Proposal Application Form
2022–2023 TWRI Graduate Student Research Programs

Basic Information

1. **Title:** Shallow stream cyanotoxin loading into Texas lakes and reservoirs
2. **Student Name and Information:** Crista Kieley, ckieley@tamu.edu, (216) 280-1351. Texas A&M University at Galveston, Marine Biology Department, pursuing PhD in Marine Biology (Start Year: 2021, Expected End Year: 2026).
3. **Committee Chair and Contact Information**: Dr. Daniel Roelke, droelke@tamug.edu, (409) 740-4750. Professor and Department Head in Marine Biology Department at Texas A&M University at Galveston.
4. **Which program(s) are you applying for?** Mills Scholarship Program
5. **Have you received either the Mills Scholarship or USGS Research Program funds before?** No.
6. **Would these funds be initiating new research or supporting ongoing research?** These funds would be supporting ongoing research. We are preparing to begin the second field year of a three year project, which has an overarching goal of understanding drivers of harmful algal blooms, anoxia events, and microbial functioning in warm, eutrophic, monomictic lakes across the state of Texas. This is accomplished by sampling twenty Texas lakes and their tributaries in the spring and summer of each field year. Samples for chlorophyll-*a*, microcystins, nutrients, metagenomics, transcriptomics, and several water quality parameters are taken biannually. Our research is funded by a federal grant, with a budget of $1,433,459. An additional departmental mini-grant of $465.12 has allowed us to expand cyanotoxin testing to the tributaries for our upcoming April sampling trip.
7. **Focus Categories:** WQL, TS
8. **Research Category:** Water Quality
9. **Keywords:** Cyanotoxin loading, downstream effects, land use, water quality, microcystin
10. **Congressional District:** TX-14
11. **Abstract:**

Cyanobacteria bloom in many areas around the globe. These potentially toxic blooms have demonstrated increasing frequency and magnitude, with climate change and anthropogenic activity likely to further intensify such blooms. Texas waters are not

immune, with several lakes across the state suffering from cyanobacterial dominance. A potentially overlooked perpetuator of harmful algal blooms in lakes and reservoirs is shallow stream loading of cyanobacteria and their toxins. Other regions of the country have reported widespread occurrences of cyanotoxins in shallow streams, and the stability of some cyanotoxins makes downstream effects likely. To determine whether microcystin (a potent hepatotoxin produced by cyanobacteria) is widespread in Texas streams and reservoirs, and whether downstream effects may be occurring, twenty Texas lakes/reservoirs and their tributaries will be sampled and the total microcystin concentration determined. These results will be compared with upstream land-use data using HAWQS, a web-based water quality model. Regression analysis and general linear models will be employed to explore cyanotoxin loading and other factors related to in-lake cyanotoxins.

Description of Proposed Research:

a. **Statement of critical regional or state water problem**

Cyanobacteria can endure a wide range of environmental conditions, and have formed blooms in many areas around the globe (Zurawell et al. 2005). Repercussions of algal blooms are far-reaching, and may include consequences such as hypoxia events, fish kills, unsafe drinking water, declining property value, the loss of commercially valuable species, and recreation losses (Wurtsbaugh et al. 2019). When these blooms are formed by cyanobacteria, an additional point of concern is the production of toxins; cyanobacteria can produce a suite of cyanotoxins, capable of causing liver and neurological disease in both animals and humans (Huisman et al. 2018). Microcystin is a particularly potent hepatotoxin (Zurawell et al. 2005), and a relatively common cyanotoxin.

Climate change and anthropogenic impacts are likely to further exacerbate cyanobacterial dominance in freshwater systems (Paerl and Huisman 2009). Cyanobacterial blooms have already proven to be increasing in frequency and magnitude across the globe (Huisman et al. 2018), posing an increasingly serious threat to water quality. Texas waters are susceptible to such blooms; high abundances of cyanobacteria have already been documented in some Texas lakes (Roelke et al. 2004, Gámez et al. 2019). Furthermore, many lakes and reservoirs throughout the state have been classified as hypereutrophic (according to TCEQ's Trophic Classification of

Texas Reservoirs in 2010), indicating their potential to support potentially toxic blooms. Our unpublished data from the spring of 2021 detected microcystins in many lakes across the state.

