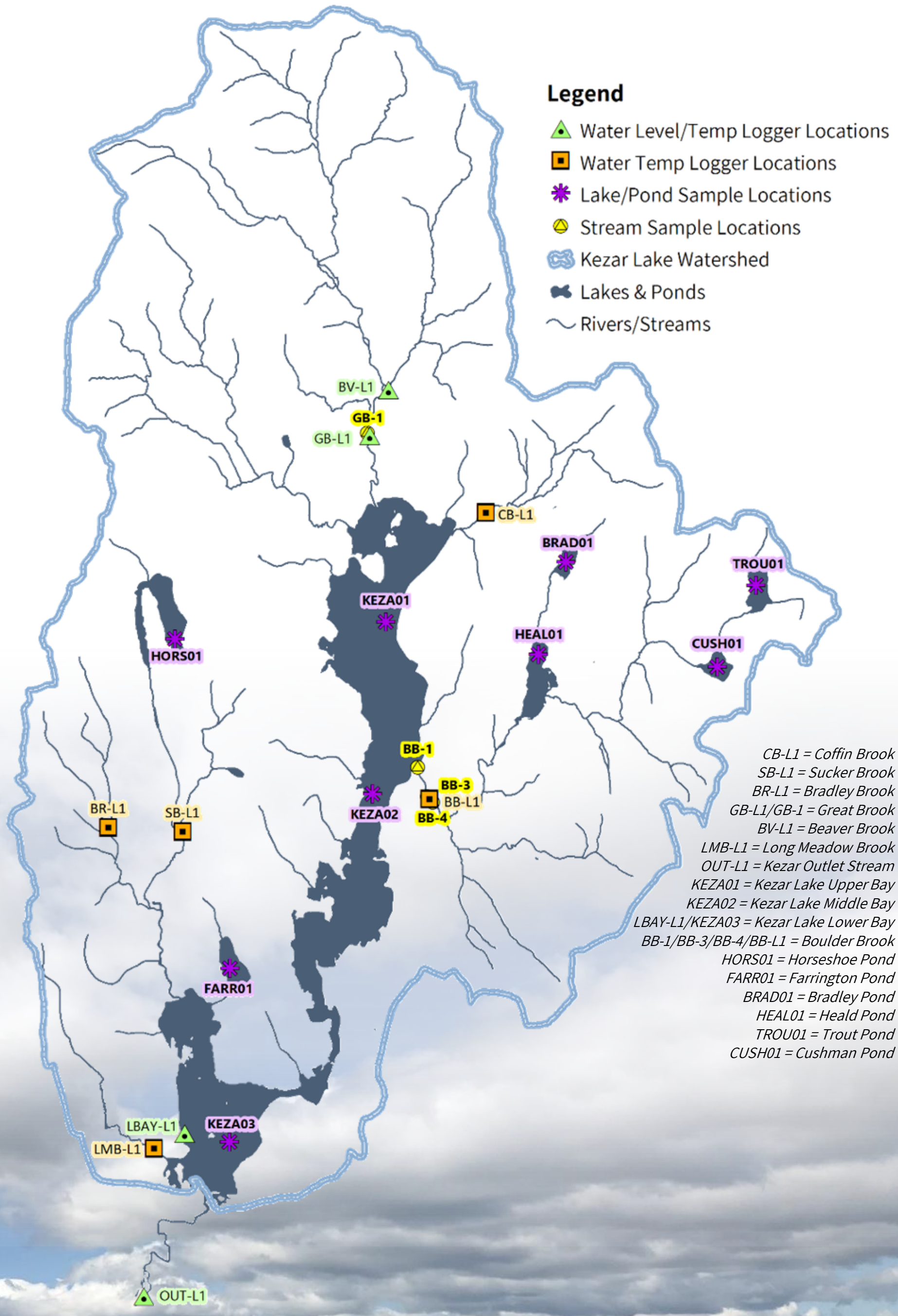
2020 KEZAR LAKE WATER QUALITY REPORT

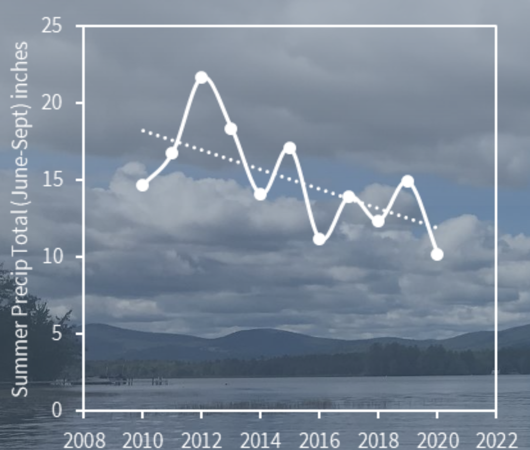
A REPORT ON THE WATER QUALITY OF KEZAR LAKE, NINE STREAMS, AND SIX WATERSHED PONDS

Kezar Lake remains one of Maine's cleanest and clearest lakes, with above average water quality and clarity.

Historically and in the current monitoring year, Kezar Lake's trophic state indicators (water clarity, total phosphorus, and chlorophyll-a) have been better than both statewide and most historic averages. Water clarity is improving in all three basins and chlorophyll-a is improving in the upper basin. The water columns of all three basins of Kezar Lake were well-oxygenated, which helped coldwater fish species survive the warmest months of the year. Some concerning water quality conditions were observed at the ponds, including lower-than-normal water clarity at Heald, Horseshoe, and Trout ponds, higher-than-normal total phosphorus and color at Heald Pond, and lower-than-normal total alkalinity at Bradley Pond. Refer to the KLWA website for long-term data and trends.

While the water quality of Kezar Lake and its tributaries and ponds is generally excellent, these waterbodies are sensitive to change. Continuing to monitor Kezar Lake, the nine streams, and six ponds will help KLWA better understand long and short-term trends in water quality and maintain the high quality of the water in the Kezar Lake watershed for future generations.





Summers are becoming drier. We experienced a ten-year low in summer precipitation totals in 2020, following a declining ten-year trend. Data from Fryeburg Weather Station (KIZG).

LAKE & PONDS **SAMPLING**

