Temperature Readings on Lake Bellaire and Intermediate Lake

By: Sydney Frederick

Introduction

During the Summer of 2020, Three Lakes Association and Intermediate Lake Association engaged in a water quality testing project aiming to amass data readings of lake temperature and dissolved oxygen at different depths of Lake Bellaire and Intermediate Lake. This data can then be used to assess changes in the lakes at different depths by comparing future water quality testing data with TLA's historic records.

For the sake of maintaining the quality ecological health of lakes, monitoring temperature and dissolved oxygen content is vital. Significant changes in data trends for temperature and or dissolved oxygen by depth would indicate a change in the health of the lake. Creating a standard trend to identify these changes is of major importance to preserving the ecosystem of the lake by indicating when action needs to be taken towards protecting the lake's inhabiting organisms. In July and August of 2020, TLA was successful in taking quality temperature readings, which were used to find the thermocline (a layer found in relatively deep lakes where the temperature drops rapidly) in Lake Bellaire and Intermediate Lake. However, the equipment available for testing was unable to take accurate dissolved oxygen readings.

Those involved in the measurement process were Dean Branson, Sydney Frederick, Richard Knopf, Sue Thomas, Jeanie Williams, and Steve Young. Special thanks to John Curtis and Jim Gilleylen who allowed TLA to use their properties and drove the measurement teams out on the lakes, and to Larry Cooley who provided the YSI measuring device and historical data for Intermediate Lake.

Research

The following section includes background research on water temperature and thermoclines concerning their importance to the water body.

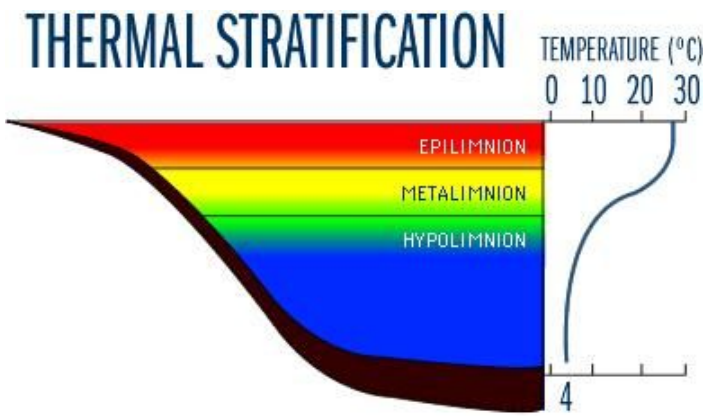
Temperature

The temperature in bodies of water are important factors to the survival of various species living in the lake. Most aquatic animals are cold-blooded (also called poikilothermic), meaning that they are unable to maintain a core body temperature. Thus, they are highly sensitive to the temperature of their surroundings. These cold-blooded animals as well as insects, zooplankton, and phytoplankton, all have a preferred temperature range. Most fish prefer colder water. If the temperature goes too

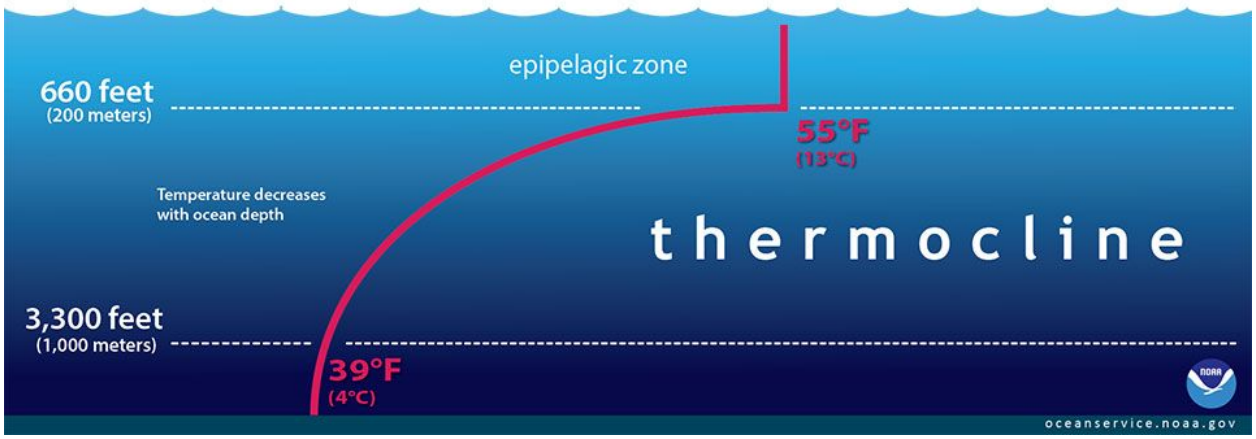
far above or below the preferred range for the present species, the number of species significantly decreases until few or none are found.