While there are many drivers of harmful algal blooms, shallow stream loading of cyanobacteria and their toxins to receiving water bodies may be an overlooked perpetuator of harmful algal bloom events in lakes. Large-scale surveys of streams have revealed widespread cyanotoxins, both in the Piedmont region (Loftin et al. 2016) and in California (Fetscher et al. 2015). Additionally, rivers are suspected sources of seed colonies of cyanobacteria, and suspected to perpetuate later lake blooms, as observed in the Maumee River that feeds into Lake Erie (Bridgeman et al. 2012). Microcystins are highly stable compounds, capable of persisting for weeks in the aquatic environment (Plaas and Paerl 2021), indicating that downstream effects are possible. Downstream effects have already been observed along the freshwater-marine continuum, where sea otter fatalities were linked to freshwater lake and tributary microcystins via the consumption of contaminated shellfish in the Monterey Bay National Marine Sanctuary (Miller et al. 2010). It is plausible that cyanotoxins produced in the shallow streams and tributaries of Texas lakes and reservoirs are carried downstream, proliferating toxicity in receiving waters.

b. **Statement of expected results or benefits**

A more comprehensive understanding of harmful algal blooms, their drivers, and mechanisms that perpetuate toxicity are vital pieces of information for water resource managers. Given global trends, as discussed above, cyanobacterial blooms are a growing threat to water quality. This research will offer a broader understanding about cyanotoxins and their sources in Texas. If streams or a particular land-use practice are significantly contributing to the total microcystins, these results may offer insight into future management and mitigation strategies.

c. **Nature, scope and objectives of the research, including a timeline of activities**

To explore the critical water problem detailed above, I will (1) determine whether microcystins are widespread in Texas streams, as they are in other regions of the country, (2) compare tributary microcystins to in-lake microcystins to assess the scale of cyanotoxin loading, and (3) search for relationships between land-use practices in tributary watersheds and stream cyanotoxins. Whole-water samples will be collected from twenty Texas lakes/reservoirs and their tributaries from April 1, 2022 to April 20, 2022. Upon return, samples will be processed for microcystin concentration. Over the subsequent months, I will analyze my data, compare my results with surrounding land-use practices, and present or publish my results.

d. **Methods, procedures and facilities**

This April, we will sample Lake Somerville, Lake o the Pines, Lake Tawakoni, Lake Ray Hubbard, Bardwell Lake, Benbrook Lake, Eagle Mountain Lake, Lake Worth, Lake Whitney, Lake Waco, Lake Proctor, Lake Brownwood, E.V. Spence Reservoir, Twin Buttes Reservoir, O.C. Fisher Reservoir, Lake Colorado City, Lake Alan Henry, Buffalo Springs Lake, Hubbard Creek Reservoir, Possum Kingdom Lake, and each of their tributaries. Whole-water samples will be taken from the lakes and tributaries to determine the total microcystin content (free and cell-bound). Microcystins will be freed from the cells by conducting five freeze-thaw cycles prior to analysis. Following the instructions included in the enzyme-linked immunosorbent assay (ELISA) kit, we will analyze a series of standards of known microcystin concentration to establish a calibration curve, then test our samples in duplicate on a Hach DR6000 laboratory spectrophotometer. Concentrations in our samples will be determined according to the calibration curve and by averaging the replicates. The tributary cyanotoxin concentrations will reveal whether Texas streams support widespread microcystins. Comparisons of stream cyanotoxins to in-lake shallow station cyanotoxins (all of which have a depth of 6 meters and are over the drowned river channel) will offer insight into potential cyanotoxin loading to downstream water bodies. Finally, to examine land-use practices of regions draining into our streams, we will employ HAWQS, a web-based modeling system built on the Soil and Water Assessment Tool (SWAT). HAWQS allows for simple watershed delineation at the user's desired catchment resolution, allowing for straightforward explorations of land-use data upstream of a chosen point. As a starting point in my statistical analysis, I will employ regression analysis and general linear models to provide insights on the role of cyanotoxin loading relative to other factors on in-lake cyanotoxin concentrations.

12. **Related Research:**

The proposed research is similar to other works in that it surveys streams for cyanotoxins, as in Fetsher et al. 2015 and Loftin et al. 2016. However, unlike these studies, we will be able to simultaneously observe downstream effects as we take our lake samples. Fetsher et al. 2015 also examined land use near sampling sites; however, their technique was to look at land within a given radius around the sampling site. By using HAWQS, we can instead examine subbasins that drain into our sampling sites; the program will automatically provide land use within the selected area.

13. **Training Potential:**

Four graduate students (including myself) and one undergraduate student will participate in field work and sample collection in April 2022, as supported by the larger project.

14. **Intended Career Path:** After completing graduate school, I hope to work for a state or federal agency on water quality and harmful algal bloom related research.