For lake and pond deep spot monitoring, FBE, with the help of KLWA volunteers, collected temperature and dissolved oxygen profiles, Secchi disk transparency readings (or water clarity), and integrated epilimnetic core samples in June and August (and September for Kezar Lake's three basins). Core samples were analyzed for total phosphorus, chlorophyll-a, and chemical parameters (total alkalinity, pH, and color). Sampling was conducted in accordance with standard methods and procedures for lake monitoring established by the Maine Department of Environmental Protection (Maine DEP), the US Environmental Protection Agency (USEPA), and Lake Stewards of Maine (formerly VLMP). Laboratory samples were analyzed at the Health and Environmental Testing Lab (HETL) in Augusta, ME. In 2020, water quality was generally excellent in the lake and ponds and better than the average water quality of Maine lakes, with some exceptions. Concerning water quality conditions were observed at the ponds, including lower-than-normal water clarity at Heald, Horseshoe, and Trout ponds, higher-than-normal total phosphorus and color at Heald Pond, and lower-than-normal total alkalinity at Bradley Pond. Farrington Pond remains one of the more vulnerable ponds with consistently elevated total phosphorus and chlorophyll-a concentrations. Refer to the KLWA website for long-term data and trends.

Water clarity, total phosphorus, and chlorophyll-a are **TROPHIC STATE INDICATORS** or indicators of biological productivity in lake ecosystems. 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.

Waterbody	Water Clarity (m)		Total Phosphorus (ppb)		Chlorophyll-a (ppb)	
	Historical[b]	Recent 2020[c]	Historical[b]	Recent 2020[c]	Historical[b]	Recent 2020[c]
Kezar Lake - Upper Bay	7.7	9.0	5.0	6.0	2.1	1.0
Kezar Lake - Middle Bay	7.3	8.7	4.5	5.0	2.0	2.0
Kezar Lake - Lower Bay*	3.2	3.3	9.0	9.0	2.3	2.0
Bradley	5.2	5.2	8.0	10.0	4.0	4.5
Cushman	5.5	5.4	7.0	7.0	2.3	3.0
Farrington*	4.4	4.0	13.0	13.0	5.8	5.5
Heald	4.6	3.7	10.0	13.5	4.0	4.0
Horseshoe	6.9	5.9	7.0	7.5	3.4	2.5
Trout	7.4	5.9	4.5	5.5	2.0	2.0
Maine Lakes[a]	4.8		12.0		5.4	

