EutroPHIX™

Mitigation of Harmful Cyanobacteria in Utah Lake Marinas

Progress Report January 2022

Prepared for:
Utah DNR, Division of Forestry, Fire, & State Lands
Utah DEQ, Division of Water Quality

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Executive Summary

Utah Lake has experienced increased occurrences of blooms of toxic cyanobacteria (HABs) during the past several years. On Utah Lake, HAB related warnings and closures have caused a significant decrease of recreation on the lake and the use of private and public marinas. Addressing the problem of HABs and the underlying source of nutrient pollution is going to take a large multi-faceted approach. In the long-term, Utah Division of Water Quality is developing site-specific nutrient criteria intended to reduce nutrient loading into the lake and therefore minimize the occurrence of blooms and improve lake ecology. Complementary to those important, longer-term initiatives, short-term solutions to mitigate the impacts of HAB's are critical to preserve the multi-dimensional immediate uses of the system (e.g., recreation, wildlife habitat, property values, safety).

EutroPHIX performed work on Utah Lake marinas in 2020 and 2021 to help demonstrate and implement short-term solutions to the problems facing Utah Lake. This summer treatments took place on all public Utah Lake marinas utilizing two algaecides. Lake conditions in 2021 were conducive to HAB growth to high abundances, likely positively influenced by low water levels. The marina treatment program started in August when cyanobacteria was already in high abundance lake wide. Treatments substantially reduced cyanobacteria abundance, but with longevity of a few days, requiring weekly applications through September. The project period this year had more wind events, lower water levels, and higher cyanobacteria abundances than treatments performed in 2020. A bubble curtain was installed in Utah Lake State Park to reduce water exchange in the marina and a treatment performed to help evaluate this technology for further use on Utah Lake. Initial results indicate bubble curtains are helping improve treatment longevity.

Treatment of blooms with algaecides is a proven tool on Utah Lake that can be used in the short-term. A treatment program designed to start earlier in the cyanobacteria season, or more aggressive in initial applications to reduce cyanobacteria below 100,000 cells/mL should be effective. Funding and administration processes need to allow for HAB mitigation from May-October for the best outcomes. Marinas also need modification to prevent rapid water exchange with the main lake as that can greatly reduce longevity of treatments in marinas. From the experience and understanding of Utah Lake environmental conditions, we present the following recommendations for short-term solutions:

1. A lake-scale cyanobacteria mitigation program utilizing algaecide treatments will be effective in controlling and substantially reducing cyanobacteria.

2. Marina Modifications to reduce water exchange from the outside lake including newly constructed marina entrances and bubble curtains. Aeration systems inside the marina would also improve water quality

3. Frequent treatment and monitoring of marinas to mitigate HABs. Automated treatment systems within the marina may be installed to suit this need. Phosphorus mitigation would reduce phosphorus availability in marinas.

HAB mitigation benefits Utah Lake and the surrounding community by reducing risks of public health issues associated with HABs and their toxins and potentially limiting the number and duration of water use warnings that reduce lake use with various economic impacts. It is prudent to invest in short-term solutions while long-term solutions are developed and implemented. As EutroPHIX continues this project in 2022, we will continue to assess and prescribe ways to manage HABs on Utah Lake. A detailed project report will be developed at the conclusion of the project period to further guide this process.

2021 Lake Conditions

Utah Lake experienced low water levels in 2021 compared to the historical average. Water levels were -2.1 ft in April then decreased to -5.2 feet in October of 2021 (Figure 1). A reduction in lake level results in a significant reduction in lake volume. From June to October, Utah Lake was about 1.75 ft below historical mean level which results in ~144,000 acre-ft less water volume (26% lower lake volume) than normal. Lower water levels and volume allow for concentration of solutes, and stronger interactions with lake sediments which may increase nutrient availability and turbidity.

