White Lake,
Bladen County, NC

Lake Monitoring Results 2022


Recently hatched midges are attracted to white surfaces
Camp Clearwater, April 20, 2022

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LIMNOSCIENCES

April 2023

1. Introduction

White Lake has been a tourist icon for generations of North Carolinians. It is a unique and valuable resource, but it has been significantly impacted by:

- Recreational boating that is not suited to a small and very shallow lake
- Lakeshore alterations and dense development, with no safeguards for the lake
- Increasing amounts of nitrogen entering the lake from atmospheric deposition

White Lake has now had five consecutive years of lake monitoring and annual aquatic vegetation surveys, with four years of lake level monitoring, facilitated by the installation of two easily accessed lake level gauges. Rainfall records have been kept for many years at the Town's wastewater treatment plant and are now reported in conjunction with lake levels and other monitoring data. In addition, several special projects have been conducted in recent years (development of a groundwater model, sediment nutrient sampling, assessment of stormwater outfalls to the lake, rainfall nutrient monitoring, winter waterfowl counts, and a geohydrological assessment of groundwater flow in the area [which was a component of a strategic management planning document developed by the Lumber River Council of Governments in September of 2022]), all of which has added significantly to what we know about White Lake.

The 2021 White Lake Monitoring report (LIMNOSCIENCES 2022, available at www.whitelakewatch.com) was developed as a comprehensive review document which includes data from most of the special projects as well as monitoring data from previous years, and a literature review. This 2022 monitoring report focuses primarily on the data collected for the year, including:

- Lake levels, rainfall, and clarity
- White Lake's nutrient levels, including comparisons with nearby Singletary Lake
- The productivity of the lake and its variability over time (suspended algae and cyanobacteria [phytoplankton], and submerged vegetation)

The Town of White Lake has provided financial support for lake monitoring work, while personnel from the Singletary Lake office of NC State Parks have provided logistical assistance. Dr. Linda Ehrlich, with Spirogyra Diversified Environmental Services, has provided detailed taxonomic work on phytoplankton abundance and biovolumes, and personnel from the Aquatic Weed Extension program at NC State University have conducted annual whole-lake surveys of submerged aquatic vegetation.

2. Lake Levels Lower, Less Winter Rainfall, and Greater Clarity at Times

While total annual rainfall was close to the long-term average for the region in 2022, there were 4 months in which rainfall levels were very low: February, October, November, and December (Table 1). The total variation in lake levels, at 7.2 inches high to low, was lower than it has been in recent years (Fig. 1).

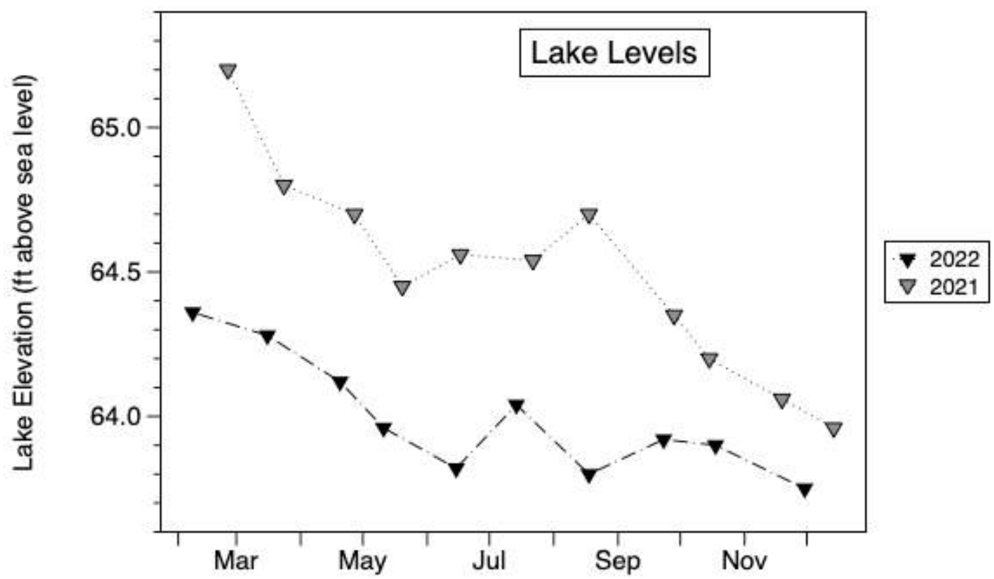


Figure 1. A comparison of Lake Levels in White Lake for 2021 and 2022. The 2022 high was 64.3 ft on January 17, while the low, 63.7 ft, was seen in May, and October, November, and December (elevation reported in feet above sea level, NAVD 88 datum).

Table 1. White Lake monthly rainfall, in inches, measured at the Town WWTP (the long-term monthly averages were determined for Elizabethtown).

Monthly Rainfall (inches) for White Lake 2012-2022

Month	2022	2021	2020	2019	2018	2017	2016	2015	2013	2012	Monthly Average for Region
January	5.75	8.25	4.5	2.75	4.20	7.0	3.0	2.5	1.75	2.75	3.81
February	1.0	9.2	6.7	2.25	2.00	1.5	10.7	5.5	2.5	4.0	3.44
March	2.45	2.7	3.7	3.25	3.95	3.7	1.55	4.15	1.0	7.0	3.91
April	3.75	1.75	5.1	7.25	6.75	6.75	6.75	4.55	1.75	2.25	3.12
May	2.2	3.0	12.25	1.20	7.70	2.7	4.5	4.20	2.25	9.25	3.67
June	6.2	7.9	7.15	5.25	10.00	4.5	3.65	8.70	17.0	2.0	4.70
July	10.5	7.5	6.85	6.00	4.75	6.75	3.75	3.0	11.25	8.6	5.75
August	5.5	6.5	7.55	5.35	6.25	5.6	4.12	9.4	8.25	9.75	5.95
September	6.5	3.2	5.95	5.00	29.45	5.2	15.0	4.7	1.0	5.0	5.29
October	0.6	0.6	3.35	3.60	2.25	2.95	14.25	9.75	1.75	2.25	3.38
November	1.55	0.4	7.5	4.90	4.25	1.0	0.50	7.25	0	2.25	3.16
December	1.2	3.4	4.25	6.00	7.5	5.45	5.1	6.5	5.75	4.25	3.14
Total	**47.2**	**54.4**	**74.85**	**52.80**	**89.05**	**53.1**	**72.87**	**70.20**	**54.25**	**59.35**	**49.32**
% of Lake Volume	**61.8**	**71**	**97**	**69**	**116**	**69**	**95**	**91**	**70**	**77**	**64**

Water clarity in April and May was very good, both in the middle of the lake (Fig. 2) and nearshore (Fig. 3).

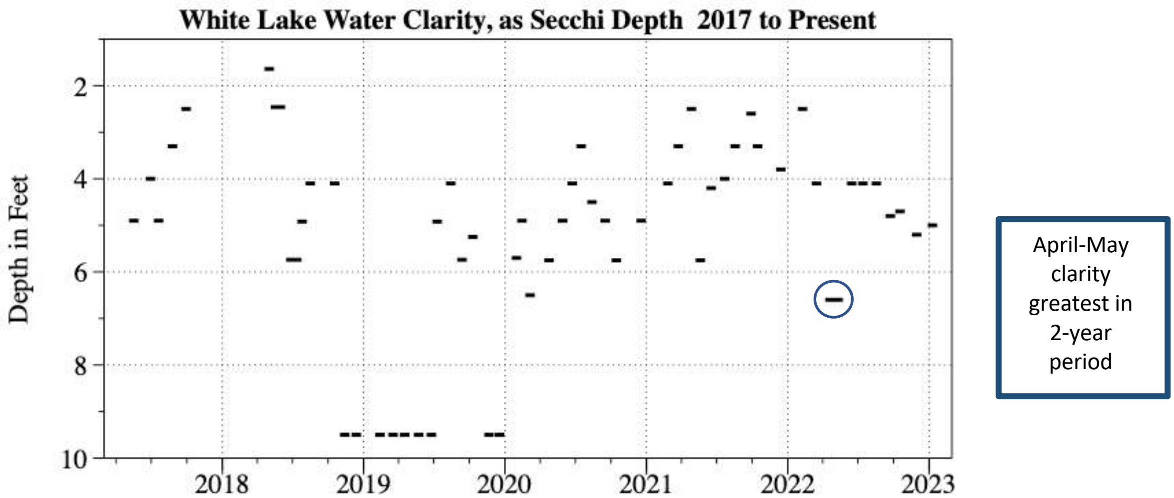


Figure 2. White Lake water clarity (in feet), as measured with a Secchi disk, from 2017 (NC DEQ data) through 2022 (LIMNOSCIENCES data for 2018-present).