Waterbody	pH		Alkalinity (ppm)		Color (PCU)	
	Historical[b]	Recent 2020[c]	Historical[b]	Recent 2020[c]	Historical[b]	Recent 2020[c]
Kezar Lake - Upper Bay	6.7	6.8	4.0	4.0	10.3	9.0
Kezar Lake - Middle Bay	6.6	6.8	4.0	4.0	10.5	10.0
Kezar Lake - Lower Bay*	6.7	6.8	4.0	4.0	13.0	14.0
Bradley	6.5	6.4	4.0	3.5	21.5	26.5
Cushman	6.7	6.7	5.0	4.5	11.0	11.0
Farrington*	6.7	6.7	4.0	4.5	16.0	19.0
Heald	6.7	6.6	5.0	5.0	24.0	43.3
Horseshoe	6.7	6.7	3.0	3.5	10.0	11.0
Trout	6.7	6.8	4.0	4.0	9.0	9.5
Maine Lakes[a]	6.8		11.8		28.0	

** Water clarity limited by lake depth - Secchi disk hits bottom*

[a] Median values calculated from the Lake Stewards of Maine, 2019, Distribution of Lake Water Quality Data. Includes datapoints through 2018. https://www.lakestewardsofmaine.org/distribution-of-water-quality-data.

[b] Median historical values calculated by FBE from all data obtained by the MEDEP through 2018; duplicate values/days were averaged; only epicore samples were used in the analyses; includes FBE-collected-only data for 2019-20

[c] Median values calculated by FBE from 2020 data

Red cells indicate median values from 2020 showing worse water quality compared to the historic median

Dark blue cells indicate median values from 2020 showing better water quality when compared to the historic median

Light blue cells indicate median values from 2020 showing no change from or within one standard deviation of the historic median

MONITORING BUOYS

METHODS

FBE and KLWA deployed a buoy with six Onset HOBO® U-26 dissolved oxygen and temperature loggers at 2, 6, 8, 10, 12, and 45 meters below the surface at the upper basin, as well as one Onset HOBO® U-26 dissolved oxygen and temperature logger and one Onset HOBO® U-24 conductivity logger at 2 meters below the surface at the lower basin (all recording at 15-minute intervals from May to November). These depths equate to critical layers in the water column, which becomes thermally stratified in summer at the upper basin.

Onset HOBO® temperature pendants were also deployed at 4, 14, 19, 25, 30, 35, and 40 meters below the surface at the upper basin and at 1 meter below the surface at the lower basin, recording temperature at 15-minute intervals continuously year-round (pendants were left over winter at 2, 4, 6, 10, 19, 30, and 40 meters below the surface at the upper basin and at 2 meters below the surface at the lower basin).

The loggers were cleaned and downloaded during each sampling event. Logger data presented here shows data for the entire water column using R statistical software. These data will serve as a baseline for future comparisons of water quality to assess long-term changes in temperature and dissolved oxygen. Until more data are collected over the next few years to begin to account for interannual variability, no major conclusions or analyses can be made on this limited dataset aside from general patterns.

WHY DOES IT MATTER?

It is important to track temperature and oxygen throughout the water column because both greatly affect the amount of suitable habitat for aquatic life in the lake. A barrier of low oxygen (< 5 ppm) prevents fish from seeking refuge in cooler, bottom waters when surface waters heat up in summer. While thermal stratification and depletion of oxygen in bottom waters is a natural phenomenon, it is important to keep tracking these parameters to make sure the extent and duration of low oxygen does not change drastically as a result of human disturbance and climate change. Additionally, low oxygen at the bottom sediment-water interface can cause a chemical reaction that releases phosphorus back into the water column to serve as food for algae, which can degrade water quality.

