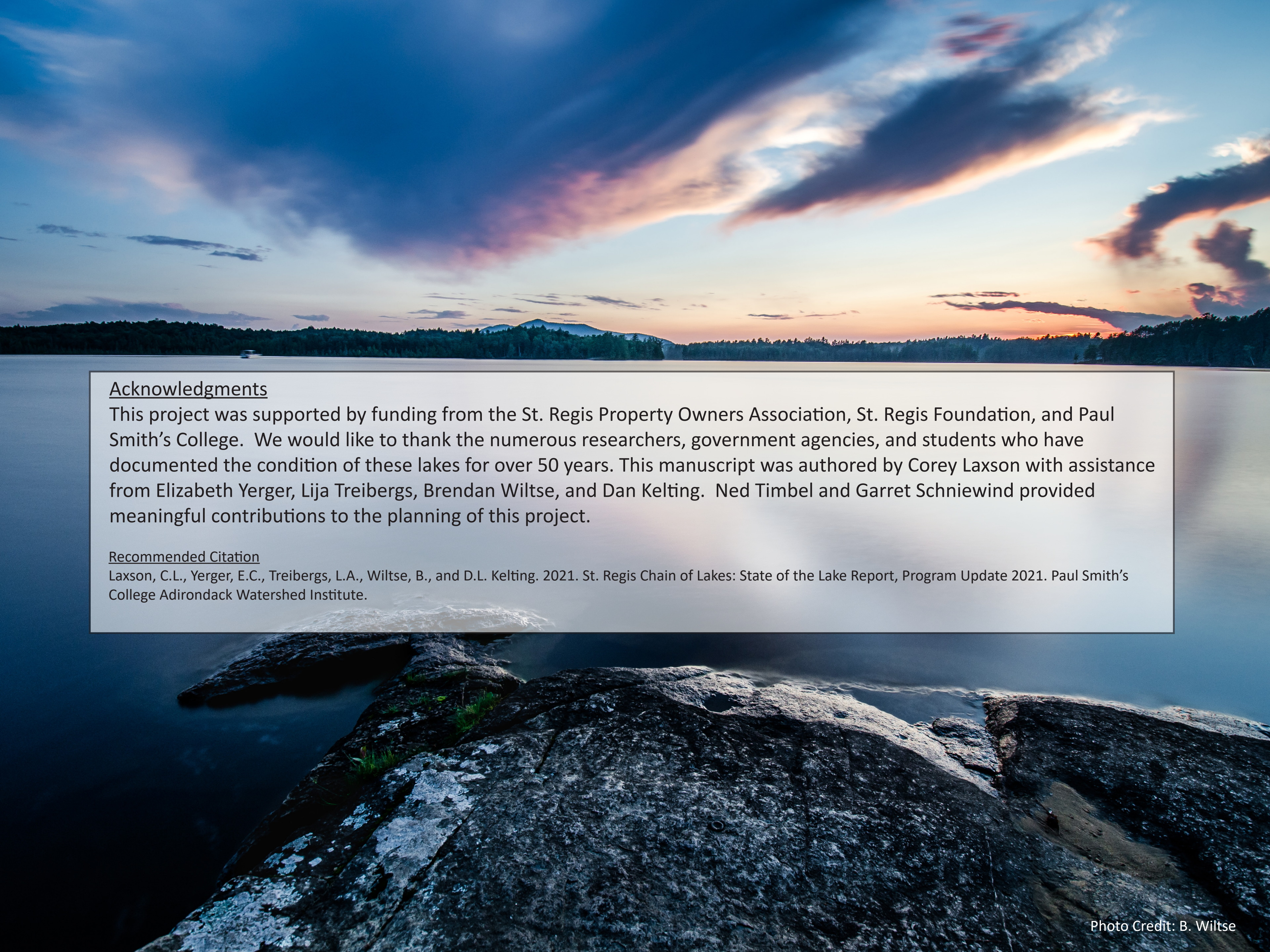
St. Regis

State of the Lakes Report
2021



Acknowledgments

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Executive Summary

The purpose of this study is to provide an update to the comprehensive **State of the Lake Report issued in 2018**. The specific objectives are to: (1) Update the lake users on the physical and chemical properties of the lakes during the 2018-2020 field seasons, (2) maintain a functioning database that contains all of the available historical water quality data for the lakes, and (3) analyze the last 20 years of data to detect <u>recent</u> trends in key water quality parameters. The report can be summarized in the following main points.