Western shore, April 20 | Eastern shore, May 11

Figure 3. White Lake nearshore water clarity in April and May 2022.

Both mid-lake and nearshore clarity declines in summer months, and this year, the evidence of boating impacts was quite dramatic, with sediment creating a skin of brown and black on the water surface at the Lake Place condos. The same trend of poor nearshore conditions over the summer months is found every year to a greater or lesser degree. It is most problematic in areas where there are seawalls, which act to confine the material.

April

July

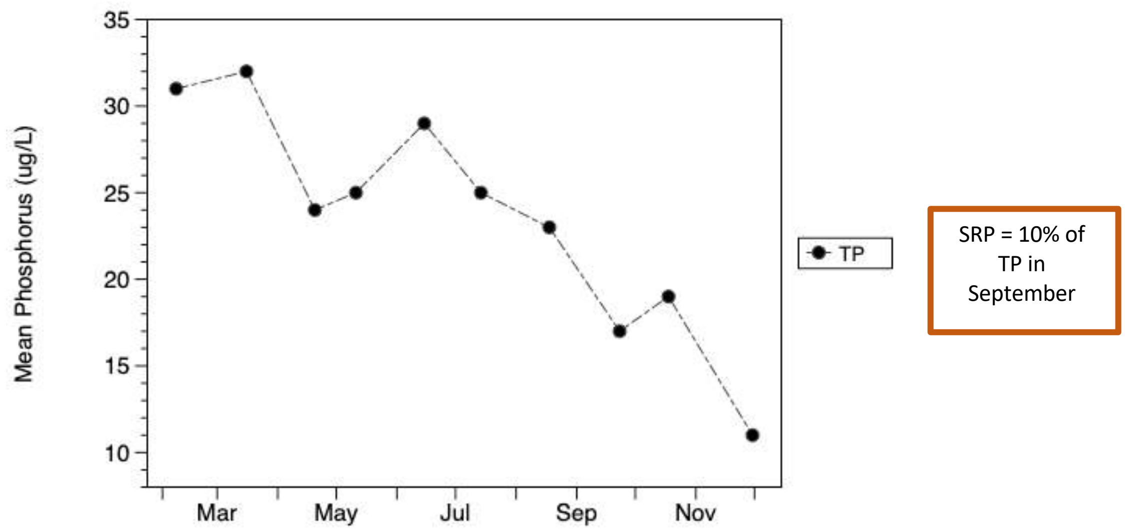
October

3. <u>White Lake Nutrient Levels Show Seasonal Variability</u>

There was a 3-fold difference between highest and lowest monthly mean levels for Total Phosphorus (TP) in 2022 (Fig. 4a), with soluble reactive phosphorus (SRP) levels ranging from below detection limits (for 3 months) to 2 µg/L (for 4 months) (Appendix 1).

Total Nitrogen (TN) showed a similar general trend for the year, with the lowest levels found from September onward (Fig. 4b). Dissolved inorganic nitrogen (DIN) was below detection limits from February through May, and was the highest in July, at 5% of TN (Appendix 1.)

a.



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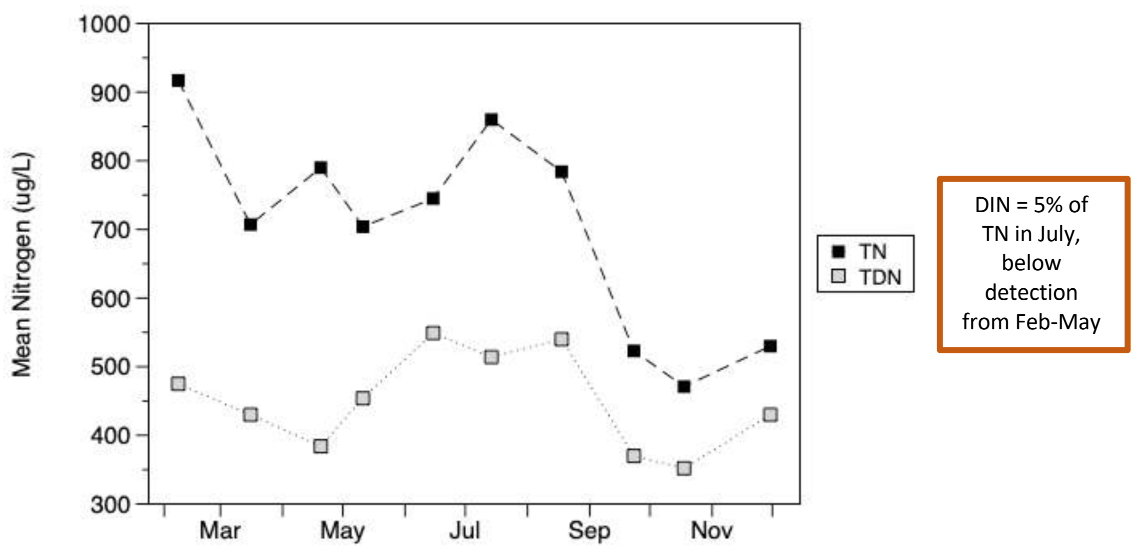


Figure 4. White Lake 2022 monthly means for a) Total Phosphorus (TP); and b) Total Nitrogen (TN) and Total Dissolved Nitrogen (TDN). All parameters reported as µg/L.

4. Nutrient Comparisons Between White Lake and Singletary Lake

Comparisons between White Lake and other Bay lakes provides a means to identify drivers of lake changes. Singletary Lake was sampled three times a year (February, June, September) in 2021 and 2022 as an acidic reference lake with an undeveloped lakeshore.

Singletary Lake is a blackwater lake that has no inlet, and the outlet was dredged long ago by the Resettlement Administration. At 569 acres, Singletary Lake occupies 56% of its bay and the remaining portion is wetlands. White Lake, at 1,067 acres, originally occupied 71% of its bay (Frey 1949), although most of the bay wetlands have been filled for lakeshore development, and the outlet has been relocated and reduced to a small ditch which has been sandbagged to prevent outflow (Fig. 5).

