BIG WINDERMERE SURVEY

Summary results from April 2023 survey - full information and dataset available from www.fba.org.uk/bws-april-2023

98 sites sampled by >100 people in largest ever spatial survey of Windermere's water quality

Key findings

Bacteria

- 100% of sites met standards for **Excellent** bathing water quality, based on *E. coli* and intestinal enterococci

Phosphorus

- 100% of river sites met standards for **High** or **Good** status
- 42% of all lake sites met standards for **High** or **Good** status; 40% of Windermere shoreline sites met these same standards

Nitrogen

- Nitrate concentrations were low in all samples, not exceeding 0.76 mg N/L at any sampling site
- Total ammonia concentrations were very low with the majority of sites being below the detection limit

FRESHWATER BIOLOGICAL ASSOCIATION

Lancaster University

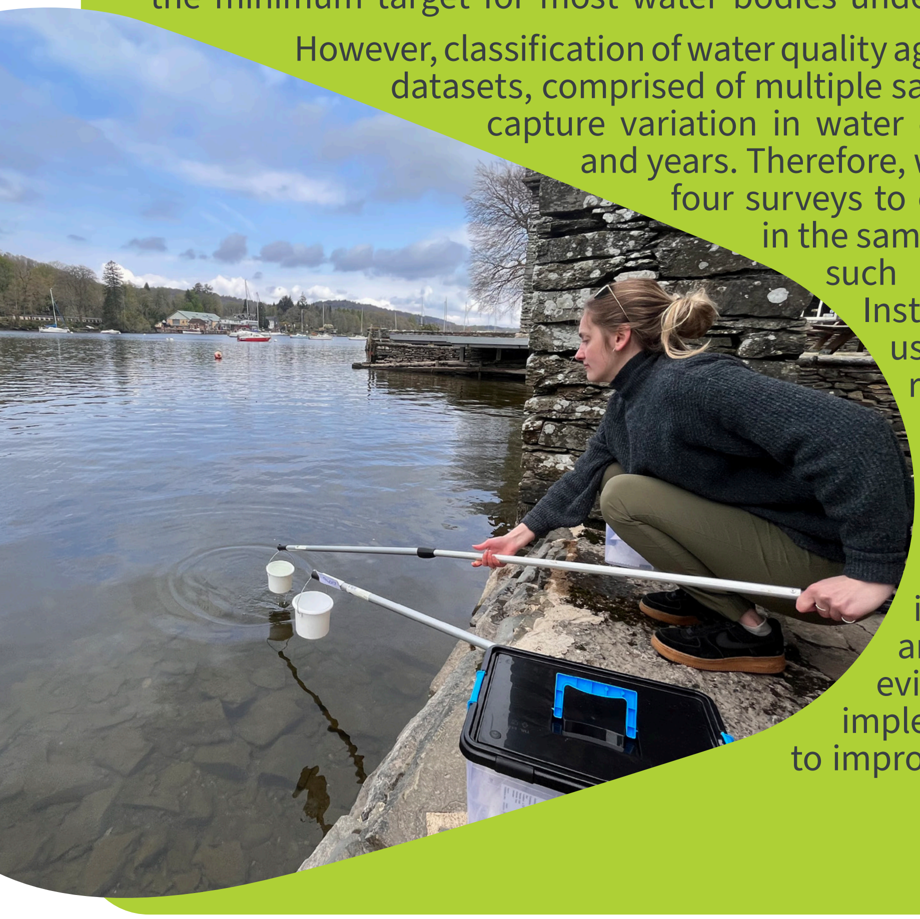
Visit the FBA website to sign up for the next survey and find out more

BACKGROUND INFORMATION

Our April 2023 survey completes one year of seasonal sampling. Look out for our first annual report on the findings from the BWS, to be released later this summer.