EPILIMNION

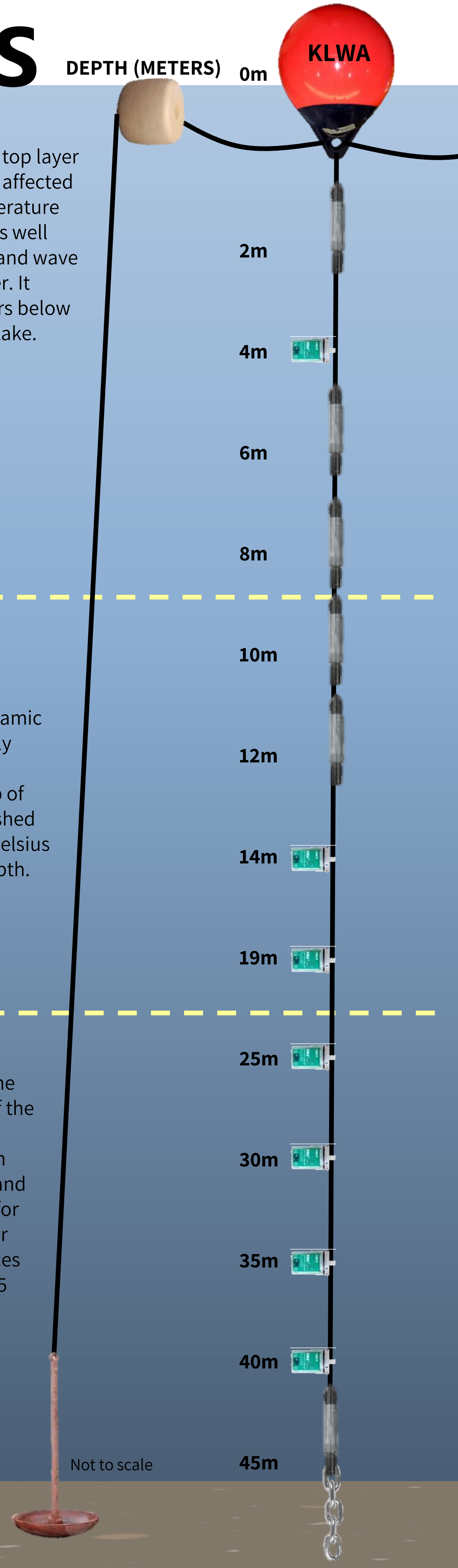
The epilimnion is the top layer of lake water directly affected by seasonal air temperature and wind. This layer is well oxygenated by wind and wave action during summer. It extends to 8-10 meters below the surface in Kezar Lake.

METALIMNION

The metalimnion or thermocline is 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.