Thermocline

A thermocline is a term for a range of temperatures at a certain depth in a body of water where the temperature drops rapidly. Thermoclines only develop in the Summer due to a change in water temperature on the surface. The warmer weather and longer days results in the surface of the water becoming warmer. This creates stratification in the water column as the warmer water is less dense compared to the colder water below. Due to the difference in density, the contents of different layers cannot interact with each other, and layers of different densities form. The warmer upper layer of the water is called the epilimnion, the colder bottom layer (often the largest) is the hypolimnion. There is a thin layer in the middle of the epilimnion and the hypolimnion known as the metalimnion, which has a steep temperature gradient where temperature drops severely. This is where the thermocline is located.



Source: Lake Access

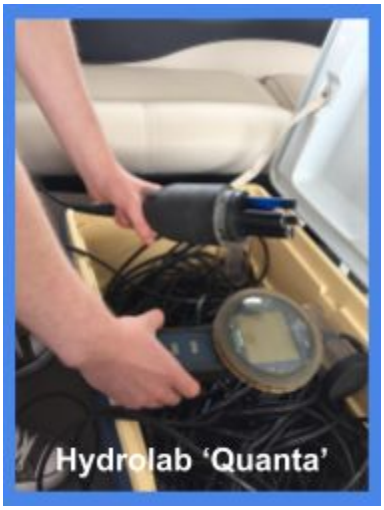


Source: National Ocean Service

During colder parts of the year, there is typically no thermocline because the water column's temperature is relatively uniform. With no stratification due to density layers, the wind is able to mix the water in the entire water column. In other words, the waves that the wind creates as it hits a shoreline is able to push surface water to a much lower depth. The wind cannot mix the water column when the water is stratified, as water from each layer is stuck within that layer. The only exception would be that a large storm may generate powerful enough wind to break through the density barrier and move water between layers.

Materials

Two different measurement tools were used in taking the measurements of the temperature and dissolved oxygen data in the lakes.



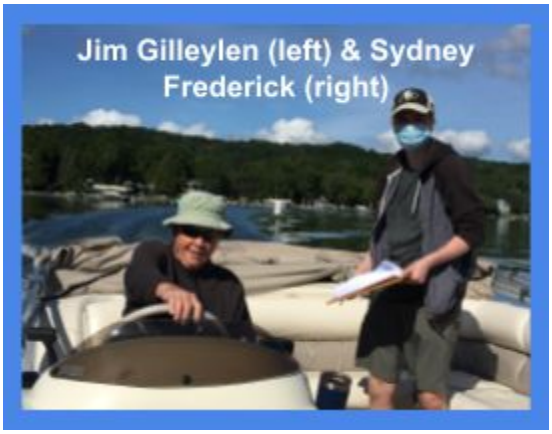
One of the instruments used to measure the temperature and dissolved oxygen is a device called the Hydrolab 'Quanta', manufactured by Hach Inc. The Hydrolab consists of two main parts: a control panel with a screen where the data collected can be read, and a receiving apparatus. The receiving apparatus is capable of measuring temperature, pH, specific conductivity, dissolved oxygen, and its depth in the water. Only depth, temperature, and dissolved oxygen were measured in these tests. The temperature is measured with a 30 K ohm resistance thermometer. The dissolved oxygen is measured by a probe with a specified membrane that only allows oxygen through. As the oxygen permeates the membrane, an oxidation-reduction reaction occurs with oxygen as a reactant. The reaction creates an electrochemical current, which is measured to determine the amount of oxygen present. On the receiving apparatus, there is a fan that can be used to circulate the surrounding water through the measuring equipment for more accurate results.

The YSI 'Pro ODO' is an additional tool that was used for measurement. The device is similar in design and function to the Hydrolab 'Quanta'. It can measure temperature and dissolved oxygen, among a variety of other parameters that were untested in these sessions. Structurally, the YSI consists of a control panel and screen used to read the data collected by a submerged receiving apparatus. There is also a fan that can circulate the water into the receiving apparatus for accurate results. However, the YSI cannot measure depth. Instead, the cable connecting the control panel and the receiving apparatus was marked with tape at every five foot interval. The cable would be lowered until the tape for each interval met the surface of the water to gather data at the depths that each of these intervals indicated.

