2019 White Lake Monitoring Results

Report Prepared by LIMNOSCIENCES
Draft: March 25, 2020

Water Quality Parameters

Monthly sampling was conducted from April-December at three established monitoring stations (Fig. 1). Grab samples for nutrients and chlorophyll a were taken at 0.5 and 2.0 m depths, so that a total of 6 samples were taken for each sample date. Algae samples were taken at 0.5 m depths. Sampling and analysis details are provided in the White Lake QAPP (available at www.whitelakewatch.com).

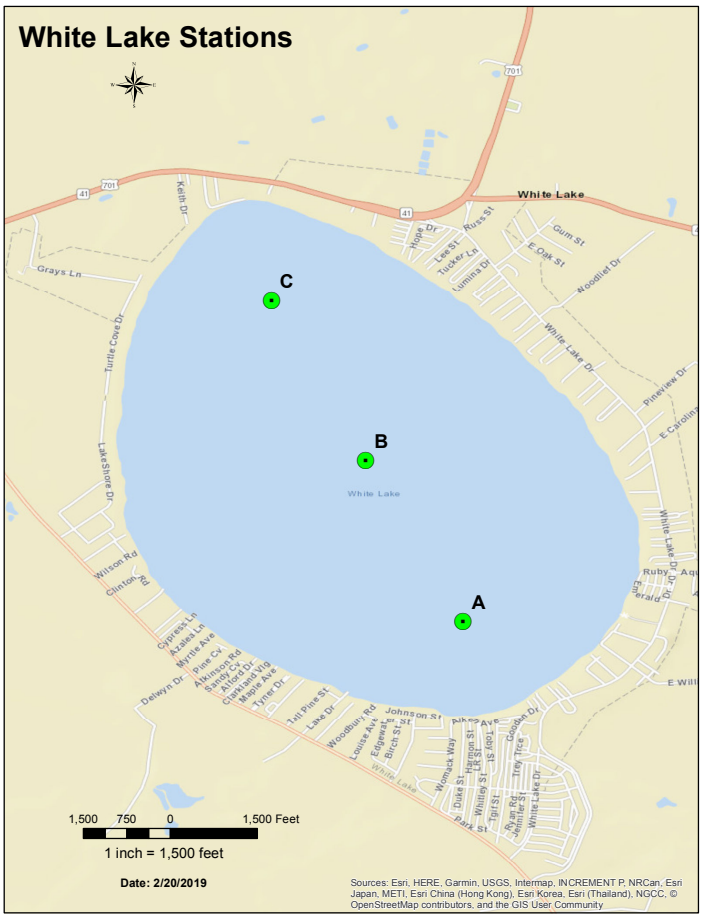


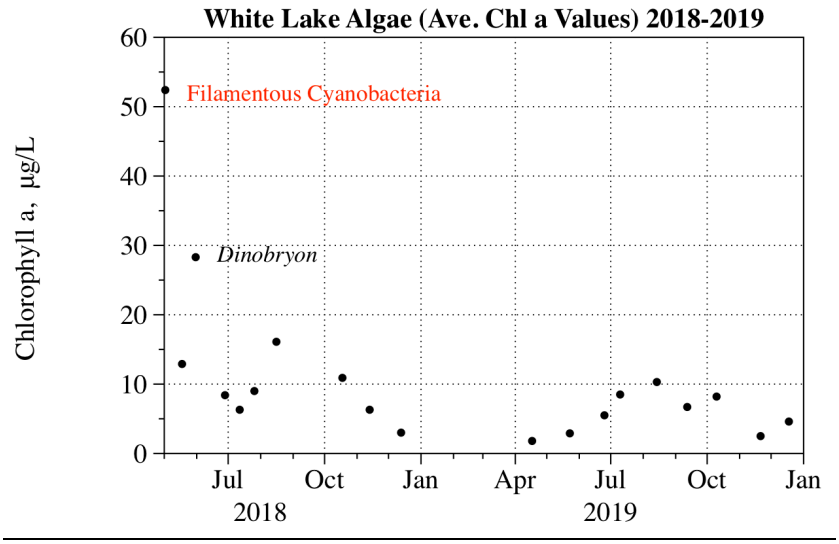
Figure 1. Monitoring stations for White Lake, which correspond to NC DEQ stations (CPF155C, CPF155B, and CPF155A).

