Evaluation of Growth, Reproduction and **Management Techniques of *Lyngbya wollei***

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Harmful algal blooms and invasive aquatic plants are typically separate problems in aquatic management, but in this case the overlap is exemplary. *Lyngbya wollei* is a native freshwater cyanobacterium, an alga by nature, yet in some ways, more comparable to an invasive, aquatic macrophyte. Forgoing the archetypal green slime or pollen-like dust appearance that is often associated with algae, the filamentous species resembles dark, entangled hair or dense wool (Figure 1). Additionally, it produces volatile organic compounds that release a prominent malodor and alter drinking water taste. A robust sheath encompassing each filament protects the cells from predation, degradation, and penetration (Hudon 2014), making control difficult.

L. wollei forms thick mats in the benthos that rise up through the water column (Figure 2) posing the typical environmental and human safety threats as both cyanobacteria and invasive plants individually do. Similar to invasive plants such as Hydrilla, the alga readily adapts to suboptimal environments, grows at a rapid rate, shades out competitors, dominates the ecosystem, and overwinters well. *L. wollei* has even been reported to out-compete Hydrilla (Cowell and Botts 1994), and of further concern, the species is capable of producing toxins (Carmichael et al. 1997). As infestations increase across North America, additional research is needed to address knowledge gaps with *L. wollei* growth, reproduction, and management.

Figure 1. Lake Gaston Lyngbya wollei *sample providing habitat to larvae.* Photo credit: E. Vulgamore.

Control of *Lyngbya wollei*

At North Carolina State University (NCSU), the Aquatic Plant Management Program is investigating a decades-old *L. wollei* infestation on Lake Gaston. Located on the border of North Carolina

Figure 2. Lyngbya wollei *mats suspended throughout the water column of a Lake Gaston cove. The mats can entangle boat engines similar to invasive aquatic macrophytes.* Photo credit: E. Vulgamore.

and Virginia, the impounded reservoir has infestations in approximately 500 of its 20,300 acres, and this area is feared to increase over time. Given the size of the water body, the affected coves vary in their environmental parameters such as average water temperature, pH, and substrate composition. Successful control methods and species behavior has primarily been reported from northern, true lakes. In contrast, Lake Gaston is a man-made water body located in a warmer climate. In order to gain information and to improve human health and safety, recreation, lake aesthetics, aquatic biodiversity and ecological health, this research investigates the biology and ecology of *L. wollei,* and evaluates the efficacy of chemical and non-chemical control options.

We are currently evaluating herbicide efficacy in a NCSU laboratory. *L. wollei* and water samples are collected from Lake Gaston and acclimated in an incubator set to simulate temperature and light conditions of the environment (Figure 3). Treatments are based on literature reviews, previous field applications, and untested options. Due to the density of *L. wollei*, rigorous washing is needed to remove nutrients, debris, and larvae. Each sample is then weighed, suspended in Lake Gaston water, chemically treated, and incubated for ten days. At harvest, the samples are re-weighed and analyzed.

Unfortunately, visual indicators for *Lyngbya* filament death are hard to detect. To confirm, both a chlorophyll measurement and viability analysis were conducted. The samples were divided into subsamples for this purpose. A portion was ground and filtered to extract chlorophyll-*a*, a measure of photosynthetic productivity. The other portion was inoculated with the mortal stain methylene-blue, which coats only the dead cells in the blue dye. Using a microscope, each stained cell in each filament was counted to determine the sample's percent of viability. This process is time consuming due to the size and number of cells and filaments per sample (Figure 4). Both analyses, with the addition to the change in weight, were used to determine how well the chemical treatment worked.

Ecology and biology of *Lyngbya wollei*

Investigations into ecology and biology started with researching temperature, substrate composition, and water quality of samples collected. Each project aims to gain a better insight into the behaviors, changes, and limits of *L. wollei* under various conditions. Questions

Figure 3. Treatment samples acclimating in an incubator set to 25 °C with a 16-hour light, 8-hour dark photo period. Photo credit: E. Vulgamore.

that were asked include: How does the species alter its environment? What are the growth patterns? What makes the current, infested coves suitable environments compared to unaffected coves? Are there ecological indicators that can be used to predict potential areas of concern?