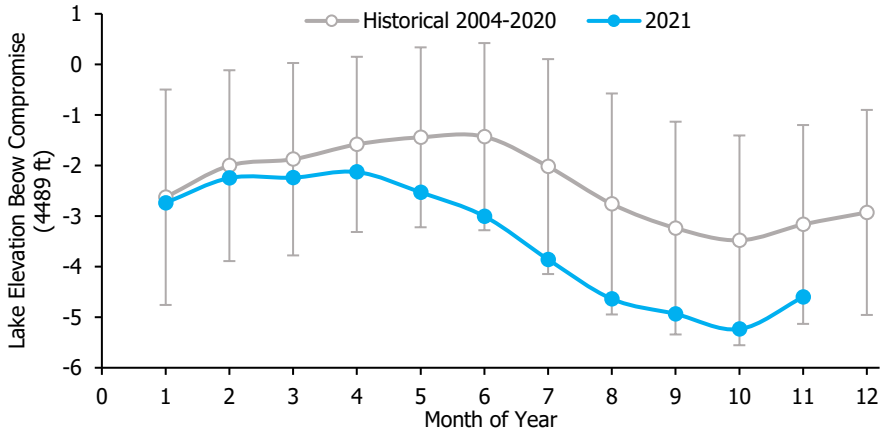


Figure 1: Historical water level reported as monthly mean ± 1SD for years 2004-2020 and as monthly means for 2021. (Utah Division of Water Rights, 2021)

Utah Lake was under a lake-wide Warning Advisory (>100,000 cells/mL of toxigenic cyanobacteria) for HABs from July through September. Provo Bay was under a warning advisory from the beginning of June. Exceptionally high levels of Planktothrix were found at Lindon Marina at the end of July triggering a Danger Advisory (>10,000,000 cells/mL of toxigenic cyanobacteria). Taxonomy data collected by DWQ HAB monitoring team found that in June most samples were dominated by *Dolichospermum* but going into July rapidly shifted to a majority composition of *Planktothrix* (Figure 2). Both genera of cyanobacteria are of concern due to their ability to produce various liver and nerve toxins.

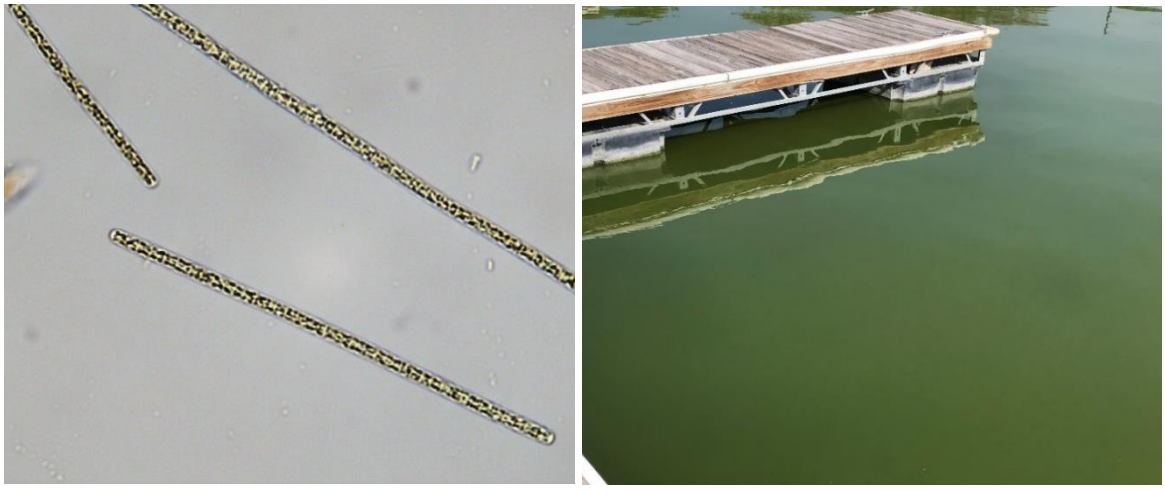


Figure 2: *Planktothrix* is a filamentous cyanobacteria that produces toxins and can migrate up and down the water column to optimize use of nutrients and light (left). Planktothrix blooms will change water color to green and usually do not form scums at the surface (right).

Treatments

Phycomycin® SCP Algaecide and Oxidizer (USEPA registration number 8959-60) and SeClear Algaecide and Water Quality Enhancer® (USEPA registration number 67690-55) were used to control cyanobacteria in Utah Lake Marinas. Phycomycin is an effective peroxide-based algaecide that can be used to selectively control cyanobacteria. SeClear is a copper-based algaecide that provides control for a broad-range of algae species while reducing in-water phosphorus levels with each application. Both treatment products are NSF/ANSI certified for use in drinking water, have been used extensively to control cyanobacteria in the United States, and have a negligible impact to wildlife and the environment when used according to the product label by trained professionals.