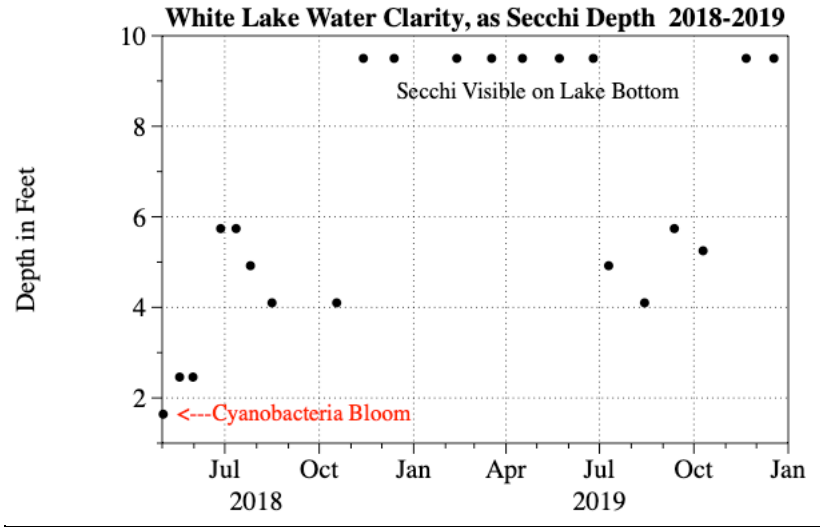
General Observations

Over the monitoring period, water-column algal biomass (measured as chlorophyll a) was lowest in April (mean of 1.8 µg/L) and highest in the month of August, at a mean of 10.3 µg/L; this month also had the highest turbidity, with a mean of 2.1 NTU, and the lowest Secchi readings, at 1.25 m (4.1 ft) (Table 1). Of note is the relatively rapid change in clarity in both the summer and fall: in July there was a reduction in visibility of around 1 m compared to June, while the opposite of that was seen in November, when water temperatures declined—an improvement of around a meter in Secchi depth compared to October, so that the Secchi disk was again visible on the bottom. Summertime (July-October) Secchi depths in 2019 were similar to values seen in 2018, after the alum treatment, with the remaining months having water clarity/Secchi visibility at the lake bottom (Fig. 2)

Table 1. Physical and chemical monitoring parameters for White Lake, March-December 2019. Samples were collected at two depths (0.5 and 2.0 m) at each of three stations (equivalent to the monitoring stations used by NC DEQ). As the depth of the lake is a function of lake level, which varies, when the Secchi is visible on the lake bottom it is recorded as a "yes" instead of a depth.

	3/18/19	4/17/19	5/23/19	6/25/19	7/10/19	8/14/19	9/12/19	10/10/19	11/21/19	12/18/19
Mean Temp (C)	17.1	20.8	27.0	29.0	29.0	30.3	28.9	21.7	10.1	11.3
Lake Level (gauge)	1.78	1.76	1.42	1.09	1.00	1.38	1.40	1.00	1.3	1.5
Secchi Depth (m)—					1.5	1.25	1.7	1.6		
Visible at Bottom?	Yes	Yes	Yes	Yes					Yes	Yes
Turbidity (NTU)					1.9	2.1	1.4	1.7	0.6	0.7
Mean DO (mg/L)	9.9	8.9	9	7.9	7.2	7.3	7.9	8.5	11.2	10.8
Mean DO % Sat.	103	99	99	103	93.5	97.4	102.8	97.1	99	99
Mean Sp. Cond.										
(uS//L)	32	31.8	32.6	34.0	34.4	33.1	31.5	33.1	35.5	34.4
Range pH (su)	6.4-6.8	6.3-6.7	6.2-6.6	6.2-6.7	6.5-6.6	6.3-6.6	6.8-7.0	6.3-6.6		6.7-6.9
Mean Chlorophyll a (µg/L)		1.8	2.9	5.5	8.5	10.3	6.7	8.2	2.5	4.6
Mean DOC (mg/L)					4.66	4.91	5.38	5.87	7.53	5.17
Mean Total N (mg/L)		0.304	0.330	0.481	0.616	0.548	0.719	0.613	0.407	0.642
NO3-NO2 (mg/L)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.010
Mean Total P (mg/L)		0.017	0.014	0.014	0.015	0.027	0.022	0.023	0.013	0.020
SRP (mg/L)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
# of Samples	3	6	6	6	6	6	6	6	6	6