1. Lower St. Regis Lake has experienced an ecological redemption since the late 1960's, one that has continued to improve since 2000. The primary trophic indicators (phosphorus, chlorophyll, and transparency) have exhibited statistically significant improvements, shifting the lake from a eutrophic to a mesotrophic condition.

2. All three of the lakes experience rapid oxygen depletion in the bottom strata. Although this information is not news to the SRPOA, the cause of the anoxia is probably a result of several factors. We hypothesize that some degree of bottom water anoxia is natural in the Regis lakes, and has probably always occurred. Ultimately, the controlling factor for anoxia is the ratio of the lakes sediment surface area to hypolimnion volume (SSA:HV). For the relatively shallow lakes in the St. Regis chain this ratio is large, indicating that oxygen depletion should be anticipated. Current and historical nutrient pollution from the watershed has certainly augmented the oxygen depletion by providing a store of organic material for decomposition.

3. Anoxia in the bottom water of the lakes creates a reducing environment that allows dissolved reactive phosphate to move out of the sediments. All of the

lakes experience a significant increase in phosphorus concentration in the bottom strata, typically ranging from 6 to 10 times higher then the surface.

4. Over the last 20 years (2000-2020) the surface water concentration of phosphorus has decreased in Lower St. Regis Lake and remained stable in Spitfire and Upper St. Regis.

5. We detected low densities of cyanobacteria in Lower and Upper St. Regis; however, a productive population of *Planktothrix* thrives near the bottom of Spitfire Lake during the warmest weeks of the summer. The low light intensity, anoxia, and nutrient supply at the bottom of the lake provide a perfect environment for *Planktothrix,* a species that can photosynthesis in suppressed light, prefers low oxygen, and requires a high supply of phosphorus. During most of the summer the cyanobacteria population is not visible. When growth conditions along the bottom change, the species can construct gas vacuoles and float to the surface. It is only at this point that they become noticeable to lake users.

6. Due to their inherent acid neutralizing capacity, the lakes in the chain are circumneutral in terms of their pH, and have not experienced noticeable degradation associated with acid deposition.

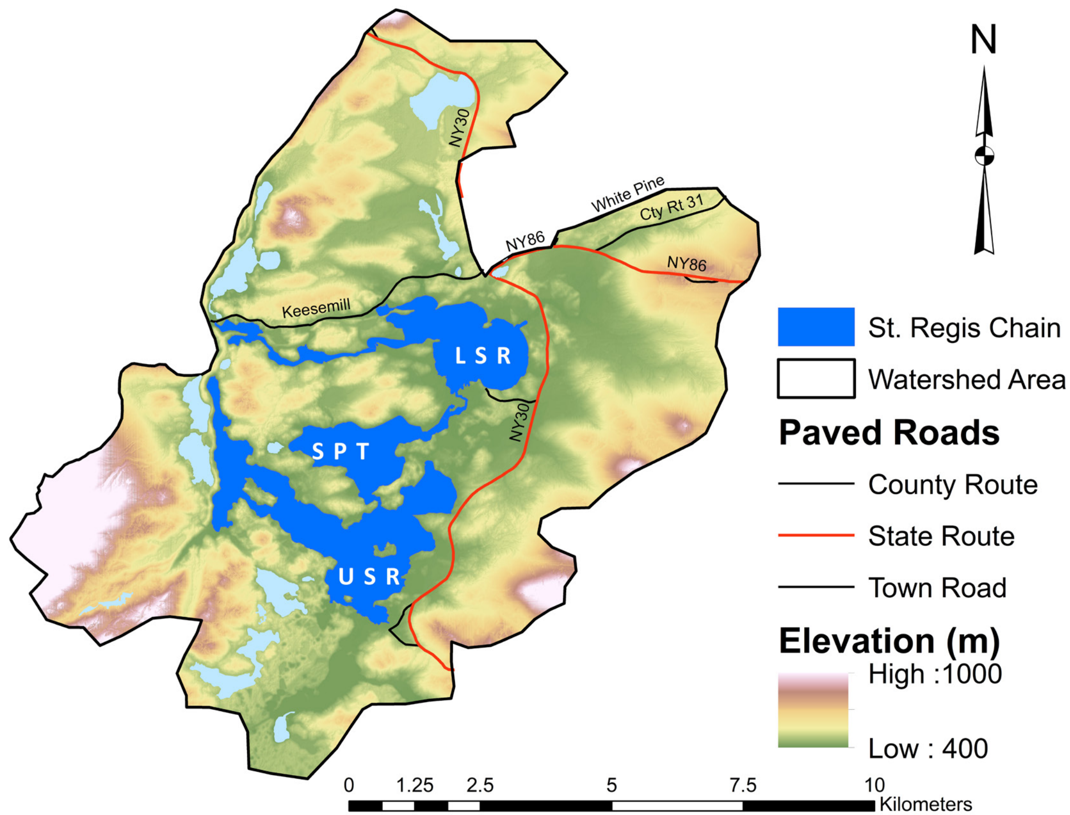
7. The chemistry of the St. Regis chain is influenced by salted roads in the watershed. The concentrations of sodium and chloride have increased in all the lakes. The greatest impact is in Lower St. Regis Lake, where the concentration of chloride is 135 times greater than the concentration observed in least impacted lakes around the Adirondacks. Spitfire and Upper St. Regis have similar salt concentration to each other, and are approximately 42 times greater than background values.

