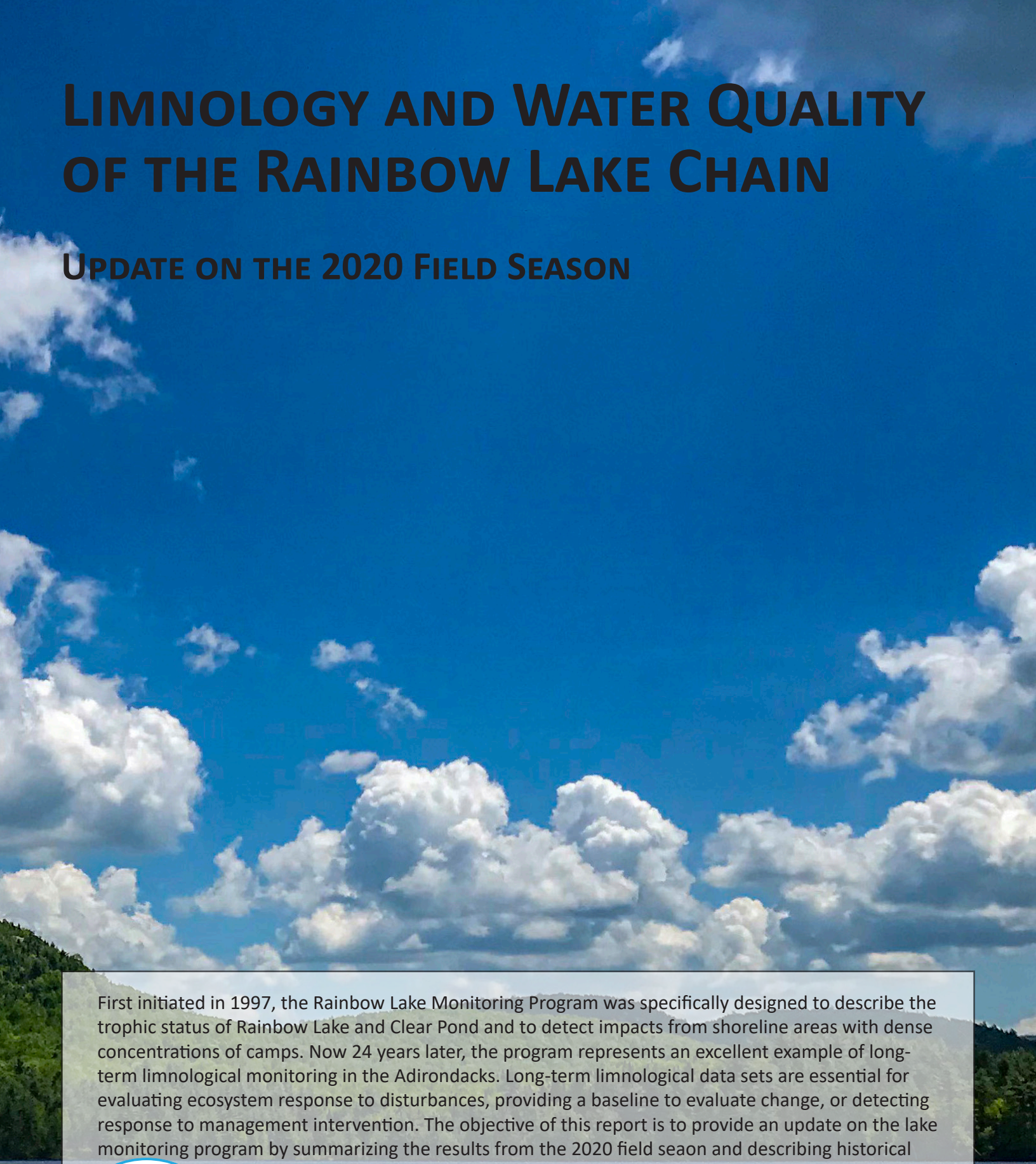
Limnology and Water Quality of the Rainbow Lake Chain

Update on the 2020 Field Season



First initiated in 1997, the Rainbow Lake Monitoring Program was specifically designed to describe the trophic status of Rainbow Lake and Clear Pond and to detect impacts from shoreline areas with dense concentrations of camps. Now 24 years later, the program represents an excellent example of long-term limnological monitoring in the Adirondacks. Long-term limnological data sets are essential for evaluating ecosystem response to disturbances, providing a baseline to evaluate change, or detecting response to management intervention. The objective of this report is to provide an update on the lake monitoring program by summarizing the results from the 2020 field seaon and describing historical trends in the key water quality indicators. Detailed descriptions of the morphometry of the lakes, field and lab methodology, and guidelines for interpreting the data can be found in the 2017 Annual Report, available on the web pages of the Rainbow Lake Association as well as the Paul Smith's Adirondack Watershed Institute.

PAUL SMITH'S COLLEGE
ADIRONDACK WATERSHED INSTITUTE

Rainbow Lake

Rainbow Lake is best classified as a mesotrophic lake with moderate nutrient concentration. The water transparency in 2020 exhibited some variability around the average of 3.1 meters. Historically, annual average transparency has fluctuated between 2.5 and 3.5 meters with no significant trend. The total phosphorus concentration ranged from 5.8 to 10.9 µg/L in 2020. Phosphorus concentration has been stable since 2010, and substantially lower than the 2000-2009 period. We believe significant method improvements initiated in 2010 are responsible for the sharp decrease in phosphrus concentration.