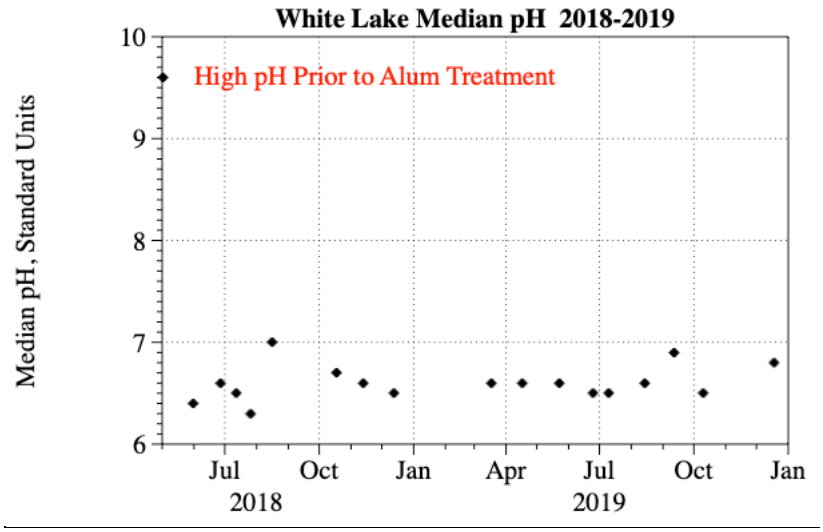


Figure 2. White Lake average chlorophyll a (µg/L), Secchi depths (ft), and median pH levels (su), from May 2, 2018 (prior to alum treatment) to December 2019.

There was no substantial increase in pH over the summer months, with median pH levels remaining below 7 (Fig. 2). The highest median pH levels were found in September and December.

Nutrients

Total Nitrogen levels were low in April and May (means of 0.304 mg N/L in April and 0.330 mg N/L in May) and increased thereafter (Table 1). The majority of TN in White Lake is found in organic form (NC DEQ 2019) so includes what is contained in algal cells suspended in the water column; one form of inorganic nitrogen, nitrate-nitrite was analyzed and was below detection limits of 0.01 mg N/L in every month with the exception of November (Table 1).

The mean Total Phosphorus over the months sampled (April-December) was 0.018 mg P/L, with the highest monthly mean, 0.027 mg P/L found in August (Table 1). Total Phosphorus includes what is in algal cells, and this parameter tracks closely with chlorophyll levels. Soluble Reactive Phosphorus (SRP), a measure of what is readily available for algal uptake, was below detection limits of 0.001 mg P/L in every month with the exception of November, when it was at 0.001 mg/L (Table 1).

Total Organic Carbon (TOC) and Dissolved Organic Carbon (DOC) have not been routinely analyzed by DEQ; in 2018, testing by Envirochem found that DOC comprised 90% of TOC on average from June through December, and ranged from 13.6 to 6.6 mg C/L; in 2019 DOC analysis was done from July through December, and mean values ranged from 4.66 to 7.53 mg C/L (Table 1).

Algae

Algal samples were taken at each station at 0.5 m depth; analyses for 2019 are underway for the months April, May, July and September. Of note so far is the increase in species richness and abundance in the summer compared to spring.

The benthic filamentous green alga Mougeotia appeared in November of 2018 as water temperatures decreased and the clarity of the water increased (Secchi visible on bottom). The mats persisted through mid-summer of 2019, at which time they disappeared.

