2021 Water Quality Committee Report

2021 Summary

Based on the findings contained in this report, the water quality of Watchic Lake remains good, and is substantially unchanged from data collected over the previous 5 years (2016-2020), and from data back to the 1970's. Specifically, water clarity and total phosphorus levels are consistent with previous years and consistent with other Maine lakes like ours. All data reported here was collected by the Watchic Lake Water Quality committee and represents over 70 hours of volunteer time with a budget of ~$1500.

2020/21 winter resulted in a short period when the lake was frozen (86 days) and had a long ice-free/algae growing period (268 days). In 2021, we experienced a very dry June (0.6 inches of rain) and very wet July (8.7 inches). Despite these extremes, lake quality as measured by trophic state indicators (water clarity and core total phosphorus and chlorophyl-A levels) was similar to recent years. Consistent to previous years, we experience long periods of low dissolved oxygen levels at the bottom of the lake in 2021. At the 11m depth, the dissolved oxygen was below 1mg/L from May-Oct and at 11.5m Total Phosphorus was elevated (averaged 32mg/L). Such conditions can restrict fish populations and increase algae growth.

The Watchic Lake Association (WLA) applied for and received a state grant to address water quality issues in Watchic Lake. With this grant, the WLA is currently working with the DEP, the city of Standish, and homeowners to help reduce nutrient laden run-off from storms (especially mega-storms) washing into the watershed and lake. These run-offs cause negative changes in the lake's water quality. Without these continued efforts, significant algae blooms could occur. In addition, while to-date no invasive plant or aquatic species have been identified in Watchic Lake, the WLA continues to monitor the lake for signs of these.

Table of Contents

Scope of Report

This report summarizes data collected on Watchic Lake and its tributaries from 22-Oct-20 to 5-Nov-21. The data is compared to historical data (mostly 2016-2020, but also older data when appropriate) to look for trends or variations which could suggest a shift in lake water quality or health. The data collected and the analysis is used to direct further monitoring efforts and if necessary, specific actions.

Background and Methodology

This report documents the results of water quality monitoring conducted at Watchic Lake by the WLA Water Quality Committee volunteers in 2021. Monitoring was conducted at the Deep Spot of the Lake (43.736590, -70.604530) and Page Brook.

Weather

In 2021, weather data for Watchic Lake was obtained from a personal weather station installed on the lake at Watchic Rd19 (at the Burnell dock). (https://dashboard.ambientweather.net/devices/public/07ab0e16e084b686213a92cd64264c2e). This station measures outdoor temperature, precipitation, wind direction/speed and other parameters. In addition, air temperature and barometric pressure were collected using an Onset HOBO® barometric pressure logger deployed on the north end of the lake (at the Watson dock).

Data is compared to historical weather data from the Portland Jetport (https://www.wunderground.com/history/monthly/us/me/south-portland/KPWM/date/2019-10).

Ice-in and Ice-out dates are taken from the Watchic Lake Dam logbook and from data reported to the Lake Stewards of Maine (resident reported, see https://www.lakestewardsofmaine.org/near-real-time-lake-data/).

Water sampling/monitoring

Water Quality Committee volunteers (Cathy Watson and David and Eileen Burnell) received formal training and certification in the proper techniques for Lake sampling/monitoring from the Lake Stewards of Maine. Due to COVID restrictions re-certification took place virtually again this year. From time to time, other volunteers join to help and learn.

Table 1 lists the dates monitoring was performed and the procedures carried out on each date.

Table 1: 2021 Volunteer Schedule

Date	Volunteer(s)	Secchi	Temp/DO	Meter	Logger reading	Water Samples	Comments
09-May-21	Cathy Watson	√	√	ProODO	√		Winter buoy and weight removed. Removed string of loggers to reconfigure to Summer configuration. Redeployed 10-May @10:50. DO loggers not added because waiting for new sensor caps.
15-May-21	Cathy Watson	√	√	ProODO	√		DO Loggers added to Buoy
28-May-21	Eileen and David Burnell	√	√	ProSolo	√		
10-Jun-21	Eileen and David Burnell	√	√	ProSolo	√		
18-Jun-21	Cathy Watson	√	√	ProODO	√	√	Lake (core and bottom grab) and Page Brook water samples taken and driven to HETL.
01-Jul-21	Eileen and David Burnell	√	√	ProSolo	√		
14-Jul-21	Eileen and David Burnell	√	√	ProSolo	√		
16-Jul-21	Cathy Watson	√	√	ProODO	√	√	Lake (core and bottom grab) and Page Brook water samples taken and driven to HETL.
07-Aug-21	Eileen and David Burnell	√	√	ProSolo	√		
17-Aug-21	Cathy Watson	√	√	ProODO	√	√	Lake (core and bottom grab) and Page Brook water samples taken and driven to HETL. Temp logger reading issues. 1m logger out of calibration.
24-Aug-21	Eileen and David Burnell	√	√	ProSolo	√		
12-Sep-21	Eileen and David Burnell	√	√	ProSolo	√		
17-Sep-21	Cathy Watson	√	√	ProODO	√	√	Lake (core and bottom grab) and Page Brook water samples taken and driven to HETL. Temp logger reading issues. 1m logger replaced with new UA-001-64 logger.
01-Oct-21	Cathy Watson and Bob Babcock	√	√	ProODO	√		
05-Nov-21	Cathy Watson, Bob Babcock and Owen Smith	√	√	ProODO	√		OD meters removed from buoy and convert buoy to winter configuration.
Winter 22	Cathy Watson						Data Analysis and report writing.

During the summer months, lake monitors upload real-time Secchi disk readings to the Lake Stewards of Maine website (https://www.lakestewardsofmaine.org/near-real-time-lake-data/). This work represents over 70 hours of volunteer time and a budget of approximately $1500.