The surface and bottom water of the lake is circumneutral in terms of its acidity, with an average pH of 7.3 and 6.3, respectively. The alkalinity of the surface water averaged 18.4 mg/L, indicating that the lake has adequate buffering ability, and is not currently sensitive to changes in pH due to acid deposition. The pH and alkalinity of the lake have not exhibited any statistical trend since 1997.

The sodium and chloride concentration in the surface water averaged 2.0 and 2.3 mg/L, respectively. These values are marginally elevated above background concentrations for Adirondack Lakes. A portion of these ions may be from the 6.6 km of roads in the watershed.

Rainbow Lake experiences significant oxygen depletion in the bottom strata. The depletion was evident in July when the bottom 2 meters of the lake contained less than 2.0 mg/L of dissolved oxygen (hypoxic). By mid-August, 51% of the water column was hypoxic and the bottom four meters were essentially devoid of oxygen (anoxic).

Table 1. Water quality indicators for the surface and bottom water of Rainbow Lake during the 2020 sampling season. BDL = below laboratory detection, ± indicates an estimated value.

WATER QUALITY INDICATOR	6/5/2020	7/2/2020	8/18/2020	AVERAGE
		Epilmnion (surface water)		
Transparency (m)	3.2	2.5	3.5	3.1
Total Phosphorus (µg/L)	9.0	10.9	5.8	8.6
Chlorophyll-a (µg/L)	3.7	4.5	2.1	3.4
Lab pH	7.1	7.5	7.3	7.3
Lab Cond (µS/cm@25C)	45.8	45.6	34.4	41.9
Apparent Color (Pt-Co)	56.8	60.0	31.1	49.3
Alkalinity (mg/L)	18.9	17.2	19.1	18.4
Total Nitrogen	215.4	188.5	219.1	207.7
Nitrate -N (µg/L)	BDL	BDL	BDL	BDL
Chloride (mg/L)	2.2	2.2	2.5	2.3
Sodium (mg/L)	1.6	1.7	2.5	2.0
		Hypolimnion (bottom water)		
Total Phosphorus (µg/L)	15.0	19.3	16.8	17.0
Lab pH	7.0	6.6	6.4	6.7
Lab Specific Cond (µS/cm@25C)	47.4	52.5	36.0	45.3
Apparent Color (Pt-Co)	66.5	95.4	72.9	78.3
Alkalinity (mg/L)	21.5	19.4	21.7	20.9
Total Nitrogen	289.2	462.0	302.2	351.1
Nitrate -N (µg/L)	45.3	37.8	86.2	56.4
Chloride (mg/L)	2.2	2.1	2.5	2.3
Sodium (mg/L)	1.6	1.7	2.4	1.9