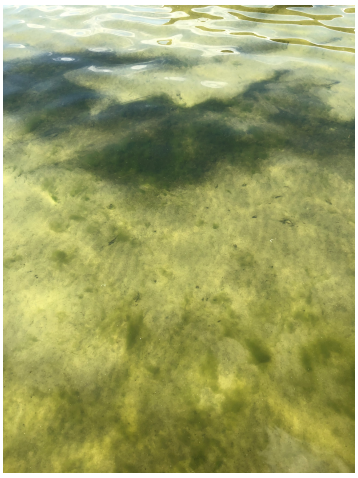


Figure 3. Filamentous algal mats at Nathan's Cove (southwestern shore) on March 18, 2019.

Aquatic Vegetation

The 2019 White Lake vegetation survey conducted by NCSU Extension found an increase in the percentage occurrence of aquatic vegetation compared to 2018, with two species—dwarf milfoil and spikerush—constituting the majority of the biomass (Table 2). Spikerush has been found in the lake at least as far back as vegetation sampling has been conducted (survey work was done in the 1970s).

Table 2. Aquatic vegetation found in annual whole-lake surveys of White Lake. Percentage occurrence is determined as the number of survey points in which each vegetation species is found divided by the total number of survey points (202) sampled (Table from 2019 NCSU White Lake Aquatic Vegetation Survey Report).

White Lake % Occurrence				
Species	**2014**	**2017**	**2018**	**2019**
Hydrilla	0%	84%	0.5%	1.5%
Dwarf Milfoil	0%	15%	20%	34%
Spikerush	40%	9%	56%	68%
Aquatic Moss	43%	63%	32%	6%
Chara	29%	66%	0%	0%
Low Milfoil	54%	0%	0.5%	0%
Bladderwort	14%	0%	0%	0%
No Vegetation	11%	6%	36%	16%
Vegetation	89%	93%	65%	84%

Hydrilla was found at three locations in 2019 at very low densities, with no floating fragments found. Its growth habit in White Lake is low—reaching a height of around 6"—compared to other lakes where it can "top out", reaching the surface of the water. So, while it appears that it does not do well, the tubers in the lake sediments were viable, sprouting some new growth. The stunted growth of Hydrilla in White Lake may be a consequence of the naturally-occurring aluminum found in the lake sediments, and/or the lower water-column pH (Dr. Rob Richardson, North Carolina State University, personal communication).

Lake Levels

Lake levels in 2019 were consistent with the historical pattern of winter highs and summer lows, with an ordinary high-water level of 64.6 ft. above sea level seen on January 25, and a low of 63.54 ft. on July 9 (these elevations are measured using the current NAVD 88 datum, which is one-foot lower than the old NGVD 29 datum). This indicates that water depths also varied by nearly one foot (from a maximum of 9.4 ft. in January to 8.5 ft. in July). The greatest decline in lake levels—5.2 inches--was seen in the month of May.

The summer season was bookended by record-setting heat in May (the record in Fayetteville and Wilmington was 100 degrees F on May 23) and October (the record in Fayetteville was 99° on October 3). According to State Climatologist Kathie Dello and applied climatologist Corey Davis, 2019 was the hottest year on record for North Carolina; in a blog post they explain "where we are really seeing the heat isn't necessarily in the daytime temperatures, but the dominant trend is in our nighttime lows. It's those readings that have consistently pushed some of our recent warm years into the top 10" (https://sciences.ncsu.edu/news/2019-the-warmest-year-in-n-c-history/?utm_medium=social&utm_source=twitter&utm_content=sciences&utm_campaign=socialhub) (web site accessed March 24, 2020).

Rainfall

Total rainfall for 2019 was 52.8 inches, slightly above the long-term average for the region (Table 2). The highest rainfall months were April, July and December. Below-average precipitation was seen across the Southeast during May, and in North Carolina, it was the 14th driest on record for the month (https://www.ncdc.noaa.gov/sotc/national/201905) (web site accessed March 24, 2020). At White Lake, May rainfall was a third of that month's long-term average for the region (Table 2.)