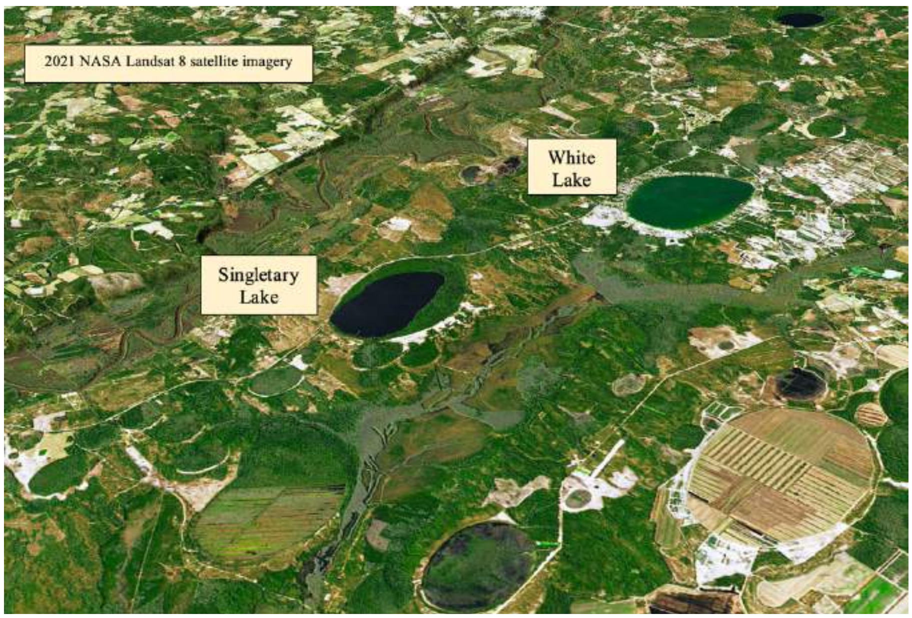
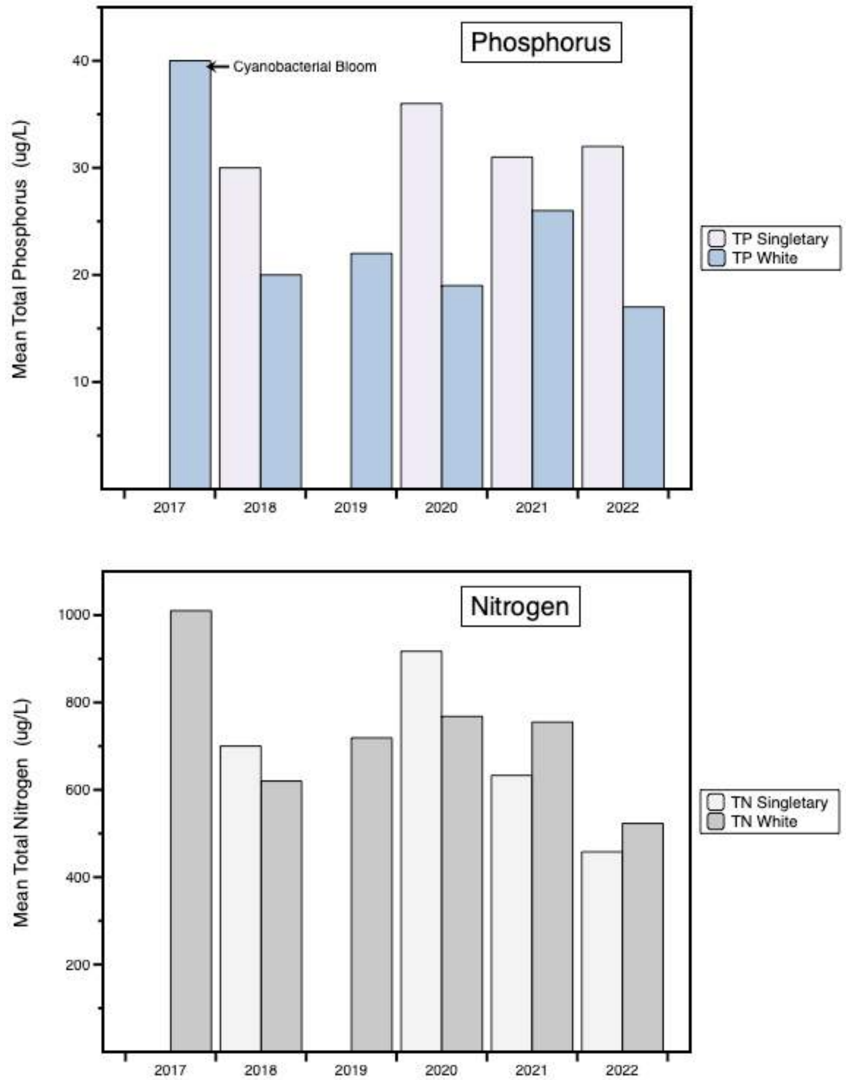


Figure 5. National Aeronautics and Space Administration (NASA) Landsat 8 satellite image of White Lake and Singletary Lake, taken in 2021.

Historically, Total Phosphorus (TP) levels have been higher at Singletary Lake compared to White Lake (e.g., Weiss and Kuenzler 1976); the exception was the period of the White Lake cyanobacterial bloom, with September 2017 TP levels (40 μg/L) the highest found in the lake up to that time. The fraction of TP that is bioavailable (SRP) is very different between the two lakes, with high SRP levels found in Singletary in both 2021 (87% of TP) and 2022 (50% of TP) (Fig. 6, Appendix 1).

Historical levels of TN were lower in both lakes compared to the present (Weiss and Kuenzler 1976). September TN levels in both 2021 and 2022 were slightly higher in White Lake (Fig. 6). Bioavailable nitrogen (DIN) was higher in Singletary (17% of TN in 2021, 12% of TN in 2022 [Appendix 2]) compared to White Lake (2% in 2021, 3% in 2022 [Appendix 1]).



In 2022, SRP = 50% of TP at Singletary

At White Lake SRP was below detection level

In 2022, DN = 75% of TN at Singletary and 71% at White Lake

Figure 6. Comparisons of Total Phosphorus (TP) and Total Nitrogen (TN) at White Lake and nearby Singletary Lake in the month of September, 2017-2022. Data from 2017 and 2018 collected and analyzed by NC DEQ; data from 2019 through 2022 collected by LIMNOSCIENCES and analyzed by IEH Analytical Laboratories.

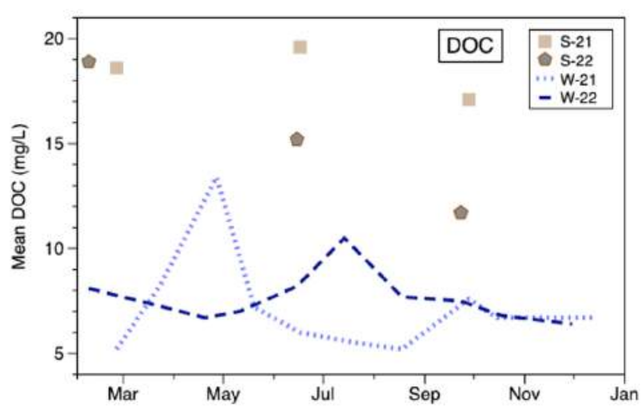
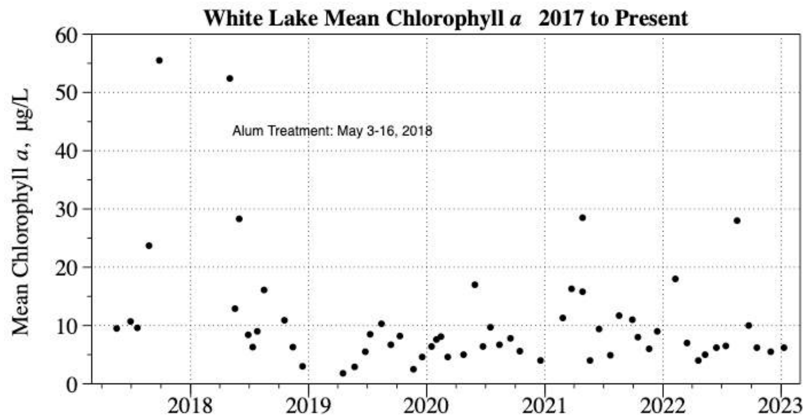


Figure 7. Dissolved Organic Carbon (DOC, reported in mg/L) at White Lake (W) and Singletary Lake (S) in 2021 and 2022.

