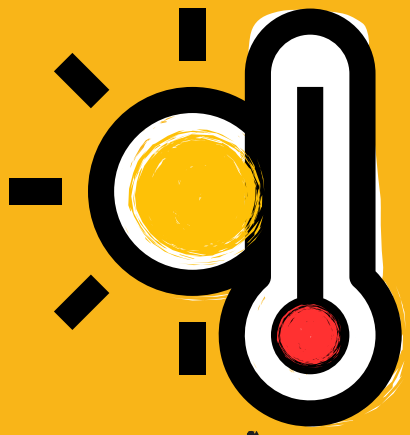
The equivalent of the population of Nottingham was present in the Windermere Catchment on specific days in 2020.

Anonymised mobile cell phone data provides a reliable source for modelling human movement and population numbers.

Human movement data highlights the vast increase in people during specific time periods within the Windermere catchment (up to 8x the population, with numbers above 320,000 on certain days, compared to the resident population of less than 40,000).

Analysis of human movement alongside other data, indicates that human waste can impact the Lake, influencing chlorophyll levels, within as little as 3 days.

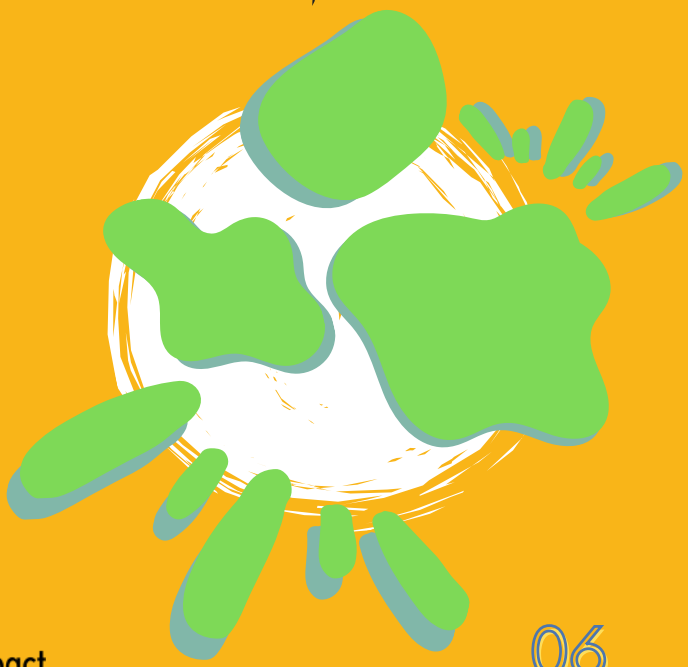
During August 2022 the Lake's mixed layer temperature exceeded 19.5°C for 7 consecutive days