Background

The St. Regis chain of lakes is over 1,300 acres of connected water in Franklin Country, NY. The chain is morphologically divided into three distinct water bodies known as Upper St. Regis, Spitfire, and Lower St. Regis Lakes.

Lake and watershed morphometry of the St. Regis Chain is detailed in the **2018 State of the Lake Report.** Upper St. Regis is the first lake in the chain with a surface area of 700 acres and a maximum depth of 66 feet. Water flows north from Upper St. Regis into Spitfire Lake, the smallest of the lakes in the chain, at 269 acres. Spitfire is also the shallowest, reaching a maximum depth of 29 feet. Water drains northeast from Spitfire to Lower St. Regis Lake through a 2,000 foot long channel referred to as “the slough”. Lower St. Regis Lake has a surface area of 350 acres and a maximum depth of 38 feet

The watershed of the St. Regis Chain encompasses 13,247 acres comprised of 35% deciduous forest, 28% coniferous forests, 3% mixed forest, 13% wetland, and 3% residential.



Historical Perspective

Development within the St. Regis watershed began in 1858 when Apollos A. Smith purchased 50 acres on the shores of Lower St. Regis Lake and began construction of his 17 room hunting lodge. Over the next several decades the rustic hunting outpost called *St. Regis House* grew to a world renowned wilderness resort known as Paul Smith's Hotel. Well before the end of the 19th century, Paul Smith owned nearly the entirety of the St. Regis watershed. Hotel guests and influential families who desired their own piece of the early Adirondack lifestyle purchased shoreline property from Paul on Spitfire and Upper St. Regis for the construction of their own camps and cottages. Development on the lakes increased rapidly. Analysis of historical USGS maps reveals a 550% increase in the number of buildings around the lake chain during the first half of the 20th century.

Water quality impacts must have been observed by the turn of the century. We know this because in August of 1901 property owners on the St. Regis Chain, including Dr. E.L. Trudeau, Phelps Smith, and Dr. Walter B. James signed a resolution promising that after June 1st 1902 they would not allow *"sewage, kitchen or sanitary water, waste water, or any other refuse of any kind whatsoever to be thrown or drained into any of the water bodies of the St. Regis Chain*". The resolution went on further to say that property owners *"will not build or continue to use any dry well or cess pool at a distance of less than 30 feet from the shore of these waters."* One can only imagine that if this was the unanimous sentiment in 1901, then surely water quality issues had been observed at that time.

