FINAL REPORT:
ON THE OWASCO LAKE HAB INHIBITING TECHNOLOGIES ASSESSMENT.
Final Version

SUBMITTED TO

DANA HALL, PROJECT MANAGER

THE OWASCO WATERSHED LAKE ASSOCIATION

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INTRODUCTION

The frequency and intensity of cyanobacteria (blue-green algae, BGA) blooms have increased markedly in recent decades (Downing et al. 2001, Heisler et al. 2008, O'Neil et al. 2012, Paerl and Paul 2012, Paerl and Otten 2013). BGA are not new to the planet as BGA have existed for over 3.5 billion years and been detected in the Finger Lakes over the past century but their recent increase is a concern. BGA can form unsightly, surface water, green slimes, typically concentrated along the shoreline degrading water quality and recreational use. BGA can also produce a variety of toxins, and different toxins are harmful to the skin, liver, and nervous system of humans and other mammals (O'Neil et al. 2012). Thus, the recent increase in BGA abundance has impacted use of our vital freshwater resources, endangered public health through threatened municipal water supplies and accumulation of shoreline blooms, and caused economic losses.

BGA blooms have historically impacted eutrophic lakes, lakes with high algal concentrations due to high nutrient concentrations. For example, total phosphorus concentrations in eutrophic lakes are greater than 20 μg/L. Nutrient reductions, typically reducing the limiting nutrient phosphorus, have been successful at decreasing these algal blooms (e.g., Edmonson 1970, Schindler 1974, Matthews et al. 2015). However, BGA blooms and blooms with high toxins have been reported in many oligotrophic lakes in New York over the past few years, lakes with low to moderate productivity with an associated low to moderate phosphorus concentrations. Owasco Lake, for example, has recently experienced numerous BGA blooms with high toxins, despite modest total phosphorus levels of 10-15 μg/L.

Blue-green algal blooms were detected in all of the Finger Lakes in 2017, and many of these blooms contained harmful concentrations of toxins. The majority and largest blooms were typically located along the shoreline. They accumulated in green slimes covering the surface of the water column, impacting the recreational, aesthetic, and economic qualities of these lakes. BGA toxins have also been detected in municipal drinking water supplies. For example, the toxins were detected in the Auburn and Owasco municipal drinking water supplies that draw water from Owasco Lake in 2016, in the City of Syracuse's municipal water intake that draw water from Skaneateles Lake in 2017, and in Rushville's municipal drinking water that draws water from Canandaigua Lake in 2018.

From 2014 through 2017, BGA blooms in Owasco Lake were detected primarily along the northeastern corner of the lake (Fig. 1, Halfman et al. 2017a). Measured BGA pigment concentrations ranged from 2 to over 10,000 μg/L with toxin concentrations from below detection to over 2,000 μg/L. Most of the blooms were concentrated along a shoreline. A few BGA events, however extended across the open lake. Many of the open lake accumulations of BGA were typically at concentrations below 25 μg/L so technically not a bloom. For reference, the NYSDEC defines a BGA bloom when the blue-green phycocyanin (chlorophyll unique to BGA) concentration exceeds 25 μg/L. A BGA bloom is reclassified as a bloom with high toxins when microcystin concentrations exceed 20 μg/L in nearshore areas and 10 μg/L in offshore areas. The EPA's drinking water guideline for microcystin is 0.3 μg/L for infants and 1.6 μg/L for school-age children and adults; and their recreational contact limit is 4 μg/L.

Water column mixing is believed to inhibit BGA accumulations at the surface. Thus, manipulation of the physical structure of a lake by artificial mixing, e.g., aerators (and natural mechanisms like wind-driven waves) should reduce BGA accumulations (Visser et al. 2016). Artificial circulation by aerators is a popular mitigation technique since it is best used alone and it is believed to have minimal impact on other aquatic organisms. Many of the benefits in algal control such as light limitation and lower pH are not easily achieved by other restoration techniques (Kishbaugh et al. 2009).

Similarly, mitigation of BGA blooms may be achieved using ultrasonic sound. Laboratory tests by Alpha Environmental, the manufacturer of the Quattro-DB Ultrasonic System, indicate that the gas vacuoles in BGA tissues are susceptible to and collapse in response to ultrasonic stress particularly at 1.7 MHz. BGA regulate their buoyancy by increasing (to rise) or decreasing (to sink) the volume of gas in these vacuoles. Thus, the ultrasonic devices may be effective at preventing the formation of surface-water BGA blooms (Tang et al. 2004). Alpha Environmental also claims that this device does not harm other planktonic organisms, rooted plants and higher organisms such as fish. We are not aware of any published assessments in the scientific literature.

This HABs inhibiting technology assessment was designed to scientifically assess the effectiveness of three different BGA inhibiting technologies, two sizes of aeration bubbler systems, SW20 and PS20, manufactured by Airmax, and a Quattro-BP Ultrasonic System, manufactured by Alpha Environmental. These technologies were installed primarily along the northeast shoreline of Owasco Lake where the duration and concentrations of past blooms were most intense. The project was designed to determine if the frequency and/or concentration of BGA blooms and their associated toxins were reduced at any of the eight mitigation sites compared to three "control" sites, i.e., neighboring sites without mitigation measures.

The project design was simple. If BGA do not bloom at sites with mitigation technologies during the August - September field season but bloom at the experimental "control" sites as in the past, it then suggests that the technologies played a role at reducing the BGA blooms at the mitigation sites.

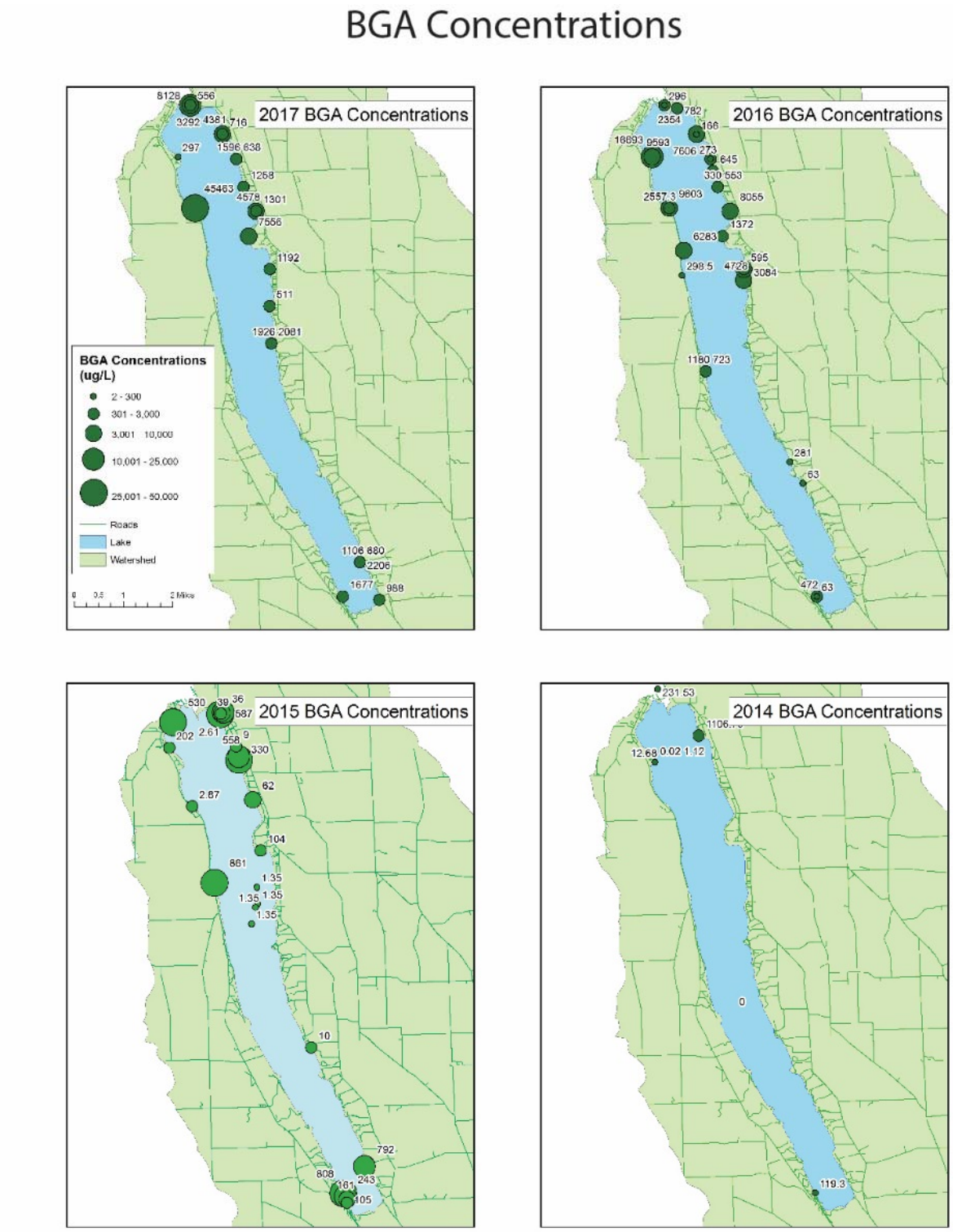

Fig. 1. Maps of the 2014 – 2017 shoreline BGA bloom dates, concentrations and microcystin and anatoxin (2017 only) toxin concentrations (Halfman et al, 2017a). Data by permission from the Owasco Lake Watershed Inspector & DEC.

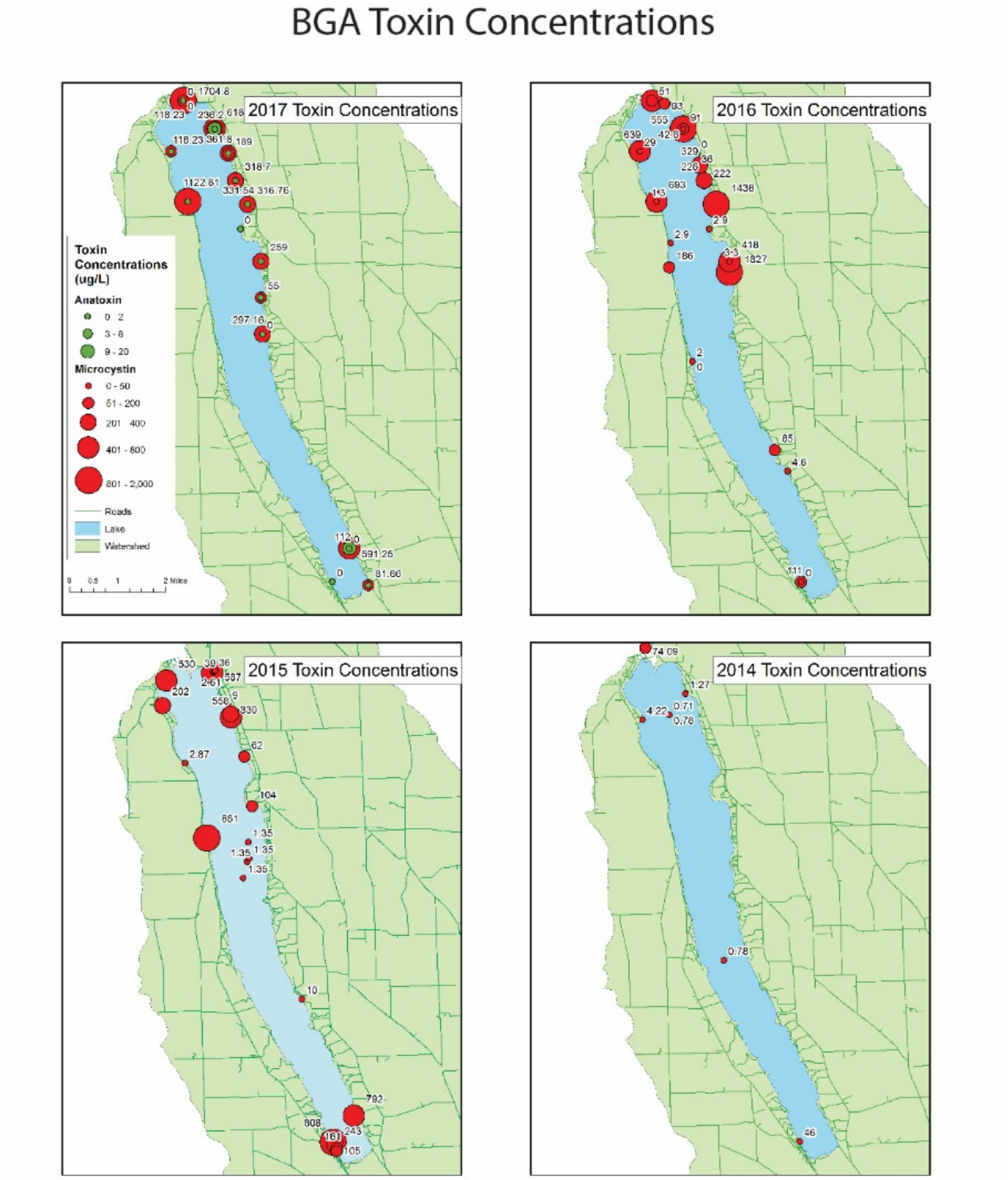

Fig. 1 (cont). Maps of the 2014 – 2017 shoreline BGA bloom dates, concentrations and microcystin and anatoxin (2017 only) toxin concentrations (Halfman et al, 2017a). Data by permission from the Owasco Lake Watershed Inspector & DEC.

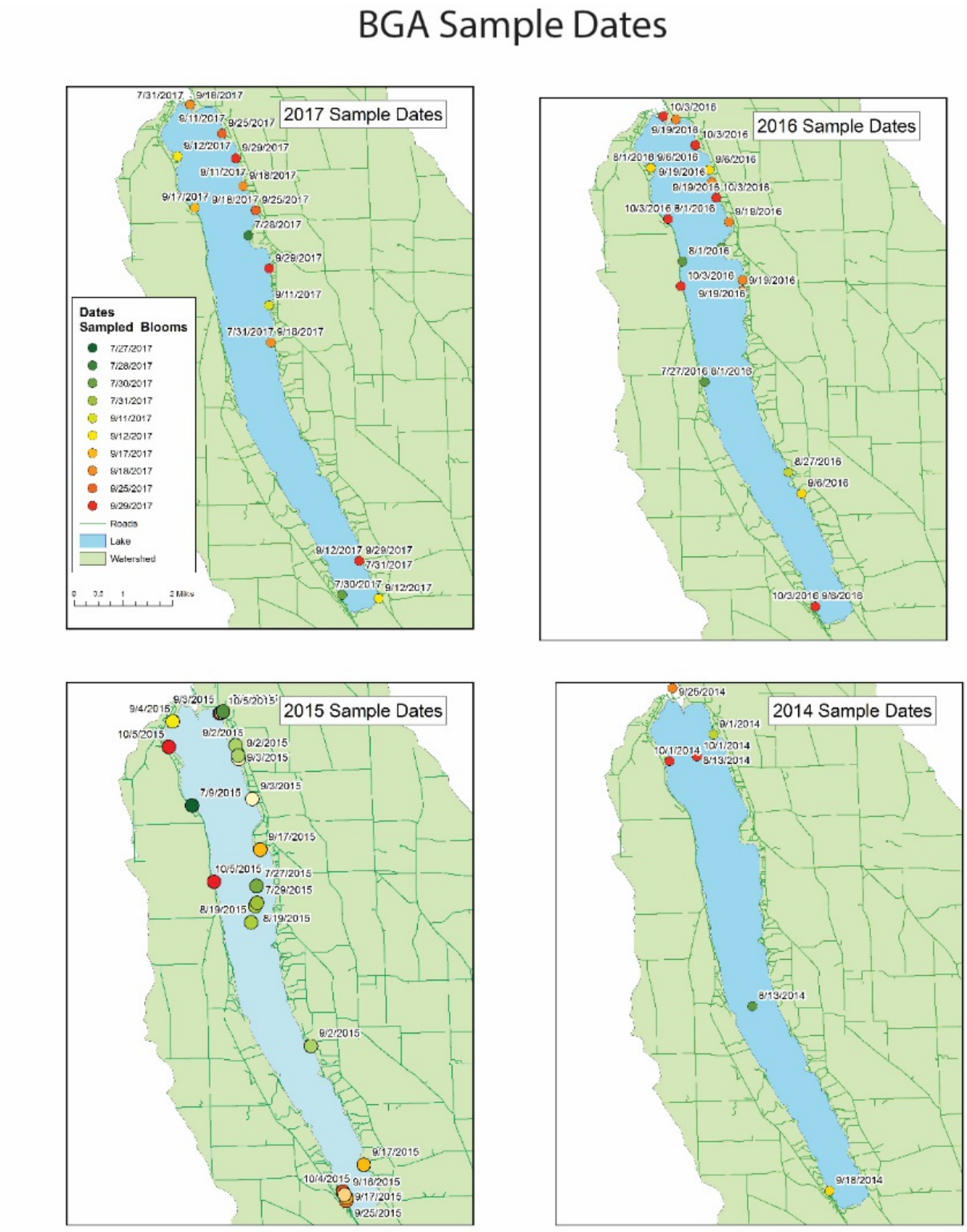

Fig. 1 (cont). Maps of the 2014 – 2017 shoreline BGA bloom dates, concentrations and microcystin and anatoxin (2017 only) toxin concentrations (Halfman et al, 2017a). Data by permission from the Owasco Lake Watershed Inspector & DEC.

This project has three parts: (1) the purchase and deployment of HABs inhibiting technologies, (2) monitoring mitigation and "control" sites to assess whether the mitigation technologies decreased the occurrence and concentration of BGA or not, and (3) documenting the process of installation, deployment and recovery of these technologies. Parts 1 and 3 were the responsibility of and will be detailed in a companion report written by the Owasco Watershed Lake Association (OWLA) volunteer(s). This report focuses on part 2, the scientific assessment of the monitoring program, and describes and summarizes the results of the weekly FluoroProbe, plankton enumeration, BGA toxin, and drone images collected from the eleven sites on every survey date, along with daily homeowner photographs of the lake near the shoreline at every site.

METHODS

Eleven sites were selected around the lake with the majority along the northeast shoreline (Fig. 2, Table 1). These sites were jointly determined between Halfman and OWLA representatives. The site selection emphasized that each site must have experienced BGA blooms in the past. Unfortunately, the locations for the past blooms were identified by Survey Zone, where each zone spans up to a mile of the shoreline. Thus, the exact history for each site was not available. Two additional site selection criteria included the willingness of the homeowner to take daily photos, and provide access to their docks for water sampling.

Mitigation technologies were deployed at eight sites (Fig. 2, Table 1). A Quattro-DB ultrasonic device was deployed at two sites, the South Martin Swim Beach on South Martin Drive and the Owasco Yacht Club. Two Airmax PS20 (larger, noisier) or SW20 (smaller, quieter) air diffusing water column aerators were deployed at six sites, the Owasco Yacht Club, Fire Lane 6, N. Burtis, S. Burtis, Glenwood, Indian Cove and Fire Lane 26. The PS20 units were deployed at sites with deeper water adjacent to the shoreline. The SW20 is designed for water depths of 6 to 10 feet, and the PW20 is designed for waters as deep as 50 feet such as reservoirs and ponds; i.e., pond water aeration bubblers or "PW". The distance between the device deployment and the sample location at each site were always within the manufacturer's estimated impact range for the device used at that site. Three sites, Sucker, N. Martin and Sunset, had no mitigation technologies installed and served as experimental "control" sites.

The measured parameters included weekly BGA concentrations, plankton assemblages, Total Microcystin concentrations, aerial images by drone, wind speed and direction, and air and water temperatures, as well as, daily nearshore photographs.

Table 1. Assessment Sites & Pertinent Site Information.

Site Name	Contact	Technology Deployed	Deployment Depth (m)	Distance from Shore (m)	Dock Length (m)	Max. Water Depth (m)
Sucker	Bill Phillips	**Control**	1.2	12	12.3	0.5
N Martin	Brian Brundage	**Control**	1.8	24	22.1	1.9
S Martin	Ed Wagner	Quattro-BP	1.8	30	25.4	1.7
Yacht Club	Yacht Club	Quattro-BP & PS20	14 & 40	150 & 55	24.7	2.3
Fire Lane 6	Linda Vitale	SW20	2.4	30	23.8	1.8
N Burtis	Jim Beckwith	SW20	1.5	27	19.1	1.4
S Burtis	Heather Wasileski	SW20	1.2	29	35.4	1.6
Sunset	Stan Gutelius	**Control**	1.4	20	27.7	1.6
Glenwood	George Bodine	SW20	1.2	26	28.6	1.4
Indian Cove	Kevin Sterzin	PS20	1.8	20	19.6	2.3
Fire Lane 26	Ken Kudla	PS20	1.7	15	23.5	1.9

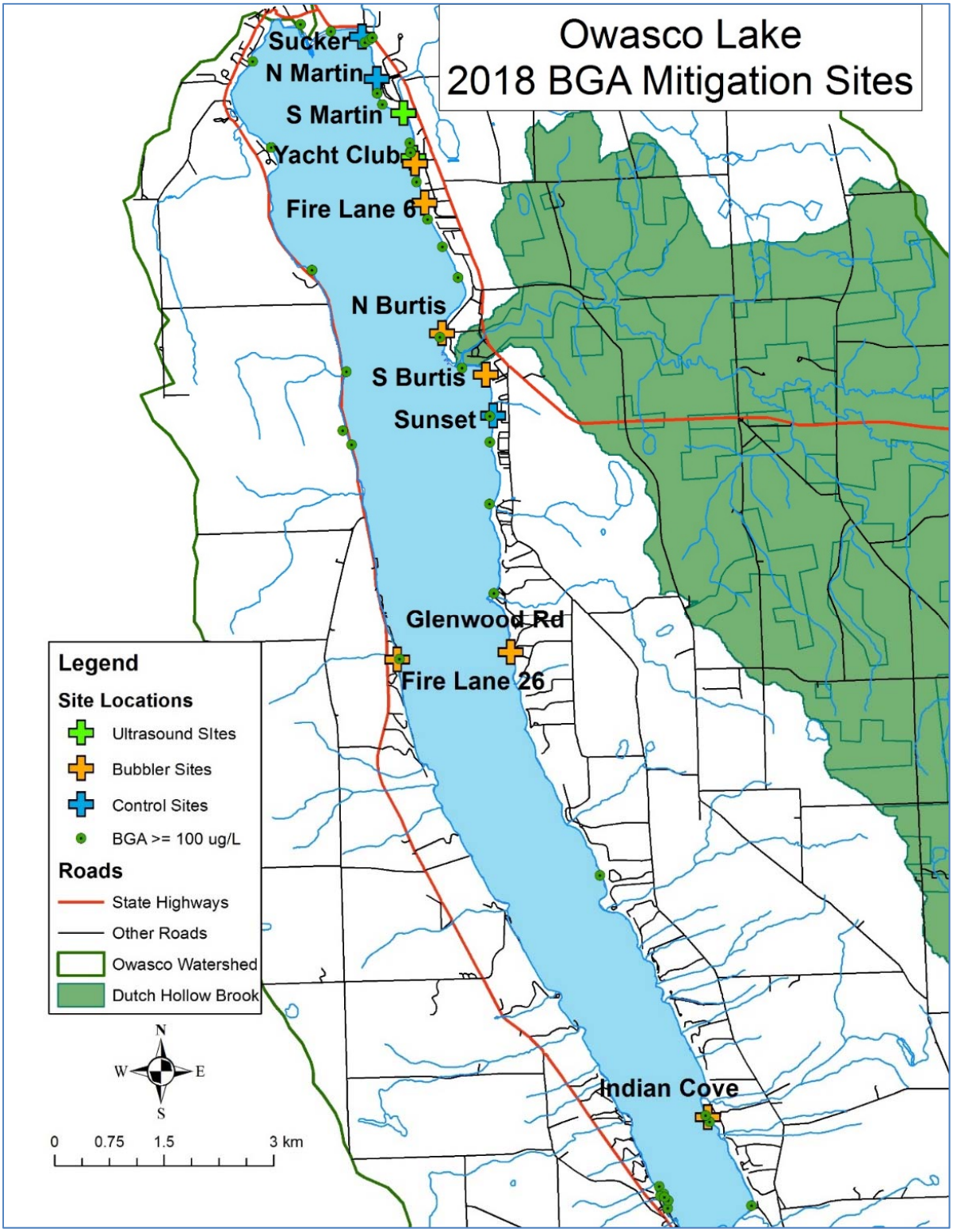

Fig. 2. Site locations (crosses) for the Owasco Lake HABs Inhibiting Technologies Assessment Project.

- BGA and other algal pigment concentrations were measured by bbe FluoroProbe. The FluoroProbe differentiates between four groups of algae, diatoms, greens, blue greens, and cryptophytes using their unique accessory chlorophyll pigments. Three samples were collected from each site. Separate surface water grab samples were collected by dipping the sample container just below the lake surface at both the nearshore and offshore ends of the homeowner's dock. A third sample was collected from ~0.2 m above the lake floor at the offshore end of the dock using a subsurface grab sampler (6000 series, CONBAR Environmental Products). The sampler is on a 6-ft pole and enabled collection of ~1 liter of water at any depth within reach of the pole. The BGA concentrations from each of the three samples at each site would quantitatively assess if BGA were concentrated at the surface and/or near the shoreline. Each sample was brought back to and measured in the lab at the Finger Lakes Institute. FluoroProbe SOP & instrumentation details are in Appendix I.
- Phytoplankton and zooplankton assemblages were determined by microscopic analysis of a vertical plankton tow (80 μm mesh) that was collected through the entire water column at the offshore end of the homeowner's dock. Each sample was immediately preserved in a 6-3-1 water-alcohol-formalin solution. Each algal colony was reported as a single individual, and typically BGA are colonial. Method details are in Appendix F.
- A drone (Phantom 3 Professional Advanced by DJI) was flown at ~50 m above the lake on each survey date to visually map surface BGA distributions. Three images were typically taken. One image was oriented vertically downward over the site, and two more images were taken obliquely up and down the shoreline at each site. The drone images were transferred to, stored, and visually analyzed on a computer at Hobart and William Smith Colleges. Drone images were not collected on rainy and/or windy (> 5 m/s or 10 mph) days because one crashed into a tree in 5.2 m/s winds. Visual inspection of the site did not detect any blooms no drone flight days. Method details are in Appendix F.
- Total microcystin concentrations (a common and regulatory BGA toxin) were measured by the ELISA technique at Upstate Freshwater Institute (UFI) from surface water grab samples collected at four sites following EPA Method 546. These sites were equally split between "control" and mitigation types: N. Martin (control), Yacht Club (ultrasonic device and aerator bubbler), S Burtis (aerator bubbler) and Sunset (control). The samples were kept cold (4°C) and sent in a cooler on ice by overnight mail to UFI for analysis the day after collection as directed by the EPA method. The toxin sample collection started on 8-26-2018. Method details are in Appendix G
- Wind speed and direction were measured with a Kestral 5000 pocket weather meter coupled with a cell phone compass app at the offshore end of the homeowner's dock. The wind speed and direction data collection was initiated on 8-6-2018. Method details are in Appendix F.
- Air and water temperatures were measured with a Kestral 5000 (air) and an Oakton CON 410 Series conductivity meter (water) at the offshore end of the homeowner's dock. The air and water temperature data collection was initiated on 8-6-2018. Method details are in Appendix F.
- The FLI Monitoring Buoy manufactured by YSI/Xylem collected two water column profiles a day of temperature, specific conductance, dissolved oxygen, total and BGA phycocyanin fluorescence and turbidity during the April to October field season. It also records 5 minute average meteorological data every 30 minutes. The parameters included air temperature, humidity, barometric pressure, light intensity, wind speed and

wind direction. The data was compared to the dockside data collected by this study, and provided a means for high resolution limnological and atmospheric data.