Note that for both the July and August measurement sessions, the Hydrolab 'Quanta' and the YSI 'Pro ODO' were not properly calibrated for collecting dissolved oxygen data due to a lack of available materials and technical difficulties. However, this does not affect the temperature data and those available readings should be accurate.

Method

Measurements were taken over the lake's deep water basin. The deep water basin is the deepest part of the lake, and is the ideal location for taking measurements that reflect the state of the lake's entirety. The depth also allows the thermocline to form. Coordinates were taken and or checked to mark or find a consistent spot for measuring.



Taking measurements involved one person lowering the measurement probe into the water while someone monitored the device's screen. For the Hydrolab, the depth of the probe was determined by one of the probe's readings, so the reader would guide the probe handler into lowering it to certain intervals. The YSI does not measure depth, so tape markers on the cord were used to indicate five and ten foot intervals all the way up to eighty feet. A weight was attached to the YSI probe to help it sink. At the depth intervals (measured in three meter intervals for the Hydrolab, and five foot intervals for the YSI), the group would wait for about a minute until the readings stabilized. Then the temperature and the dissolved oxygen (although the dissolved oxygen measurements were disregarded) would be written down by a designated recorder.

Results

Below includes a link to the data sheet used to record the temperature readings from both lakes as well as a series of graphs representing the recording data. Basic data approximations for the thermoclines as well as the surface and floor temperatures of the lakes have been compiled into tables. The measurements for the tables referring to both Lake Bellaire and Intermediate Lake in 2020 were considered from the data collected by the YSI and the Hydrolab. The number shown is the average between the corresponding data points between the different measuring tool's data sets. They show relatively similar results, so the data set from each tool serves to corroborate the other. There were more measurements taken with the YSI because the cord was marked at every five feet rather than the three meters that were used as the interval of measurement for the hydrolab. Because there were more measurements taken with the YSI, the data from that measuring tool could be considered more precise in determining the positions of temperature change in the water.

Also note that for there were two data collection tests with the hydrolab in Intermediate Lake, so all shown data from Intermediate Lake collected with the Hydrolab is the average between the data collected between the two tests.

Historical water quality data was graciously provided by Larry Cooley, an associate of TLA who took temperature and dissolved oxygen readings in Intermediate Lake from 2016 to 2018. This data was then compiled together with the collected 2020 data to compare the temperatures at various depths and the locations of the thermoclines. The closest calendar date to July 21st and August 21st were used for the data representing its respective year (because these were the dates the 2020 data was collected). Only the data collected with the YSI instrument was used in the comparison because Cooley's data was collected with the same instrument.

Link to Data Sheet

Lake Floor Depths
Lake Bellaire Floor Depth: 28.3 meters/92.85 feet
Intermediate Lake Floor Depth: 24.38 meters/80 feet

Note that the temperature at the bottom of Intermediate Lake (24.38 meters/80 feet) was unable to be measured during the July 2020 test. The lowest depth where the temperature was recorded was 21.34 meters/ 70 feet.

Surface and Floor Temperatures (2020) - Lake Bellaire and Intermediate Lake

	July Surface Temp (C)	July Floor Temp (C)	August Surface Temp (C)	August Floor Temp (C)
Lake Bellaire	24.43	7.29	24.06	7.5
Intermediate Lake	25	9.27*	23.75	9.05

*21.34 meters/ 70 feet

Thermocline Data (2020) - Lake Bellaire and Intermediate Lake
Approximate Depth and Temperature Ranges

	July Top Depth (m)	July Bottom Depth (m)	July Top Temp (C)	July Bottom Temp (C)	Aug Top Depth (m)	Aug Bottom Depth (m)	Aug Top Temp (C)	Aug Bottom Temp (C)
Lake Bellaire	5	9	24	12.5	5	9	22	12.5
Intermediate Lake	5	9	24.4	13.4	6	9	22.5	12.9