Multiple treatments were applied at the public marinas on Utah Lake starting in August 2021, taking place every 1-2 weeks (Appendix A). Due to timing of funding for this project, treatments started later than optimal timing (June). Due to the high abundances of cyanobacteria in August, treatment rates of 40-100% of the product label were used to achieve control. One treatment occurred in October to demonstrate effectiveness of bubble curtains in reducing water exchange for marinas. For all treatments, algaecides were applied by boat across the water surface by licensed applicators adhering to guidelines of Utah's General Pesticide Permit (Figure 3).

Figure 3: Application of Phycomycin SCP to Utah Lake State Park Marina. The application boat maneuvers around docks to evenly disperse the treatment product in the marina.

To adaptively manage HABs in the marinas, monitoring was performed before and around 1 day after most applications. A grab sample for algae taxonomy, dissolved oxygen and temperature profile (YSI 556 MPS), water clarity (secchi disk), color (EyeonWater App, https://www.eyeonwater.org/), and in-situ algae fluorescence (CyanoHAB fluorometer, Turner Designs) was collected and recorded for inside and outside each marina (treatment vs control). Three AlgaeTrackers® (AquaRealTime) were deployed to help monitor water and algae conditions continuously in between treatments. Dissolved copper samples were collected after treatments of SeClear.

Project Results

Cyanobacteria Abundance

Samples collected for algae taxonomy from outside the marinas (un-impacted by treatment) show that cyanobacteria were abundant through out the project period in concentrations above 100,000 cell/mL (Advisory Warning level by Utah DWQ due to potential risk of toxin exposure). *Planktothrix* was the dominant genera of cyanobacteria during the 2021 project period, usually composing >90% of the sample compositions. Cell abundances were ~1.5x higher in August and September compared to late October and November (Figure 4). Cyanobacteria were also in similar abundance outside of all the public marinas which suggests that HAB impacts were evenly distributed around the lake shoreline over the summer and that short-term weather patterns likely drive day to day variance in cyanobacteria abundances at marinas.