- Each homeowner was also asked to collect a cell phone, iPad or similar image of the lake at the nearshore end their dock between 10 am to 2 pm on a daily basis. These images were sent to Peter Rogers, OWLA volunteer, who compiled and catalogued the images, tallied the success of daily image collection at each site, and sent Halfman all images with suspected BGA blooms. For comparison, Halfman also collected a cell phone image of each site on each sample date. Method details are in Appendix F.
- Example CoCs are in Appendix H

Samples were collected weekly starting on 7-30, typically on Sunday or Monday of the week. Which day of the week depended on the availability of the scientific team and the weekly weather forecast. The field team attempted to select forecasted sunny and calm weather for the weekly survey date, two atmospheric variables suspected to increase the chance of BGA blooms. This strategy assumes that blooms are "born" locally and not blown in by strong winds. Thus, the survey date selection strategy might have missed blooms blown to a site on windy days. Two additional sample dates facilitated collection of a second sample during any given week at the discretion of the survey team. The extra dates focused on those days when the weather forecast predicted more than one day with favorable BGA blooms conditions. Unfortunately, the forecast was typically a day off and some calm and sunny days were missed. The long field day (8 – 10 hours), precluded waiting for a bloom before sampling as an alternative. The dates were: 7-30, 8-6, 8-11, 8-20, 8-26, 9-3, 9-5, 9-9, 9-14, 9-16, and 9-30, for a total of eleven sample dates. Drone images were not collected on 8-26 (it crashed in high winds), and images were not collected on 8-6 from S Martin and Yacht Club, and on 9-16 from S Burtis due to operator error.

RESULTS

Homeowner Photos: The daily homeowner photographs provided the most frequent record of BGA blooms (Fig. 3). The daily submission rate at each site ranged from 62 to 97%, and averaged 82% of the time during the 63 day survey (Fig. 3). Their submission rate is very high for a volunteer workforce, and underlies the remarkable dedication of each homeowner to this project and more importantly the health and wellbeing of Owasco Lake. Only six of the 128 missing photos were from days when other sites detected blooms, thus minimizing but not eliminating the bloom detection impact of the missing photos. Some homeowners submitted more than one photo on days with a bloom.

Spatially, the number of suspected blooms imaged at each site ranged from one to four days during the study (Fig. 3). The mean number of suspected blooms was 2.7 days. Temporally, blooms were detected at one or more sites on eight different days during the study. The dates when at least one site detected a bloom (with the number of sites reporting a suspected bloom in parentheses) were 8-15 (1), 8-16 (5), 8-21 (4), 9-4 (6), 9-12 (6), 9-13 (4), 9-14 (2), and 9-16 (2).

A chance exists that some daily images missed a bloom on that day at that site because the blooms can be transitory and homeowners typically took a single photograph between 10 am and 2 pm. The following evidence supports this claim. A three day sequence of before, during and after photos by numerous homeowners confirmed a no bloom, bloom, to no bloom transition (Fig. 4). Hourly photographs at N Burtis, and multiple photographs taken on a single day at other sites detected an hourly progression from no bloom, bloom, to no bloom within a single day. A similar transitory nature for BGA was observed in the USGS nearshore photos at the

north end of Skaneateles Lake. Thus, it was possible to miss a bloom. It highlights the need for more frequent, perhaps hourly, photographs at each site. Despite this challenge, the record is clear, at least one and up to four, hour to day long, suspected blooms were detected at every site.

Record of Daily Images Photographed by Homeowner and Compiled by Peter Rogers, OWLA

Location C - Control U - Ultrasonic A - Aerator	7/30/2018	7/31/2018	8/1/2018	8/2/2018	8/3/2018	8/4/2018	8/5/2018	8/6/2018	8/7/2018	8/8/2018	8/9/2018	8/10/2018	8/11/2018	8/12/2018	8/13/2018	8/14/2018	8/15/2018	8/16/2018	8/17/2018	8/18/2018	8/19/2018
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
**Sucker - C	X	X	X	X	X	X	O	X	X	X	O	X	X	X	X	X	O	X	O	X	X
**N Martin - C	O	X	X	X	X	O	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X
**Sunset - C	X	X	X	X	X	X	O	X	X	X	O	X	X	X	X	X	X	X	X	X	X
S Martin - U	X	X	X	X	X	X	O	X	X	X	X	X	X	X	X	O	X	S	X	X	O
Yacht Club - UA	O	O	O	O	X	O	O	X	X	X	X	X	X	X	X	X	X	S	O	X	O
FL 6 - A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	S	X	X	X
N Burtis - A	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	X
S Burtis - A	O	X	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	S	O	O	X
Glenwood - A	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	S	S	X	X	X
Indian - A	O	X	X	X	X	O	O	X	X	X	X	X	X	X	X	X	X	X	O	X	X
FL 26 - A	O	X	O	O	O	O	O	X	X	X	O	X	X	X	X	X	X	X	X	O	X
FLI Sample Date	Sample							Sample					Sample								

X Photo Received
O No Photo Received
S BGA Suspected in Photo Received

Continued

Location C - Control U - Ultrasonic A - Aerator	8/20/2018	8/21/2018	8/22/2018	8/23/2018	8/24/2018	8/25/2018	8/26/2018	8/27/2018	8/28/2018	8/29/2018	8/30/2018	8/31/2018	9/1/2018	9/2/2018	9/3/2018	9/4/2018	9/5/2018	9/6/2018	9/7/2018	9/8/2018	9/9/2018
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
**Sucker - C	X	S	X	X	X	X	O	X	X	O	X	X	X	X	X	X	X	X	O	X	X
**N Martin - C	O	S	O	O	O	O	X	X	O	O	O	X	O	X	O	X	X	X	X	X	X
**Sunset - C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	S	X	X	X	X	X
S Martin - U	X	O	O	X	X	O	X	O	X	O	X	X	X	X	X	S	O	O	O	O	O
Yacht Club - UA	X	X	X	X	X	O	O	X	X	O	X	X	X	X	X	S	X	X	X	X	X
FL 6 - A	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	S	X	X	X	X	X
N Burtis - A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
S Burtis - A	O	X	X	X	X	X	X	X	X	X	X	O	X	O	X	S	X	X	X	O	X
Glenwood - A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Indian - A	X	S	X	X	O	X	O	X	X	X	X	X	O	O	O	X	O	X	O	X	X
FL 26 - A	X	S	X	X	X	X	X	X	X	X	X	X	X	X	X	S	X	O	X	X	X
FLI Sample Date	Sample						Sample								Sample		Sample				Sample

Continued

Location C - Control U - Ultrasonic A - Aerator	9/10/2018	9/11/2018	9/12/2018	9/13/2018	9/14/2018	9/15/2018	9/16/2018	9/17/2018	9/18/2018	9/19/2018	9/20/2018	9/21/2018	9/22/2018	9/23/2018	9/24/2018	9/25/2018	9/26/2018	9/27/2018	9/28/2018	9/29/2018	9/30/2018
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
**Sucker - C	X	X	X	X	O	O	O	X	X	X	X	X	X	X	X	X	O	X	X	X	X
**N Martin - C	O	X	O	X	X	X	S	X	O	O	X	O	O	X	X	X	O	O	O	O	O
**Sunset - C	X	X	S	X	S	O	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X
S Martin - U	O	O	X	X	S	X	S	O	X	O	X	X	O	X	X	X	X	X	X	X	O
Yacht Club - UA	X	X	S	S	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X
FL 6 - A	X	X	S	S	X	X	X	X	X	X	O	X	X	X	X	X	X	X	O	O	O
N Burtis - A	X	X	S	S	X	X	X	O	X	X	O	O	O	O	O	X	X	X	X	O	O
S Burtis - A	X	X	X	O	X	X	O	X	O	X	X	X	X	X	X	X	X	X	X	O	X
Glenwood - A	X	X	X	S	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X
Indian - A	X	O	S	X	O	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X
FL 26 - A	X	X	S	O	X	X	O	X	X	X	X	X	X	X	X	X	X	X	O	O	O
FLI Sample Date					Sample		Sample														Sample

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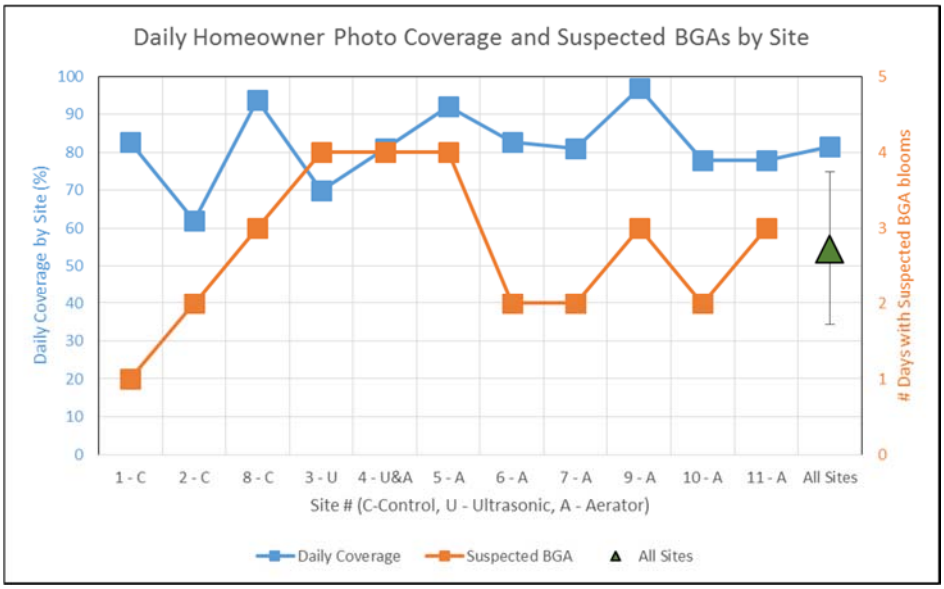


Fig. 3. The complete record of daily homeowner photographs (above). The percentage of days photos were taken, submitted and catalogued at each site, and the number of days blooms were suspected in the photographs (below). The green triangle, lower plot on right side, is the all site detected suspected bloom mean (±1σ standard deviation).

The number of blooms detected at each site, on first analysis, does not support a successful test of the mitigation technologies. The smallest number of blooms were detected at Sucker, a "control" site, and the largest number of blooms were detected at three mitigation sites, S Martin, the Yacht Club, and Fire Lane 6, where an Ultrasonic device, an Ultrasonic device and Aerator bubber, & Aerator bubblers, respectively, were deployed. Averaging the available data for each type of site, the "control" sites appeared to experience the fewest blooms and the ultrasonic device sites experienced the most blooms, but the variability is small (means within ±1σ standard deviation), thus these averages were statically indistinguishable from each other (Fig. 5).

The ultrasonic devices are designed to disrupt the floatation vacuoles in BGA. When the BGA then sink below the photic zone, they supposedly die, removing their presence from the surface waters. This might be problematic for this assessment. Assuming the ultrasonic devices caused the BGA to sink to the lake floor, the lake floor in the nearshore regions of Owasco Lake are still in the photic zone and have amply sunlight for photosynthesis. Light availability is confirmed by the growth of macrophytes and CTD PAR profiles at these same water depths (Halfman et al., 2017b). It suggests that the BGA on the lake floor could still photosynthesize and multiply, replacing the sinking or sunk BGA with a supply of new, surface water, invading BGA colonies, and reducing the mitigation success of the ultrasonic devices. Other interpretations are possible. For example, BGA may be continually brought to the site by winds, however the wind data indicate that BGA blooms preferred calm days (see wind discussion below).

The aerators were also deployed in water depths near the minimum recommended depth limits for the devices. The shallow depths may have decreased the effectiveness of the devices, and decreased the radii of their influence.

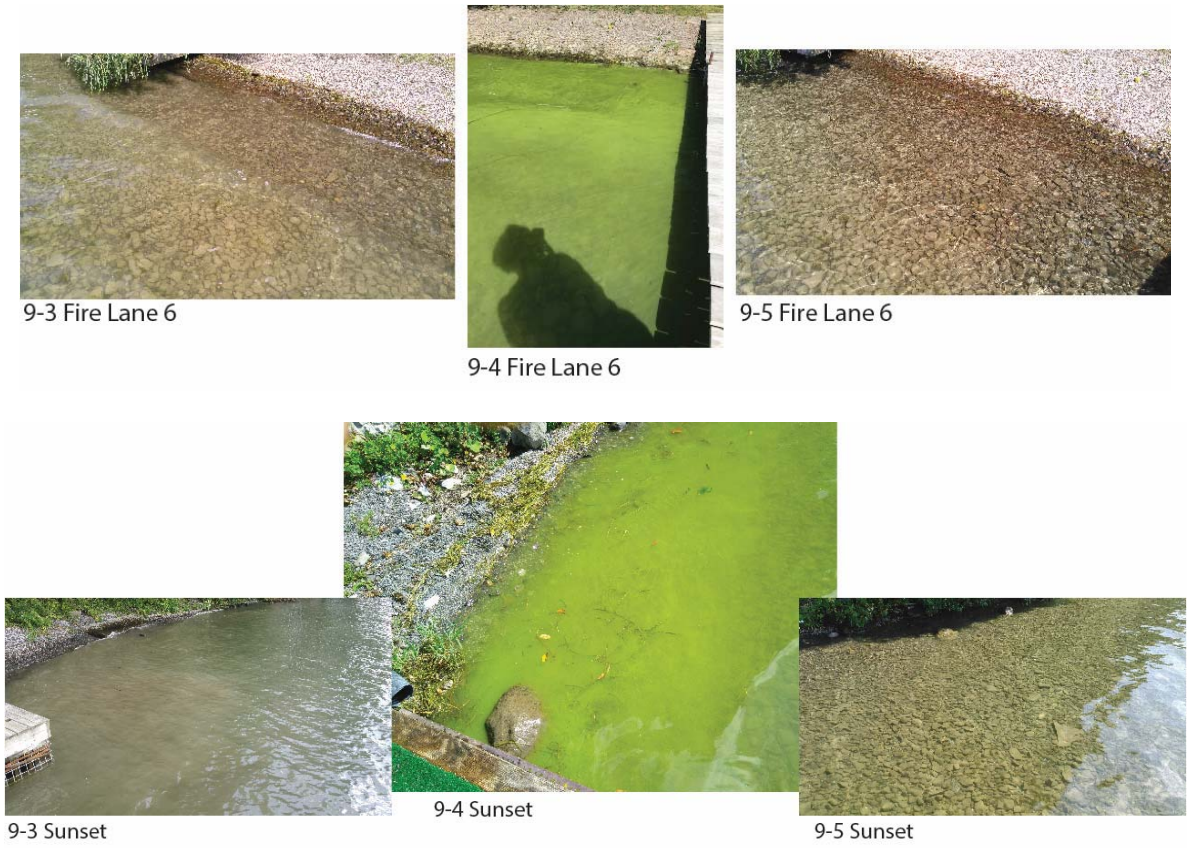


Fig. 4. Example homeowner images of a significant BGA bloom on 9-4, sandwiched between no blooms on the preceding (9-3) and following (9-5) days.

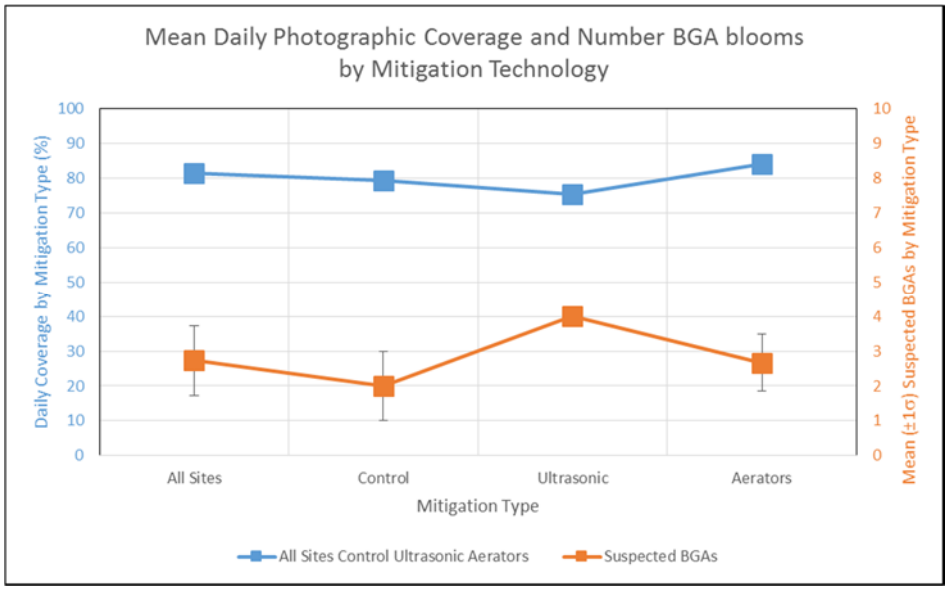


Fig. 5. The mean daily photographic coverage (blue) and the average number blooms (orange ±1σ) by site type.

The number of days suspected blooms were detected in the homeowner photographs was similar to number of days when confirmed blooms were sampled by the HABs Shoreline Surveillance Program under the guidance of NYS-DEC. Interestingly, the dates with detected blooms and the locations of these blooms were typically different. The Inspector's Office data documented confirmed blooms on four days in their thirteen week, once a week, surveillance program (7/9 - 10/1). For example, the Surveillance team detected multiple confirmed blooms with toxins on September 4th. Blooms were also detected in many of the homeowner's photos on this date but typically at different locations. This mismatch is true for other dates as well. These discrepancies emphasize the highly transitory and localized nature of the BGA blooms.

The HABs Shoreline Surveillance team also detected fewer confirmed blooms in 2018 than in earlier years (Fig. 7). For example, weekly site visits at N Burtis consistently detected blooms in 2017 but this site rarely had blooms in 2018. A decreased presence of BGA was also highlighted in the drone images from 2018 compared to earlier years. Two example images from N Burtis point are shown for comparison (Fig. 6). One may argue that the lower frequency of blooms at N Burtis was due to the aerator mitigation. However, the lower frequency of blooms was lake wide and not just at the mitigation sites. The lack of blooms around the lake and similar results between the "controls" and the mitigation sites in every parameter made it impossible to assess the technologies. Perhaps this study should be repeated when blooms are more prevalent around the lake.

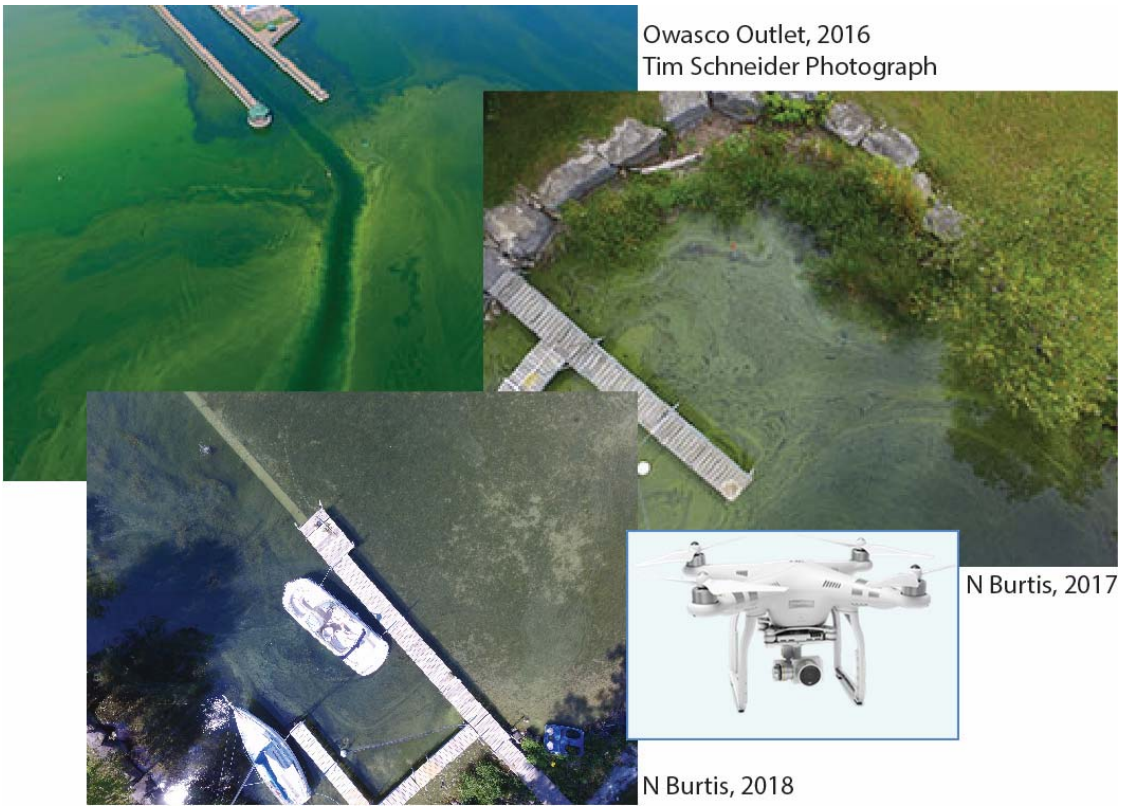


Fig. 6. Drone images of significant BGA blooms from previous years (above) and no bloom during 2018 (below), conclusions confirmed by water samples. The bottom and top right-hand images were from the identical site. The intensity of the green in the earlier images greatly exceeds the worse bloom imaged by drone in 2018.

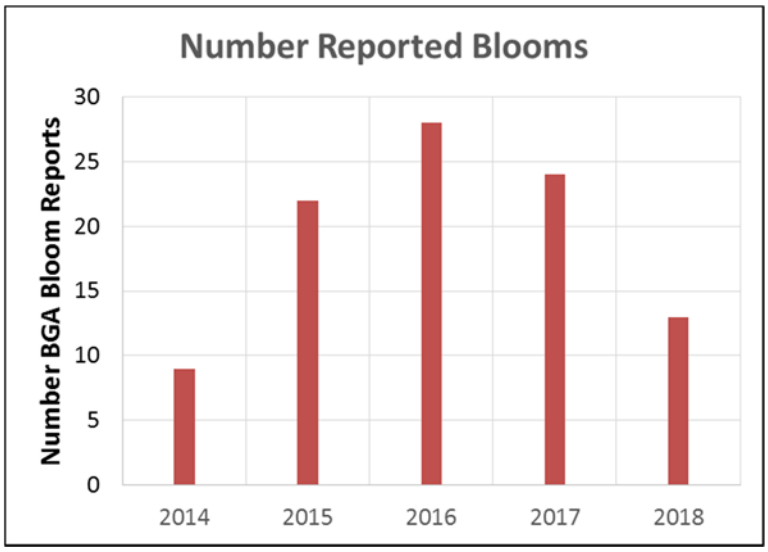


Fig. 7. Number of blooms detected in Owasco Lake from 2014 - 2018 by the HABs Surveillance team.

The scarcity of BGA blooms in 2018 should NOT be interpreted as a successful, lake-wide, mitigation technology assessment. The manufacturers stated that deployment of their devices should only impact the local area surrounding the device and NOT the entire lake.

bbe FluoroProbe: BGA chlorophyll (phycocyanin) concentrations measured by the bbe FluoroProbe ranged from 0 to 68 μg/L, with an average concentration of 1.3. Appendix A has the raw data with daily plots. The two largest concentrations (46 and 68 μg/L) were detected on 8-11 at Glenwood (aerator) and N Martin (control), respectively. Only these two concentrations exceeded DEC's threshold (25 μg/L) for a confirmed bloom. Six more samples, one sample at S Burtis (aerator) on 9-5, and on 9-16, two samples from N Burtis (aerator), two more samples from S Burtis (aerator) and one from Sunset ("control") were between 15 to 20 μg/L. The lowest concentration, 0 μg/L, was detected on 9-3, 9-9, 9-14 and 9-16 at numerous sites that were evenly split between "control", ultrasonic device and aerator bubbler sites. All but eleven of the 363 samples were below 5 μg/L. The large population of low concentrations highlights the persistence of BGA in the water column throughout the study, the lack of significant BGA blooms during the study, and minimal overlap between suspected blooms in the photographs and the survey dates. This challenge, again, highlights the recommendation to continuously monitor the docks, perhaps on an hourly basis, using data loggers with appropriate BGA sensors and/or automated cameras, rather than a daily or weekly sample period.

Daily mean BGA concentrations were calculated for each mitigation type ("control", ultrasonic device and aerator bubbler) and each dock location (nearshore, offshore surface and offshore bottom water, Fig. 8). The BGA results are the black bar within the stacked bar graph. The largest mean BGA concentrations were detected at the "control" sites on every survey date except for 9-16, a suspected bloom date. In contrast, the smallest total fluorescence concentrations were typically detected at the "control" sites. This suggests that the mitigation devices decreased the background BGA concentrations but were less successful at depressing BGA concentrations during a suspected bloom. The survey mean concentrations for each

mitigation type however, were statistically indistinguishable and precludes any scientifically-based assessment. Means might not be the best statistical tool to compare a limited number of data points that potentially are not normally distributed but means provide a simple tool understandable by the general public, and if the difference between the means do not exceed a standard deviation, it probably would also have not been significant using more sophisticated statistical tools.

The mean daily nearshore BGA concentrations were slightly (a few μg/L) larger or similar to the other dock locations (Fig. 8). The difference ranged from 0.1 to 11.4 μg/L and averaged 1.3 μg/L. On 9-16, the mean offshore surface sample concentration was larger than the other two locations but only by 0.8 μg/L. During the largest blooms, the nearshore location and occasionally both the nearshore and offshore surface samples detected larger BGA concentrations than the other location(s) by 10 to 67 μg/L. It highlights the surface accumulating and nearshore hugging nature of BGA.