Intermediate Lake Surface and Floor Temperatures Over Time

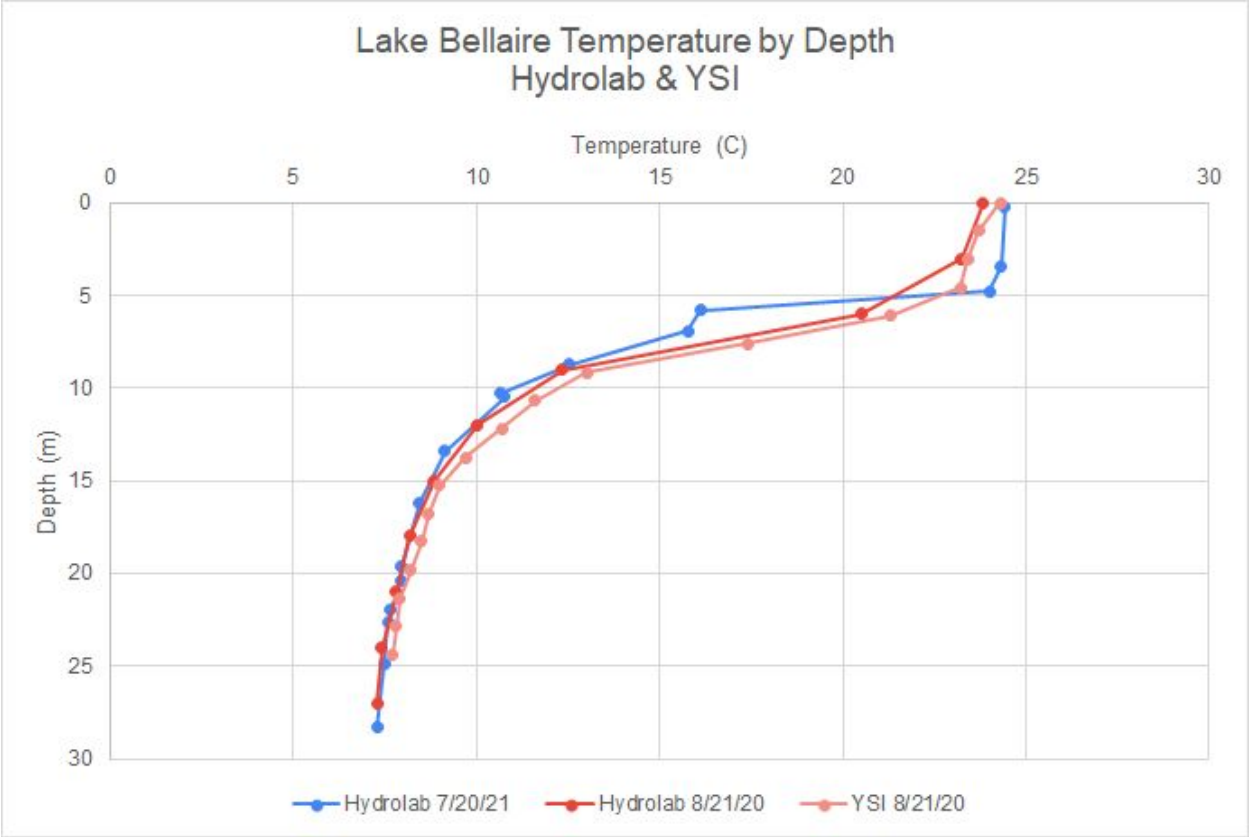
	July Surface Temp (C)	July Floor Temp (C)	August Surface Temp (C)	August Floor Temp (C)
2016	25.5	8.5	26.3	8.6
2017	23.6	9.5	21.4	9.2
2018	25.8	6.2	26.8	5.7
2020	25.4	9.3*	23.5	9.1