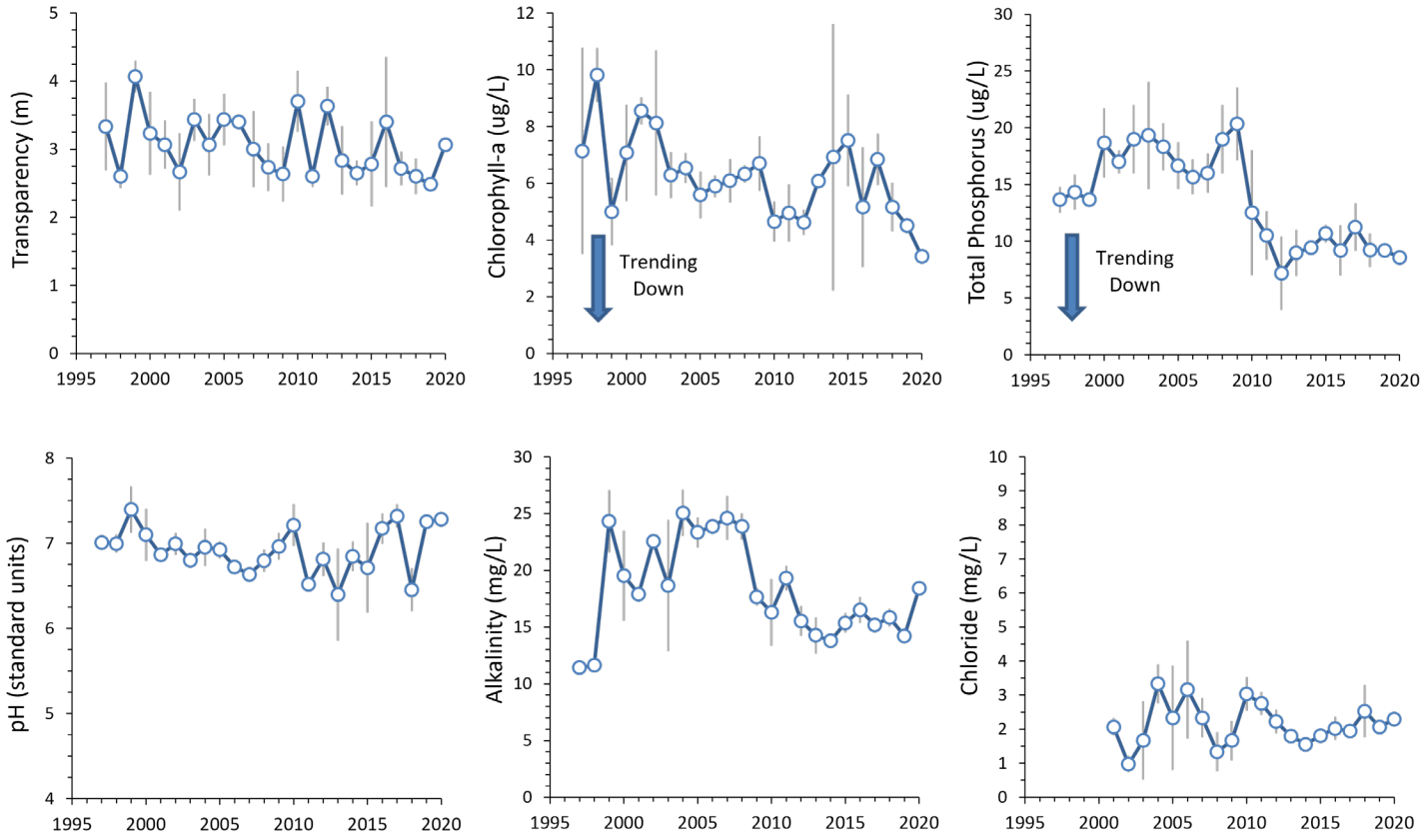


Figure 1. Annual average values of key water quality indicators in Rainbow Lake, 1997-2020. Error bars represent one standard deviation of the mean. Upward or downward facing arrows denote statistically significant historical trends.

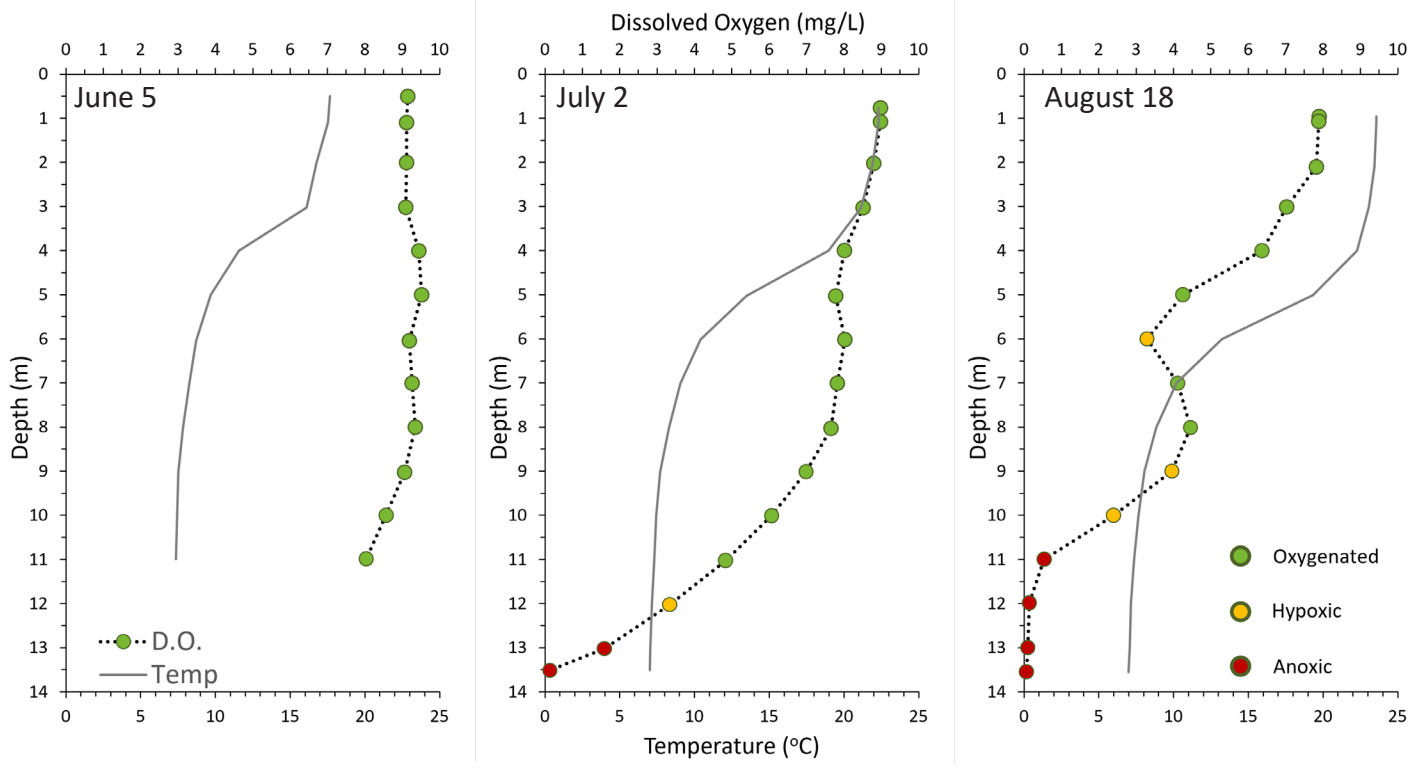


Figure 2. Profiles of dissolved oxygen and temperature in Rainbow Lake during the 2020 sampling season. Zones of oxygen depletion denoted by orange and red markers. Hypoxic = D.O ≤ 2.0 mg/L. Anoxic = D.O. ≤ 0.5 mg/L.