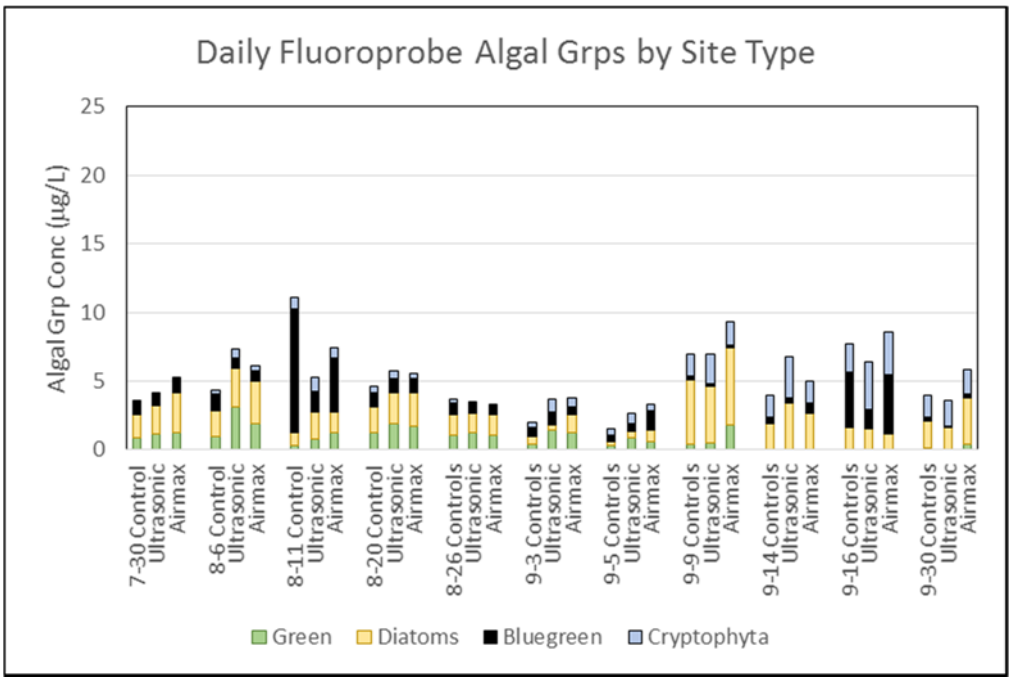
The HABs Shoreline Surveillance volunteers detected similar bloom frequency but their blooms had larger concentrations. Shoreline samples collected by the HABs Shoreline Surveillance volunteers on 9-4 at Surveillance Zones 4, 6, 17, 21 and 22 detected BGA concentrations from ~1,000 to 14,000 μg/L. These large concentrations may be due to skim sampling, as the technique concentrates the surface hugging BGA. It was unfortunate that these blooms were not detected by the 9-3 or 9-5 dockside survey. In fact, the homeowner's photos and sample analyses did not detect any blooms on 9-3 or 9-5 but instead photographs detected many blooms on 9-4. It again highlights how quickly blooms develop and then disappear, and how localized blooms extend geographically.

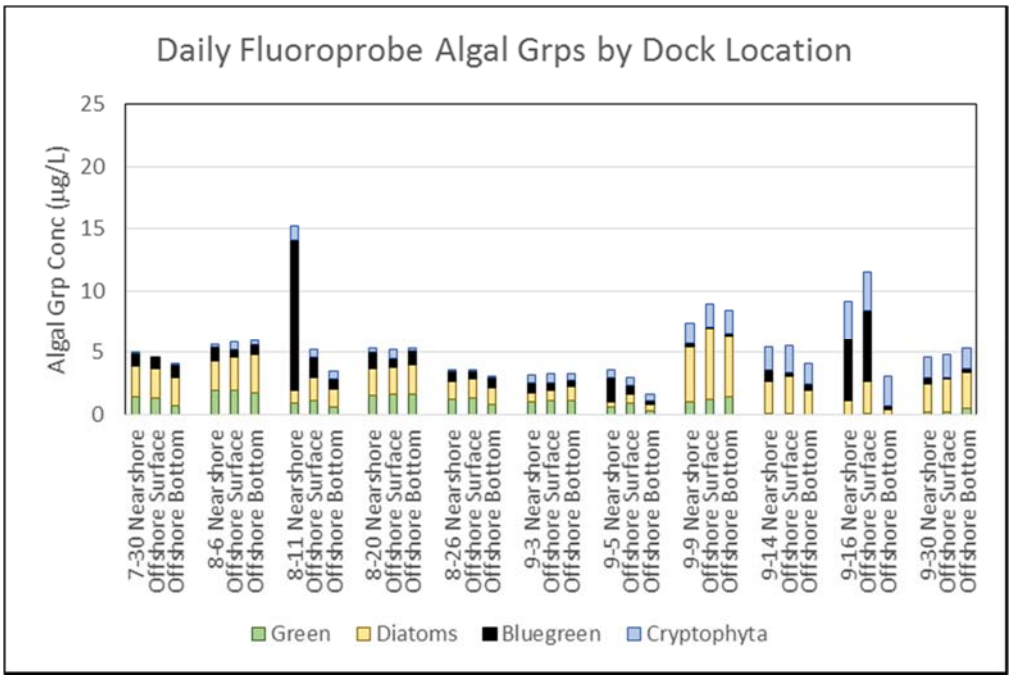
The field team was busy sampling Owasco Lake on 9-4. Visual observations from the JB Snow (FLI's pontoon boat) on this date suggested that BGA concentrations did not change much from the open lake to the ultrasonic devices. However, the aeration bubbles appeared to push floating BGA and other debris away from the aerator, radially outward from the bubbles to form a ring of BGA around the aerator site. This pattern was confirmed at another site by a homeowner and in drone images (see the drone discussion below). It appears that the waves created by the upwelling bubbles pushed BGA away from the aerator location. One concentrated ring was sampled at Indian Cove on 9-14. The BGA concentration from the ring was 23 μg/L whereas the surface water concentrations at the nearshore and offshore ends of the dock were 4 and 2 μg/L, respectively, and the offshore bottom water concentration was 2.5 μg/L.

Plankton Assemblages: Diatoms ("good" algae), primarily *Fragilaria* with lesser amounts of *Asterionella* and undifferentiated penates, dominated the plankton assemblages, except on 8-11 (Fig. 9 and Appendix B). The relative percentage of BGA in the plankton tows ranged from 0 to 71% of the assemblage and averaged 14% over the course of the project. The largest percentage of BGA was detected at N Martin ("control") on 8-11. No BGA were detected at many sites on 7-30 and at Fire Lane 26 (aerator) on 9-5. The largest BGA percentages were detected on 8-11, 9-3, 9-5, 9-16 and 9-30, late in the bloom season.

The BGA shared assemblage dominance with diatoms on 8-11, 9-3 and 9-5 and again on 9-14, 9-16 and 9-30. Four of these dates were a day before (9-3), a day after (9-5), or on (9-14 & 9-16) suspected bloom dates in the homeowner photos. It suggests that BGA begin to dominate the assemblage just before a bloom, dominate the assemblage during a bloom, and return to pre-

bloom levels just after a bloom, as expected. The confirmed increase just before a bloom is intriguing because it might provide a means to predict a pending bloom. However, the weekly samples and the incongruence between samples dates and suspected blooms dictates additional research to confirm this linkage.





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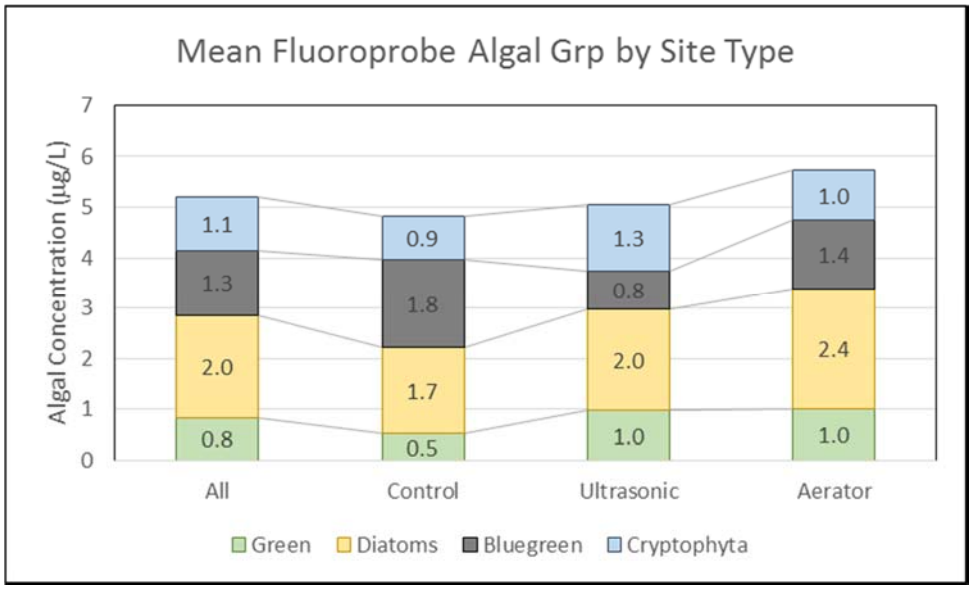


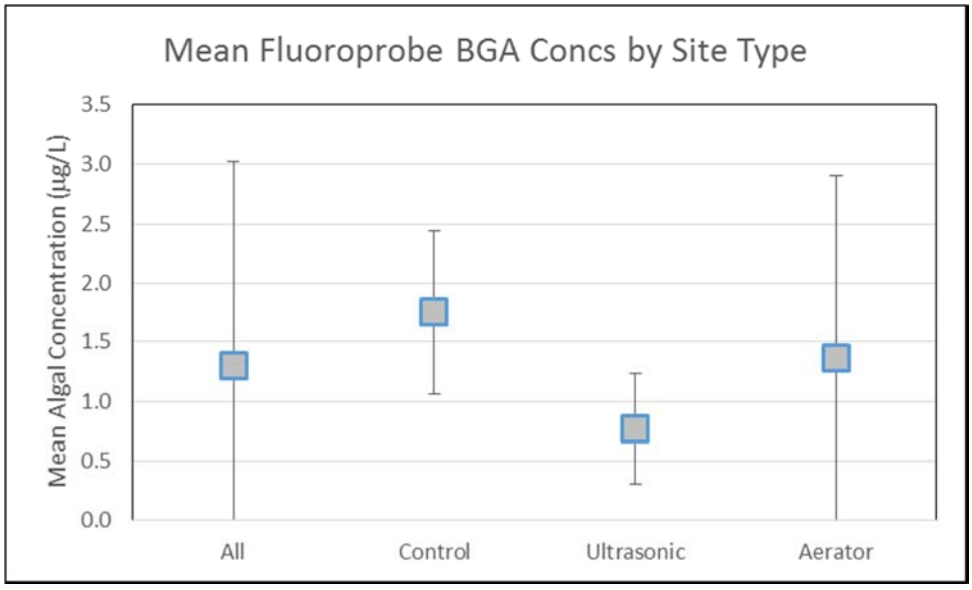


Fig. 8. Daily mean bbe FluoroProbe results, averaged by mitigation type (above), dock location (middle top), survey mean bbe FluoroProbe results for all samples (middle bottom), and survey mean BGA concentrations by site type (bottom, ±1σ). .

Even though the daily mean BGA relative percentage was larger at the "control" sites than the mitigation sites, i.e., 17.6 vs. 13.5 and 13.0 (Fig. 9) and suggests that the mitigation technologies were successful, this is not the case. The survey mean BGA percentages by mitigation type, were again statistically indistinguishable (±1σ standard deviation) and preclude any conclusion.

The BGA genera/species identified in the samples changed from *Dolichospermum* (formerly *Anabaena*), which were most prevalent on 8-6 and 8-11, to *Microcystis* starting on 9-3 and continuing through the end of the survey. Other BGA species were occasionally detected but they were too small to identify under a microscope. The in-between dates, 8-20 and 8-26, has equal numbers of *Dolichospermum* and *Microcystis*, if any, BGA species. The *Dolichospermum*

to *Microcystis* seasonal succession was noted during earlier years in Owasco Lake and has been detected on other lakes as well but the reason(s) for the shift are unclear at this time. The seasonal change may reflect the unique nitrogen fixing capabilities of *Dolichospermum* and low phosphorus-requirements by *Microcystis* (e.g., Chia et al. 2018). We speculate that the lack of nitrogen promotes *Dolichospermum* over *Microcystis* early in the season. Once a few *Dolichospermum* blooms pass, nitrogen concentrations (in the form of ammonium) may rise in the nearshore muds as the dead *Dolichospermum* biomass decays. Subsequent release of the buildup ammonium may allow the *Microcystis* to dominate future blooms. The observation suggests that the BGA original from the local muds but does not prove it. The wind section has more information on the source of the BGA.

The zooplankton numbers were too small to detect any significant changes between sites and between dates. Minimal variability in the presented data suggest that the mitigation devices did not change the plankton community in the lake.

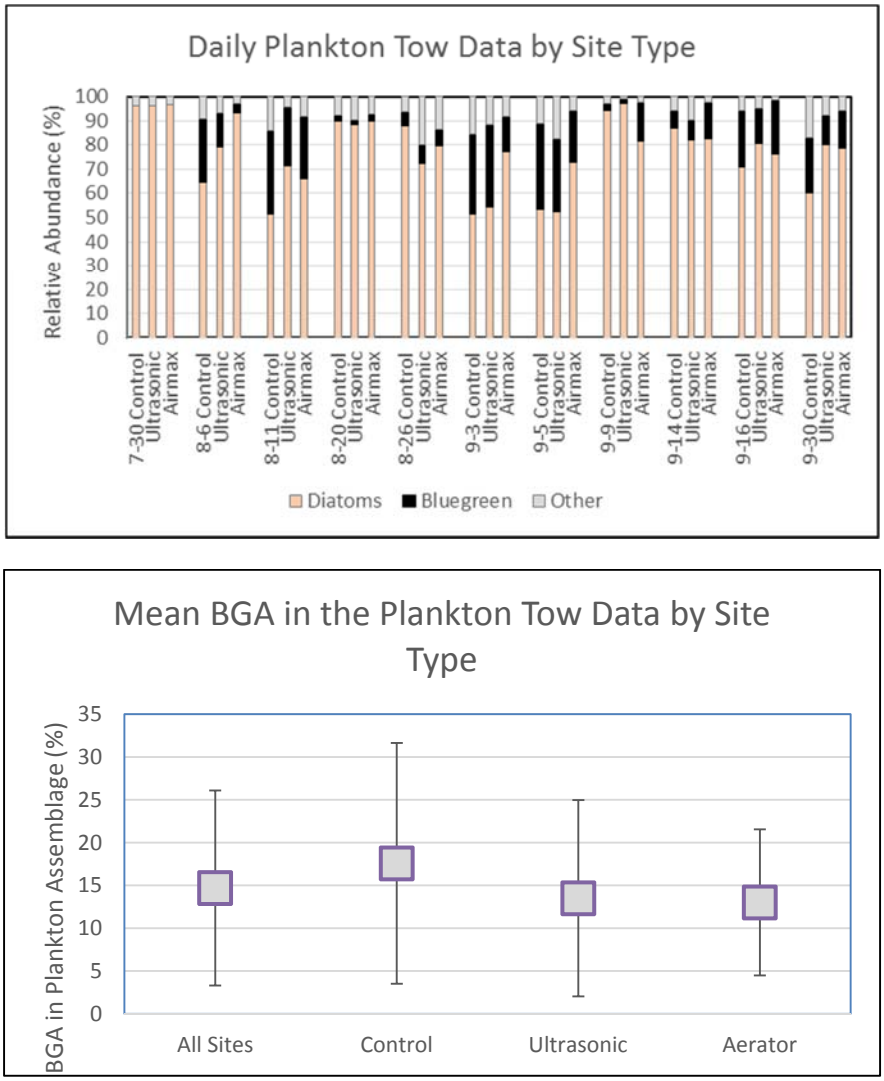


Fig. 9. Above daily mean plankton assemblage data form the plankton tows, averaged by mitigation type. Below survey mean BGA from the plankton tows (±1σ).

Toxin Analyses: Total microcystin concentrations ranged from below detections (<0.3 µg/L) to 14 µg/L, and averaged 1.3 µg/L from 8-26 through 9-30. Appendix C has the raw data and daily plots. Several samples for microcystin analysis were received by UFI slightly above the 10°C limit described in EPA Method 546: Determination of Total Microcystins and Nodularins in Drinking Water and Ambient Water by Adda Enzyme-Linked Immunosorbent Assay. These samples were originally on ice, but warming due to elevated temperatures during overnight shipping. It was unlikely that the small deviation in temperature negatively impacted the sample results.

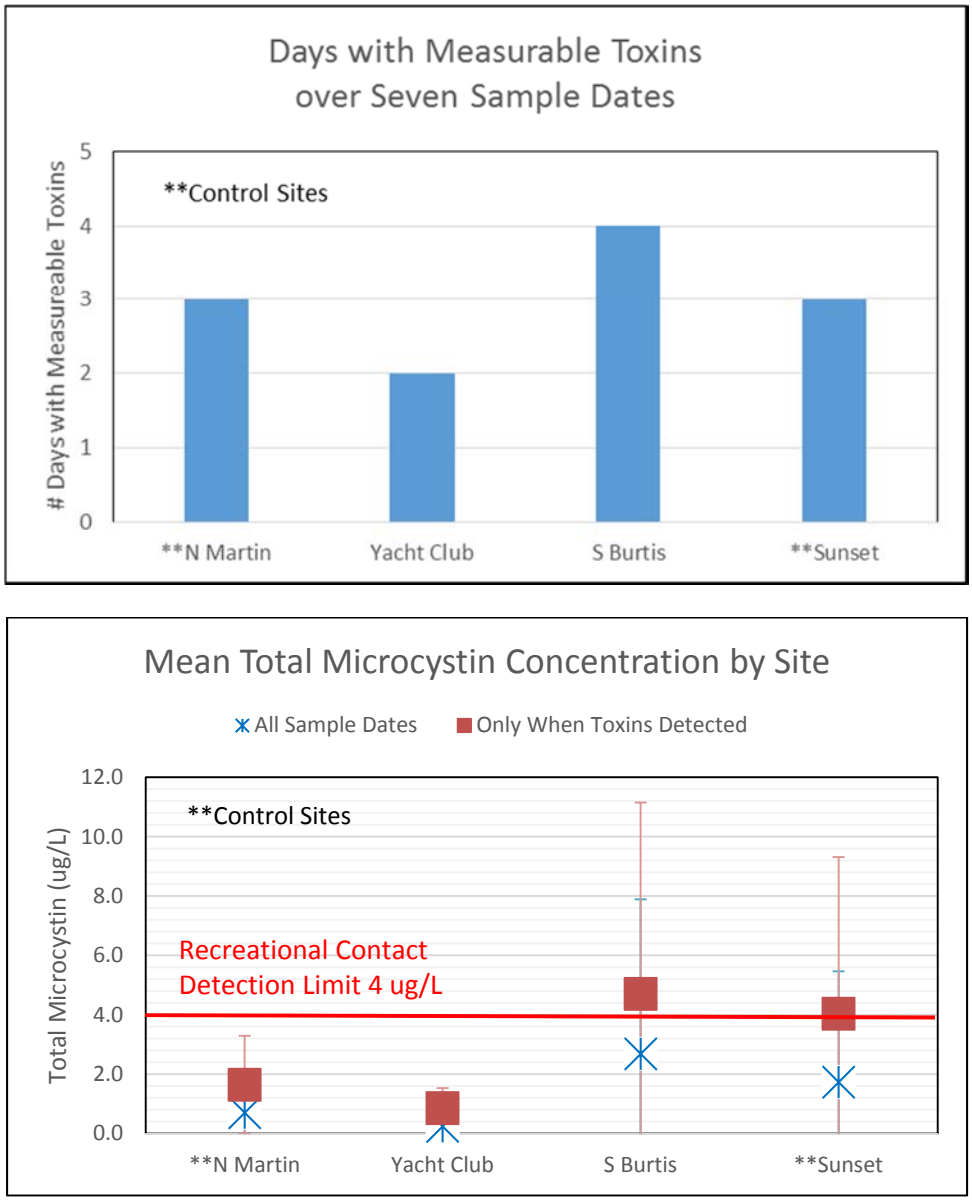


Fig. 10. Days with measurable toxins (above), and toxin concentrations averaged by site type (±1σ, below).

Five samples had toxin concentrations above 1 µg/L (Fig. 10). The sample on 9-5 at S Burtis had a concentration of 4 µg/L. The other three sites did not detect toxins on this date. On 9-16, above background concentrations were detected at the Yacht Club, N Martin, Sunset and S

Burtis with concentrations of 1.3, 3.5, 10.1 and 14 μg/L, respectively. Fifteen samples were below the detection limit (0.3 μg/L) and 24 of the 27 samples were below 4 μg/L the recreational limit. Low toxin concentrations parallel low BGA concentrations and a smaller BGA impact on Owasco Lake in 2018 than previous years. None of these samples experienced toxins as large as those detected by the HABs Shoreline Surveillance volunteers, however the difference may be an artifact of the different sampling techniques. On 9-4, BGA concentrations were between 1,000 and 10,000 μg/L with microcystin concentrations between 0 and 1,300 μg/L elsewhere in the lake. It is unfortunate that the sample dates used for this study missed the majority of the suspected blooms detected in the daily homeowner photographs. It reinforces the need for more frequent and/or automated data logging with appropriate BGA sensors.

The toxin data provided some insight into the half-life of microcystin in the environment after a bloom. Toxin samples were collected the day before (9-3) and the day after (9-5) the 9-4 confirmed blooms. On 9-3 and 9-5, toxin concentrations detected by this study were at or below recreational contact maximum concentrations (<4 μg/L). The 9-4 microcystin concentrations in the samples collected by the Surveillance team at five different sites, two sites adjacent to the mitigation sites, ranged from 210 to 4,800 μg/L. During this one occasion, it suggests that the toxins appeared and disappeared with the BGA, and the toxins did not linger in the water column after the 9-4 bloom. This assumes that no other mechanism was at work to change the toxin concentration, e.g., winds and/or currents pushing the blooms around the lake. Again a note of warning: The available data only bracketed one bloom, and data bracketing more blooms are essential to define a clear and ambiguous trend as subsequent blooms might respond in a different manner.

The impact of the mitigation technologies on toxin concentrations was not definitive, as well. The mean total microcystin concentration and number of days with measureable toxins were highest at S Burtis (aerator) but lowest at the Yacht Club (aerator bubbler and ultrasonic device). Unfortunately the relationship is skewed to only 4 or 5 large results. Yet, the survey means for each mitigation type were statistically indistinguishable (within $\pm 1\sigma$ standard deviation). This study therefore cannot definitively state if the mitigation technologies reduced (or enhanced) the concentration of BGA and their toxins.

Aerial Drone Images: Visual inspection of the drone images identified only a few dates with BGA (Fig. 11). For example, BGA were detected at the surface of the lake at N Burtis on 9-16 when surface BGA concentrations were measured at 16 and 20 μg/L. Streaks of accumulating BGA were observed surrounding the boats and dock at this site. Perhaps the BGA were pushed by the waves resulting from the rocking boats. BGA surface accumulations were not visually detected in the majority of the images, a finding consistent with the sample analyses. We suggest that the BGA were not concentrated enough and/or their distributions were too uniform in the images for visual discrimination. We are still working on algorithms to calculate the concentration of algae based on the image data.

The drone images revealed an occasional ring composed of accumulating BGA and other debris around the aerator's bubbles (Fig. 12). For example, 30 m diameter rings formed around the aeration bubbler sites at the Yacht Club on 9-16. White-foam streaks, that form and float at the surface due to wind-blown Langmuir circulation cells, were also disturbed by the aeration bubblers at Glenwood on 9-30, and the foam was displaced 10 to 15 m to either side of the bubbles in an parabolic pattern. It appears that waves formed by the bubbles breaking the

water's surface could push surface scums of BGA and foam radially outward approximately 10 to 15 meters away from the bubble's surface-breaking origin.

The ring formation and their 30 m, i.e., limited, diameters introduces an interesting question. Did the mitigation technologies have a greater impact at some locations because they were deployed closer to the dock where samples were collected? Three aerator sites, N Burtis, S Burtis and Indian Cove, detected only two days of BGA blooms compared to three or more suspected blooms at the other mitigation sites. The aerators at these three sites were positioned at or very close to the docks compared to the other mitigation sites. The ultrasonic devices at S Martin and the Yacht Club were deployed farther away from the sample docks than any of the aeration bubblers, and these two sites along with one aerator site (Fire Lane 6) experienced the largest number of blooms. This speculation however is tentative at this time because separation between the most (4) and least (1) number of blooms is very small, and may be subject to other factors like missed blooms at any of the sites, and other issues with deploying ultrasonic devices in shallow water identified above. Similar rings were not detected around the ultrasonic devices (Fig. 12). It suggests that a BGA sensor string should be deployed at each device extending at along surface from the device to open water and/or towards shore, and vertically in the water column at the device to quantify the concentration and displacement distances in the future.

Wind Speed, Wind Direction, Air & Water Temperatures: Dock-side wind speeds ranged from 0 to 3.9 m/s (~8 mph), and averaged 1.6 m/s on the survey dates. Appendix D (wind) & E (temperature) tabulates the raw data. The strongest winds were detected on 9-30, and the weakest winds on 9-16. Wind speed appears to impact FluoroProbe BGA concentrations. BGA concentrations never exceeded 1.5 mg/L, and averaged 0.5 mg/L, when wind speeds at the docks exceeded 1.5 m/s (3.5 mph, Fig. 13a).

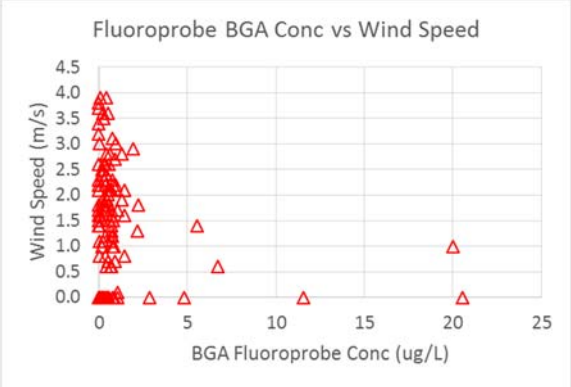


Fig. 13a. Wind speeds vs. FluoroProbe BGA concentrations that indicate that even gentle winds (>1.5 m/s) appear to limit BGA accumulations.

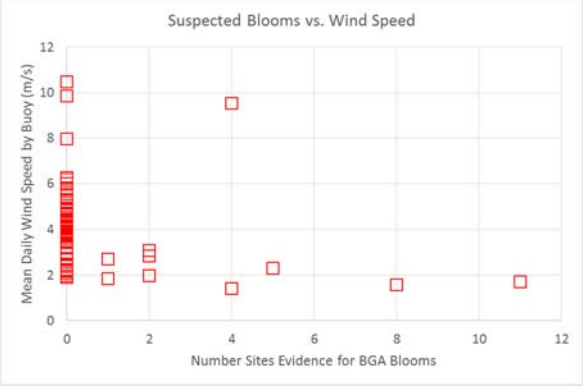


Fig. 13b. Buoy mean daily wind speed vs. suspected blooms detected in the homeowner photographs. Again, BGA accumulations are restricted to calm weather except on 8-21.