On Sunday 23rd April 2023, the fourth Big Windermere Survey (BWS) took place in the spring season, rounding off one full year of the BWS. Water samples were collected by volunteers from 98 sites throughout the Leven catchment, including from Grasmere, Rydal Water, Blelham Tarn, Esthwaite Water, Ghyll Head reservoir, Windermere and a number of key inflow streams for Windermere. All samples were taken between approximately 10 am and 2 pm. Local weather conditions on the day were generally dry and bright. River discharge conditions were between those seen in June (lowest) and November (highest) 2022. Samples were analysed for a range of water quality parameters within research laboratories at Lancaster University and bacterial analysis was completed at externally-accredited laboratories following standard protocols. The full data set is now available on Cartographer.

We have used national monitoring standards to provide context for some of the data. However, it should be noted that these classifications require long-term datasets which the four datapoints from the BWS in June and November 2022, and February and April 2023 don't yet provide. For bacterial levels, we have used standards from the European Union Bathing Water Directive which provides an indication of the suitability of water for human use, but does not account for any potential ecological impacts of bacteria in water. For chemical water quality parameters, such as phosphorus, we have used standards from the European Union Water Framework Directive, which focusses on the ecological health of water bodies. 'Good' status is the minimum target for most water bodies under the Water Framework Directive.



However, classification of water quality against standards requires long-term datasets, comprised of multiple samples taken from each location to capture variation in water quality, such as between seasons and years. Therefore, we cannot use data from these first four surveys to classify the status of water bodies in the same way as reported by organisations such as the Environment Agency. Instead, water quality standards are used to provide context for the results. As future surveys generate additional data, we will be able to undertake more accurate comparisons of water bodies against water quality standards. Regular sampling through the BWS is already allowing us to pinpoint areas for further investigation, using evidence to underpin the design and implementation of appropriate actions to improve water quality in the catchment.

Big Windermere Survey: April 2023 Briefing Note

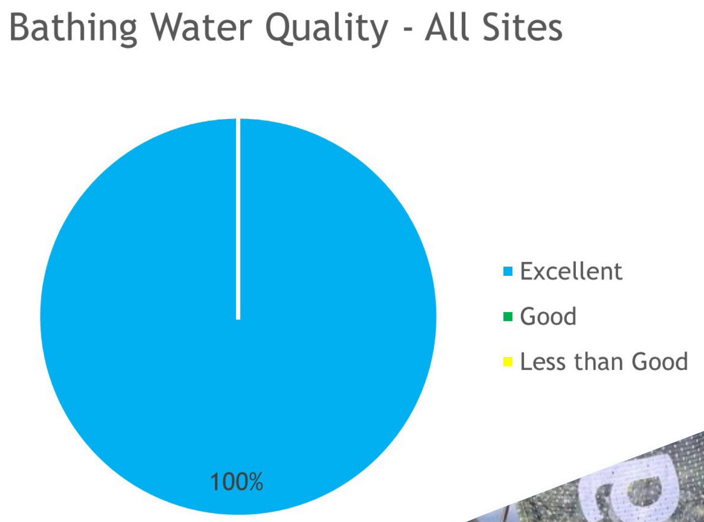
Bacteria

As with previous Big Windermere Surveys, our analyses included intestinal enterococci and *E. coli*. These bacteria live in the intestines of people and animals and their presence in a sample suggests possible contamination of water by faecal material.

We have again grouped sites into 'Excellent', 'Good' and 'Less than Good' classes for *E. coli* and intestinal enterococci, using inland bathing water standards from the European Union Bathing Water Directive.

Across all 98 sites in the survey, 100% were consistent with standards required for Excellent bathing water quality for both *E. coli* and intestinal enterococci.

If present, high levels of intestinal enterococci or *E. coli* would suggest possible contamination by faecal material



Phosphorus

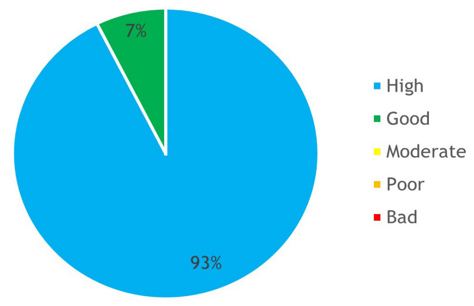
Phosphorus (P) is a key nutrient for organisms living in water, such as algae. Increases in P concentration in water bodies can trigger eutrophication and undesirable impacts such as cyanobacterial (or blue-green algal) blooms. For lakes, total P (TP) concentrations are used to determine status under the Water Framework Directive. This includes P that is dissolved in the water, as well as P in particulate material such as algal cells or attached to sediment. For rivers, a parameter termed soluble reactive P (SRP) is used to assess status. This includes only dissolved P within the sample.