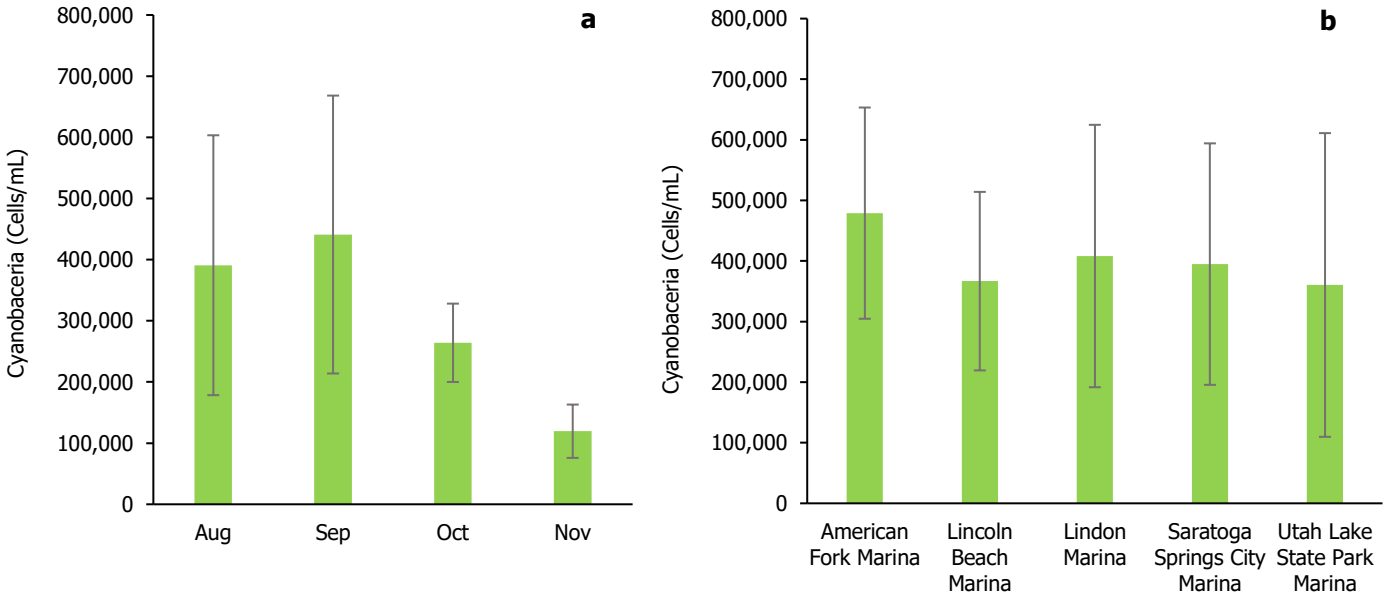


Figure 4: Abundance of cyanobacteria measured outside marinas (control sites) in 2021 by month (panel a) and by marina (panel b) reported as mean ± 1SD.

Treatment Impact

Treatments started the second week in August during the peak of the summer when cyanobacteria were in high abundances. High abundances of cyanobacteria can create challenges to achieving contact and exposure times required for complete control. Due to the high biomasses present, treatment rates were increased, and adequate coverage achieved during treatment application. Despite high abundances, large reductions in cyanobacteria were made during treatments, even at American Fork Marina which had the highest cyanobacteria abundances pre-treatment (Figure 5 & 6).

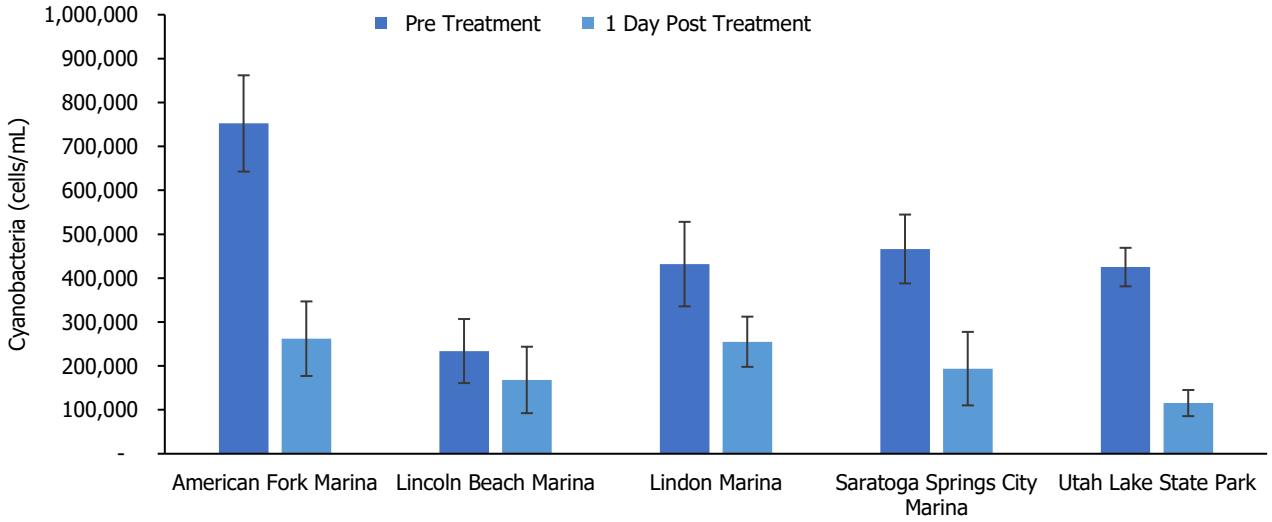


Figure 5: Reductions in cyanobacteria from monitored treatments at each marina reported as mean ± SE. The treatment program substantially reduced cyanobacteria at American Fork Marina, Lindon Marina, Saratoga Springs City Marina, and Utah Lake State Park.

Figure 6: Treatment at American Fork Marina reduced cyanobacteria 70% from 770,000 cells/mL 9/22/2021 before treatment (left) to 220,000 cells/mL by 8 hours after treatment (right). Water clarity increased from 6-inch to 12-inch secchi disk measurement and water color changed from bright green to blue.

Longevity of treatment impact was often short lived as cyanobacteria reestablished within the week. Reintroduction of cyanobacteria outside the treatment zones may have had an impact on samples taken post treatment. Water exchange in/out of treatment areas can replenish cyanobacteria populations on the order of hours to days, depending on the wind and weather. Due to the conditions present, treatments often did not reduce cyanobacteria below 100,000 cells/mL (Advisory Warning Level) measured by 1 day post samples (Table 1). In comparison, treatments made in Utah Lake State Park and Lincoln Beach in 2020 achieved treatment longevity of 1-3 weeks and often reduced cyanobacteria below 20,000 cells/mL (SePRO, 2020). The previous project in 2020 had lower abundance of cyanobacteria, higher water levels, and relatively calm treatment periods.