More frequent wind data are required to test the relationship between wind speed and suspected blooms detected by the homeowner photographs. The FLI Monitoring Buoy records wind speeds at 30 minute intervals. Daily mean wind speeds calculated from the buoy wind speed data correlate nicely with available dockside data and thus can be used as a proxy to dockside data ($r^2 = 0.6$, Fig. 14). The offshore winds were a few m/s faster than the measured dockside data, and these differences can be attributed to the more protected nearshore locations than

offshore. Plotting the number of suspected blooms on any given day detected by the homeowner photographs and the HABs Surveillance Team versus mean daily wind speed detected at the buoy suggests that BGA blooms prefer calm or near calm conditions except on 8-21 (Fig. 13b). The four suspected bloom sites on 8-21 were more protected from the south-southeasterly winds than the other sites.

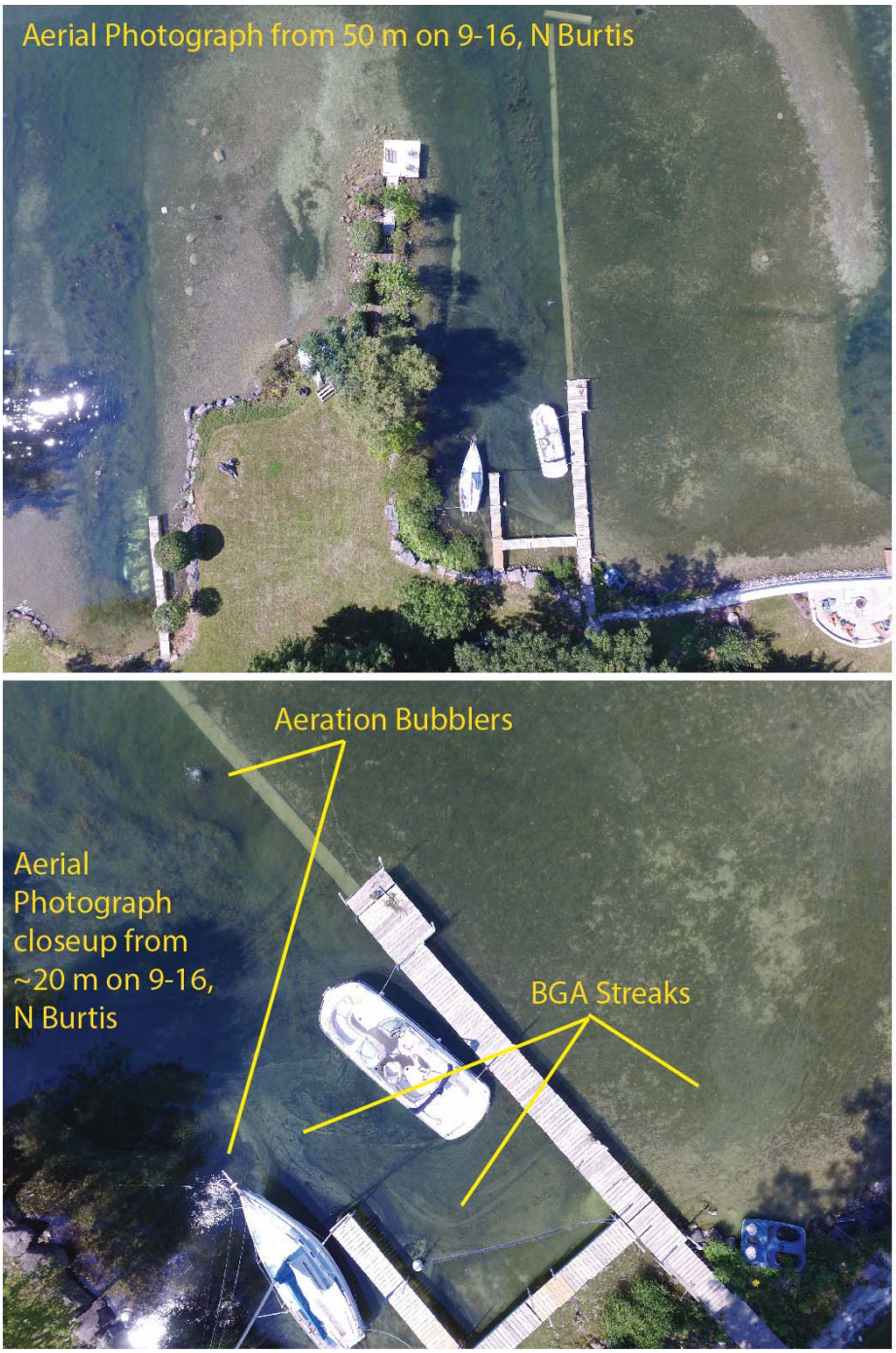


Fig. 11. Streaks of BGA at the N Burtis site from 50 and 20 m above the lake surface.

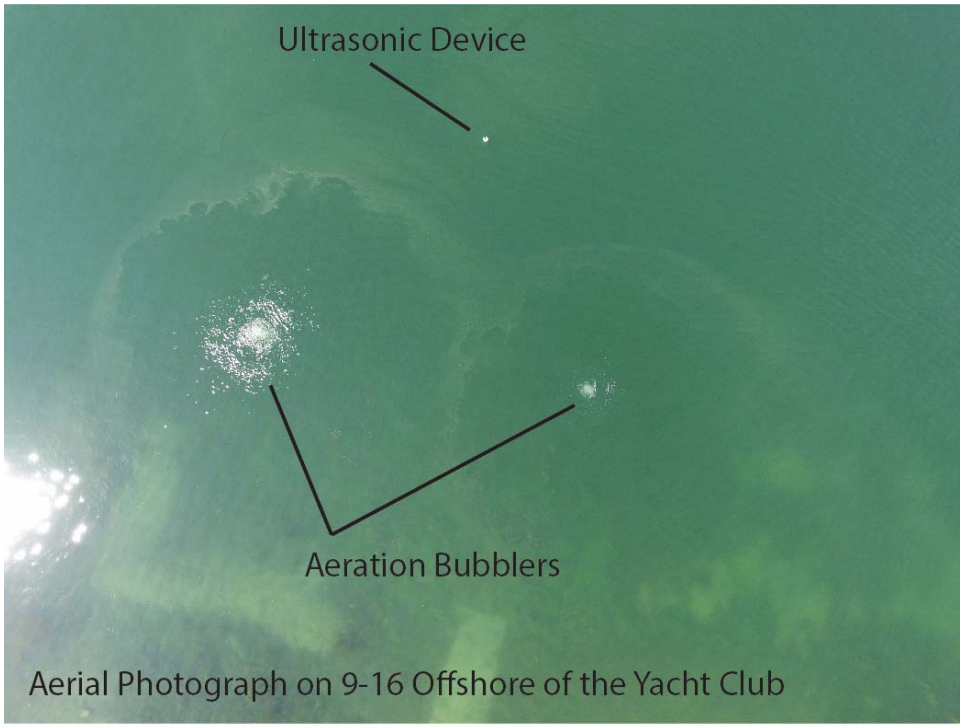
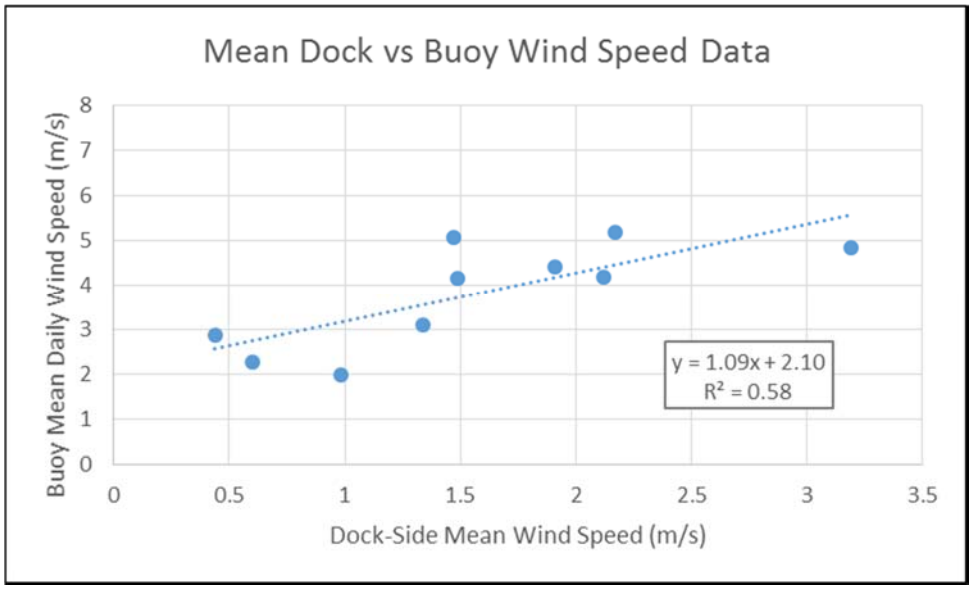


Fig. 12. BGA circles and white-foam streaks displaced around the aeration bubbles at the Yacht Club (above) and Glenwood (below) sites. It suggests that the aeration bubbler devices push surface accumulations of materials up to ~30 meters (~100 ft) away from the bubbles, even on windy days.



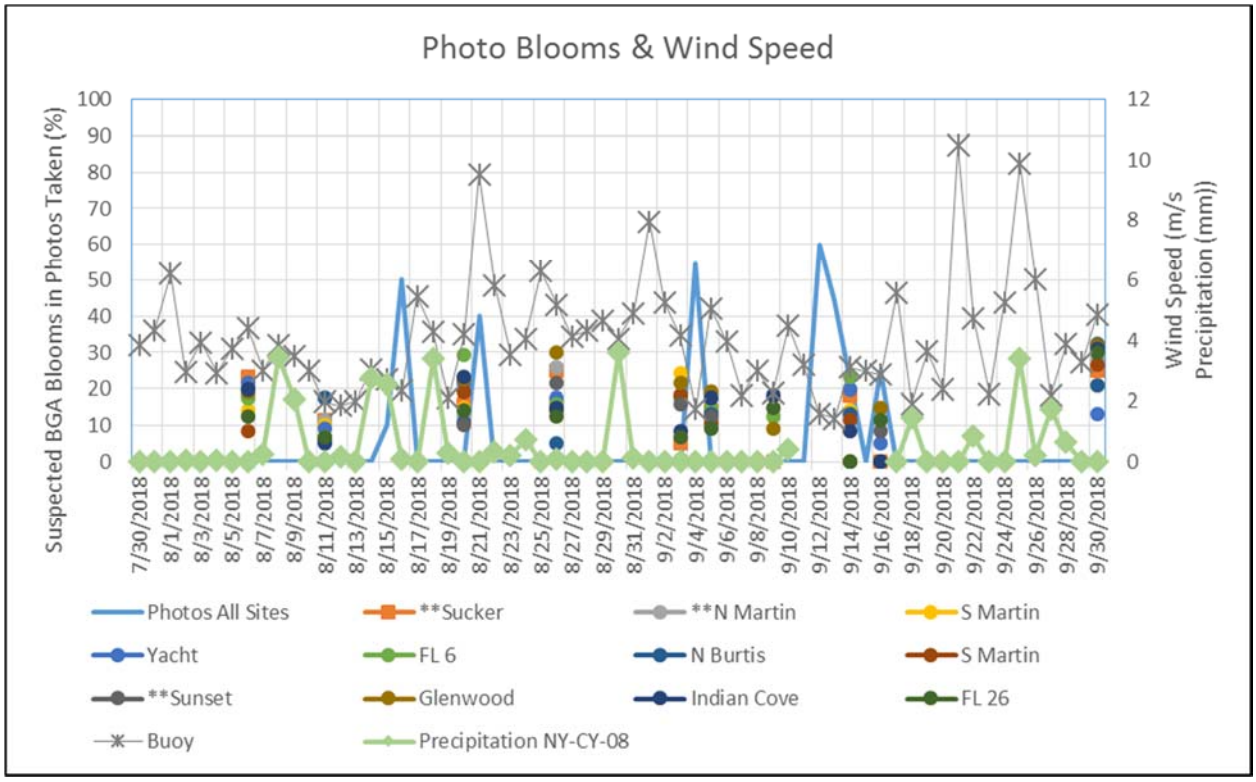


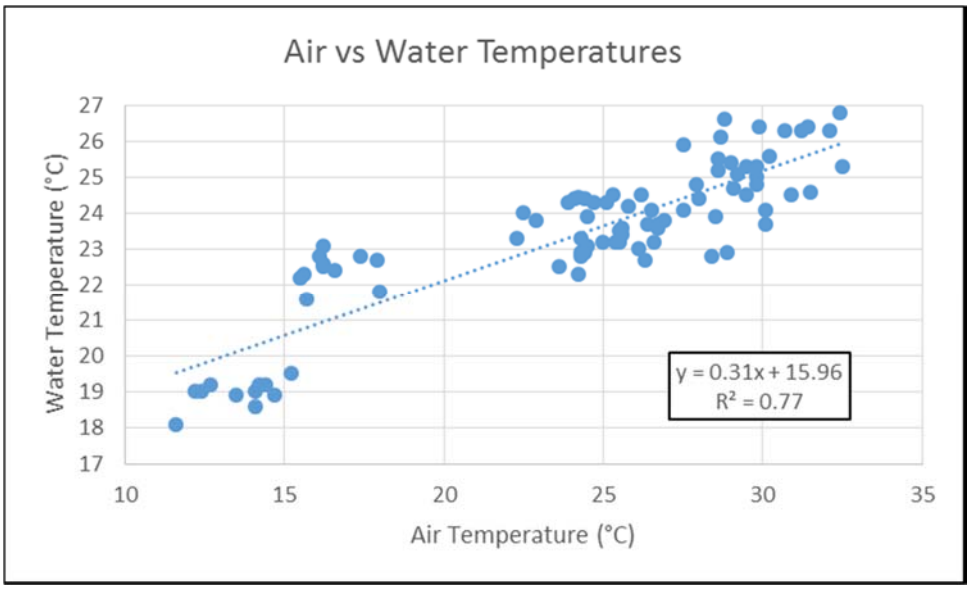
Fig. 14. Wind speed detected at the FLI monitoring buoy weakly correlated to the dockside measurements (above). Wind speeds vs the homeowner record of suspected blooms (below). It appears that more blooms were detected on calmer days just after rain events.

Calm days were not a unique predictor, because every calm day did not generate a bloom. It only suggests that calm winds and sites protected from offshore winds allow the development of surface accumulations of nearshore BGA blooms, or, more appropriately, windy days and their waves disrupt and/or prevent surface accumulations of BGA and BGA blooms. Calm conditions for blooms also suggest that winds do not push the blooms towards the shoreline locations but

they instead probably form in place in Owasco Lake. In support, the nearshore sediments have sufficient phosphorus for the detected blooms from decaying macrophytes, mussel excretions and other sources (Halfman et al., 2017a). More detailed, e.g., hourly, monitoring of the nearshore locations in the future for wind speeds and bloom status would provide a stronger test of this relationship. Nitrogen fluxes from the sediments should also be analyzed as well as mussel and macrophytes densities. We note that many days with some wind in the daily average were actually calm for a portion of the day.

Dock-side air temperatures measured in this study ranged from 11.6 to 32.5°C (53 to 90°F), and averaged 24°C (75°F), and dock-side water temperatures ranged from 18.1 to 26.8°C (65 to 80°F) and averaged 23.4°C (74°F, Appendix E). Air and water temperatures correlated nicely (r^2 = 0.8); the air experienced larger temperature swings than the water, as expected (Fig. 15). Like wind speeds, minimal correlation was found between the weekly temperatures measured at each site and the BGA and toxin concentrations other than suspected blooms were detected when the water was above 20°C, but blooms did not develop on every > 20°C day.

Daily air and surface water temperatures were also measured by the FLI monitoring buoy. The dockside water temperatures correlated very well to the buoy surface water temperatures (r^2 = 0.98, Fig. 15). The shallower, nearshore sites are cooler than the offshore buoy during cooling trends and warmer during warming trends, as expected, because the docks are at shallower locations with thinner thicknesses (mass) of water to warm up or cool down.



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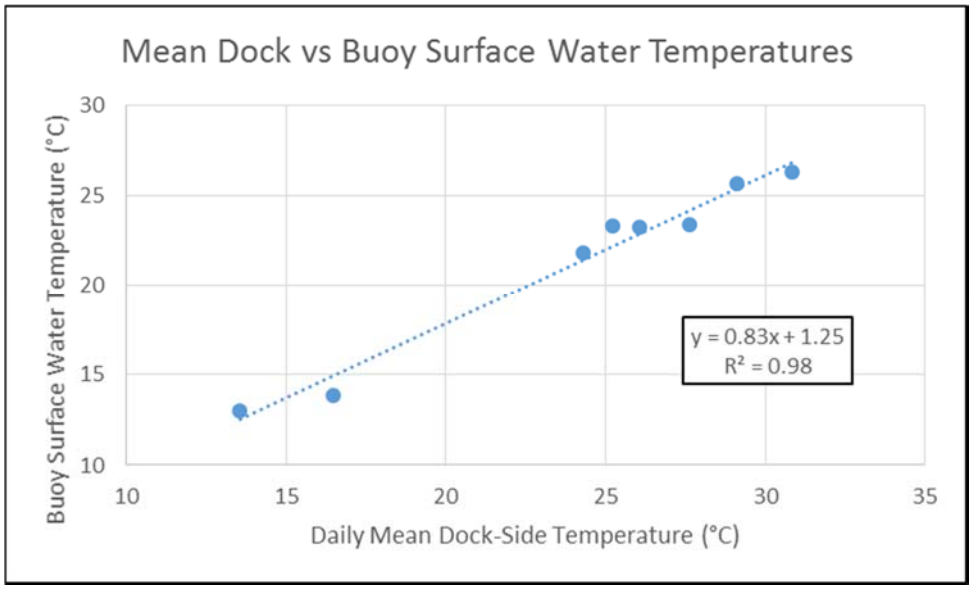

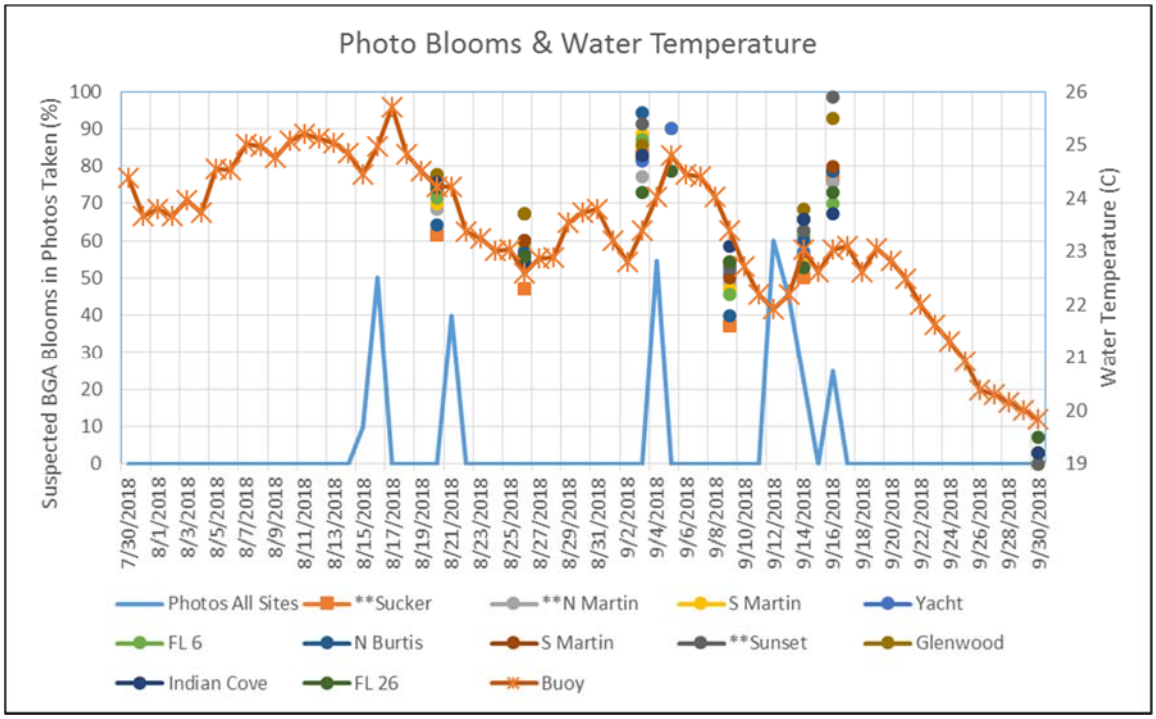

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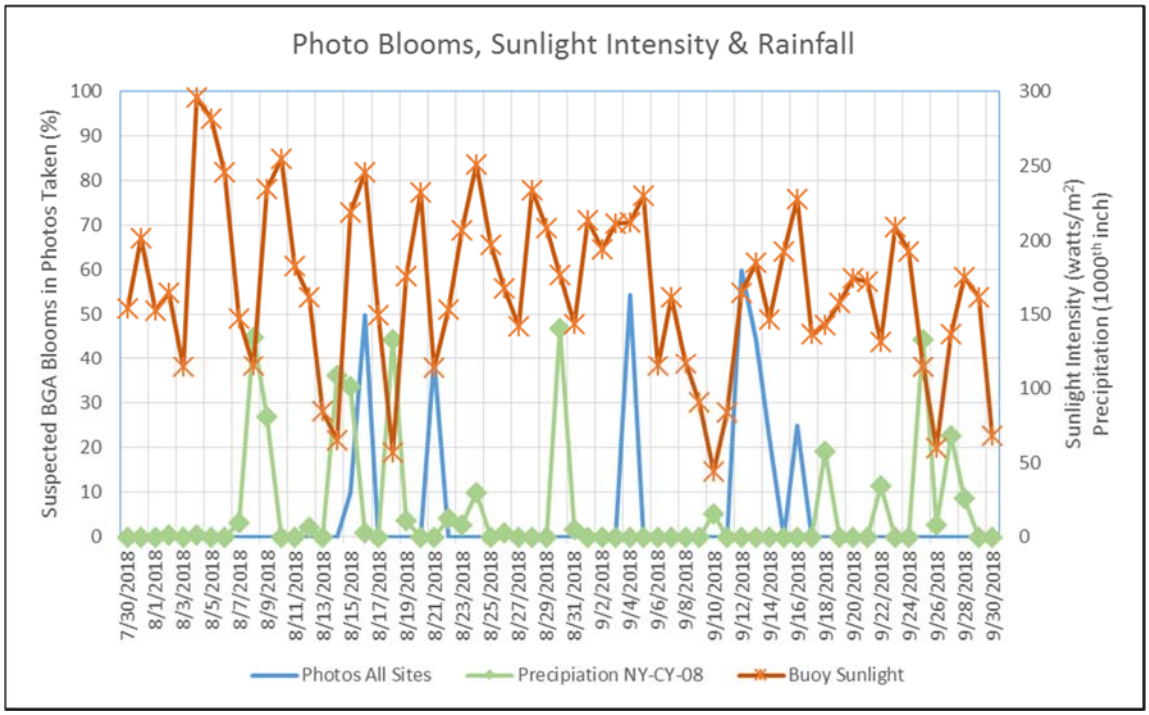

Fig. 15. Air and water temperatures measured at each site correlate nicely (above), as do daily mean dock and buoy surface water temperatures (middle top). Water temperatures appear to dip a day or two before the majority of the suspected blooms detected in the homeowner photographs (middle bottom). Finally, sunlight intensity appear to dip before a bloom then peak during the bloom. Perhaps a storm brought in cooler temperatures, introduced nutrients (runoff or sediment disturbance) and enough wave turbulence to release resting BGA from the sediments. It all facilitated a BGA bloom on the first subsequent calm and sunny day.

A comparison of the daily mean buoy air and surface water temperatures to the suspected bloom history in the homeowner photos suggest that the blooms appeared after a dip in air and water temperatures but blooms were not detected after every temperature dip (Fig. 15). A similar temperature dip then bloom occurrence was discovered last year, and it was speculated at that time, that cooler weather from associated winds and/or storm activity could introduce more nutrients from runoff and/or from disturbance of the sediments by waves. The wave turbulence may also release resting stage BGA cells from the sediments to the water column. These factors then combined to increase the chance for a BGA bloom.

In support, mean daily wind speeds measured by the FLI buoy were higher a day or two before many of the detected blooms. Buoy mean daily sunlight intensity (measured as light intensity) data averaged from the 30-minute measurements also dipped lower just before a bloom (less light ➔ more clouds – more stormy weather). Blooms also appeared after rainfall events using the adjacent NY-CY-08, CoCoRaHS site's daily precipitation data. Sunlight was more intense (sunny cloud-free days) during the subsequent bloom (Fig. 15). Perhaps the cooler temperature during the storm event released nutrients, i.e., more runoff and/or sediment disturbance by waves, combined with sediment disturbance that released resting BGA cells from the sediments. Then all these factors coalesced into a BGA bloom on the first subsequent calm and sunny day. The data presented here and the lack of major blooms during sample dates does not exclude bloom development and formation due to other factors. Calm weather may facilitate

concentration of BGA at the lake surface, and subsequent slight winds may further concentrate them along the shoreline. These factors complicate the interpretation of the ultrasonic data.

CONCLUSIONS

This project was designed to scientifically assess the impact of three types of BGA mitigation devices. However, 2018 experienced far fewer blooms at these sites than previous years and made the assessment very challenging. The statistically similar and low concentrations of BGA, their toxins, and the percentage of BGA in the plankton assemblages, as well as the infrequent nature of the blooms in 2018, hampered the assessment process.

PROMISING OUTCOMES AND FUTURE RECOMMENDATIONS

This assessment should be performed again in the future to test some promising outcomes. The methodology should be tweaked to overcome some of the challenges observed in this study. The promising outcomes and suggested tweaks to future research are highlighted below.

- The photographic data suggested that BGA blooms are transitory over both space and time. This requires confirmation and future images should be collected on a more frequent basis, e.g., hourly, and at more sites to avoid missing blooms.
- BGA concentrations and its percentage of the plankton assemblage increased just before a bloom. The increase, if confirmed by future research, may provide a bloom predictor tool.
- The observed change in microcystin concentrations spanning a no bloom, bloom to no bloom sequence suggests that the toxin may appear and disappear with the BGA bloom, and not linger in the water afterwards. Additional no blooms, bloom, no bloom sequences must be investigated to determine if this is a general rule.
- The transitory nature of the BGA indicate that an array of water quality sensors measuring, e.g., fluorescence (total and BGA), turbidity, temperature, dissolved oxygen, and meteorological sensors measuring, e.g., wind speed, wind direction, air temperature, precipitation and light intensity should be deployed at numerous sites to monitor these parameters on an hourly basis to better understand the limnological and atmospheric conditions for the development and decay of BGA blooms.
- Aerators appeared to push surface BGA up to 30 meters away from the bubbles. Future efforts should place a string of BGA phycocyanin sensors on a 50 m horizontal, lake surface transect. The string should originate at the device and extend radially away from the device to assess if the BGA concentrations change along the transect. Another sensor string should be placed vertically in the water column at, or near, the device to assess the vertical distribution and potential migrations of BGA. Control sites are also required.
- A similar test should be performed at the ultrasonic devices.
- Homeowners may want to decrease the distance from their dock to the device to maximize the potential benefits, although the repositioning might push the BGA towards and concentrate them along the shoreline.
- Wind and/or storms events may initiate BGA blooms. Perhaps a dip to cooler water temperatures, stronger winds and/or stormy weather released nutrients and resting BGA cells from the sediments to facilitate a BGA bloom on the next subsequent calm and sunny day.