Table 3. Monthly rainfall at the White Lake Wastewater Treatment Plant in 2018 and 2019. The long-term average for the region is taken from data collected at Elizabethtown, which is posted at https://www.usclimatedata.com/climate/elizabethtown/north-carolina/united-states/usnc0205

Monthly Rainfall (inches) for White Lake 2018-2019

Month	2019 Monthly	2019 Total-Year to Date		2018 Monthly	2018 Total-Year to Date		Long-Term Average for Region
January	2.75	2.75		4.20	4.20		3.81
February	2.25	5.00		2.00	6.20		3.44
March	3.25	8.25		3.95	10.15		3.91
April	7.25	15.50		6.75	16.90		3.12
May	1.20	16.70		7.70	24.60		3.67
June	5.25	21.95		10.00	34.60		4.70
July	6.00	27.95		4.75	39.35		5.75
August	5.35	33.3		6.25	45.60		5.95
September	5.00	38.3		29.45	75.05		5.29
October	3.60	41.9		2.25	77.30		3.38
November	4.90	46.8		4.25	81.55		3.16
December	6.00	52.80		7.5	89.05		3.14
Total	52.80			89.05			49.32

Conclusions

Sustained, long-term monitoring is critical to understanding lake dynamics, particularly with respect to the development of algae blooms, as variability due to climate can be difficult to distinguish from changes due to human impacts (Paerl 2014, Havens et al. 2016). Climate change-related increases in temperatures (and evaporation) and greater hydrologic variability can be expected to have significant impacts on a relatively shallow lake such as White Lake (with a mean depth of 6.5 ft. or less) as water temperatures can change fairly rapidly with changes in air temperatures.

For 2019, the weather—both record-setting heat and low rainfall in May—contributed to the substantial drop in lake level seen that month, as losses due to evaporation from the lake surface were much higher than the inputs of water via rainfall.

Lower lake levels and elevated temperatures are two of the characteristics which can contribute to the development of cyanobacterial blooms in lakes (Dokulil and Teubner 2000, Paerl and Otten 2013); the absence of a full-scale bloom in White Lake in 2019, when lake levels were low and the summer season was expanded (starting earlier and lasting later) suggests that the relationship between blooms and lake conditions is more complex here. The same holds for the relative abundance of Hydrilla—the lake conditions would seem to favor the robust growth of this aquatic invasive weed, and yet it is subsisting, not thriving.

Aquatic ecosystems such as lakes are constantly changing due to natural and human-influenced stressors (Smol 2019). As White Lake continues to recover from acidic deposition (a major stressor that was unrecognized), with present lake pH levels substantially different from what they had been, we are starting to discern what these natural changes look like: there is some variability in conditions, but not too much. This 2020 monitoring report essentially represents a chapter in what should be a larger and longer story.

References

Dolulil, M.T. and K. Teubner. 2000. Cyanobacterial dominance in lakes. Hydrobiologia 438: 1-12.

Havens, K.E., H.W. Paerl, E.J. Phlips, M. Zhu, J.R. Beaver, and A. Srifa. 2016. Extreme weather events and climate variability provide a lens into how shallow lakes may respond to climate change. Water 8: 229; doi:10.3390/w8060229

North Carolina Department of Environmental Quality. 2019. 2018 White Lake Monitoring Report. White Lake, Bladen County, NC. September 2019. NC Department of Environmental Quality Division of Water Resources, Water Sciences Section.

North Carolina State University. 2019. 2019 White Lake aquatic vegetation survey. NCSU Extension, Aquatic Weed Program.

Paerl, H.W. 2014. Mitigating harmful cyanobacterial blooms in a human- and climatically-impacted world. Life 4: 988-1012; doi:10.3390/life4040988

Paerl, H.W. and T.G. Otten. 2013. Harmful cyanobacterial blooms: causes, consequences, and controls. Microbial Ecology

Smol, J.P. 2019. Under the radar: long-term perspectives on ecological changes in lakes. Proc. R. Soc. B 286: 20190834.