Dissolved Organic Carbon (DOC) levels are relatively high in blackwater systems such as Singletary Lake; of note is the seasonal as well as annual variability in both lakes. In White Lake, DOC can spike during blooms, as in April 2021, and, it seems, also at times when phytoplankton biovolume is relatively low, as in July 2022 (Fig. 7, 8b).

a.



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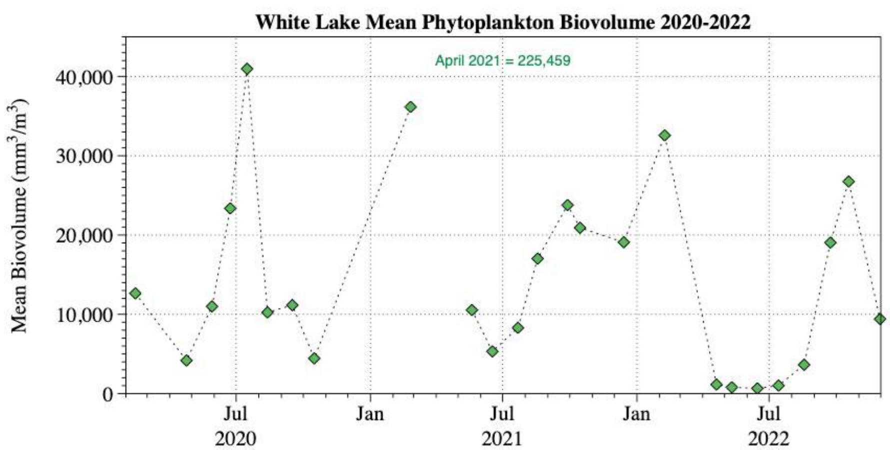

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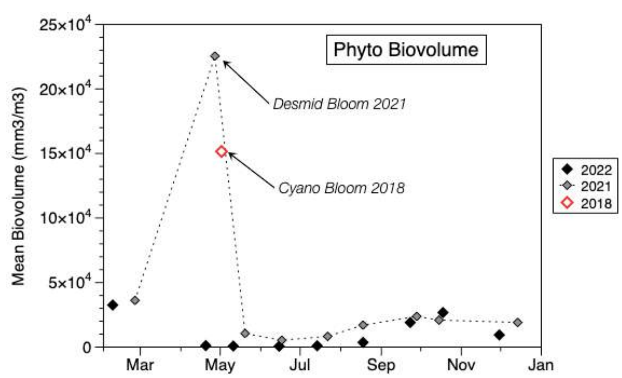


Figure 8. White Lake monthly means for: a) chlorophyll *a* (µg/L); b) phytoplankton biovolumes (mm^3/m^3); and c) phytoplankton biovolume comparisons, showing the scale of the 2021 desmid bloom and 2018 cyanobacterial bloom.

5. <u>A Sharp Decline in Phytoplankton Biovolume, Then a Resurgence of Desmids</u>

The trends in phytoplankton community dynamics (as measured by chlorophyll *a* levels) have been similar since the 2017-18 cyanobacterial bloom, with short duration peaks (Fig. 6a). However, in 2022 the biovolume lows were much lower than levels seen in recent years, and the February peak in biovolume was lower compared to the previous two years (Fig. 6b and c).

Comparisons of phytoplankton data from the month of July since 2013 (the first large bloom in White Lake, which followed large amounts of rain [Table 1]) shows the biovolume dominance by desmids has persisted, while small cyanobacteria (especially the ubiquitous *Synechococcus* sp.) can dominate numerically (it has not been counted by NC DEQ taxonomists, however) (Table 2).

Table 2. White Lake phytoplankton data comparisons for the month of July, from 2013 to 2022 (2013-2017 data from NC DEQ; 2018 to 2022 data from LIMNOSCIENCES, with algal identifications by Spirogyra Diversified Environmental Services).

A Comparison of White Lake Algae Data for July, From 2013-2022

	2013	2015	2016	2017	2018	2019	2020	2021	2022
Secchi Depth (m)	1.25	2.6	ND	1.5	1.75	1.5	1.0	1.2	1.25
Turbidity (NTU)	4.3	1.7	2.0	3.0	1.9	1.9	2.6	2.7	2.1
Chl a (µg/L)	27.7	16.3	6.2	9.6	6	8.5	9.7	4.9 (11)	6.5 (9.8)
Algal Cells/mL	114,533	2,367	45,433	241,873	150,643	38,033	169,176	221,699	34,488
Dominant Taxa (#cells/mL)	*Cosmarium* (99%)	*Staurastrum* (35%)	*Planktolyngbya* (95%)	*Planktolyngbya* (79%)	*Synechococcus* (52%)	*Synechococcus* (36%) *Staurastrum* (34%)	*Staurodesmus* (43.6%)	*Aphanocapsa* (37%) *Planktolyngbya* (32%)	*Synechococcus* (42%) *Planktolyngbya* (13%)
Algal Biovolume (mm^3/m^3)	28,400		1,400	1,967	18,307	12,128	40,965	8,297	1,011
Dominant Taxa (Biovolume)	*Cosmarium* (99%)	*Oocystis*	*Planktolyngbya Peridinium*	*Gonatozygon* (53%)	*Staurastrum* (79%)	*Staurastrum* (61%)	*Staurodesmus* (82%)	*Cosmarium* (21%) *Staurastrum* (15%)	*Cosmarium* (23%)
pH Range (su)	8.0-8.3	6.0-6.7	6.3-6.7	6.6-6.8	6.5-6.9	6.5-6.6	6.9-7.0	6.9-7.3	6.9-7.0

A comparison of chlorophyll *a* data using two methods, 1) laboratory analysis of samples sent to IEH Analytical Labs, and 2) field measurements with a handheld Turner fluorometer, found generally good agreement between the two (Fig. 7a).

Chlorophyll analysis is used as a surrogate for phytoplankton biovolume, although the two are not always correlated at White Lake. The chlorophyll data did not reflect the sharp decline in phytoplankton biovolume that was observed in April, May, and June (Fig. 7b). The samples from these months had a cloudy appearance, and the taxonomist (Dr. Linda Ehrlich) noted that "even the living cells don't look healthy".

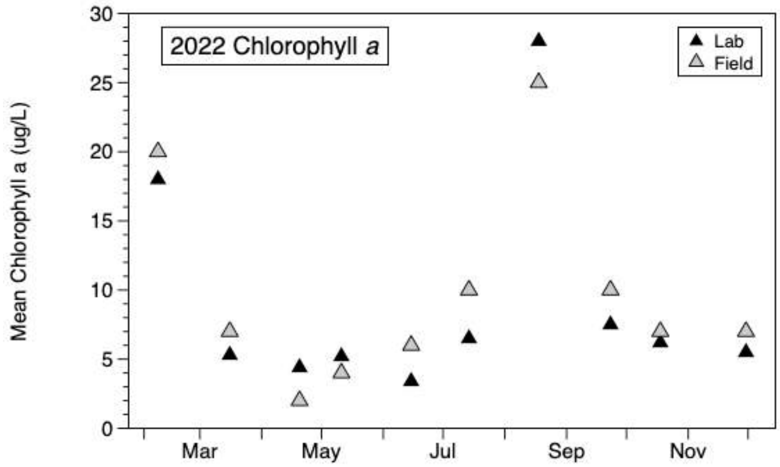
The spike in August chlorophyll corresponded with a density peak of a small colonial green alga, *Eutetramorus planktonica*, (which had nearly disappeared by September), but this correspondence was not seen with mean biovolume (Fig. 7a, b, c).

Desmids dominated biovolume in September (79%), October (90%), and November (80%), with the unicellular *Cosmarium tinctum* and the filamentous *Gonatazygon brebissoni* the dominant desmid species.