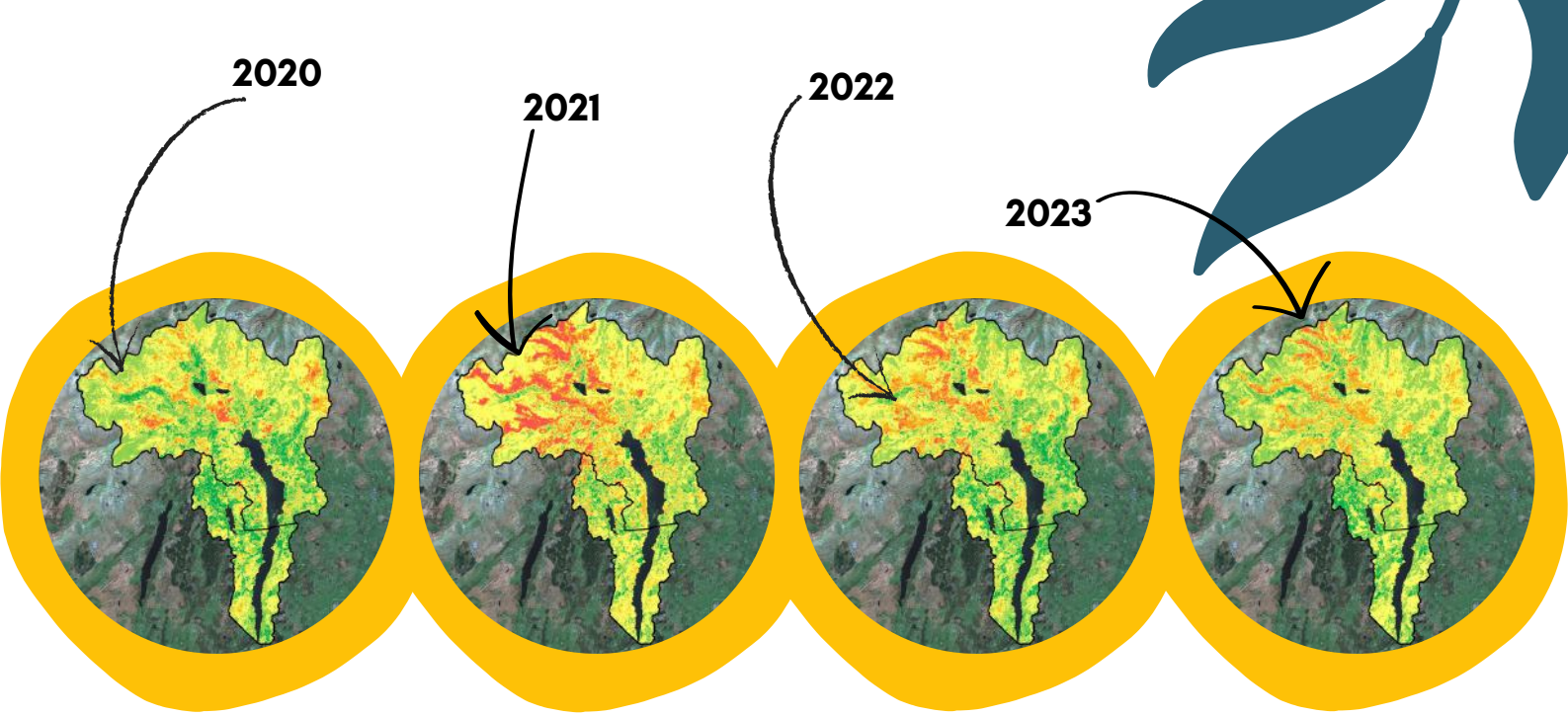


Temperature has a direct impact on algal bloom prevalence and strength – higher temperatures support algae growth – with the north and south basins of Windermere showing different behaviour, which can be ascribed to due to different water depths and other parameters.

There is a lag time between hot weather and algae which varies from 2 to 10 days.

Strong links were shown between temperature and algal blooms, with the most significant bloom in recent years occurring in August 2022. This also directly aligned with marked increases in people in the north basin – there were almost 90,000 people present on average (more than 3.5 times the usual population).





Impact from land use & agriculture is relatively stable

Nutrients from agriculture (such as fertilisers) running into water can contribute to algal blooms. Satellites allow us to monitor changes in agriculture and land use over time and understand whether patterns of land management and fertiliser use are increasing.

The areas directly surrounding Lake Windermere show stable temporal behaviour. For the period 2019 to 2023, 7% of the Windermere catchment showed changes in vegetation, which was in the non-agricultural uplands of the north basin.

There were no significant changes in the land management, dynamics of the land cover and land use, agricultural turnover, or signs of the increasing use of fertilisers, which can lead to an increases in algal bloom intensity within Lake Windermere.

Impacts don't work in isolation

This study, leveraging satellite imagery, offered a fresh lens on rising algal blooms in the catchment area, revealing consistent agricultural activity but highlighted temperature and human movement as key bloom drivers. It underscores the intricate interplay between natural and anthropogenic factors influencing lake ecology.

What makes a Toxic Lake?

Human Movement:
There is a correlation between increases in human movement in the north and south basins, and increases in chlorophyll and algae bloom incidents derived from satellites.

Weather & Climate:
Although temperature is a factor that correlates with increases in chlorophyll and algal blooms seen with satellites, there is a different "lag" time to human movement i.e. human movement can be separated as an indicator in several instances.

Land use:
Satellite analysis shows that land use / land cover has remained consistent at a catchment wide scale, and so does not correlate with increases and decreases in chlorophyll in the Lake.

Case Study:

Beyond Algae: The mystery of Cunsey Beck

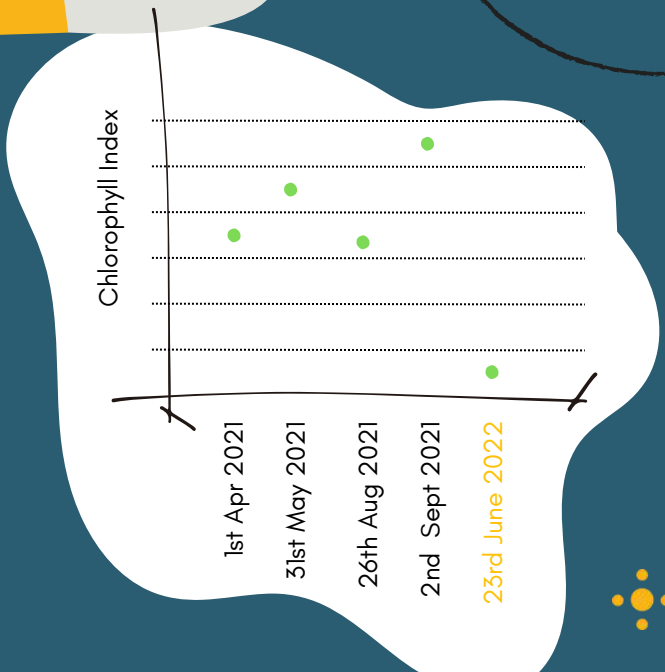
New Evidence

On the 21st of June 2022, hundreds of fish, including Atlantic salmon, were killed on the Cunsey Beck.

Detailed satellite chlorophyll analysis has shown an algae event on 23rd June.

However, this chlorophyll event was not "unusual" - several other events during 2021 and 2022 showed the same or stronger presence of Chlorophyll - without a reported fish death.

THE SUSPECTS



So whodunnit?

to be continued...