Acknowledgements: We thank the numerous homeowners (and/or their neighbors/proxies) for the daily photographs and access to their docks to sample the lake; and the field and laboratory team, Katie Valicenti, Shelby Johnson, Josh Andrews, Barb Halfman, Trevor Massey and Kely Amejecor for their help in the field and/or in the laboratory. We also thank Peter Rogers (an OWLA volunteer) for his diligent work compiling and assessing the occurrence of BGAs in the daily photographs from the homeowners, and Dana Hall (another OWLA volunteer) for his diligence as Program Manager and persistence at developing and submitting multiple drafts of a Data Usability Assessment Report (DUAR). Thanks are extended to many members of NYS-DEC, especially Anthony Prestigiacomo, who reviewed multiple drafts of the QAPP, DUAR and the two final reports. Their comments greatly improved the earlier drafts. Financial support to Halfman was provided by a subcontract from the Owasco Watershed Lake Association. The ultimate source of the funds was the NYS Environmental Protection Fund, with budget details overseen by Cayuga County Community College.

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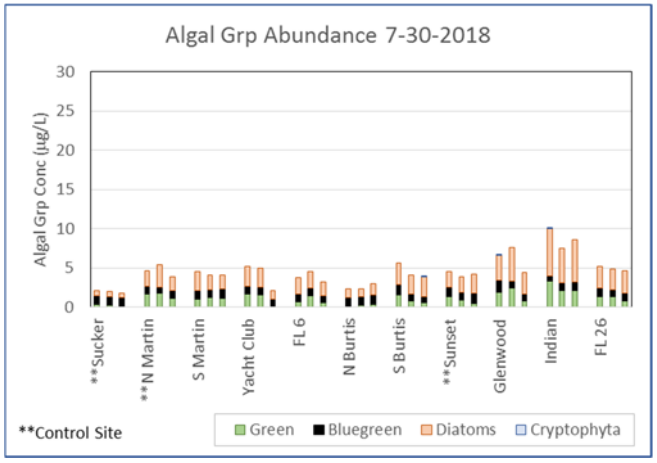
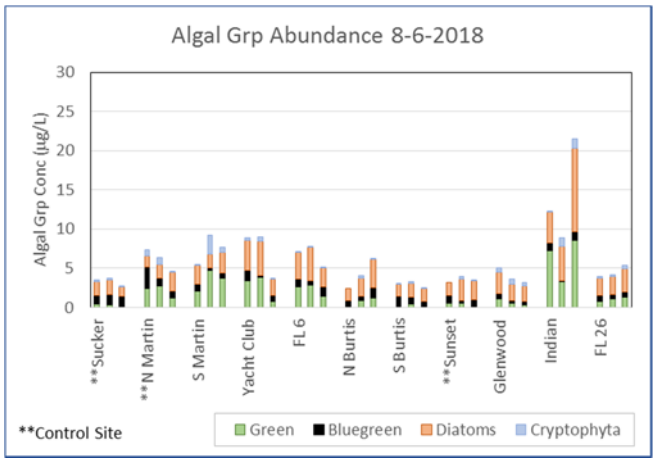
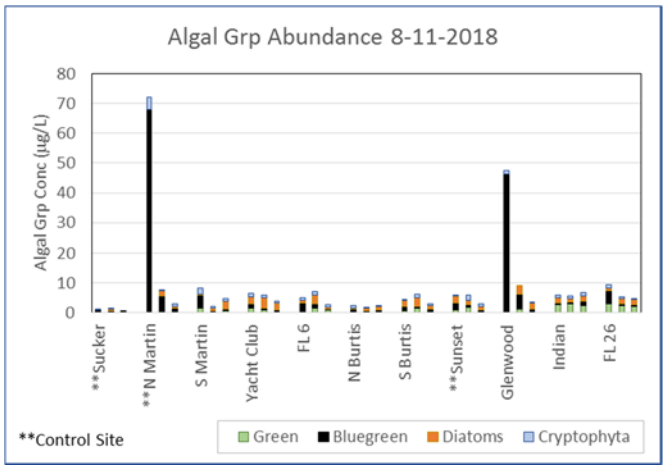
APPENDIX A: DAILY BBE FLUOROPROBE AND PLANKTON ID RESULTS

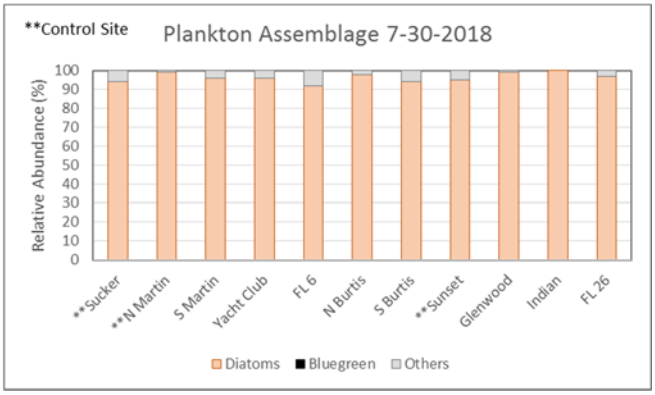
bbe FluroProbe Results (µg/L)

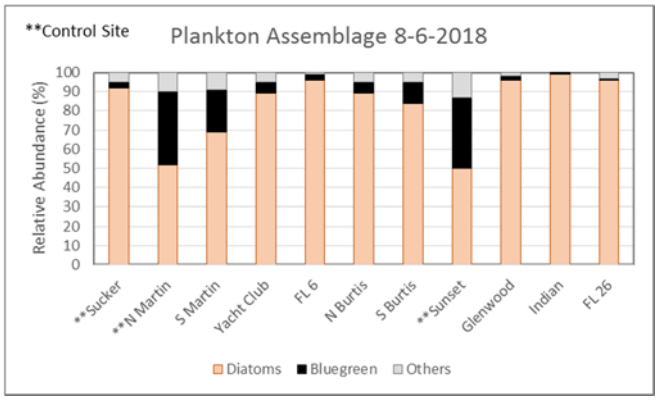


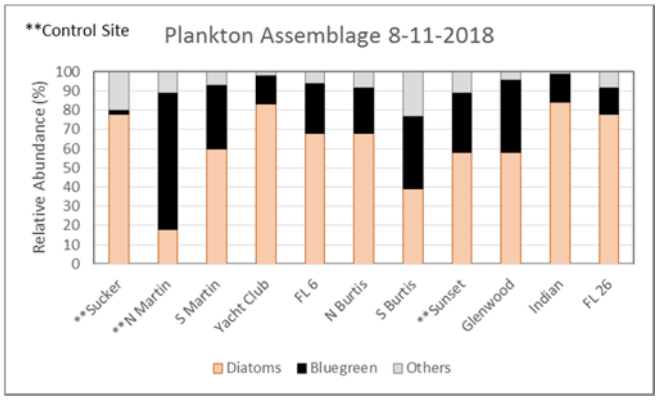


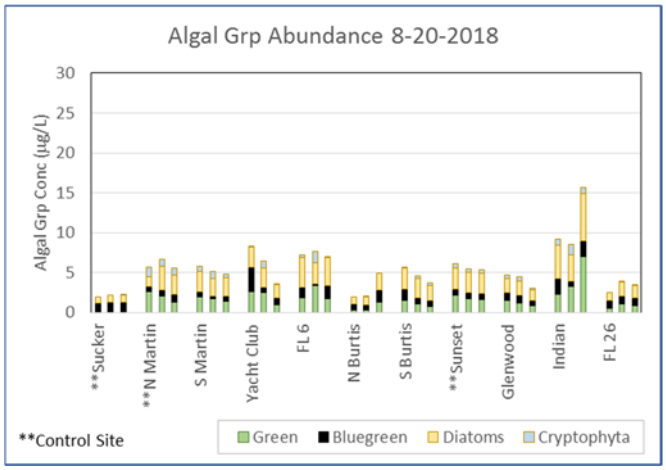


Plankton ID Results (Relative %)





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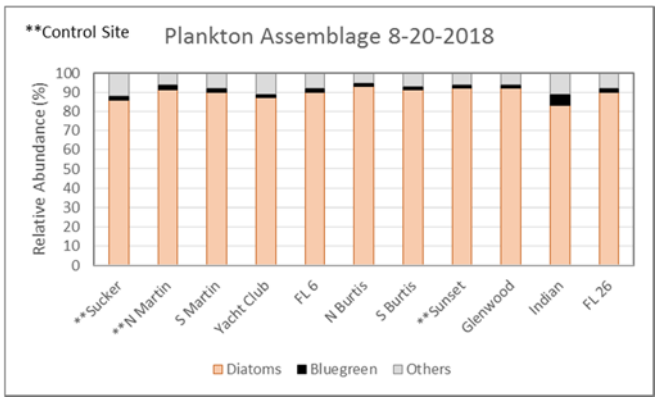
Algal Grp Conc (µg/L)
30
25
20
15
10
5
0
**Sucker
**N Martin
S Martin
Yacht Club
FL 6
N Burtis
S Burtis
**Sunset
Glenwood
Indian
FL 26
**Control Site
Green
Bluegreen
Diatoms
Cryptophyta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70
60
50
40
30
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10
0
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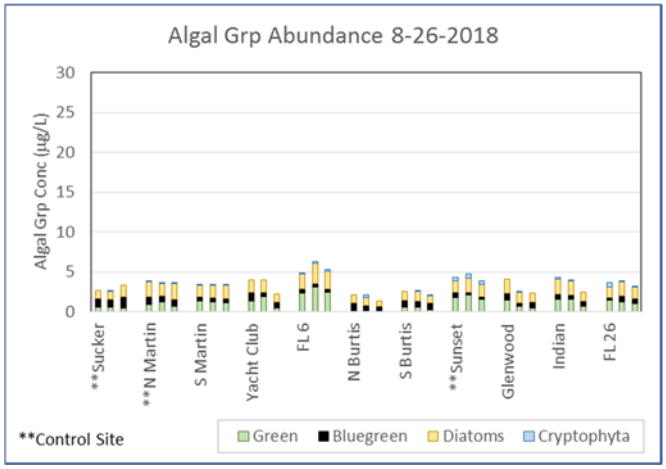
S Martin
Yacht Club
FL 6
N Burtis
S Burtis
**Sunset
Glenwood
Indian
FL 26
Diatoms
Bluegreen
Others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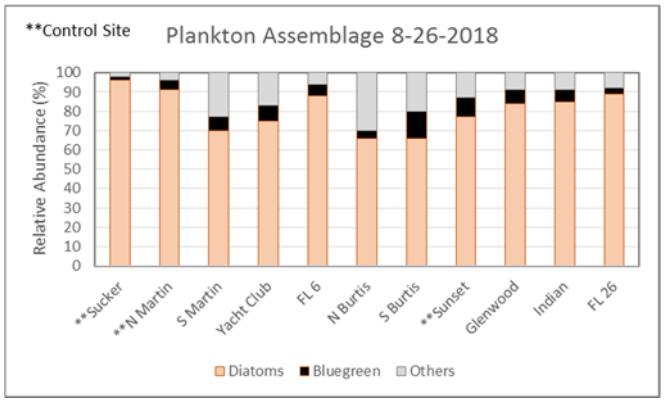
S Martin
Yacht Club
FL 6
N Burtis
S Burtis
**Sunset
Glenwood
Indian
FL 26
**Control Site
Green
Bluegreen
Diatoms
Cryptophyta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60
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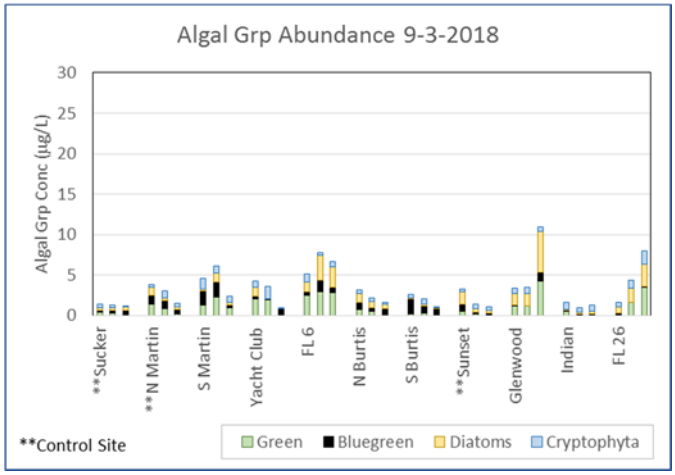
Yacht Club
FL 6
N Burtis
S Burtis
**Sunset
Glenwood
Indian
FL 26
Diatoms
Bluegreen
Others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FL 6
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S Burtis
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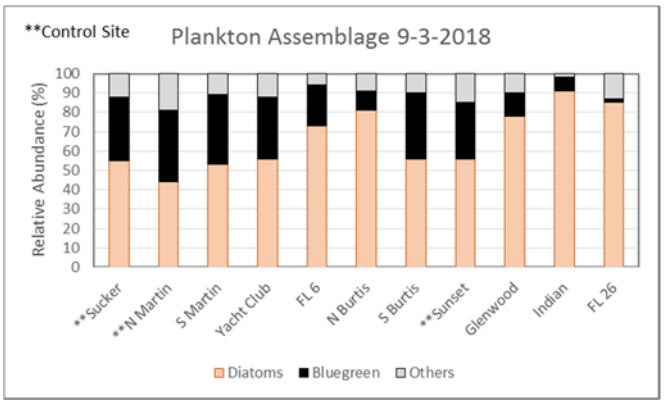
Glenwood
Indian
FL 26
**Control Site
Green
Bluegreen
Diatoms
Cryptophyta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FL 6
N Burtis
S Burtis
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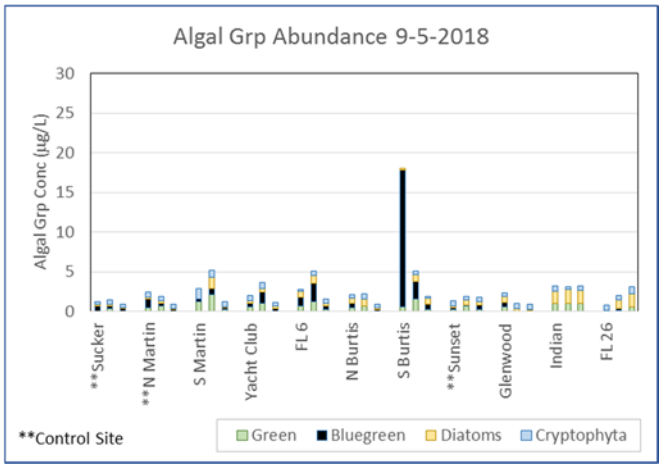
Glenwood
Indian
FL 26
Diatoms
Bluegreen
Others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Yacht Club
FL 6
N Burtis
S Burtis
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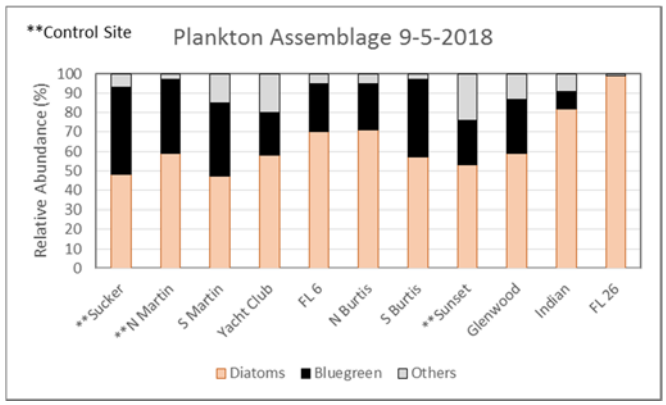
Glenwood
Indian
FL 26
**Control Site
Green
Bluegreen
Diatoms
Cryptophyta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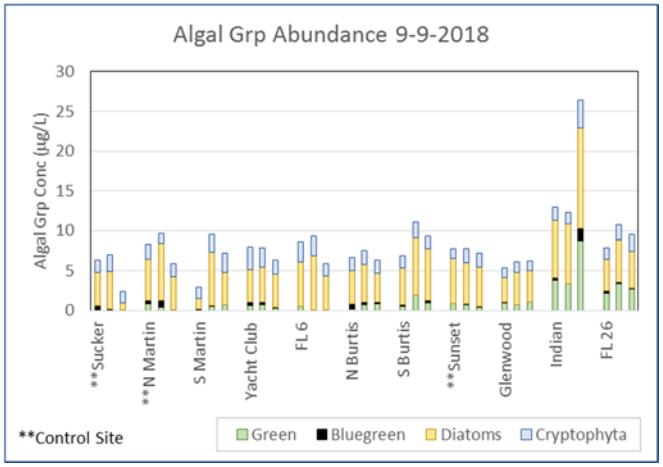
Yacht Club
FL 6
N Burtis
S Burtis
**Sunset
Glenwood
Indian
FL 26
Diatoms
Bluegreen
Others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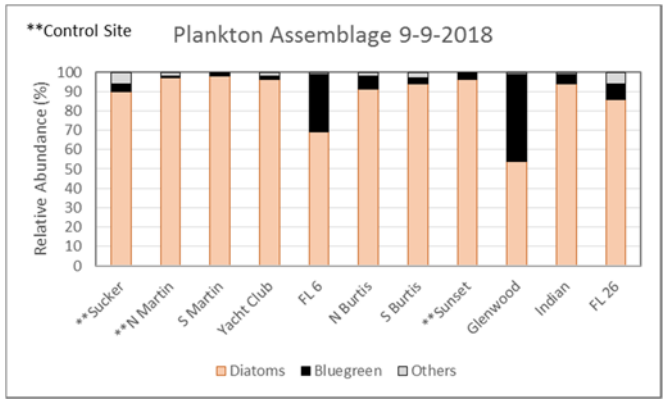
Yacht Club
FL 6
N Burtis
S Burtis
**Sunset
Glenwood
Indian
FL 26
**Control Site
Green
Bluegreen
Diatoms
Cryptophyta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Plankton Assemblage 9-9-2018
Relative Abundance (%)
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60
50
40
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10
0
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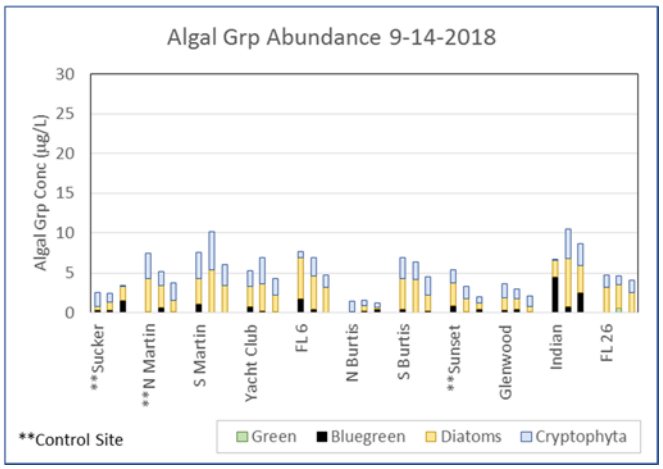
S Martin
Yacht Club
FL 6
N Burtis
S Burtis
**Sunset
Glenwood
Indian
FL 26
Diatoms
Bluegreen
Others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Algal Grp Conc (µg/L)
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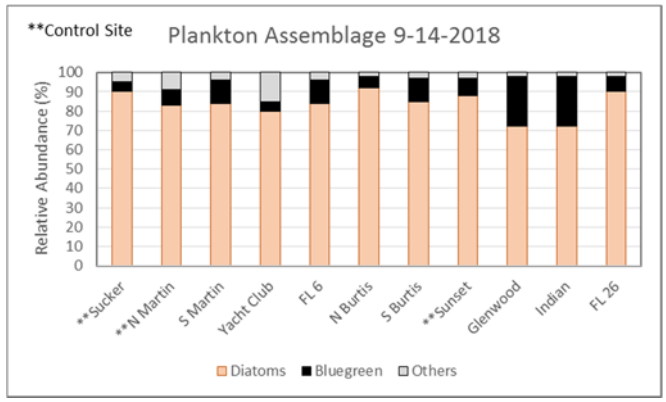
S Burtis
**Sunset
Glenwood
Indian
FL 26
**Control Site
Green
Bluegreen
Diatoms
Cryptophyta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Relative Abundance (%)
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Yacht Club
FL 6
N Burtis
S Burtis
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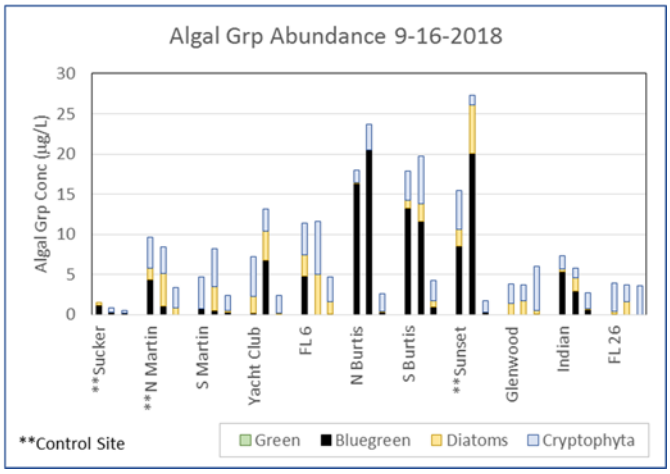
Glenwood
Indian
FL 26
Diatoms
Bluegreen
Others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S Burtis
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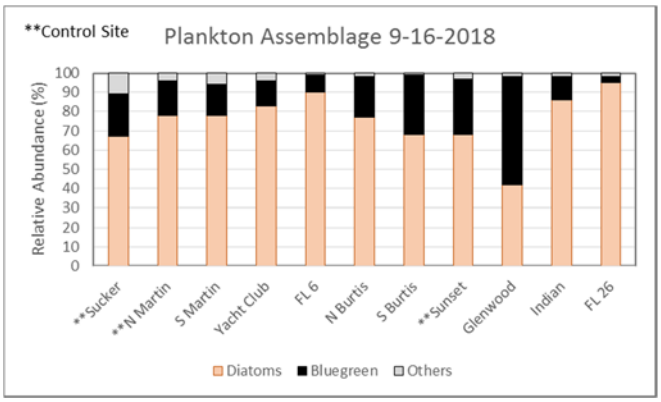
Glenwood
Indian
FL 26
**Control Site
Green
Bluegreen
Diatoms
Cryptophyta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Plankton Assemblage 9-16-2018
Relative Abundance (%)
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80
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60
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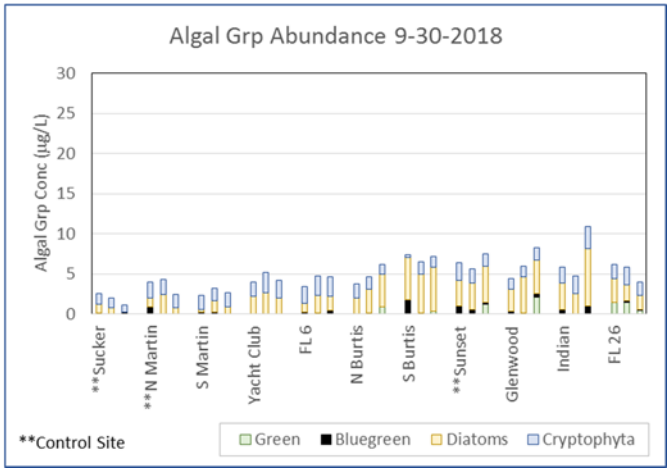
Yacht Club
FL 6
N Burtis
S Burtis
**Sunset
Glenwood
Indian
FL 26
Diatoms
Bluegreen
Others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Algal Grp Conc (µg/L)
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S Burtis
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Glenwood
Indian
FL 26
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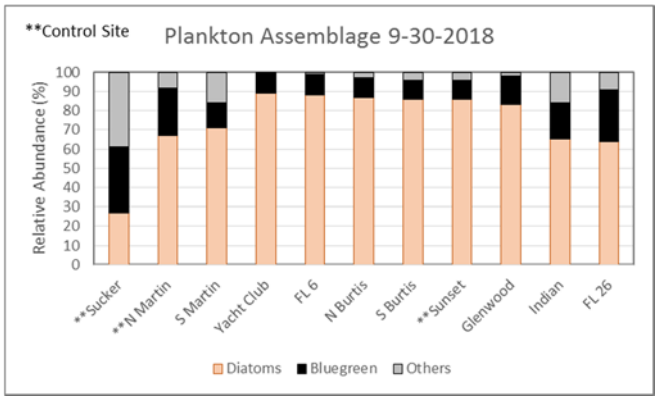
Green
Bluegreen
Diatoms
Cryptophyta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Plankton Assemblage 9-30-2018
Relative Abundance (%)
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80
70
60
50
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30
20
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0
**Sucker
**N Martin
S Martin
Yacht Club
FL 6
N Burtis
S Burtis
**Sunset
Glenwood
Indian
FL 26
Diatoms
Bluegreen
Others

APPENDIX A (CONTINUED): DAILY BBE FLUOROPROBE RAW DATA (µG/L)