Lake Monitoring at Deep Spot - WLA Buoy

WLA Water Quality volunteers maintained a series of Onset HOBO® continuous logging devices at the WLA Buoy at the Deep Spot of the lake (43.736590, -70.604530). The winter buoy consists of 8 Onset HOBO® UA-002 temperature loggers at 1-meter intervals starting at 2 meters from the bottom of the lake (Figure 3). The winter buoy was deployed on 22-Oct-2020 and remained in place over the 2020/2021 winter. The winter buoy was removed on 9-May-21, the temperature loggers were reconfigured to the summer buoy and redeployed 10-May-21

(Figure 3). The DO loggers were added to the string of loggers on 15-May-21. The loggers were cleaned and downloaded during each monthly sampling event thereafter. The 1m logger was out of calibration, and was replaced with a UA-001-64 logger (serial# 21183777) on 17-Sep-21. On 5-Nov-2021, the summer buoy was pulled from the water. All U26 temperature/dissolved oxygen loggers were removed from the line and moved to the winter buoy design (Figure 3). At 2:12pm, the reconfigured line was redeployed for the winter. All loggers are set to read every 15 minutes while deployed.

Figure 3: Buoy and HOBO® Logger configurations

Winter Buoy

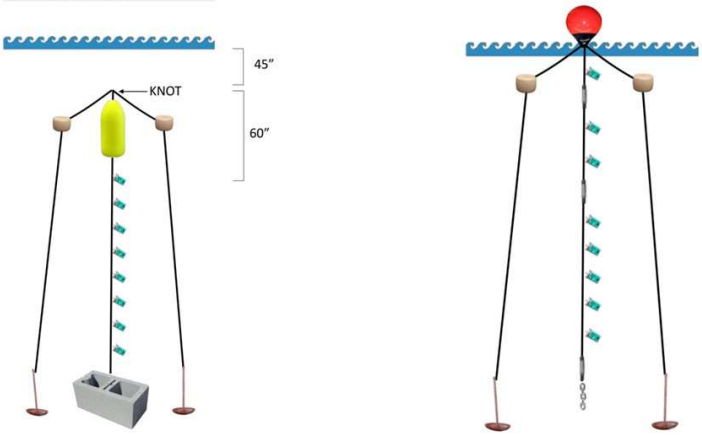
Meters from Bottom	Serial Number	Logger
11		
10		
9	20160224	Temp
8	20160222	Temp
7	20160225	Temp
6	20160223	Temp
5	20160221	Temp
4	20160226	Temp
3	20160227	Temp
2	20160228	Temp
1		

Temp = UA-002 temperature logger

Summer Buoy

Meters from Top	Serial Number	Logger
-1	20160223*	Temp
-2	10932891	Temp/DO
-3	20160222	Temp
-4	20160225	Temp
-5	10932892	Temp/DO
-6	20160221	Temp
-7	20160226	Temp
-8	20160227	Temp
-9	20160228	Temp
-10	20160224	Temp
-11	10932893	Temp/DO

Temp = UA-002 temperature logger Temp/DO = U26 temperature/ dissolved oxygen logger
*Replaced 20160223 with a new UA-001 logger on 17-Sep-21



WLA volunteers collected manual temperature and dissolved oxygen profiles (using YSI DO meters) and Secchi disk transparency readings bi-weekly from May – November (Table 1).

In addition to the above measurements, integrated epilimnetic cores (a column of water taken from the surface of the lake, through the epilimnion (biologically active area) to the upper part of the thermocline (where the water temperature changes rapidly) were extracted monthly during the 2021 season (see Table 1 for dates). The thermocline was determined based on the Secchi disk, temperature and dissolved oxygen readings on the day of sampling. These core samples represent an average of lake water quality and were analyzed for trophic state indicators (total phosphorus and chlorophyll-a) and chemical parameters (total alkalinity, pH, and color). In addition to the core sample, grab samples from the bottom of the lake were taken using a Kemmerer Bottle (1.2 L PVC, Silicone) sampler on the same dates (Table 1 above). Immediately after sampling, all samples were driven to the Health and Environmental Testing Laboratory (HETL) in Augusta, ME for analyses.

Page Brook Monitoring

Page Brook was monitored at the sampling station just downstream from the Route 113 bridge near the Outpost Restaurant. This sampling stations is located far enough upstream from the

brook's outlet to the lake in order to minimize the impact of any mixing with lake water. The brook was monitored for dissolved oxygen and temperature and total phosphorus (analyzed at HETL) monthly (Table 1 above).

Metaphyton/Algae Monitoring

No formal metaphyton monitoring was conducted this year. Informal visual surveys were conducted at least monthly, but no significant accumulations were found.
A strange brown filmy substance was observed around the shore on the east side of the lake (near Burnell Dock). A sample was obtained and submitted to the LSM for analysis.

Data Gaps

When examining the logger data and comparing it to the YSI meter data, it was noted that the 1m logger appeared to be out of calibration by a few degrees. For this reason, the 1m data from 9-May to 17-Sep-21 is not reported.
The 3m logger stopped recording between 2 logger readings (17-Sep-21, 9:00 and 1-Oct-21 10:15). The 4m logger did not record throughout the winter deployment. Despite multiple attempts, the 10m logger data from 17-Aug-21 9:45 to 5-Nov-21 could not be downloaded ('Bad Header' reading). Likely this logger will need to be replaced. Temperature data at these levels is available from the intermittent YSI meter monitoring.