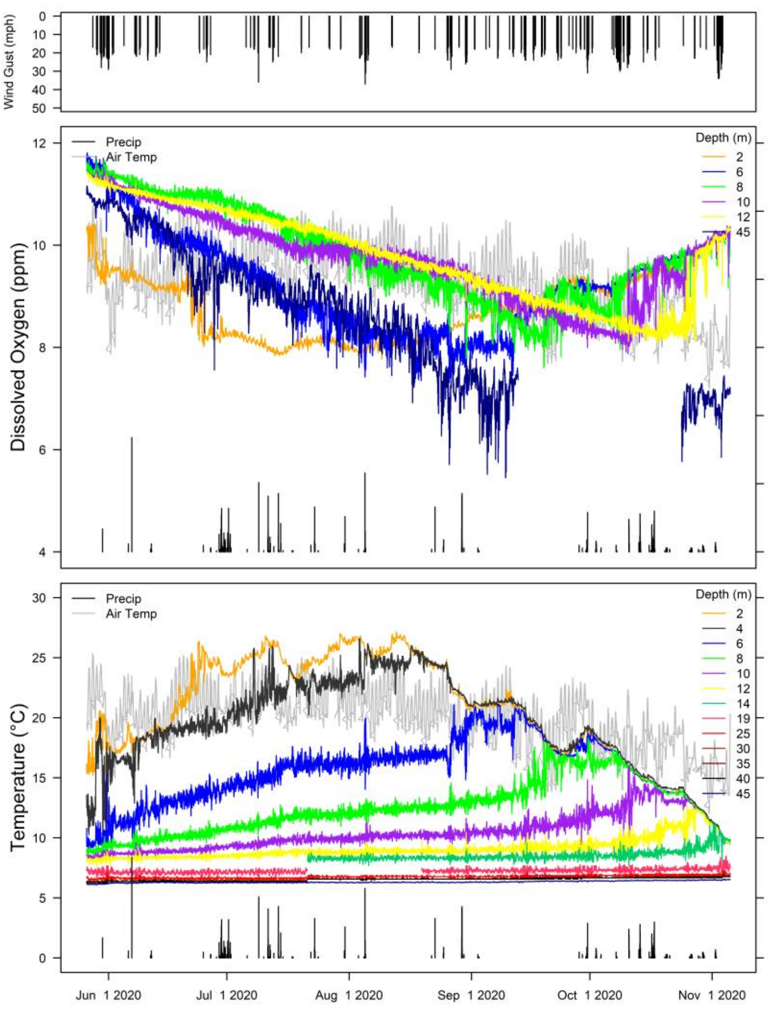
HYPOLIMNION

The hypolimnion is the bottom-most layer of the lake. It experiences periods of low oxygen during stratification and is devoid of sunlight for photosynthesis. Kezar Lake rarely experiences low oxygen even at 45 meters.



UPPER BAY **BUOY**

Historically, Kezar Lake has experienced some DO depletion in the upper and middle basins in summer. In 2020, DO depletion (<5 ppm) was not evident at the upper and middle basins. In May and November following turnover events (not shown), the upper basin experienced relatively uniform temperature-oxygen profiles from the surface to the lake bottom. Following spring turnover, the water column in the upper 14 meters began to stratify with warm surface waters reaching a maximum of 27.2°C at 2 meters depth on 8/12/20. In June-August, a metalimnetic maximum (a 'bump' in oxygen) occurred at the thermocline (~8-12 meters) where non-motile, buoyant algae settled and were producing oxygen through photosynthesis. The pattern reversed in September with an oxygen depression at the thermocline, likely as a result of decomposition of dead algae. The upper basin had not yet experienced complete fall turnover when the loggers were removed on 11/5/20, as only the upper 12-14 meters had been mixed at that point. Year-round temperature data at the upper basin showed that fall turnover occurred on 11/30/19 and spring turnover occurred on 4/4/20 (data not shown). Formation of the metalimnion (thermocline) began between 6 and 12 meters below the surface at the upper and middle basins.