Out of 27 river sites, 93% were consistent with SRP standards for High status and 7 % were consistent with standards for Good status.

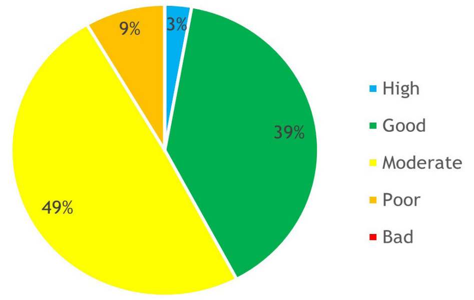
Across the 71 lake sites, 42% were consistent with TP standards for at least Good status, whilst the other 58% of sites were consistent with TP standards for Moderate or Poor status. No sites were consistent with TP standards for Bad status.

For the 63 Windermere shoreline sites, 40% were consistent with TP standards for High or Good status, with 60% being consistent with TP standards for Moderate or Poor status. No sites were consistent with TP standards for Bad status.

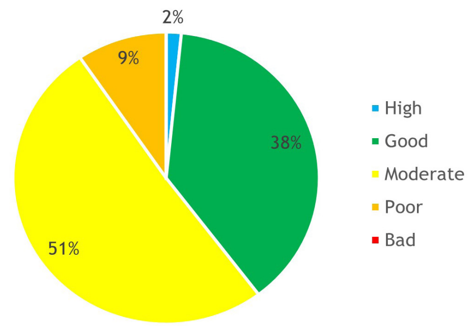
Phosphorus Standards - River Sites



Phosphorus Standards - Lake Sites



Phosphorus Standards - Windermere Sites



Nitrogen

The main parameters of interest here are nitrate, a source of nitrogen which is another key nutrient for organisms such as algae, and total ammonia which is another potential source of nitrogen but also includes forms of ammonia that are toxic to organisms such as fish.

Nitrate concentrations in April 2023 (average = 0.39 mg N/L, range = 0.18 – 0.75 mg N/L) were comparable to June 2022 (average = 0.32 mg N/L; range = 0.00 - 1.15 mg N/L) and November 2022 (average = 0.34 mg N/L; range = 0.01 - 0.74 mg N/L), and lower than February 2023 (average = 0.50 mg N/L; range = 0.26 – 0.95 mg N/L).

These slightly lower average concentrations may be due to increased biological demand for nitrogen, e.g. higher growth rates of algae and plants in spring, summer and autumn, compared to winter. They may also reflect decreased input of nitrate from surrounding land due to less rainfall and runoff compared to winter. Lower maximum concentrations in November (0.74 mg N/L), February (0.95 mg N/L) and April (0.75 mg N/L) compared to June (1.15 mg N/L) may reflect higher river discharge and greater dilution of point sources in these seasons compared to summer. In all seasons, concentrations of nitrate were significantly below the 11.3 mg N/L threshold at which additional work would be required to protect abstractions used for public water supply in the catchment.

All total ammonia concentrations were low, with the vast majority of samples being below the laboratory detection limit of 0.02 mg N/L.