Table 1: Effectiveness of Monitored Treatments to Reduce Cyanobacteria below Utah's Warning Advisory Guidelines

Marina	Percent Control (mean ± 1SD)	Number of treatments that achieve metric 1 day post treatment	
		Control of Cyanobacteria > 0%	Cyanobacteria under 100,000 cells/mL
American Fork Marina	63% ± 33%	5/6	1/6
Lincoln Beach Marina	43% ± 39%	5/6	3/6
Lindon Marina	39% ± 31%	5/6	1/6
Saratoga Springs City Marina	54% ± 39%	4/5	2/5
Utah Lake State Park	70% ± 21%	6/6	3/6

AlgaeTrackers were deployed inside Lindon Marina and Utah Lake State Park to continuously monitor water conditions and algae community. These devices monitor air & water temperature, solar radiation, turbidity, phycocyanin (pigment specific to cyanobacteria) and chlorophyll (algae + cyanobacteria) multiple times an hour and send data to an online dashboard for real time monitoring. AlgaeTrackers provided useful information on how cyanobacteria rebounded from treatment, and when turbidity increased indicating wind and wave activity. For example, SeClear was applied in the morning of 8/24 at Lindon Marina, on the AlgaeTracker dashboard we were able to detect a ~75% drop in chlorophyll and phycocyanin followed by a steady recovery over 4 days (Figure 7).

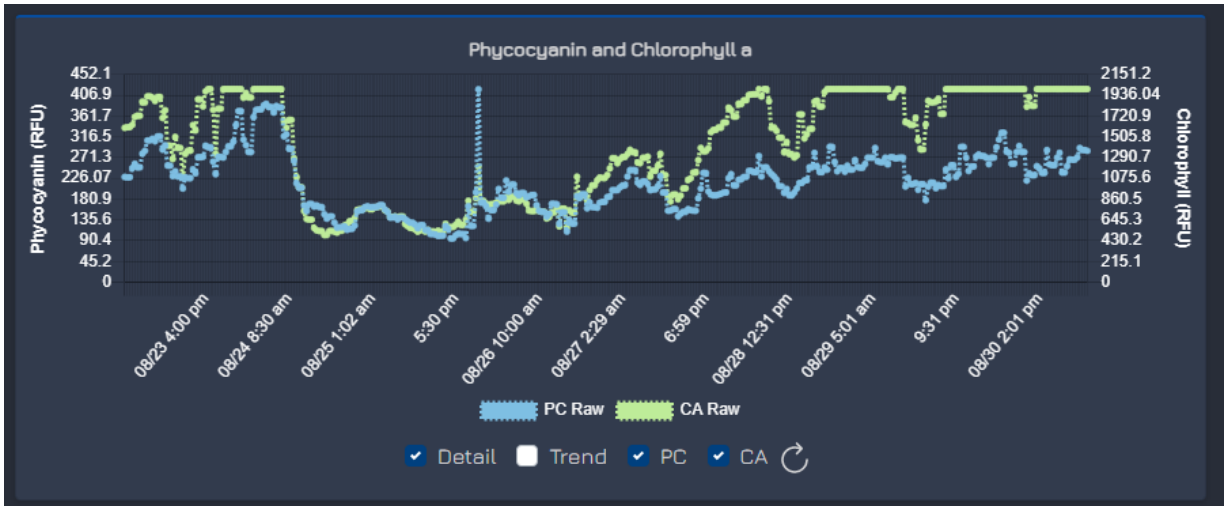


Figure 7: Dashboard of an AlgaeTracker at Lindon Marina during time frame of 8/23/21 – 8/30/21. Treatment of SeClear occurred after 8:00am on 8/24 coinciding with a rapid decrease in chlorophyll and phycocyanin RFU.