Clear Pond

Clear Pond is best classified as a mesotrophic lake with moderate nutrient concentration and algal productivity. The trophic state has been stable since monitoring began in 1997. The water transparency in 2020 ranged from 3.2 to 3.7 meters. Historically, annual average transparency has fluctuated between 3 and 4 meters with no significant trend detected. The total phosphorus concentration averaged 6.4 µg/L in 2020. Phosphorus concentration has been low since 2010, and substantially lower than the 2000-2009 period. We believe significant method improvements initiated in 2010 are responsible for the sharp decrease in phosphorus concentration.

The surface and bottom water of the lake is circumneutral in terms of its acidity, with an average pH of 6.4 and 6.7, respectively. The alkalinity of the surface water averaged 13.5 mg/L, indicating that the lake has adequate buffering ability, and is not currently sensitive to changes in pH due to acid deposition. The pH and alkalinity of the lake have not exhibited any statistical trends since 1997.

The sodium and chloride concentration in the surface water averaged 1.3 and 0.8 mg/L, respectively. These values are marginally elevated above background concentrations for Adirondack Lakes.

Clear Pond exhibits a positive heterograde oxygen profile, where phytoplankton photosynthesis results in the greatest D.O. content at intermediate depths. Clear Pond experiences moderate oxygen depletion in the bottom strata. The hypoxic region reached the bottom six meters by mid-August.

Table 2. Water quality indicators for the surface and bottom water of Clear Pond during the 2020 sampling season. BDL = below laboratory detection, ± indicates an estimated value.

WATER QUALITY INDICATOR	6/5/2020	7/2/2020	8/18/2020	AVERAGE
		Epilmnion (surface water)		
Transparency (m)	3.2	3.7	3.6	3.5
Total Phosphorus (µg/L)	5.5	7.1	6.5	6.4
Chlorophyll-a (µg/L)	2.7	2.1	1.5	2.1
Lab pH	7.0	7.4	7.7	7.4
Lab Cond (µS/cm@25C)	32.5	32.5	53.6	39.5
Apparent Color (Pt-Co)	31.1	24.6	34.3	30.0
Alkalinity (mg/L)	15.1	11.8	13.7	13.5
Total Nitrogen	167.5	212.1	138.8	172.8
Nitrate -N (µg/L)	BDL	BDL	BDL	BDL
Chloride (mg/L)	0.7	0.8	1.0	0.8
Sodium (mg/L)	1.0	1.1	1.9	1.3
		Hypolimnion (bottom water)		
Total Phosphorus (µg/L)	8.7	10.3	20.8	13.3
Lab pH	6.8	6.7	6.6	6.7
Lab Specific Cond (µS/cm@25C)	32.9	34.2	43.5	36.9
Apparent Color (Pt-Co)	31.1	40.7	50.4	40.7
Alkalinity (mg/L)	10.8	12.5	13.0	12.1
Total Nitrogen	264.2	320.6	314.8	299.9
Nitrate -N (µg/L)	26.8	18.9	67.9	37.9
Chloride (mg/L)	0.6	0.7	0.9	0.7
Sodium (mg/L)	0.9	1.0	1.9	1.3