*21.34 meters/ 70 feet

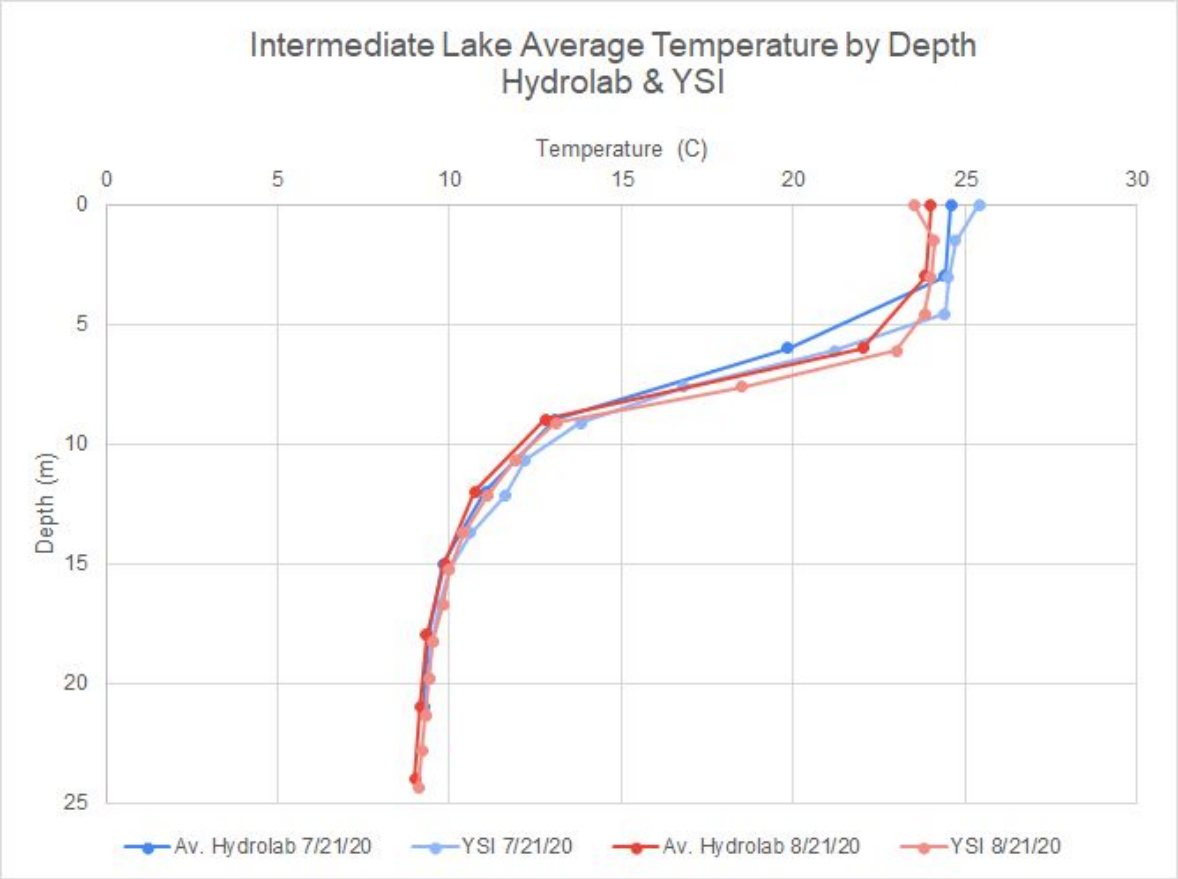
Intermediate Lake Thermocline Data Over Time