Despite the property owner's efforts to curb pollution, it appears the water quality of the lakes continued to trend down through the middle of the 19th century. Historical documentation of specific water quality concerns focused on Lower St. Regis Lake, and rightfully so. Development associated with the Paul Smith's Hotel, and later Paul Smith's College, outpaced the waste water management technology of the time as well as our scientific

Paul Smith's Hotel during the mid 1880's. Paul Smith's College historical archive understanding of lake ecology. The results to Lower St. Regis Lake were long lasting blooms of cyanobacteria, extreme anoxia, and changes to the fish community. One of the worst algae blooms occurred in the summer of 1968 when the waters of Lower St. Regis were so thick with cyanobacteria that the bloom could be observed 32 km downstream in the St. Regis River. Total phosphorus concentrations during this event were as high as 144 µg/L, nearly six times greater than the total phosphorus values in the adjacent Spitfire Lake (Fuhs et al. 1977). To their credit, Paul Smith's College initiated major changes to waste water handling on campus in the late 1960's. These efforts culminated in 1974 when waste water effluent was diverted from the lake to sand percolation beds for 100% nutrient removal. Subsequent studies of the lower lake reported noteworthy improvements to water quality

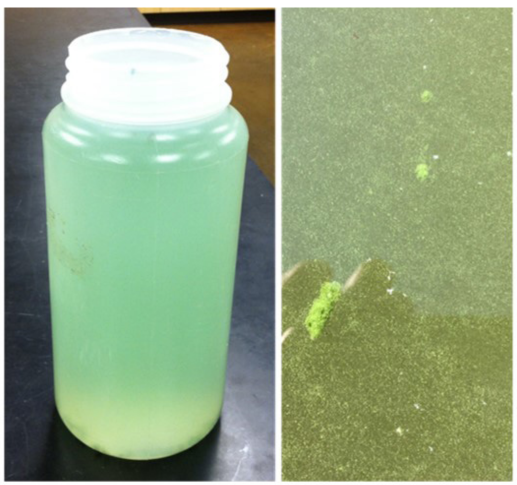
In more recent decades the water quality focus has shifted towards the upper lakes. In 1994, the SRPOA (St. Regis Property Owners Association) commissioned a study on the limnology of Spitfire and Upper St. Regis Lake. In the report, Hyde and Martin (1995) described bottom water anoxia, release of sediment bound phosphorus, and cyanobacteria blooms as evidence that both upper lakes had been impacted by shoreline development. The results of this study spurred the SRPOA to support regular water quality monitoring on the lake chain, a task that has been carried out by no less than 6 entities since 1994. Recently, some members of the SRPOA have noted an apparent increase in the prevalence of cyanobacteria blooms, and expressed concern over the oxygen depletion and

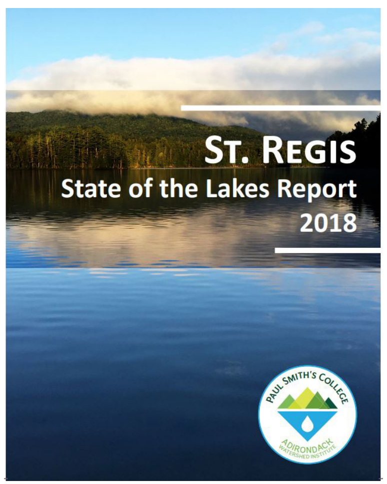
Aerial view of a large scale cyanobacteri bloom on Lower St. Regis Lake (Left), NYS Department of Health Researchers arriving on campus to investigate the poor condition of the lower lake. Photos taken on August 5th, 1971.

subsequent internal phosphorus loading in the upper lakes. In an effort to promote stewardship of the lakes, the SRPOA commissioned O'Brien & Gere to use recent lake data to develop a phosphorus budget for the St. Regis Lakes (OBG 2015). The results of the study revealed that internal phosphorus loading from the sediments represented the largest phosphorus input, ranging from 30 to 40% across the three lakes. The OBG report also identified additional monitoring needs, such as extending the time period for sampling, analyzing additional nutrients, and more detailed analysis of oxygen depletion.

In 2017, The SRPOA expanded their partnership with the Paul Smith's College Adirondack Watershed Institute (AWI) to provide a comprehensive analysis of the water quality of the St. Regis Chain. The specific objectives of the partnership are to: (1) synthesis and interpret the physical and chemical properties of the lakes during the 2017 ice free season, (2) create a functioning database that contains all of the available historical water quality data for the lakes, and (3) analyze the historical data for trends in key water quality parameters.

In 2018, the AWI released a comprehensive report titled **St. Regis: State of the Lake Report.** The report detailed the current and historical conditions of the lakes spanning back to the earliest recored data from 1967. The objective of this current document is to update lake users on the last three years of data collection. We specifically set out to analyze historical trends in key water quality indicators over the last 20 years (2000-2020).