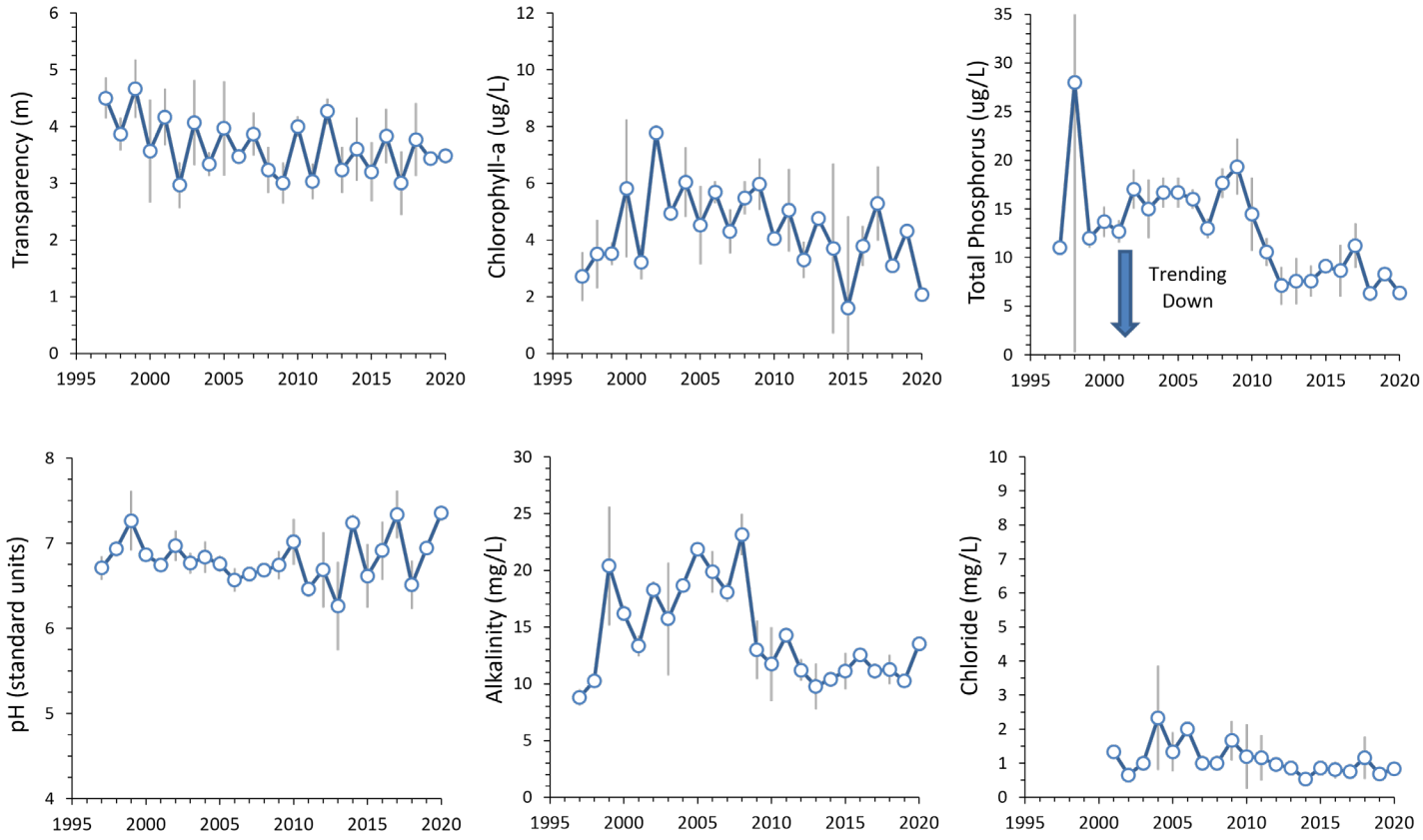


Figure 3. Annual average values of key water quality indicators in Clear Pond, 1997-2020. Error bars represent one standard deviation of the mean. Upward or downward facing arrows denote statistically significant historical trends.

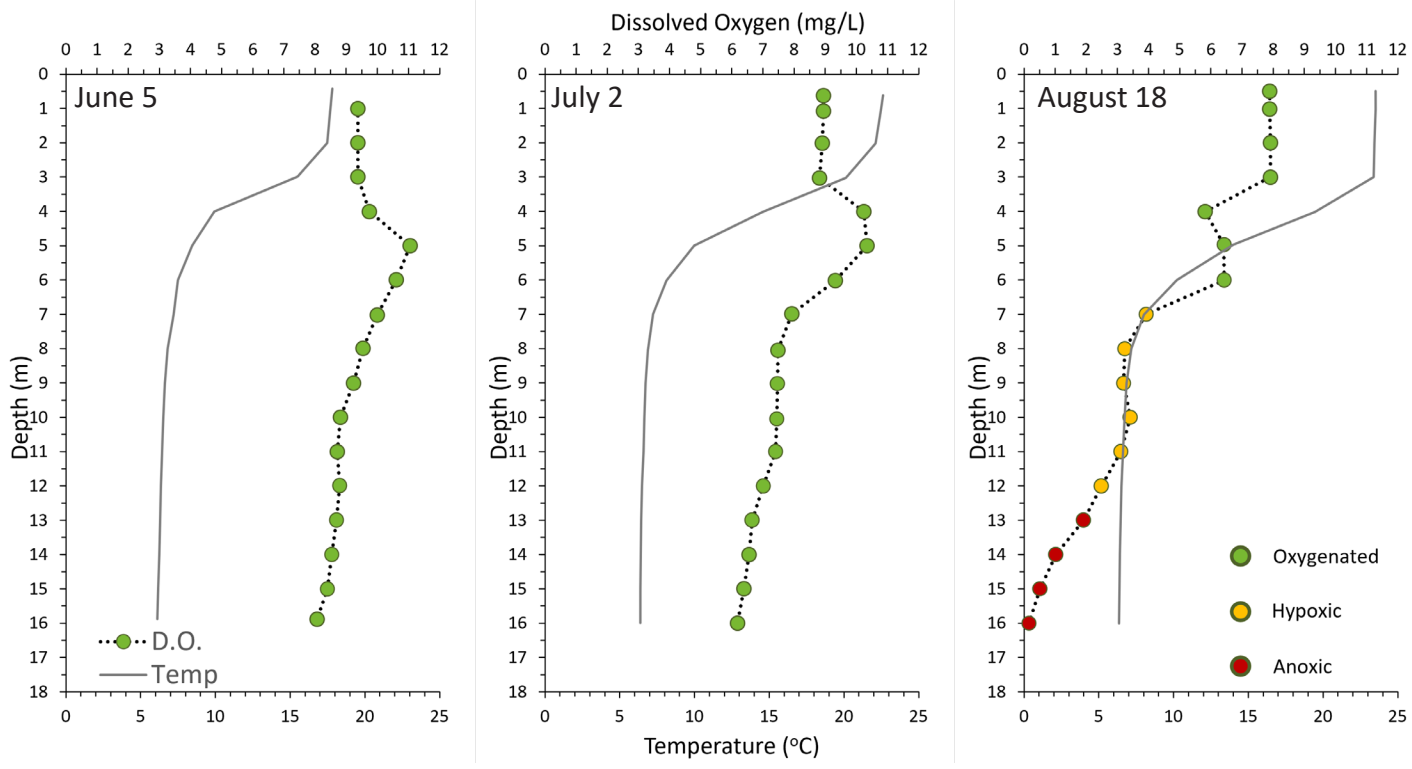


Figure 4. Profiles of dissolved oxygen and temperature in Clear Pond during the 2020 sampling season. Zones of oxygen depletion denoted by orange and red markers. Hypoxic = D.O ≤ 2.0 mg/L. Anoxic = D.O. ≤ 0.5 mg/L.