Approximate Depth and Temperature Ranges

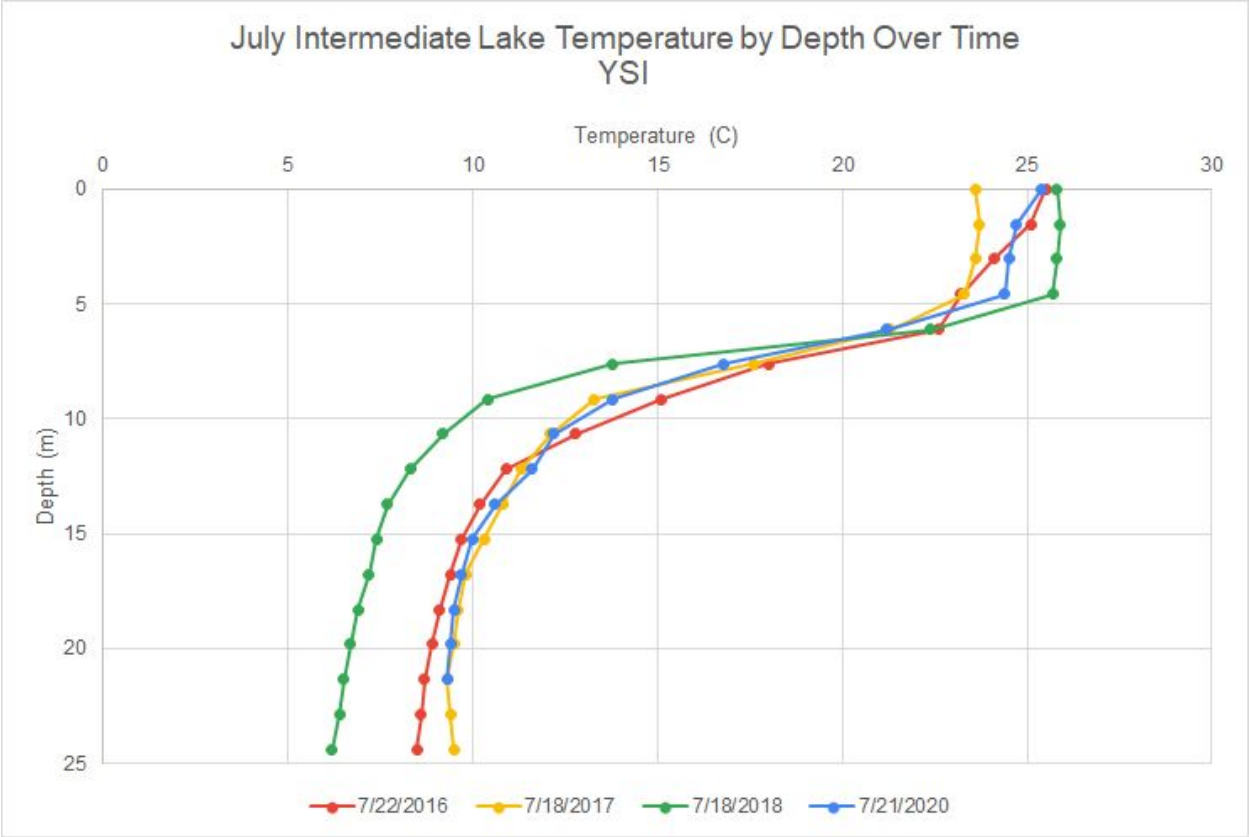
	July Top Depth (m)	July Bottom Depth (m)	July Top Temp (C)	July Bottom Temp (C)	Aug Top Depth (m)	Aug Bottom Depth (m)	Aug Top Temp (C)	Aug Bottom Temp (C)
2016	6	12	22.6	10.9	5	11	25.7	12.4
2017	5	9	23.3	13.3	8	11	21.2	12.9
2018	5	9	25.7	10.4	5	11	25.3	8.7
2020	5	9	24.4	13.8	6	11	23	11.9



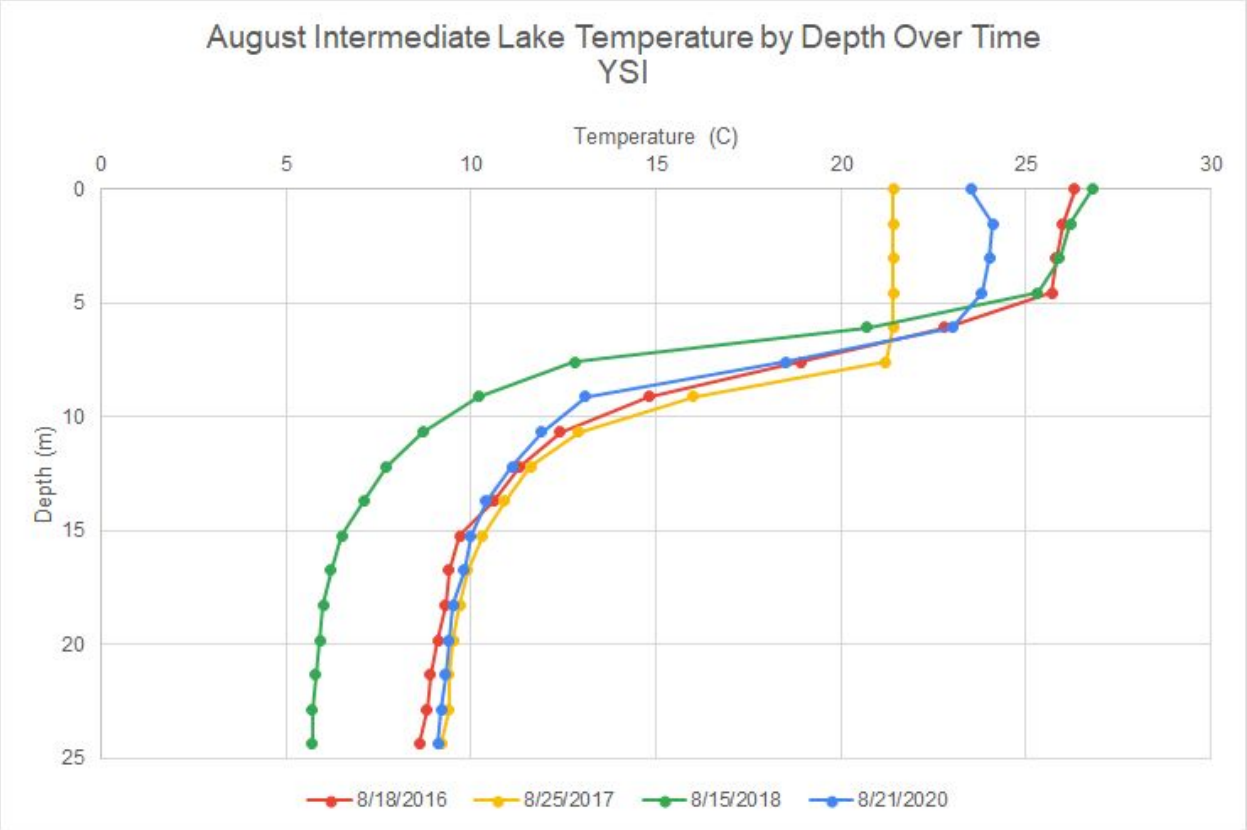
Lake Bellaire July and August Temperature by Depth: There is a slight drop in surface temperature from July (blue) to August (red). The starting thermocline temperature and depth also decreases in August. There is a more gradual decrease in temperature from the surface to the top of the thermocline in August as well. The thermoclines end at approximately the same depth and temperature along with the rest of the subsequent data points.