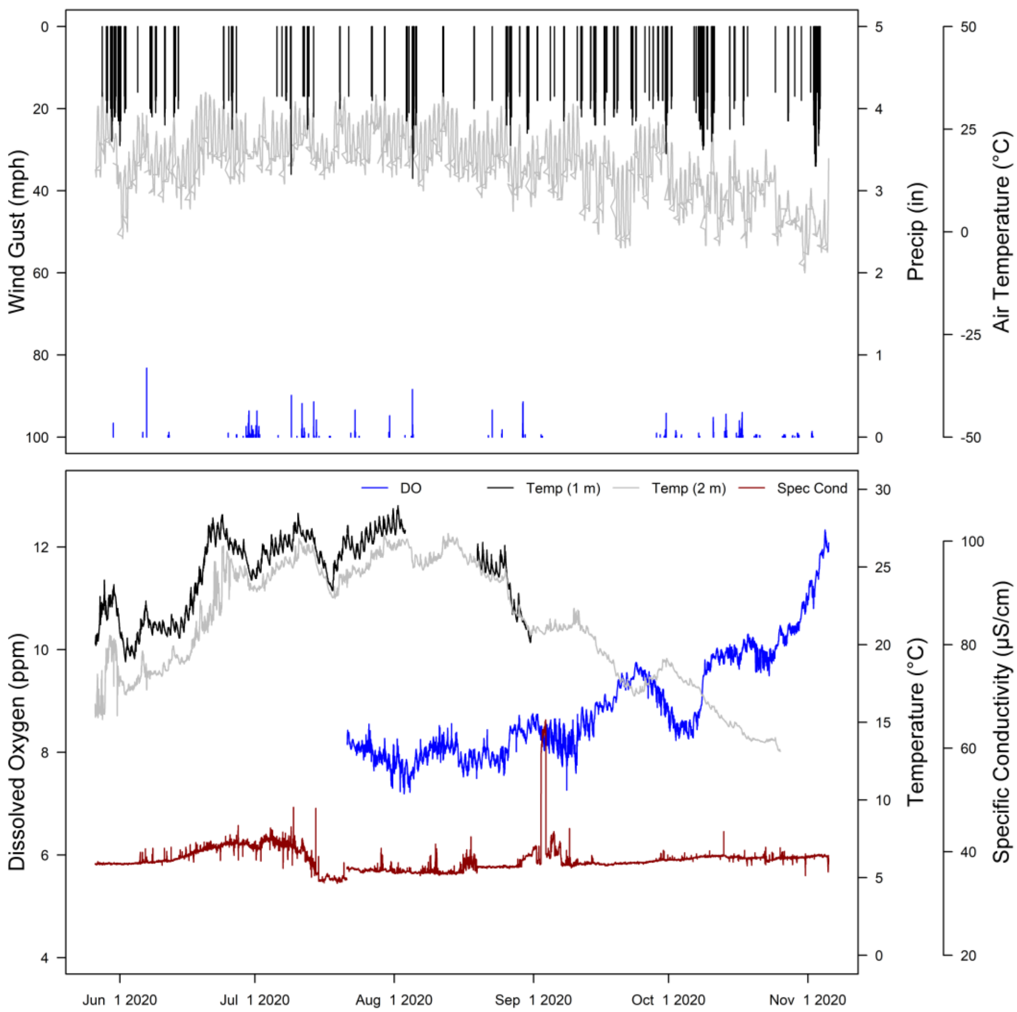


Hourly maximum wind gust (top) and dissolved oxygen (middle) and temperature (bottom) readings taken every 15 minutes during the summer at various depths at the deep spot of Kezar Lake's upper basin. Precipitation, air temperature, and wind gust data were obtained from NOAA NCEI QCLCD Fryeburg Eastern Slopes Regional Airport (54772/IZG).

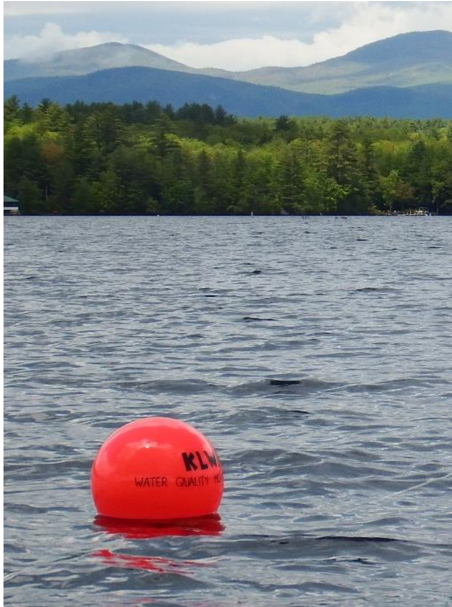
LOWER BAY **BUOY**

In 2020, DO depletion (<5 ppm) was not evident at the lower basin. The entire water column of the lower basin was uniform and well oxygenated, never measuring below 7.2 ppm. A thermocline cannot develop at the lower basin due to shallow water depth. Surface waters at the lower basin reached a maximum of 29.0°C on 8/1/20. Temperature and dissolved oxygen displayed an inverse relationship throughout the deployment (e.g., as temperature declined, oxygen increased). Warmer waters hold less oxygen and stimulate algae/plant growth, the organic material of which can be decomposed via oxygen consumption.

Conductivity can serve as a surrogate measure for the ionic materials (including nutrients) present in water. Conductivity spikes throughout the deployment period largely corresponded with rain events, likely due to transport of ion-rich water from the landscape to the lake. Spikes in conductivity not associated with rain events (unless very localized) may have been due to wind or wave action (from motorized boats) or from an algae bloom.