Results

Weather

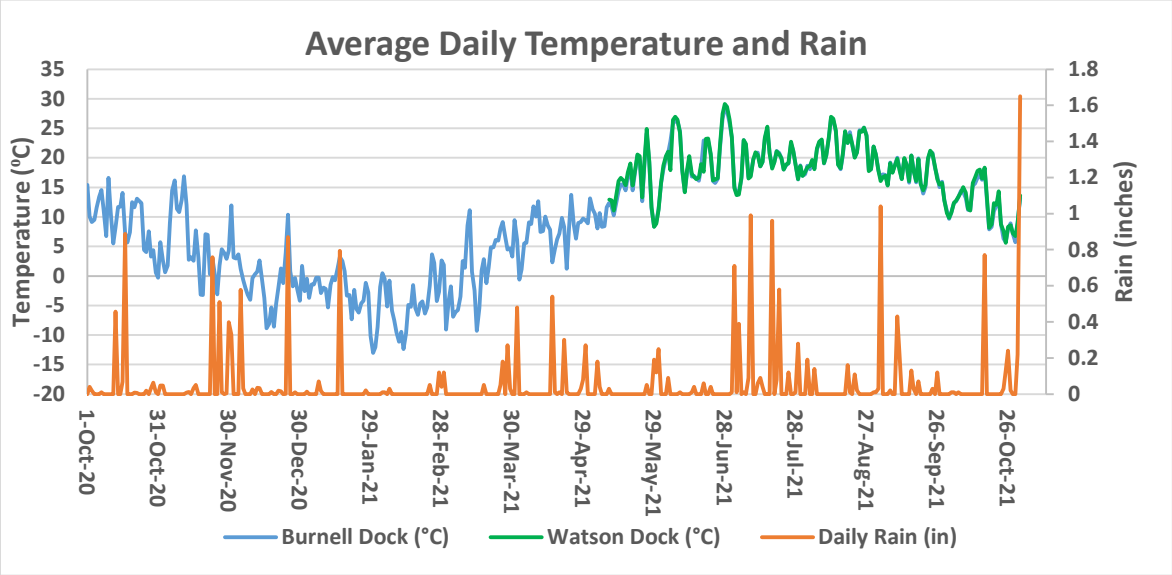
Weather has a major effect on the water quality of a lake. A summary of the weather conditions from Oct-2020 to Oct-2021 is given below.
Ice-in and Ice-out time can affect water quality by increasing/decreasing the growing season for algae in the lake. Dates for the last 6 years are shown in Table 2. 2021 was another early ice-out year. The earliest ice-out recorded at Watchic Lake in recent years was 09-Mar-2010. The early ice-out teamed with a late ice-in date (31-Dec), made 2020/21 winter the shortest frozen period in recent years (86 days).

Table 2: Ice-in/Ice-Out Dates

YEAR	ICE-OUT	ICE-IN	Ice-free Days	Frozen days
2016	13-Mar-16	Not Recorded		
2017	15-Apr-17	15-Dec-17	244	
2018	22-Apr-18	13-Dec-18	235	128
2019	16-Apr-19	17-Dec-19	245	124
2020	23-Mar-20	31-Dec-20	283	97
2021	27-Mar-21	21-Dec-21	268	86

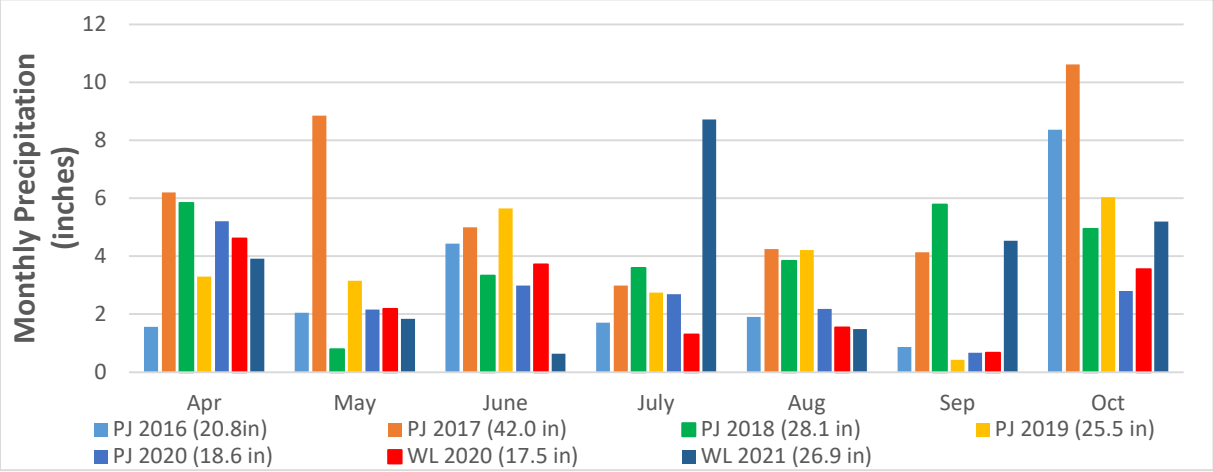
The average daily air temperature and precipitation recorded at the local weather station (Burnell dock) and the temperature from the HOBO logger (Watson dock) are shown in Figure 4. Temperatures in both locations on the lake were very similar.

Figure 4: Average Daily Air Temperature and Precipitation



The total monthly precipitation recorded is presented in Figure 5. June this year was unusually dry with only 0.6 inches of rain. In contrast July was wet with 4.4 inches.