This ecological research involves both Lake Gaston and general parameters. For example, single strands of benthic and surface mats were suspended in deionized water, free of any nutrients, and placed across a gradient table. Weights, viability, and qualitative observations were noted over the course of ten days. The results suggest that temperature is a factor to continue investigating. The next phase of trials will include additional temperatures variables, Lake Gaston water compared to deionized water, and varying *L. wollei* biomasses; observing single strands, benthic and surface mats, and intact mat dynamics.

Additional topics of toxicity and strain differentiation were also of question. Understanding the molecular science behind Lake Gaston's *L. wollei*, compared to other populations across North Carolina and elsewhere, and gaining insight into toxin production will further address uncertainties. Thus far, North Carolina has yet to report a toxic bloom of *L. wollei*; though studies have been limited. There is additional concern that different strains of the species are present in Lake Gaston, which would create an entirely new factor to consider in research and management approaches.

The future

Overall, findings will be used to modify algaecide programs to improve results. Understanding herbicide efficacy and behavior of *L. wollei* allows for improved field applications and management directions. For Lake Gaston, the goal is to find a solution that controls the noxious cyanobacterium, which likely relies on understanding how the species function in their environment. Though the lake serves as a research site, the results will be applicable to populations in other locations, and will serve to expand future investigations.

L. wollei is an under-studied species considering the potential human health and environmental safety risks posed by the toxins it produces. As populations and sites continue to proliferate across the United States, the need for comprehensive biological research and development of additional management options is imperative for water bodies and their many uses. Both harmful algal blooms and invasive aquatic plants are of continual concern for the future, and *L. wollei* is unique in that it factors into both sectors of management.

Applying cultural eutrophication models that indicate increased nutrient pollution loads and climate change models that predict variable environmental changes suggest that *L. wollei* has the potential to cause the same problems in other water bodies as those observed in Lake Gaston. It is imperative to fill in the gaps of knowledge and find viable methods that protect susceptible water resources.

References

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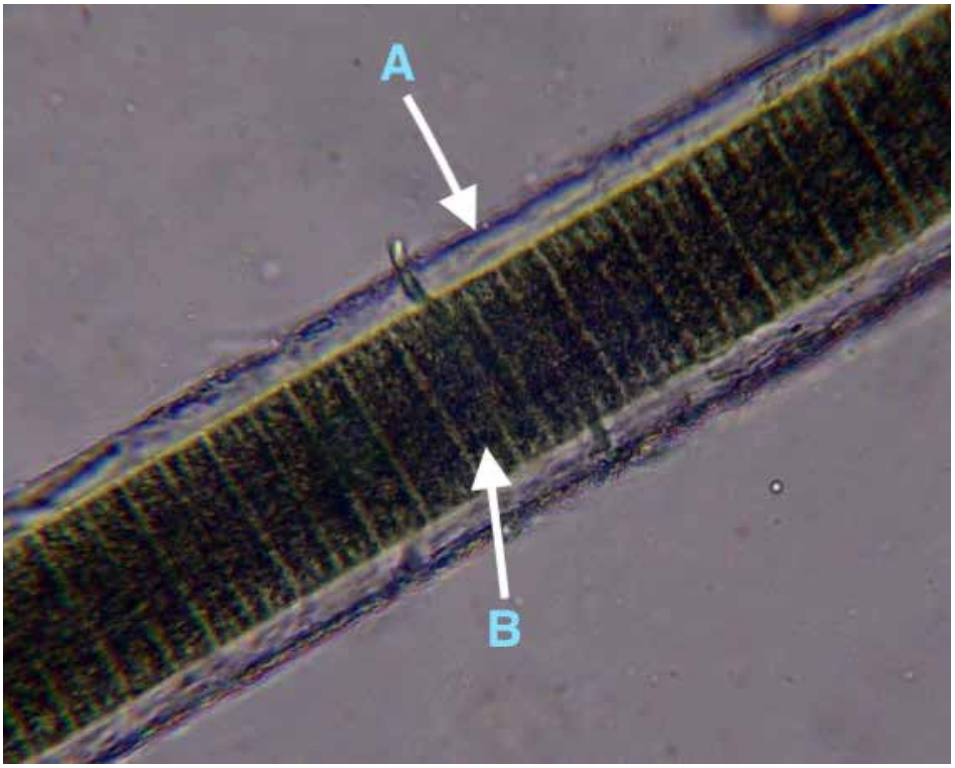

Figure 4. A single Lyngbya wollei *filament noting (A) the robust sheath and (B) individual cells appearing as the bands.* Photo courtesy of West Bishop.

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