Big Windermere Survey: April 2023 Briefing Note

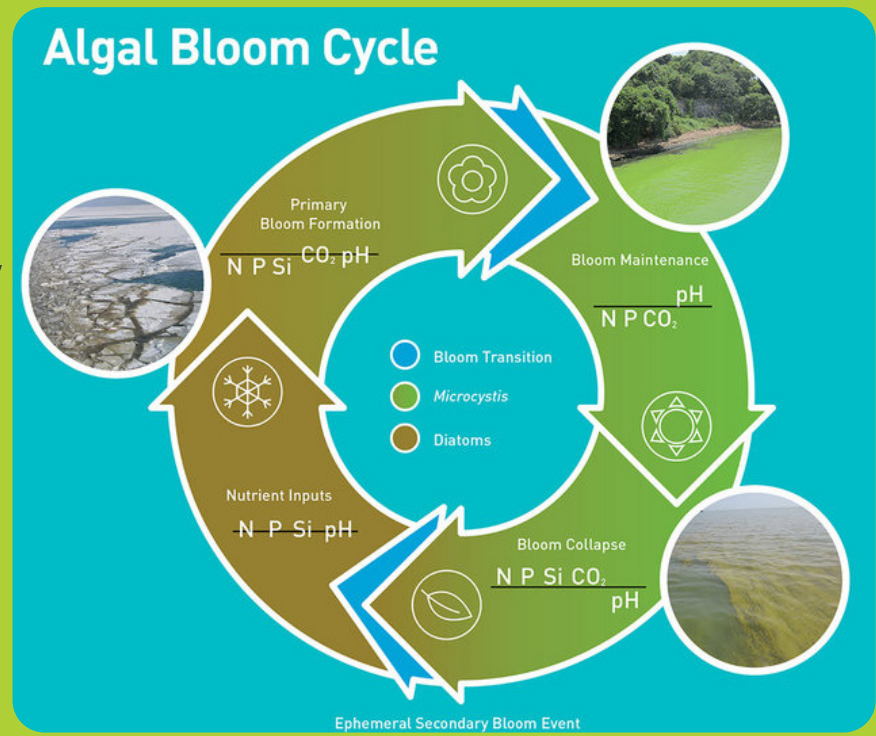
Explainer note: The seasonal cycle of algae in lakes

Algae occur naturally in aquatic systems worldwide. They are the foundation of food webs and produce the oxygen required for life to survive in water via photosynthesis.

Algae are present in Windermere throughout the year, but usually at levels that cannot be seen by the naked eye. There are typically two so-called ‘peaks’ when the concentration of algae in Windermere increases: one in spring and one in summer. Diatoms, which are one type of algae, generally dominate the spring peak, because they use silica (Si) that has accumulated in the water through autumn and winter. During the second peak in summer, Si concentrations are depleted and diatoms are replaced by other types of algae which do not need Si, such as cyanobacteria.

Many factors control the types and amount of algae growing in Windermere over the year, including nutrients, temperature and light. The figure below, reproduced from Wilhelm et al. (2020) with permission, illustrates the typical seasonal cycle of algae that occurs in lakes such as Windermere. This shows the change between diatoms (brown shading) in winter and spring, and *Microcystis* (one type of cyanobacteria, green shading) in summer and autumn. The availability of phosphorus (P), nitrogen (N), and Si, as well as dissolved carbon dioxide (CO_2) and pH conditions, are indicated by the position of letters above (i.e. high) or below (i.e. low) the black horizontal lines in this figure.

Beyond this seasonal cycle, under certain conditions algae can form dense blooms, as occurred on the date of our November 2022 survey. These blooms are often associated with cyanobacteria. Although cyanobacteria are actually many different types of bacteria, they are often collectively known as blue-green algae. Blooms of cyanobacteria can form surface ‘scums’ or ‘slicks’ on lakes such as Windermere. These blooms can also be harmful if they contain cyanobacteria that are producing toxins, or if the bloom reduces oxygen concentrations in the water to levels that threaten the survival of other plants and animals.



Cyanobacterial blooms are more common in summer, but their frequency and intensity are changing due to many factors, including nutrient availability and climate change. Warm, dry, still periods of weather allow cyanobacteria to grow rapidly. Many types of cyanobacteria are buoyant, meaning they can remain in surface water with maximum access to light and nutrients for growth. This gives them an advantage over other groups of algae that tend to sink, particularly when Windermere “stratifies” into an upper warm layer and lower cool layer in the spring and summer. Blooms can last a few days to several months depending on weather conditions (particularly rainfall and wind), and on the availability of light and nutrients, such as P and N.