7/30/2018						8/6/2018						8/11/2018					
Location	Green	Diatoms	Bluegreen	Cryptophyta	% BGA	Location	Green	Diatoms	Bluegreen	Cryptophyta	% BGA	Location	Green	Diatoms	Bluegreen	Cryptophyta	% BGA
**Sucker	0.3	0.6	1.1	0.0	54.2	**Sucker	0.4	1.8	1.1	0.2	30.7	**Sucker	0.0	0.2	0.8	0.0	79.9
Su-OS	0.3	0.7	1.1	0.0	52.7	Su-OS	0.3	1.9	1.3	0.2	35.4	Su-OS	0.0	0.5	0.7	0.0	56.0
Su-OD	0.0	0.6	1.2	0.0	68.5	Su-OD	0.1	1.2	1.3	0.1	50.2	Su-OD	0.0	0.0	0.7	0.0	100.0
**N Martin	1.6	2.0	1.0	0.0	21.4	**N Martin	2.4	1.4	2.8	0.7	38.4	**N Martin	0.0	0.0	68.0	4.0	94.5
NM-OS	1.7	2.9	0.8	0.0	14.1	NM-OS	2.7	1.7	1.0	0.9	15.2	NM-OS	0.0	1.7	5.5	0.0	76.6
NM-OD	1.1	1.7	1.1	0.0	27.8	NM-OD	1.1	2.4	0.9	0.1	20.2	NM-OD	0.0	0.8	1.4	0.7	48.6
S Martin	1.1	2.3	1.1	0.0	24.6	S Martin	2.1	2.5	0.9	0.1	15.5	S Martin	1.4	0.4	4.4	2.1	53.0
SM-OS	1.2	1.8	1.0	0.0	25.5	SM-OS	4.7	1.7	0.3	2.4	3.7	SM-OS	0.0	0.8	0.7	0.6	33.8
SM-OD	1.2	1.9	1.1	0.0	26.9	SM-OD	3.7	2.7	0.7	0.7	9.1	SM-OD	0.6	2.5	0.8	0.9	16.1
Yacht Club	1.7	2.5	0.9	0.0	18.0	Yacht Club	3.3	3.9	1.3	0.3	14.8	Yacht Club	1.4	2.3	1.6	1.2	24.7
YC-OS	1.6	2.4	1.0	0.0	19.4	YC-OS	3.8	4.3	0.3	0.5	2.9	YC-OS	0.8	3.4	0.7	1.1	11.7
YC-OD	0.1	1.1	0.9	0.0	42.2	YC-OD	0.8	2.1	0.7	0.0	20.0	YC-OD	0.4	2.3	0.7	0.6	18.0
FL 6	0.7	2.1	1.0	0.0	26.8	FL 6	2.6	3.3	1.0	0.1	14.6	FL 6	0.1	0.7	3.2	0.9	65.5
F6-OS	1.4	2.0	1.0	0.0	23.3	F6-OS	2.8	4.3	0.6	0.1	7.8	F6-OS	1.5	2.8	1.4	1.4	20.3
F6-OD	0.6	1.7	0.9	0.0	27.1	F6-OD	1.4	2.4	1.1	0.0	22.9	F6-OD	0.8	0.7	0.3	0.7	12.9
N Burtis	0.0	1.0	1.3	0.0	54.9	N Burtis	0.1	1.5	0.7	0.0	29.4	N Burtis	0.0	0.3	1.3	0.6	57.0
NB-OS	0.2	0.9	1.1	0.0	48.4	NB-OS	0.8	2.3	0.6	0.3	13.8	NB-OS	0.0	0.9	0.7	0.1	42.5
NB-OD	0.3	1.5	1.2	0.0	40.7	NB-OD	1.1	3.6	1.4	0.1	22.7	NB-OD	0.4	1.2	0.7	0.2	27.9
S Burtis	1.6	2.7	1.3	0.0	23.7	S Burtis	0.0	1.6	1.4	0.0	46.8	S Burtis	0.6	1.9	1.6	0.3	36.3
SB-OS	0.8	2.5	0.9	0.0	21.2	SB-OS	0.4	1.8	0.9	0.2	26.9	SB-OS	1.6	2.8	0.5	1.2	8.9
SB-OD	0.5	2.5	0.8	0.0	21.4	SB-OD	0.0	1.6	0.8	0.1	31.2	SB-OD	0.1	1.1	1.0	0.7	34.9
**Sunset	1.4	2.0	1.2	0.0	26.0	**Sunset	0.5	1.6	1.0	0.0	31.6	**Sunset	0.9	2.3	2.3	0.3	40.0
Sn-OS	1.0	2.0	0.9	0.0	24.0	Sn-OS	0.5	2.7	0.4	0.3	10.4	Sn-OS	1.9	1.4	0.9	1.8	15.4
Sn-OD	0.5	2.3	1.4	0.0	32.9	Sn-OD	0.1	2.4	0.9	0.1	25.5	Sn-OD	0.0	1.2	0.9	0.7	32.3
Glenwood	1.9	3.1	1.6	0.0	23.9	Glenwood	1.1	2.7	0.7	0.5	13.5	Glenwood	0.0	0.1	46.3	1.2	97.3
Gl-OS	2.5	4.3	0.8	0.0	10.7	Gl-OS	0.6	2.0	0.3	0.7	9.6	Gl-OS	1.3	3.1	4.8	0.0	52.4
Gl-OD	0.7	2.7	1.0	0.0	22.1	Gl-OD	0.3	1.9	0.4	0.5	13.9	Gl-OD	0.1	1.9	1.1	0.3	32.8
Indian	3.3	6.1	0.6	0.0	6.2	Indian	7.2	3.9	1.0	0.0	8.0	Indian	2.7	1.8	0.7	0.8	12.0
In-OS	2.2	4.3	1.0	0.0	12.8	In-OS	3.3	4.4	0.2	1.1	1.8	In-OS	2.8	1.1	0.7	1.1	12.6
In-OD	2.1	5.4	1.0	0.0	11.9	In-OD	8.5	10.7	1.1	1.2	5.2	In-OD	2.3	1.8	1.5	1.1	22.3
FL 26	1.3	2.8	1.1	0.0	20.7	FL 26	0.8	2.2	0.7	0.2	19.1	FL 26	3.0	0.9	4.3	1.2	45.6
F26-OS	1.3	2.5	0.9	0.0	19.4	F26-OS	1.0	2.3	0.6	0.2	14.6	F26-OS	2.5	2.0	0.4	0.4	6.9
F26-OD	0.8	2.8	1.0	0.0	22.0	F26-OD	1.3	2.9	0.7	0.4	12.6	F26-OD	2.1	1.7	0.6	0.3	12.1
	Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA
7-30 Control	0.9	1.6	1.1	0.0	30.1	Controls 8-6	0.9	1.9	1.2	0.3	27.7	Controls 8-11	0.3	0.9	9.0	0.8	81.6
Ultrasonic	1.1	2.0	1.0	0.0	24.2	Ultrasonic	3.1	2.9	0.7	0.7	9.6	Ultrasonic	0.7	1.9	1.5	1.1	28.2
Airmax	1.2	2.8	1.0	0.0	20.1	Airmax	1.9	3.1	0.8	0.3	13.1	Airmax	1.2	1.5	4.0	0.7	53.9
	Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA
7-30 Nearshore	1.4	2.5	1.1	0.0	27.3	8-6 Nearshore	1.9	2.4	1.1	0.2	23.9	8-11 Nearshore	0.9	1.0	12.2	1.2	55.1
Offshore Surface	1.3	2.4	1.0	0.0	24.7	Offshore Surface	1.9	2.7	0.6	0.6	12.9	Offshore Surface	1.1	1.9	1.6	0.7	30.6
Offshore Bottom	0.7	2.2	1.1	0.0	31.2	Offshore Bottom	1.7	3.1	0.9	0.3	21.2	Offshore Bottom	0.6	1.4	0.9	0.6	32.5

8/20/2018						8/26/2018						9/3/2018					
Location	Green	Diatoms	Bluegreen	Cryptophyta	% BGA	Location	Green	Diatoms	Bluegreen	Cryptophyta	% BGA	Location	Green	Diatoms	Bluegreen	Cryptophyta	% BGA
**Sucker	0.0	0.8	1.1	0.0	59.4	**Sucker	0.6	1.0	1.1	0.0	41.5	**Sucker	0.3	0.3	0.3	0.4	23.7
Su-OS	0.0	0.9	1.3	0.0	60.1	Su-OS	0.5	1.0	1.0	0.1	37.5	Su-OS	0.2	0.3	0.4	0.3	32.0
Su-OD	0.0	0.9	1.3	0.0	60.6	Su-OD	0.4	1.5	1.4	0.0	42.7	Su-OD	0.0	0.4	0.6	0.1	60.7
**N Martin	2.6	1.2	0.6	1.3	10.8	**N Martin	0.9	1.8	1.0	0.2	26.6	**N Martin	1.4	1.0	1.0	0.4	27.1
NM-OS	2.0	2.9	0.8	0.9	12.1	NM-OS	1.3	1.5	0.7	0.1	20.8	NM-OS	0.8	0.3	1.1	0.9	35.0
NM-OD	1.3	2.5	0.9	0.8	16.8	NM-OD	0.7	1.9	0.9	0.0	24.5	NM-OD	0.2	0.3	0.6	0.4	42.9
S Martin	1.9	2.6	0.7	0.7	12.0	S Martin	1.3	1.4	0.6	0.0	18.4	S Martin	1.3	0.2	1.8	1.3	39.0
SM-OS	1.7	2.2	0.4	0.9	7.2	SM-OS	1.3	1.6	0.5	0.0	14.9	SM-OS	2.2	1.1	1.9	0.9	31.5
SM-OD	1.4	2.3	0.6	0.5	13.2	SM-OD	1.2	1.6	0.5	0.0	16.1	SM-OD	0.9	0.3	0.4	0.8	14.6
Yacht Club	2.5	2.5	3.1	0.0	38.2	Yacht Club	1.3	1.6	1.1	0.0	27.7	Yacht Club	2.0	1.1	0.4	0.8	9.2
YC-OS	2.5	2.5	0.6	0.9	9.0	YC-OS	1.8	1.6	0.5	0.0	13.5	YC-OS	1.9	0.0	0.1	1.5	4.0
YC-OD	0.9	1.6	0.9	0.2	24.1	YC-OD	0.5	1.0	0.8	0.0	34.0	YC-OD	0.0	0.0	0.8	0.1	92.9
FL 6	1.8	3.8	1.3	0.3	17.5	FL 6	2.3	1.8	0.6	0.2	12.3	FL 6	2.4	1.2	0.4	1.0	8.5
F6-OS	3.4	2.6	0.3	1.5	3.3	F6-OS	3.1	2.5	0.5	0.2	7.3	F6-OS	3.0	3.0	1.5	0.4	18.7
F6-OD	1.7	3.5	1.7	0.0	25.2	F6-OD	2.5	2.2	0.4	0.2	7.9	F6-OD	2.8	2.5	0.7	0.7	11.0
N Burtis	0.2	0.8	0.8	0.0	43.5	N Burtis	0.1	1.1	0.9	0.0	43.3	N Burtis	0.7	1.1	0.9	0.4	29.5
NB-OS	0.3	1.0	0.7	0.1	35.1	NB-OS	0.2	0.9	0.7	0.3	32.7	NB-OS	0.5	0.8	0.4	0.4	19.8
NB-OD	1.3	2.0	1.6	0.0	32.0	NB-OD	0.0	0.7	0.7	0.0	48.9	NB-OD	0.1	0.6	0.7	0.2	45.7
S Burtis	1.5	2.6	1.5	0.1	25.8	S Burtis	0.6	1.0	0.9	0.0	36.2	S Burtis	0.1	0.1	1.9	0.5	71.6
SB-OS	1.1	2.3	0.8	0.4	16.6	SB-OS	0.6	1.3	0.7	0.0	28.3	SB-OS	0.3	0.3	0.8	0.6	38.9
SB-OD	0.7	1.9	0.8	0.4	20.5	SB-OD	0.2	0.9	0.9	0.0	44.9	SB-OD	0.0	0.0	0.9	0.1	87.4
**Sunset	2.1	2.7	0.8	0.5	13.0	**Sunset	1.7	1.5	0.7	0.4	15.4	**Sunset	0.5	1.6	0.9	0.3	26.7
Sn-OS	1.7	2.5	0.8	0.5	13.9	Sn-OS	2.1	1.8	0.4	0.5	8.3	Sn-OS	0.2	0.5	0.2	0.5	15.8
Sn-OD	1.6	2.5	0.8	0.4	15.7	Sn-OD	1.5	1.6	0.4	0.4	9.4	Sn-OD	0.0	0.3	0.3	0.5	28.0
Glenwood	1.4	1.8	1.0	0.4	21.7	Glenwood	1.4	1.8	0.9	0.0	22.3	Glenwood	1.1	1.4	0.2	0.6	6.1
Gl-OS	1.2	1.8	0.9	0.5	19.9	Gl-OS	0.6	1.3	0.5	0.1	20.8	Gl-OS	1.2	1.5	0.0	0.9	0.0
Gl-OD	0.9	1.3	0.7	0.2	21.6	Gl-OD	0.5	1.0	0.8	0.0	34.7	Gl-OD	4.3	5.0	1.1	0.6	9.9
Indian	2.3	4.2	2.0	0.7	21.7	Indian	1.6	1.8	0.7	0.2	16.3	Indian	0.5	0.1	0.2	0.9	9.7
In-OS	3.3	3.3	0.6	1.3	7.1	In-OS	1.6	1.7	0.5	0.2	13.1	In-OS	0.0	0.2	0.2	0.6	20.7
In-OD	7.0	6.0	2.0	0.8	12.5	In-OD	0.7	1.1	0.7	0.0	27.6	In-OD	0.0	0.4	0.2	0.8	11.8
FL 26	0.5	0.9	1.0	0.0	41.9	FL 26	1.4	1.3	0.4	0.6	10.9	FL 26	0.1	0.8	0.2	0.5	14.8
F26-OS	1.0	1.7	1.0	0.1	26.7	F26-OS	1.2	1.7	0.8	0.2	20.3	F26-OS	1.6	1.7	0.0	1.1	0.3
F26-OD	0.8	1.6	1.0	0.0	28.8	F26-OD	1.0	1.4	0.7	0.1	22.5	F26-OD	3.5	2.8	0.1	1.6	1.0
	Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA
8-20 Controls	1.3	1.9	0.9	0.5	20.8	8-26 Controls	1.1	1.5	0.8	0.2	23.3	9-3 Controls	0.4	0.5	0.6	0.4	31.0
Ultrasonic	1.8	2.3	1.0	0.5	18.5	Ultrasonic	1.2	1.4	0.7	0.0	20.0	Ultrasonic	1.4	0.4	0.9	0.9	24.8
Airmax	1.7	2.4	1.1	0.4	19.5	Airmax	1.1	1.4	0.7	0.1	20.7	Airmax	1.2	1.3	0.6	0.7	15.3
	Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA
8-20 Nearshore	1.5	2.2	1.3	0.4	27.8	8-26 Nearshore	1.2	1.5	0.8	0.1	24.6	9-3 Nearshore	1.0	0.8	0.7	0.6	24.2
Offshore Surface	1.7	2.1	0.7	0.7	19.2	Offshore Surface	1.3	1.5	0.6	0.2	19.8	Offshore Surface	1.1	0.9	0.6	0.7	19.7
Offshore Bottom	1.6	2.4	1.1	0.3	24.6	Offshore Bottom	0.8	1.3	0.7	0.1	28.5	Offshore Bottom	1.1	1.1	0.6	0.5	36.9

9/5/2018						9/9/2018						9/14/2018					
Location	Green	Diatoms	Bluegreen	Cryptophyta	% BGA	Location	Green	Diatoms	Bluegreen	Cryptophyta	% BGA	Location	Green	Diatoms	Bluegreen	Cryptophyta	% BGA
**Sucker	0.0	0.1	0.7	0.3	59.6	**Sucker	0.0	4.2	0.6	1.5	9.1	**Sucker	0.0	0.5	0.3	1.7	13.2
Su-OS	0.3	0.2	0.4	0.5	30.0	Su-OS	0.1	4.7	0.1	2.0	2.0	Su-OS	0.0	1.0	0.4	1.1	14.3
Su-OD	0.0	0.0	0.4	0.5	42.3	Su-OD	0.0	0.9	0.1	1.4	4.4	Su-OD	0.0	1.7	1.5	0.2	45.1
**N Martin	0.5	0.2	1.1	0.7	43.1	**N Martin	0.9	5.1	0.5	1.9	5.7	**N Martin	0.0	4.1	0.1	3.2	1.9
NM-OS	0.7	0.3	0.4	0.5	19.2	NM-OS	0.4	7.1	0.9	1.2	9.0	NM-OS	0.0	2.7	0.7	1.7	14.1
NM-OD	0.0	0.1	0.2	0.6	23.5	NM-OD	0.1	4.1	0.0	1.7	0.0	NM-OD	0.0	1.4	0.2	2.2	4.1
S Martin	1.2	0.0	0.4	1.3	12.5	S Martin	0.0	1.4	0.1	1.4	4.2	S Martin	0.0	3.2	1.1	3.2	14.9
SM-OS	2.1	1.5	0.8	0.9	15.2	SM-OS	0.5	6.7	0.0	2.2	0.3	SM-OS	0.0	5.4	0.0	4.7	0.0
SM-OD	0.2	0.1	0.2	0.7	15.0	SM-OD	0.7	4.1	0.0	2.4	0.4	SM-OD	0.0	3.4	0.0	2.6	0.0
Yacht Club	0.6	0.4	0.4	0.7	19.2	Yacht Club	0.6	4.1	0.4	2.8	4.9	Yacht Club	0.0	2.5	0.8	2.0	14.6
YC-OS	0.9	0.5	1.4	0.8	39.0	YC-OS	0.8	4.4	0.3	2.4	3.3	YC-OS	0.0	3.4	0.2	3.3	2.6
YC-OD	0.1	0.3	0.3	0.4	27.5	YC-OD	0.2	4.2	0.2	1.7	2.8	YC-OD	0.0	2.1	0.2	2.1	3.7
FL 6	0.7	0.8	1.1	0.3	37.7	FL 6	0.5	5.6	0.0	2.5	0.0	FL 6	0.1	5.2	1.6	0.8	21.1
F6-OS	1.2	1.1	2.2	0.5	44.4	F6-OS	0.1	6.8	0.0	2.4	0.0	F6-OS	0.0	4.2	0.4	2.3	6.2
F6-OD	0.3	0.4	0.4	0.5	25.0	F6-OD	0.0	4.3	0.0	1.6	0.0	F6-OD	0.0	3.2	0.0	1.5	0.0
N Burtis	0.5	0.6	0.6	0.5	27.2	N Burtis	0.2	4.2	0.6	1.6	8.6	N Burtis	0.0	0.0	0.0	1.3	2.6
NB-OS	0.6	0.9	0.1	0.7	2.5	NB-OS	0.7	4.7	0.3	1.8	4.5	NB-OS	0.0	0.6	0.3	0.7	17.7
NB-OD	0.0	0.2	0.2	0.5	26.0	NB-OD	0.9	3.7	0.2	1.6	2.4	NB-OD	0.0	0.2	0.5	0.6	39.2
S Burtis	0.6	0.3	17.2	0.0	95.3	S Burtis	0.5	4.6	0.1	1.5	2.2	S Burtis	0.0	3.9	0.4	2.6	6.3
SB-OS	1.6	0.8	2.2	0.5	42.7	SB-OS	2.0	7.2	0.0	2.0	0.1	SB-OS	0.0	4.2	0.0	2.1	0.3
SB-OD	0.3	0.8	0.6	0.2	30.8	SB-OD	0.9	6.6	0.3	1.5	3.3	SB-OD	0.0	2.0	0.2	2.3	4.8
**Sunset	0.3	0.2	0.2	0.7	13.9	**Sunset	0.8	5.7	0.0	1.1	0.0	**Sunset	0.0	2.8	0.9	1.7	16.7
Sn-OS	0.6	0.7	0.2	0.4	9.0	Sn-OS	0.7	5.1	0.2	1.8	2.0	Sn-OS	0.0	1.6	0.2	1.5	5.2
Sn-OD	0.2	0.5	0.5	0.5	30.3	Sn-OD	0.4	5.0	0.0	1.8	0.2	Sn-OD	0.0	0.8	0.4	0.9	21.2
Glenwood	0.5	0.8	0.6	0.4	25.1	Glenwood	0.9	3.1	0.1	1.3	2.3	Glenwood	0.0	1.5	0.4	1.8	10.3
Gl-OS	0.0	0.3	0.0	0.7	0.1	Gl-OS	0.7	4.0	0.0	1.3	0.4	Gl-OS	0.0	1.3	0.4	1.2	15.0
Gl-OD	0.0	0.1	0.1	0.7	10.1	Gl-OD	1.1	3.9	0.0	1.2	0.0	Gl-OD	0.0	0.7	0.1	1.3	4.8
Indian	1.0	1.6	0.0	0.6	0.3	Indian	3.8	7.2	0.3	1.7	2.1	Indian	0.0	2.1	4.5	0.1	66.8
In-OS	1.0	1.7	0.0	0.4	0.0	In-OS	3.3	7.5	0.0	1.4	0.0	In-OS	0.0	6.0	0.8	3.7	7.3
In-OD	1.0	1.7	0.0	0.5	1.3	In-OD	8.7	12.6	1.6	3.5	6.2	In-OD	0.0	3.4	2.6	2.7	29.9
FL 26	0.0	0.1	0.0	0.6	5.0	FL 26	2.2	3.9	0.4	1.5	4.4	FL 26	0.0	3.2	0.0	1.5	0.0
F26-OS	0.2	1.0	0.2	0.6	10.1	F26-OS	3.3	5.3	0.2	1.8	2.0	F26-OS	0.6	3.0	0.0	1.1	0.2
F26-OD	0.5	1.7	0.0	0.8	0.0	F26-OD	2.7	4.7	0.1	2.0	0.8	F26-OD	0.0	2.6	0.0	1.5	0.0
												Indian Cove Mid [	1.2	1.1	22.8	1.5	
	Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA
9-5 Controls	0.3	0.3	0.4	0.5	29.3	9-9 Controls	0.4	4.7	0.3	1.6	3.7	9-14 Controls	0.0	1.8	0.5	1.6	13.4
Ultrasonic	0.8	0.5	0.6	0.8	21.5	Ultrasonic	0.5	4.1	0.2	2.1	2.4	Ultrasonic	0.0	3.3	0.4	3.0	5.6
Airmax	0.6	0.8	1.4	0.5	43.0	Airmax	1.8	5.5	0.2	1.8	2.5	Airmax	0.0	2.6	0.7	1.6	13.7
	Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA
9-5 Nearshore	0.5	0.5	2.0	0.5	30.8	9-9 Nearshore	1.0	4.5	0.3	1.7	3.9	9-14 Nearshore	0.0	2.6	0.9	1.8	15.3
Offshore Surface	0.8	0.8	0.7	0.6	19.3	Offshore Surface	1.2	5.8	0.2	1.8	2.2	Offshore Surface	0.1	3.0	0.3	2.1	7.5
Offshore Bottom	0.2	0.5	0.3	0.5	21.1	Offshore Bottom	1.4	4.9	0.2	1.9	1.9	Offshore Bottom	0.0	1.9	0.5	1.6	13.9

9/16/2018						9/30/2018					
Location	Green	Diatoms	Bluegreen	Cryptophyta	% BGA	Location	Green	Diatoms	Bluegreen	Cryptophyta	% BGA
**Sucker	0.0	0.3	1.2	0.0	78.1	**Sucker	0.0	1.1	0.1	1.3	4.5
Su-OS	0.0	0.0	0.3	0.6	28.7	Su-OS	0.0	0.7	0.0	1.2	0.3
Su-OD	0.0	0.0	0.2	0.2	48.0	Su-OD	0.0	0.0	0.3	0.8	25.3
**N Martin	0.0	1.4	4.4	3.8	45.6	**N Martin	0.0	1.1	0.9	1.9	23.9
NM-OS	0.0	4.1	1.0	3.3	12.4	NM-OS	0.0	2.4	0.0	1.8	0.0
NM-OD	0.0	0.9	0.0	2.5	0.0	NM-OD	0.0	0.7	0.0	1.7	1.0
S Martin	0.0	0.0	0.8	4.0	16.0	S Martin	0.0	0.3	0.3	1.7	12.0
SM-OS	0.0	2.9	0.5	4.8	6.3	SM-OS	0.0	1.4	0.2	1.5	7.6
SM-OD	0.0	0.2	0.3	1.8	13.4	SM-OD	0.0	0.9	0.0	1.8	0.0
Yacht Club	0.0	2.1	0.2	4.9	3.1	Yacht Club	0.0	2.2	0.0	1.8	0.0
YC-OS	0.0	3.6	6.7	2.7	51.4	YC-OS	0.0	2.6	0.0	2.5	0.0
YC-OD	0.0	0.2	0.0	2.2	0.7	YC-OD	0.0	2.0	0.0	2.2	0.0
FL 6	0.0	2.7	4.7	4.0	41.6	FL 6	0.0	1.1	0.3	2.0	8.4
F6-OS	0.0	5.0	0.0	6.6	0.0	F6-OS	0.0	2.3	0.1	2.5	1.4
F6-OD	0.0	1.6	0.0	3.1	0.4	F6-OD	0.0	1.7	0.4	2.5	9.6
N Burtis	0.0	0.1	16.3	1.5	90.8	N Burtis	0.0	2.0	0.0	1.9	0.0
NB-OS	0.0	0.0	20.5	3.2	86.6	NB-OS	0.0	2.9	0.2	1.5	3.4
NB-OD	0.0	0.1	0.3	2.2	10.8	NB-OD	0.9	4.0	0.0	1.2	0.0
S Burtis	0.0	1.0	13.2	3.7	73.8	S Burtis	0.0	5.3	1.8	0.3	24.6
SB-OS	0.1	2.2	11.6	6.0	58.5	SB-OS	0.1	4.9	0.0	1.5	0.0
SB-OD	0.0	0.7	0.9	2.5	22.2	SB-OD	0.4	5.5	0.0	1.3	0.0
**Sunset	0.0	2.1	8.5	4.8	55.3	**Sunset	0.0	3.3	0.9	2.2	14.9
Sn-OS	0.0	6.0	20.0	1.3	73.1	Sn-OS	0.1	3.2	0.4	1.8	7.8
Sn-OD	0.0	0.0	0.3	1.3	20.5	Sn-OD	1.2	4.5	0.2	1.6	3.0
Glenwood	0.0	1.3	0.0	2.5	0.0	Glenwood	0.1	2.8	0.2	1.4	5.2
Gl-OS	0.0	1.8	0.0	1.9	0.0	Gl-OS	0.2	4.5	0.0	1.3	0.0
Gl-OD	0.0	0.4	0.1	5.4	1.8	Gl-OD	2.1	4.2	0.3	1.6	4.2
Indian	0.0	0.4	5.3	1.7	72.4	Indian	0.0	3.3	0.6	2.0	10.2
In-OS	0.0	1.7	2.9	1.2	50.2	In-OS	0.0	2.5	0.0	2.3	0.0
In-OD	0.0	0.1	0.6	2.0	23.0	In-OD	0.0	7.1	1.0	2.7	9.5
FL 26	0.0	0.4	0.0	3.5	0.4	FL 26	1.4	2.9	0.1	1.7	1.4
F26-OS	0.0	1.6	0.0	2.1	0.0	F26-OS	1.5	2.0	0.2	2.2	3.4
F26-OD	0.0	0.0	0.0	3.5	0.0	F26-OD	0.5	1.7	0.1	1.6	3.4
	Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA
9-16 Controls	0.0	1.6	4.0	2.0	52.3	9-30 Controls	0.1	1.9	0.3	1.6	8.3
Ultrasonic	0.0	1.5	1.4	3.4	22.5	Ultrasonic	0.0	1.6	0.1	1.9	2.4
Airmax	0.0	1.2	4.3	3.1	49.7	Airmax	0.4	3.4	0.3	1.7	5.2
	Green	Diatoms	Bluegreen	Cryptophyta	% BGA		Green	Diatoms	Bluegreen	Cryptophyta	% BGA
9-16 Nearshore	0.0	1.1	5.0	3.1	43.4	9-30 Nearshore	0.1	2.3	0.5	1.6	9.6
Offshore Surface	0.0	2.6	5.8	3.1	33.4	Offshore Surface	0.2	2.7	0.1	1.8	2.2
Offshore Bottom	0.0	0.4	0.3	2.4	12.8	Offshore Bottom	0.5	2.9	0.2	1.7	5.1

APPENDIX B: PLANKTON ID RAW DATA (ASSEMBLAGE RELATIVE PERCENTAGE)

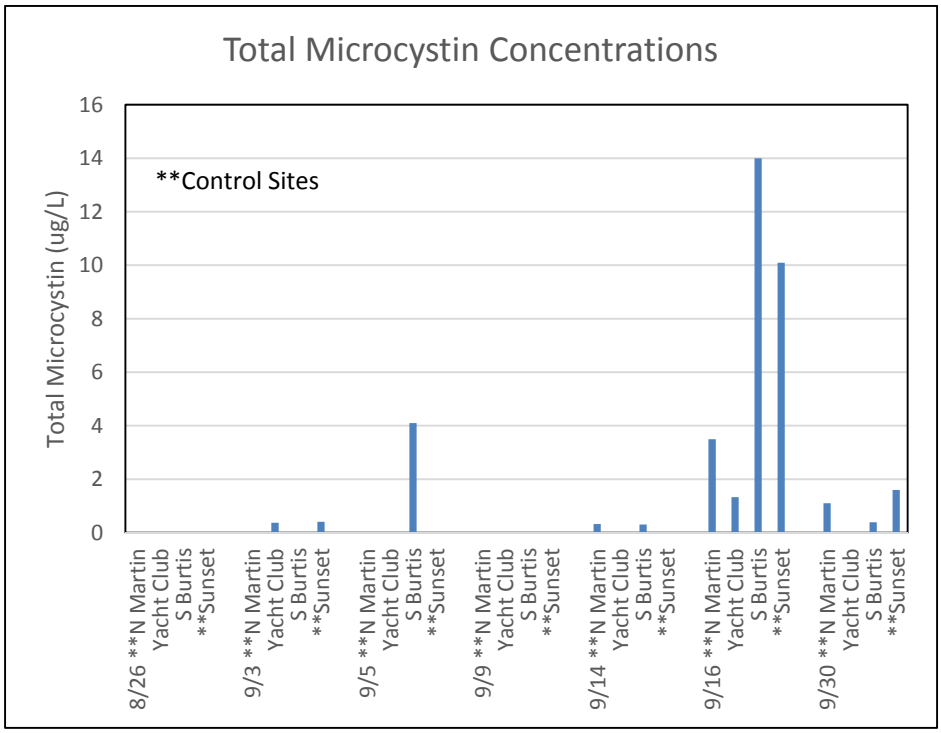
Plankton - Zooplankton Data for Owasco Dockside Monitoring Effort - 2018

All counted taxa.