There was a total of 19 different cyanobacterial (Cyanophyta) taxa found in White Lake in 2022, with 3 species found for the first time: a third *Planktolyngbya* species (*P. tallingii*), a second *Limnothrix* species (*L. planktonica*), and the filamentous *Oscillatoria sancta* (Appendix 2).

There was a total of 18 different desmid (Charophyta) taxa found in 2022, with seven species of *Staurastrum*. By comparison, 21 desmid taxa were found in 2021 (with 7 taxa found consistently in each of the 9 sample dates) (Appendix 3).

a.



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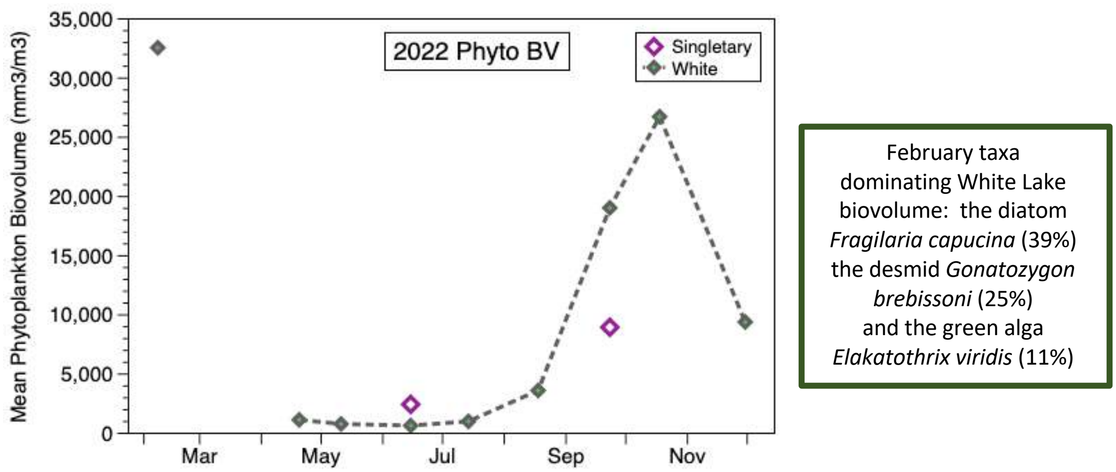

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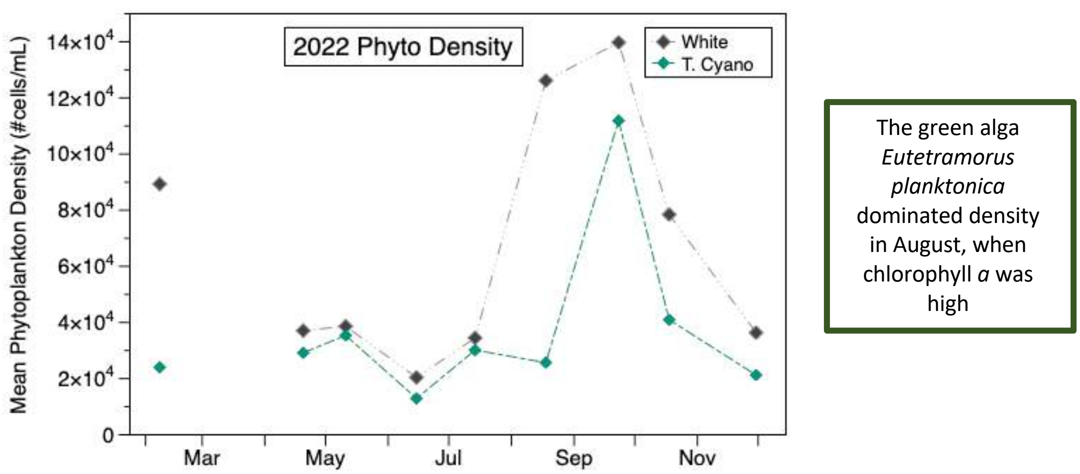

Figure 7. White Lake 2022 data means for: a) chlorophyll *a* (field = handheld fluorometer) reported as µg/L; b) phytoplankton biovolumes (BV, as mm^3/m^3) (Singletary BVs for June and September also shown); and c) phytoplankton total densities, and total cyanobacteria densities, reported as # cells/mL.

6. Phytoplankton Comparisons Between White Lake and Singletary Lake

Levels of bioavailable phosphorus and nitrogen are higher in Singletary Lake, and at times, chlorophyll *a* levels are higher than in White Lake, despite the tea-colored water (which reduces light penetration, with Secchi depths of 0.5 meters or less [Appendix 2]). In June 2022 Singletary phytoplankton biovolume was higher than that in White Lake (Fig. 7b). The flagellated alga *Gonyostomum semen*, which is characteristic of dystrophic systems (Wehr and Sheath 2003, see also Life in Water 2022 web site for microphotographs of this species) dominates Singletary BV at times (it comprised 73% of biovolume in September 2021).

Phytoplankton diversity is much lower in Singletary Lake, with 8 cyanobacteria taxa and 8 desmid taxa found (Appendix 5); except for one desmid species, all these taxa are also found in White Lake. The tiny cyanobacterium *Synechococcus* sp. dominates abundance at times in Singletary Lake (Appendix 5), as it does in White Lake (Table 2).

7. Bottom Algal Flocs Abundant in White Lake; No Hydrilla Found in 2022

Divers reported a deep layer of floc had formed above the lake bottom in the summer; some of this organic material floated to the lake surface in the fall, where it collected in nearshore areas (Fig. 8 a,b). A great deal of this material washed ashore after the cyclone-level winds of Hurricane Ian on September 30 (Fig. 8c). State Parks personnel noted that these floating blobs have been seen occasionally in previous years.

a. **b.** **c.**

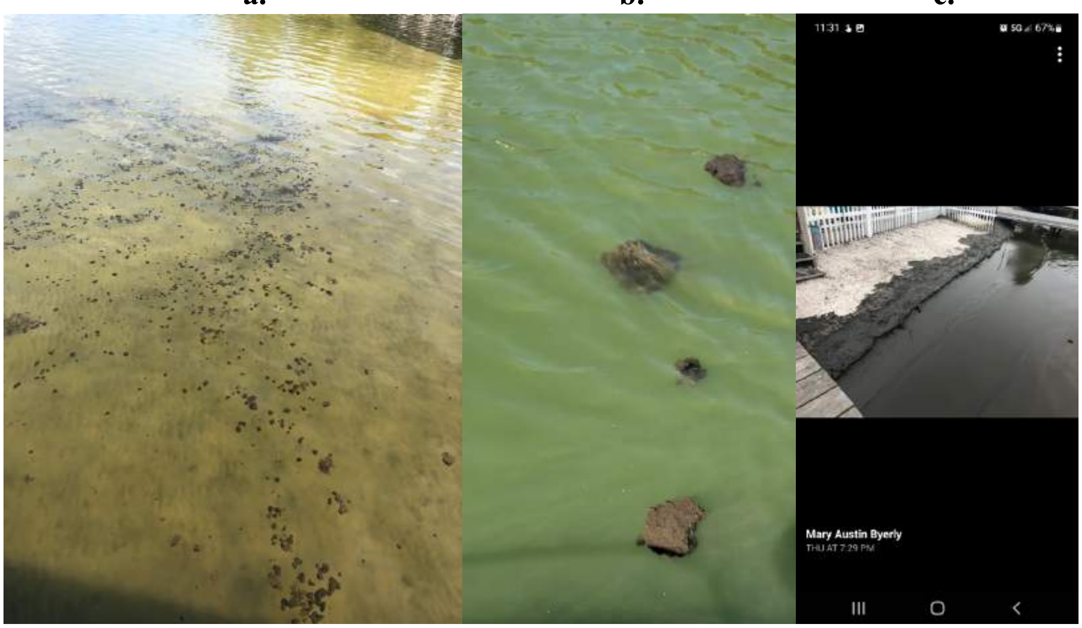

Figure 8. Clumps of floating algal material: a) at Lake Place condos (southwestern shore) on September 24; b) near the marina (northern shore) on September 24; and c) a Facebook post after Hurricane Ian.