Bubble Curtain Implementation

Bubble curtains have been a proven tool in marine and freshwaters to divert/contain floating debris and reduce/contain turbidity. A unique benefit of this barrier technology is allowing the free passage of boats as there are no obstructions at the water's surface, and only an air diffuser resting on the lake bottom. Bubble curtains are relatively easy to install but require access to electrical utilities to operate. To further develop this technology for use on Utah Lake we installed a bubble curtain system across the middle jetty of Utah Lake State Park Marina to reduce water movement and divert surface scums of cyanobacteria from the inner marina area (Figure 8).

Figure 8: Installation and operational photos of bubble curtain at Utah Lake State Park preventing a surge of cyanobacteria from entering the inner marina area from the outer marina.

After the bubble curtain was installed, a treatment was applied to the inner marina of the state park to collect data demonstrating its effectiveness for increasing longevity of treatment. After this treatment cell abundances decreased up to 88% by 4 days after treatment to under 50,000 cells/mL of cyanobacteria and maintained control beyond 6 days after application (Figure 9). This initial treatment will be replicated further in 2022 to continue the assessment of bubble curtains.

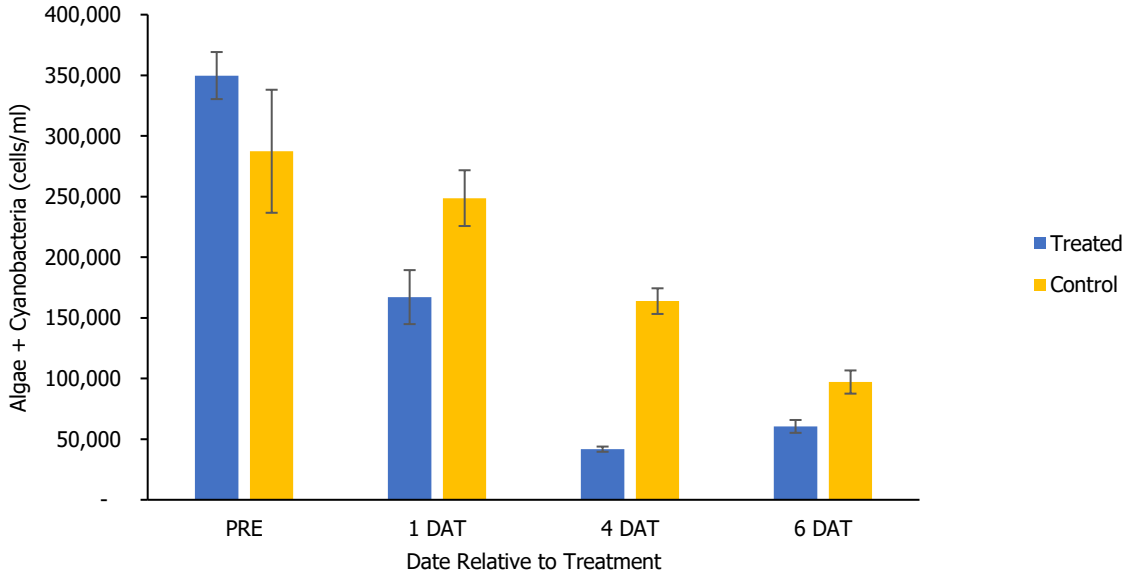
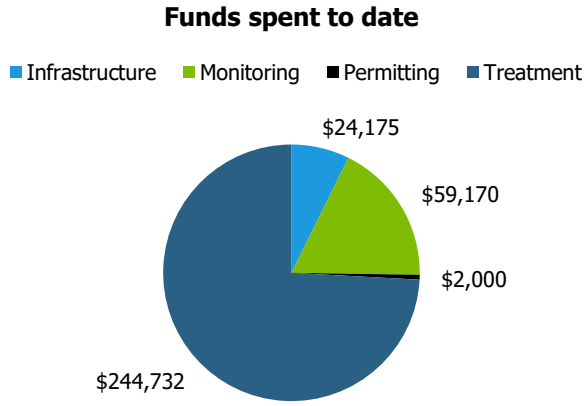


Figure 9: Abundance of cyanobacteria at Utah Lake State Park after treatment with bubble curtain in operation. PRE = Pre-treatment, DAT=day after treatment.

Project Funds

This project has utilized most of its available funding for the contract period extending to June 30th, 2022. A total of $330,077 (~76%) has been spent of the $436,021 available for use. Of those spent dollars, 74% went towards treatment, 18% went to treatment monitoring, 7% went to installing bubble curtain and associated infrastructure, and 1% to permitting. With funds still available for use in 2022, additional treatments are planned for the beginning of summer on all marinas and further assessment of bubble curtains.