Figure 5: Monthly Precipitation at Watchic Lake (Burnell Dock)



Water Sampling - Lake

Temperature and Dissolved Oxygen

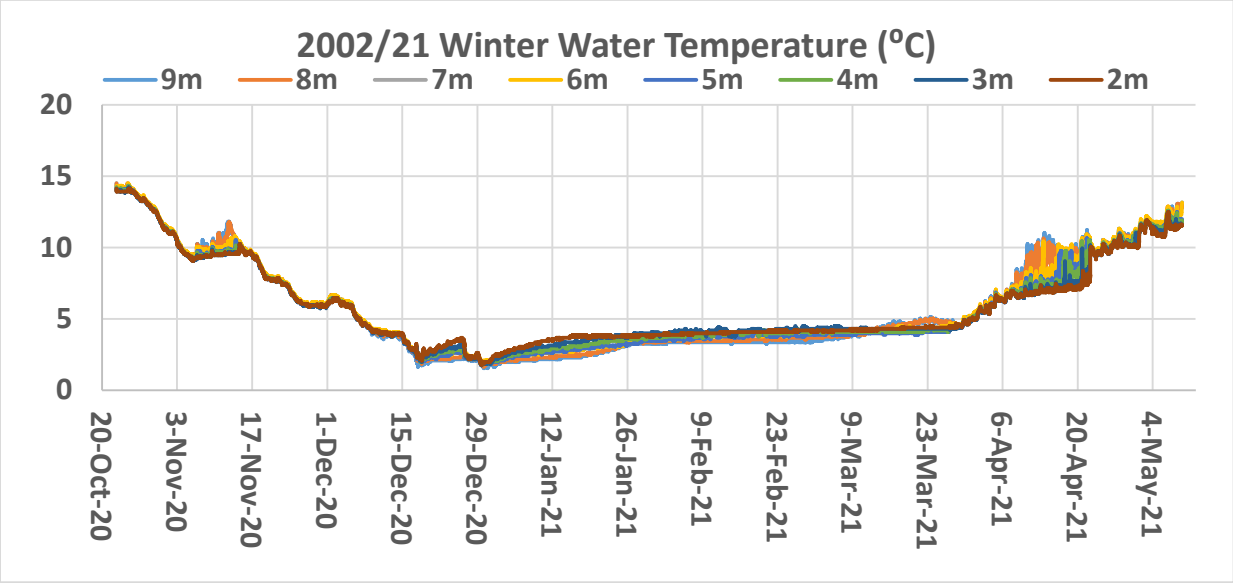
At the Deep Spot of the lake, temperature and Dissolved Oxygen (Temp/DO) were measured using continuous Onset HOBO® loggers attached to the WLA buoy (see Figure 3), and bi-weekly during the summer using DO/Temp YSI meters. Figure 6A shows the water temperature at 1-meter intervals during the Winter buoy configuration from 22-Oct-2020 to 9-May-2021. In this configuration, depths are measured from the bottom of the lake upwards, with higher numbers

representing locations closer to the surface of the lake (*e.g*. 8m). Fall turnover (when the lake mixes top to bottom), occurred on ~12-Oct-20, eliminating the lake's temperature and DO stratification. Ice-out was 27-Mar-21 and the lake started to warm up through April, stratifying briefly in mid-April. Spring turnover occurred ~7-May-21.

Figure 6, Panel B show the water temperature at 1-meter intervals during the Summer buoy configuration collection from 9-May-2021 to 5-Nov-2021. In this configuration, depths are measured from the top of the lake downward, with larger negative numbers representing locations closer to the bottom of the lake (e.g. -11m). Consistent with past years, the temperature at the bottom of the lake remained constant at ~10°C while the top warmed up during the season. Lower depths continued to warm into September. Fall turnover appears to have occurred between ~27-Oct-21. Data collected bi-weekly using the YSI meters (Figures 7 and 8) are consistent with those from the continuous loggers (Figures 6B and 9).

Figure 6: Water Temperature from HOBO® Loggers

A: Winter - 22-Oct-2020 to 9-May-2021 (distance from bottom)



B: Summer – 9-May-2021 to 5-Nov-2021

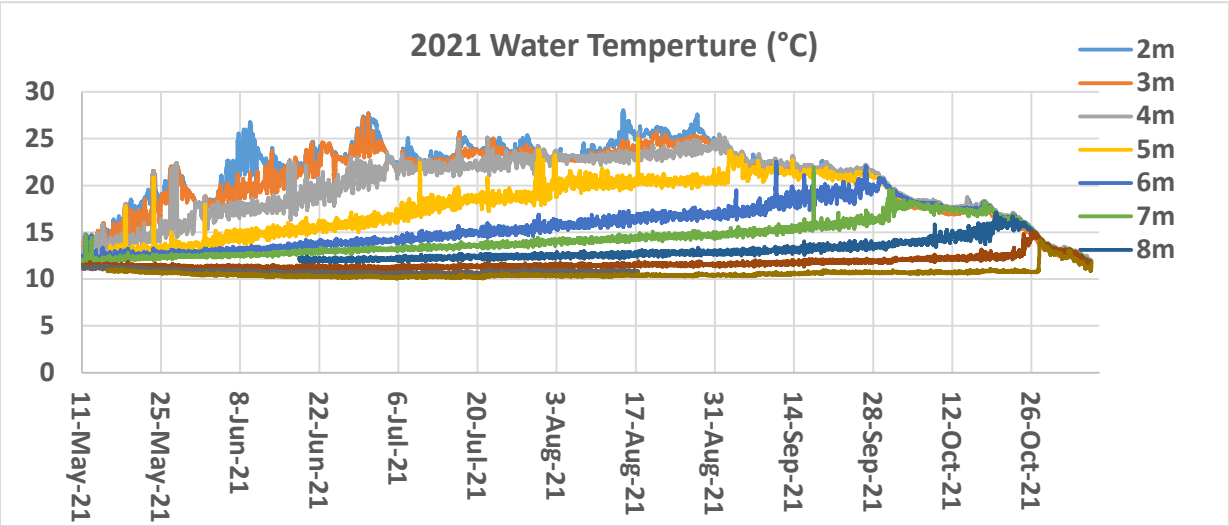
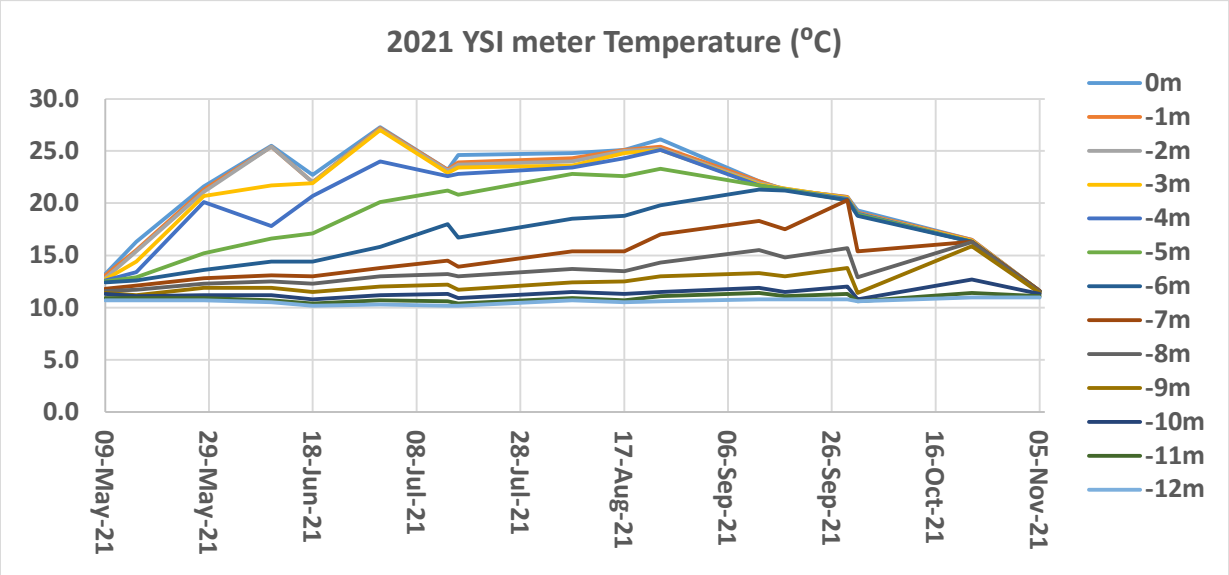