Submerged aquatic vegetation can also be seen floating on the lake surface at times, such as the bladderwort *Utricularia purpurea* (which has been commonly found in the lake [e.g., Tebo 1961]), spikerush fragments, and dwarf milfoil (Fig. 9).

Bladderwort floating on lake surface, April 20

Proliferating spikerush

Dwarf milfoil collected from lakeshore, September 24

Figure 9. Common White Lake aquatic vegetation: bladderwort, spikerush, dwarf milfoil.

The annual whole-lake submerged aquatic vegetation survey was conducted on October 11, when the lake level was at 63.8 feet NAVD 88 (five inches of rain fell during the hurricane [Table 1]) and the Secchi depth was 1.4 meters (Appendix 1). No hydrilla was found, and vegetation coverage was at the lowest level seen since the surveys were initiated (NCSU 2023).

Table 3. White Lake submerged aquatic vegetation and percent occurrence at sample points. Table taken from NC State University aquatic vegetation survey report for 2022, which was done after Hurricane Ian.

Table 1: White Lake SAV % Occurrence

Species	2014	2017	2018	2019	2020	2021	2022
Hydrilla	0%	84%	0.50%	1.50%	0%	0.5%	0%
Tuckerman's Pondweed	0%	0%	0%	0%	13%	9%	6%
Spikerush	40%	9%	56%	68%	45%	3%	31%
Bladderwort	14%	0%	0%	0%	0%	4%	<1%
Dwarf Milfoil	0%	15%	20%	34%	20%	14%	20%
Low Milfoil	54%	0%	0.50%	0%	0%	0%	0%
Filamentous Algae	0%	0%	0%	0%	24%	28%	0%
Macroalgae	29%	66%	0%	0%	6%	27%	<1%
Aquatic Moss	43%	63%	32%	6%	8%	0%	0%
No Vegetation	11%	6%	36%	16%	25%	36%	60%
Vegetation	89%	93%	65%	84%	75%	64%	40%

Spikerush and dwarf milfoil were the most common taxa in the 2022 survey; both can be uprooted by boating activity and can collect along shorelines (e.g., Fig. 9). Vegetation relative abundance was low in the 2022 survey (Fig. 10).

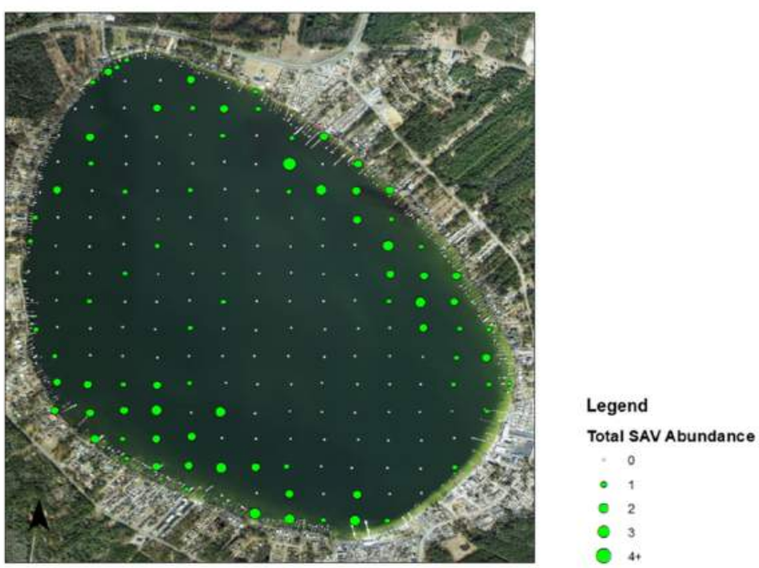

Figure 10. Aquatic vegetation relative abundance in 2022: a ranking of 1 = trace, 2 = sparse, 3 = moderate, and 4 = dense (NCSU 2023).

8. Finally, a Look at an Ongoing Focus of Interest: pH

The range in pH levels for 2022 was similar to what has been seen in recent years (6.3-7.1), with higher values found in August (8.5-8.7) when the small green alga *Eutetramorous planktonica* was abundant (Fig. 11, Fig. 7). The pH of rainfall has continued to increase at the nearby Clinton monitoring station (Fig. 12, graph taken from the National Atmospheric Deposition Program web site: https://nadp.slh.wisc.edu/sites/ntn-NC35/ accessed March 4, 2023).

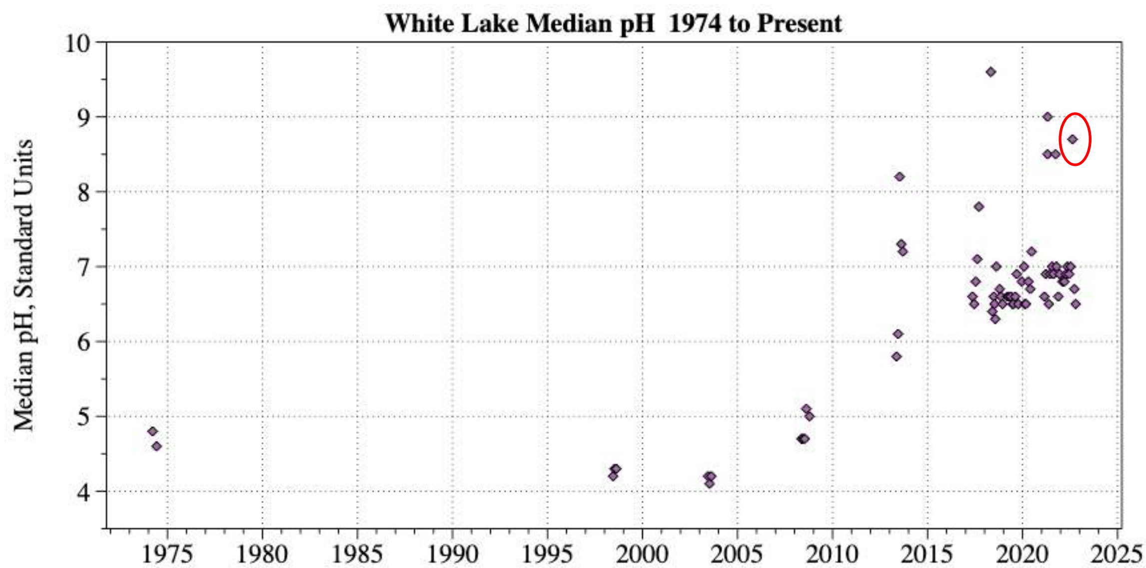

Figure 11. White Lake median pH from 1974 (Weiss and Kuenzler data), 1998-2017 (NC DEQ data), and 2018-2022 (LIMNOSCIENCES data). August 2022 pH is circled in red.