Intermediate Lake July and August Temperature by Depth: July (blue) has a higher surface temperature reading than August (red) as well as a higher maximum depth for the thermocline. The end thermocline depth and temperature. The temperatures after the end of the thermoclines are uniform between the months.



July Intermediate Lake Temperature by Depth Over Time: The surface temperatures were relatively similar except for the year 2017 (yellow) which was colder than the others. The top and bottom of the thermoclines for the years 2017 (yellow), 2018 (green), and 2020 (blue) were approximately the same. The thermocline in 2016 (red) had a deeper beginning and end to the thermocline than the rest. The temperatures at the start and ends of the thermoclines varied over the years. The temperatures in the lower level of the lake were similar except for the year 2018, which is shown to be much colder.



August Intermediate Lake Temperature by Depth Over Time: The surface temperatures and depths of the beginning of the thermoclines varied over the years, except for the years 2016 (red) and 2018 (green). Their surface temperatures and temperatures at the tops of the thermocline as well as their depths are shown to be close. 2017 (yellow) has very little temperature change from the surface to the beginning of the thermocline. This is likely from a recording error. The ends of the thermoclines are similar in depth for all of the years with different temperatures. The temperatures in the lower level of the lake are similar except for the much colder 2018 (which is also seen in July).

Discussion

Lake Bellaire and Intermediate Lake 2020

The units used in the following discussion will be metric to keep with scientific standards and to avoid confusion involved with including both metric and imperial units. The imperial conversions are available on the data sheet. Also note that approximate ranges when determining thermocline area or temperature range refer to the closest data point to when concerning a single series, and the average of the closest data points when concerning multiple.

Both Lake Bellaire and Intermediate Lake decreased in surface temperature from July to August. This may be from a seasonal temperature change as summer progresses, or from random weather events. TLA was unable to consistently measure the bottom of the lakes due to the length of the

YSI chord and weather difficulties. However, the temperatures are steady in the lower portion of the lake, so there would be little difference between the temperature at the lake floor and slightly above the lake floor.

In Lake Bellaire, the thermocline was located at approximately five to nine meters in both July and August. The range of thermocline temperatures in July had a 2 °C greater maximum temperature (highest temperature in the thermocline) than August, while the minimum temperature (lowest temperature in the thermocline) was only 0.5 °C higher in July. Therefore it seems that there is a greater temperature change towards the surface of the water body between seasons. During July, there seems to be a small section in the middle of the thermocline where little temperature change occurs. There is only a -0.32 °C per meter rate of change between 5.8 to 6.9 meters compared to the preceding -7.88 °C per meter rate of change between 4.8 to 5.8 meters. These rates of change are inconsistent with the more gradual and uniform slopes of temperature change seen in August. This is likely from an error in the equipment concerning its adjustment to the change in temperature.