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Acknowledgements and further reading

With backing from the UK Space Agency under the Climate Services funding initiative, the project ran for six months from September 2023 to February 2024, concentrating on utilising satellite technology, human movement data, and climate data to provide fresh understanding of the state of the Windermere catchment.

This comprehensive approach has provided new evidence about the ecological challenges faced by Lake Windermere and its surrounding regions, leveraging advanced technologies and diverse data sets to gain deeper insights and develop effective solutions.

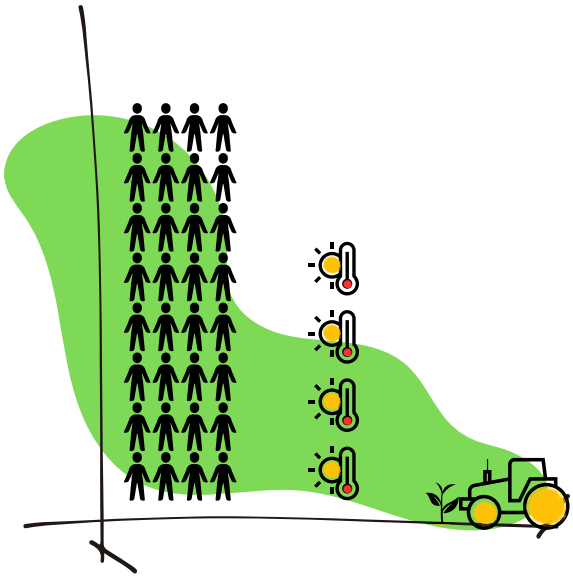
In the interests of transparency all results have been openly published and we encourage use of the data by all parts of the community to aid understanding of the environmental challenges faced and to support mitigation activities.

Cunsey Beck analysis was based on data provided by Planet Labs.

We would like to give special thanks to Matt Staniek and the Save Windermere Team, for their constant support and local knowledge in scrutinising these novel data sources.

For further information and to access the full report and results, please visit:

www.mapimpact.io/project/windermere-catchment-analysis/



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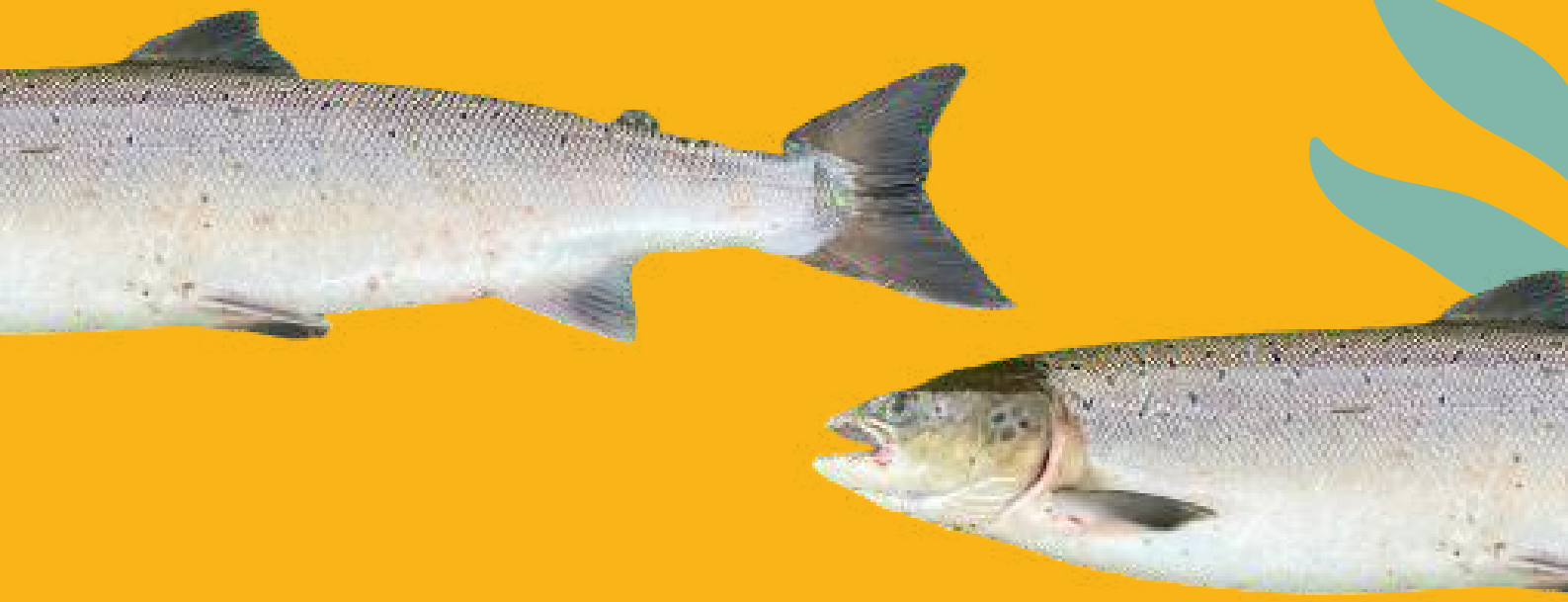

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