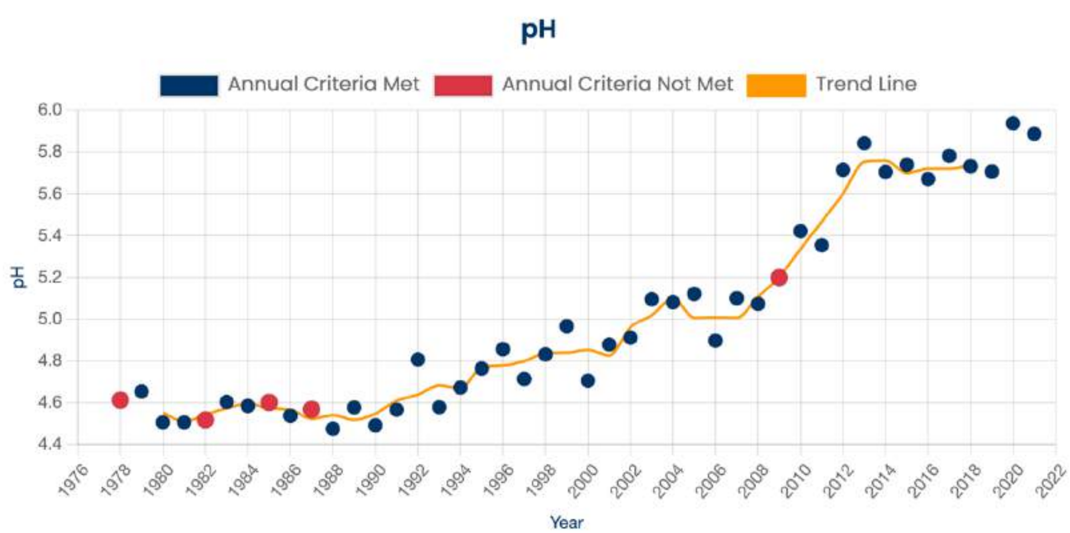

Figure 12. Annual pH levels at the Clinton, NC National Atmospheric Deposition Program station.

Summary

1. It was a very dry February in 2022, so lake levels did not exhibit a winter recovery to the same extent as in the previous three years.

2. White Lake's phytoplankton community continues to be quite dynamic, with a sharp decline in biovolume seen in April through June 2022 likely due to the absence of bioavailable nitrogen. The general trends have persisted: desmid dominance in summer/fall, increasing phytoplankton diversity, and low filamentous cyanobacterial biovolume since the 2018 alum treatment.

3. Singletary Lake has higher levels of bioavailable phosphorus and nitrogen, and at times has more phytoplankton than does White Lake. The phytoplankton that is found in Singletary is bright green due to the abundance of photosynthetic pigments in their cells, which allows them to maximize the limited amount of sunlight available in this darkly stained lake. The phytoplankton community is much less diverse compared to White Lake, however.

4. Lake clarity can at times be very good, although there are also times when the lake appears to be green. There is no evidence that the increased pH of the lake is the cause of the "discoloration" of the water; rather it is the availability of nutrients.

5. About half of While Lake's shoreline is hardened with seawalls, and these areas can be collection zones for sediments and vegetation that has been stirred up by boating activity, keeping the material in the lake rather than washing ashore. In addition, the seawalls deflect wave energy back to the lake, lengthening the period of disturbance, which helps to keep material suspended in the water. More muddy sediments were seen in shallow areas in some places in 2022 compared to previous years.

6. White Lake has always been a relatively productive lake, with most of the productivity associated with the lake bottom, as the sediments are a source of nutrients. Variability in the relative abundance of bottom algae and/or aquatic vegetation both seasonally and annually has been substantial. There have been times in the past where mechanical means have been used to remove material from shallow areas and shorelines (although removal or pumping in the lake is not permitted). In 2022, benthic algal flocs were abundant in the summer and fall, and this material washed ashore in places after Hurricane Ian. Collection and disposal of this decomposing organic matter can be difficult for property owners.

7. Grass shrimp were observed in the lake in 2022; they live amidst the bottom vegetation and dine on organic matter. They (and other small invertebrates, such as the aquatic larval stages of the midges shown on the front cover of this report) are a link in the aquatic food web of the lake and are an important food source for small fish.

8. Stewardship actions which can improve nearshore conditions include removal of seawalls and first and foremost, **responsible boating practices which can reduce the amount of material stirred up from the lake bottom.**

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Appendix 1. Means for physical and chemical parameters for White Lake, January-December 2021. Samples were generally collected at two depths (0.5 and 2.0 m) at each of three stations (equivalent to the monitoring stations used by NC DEQ). Chlorophyll *a* was measured by the analytical laboratory and in the field with a Turner hand-held fluorometer (field measurements are indicated in parenthesis).

White Lake Monitoring Project 2022

	12/14/21	2/8/22	3/16/22	4/20/22	5/11/22	6/15/22	7/14/22	8/18/22	9/23/22	10/18/22	11/30/22
Mean Temp (C)	12.1	8.7	14.4	17.6	19.6	29.6	28.1	27.3	26.0	20.2	14.4
Lake Level (gauge)	1.36	1.76	1.68	1.52	1.36	1.22	1.44	1.20	1.32	1.30	1.15
Secchi Depth (m)	1.1	0.75	1.25	2.1	2.1	1.25	1.25	1.25	1.4	1.4	1.5 (w)
Turbidity (NTU)	3.1	5.8	3.6	2.5	1.9	2.6	2.1	2.3	2.1	2.4	
Mean DO (mg/L)	10.8	12.1	10.5	9.38	9.6	8.1	8.3	9.4	8.6	10.0	10.8
Mean DO % Sat.	100	104	104	97	108	106	106	119	106	110	105
Mean Sp. Cond. (uS//L)	34.6	28	28.2	28.8	28.8	25.9	23.4	25.1	27.0	26.6	27.5
Range pH (su)	6.9-7.0	6.3-6.9	6.7-6.8	6.8-7.0	7.0-7.1	6.7-6.9	6.9-7.0	8.5-8.7	6.5-6.7	6.3-6.6	
Mean Chlorophyll a (µg/L)	8.2 (10)	18 (20)	5.3 (7)	4.4 (2)	5.2 (4)	3.4 (6)	6.5(10)	28(25)	7.5(10)	6.2(7)	5.5(7)
Mean Algal Biovol. (mm3/m3)	19,089	32,568		1,138	794	657	1,011	3,625	19,042	26,743	9,405
Mean Algal Density (# cells/mL)	96,512	89,336		37,090	38,634	20,423	34,488	126,135	139,747	78,470	36,365
Mean DOC (mg/L)	6.7	8.1	7.4	6.7	7.04	8.17	10.5	7.70	7.5	6.8	6.4
Mean Total N (mg/L)	0.738	0.917	0.707	0.79	0.704	0.745	0.860	0.784	0.523	0.471	0.530
NO3-NO2 (mg/L)	0.014	<0.010	<0.010	<0.010	<0.010	<0.010	0.014	0.012	0.013	<0.010	0.012
NH4-NH3 (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	0.010	<0.010	<0.010	0.013	<0.010
TDN (mg/L)		0.475	0.430	0.384	0.454	0.549	0.514	0.540	0.370	0.352	0.430
Mean Total P (mg/L)	0.022	0.031	0.032	0.024	0.025	0.029	0.025	0.023	0.017	0.019	0.011
SRP (mg/L)		0.002	0.002	0.001	0.002	<0.001	0.001	0.002	<0.001	0.002	<0.001
Mean TN : TP (mass)	33.5	26.6	22.0	29.8	27.9	26.0	34.4	34.1	30.0	25	47.6

Appendix 2. Physical and chemical parameters and phytoplankton abundance and biovolume for Singletary Lake, 2020-2022. Samples were collected at 0.5 m depth, and chlorophyll *a* was measured by the analytical laboratory and in the field with a Turner hand-held fluorometer (field measurements are indicated in parenthesis).