In Intermediate Lake, the July thermocline's top was about five meters deep, while the August thermocline's top was at six meters. Both ended at approximately nine meters. The range of thermocline temperature in July was around 24.4 °C to 13.4 °C. In August, the range was 22.51 °C to 12.9 °C.

In both Lake Bellaire and Intermediate Lake, the temperatures at the top of the thermoclines cooled more than the temperatures at the bottom between July and August. This is likely because the water in the hypolimnion is less affected by cooling air temperatures The maximum thermocline temperature decreasing in August reflects how the surface temperature of the water also decreased in August. This is because the surface temperature of the water has a corresponding effect on the maximum temperature of the thermocline. This effect doesn't seem to apply to the bottom of the thermocline as much, as the decrease in temperature there was much smaller.

Intermediate Lake Over Time

The surface temperatures in Intermediate Lake during July were similar in the years 2016, 2018, and 2020, all being approximately 25.6 °C. The temperature in 2017 was 23.6 °C. In August, the surface temperatures were approximately 26.6 °C in 2016 and 2018. In 2017 the surface temperature was 24.1 °C and in 2020 it was 23.5 °C. The varying temperatures may be from different weather conditions. The temperatures at lower depths tended to stay the same from year to year, except for 2018, which has a higher surface temperature, and a much lower temperature at the lake floor. The minimum temperature for 2018 was 6.2 °C in July and 5.7 °C in August, while the other years had minimum temperatures between 9.5 and 8.5 °C in both months.

Note that in August of 2017, the first five intervals (0 to 6.1 meters) were all recorded to be 21.4 °C. The next point at 7.62 meters is within the area where the thermocline begins and has a slightly lower temperature of 21.2 °C. The repeated temperature readings may be a recording error, where there was not enough time for the YSI probe to adjust to the current temperature. This is

suggested from the lack of the small drops in temperature between the intervals before the thermocline, which is seen in the other series in both July and August.

In July, the thermocline in 2017, 2018, and 2020 begin around five meters and end around nine meters. The 2016 thermocline begins at approximately six meters and ends at twelve meters. The year 2016 doesn't have a very defined main thermocline. The entire data set shows a changing temperature before six meters as well, however, the temperature change is not as severe. Thus July 2016 is rather anomalous in thermocline composition. The top depth of the thermoclines change in August. In 2016 and 2018, the depths of the top are at approximately five meters, in 2017 the top of the thermocline is at eight meters, and in 2020 the top is at a depth of six meters. All of the thermoclines end at approximately eleven meters. The rate of change decreases to a comparatively normal rate when observing the others after the end of the thermocline. The temperature ranges of the thermoclines varied between years. The range at the top of the thermoclines in July was 25.7 to 22.6 °C, the end ranging from 16.8 to 10.4 °C. In August the temperatures at the tops ranged from 25.7 to 21.2 °C, and the end ranged from 12.8 to 8.7 °C. This may be due to the changing air temperatures, and their possible effect on the thermocline temperature range, as discussed previously.

Note on Dissolved Oxygen

While in this effort, TLA was unable to obtain dissolved oxygen readings, yet dissolved oxygen is a vital factor to determining the health of the lake. There is a small amount of oxygen (up to about ten molecules per million water molecules) that is dissolved in water. Fish require this oxygen in order to respire and survive. Issues can arise where a water body becomes oxygen deficient. This most commonly occurs in water with excess amounts of decaying organic matter. Bacteria consume oxygen as organic matter decays. If done in excess, the available oxygen may not be enough to support the fish in that area. This can be especially problematic in the summer. A lot of the dissolved oxygen that enters a water body is from phytoplankton photosynthesis. Phytoplankton live exclusively in the lit portions of the water and therefore live primarily in the epilimnion. If a thermocline develops (due to warm weather), the dissolved oxygen that is produced from phytoplankton in the epilimnion is separated from the hypolimnion, which is where most fish aggregate due to its cold temperatures. There is also oxygen that enters from the atmosphere, which would also be separated from the hypolimnion if a thermocline is present since it enters from the surface of the water. Thus, dissolved oxygen readings combined with temperature readings are highly informative on the state of a water body's ecosystem. Taking dissolved oxygen readings should be strongly considered in future water quality testing projects.

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