Lake Kushaqua

The water transparency Lake Kushaqua is the lowest in the lake chain, and averaged 2.8 meters in 2020. We detected a significant downward trend in transparency since monitoring began in 2000. The reduction in transparency is likely a part of a regional phenomenon. We have observed reduced transparency trends in several of our study lakes. Current research suggests that increased dissolved organic carbon (DOC) is responsible for the transparency changes. Increased DOC in lakes is likely the result of a combination of recovery from acid deposition as well as increased precipitation. Apparent color is a useful surrogate measure for DOC. The color of Lake Kushaqua was greater than 90% of the lakes in the AWI dataset.

The surface and bottom water of the lake is circumneutral in terms of its acidity, with an average pH of 7.8 and 6.5, respectively. The alkalinity of the surface water averaged 22.8 mg/L, indicating that the lake is highly buffered, and not sensitive to changes in pH due to acid deposition. The pH and alkalinity of the lake have not exhibited any statistical trends.

The sodium and chloride concentration in the surface water averaged 1.6 and 1.0 mg/L, respectively. These values are marginally elevated above background concentrations for Adirondack Lakes.

The vast majority of the Lake Kushaqua water column was oxygenated throughout the summer. Some oxygen depletion was noted during the month of August when the bottom two meters were found to be slightly hypoxic.

Table 3. Water quality indicators for the surface and bottom water of Lake Kushaqua during the 2020 sampling season. BDL = below laboratory detection, ± indicates an estimated value.

WATER QUALITY INDICATOR	6/5/2020	7/2/2020	8/18/2020	AVERAGE
		Epilmnion (surface water)		
Transparency (m)	2.6	3.1	2.7	2.8
Total Phosphorus (µg/L)	8.1	7.3	8.1	7.8
Chlorophyll-a (µg/L)	3.5	1.4	3.2	2.7
Lab pH	7.4	7.5	7.6	7.5
Lab Cond (µS/cm@25C)	45.6	48.0	48.2	47.3
Apparent Color (Pt-Co)	46.2	37.5	43.9	42.5
Alkalinity (mg/L)	23.4	21.1	23.9	22.8
Total Nitrogen	195.5	230.8	150.4	192.2
Nitrate -N (µg/L)	BDL	BDL	BDL	BDL
Chloride (mg/L)	0.9	1.0	1.1	1.0
Sodium (mg/L)	1.2	1.4	2.2	1.6
		Hypolimnion (bottom water)		
Total Phosphorus (µg/L)	9.6	10.0	31.9	17.2
Lab pH	7.0	6.8	6.6	6.8
Lab Specific Cond (µS/cm@25C)	40.1	40.5	53.5	44.7
Apparent Color (Pt-Co)	66.5	53.6	24.6	48.2
Alkalinity (mg/L)	18.5	16.1	16.8	17.1
Total Nitrogen	327.2	317.9	383.7	342.9
Nitrate -N (µg/L)	65.1	77.6	128.0	90.2
Chloride (mg/L)	0.7	0.8	0.8	0.8
Sodium (mg/L)	1.0	1.1	2.0	1.4