Singletary Lake Monitoring Project 2020-2022

	9/16/20	2/25/21	6/17/21	9/28/21	2/8/22	6/15/22	9/23/22
Temp (oC) at 0.5m	25.3	11.3	29.1	26.3	9.0	29.2	25.4
Secchi Depth (m)	0.3	0.5	0.25	0.25	0.25	0.5	0.5
Turbidity (NTU)	3.3	2.2	2.6	2.4	6.5	3.9	4.4
DO (mg/L)	7.54	11.3	7.3	8.0	11.8	6.36	8.23
DO % saturation	92	102	95	99	101	83	100
Sp. Conductivity (uS//L)	38.2	40.1	34.5	32	29	26	27.3
pH (su)	4.11	4.27	4.3	4.12	4.08	4.26	4.23
Alkalinity (mg CaCo3/L)		<1.00					
Total Aluminum (mg/L)		0.302					
Chlorophyll a (µg/L)	(7)	10 (11)	11 (14)	11 (10)	(7)	11 (10)	30 (7)
Algal Biovolume (mm3/m3)		2,707	4,127	3,588		2,448	8,961
Gonyostomum semen (% T. BV)		58%	12.7%	73%		21%	
Carteria sp. (% T. BV)			48.4%				
Pleodorina california (% T. BV)						29%	
Fragillaria cappuccina (% T. BV)							60.8%
Chlorophyta % T. BV		1%	60.8%	8.8%		40.7%	
Cryptophyta % T. BV			20.8%			17.8%	12%
Charophyta % T. BV			1.2%			12%	
Algal Density (# cells/mL)		5,896	17,156	9,276		14,140	16,704
Synechococcus % T. Density		81.4%	69.5%	69%		31.7%	32.6%
Cyanoganis ferriginea						45.3%	
Cyanophyta % T. Density						80.2%	32.6%
Bacillariophyta % T. Density		10.2%	1.7%				23.3
Chlorophyta % T. Density		1.6%	27.4%	14.7%			32.9%
DOC (mg/L)	16.4	18.6	19.6	17.1	18.9	15.2	11.7
Total N (mg/L)	0.917	0.889	0.881	0.633	0.627	0.625	0.458
NO3-NO2 (mg/L)		<0.010	0.101	0.072	0.127	<0.010	0.031
NH4-NH3 (mg/L)		<0.010	0.036	0.036	0.043	0.059	0.024
TDN (mg/L)	0.668	0.756	0.623		0.453	0.624	0.343
Total P (mg/L)	0.0360	0.033	0.038	0.031	0.037	0.030	0.032
SRP (mg/L)		0.018	0.030	0.027	0.032	0.022	0.016
TDP (mg/L)		0.020					
SRP %TP		54.5	78.9	87.1	86.5	73.3	50
TN : TP (mass)		26.9	23.2	20.4	16.9	20.8	14.3
# of Samples	2	1	1	1	1	1	1

Appendix 3. Cyanobacterial taxa found in White Lake in 2022. An asterisk indicates species found for the first time.

White Lake Cyanobacteria Taxa 2022

	2/8/22	**4/20/22**	**5/11/22**	**6/15/22**	**7/14/22**	**8/18/22**	**9/23/22**	**10/18/22**	**11/30/22**
Synechococcus	x	x	x	x	x	x	x	x	x
Aphanocapsa delicatissima	x	x	x	x		x	x	x	
Aphanocapsa incerta		x							
Aphanocapsa sp.		x	x		x	x	x	x	x
Borzia sp.							x	x	
Chroococcus aphanocapsoides	x	x	x	x	x	x		x	x
Aphanothece sp.		x			x	x			
Planktolyngbya crassa	x	x		x	x	x	x	x	x
Planktolyngbya limnetica				x	x	x	x	x	x
*Planktolyngbya tallingii**						x			
*Limnothrix planktonica**									x
Limnothrix redekei	x								
Cyanoganis ferriginea	x	x	x	x	x	x	x		
Pseudanabaena limnetica			x	x					
Jaaginema sp.	x								
Aphanizomenon sp.	x				x	x		x	
Cylindrospermopsis phillipinensis								x	
Cylindrospermopsis raciborskii	x			x					
Komvophoron sp.						x			
*Oscillatoria sancta**								x	x
Total Cyanos = 19									

Appendix 4. Desmid taxa found in White Lake in 2022 and 2021. An asterisk indicates species found for the first time.

White Lake Desmid Taxa 2022

	2/8/22	**4/20/22**	**5/11/22**	**6/15/22**	**7/14/22**	**8/18/22**	**9/23/22**	**10/18/22**	**11/30/22**
Closterium acutum	X			X	X	X	X	X	X
Closterium dydimoticum							X	X	
Closterium gracile	X								
Closterium venus						X	X	X	X
Cosmarium tinctum	X	X	X	X	X	X	X	X	X
Cosmarium regnesi v. montanum					X		X		
Gonatozygon brebissoni	X		X	X	X	X	X	X	X
Spondylosium pygaeum	X			X	X	X	X	X	X
Staurastrum americanum	X				X	X	X	X	
Staurastrum brachiatum[*]						X			
Staurastrum chaetoceras	X				X	X	X	X	X
Staurastrum ellipticum v. minutum						X	X	X	
Staurastrum margaritaceum	X			X		X	X	X	X
Staurastrum spiculiferum								X	
Staurastrum tetracerum	X	X		X	X	X	X	X	X
Staurodesmus dejectus v. apiculatum	X	X	X	X	X	X	X	X	X
Staurodesmus subulatus	X	X	X			X	X	X	X
Staurodesmus triangularis	X	X	X	X	X	X	X	X	X
Total Desmids= 18									

Appendix 4 (continued).

White Lake Desmid Taxa 2021

	2/25/21	4/27/21	5/20/21	6/11/21	7/22/21	8/18/21	9/28/21	10/15/21	12/14/21
Closterium acutum	X	X	X	X	X	X	X	X	X
Closterium dydimoticum			X	X			X	X	X
Closterium gracile		X					X	X	X
Closterium parvulum v. angustum									X
Closterium venus									X
Cosmarium achondroides[*]			X						
Cosmarium tinctum	X	X	X	X	X	X	X	X	X
Cosmarium regnesi v. montanum			X		X	X	X	X	X
Gonatozygon brebissoni	X	X	X	X	X	X	X	X	X
Sphaerozosma sp.							X	X	X
Spondylosium pygaeum						X	X	X	X
Staurastrum americanum				X	X	X	X	X	X
Staurastrum chaetoceras		X	X	X	X	X	X	X	X
Staurastrum curvatum[*]						X	X		
Staurastrum ellipticum v. minutum							X	X	X
Staurastrum margaritaceum	X	X	X	X	X	X	X	X	X
Staurastrum spiculiferum	X		X		X				X
Staurastrum tetracerum	X	X	X	X	X	X	X	X	X
Staurodesmus dejectus v. apiculatum	X	X	X	X	X	X	X	X	X
Staurodesmus subulatus					X	X	X	X	X
Staurodesmus triangularis	X	X	X	X	X	X	X	X	X
Staurodesmus sp.	**X**	**X**	**X**						
Total Desmids= 22									

Appendix 5. Singletary Lake cyanobacterial and desmid taxa found in 2021-2022. A single sample was taken at each sample data. *Staurastrum longipes* is the only species that has not been found in White Lake.

Singletary Lake Cyanobacteria Taxa 2021-2022

	2/25/21	6/17/21	9/28/21	6/15/22	9/23/22
Synechococcus	x	x	x	x	x
Planktolyngbya limnetica	x	x	x	x	
Cyanoganis ferriginea				x	
Romeria sp.				x	
Pseudanabaena limnetica		x			
Aphanizomenon sp.			x	x	
Cylindrospermopsis phillipinensis		x			
Cylindrospermopsis raciborskii				x	
Total Cyanos = 8					

Singletary Lake Desmid Taxa 2021-2022

	2/25/21	6/17/21	9/28/21	6/15/22	9/23/22
Closterium acutum	X	X		X	X
Closterium gracile		X	X	X	X
Gonatozygon brebissoni				X	
Staurastrum brachiatum					X
Staurastrum chaetoceras		X	X	X	X
Staurastrum longipes					X
Staurastrum tetracerum		X	X		X
Staurodesmus dejectus v. apiculatum		X	X		
Total Desmids = 8					