Figure 7: Water Temperature from YSI Meters



The dissolved oxygen (DO) pattern observed this 2021 season is similar to what has been seen in recent years. For the most part, oxygen levels are high, and fairly uniform throughout the water column in May (Figures 8 and 9). Interestingly, the DO at the 12m depth remained below 1ppm throughout the season. As the season progressed, the deeper water systematically became oxygen depleted. By 1-Jul, depths of ≥10m are below 2mg/L of oxygen. This depletion extends to ≥9m by the mid-July and to ≥7m by mid-August. The lack of oxygen at the bottom of the lake is known to restrict fish species that require colder water to survive, but may also cause phosphorus bound at the bottom of the lake to be released into the water column. This phosphorus can fuel further algae growth.

Figure 8: Dissolved Oxygen from YSI Meters

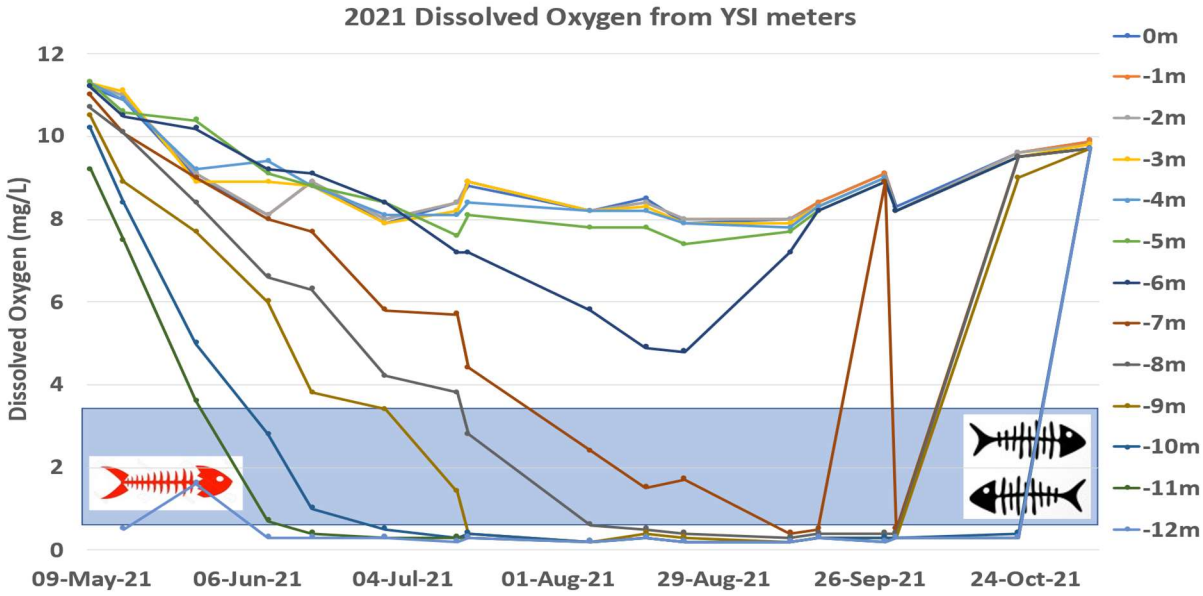
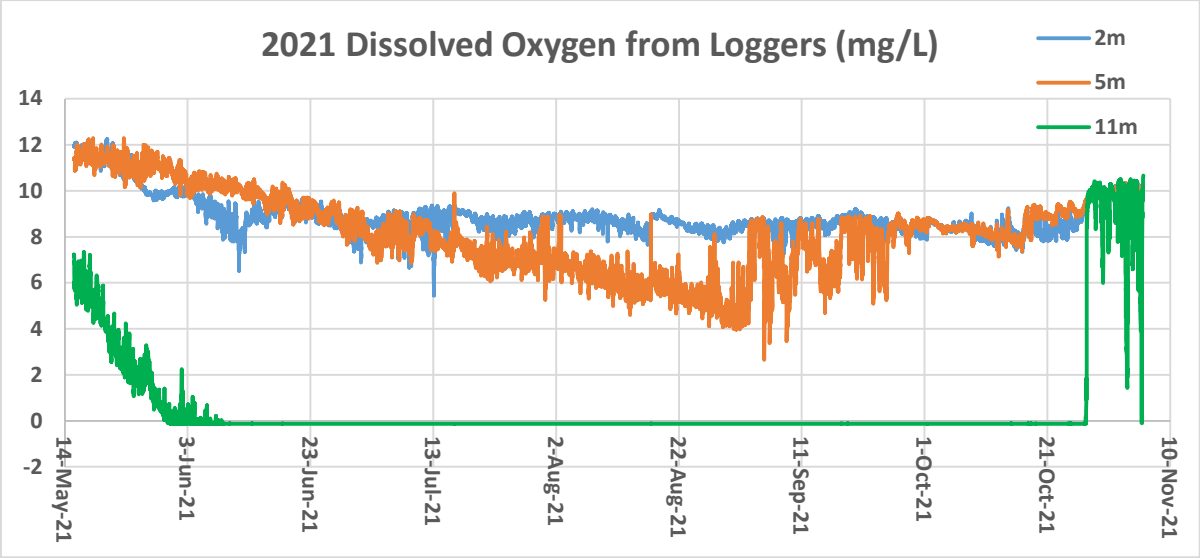