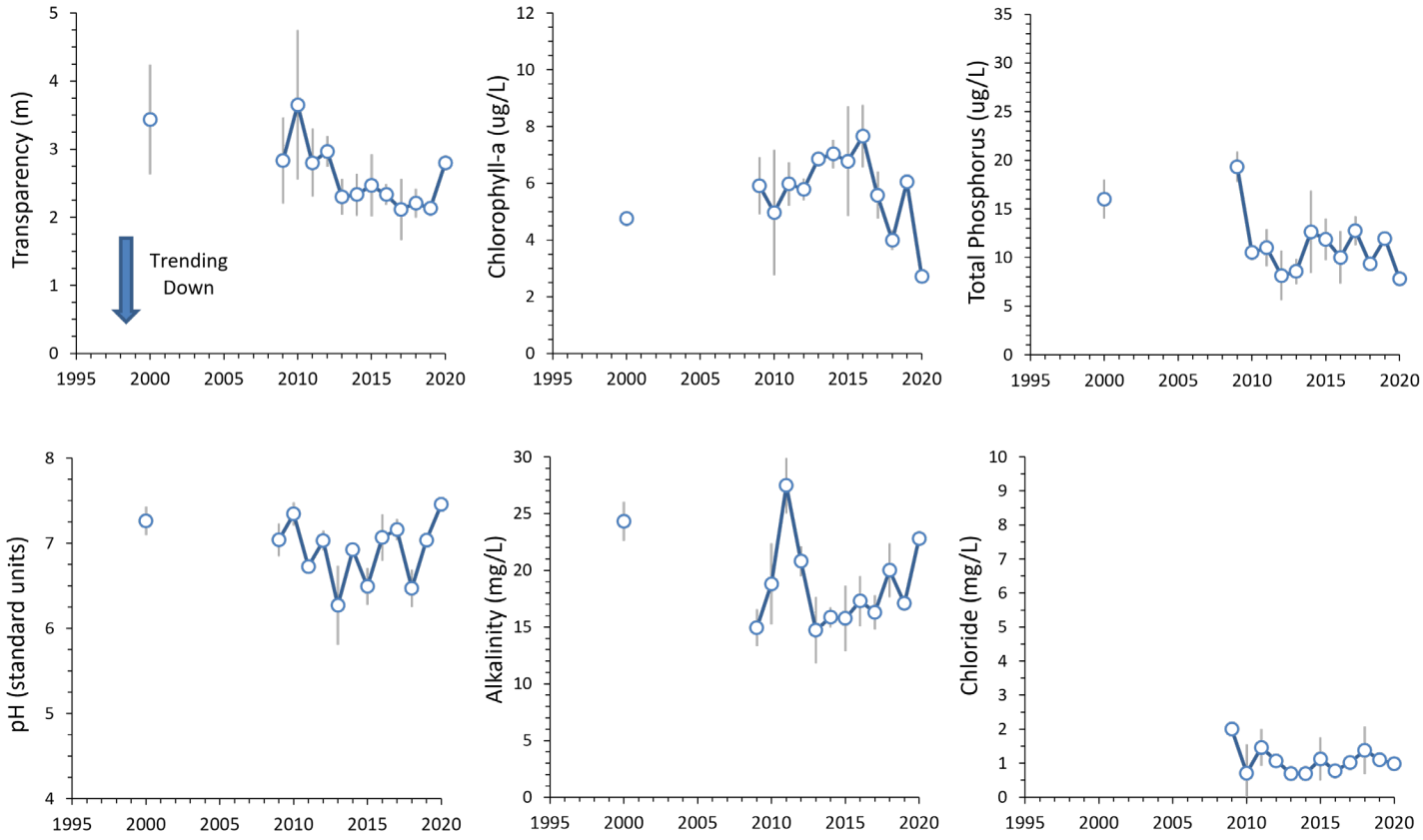


Figure 5. Annual average values of key water quality indicators in Lake Kushaqua, 1997-2020. Error bars represent one standard deviation of the mean. Upward or downward facing arrows denote statistically significant historical trends.