Hourly maximum wind gust, air temperature, and precipitation (top). Dissolved oxygen, temperature, and specific conductivity readings taken every 15 minutes during the summer at 2 meters depth (temperature also included 1-meter depth) at the deep spot of Kezar Lake's lower basin (bottom). Precipitation, air temperature, and wind gust data were obtained from NOAA NCEI QCLCD Fryeburg Eastern Slopes Regional Airport (54772/IZG).



TRIBUTARY **MONITORING**

For tributary monitoring, two sites (Great and Boulder Brooks) were sampled in June and September for temperature, dissolved oxygen, pH, *E. coli*, and total phosphorus (results in table below). FBE also monitored water temperature and/or water level using continuous Onset HOBO® loggers at the lower basin, Kezar outlet stream, and seven tributaries to Kezar Lake: Beaver, Boulder, Bradley, Coffin, Great, Long Meadow, and Sucker Brooks (results on next page).

Water temperatures fell below 24°C, which is excellent for coldwater fish species, but were abnormally warm for Great Brook in 2020. Dissolved oxygen readings in both brooks for 2020 averaged above 7 ppm, which is the Maine DEP criterion for Class A streams and the minimum concentration required by sensitive aquatic species for survival and growth. Note that dissolved oxygen is lowest before 8 am; mid-day sampling usually represents best-case conditions.

pH in both brooks was less acidic than historical averages and has rebounded from record lows measured in 2015-16. *E. coli* measured in 2020 were well below the Maine DEP instantaneous criterion of 236 col/100mL and the geometric mean of 64 col/100mL, though *E. coli* in Great Brook in 2020 was abnormally elevated above historic variation. Refer to the KLWA website for long-term data and trends.

Total phosphorus in both brooks has remained relatively stable over time, with greater variability historically in Boulder Brook, though total phosphorus in Great Brook in 2020 was abnormally elevated above historic variation. Refer to the KLWA website for long-term data and trends.

In 2012, elevated *E. coli* measured at BB-3 (461 col/100mL) and BB-4 (548 col/100mL) prompted continued monitoring at Boulder Brook. Elevated *E. coli* under low flow conditions may indicate fecal contamination from groundwater sources (e.g., septic systems or wildlife). Additional sampling was conducted on 9/15/20 at the outlet to Boulder Brook and at BB-4 and BB-3, upstream and downstream of Boulder Brook's crossing under Route 5. *E. coli*, total phosphorus, nitrate-nitrite, and ammonium were analyzed but did not show any conclusive patterns that would help identify possible fecal contamination sources (all results were low and of no concern). Further sampling and reconnaissance would be needed under wet weather conditions, as well as during peak summer months (July-August), to refine potential sources to Boulder Brook.

Waterbody	**Temp (°C)**		**DO (mg/L)**		**pH**		**E. coli (col/100mL)**		**TP (ppb)**	
	Historical[b]	Recent 2020[c]	Historical[b]	Recent 2020[c]	Historical[b]	Recent 2020[c]	Historical[b]	Recent 2020[c]	Historical[b]	Recent 2020[c]
Great Brook (GB-1)	15.0	19.4	9.1	7.2	6.4	6.7	21	32	5	11
Boulder Brook (BB-3)	18.0	16.6	7.9	8.6	6.3	6.5	27	27	18	21

[b] *Median historical values calculated by FBE from all data obtained by the MEDEP through 2018; duplicate values/days were averaged; only epicore samples were used in the analyses; includes FBE-collected-only data for 2019-20*