Figure 9: Dissolved Oxygen Levels from HOBO® Loggers



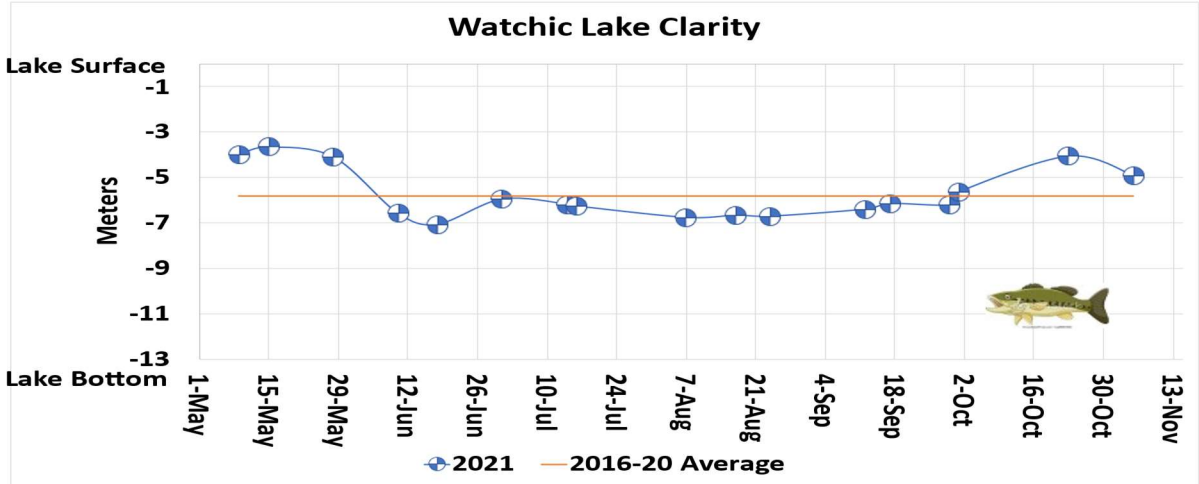
Trophic State indicators

Trophic state indicators (water clarity, total phosphorus, and chlorophyll-a) reflect the biological productivity (e.g. algae growth) of lakes.

Water Clarity

Water clarity (how far you can see down into the water) is measured using a Secchi disk. Figure 10 shows the readings this year and the historical average for 2016-20. The DEP Mesotrophic Water Clarity Acceptable Range of 4-8m. On 9-May and 15-May-21, the Secchi disk readings were -3.95m and -3.65m, respectively. These low spring values may reflect the early ice-out date or short iced times. Values in this range were also recorded in October 2017 and in the 1990's. The average of all Secchi disk readings for 2020 was -5.72m, which is slightly lower than the 2016-2020 average (-5.8m).

Figure 11: Watchic Lake Secchi Disk Readings



Phosphorus and Chlorophyll-A

Phosphorus in the key nutrient for algae growth in lakes, while chlorophyll-A is a direct measurement of the amount of plant material, mostly algae, in the water.

To sample the most productive part of the lake (relative to algae growth), an epicore sample (a column of water collected from the surface through the epilimnion (usually about 5-6m down in Watchic Lake) was obtained each month at the deepest spot of the lake (WLA buoy). The results represent the average biological and chemical conditions in Watchic Lake.

The 2021 total phosphorus (TP) and chlorophyll-A (Chl-A) results are presented in Table 4. Average TP and Chl-A values for 2020 are similar to those obtained in 2016-20 (Table 5) and individual values are within the min/max values recorded between 2016-2020.

Table 4: 2020 Water sampling results

Station	Date Sampled	Core Depth (m)	Bottom (ft)	pH	Color (PCU)	Chl-a (ppb)	Alk. (ppm)	TP (ppb)
WATC-5040-01	18-Jun-21	4	40	7	16	2	8	8
WATC-5040-01	16-Jul-21	5	41	7.1	14	3	7	8
WATC-5040-01*	17-Aug-21	5	40.5	6.9	13	2	7	7
WATC-5040-01	17-Sep-21	6	41	6.8	14	3	7	7
Annual Mean		5.0	40.6	7.0	14.3	2.5	7.3	7.5
Annual Median		5	40.75	6.95	14	2.5	7	7.5