		Diatoms											Dinoflagellates						Green Algae				Blue Green Algae				Zooplankton								Others					
Date	Station	Fragillaria %	Diatoma %	Asterionella %	Synedra %	Melosira %	Rhoicosphenia %	Rhizoselenia %	Cocconeis %	Cymbella %	Other Diatom %	Unknown Diatom %	Total Diatoms %	Micractimium %	Dinobryon %	Ceratium %	Coalcium %	Unknown Dinoflag. %	Total Dinoflagellates %	Scenedesmus %	Pediastrum 5	Trochiscia %	Unk. Green Filament %	Chroococcus %	Stichosiphon %	Trichodesmium %	Dolichospermum (Anabaena) %	Microcystis %	Copepod %	Keratella %	Polyarthra %	Vorticella %	Asplanchna %	Unknown Rotifer %	Total Rotifers %	Cladoceran %	Cercopagis %	Wolfiella %	Zebra Mussel Larva %	Quagga Mussel Larva %	Unknown 5	Others %	TOTAL %
7/30/2018	FL-6				56		1	18	4	1		13	92	1	3				3					1									3	3	1						1	100
	FL-26				91		1	6					97		1				1											1		1	2	1							100
	N. Burtis				38		8	8	2	4		37	98		1				1									1						1							100
	S. Burtis				60		8	20				7	94		2				2								1				2		2	3	1							100
	Glenwood				85		3	10				1	99																			1	1								100
	Indian Cov				89		3	7				1	100																												100
	N. Martin				75		1	21				2	99																			1	1	1							100
	S. Martin				81		2	8		1	4		96												1							1	2	2						1	100
	Sucker				21		9	2		9		53	94					2	2		1			1					2											1	100
	Sunset				71		6	8				10	95		1				1	0											0		0	1	2	0						100
	Yacht Cr.				72		5	9				10	96									1												1	1	3						100
8/6/2018	FL-6				51		16	1		1		24	93	2					2								3														100
	FL-26				71		5	4				16	96	1	1				1	1							1												1		100
	N. Burtis				38		10	4		4		34	89					0	0	1							6			0		3			3	0			0		100
	S. Burtis				33		8	1		2		41	84	0					0	1							11	0								0			1		1	100
	Glenwood				11	1	9	2	1	4		69	96							1					1		2			1		1			1						100
	Indian Cov				86		3	1		1		9	99														1												1		100
	N. Martin				43			7				1	52	1					1								38					8			8	1					100
	S. Martin				61		1	3		1		2	69	2	1			1	3	1							22					5			5				1		100
	Sucker				29		29	2		1		31	92	2	1			1	4								3					1			1						100
	Sunset				8		8	0	1	6		27	50							1	0						37	2				6			6	1				3	100
	Yacht Cr.				80		2	2	1	1		3	89	1					1						1		6			1		1	1	2				1			100
8/11/2018	FL-6				57		2	3	0	0		4	68														26		0			1		1	2	2					100
	FL-26				62		2	6		1		7	78		1			1	1							12	2			1	6			6						100
	N. Burtis				44		6	4		2		13	68														24					6		1	7	1					100
	S. Burtis				32		1					6	39														38	3	1		1	16		2	18	3					100
	Glenwood				46		1	8				3	58	1					1								34					5		1	6	1					100
	Indian Cov				61		6	3	1			13	84														15				1				1					1	100
	N. Martin				10				1	1		7	18					1	1								71					6		1	6	5					100
	S. Martin		1		48		2	1				8	60					1	1								33			1		4		1	5	2					100
	Sucker				39		4	3	2	7		23	78							1	2		11					1	2							1		1	2	1	100
	Sunset		1		46		2	4				6	58					1	1								31			1	1	6		2	10	2					100
	Yacht Cr.				70		3	3		1		7	83					1	1								15					1		1	1						100
8/20/2018	FL-6			1	58		2	5	1	1		24	90	1			1	1	2								1	1		4	1		1	1	6						100
	FL-26				42		7	4	1			36	90					1	1						1		1	1					1	2	3				4		100
	N. Burtis				18		13	4	5	4		49	93														1	1	1	2			1	1	3	1				1	100
	S. Burtis				42		9	7	3	2		28	91							1				2			1	1				1		1	2	1				2	100
	Glenwood				21		21	1	3	1		46	92															1		1				5	6					1	100
	Indian Cov	0			33		11	3	4	1		31	83							0				1			6	0		2	0	1	1	3	8	0			1		0	100
	N. Martin				57		3	6	6	1		18	91	1					1	1				1	1		3			1		1			1					2	100
	S. Martin				50		5	14	1	1		18	90				1		1					1			1	1	1			1		1	3	2					1	100
	Sucker				9	0	16		15	6		39	86							0							1	0	1	0	0		1	2	4			1	1	1	4	100
	Sunset				39		10	4	3	3		34	92	0				0	1	1	0							1	0	0					0	2				0	2	100
	Yacht Cr.			0	43		13	1	4	1		24	87					2	2	0					0		1	0		2		0		2	4	4				1	100
8/26/2018	FL-6	1			44		3	3				38	88	2				1	3	1			1	0	1		2	3		2				1	3						100
	FL-26	1		1	39		2	2	1		1	45	89	1		1	2	1	3	1	1						2	1	1	2	1			2	1			1	1		100
	N. Burtis	1		2	9		17					37	66	2			1	1	3	1							4	1	2	2	1		2	6	4					15	100
	S. Burtis			1	13		19					33	66				1	1	2	1				2		1	1	10		6	2			2	9	4		1	1		3	100
	Glenwood				24		14	1	3			42	84	1				1	1		1			3	1		1	2		2				1	3	2			1		1	100
	Indian Cov	1		1	24		8		1	1		51	85					1	1	1	1			1			1	3		3		2			5		1			1	2	100
	N. Martin				5		66		1			23	95														1	1		1					1					1	100
	S. Martin	1		1	24		6	1				38	70					1	1					1			1	5		8	1	1			10	10	1			1		100
	Sucker				2		68		1	1		23	96					1	1	1							2													1	100
	Sunset			1	31		7	1				38	77					1	1					2			3	5		6	1	3		1	10	2			1	2		100
	Yacht Cr.	2		1	25		14	1				32	75					1	1	1	1						3	5		3	2			1	7	8					1	100
9/3/2018	FL-6			1	6		2	9	1			55	73	1	1				2		1						2	19		1		1			2	1				1		100
	FL-26	1			8		4	2	1	1		69	85	1					1								1			4	1				5						7	100
	N. Burtis				5		9	2	1			63	81	4	2				6	1	1			1			1	9			1	1			1							100
	S. Burtis	1		1	4		3	1				47	56					1	1		1					1	4	30		1	2	2			5	2					1	100
	Glenwood	1		1	7		7	2			1	58	78	1					1		1					1	2	10		1	1				2	3			1	1	1	100
	Indian Cov		2	1	5		2	3			1	78	91	1					1	1				4			1	2	1													100
	N. Martin	1		0	5		7	2				29	44	0	2			0	3	0				1			7	30	1	1	0	2			3	8				0	1	1	100
	S. Martin	1		1	7		1					44	53	1	1			1	2	1	1					1	6	30		1	1		1	2	4					1	1	100
	Sucker						20		6	2		27	55					2	2	1				1				33		1					1	2					5	100
	Sunset		1		2		11	5	1			36	56		1		1	1	3	2	1						4	25	1	2	3	2			7	2					2	100
	Yacht Cr.	1		1	4		2					49	56		1				1								3	29		2	1	1			4	5			1		1		100

| | | |

APPENDIX C: TOTAL MICROCYSTIN TOXICITY DATA (µG/L)



Microcystin Data			
8/26/2018	Total Microcystins (ug/L)	9/14/2018	Total Microcystins (ug/L)
8/26 **N Martin	<0.30	9/14 **N Martin	0.3
Yacht Club	<0.30	Yacht Club	<0.30
S Burtis	<0.30	S Burtis	0.3
**Sunset	<0.30	**Sunset	<0.30
9/3/2018		9/16/2018	
9/3 **N Martin	<0.30	9/16 **N Martin	3.5
Yacht Club	0.4	Yacht Club	1.3
S Burtis	<0.30	S Burtis	14.0
**Sunset	0.4	**Sunset	10.1
9/5/2018		9/30/2018	
9/5 **N Martin	<0.30	9/30 **N Martin	1.1
Yacht Club	<0.30	Yacht Club	<0.30
S Burtis	4.1	S Burtis	0.4
**Sunset		**Sunset	1.6
9/9/2018			
9/9 **N Martin	<0.30		
Yacht Club	<0.30	Detection Limit 0.30 ug/L	
S Burtis	<0.30		
**Sunset	<0.30		
Average Toxins		Days Toxin > 0.3 ug/L	
**N Martin	0.7	**N Martin	3
Yacht Club	0.2	Yacht Club	2
S Burtis	2.7	S Burtis	4
**Sunset	1.7	**Sunset	3

APPENDIX D: WIND SPEED & DIRECTION DATA FROM EACH DOCKSIDE (START 8-6-2018).

Site Name (Technology)	7-30-2018 Wind Speed (m/s)	Direction (360°)	8-6-2018 Wind Speed (m/s)	Direction (360°)
Sucker Br (**control**)	Not measured,		2.8	196
N Martin (**control**)	but light &		2.2	215
S Martin (ultrasound)	variable		1.7	222
Yacht Club (ultrasound & PS20)			2.6	225
Fire Lane 6 (SW20)			2.1	221
N Burtis (SW20)			0.0	--
S Burtis (Sw 20)			1.0	242
Sunset Beach (**control**)			2.4	263
Glenwood Rd (SW 20)			2.3	255
Indian Cove (PS 20)			2.4	279
Fire Lane 26 (SW 20)			1.5	148
Site Name (Technology)	**8-11-2018**		**8-20-2018**	
Sucker Br (**control**)	1.4	205	1.9	199
N Martin (**control**)	1.4	190	1.5	230
S Martin (ultrasound)	1.2	220	1.8	205
Yacht Club (ultrasound & PS20)	1.1	295	2.6	232
Fire Lane 6 (SW20)	0.8	305	3.5	216
N Burtis (SW20)	2.1	312	1.3	227
S Burtis (Sw 20)	0.7	277	2.3	221
Sunset Beach (**control**)	0.7	311	1.2	243
Glenwood Rd (SW 20)	0	--	2.7	288
Indian Cove (PS 20)	0.6	308	2.8	157
Fire Lane 26 (SW 20)	0.8	125	1.7	145
Site Name (Technology)	**8-26-2018**		**9-3-2018**	
Sucker Br (**control**)	3.0	193	0.6	245
N Martin (**control**)	3.1	218	0.1	235
S Martin (ultrasound)	2.0	236	2.9	250
Yacht Club (ultrasound & PS20)	2.1	240	2.2	240
Fire Lane 6 (SW20)	1.9	270	2.1	255
N Burtis (SW20)	0.6	240	0	--
S Burtis (Sw 20)	1.7	250	2.2	245
Sunset Beach (**control**)	2.6	215	1.9	215
Glenwood Rd (SW 20)	3.6	240	2.6	205
Indian Cove (PS 20)	1.8	235	1.0	185
Fire Lane 26 (SW 20)	1.5	150	0.8	180
Site Name (Technology)	**9-5-2018**		**9-9-2018**	
Sucker Br (control)	1.7	175	0.0	
N Martin (control)	1.2	176	0.0	
S Martin (ultrasound)	0	--	0.0	
Yacht Club (ultrasound & PS20)	1.6	197	0.0	
Fire Lane 6 (SW20)	1.8	205	1.5	182
N Burtis (SW20)	1.6	190	0.0	
S Burtis (Sw 20)	1.3	185	0.0	
Sunset Beach (control)	1.5	195	0.0	
Glenwood Rd (SW 20)	2.3	225	1.1	315
Indian Cove (PS 20)	2.1	170	2.2	190
Fire Lane 26 (SW 20)	1.1	215	1.8	92
Site Name (Technology)	**9-14-2018**		**9-16-2018**	
Sucker Br (control)	2.2	190	0.0	
N Martin (control)	1.6	13	0.0	
S Martin (ultrasound)	1.7	188	0.0	
Yacht Club (ultrasound & PS20)	2.4	193	0.6	182
Fire Lane 6 (SW20)	2.8	206	0.0	
N Burtis (SW20)	1.6	188	0.0	
S Burtis (Sw 20)	1.4	185	0.0	
Sunset Beach (control)	0.0		1.0	212
Glenwood Rd (SW 20)	0.0		1.8	210
Indian Cove (PS 20)	1.0	291	0.0	
Fire Lane 26 (SW 20)	0.0		1.4	3
Site Name (Technology)	**9-30-2018**			
Sucker Br (control)	3.0	140		
N Martin (control)	3.4	145		
S Martin (ultrasound)	2.5	148		
Yacht Club (ultrasound & PS20)	1.6	155		
Fire Lane 6 (SW20)	3.9	145		
N Burtis (SW20)	2.5	140		
S Burtis (Sw 20)	3.2	145		

Sunset Beach (control)	3.9	148
Glenwood Rd (SW 20)	3.8	154
Indian Cove (PS 20)	3.7	140
Fire Lane 26 (SW 20)	3.6	150

Please note: 5 miles/hour = 2.2 meters/second, 10 mph = 4.5 m/s

APPENDIX E: AIR AND WATER TEMPERATURE DATA FROM EACH DOCK (START 8-20-2018)

Site Name (Technology)	8-20-2018 Air Temp (°C)	Water Temp (°C)	8-26-2018 Air Temp (°C)	Water Temp (°C)
Sucker Br (**control**)	22.3	23.3	24.2	22.3
N Martin (**control**)	22.9	23.8	24.3	22.9
S Martin (ultrasound)	24.5	23.9	24.5	23.1
Yacht Club (ultrasound & PS20)	26.5	24.1	25.0	23.2
Fire Lane 6 (SW20)	22.5	24.0	25.4	23.2
N Burtis (SW20)	25.5	23.5	26.1	23.0
S Burtis (Sw 20)	24.1	24.4	26.6	23.2
Sunset Beach (**control**)	23.9	24.3	26.4	23.7
Glenwood Rd (SW 20)	24.2	24.5	26.7	23.7
Indian Cove (PS 20)	25.1	24.3	28.4	22.8
Fire Lane 26 (SW 20)	25.8	24.2	28.9	22.9
Site Name (Technology)	**9-3-2018**		**9-5-2018**	
Sucker Br (**control**)	22.3	23.3	28.8	26.6
N Martin (**control**)	22.9	23.8	29.8	25.3
S Martin (ultrasound)	24.5	23.9	32.5	25.3
Yacht Club (ultrasound & PS20)	26.5	24.1	29.5	25.3
Fire Lane 6 (SW20)	22.5	24.0	30.7	26.3
N Burtis (SW20)	25.5	23.5	32.1	26.3
S Burtis (Sw 20)	24.1	24.4	32.4	26.8
Sunset Beach (**control**)	23.9	24.3	29.9	26.4
Glenwood Rd (SW 20)	24.2	24.5	31.2	26.3
Indian Cove (PS 20)	25.1	24.3	31.4	26.4
Fire Lane 26 (SW 20)	25.8	24.2	30.9	24.5
Site Name (Technology)	**9-9-2018**		**9-14-2018**	
Sucker Br (control)	15.7	21.6	23.6	22.5
N Martin (control)	16.6	22.4	24.3	22.8
S Martin (ultrasound)	15.6	22.3	24.4	22.9
Yacht Club (ultrasound & PS20)	16.2	22.6	24.4	23.0
Fire Lane 6 (SW20)	15.5	22.2	24.3	23.3
N Burtis (SW20)	18.0	21.8	25.5	23.2
S Burtis (Sw 20)	16.2	22.5	25.6	23.6
Sunset Beach (control)	17.9	22.7	25.6	23.4
Glenwood Rd (SW 20)	17.4	22.8	26.9	23.8
Indian Cove (PS 20)	16.2	23.1	26.7	23.6
Fire Lane 26 (SW 20)	1.1	215	26.3	22.7
Site Name (Technology)	**9-16-2018**		**9-30-2018**	
Sucker Br (control)	24.4	24.4	11.6	18.1
N Martin (control)	24.7	24.3	12.2	19.0
S Martin (ultrasound)	26.2	24.5	12.4	19.0
Yacht Club (ultrasound & PS20)	25.3	24.5	12.7	19.2
Fire Lane 6 (SW20)	28.5	23.9	13.5	18.9
N Burtis (SW20)	29.5	24.5	14.1	18.6
S Burtis (Sw 20)	31.5	24.6	14.2	19.2
Sunset Beach (control)	27.5	25.9	14.1	19.0
Glenwood Rd (SW 20)	28.6	25.5	14.7	18.9
Indian Cove (PS 20)	30.1	23.7	14.4	19.2
Fire Lane 26 (SW 20)	27.5	24.1	15.2	19.5

Please note: 60°F = 15.6°C, 70°F = 21.1°C, 80°F = 26.7°C

APPENDIX F: PLANKTON ID, DRONE IMAGERY, HOMEOWNER PHOTOGRAPHS, AIR & WATER TEMPERATURES, AND WIND SPEED & DIRECTION DETAILED METHODS

Plankton and Algal Assemblages:

At each site, the scientific team under the direction and oversight of Dr. John Halfman, FLI/HWS, collected one vertical plankton tow through the entire water column at the deep-water end of each survey dock at each site using a 20-cm diameter plankton net with an 80-micron mesh. Each sample was preserved in a water-ethanol-formalin (6-3-1 by volume) solution and brought back to HWS for plankton identification under microscope. Over 100 organisms were identified to genus level, or species level when possible, and results reported as relative percentages. Each colony was counted as an individual which biased the BGA percentages because they are predominately colonial. This method results in an estimated 20% standard deviation. Results of selected duplicate analyses were well within the protocol (20% standard deviation). Identification were based on keys advocated by Rosen and St. Amand; 2015, Prescott, 1978; and Wehr and Sheath, 2003. Samples from each survey date were delivered with an appropriate Chain of Custody (CoC) form. Example CoC forms are available in Appendix H.

Prescott, G.W., 1978. How to Know the Freshwater Algae, 3rd Edition. WmC Brown Co Publishers, Dubuque, Iowa.

Rosen, B.H. and A. St. Amand, 2015. Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for North America and Alaskan Native Communities. US Geological Survey Open File Report, 2015-1164.

Wehr, J.D. and R.G. Sheath, 2003. Freshwater algae of North America, Ecology & Classification. Academic Press, New York, New York.

Drone Imagery:

Color images using the blue, green and red spectral bands, were collected by Dr. John Halfman along the nearshore region of each survey site by drone. A Phantom 3 Advanced or similar drone manufactured by DJI, outfitted with a Sony EXMOR gimbaled camera capturing 12 megapixel red, green, and blue digital images was used. The drone was flown at 50 m (~150 ft) above the lake surface and collected a vertical and two oblique images with the drone centered above the survey dock. The oblique photos imaged the nearshore region up and down the shoreline from the site. The resolution of the vertical image was ~3 cm^2/pixel. These images were used to assess the spatial and temporal distribution of observed blooms.

Homeowner Photos, Submission, and Management Process:

The homeowners were asked to collect one photograph each day at each of the 11 sites in the project for the duration of the project. The homeowners were directed to collect images: (1) between 10 am and 3 pm or whenever possible given volunteer schedule; (2) to include the shoreline inside the area of influence of the in-lake technology devices (ultrasound vibrators and aerators); (3) with a nearly vertical orientation and (4) from arms height. The images, identified with the date and site number, were emailed to Peter Rogers, the pertinent OWLA representative, for processing. Please note: Photos were being taken using a variety of mobile phones, iPads and automatic cameras. The homeowners attempted to find others to take the photos if the property owner was not available.

Peter Rogers, OWLA, catalogued and electronically stored the photos from each site. The completeness of the record was reported to all site volunteers on a weekly basis. He reviewed each photos for compliance, clarity, and indication of any BGAs. Discrepancies or missing data was reported back to the site participant. Photos with suspected HABs were forwarded on to Dr. Halfman. David Carr, OWLA Program Coordinator, stored each submitted photograph on Microsoft's OneDrive using separate folders for each week and each site.

Water Temperature:

Surface water temperature was measured at the offshore end of the dock at each site using an Oakton CON 410 meter starting on 8-20-2018. The Oakton 410 specifications are below.

The Oakton 410 Specifications:

Mode	Conductivity *(CON 400 & 410 meters)*	TDS *(TDS 400 & CON 410 meters)*	Temperature
Range (Resolution)	0.00 to 19.99 µS (0.01 µS) 0.0 to 199.9 µS (0.1 µS) 0 to 1999 µS (1 µS) 0.00 to 19.99 mS (0.01 mS) 0.0 to 199.9 mS (0.1 mS)	0.00 to 9.99 ppm (0.01 ppm) 10.0 to 99.9 ppm (0.1 ppm) 100 to 999 ppm (1 ppm) 1.00 to 9.99 ppt (0.01 ppt) 10.0 to 200 ppt (0.1/1 ppt)	0.0 to 100.0°C or 32.0 to 212.0°F (0.1°C or °F)
Accuracy	±1% full scale	±1% full scale	±0.5°C or °F

Cell constant: 1.0, 0.1, or 10 selectable (cell constant of included cell = 1.0)

Temperature compensation: Automatic or manual 0 to 50°C (32 to 122°F)

Temperature coefficient: 0 to 10% per °C or °F

TDS factor: adjustable from 0.4 to 1.0

Operating temperature: 0 to 50°C (32 to 122°F)

Memory: up to 50 points (includes measurement, temperature, date and time)

Real time clock: stamps calibration data and stored data with time and date (month and day)

Power: 4 x 1.5 V AAA batteries (>100 hours)

Dimensions: 7.5"L x 3.5"W x 1.75"H (meter only); 9.2"L x 9.2"W x 2.75"H (boxed)

Weight: 1.0 lb (meter only); 2.0 lbs (boxed complete)

Wind Direction, Wind Speed, and Air Temperature:

Wind speed and air temperature were measured with a Kestral 5000 hand held wind & weather meter. Wind direction was measured with a compass application on a cell phone. The meteorological data were collected at the offshore end of the dock at each site on each survey day starting on 8-20-2018. The Kestral 5000 specifications are below. In addition, mean daily wind speed, air and water temperatures and sunlight light intensity from the Owasco Buoy (YSI/Xylem water profiling – meteorological monitoring buoy operated by HWS) were used in the analysis for a complete record of these variables and a comparison to the sample date measurements.

Kestral 5000 Specifications:

SENSORS	ACCURACY	RESOLUTION	SPECIFICATION RANGE	NOTES
Wind Speed | Air Speed	Larger of 3% of reading, least significant digit or 20 ft/min Speed	0.1 m/s 1 ft/min 0.1 km/h 0.1 mph 0.1 knots 1 B* 0.1 F/S*	0.6 to 40.0 m/s 118 to 7,874 ft/min 2.2 to 144.0 km/h 1.3 to 89.5 mph 1.2 to 77.8 knots 0 to 12 B* 2-131.2*	1 inch|25 mm diameter impeller with precision axle and low-friction Zytel® bearings. Startup speed stated as lower limit, readings may be taken down to 0.4 m/s |79 ft min|1.5 km/h |.9 mph |.8 kt after impeller startup. Off-axis accuracy -1% @ 5º off axis; -2% @ 10º; -3% @ 15º. Calibration drift < 1% after 100 hours use at 16 MPH|7 m/s. Replacement impeller (NK PN-0801) field installs without tools (US Patent 5,783,753). Wind speed calibration and testing should be done with triangle on impeller located at the top front face of the Kestrel. Measuring wind speeds above 60 m/s / 134.2 mph can damage the impeller
Ambient Temperature	0.9 °F 0.5 °C	0.1 °F 0.1 °C	-20.0 to 158.0 °F -29.0 to 70.0 °C	Airflow of 2.2 mph|1 m/s or greater provides fastest response and reduction of insolation effect. For greatest accuracy, avoid direct sunlight on the temperature sensor and prolonged sunlight exposure to the unit in low airflow conditions. Calibration drift is negligible for the life of the product. For further details, see Display & Battery Operational Temperature Limits.

APPENDIX G: TOTAL MICROCYSTIN TOXIN SAMPLING AND ANALYSIS:

Four sites were selected after consultation between Halfman and OWLA representative for microcystin toxin analysis each week to more fully assess the effects of the HAB inhibiting technologies. Two sites had mitigation technologies and two were neighboring control sites. These sites were the Owasco Yacht Club (ultrasonic device), North Martin (neighboring control), S. Burtis (aerator), and Sunset Beach (neighboring control). These samples were collected from the nearshore end of the property owner's dock, where the HAB concentrations were suspected largest on any given day. Toxins collection was initiated on 8-26-2018.