[c] *Median values calculated by FBE from 2020 data*

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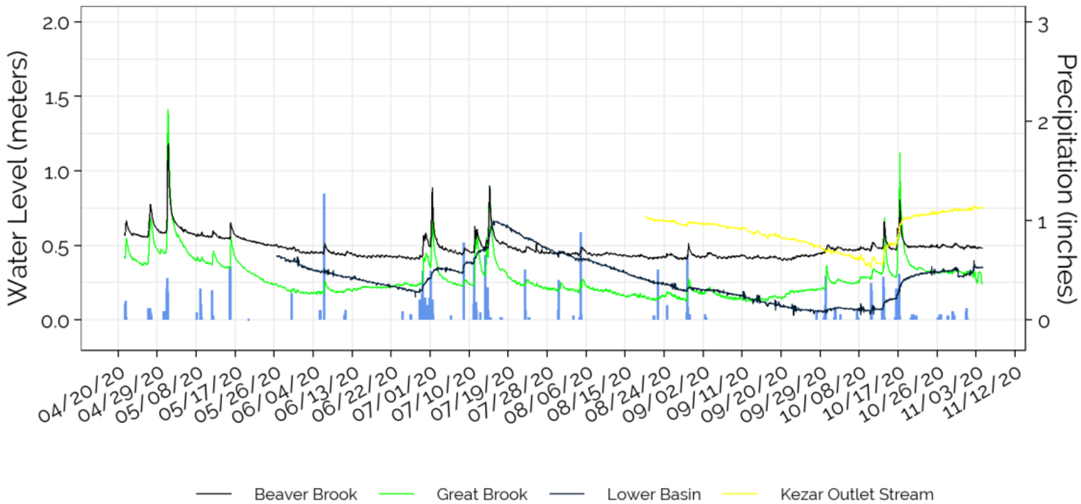
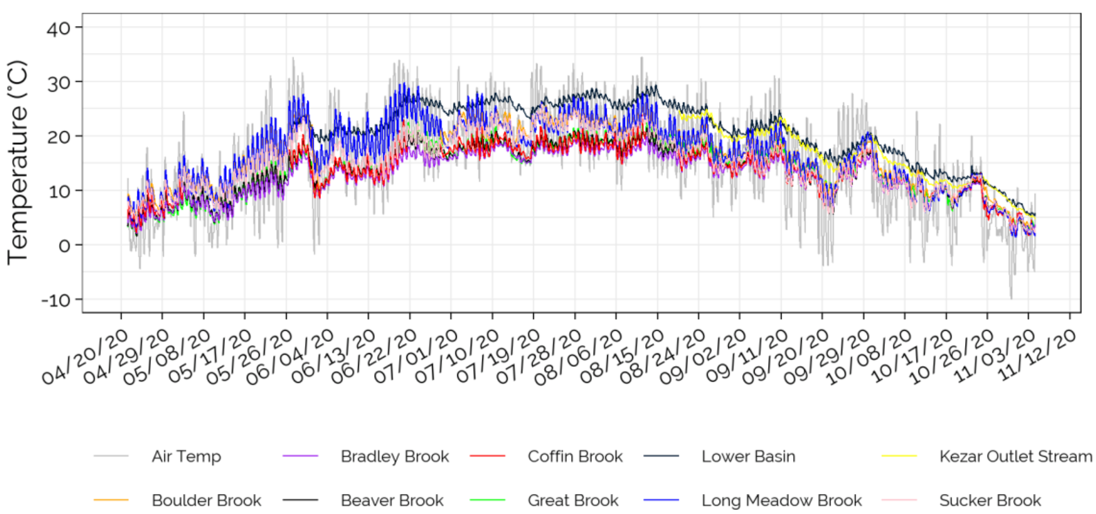


Water level at the four stations gradually declined from April-October (due to evaporation and low precipitation in summer except following a series of July storms) until a series of October-November storms increased lake and stream flows. Due to the larger volume of water flowing from the lake through the outlet stream, water level increased and decreased much slower in the lower basin and outlet stream compared to the smaller headwater streams, Great and Beaver Brooks. Water level in Great and Beaver Brooks responded quickly to precipitation. *Daily precipitation data were obtained from NOAA NCEI QCLCD Fryeburg Eastern Slopes Regional Airport (54772/IZG).*



Water temperature increased at all sites from April to August and then steadily declined until retrieval in November, which followed closely with observed air temperature. Water temperature at all sites began to converge by November. This likely represents leaf senescence in the fall after which all streams were exposed to similar light and air temperatures. Kezar outlet stream, the lower basin, Boulder Brook, Long Meadow Brook, and Sucker Brook experienced higher water temperatures than the other streams, likely due to having more open canopies. *Hourly air temperature data were obtained from NOAA NCEI QCLCD Fryeburg Eastern Slopes Regional Airport (54772/IZG).*


Great Brook


Beaver Brook


Lower Bay


Kezar Outlet Stream

Kezar Lake
WATERSHED ASSOCIATION

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