* ppb-parts per billion, ppm-parts per million, PCU-platinum-cobalt units

Table 5: Average Water sampling results for 2016-2020

Year	Core Depth (m)	pH	Color (PCU)	Chl-A (ppb)	Alk (ppm)	Total Phos (ppb)
2016	6.8	6.5	12.8	2.9	7.3	7.9
2017	5.8	6.5	22.1	4.1	6.8	8.1
2018	5.3	6.8	14.6	3.3	7.0	7.3
2019	5.25	7.0	21.0	3.8	6.5	7.5
2020*	5.81	6.97	14.75	3.31	6.88	5.38
2021	5	6.8	18.1	3.6	6.8	7.1
Average 2016-20	5.8	6.7	17.1	3.5	6.9	7.2
Max 2016-20	8	7.1	26.5	6.2	8	11
Min 2016-20	5	5.9	10	1.8	6	5

*** no Jun/Jul sample, Aug-Sep only**

ppb-parts per billion, ppm-parts per million, PCU-platinum-cobalt units

In addition to the epicore samples, a sample was obtained from the bottom of the lake and analyzed for total phosphorus (TP, Table 6). Results suggest that there is considerably more

total phosphorus at the bottom of the lake than at the top (thermocline). There are historical bottom grab TP results dating back to 1978, with the most comprehensive data coming between 1998-2001. From 1998-2001, most sample were obtained from a 10m depth and had an average TP value of 18.3ppb and a range of 7-31ppb. This year we settled on a sample depth of 11.5m based on consultation with Scott Williams from Lakes Stewards of Maine (LSM). The average TP this year was 32ppb.

Table 6: 2020 Bottom Grab Total Phosphorus Samples

Station	Date Sampled	Depth (m)	TP (ppb)
WATC-5040-01	12-Aug-19	13	63
WATC-5040-01	25-Sep-19*	12.5	30
WATC-5040-01	25-Sep-19*	12.5	30
WATC-5040-01	10-Aug-20	12.5	94
WATC-5040-01	3-Sep-20*	11	26
WATC-5040-01	3-Sep-20*	11	33
WATC-5040-01	29-Sep-20	12	45
WATC-5040-01	18-Jun-21	11.5	25
WATC-5040-01	16-Jul-21	11.5	28
WATC-5040-01	17-Aug-21	11.5	36
WATC-5040-01	17-Sep-21	11.5	39

*** duplicates**
ppb-parts per billion

Chemical Parameters

In addition to TP and Chl-A, pH, alkalinity and color were measured in the monthly core water samples (Table 5 above). All 3 parameters were fairly constant throughout the sampling time period (Aug-Sep).

Metaphyton and other Algae concerns

Metaphyton is cotton candy-like algae that usually floats near the top of the shallow water, but can get stuck in lake vegetation and accumulate. No formal surveys were performed this year, the areas were visually examined at least monthly.

A slimy brownish substance was observed on the east side of the lake (around Burnell dock) in late October. A sample of which was sent to the LSM for analysis. Experts at LSM concluded that the sample was either degrading algae or diatoms that were driven to shore by the strong winds or it was a picocyanobacterium such as *Aphanocapsa delicatissima*. Neither was thought to be of concern.

Water Sampling - Tributaries

Temperature, dissolved oxygen and total phosphorus were measured in Page Brook in August and September. The results are shown in Table 7. The bridge just upstream from the sample

site was replaced in September this year. The repairs involved stopping/diverting the Brook water. The sample taken on 3-Sep and 29-Sep were taken before and immediately after, respectively.

Table 7: 2020 Monitoring of Page Brook

Station	Date Sampled	Temp (°C)	DO (ppm)	TP (ppb)
Page Brook-01	18-Jun-21	14	6.2	26
Page Brook-01	16-Jul-21	21.7	6.02	39
Page Brook-01	17-Aug-21	18	6	21
Page Brook-01	17-Sep-21	13.2	5.8	23
Yearly Averages	2016	16.9	5.6	32.0
	2017	17.0	6.0	29.1
	2018	17.0	5.5	26.3
	2019	16.0	4.7	36.5
	2020	19.0	4.4	57.8
	2021	16.7	6.0	27.3

Conclusions and Recommendations

Based on monitoring performed by the Watchic Lake Water Quality Volunteers in 2020, the water quality of Watchic Lake remains good and is substantially unchanged from data collected over the previous 5 years (2016-2020).

While water quality is good today, Watchic Lake remains at risk over the long term. For example, low oxygen levels at the lower depths of the lake again this summer, and the high total phosphorus levels from the bottom of that lake are of concern. The biggest risks to the lake are nutrients from storm run-off and invasive plants. Homeowners must continue to be diligent to protect the lake by stopping storm run-off entering the lake through their property and always remove plant and other organic material from boats and fishing gear.

Recommendations for Continued Water Monitoring

Based on observations this year and 2016-2020, the following efforts should be continued and/or intensified:

Observation	Recommendation
Loss of oxygen in the lower depths	Continue bottom grab TP sampling
	Consider TP grab samples at various depths
	Move 11m OD logger to a higher depth (e.g. 9m)
	Collaborate with researchers to look at composition of soil at bottom of lake for potential of phosphorus recycling
Logger Maintenance	Replace old/failing Temperature loggers

General Recommendations for Lake Users to maintain and improve Water Quality

- Become LakeSmart by controlling phosphorus-laden sediment in runoff with best management practices (BMPs).
- Avoid using fertilizers, herbicides, and pesticides within 150 feet of lake, ponds, and streams.
- Leave duff and grass clippings; minimize lawn area and cut grass to 3 inches.
- Pump septic system every 3-5 years and keep leach field clear of trees. Inspect systems more than 20 years old.
- Reduce household chemical and Phosphorus-based product use.
- Wash car and boat in area where runoff is absorbed into the ground.
- Use oil-absorbing pillow or 'bilge snakes' to prevent pollutants from entering the lake via inboard motors.
- Store gas and oil in approved secondary containers and dispose at local repair shops. Clean fluid leaks with cat litter.
- Remove fishing line from water and use lead-free lures.
- Dispose of pet waste in trash or toilet.