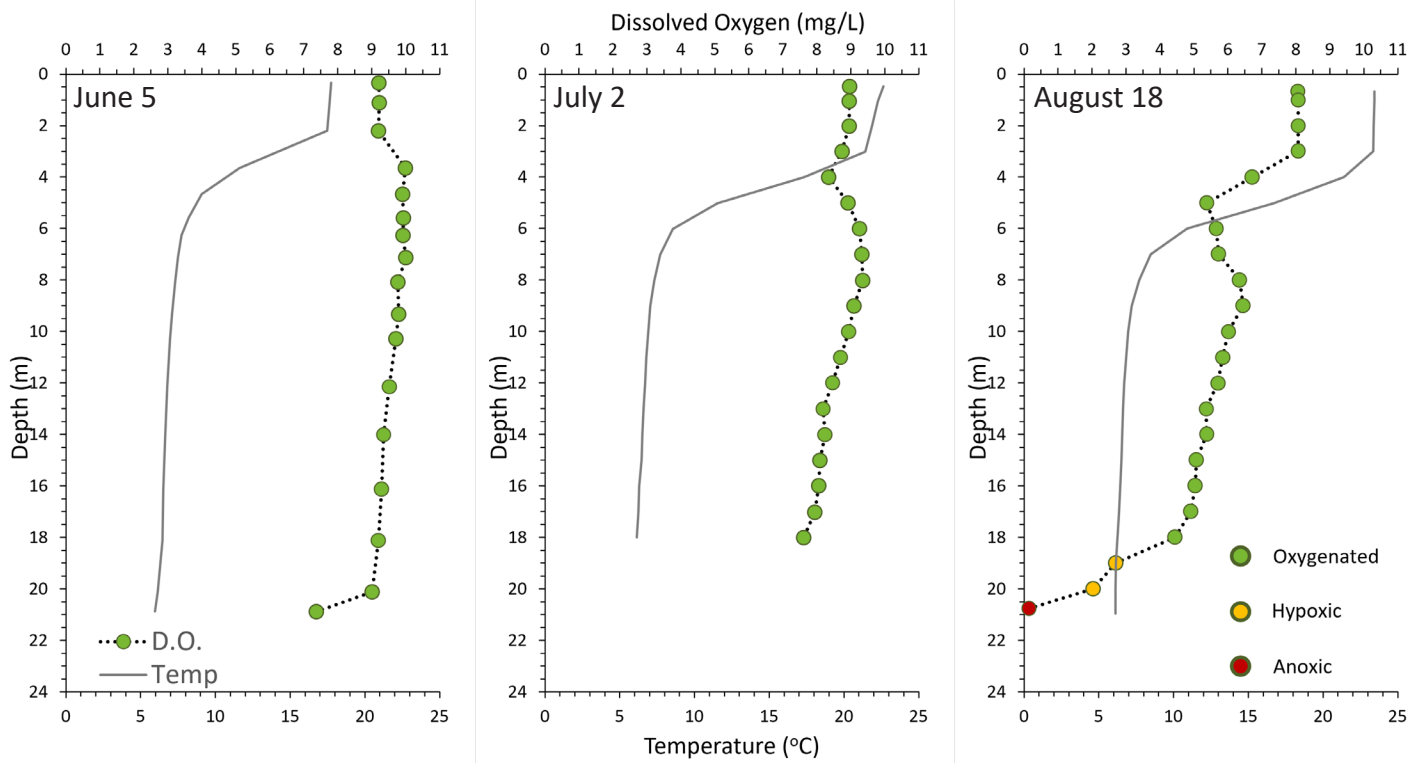
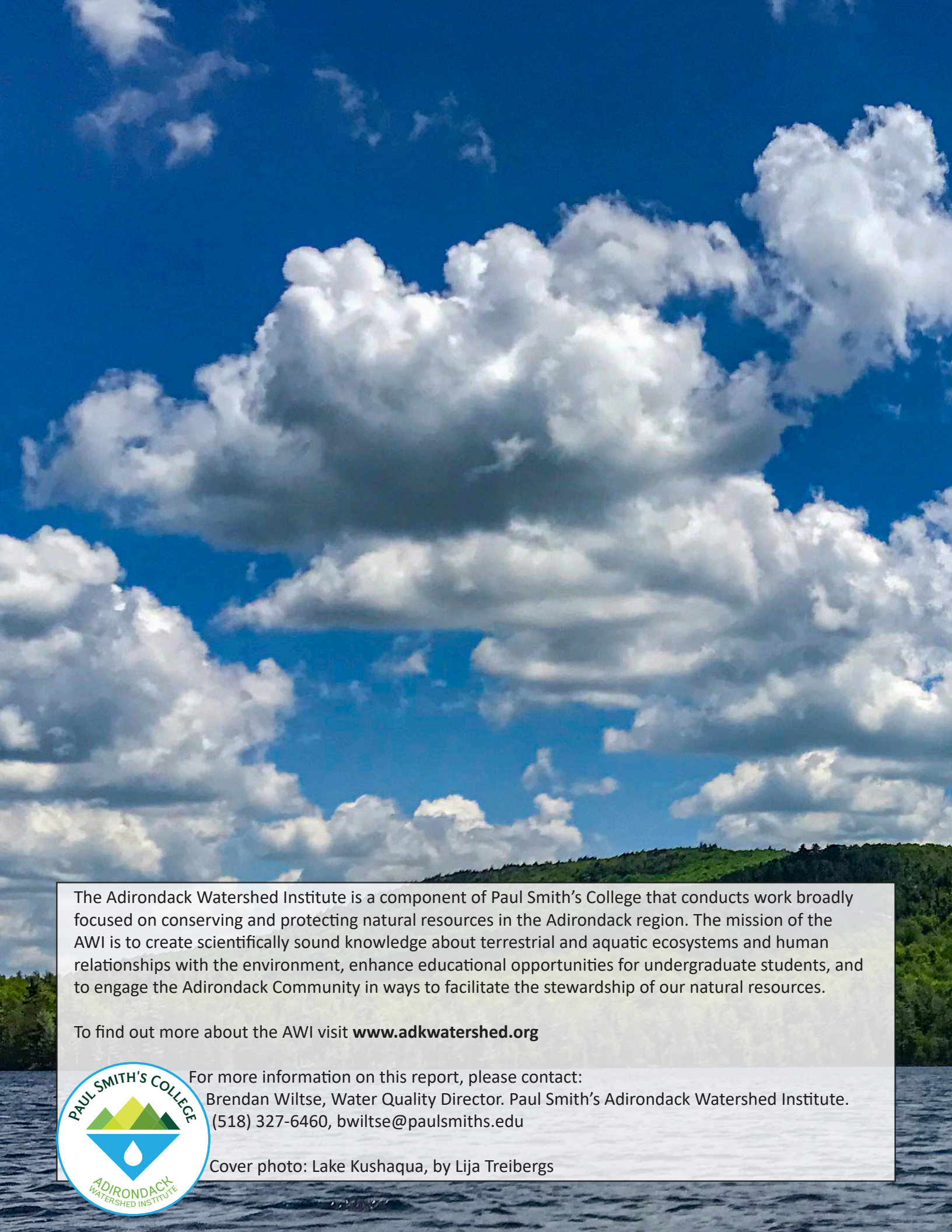


Figure 6. Profiles of dissolved oxygen and temperature of Lake Kushaqua during the 2020 sampling season. Zones of oxygen depletion denoted by orange and red markers. Hypoxic = D.O ≤ 2.0 mg/L. Anoxic = D.O. ≤ 0.5 mg/L.



The Adirondack Watershed Institute is a component of Paul Smith's College that conducts work broadly focused on conserving and protecting natural resources in the Adirondack region. The mission of the AWI is to create scientifically sound knowledge about terrestrial and aquatic ecosystems and human relationships with the environment, enhance educational opportunities for undergraduate students, and to engage the Adirondack Community in ways to facilitate the stewardship of our natural resources.

To find out more about the AWI visit **www.adkwatershed.org**

For more information on this report, please contact:
Brendan Wiltse, Water Quality Director. Paul Smith's Adirondack Watershed Institute.
(518) 327-6460, bwiltse@paulsmiths.edu

Cover photo: Lake Kushaqua, by Lija Treibergs