Conclusions & Recommendations

Utah Lake is a dynamic and shallow lake that sustains high abundances of toxic cyanobacteria. While efforts are underway to find long-term solutions to restoring the lake, short-term solutions need to be implemented to alleviate the impairment to humans and wildlife from HABs. HAB mitigation benefits Utah Lake and the surrounding community by reducing risks of public health issues associated with HABs and their toxins and potentially limiting the number and duration of water use warnings that reduce lake use with various economic impacts. Based on treatments done in 2020 and 2021, treating with algaecides when cyanobacteria are around 50,000-100,000 cells/mL is more effective than starting treatment >500,000 cells/mL. A treatment program designed to start earlier in the cyanobacteria season, or more aggressive in initial applications to reduce cyanobacteria below 100,000 cells/mL should be most effective. Funding and project administration processes for HAB mitigation activities needs to operate so that mitigation work on Utah Lake can occur during May-October, so that management has the best opportunities for success. Marinas also need modification to prevent rapid water exchange with the main lake as that can greatly reduce longevity of treatments in marinas. From the knowledge gained on Utah Lake's specific conditions and experience in HAB management we have the following recommendations for short-term mitigation solutions:

Whole Lake Treatment Program

A lake-scale cyanobacteria mitigation program utilizing algaecide treatments will be effective in substantially reducing cyanobacteria. A mitigation program would need to treat large areas of the lake (up to 50%) and utilize monitoring to determine treatment triggers for applications across the season. Reducing cyanobacteria early in the summer gives space for beneficial green algae to compete and may further increase longevity of treatments. When substantial reductions of cyanobacteria occur across the lake, shoreline accumulations and impacts of HABs to swim beaches and marinas will be reduced. Costs to manage HABs at marinas would also be reduced with this program. This is the most impactful and cost-efficient short-term mitigation option for HABs seasonally on Utah Lake.

Marina Modifications

Water exchange from the main body of Utah lake can rapidly bring in cyanobacteria back into marinas, especially with a wind direction facing the mouths of the marinas. To reduce water exchange, seawalls or jetties that blocks waves from the marina entrance can be constructed. It would be beneficial to dredge the marinas to help construct these seawalls to improve marina functionality. Bubble curtains are an aeration technology that also help reduce water exchange at marina entrances without impeding boat traffic. Installing diffused aeration across the marina would also generally improve water quality and improve dissolved oxygen levels during periods of high biological oxygen demand.

Marina Treatments

Marinas are one of the places on the lake with the most points of contact with the public and should be kept clear of HABs. To do this, frequent treatment and monitoring of marinas are needed. Treatment intervals of 2 days – 2 weeks are likely needed in marinas depending on intensity and reestablishment rates of cyanobacteria. Realtime monitoring tools such as AlgaeTrackers® can be paired with rapid treatment mobilization to achieve this. One way to rapidly implement treatments is to setup automated treatment systems within marinas. This would allow for rapid deployments of cyanobacteria treatments as they develop and keep marinas open for recreational uses. Phosphorus mitigation would also be beneficial to water quality, reducing the availability of phosphorus in the water column and sediment in marinas. Phosphorus is a key nutrient for algae and cyanobacteria growth.

As EutroPHIX continues this project into 2022, we will continue to assess and prescribe ways to manage HABs on Utah Lake. A detailed project report including all data generated will be developed at the conclusion of the project period to further guide this process.

Citations

SePRO Corporation (2020). Mitigation of Harmful Cyanobacteria on Utah Lake. *Utah Lake Commission*. Available at: https://utahlake.org/reports-from-2020-algae-treatments-at-utah-lake/

Utah Division of Water Quality (DWQ). (2021). Utah Lake Recreational Monitoring 2021. *State of Utah Department of Environmental Quality*. Available at: https://deq.utah.gov/health-advisory-panel/utah-lake-recreational-monitoring-2021

Utah Division of Water Rights (DWR). (2021). DVRTVIEW River Commissioner Records Viewer. State of Utah Department of Natural Resources. Available at: https://waterrights.utah.gov/cgi-bin/dvrtview.exe