Recommendations for Lake Users to avoid the spread of Invasive Plants and other Species

Follow the CLEAN, DRAIN, DRY procedures to prevent the spread of Invasive Species

- **Clean** off visible aquatic plants, animals, and mud from all equipment before leaving a body of water.
- Rinse equipment, boat hulls (with high pressure, when possible), interior compartments and flush motor. Use hot water (120F) when possible.
- **Drain** motor, bilge, livewell, and other water containing devices before leaving water access.
- **Dry** everything for at least 5 days OR wipe with a towel to dry before reuse.
- **Dispose** of any unwanted bait, worms and fish parts in the TRASH.
- If CLEAN, DRAIN, DRY was not done prior to leaving a body of water, ensure that it is done BEFORE entering a new body of water. Be sure to perform the CLEAN and DRAIN activities well away from any body of water.

GLOSSARY OF KEY TERMS

Chlorophyll-a (Chl-A): A measurement of the green pigment found in plants, including microscopic plants like algae. It is used as an estimate of algae biomass; higher Chl-A equates to greater concentration of algae in the lake.

Color: A measure of the influence of suspended and dissolved particles in water from weathered geologic material, vegetation cover, and land use activity. Colored lakes (>25 platinum-cobalt units -PCU) can have reduced water clarity and increased phosphorus concentrations.

Dissolved Oxygen (DO): The concentration of oxygen dissolved in water. Adequate oxygen is critical to the healthy metabolism of many creatures that reside in the water. DO levels in lake water are influenced by a number of factors, including water temperature, amount of algae and other plants in the water, and the amount of nutrients and organic matter that flow into the waterbody from the watershed. DO concentrations may change dramatically with lake depth. Oxygen is produced in the top portion of a lake (where sunlight drives photosynthesis), and oxygen is consumed near the bottom of a lake (where organic matter accumulates and decomposes).

Epilimnion: The top layer of lake water that is directly affected by seasonal air temperature and wind. This layer is well oxygenated by wind and wave action during summer. It extends to 5-7 meters below the surface in Watchic Lake.

Escherichia coli (E. coli): An indicator of harmful pathogens from fecal contamination that can derive from a number of mammalian sources, including human, canine, and wildlife.

Eutrophication: Process by which lakes become more productive over time. Lakes with high productivity have high levels of phosphorus and chlorophyll-a, low water clarity, and abundant biomass with significant accumulation of organic matter on lake bottom. Eutrophic lakes are susceptible to algae blooms and severe oxygen depletion in the hypolimnion. Lakes naturally become more productive or "age" over thousands of years. In recent geologic time, however, humans have enhanced the rate of enrichment and lake productivity, speeding up this natural process to tens or hundreds of years.

Fall Turnover: the process of complete lake mixing when cooling surface waters become denser and sink, forcing lighter, less-dense water to the surface. This process is critical for the natural exchange of oxygen and nutrients between surface and bottom layers in the lake.

Hypolimnion: the bottom-most layer of the lake. It experiences periods of low oxygen during stratification and is devoid of sunlight for photosynthesis. Watchic Lake experiences low oxygen in summer from 7 meters to the bottom at 12 meters.

Integrated Epilimnetic Core: A water sample that is taken with a long tube to determine average nutrient concentration from the lake surface to the top of the thermocline.

pH: The standard measure of the acidity or alkalinity of a solution on a scale of 0-14. Most aquatic species require a pH between 6.5 and 8. As the pH of a lake declines, particularly below 6, the reproductive capacity of fish populations can be greatly impacted as the availability of nutrients and metals changes. pH is influenced by bedrock, acid rain or snow deposition, wastewater discharge, and natural carbon dioxide fluctuations.

Secchi Disk Transparency (SDT) or Water Clarity: A vertical measure of water transparency (ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Measuring water clarity is one of the most useful ways to show whether a lake is changing from year to year. Changes in water clarity may be due to increased or decreased algae growth or the amount of dissolved or particulate materials in a lake, resulting from human disturbance or other impacts.

Spring Turnover: the process of complete lake mixing following ice-out when surface waters are exposed to wind action, bringing oxygen to the bottom and nutrients to the top of the water column.

Summer Stratification: the development of a thermal barrier that separates warm surface waters from dense, cool bottom waters. Without oxygen replenishment from the surface, bottom-dwelling organisms rapidly consume oxygen throughout the summer and early fall.

Thermocline: the markedly cooler, dynamic middle layer of rapidly changing water temperature. The top of this layer is distinguished by at least a degree Celsius drop per meter of depth.

Total Alkalinity: A measure of the buffering capacity of a lake (i.e., the capacity of water to neutralize acids). The buffering capacity or the concentration of bicarbonate, carbonate, and hydroxide ions in water, is largely determined by the geology of soils and rocks surrounding the lake. Total alkalinity above 20 ppm buffers against drastic changes in pH that could impact aquatic plants and animals.

Total Phosphorus (TP): The total concentration of phosphorus found in water, including organic and inorganic forms. Phosphorus is one of the limiting nutrients needed for plant growth; as phosphorus increases, the amount of algae generally increases. Humans can add excess phosphorus to a lake through stormwater runoff, lawn or garden fertilizers, and leaky or poorly-maintained septic systems.

Trophic State Indicators: Are indicators of biological productivity in lake ecosystems, including water clarity, total phosphorus, and chlorophyll-a. The combination of these parameters helps determine the extent and effect of eutrophication in lakes, and helps signal changes in lake water quality over time.

Watershed: An area of land that drains water to the outlet of a stream, river, or lake.

Winter Stratification: the development of a physical ice barrier and snowpack layer that limit the exchange of oxygen and nutrients between surface and bottom waters. A layer of ice forms at the lake surface, protecting waters below from frigid temperatures and wind storms. Cold winters with significant snowpack can block sunlight and limit photosynthesis that would otherwise replenish the lake