Each surface grab sample was collected in a 125 mL amber glass bottle, transported back to HWS on ice, stored overnight at 4°C and subsequently overnight mailed the following morning on ice to UFI. Several samples for microcystin analysis were received slightly above the 10°C limit described in EPA Method 546: Determination of Total Microcystins and Nodularins in Drinking Water and Ambient Water by Adda Enzyme-Linked Immunosorbent Assay. These samples were originally on ice, but warming due to elevated temperatures during overnight shipping. It was unlikely that the small deviation in temperature negatively impacted the sample results. Samples from each survey date were delivered with an appropriate Chain of Custody (CoC) form. Example CoC forms are available in Appendix H.

The mycrocystin analyses followed EPA Method 546, a NYS-DEC approved analytical procedure.

Mycrocystin SOP, QA/QC:

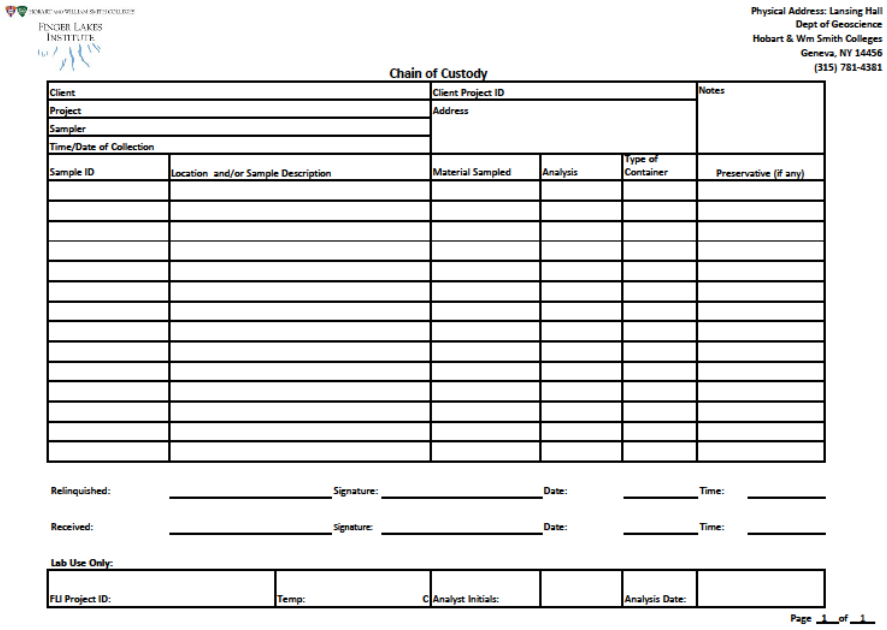
The total microcystin analytical specifications from UFI SOP 244 using EPA Method 546.

Requirement	Specification and Frequency	Acceptance Criteria	Include in freeze/thaw and filter cycle?
ELISA Calibration Standards	Use Abraxis kit standards (as sent) or prepare to similar concentrations. Two well replicates per standard.	% CV of absorbance ≤ 10%; ≤15% allowed for 1 pair r2 ≥ 0.980	No
Well replicates	Assay field and QC samples in two wells	Sample invalid if %CV of absorbance values ≥ 15%	No
Laboratory Reagent Blank (**LRB**)	Lyse two LRBs per Analysis Batch. Assay in duplicate on opposite sides of the plate	MC/NOD concentration must be less than one-half the Minimum Reporting Level (MRL) in each LRB (< 0.15 µg/L)	Yes
546 Low Calibration Verification (**546 Low-CV**)	Calibration standard at, or below, the MRL concentration. One per Analysis Batch. Use Low-CV sample included with Abraxis Method 546 Accessory Kit. Use solution as provided, no additional preparation is necessary.	Percent recovery ≥ 50% and ≤ 150% of the true value. Abraxis solution fortified at 0.3 µg/L and have an acceptable range of ≥ 0.15 µg/L ≤0.45 µg/L.	No

Laboratory Fortified Blank (**LFB**)	Reagent water fortified near the EC50. Lyse and assay 2 per Analysis Batch.	Percent recovery for each LFB ≥ 60% and ≤ 140% of the true value. Fortified at 0.6 µg/L and have an acceptable range of ≥ 0.36 µg/L ≤0.84 µg/L.	Yes
Quality Control Sample (**546 QCS**)	Assay 1 546-QCS for each new lot of calibration standards. Use QCS sample included in Abraxis Method 546 Accessory Kit. Use solution as provided, no additional preparation is necessary. Otherwise, prepare a QCS near the EC50 with MF-LR from a source independent of the calibration standards.	Percent recovery ≥ 70% and ≤ 130% of the true value. Abraxis solution fortified at 0.6 µg/L; acceptance range 0.42 - 0.78µg/L	No
Laboratory Fortified Sample Matrix (**LFSM**) and LFSM Duplicate (**LFSMD**)	Fortify near the EC50 and twice native concentration. One LFSM and LFSMD per sample type (i.e., drinking/recreational water) per 20 samples (if a mixed batch, one set for drinking water and one set for recreational water).	Mean percent recovery of LFSM and LFSMD pair ≥ 60% and ≤ 140%. Relative percent difference (RPD) ≤ 40%. Qualify results for samples failing these limits as "suspect-matrix".	Yes

APPENDIX H: EXAMPLE CHAIN OF CUSTODY FORMS

Plankton ID Samples CoC



FINGER LAKES INSTITUTE

Physical Address: Lansing Hall
Dept of Geoscience
Hobart & Wm Smith Colleges
Geneva, NY 14456
(315) 781-4381

Chain of Custody

Client		Client Project ID			Notes
Project		Address			
Sampler					
Time/Date of Collection					
Sample ID	Location and/or Sample Description	Material Sampled	Analysis	Type of Container	Preservative (if any)

Relinquished: _____ Signature: _____ Date: _____ Time: _____

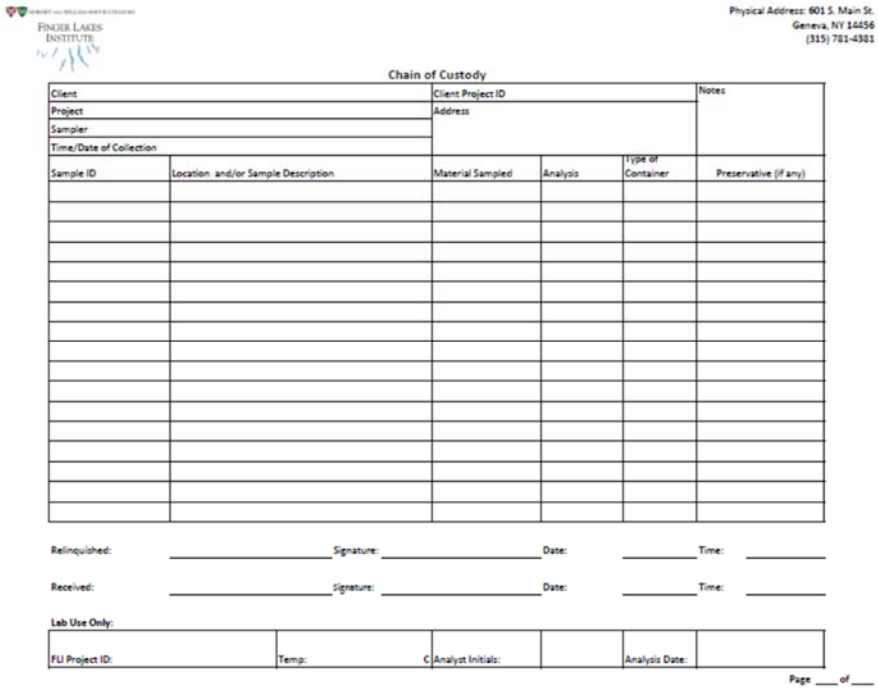
Received: _____ Signature: _____ Date: _____ Time: _____

Lab Use Only:

FLI Project ID:	Temp: C	Analyst Initials:		Analysis Date:	

Page 1 of 1

FluoroProbe Samples CoC



FINGER LAKES INSTITUTE

Physical Address: 601 S. Main St.
Geneva, NY 14456
(315) 781-4381

Chain of Custody

Client		Client Project ID			Notes
Project		Address			
Sampler					
Time/Date of Collection					
Sample ID	Location and/or Sample Description	Material Sampled	Analysis	Type of Container	Preservative (if any)

Relinquished: _____ Signature: _____ Date: _____ Time: _____

Received: _____ Signature: _____ Date: _____ Time: _____

Lab Use Only:

FLI Project ID:	Temp: C	Analyst Initials:		Analysis Date:	

Page ___ of ___

Total Mycrocystin Sample CoC

UPSTATE FRESHWATER INSTITUTE

Chain of Custody and
Laboratory Analysis Request

224 Midler Park Drive;
Syracuse, NY 13207
Phone: (315) 431-4972 ext.115;
Fax: (315) 431-4979
ufilab@upstatefreshwater.org

Project Name: 2017 Owasco Lake Tributaries	**Client: Robert Brower, Cayuga Community College, Inc**
Address: Inst. for the Application of Geospatial Technol. at Cayuga Community College, Inc. 199 Franklin St., Suite 300, Auburn, NY 13021-3025	**Sampled by:**
Phone: (315) 252-8779; fax:; Email: bbrower@iagt.org	**Sampling Date:**

UFI LAB ID	Field Code (Client ID)	Replicate	System Code	Station Code	Sample Type[a]	Device Code[b]	Sample Depth (m)	Time	Field Preserved (Y/N)	Requested Analyses		Comments	*For Lab Use Only*
										TP, TDP,SRP [1]	NO_x, NH_3 [2]		Preserved (Y/N)
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		
2017 _____		na	OW		G	G	1	(hhmm)	N	1 ☐	1 ☐		

APPENDIX I: BBE FLUOROPROBE SPECIFICATIONS & SOP

bbe FluoroProbe: Surface water grab samples were collected by the scientific team at the nearshore and offshore ends of the dock at each site. In addition, a lake floor sample was collected using a CON 410 Series stainless steel subsurface grab sampler. Each sample was stored in a 250 mL amber HDPE bottle and transported on ice to FLI for analysis. At the FLI lab, algal assemblages were determined from each water sample using a bbe FluoroProbe. The bbe FluoroProbe measures four different algae groups based on their accessory pigments. It distinguishes between 'green' algae (Chlorophyta and Euglenophyta), 'brown' algae (Baccillariophyta, Chyrsophyta, and Dinophyta), 'blue-green' algae (Cyanophyta), and 'red' algae (Cryptophyta). Samples from each survey date were delivered with an appropriate Chain of Custody (CoC) form. Example CoC forms are available in Appendix H. Instrument specifications and the SOP are below.

bbe FluoroProbe Specifications:

Chlorophyll	0 - 200 µg chl-a/l
Resolution	0.01 µg chl-a/l
Transmission	0 - 100%
Temperature	Sample: -2 - 40°C / Environment: -2 - 40°C
Housing material	reinforced carbon fibre/V4A steel
Weight	6.4 kg (7.2 kg with lightshield)
Dimensions (H x D)	450 x 140 mm
Voltage	12 V
Battery capacity	3900 mA h
Operating time	continuously up to 10 h; interval up to 30 days
Memory capacity	2 GB memory card, 10 million datasets
Interfaces	RS485
Maximal diving depth	0 - 100 m (standard) 0 - 300 m (extended range1) 0 - 1000 m (extended range2)

APPENDIX I (continued): DETAILED FLUOROPROBE SOP

1) Test Method: Algal Classification, bbe Moldaenke FluoroProbe II or III

2) Applicable Matrix or Matrices:

Fresh or saline surface waters.

3) Limit of Detection and Quantification (for each fingerprint/channel):

LOD: 0.0 µg Chl-*a*/L (specified by manufacturer)

LOQ = (based on Upstate Freshwater Institute SOP and conversations with bbe).

4) Scope and Application:

Drinking water, surface freshwater source waters (lakes, ponds, impoundments, rivers, etc.) and surface saline waters.

5) Summary of Test Method:

The bbe FluoroProbe III is an instrument that analyzes chlorophyll-*a* and other algal class determination. The fluorescence of algae due to excitation by visible light mainly depends on the presence of chlorophyll-*a*, a common pigment in the plant world. The occurrence of other pigments is typical for the different algae classes. Interactions between these different pigment systems with chlorophyll-*a* result in a special excitation spectrum for the taxonomical algae classes.

The special patterns of this algae fluorescence - so-called *fingerprints* - are used by the FluoroProbe III for the quantification of different algae classes. The excitation light sources are LEDs with different wavelengths. The fingerprints of four algae classes (greens, blue-greens, diatoms, and cryptophytes) and yellow substances are already stored in the FluoroProbe.

Yellow substances may fluoresce and affect the determination of algal classes. Measurement and compensation for yellow substances interference is integrated into the FluoroProbe III through the use of a UV-LED. Chlorophyll measurements can also be affected by particulate matter in the water. Use of the FluoroProbe's turbidity correction improves reliability of the results.

6) Definitions:

Algal Classes – By default, the FluoroProbe has four algal classes: Greens, Bluegreens (cyanobacteria), Diatoms, and Cryptophytes.

Algal Fingerprint – The fluorescence of algae at various wavelengths (depending on the algal class) due to excitation by visible light mainly depends on the presence of chlorophyll-*a*, a common pigment in the plant world. The occurrence of accessory pigments is typical for the different algae classes. Interactions between these different pigment systems with chlorophyll-*a* result in unique excitation spectra for different taxonomical

algae classes. These special patterns of algae fluorescence - so-called fingerprints - are used by the FluoroProbe for the quantification of different algae classes.

CDOM – chromophoric/colored dissolved organic matter.

Chlorophyll – a pigment, present in all green plants and in cyanobacteria, responsible for the absorption of light to provide energy for photosynthesis.

Fluorescence – the property of absorbing light of short wavelength and emitting light of longer wavelength. In the FluoroProbe the excitation light sources are LEDs with different wavelengths (370, 470, 525,570,590, 610 nm) and 700 nm for Transmission.

FluoroProbe – an instrument that measures the combination of fluorescence signatures from a water sample to determine the chlorophyll-*a* concentration of the algae classes present in the sample.

Turbidity – a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity.

7) Interferences:

CDOM and turbidity are known interferences related to determination and classification of algal fluorescence. In addition, Euglenophytes may depart from the "green" classification due to varying pigment content in response to environmental conditions.

8) Safety:

No hazardous materials are required for this test. Proper laboratory procedures should be followed at all times.

9) Equipment and Supplies:

- pipettes (glass or calibrated automatic), graduated cylinders (Class A)
- Workstation 25 (for bench tests)
- 25 ml square cuvette (purchased from bbe)
- bbe FluoroProbe with light shield
- Computer with bbe++ software installed

10) Reagents and Standards:

- Distilled water.

11) Sample Collection, Preservation, Shipment and Storage:

Sample collection techniques may vary and once collected may be stored in glass or plastic bottles. Sample preservation consists of samples being kept cool (4 – 6 °C; not frozen) and stored in the dark prior to processing. DO NOT FREEZE as freezing disrupts/lyses the algal cells and results will not be representative. Samples may be delivered by courier or field sampling personnel.

For best results, samples should be run as soon as practical after collection. Once samples are ready to be processed, they should be kept out of direct sunlight and brought to room

temperature (takes approximately one hour once samples are removed from ice/refrigerator if sample volume is 10 – 100 mls; more time is needed for larger volume samples).

12) Quality Control:

Quality Control (QC) parameters are outlined in the Method Performance Section. They are monitored on a variety of levels; by the analyst(s), the Laboratory Director, and the Quality Assurance Officer as needed. In addition, basic knowledge of the characteristic features of the limnological systems may be used to aid in evaluating QC data.

13) Calibration and Standardization:

a. Calibration: The manufacturer recommends the FluoroProbe be sent back for inspection, calibration, and maintenance every two years. Calibration certificates should be kept in the appropriate equipment logbook.
b. Standardization: An intercomparison with another laboratory (Upstate Freshwater Institute) was completed in July 2018. A total of 41 samples were screened and the total chlorophyll values for the two FluoroProbes were found to be in agreement with no statistically significant difference between the FluoroProbes with regard to total chlorophyll. More intercomparisons are planned for the future to ensure that data from different FluoroProbes in use for Harmful Algal Bloom screening in New York State provide equivalent data. The New York State Department of Environmental Conservation is engaged in these communications and efforts.

14) Procedure (for using FluoroProbe in Workstation 25/lab bench mode):

1. **FluoroProbe Workstation 25 Setup**
    a. Place instrument in Workbench 25 holder
    b. Use the light cover over the cuvette holder
    c. Plug the FluoroProbe into the power source
        i. Use the short (1m) black cable, plug one end into FluoroProbe and the other into the FluoroProbe control unit (pin connector on the left front of the control unit; red tape to red tape)
        ii. Plug the data communications cable into the back of the FluoroProbe control unit (purple tape to purple tape) and then plug the USB port side of the communications cable into the computer
        iii. Turn the control unit on (switch on the back of the FluoroProbe control unit)
2. **Start the bbe++ Software on the Computer**
    a. Open the bbe++ application by using the shortcut on the desktop
    b. Software should start up and connect with the FluoroProbe – confirm the connection by checking the small circle icon in the toolbar at the top left side of the window. The circle will be green if the instrument and computer are communicating. It will be black if the instrument and computer are NOT communicating. The instrument must be communicating with the laptop for the

software to work and to be able to make measurements. Do not proceed if you do not have a green circle.

c. Sync the time of day between the instrument and the computer – TOOLS → Device → Sync Device with PC Time (ensure PC time is correct)
d. Set the air pressure for the instrument – press the large white "Set Air Pressure" button in the menu at the top left of the screen. Wait a few seconds for the air pressure value to register and then press the "Apply" button
e. Load the parameter utility file for the Workbench 25 lab setup
    i. TOOLS → parameter utility → a dialogue box will open, click the "SEND PARAMETERS" button → choose file name "TS-23-48_kuv_051617.prm" then click "OPEN". This will load the necessary parameter file for the FluoroProbe to work in the laboratory workstation mode. You will see a message that says "Syncing Parameters". Once that message clears, the instrument is ready to start running samples.

3. Running Samples in Workstation 25 Mode

a. Use a FluoroProbe bench sheet to track sample information (lake name, sample ID, sample type) and start time for each sample. It is **CRITICAL** that the start time for each sample (hour:min:sec) is recorded or it will be very difficult to go back and pair up the samples with the measurement results.
b. Using the FluoroProbe cuvette – this cuvette is EXTREMELY brittle and the glass chips EXTREMELY easily. Please handle it very carefully. Ensure the samples are at room temperature before running to prevent condensation on the cuvette. Condensation on the cuvette will produce erroneous sample results. Make sure all water is dried off (using a Kimwipe) of the outside and bottom of the cuvette before placing in the instrument. The plastic black light shield **MUST BE USED** during a measurement or the measurement is invalid.
c. Running Initial Calibration Blank (ICV) and other QC samples
    i. Fill the cuvette with a little more than 25 mls of DI water
    ii. Wipe off all outer surfaces of the cuvette with a Kimwipe – make sure no moisture is on the glass
    iii. Remove the plastic light shield, place the cuvette into the sample holder with the 25 ml label facing outwards, replace the black plastic light shield
    iv. Press the START button (upper left corner of screen) to begin the sample measurement. The instrument will load parameters, initialize the LEDs and then begin the measurements (takes about 30 seconds before actual measurements start). RECORD the START time of the sample on the bench sheet for each sample.
    v. The instrument will collect 10 measurements for each sample or QC sample and then automatically stop. When the START button turns white, the instrument is ready for the next sample.
    vi. Rinse cuvette 3 times between samples with DI water

vii. Run an initial calibration blank (ICB) at the start of each run, after every 10 samples (continuing calibration blank; CCB), and at the end of the run. Run a duplicate (DUPE) sample every 10 samples.

d. Running a sample:
   i. Gently mix sample by inverting bottle several times (3 – 5 times).
   ii. Shake DI water out cuvette before pouring sample into cuvette and fill cuvette to slightly above the 25 ml mark on the cuvette
   iii. Wipe off all outer surfaces of the cuvette – make sure no moisture is on the glass
   iv. Remove the plastic light shield, place the cuvette into the sample holder with the 25 ml label facing outwards, replace the black plastic light shield
   v. Press the START button (upper left corner of screen) to begin the sample measurement. The instrument will load parameters, initialize the LEDs and then begin the measurements (takes about 30 seconds before actual measurements start). RECORD the START time of the sample on the bench sheet for each sample.
   vi. The instrument will collect 10 measurements for each sample or QC sample and then automatically stop. When the START button turns white the instrument is ready for the next sample.
   vii. Rinse cuvette 3 times between samples with DI water
   viii. Repeat steps d(i) through d(vii) above.

e. If the total chlorophyll-*a* (sum of the four algal class concentrations) is greater than 200 µg/L then the sample must be diluted so that the total chlorophyll-*a* concentration is less than 150 µg/L. If the sample percent transmission is less than 90% then the sample must be diluted so that the percent transmission is greater than 90% AND the chlorophyll-*a* concentration must be less than 200 µg/L.

f. Continue running samples and QC until all the samples are run. Run a closing CCB at the end of the run.

4. Export FluoroProbe Data for Reporting

a. On the top toolbar choose WINDOW → Select Data → Time Range → "last day" → Click "OK"

b. On the top toolbar choose FILE → Export (ASCII) → Export All →choose the directory you want the file stored in on the server → type in filename using the format "mmddyy_XXXX.txt" where yymmdd is the year, month, day of the day samples are run and XXXX is a brief project name (i.e., Seneca, Canandaigua, Owasco, etc.). Click Ok. File will export in ascii format to directory chosen.

5. Creating a FluoroProbe Client Report

a. Navigate to where the exported text file is. Right click on the file name and use "Open with" and choose "Excel"

b. Copy all the data (rows and columns) **BELOW** the headers (do NOT include the header info in the copy/paste; it will "break" the template you are going to be pasting into)
c. Open the FluoroProbe report template (Excel workbook called FP_FLI_XXXX_template.xls) where XXXX is project name.
d. Go to the last tab in the workbook ("Lab Raw Data Export" and paste the data into this sheet (cursor in cell B3 and Paste)
e. There should not be more than 50 samples pasted into this sheet. Anything after 50 samples (500 lines) will be ignored by the following calculation tabs. If you have more than 50 samples, create a second data report.
f. Verify that the date and time stamps have been separated on the next sheet ("Separate Date and Time"). Do not enter any info on this sheet; its sole purpose is to break the timestamp into two parts.
g. Click on the next sheet "Dilution Correction" ONLY if you need to enter a dilution. Enter the number of mls of sample used and the number of mls of DI water added (NOT the total volume of the diluted sample) for any samples that required dilution. If no dilutions were done you can skip over this sheet.
h. Next click on the "Pivot Table" tab. Click inside cell AM3, right mouse click and click on "Refresh". This should refresh the pivot table and you should see the correct number of samples that you ran (including CCBs). Each row is the average of the 10 rows of measurements made.
i. Go back up to the sample pivot table and copy all the rows and columns in the table (click on cell AM3, CTL SHIFT ARROW RIGHT and ARROW DOWN to quickly highlight all the cells in the table) and then click COPY.
j. Go to tab "Sample Average Results" and PASTE into cell A5. This copies the results from the pivot table and then allows the ""Final Report" tab to pull the results into the front page to form the basis of the client's data report.
k. On the "Final Report" page, enter the UFI Lab ID, Lake Name and sample location, CSLAP (or client) ID, and the date the sample was collected. Add any microscopic visual ID info if requested.
l. Delete the FP reference numbers in column N and remove any remaining yellow highlighting in the report.
m. Update the report date and number (use yymmdd in place of the -001).
n. Ensure all Continuing Calibration Blanks (CCBs) read 0 (not divide/zero or showing a large positive % which can happen if all the cells are 0 or if there are very small decimal fractions in the blank). Any CCB's that are not a result of this math artifact should be left as calculated.
o. Once the Excel report is finalized, save it as "FP_report_mmddyy_XXXX.xls) and then print a hardcopy and put in the binder. Create a PDF of the report (FILE → Save As PDF) with the same name.
p. E-mail the report to the client.

6. **Recordkeeping**
   All sample chain of custody forms, bench sheets, and hardcopies of reports should be filed together, in chronological order, in the data notebook for each year. All electronic data (exported files, excel calculation spreadsheets, and report PDFs) should be stored on the server in the appropriate location. Document storage should follow ELAP requirements (at least 5 years).
7. **E-mailing Report to Client**
   Please e-mail only the PDF of the report to the client.

15) Calculations:

All calculations are done within the Excel data processing spreadsheet using regular mathematical expressions and pivot tables.

16) Method Performance:

Table 1 identifies the required QC samples for FluoroProbe analyses.

Table 1: QA\QC for FluoroProbe Analysis

QC Sample Type	Description/Definition	Frequency performed	Abbreviation
Initial and Continuing Calibration Blank	Type II water	First sample run and every 10^{th} sample after	ICB/CCB
Duplicate	An identical sample to another one, from the same sample container	Every 10 samples	DUPE

17) Pollution Prevention:

Sample may be discarded down the drain. For most natural water systems, this procedure has no negative impact on the environment.

18) Data Assessment and Acceptance Criteria for Quality Control Measures:

Since this is a new project, procedure are being developed. Based on Upstate Freshwater Institute's procedures, the following is the procedure to be developed to define acceptance criteria for 2018 and beyone.

Record all results into database template and commit to database. Query database for QC results to view the control charts. Control charts are designed so that the mean is displayed through the

middle, with an upper warning limit, a lower warning limit, an upper control limit and a lower control limit. The warning limits are calculated from the previous year's data and are automatically flagged. The process should be shut down for troubleshooting if one or more of the following occur:

- a single action outside the control limit
- 2 out of 3 consecutive measurements between the warning and control limit
- 7 consecutive measurements above or below the mean
- 6 consecutive measurements all steadily increasing or all steadily decreasing wherever they are located
- 14 consecutive points alternating up and down, regardless of where they are located
- an obvious nonrandom pattern

All data that falls outside stated control limits will be appropriately flagged.

19) Corrective Actions for Out-of-Control or Unacceptable Data:

If QC measures are determined to be outside acceptable limits the analysis is considered Out-of-Control and the data is to be considered suspect. If 2 out of 3 consecutive measurements are between the warning and control limits then causes should be investigated and a Corrective Action Report may be initiated (see Quality Manual for C.A.R protocol). Based on the Laboratory Directors judgement a comment may be inserted into the comment section of affected data packets. If a cause is found, then a corrective action must be initiated and fully documented.

20) Contingencies for Handling Out-of-Control or Unacceptable Data:

If sufficient sample exists, samples should be re-run once the analysis is back in control. If there is insufficient sample, data should be flagged with an explanation of the circumstances.

21) Waste Management:

Samples may be discarded down the drain with running tap water.

22) References:

bbe Moldaenke. 2017. bbe FluoroProbe User Manual, version 2.6 E2 (October 2017). 125pp.