Appendix A – Treatments to Marinas

Marina	Date	Product	Application Rate	Amount Used
American Fork Marina	8/11/2021	SeClear	2.58 gallons/acre-ft	110 gallons
American Fork Marina	8/17/2021	Phycomycin SCP	78 lbs./acre-ft	2,000 lbs.
American Fork Marina	8/25/2021	SeClear	4.32 gallons/acre-ft	110 gallons
American Fork Marina	9/1/2021	Phycomycin SCP	78 lbs./acre-ft	2,000 lbs.
American Fork Marina	9/8/2021	SeClear	4.51 gallons/acre-ft	115 gallons
American Fork Marina	9/22/2021	SeClear	5.49 gallons/acre-ft	140 gallons
American Fork Marina	9/29/2021	Phycomycin SCP	85.55 lbs./acre-ft	2,000 lbs.
Lincoln Beach Marina	8/11/2021	SeClear	3.15 gallons/acre-ft	55 gallons
Lincoln Beach Marina	8/17/2021	Phycomycin SCP	47.58 lbs./acre-ft	500 lbs.
Lincoln Beach Marina	8/25/2021	SeClear	3.81 gallons/acre-ft	40 gallons
Lincoln Beach Marina	8/31/2021	Phycomycin SCP	47.58 lbs./acre-ft	500 lbs.
Lincoln Beach Marina	9/8/2021	SeClear	4.28 gallons/acre-ft	45 gallons
Lincoln Beach Marina	9/22/2021	SeClear	4.68 gallons/acre-ft	45 gallons
Lincoln Beach Marina	9/29/2021	Phycomycin SCP	63.5 lbs./acre-ft	500 lbs.
Lindon Marina	8/10/2021	SeClear	2.6 gallons/acre-ft	130 gallons
Lindon Marina	8/18/2021	Phycomycin SCP	85.7 lbs./acre-ft	3,000 lbs.
Lindon Marina	8/24/2021	SeClear	4.57 gallons/acre-ft	160 gallons
Lindon Marina	8/31/2021	Phycomycin SCP	85.7 lbs./acre-ft	3,000 lbs.
Lindon Marina	9/9/2021	SeClear + Phycomycin SCP	4.29 gallons/acre-ft 42.85 lbs./acre-ft	150 gallons 1,500 lbs.
Lindon Marina	9/21/2021	Phycomycin SCP	90.9 lbs./acre-ft	2,500 lbs.
Lindon Marina	9/28/2021	Phycomycin SCP	88.9 lbs./acre-ft	2,000 lbs.
Lindon Marina	10/28/2021	Phycomycin SCP	100 lbs./acre-ft	2,000 lbs.
Saratoga Springs City Marina	8/11/2021	SeClear	3.33 gallons/acre-ft	50 gallons
Saratoga Springs City Marina	8/25/2021	SeClear	3.89 gallons/acre-ft	35 gallons
Saratoga Springs City Marina	9/1/2021	Phycomycin SCP	55.56 lbs./acre-ft	500 lbs.
Saratoga Springs City Marina	9/8/2021	SeClear	3.89 gallons/acre-ft	35 gallons
Saratoga Springs City Marina	9/22/2021	SeClear	4.25 gallons/acre-ft	35 gallons
Saratoga Springs City Marina	9/29/2021	Phycomycin SCP	66.70 lbs./acre-ft	500 lbs.
Utah Lake State Park Marina	8/10/2021	Phycomycin SCP	60 lbs./acre-ft	15,000 lbs.
Utah Lake State Park Marina	8/17/2021	Phycomycin SCP	60 lbs./acre-ft	12,000 lbs.
Utah Lake State Park Marina	8/24/2021	Phycomycin SCP	40 lbs./acre-ft	8,000 lbs.
Utah Lake State Park Marina	8/31/2021	Phycomycin SCP	60 lbs./acre-ft	10,000 lbs.
Utah Lake State Park Marina	9/9/2021	Phycomycin SCP	80 lbs./acre-ft	6,000 lbs.
Utah Lake State Park Marina	9/21/2021	Phycomycin SCP	40 lbs./acre-ft	7,500 lbs.
Utah Lake State Park Marina	9/28/2021	Phycomycin SCP	82.22 lbs./acre-ft	7,000 lbs.
Utah Lake State Park Marina	10/28/2021	Phycomycin SCP	95.65 lbs./acre-ft	5,500 lbs.