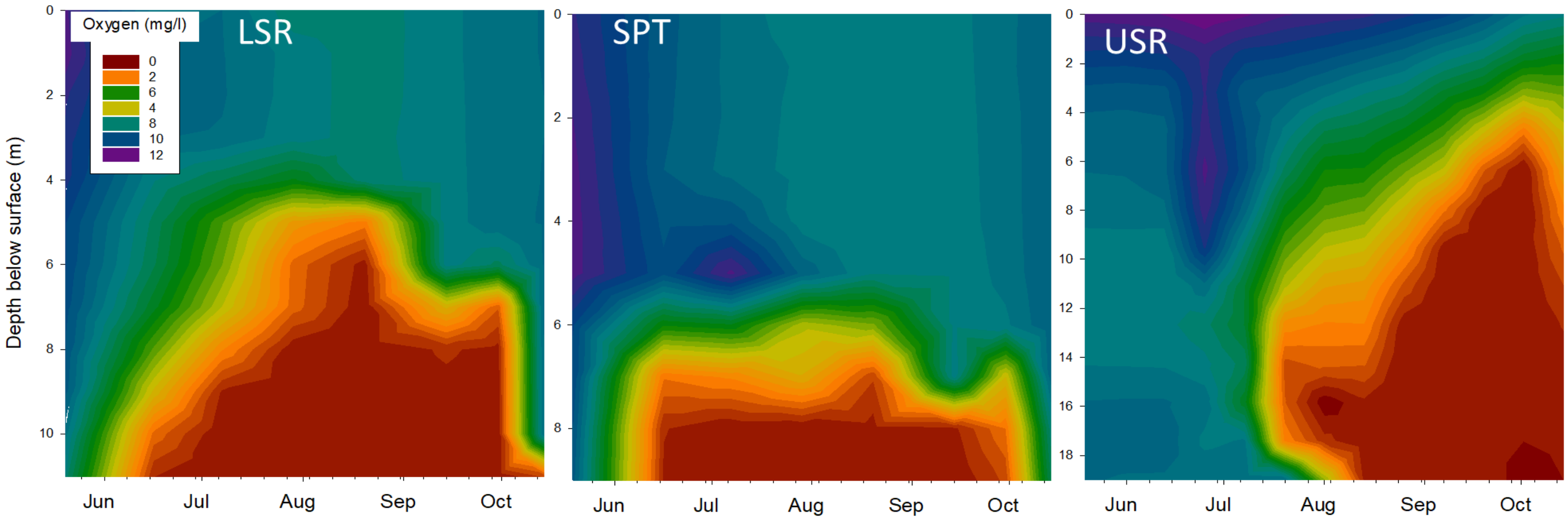




Sample from a bloom of the cyanobacteria, Planktothrix, in Spitfire Lake, July 7th, 2016 (left). AWI Research Associate Elizabeth Yerger measuring transparency on Upper St. Regis (center). St. Regis State of the Lake Report 2018 , available on the AWI website (right).

Dissolved oxygen is perhaps the most fundamental parameter of a lake, aside from the water itself. Available oxygen is essential for aerobic metabolism and non-biotic chemical reactions. In addition the presence or absence of oxygen directly affects the solubility of a number of important inorganic nutrients such as phosphorus. The primary source of oxygen in a lake is the atmosphere, thus, in lakes that are thermally stratified the hypolimnion is isolated from the oxygen source. When lake sediments contain high amounts of organic material, bacterial decomposition consumes all of the dissolved oxygen resulting in hypoxia (very low O2 in hypolimnion). In some lakes a certain amount of hypoxia may be natural; however, nutrient enrichment resulting from human activities stimulates algal productivity and subsequent algal settlement, decomposition, and oxygen loss.

All of the Regis Lakes experience rapid oxygen depletion in the bottom strata. This feature of the Regis Lakes has been occurring annually since monitoring began. The rapid oxygen depletion is certainly related to long-term nutrient pollution experienced over the last 150 years. We suspect that some degree of oxygen depletion is a natural occurrence in the lakes, particularity where the sediment surface area to hypolimnion volume ratio is large (Spitfire), or the dendritic shoreline is long relative to the lakes surface area (Upper St. Regis).



Dissolved oxygen profile for the St. Regis Lakes, May - October, 2020. Areas in orange denote hypoxia (D.O. less than 2.0mg/L), areas in red denote anoxia (lack of oxygen).

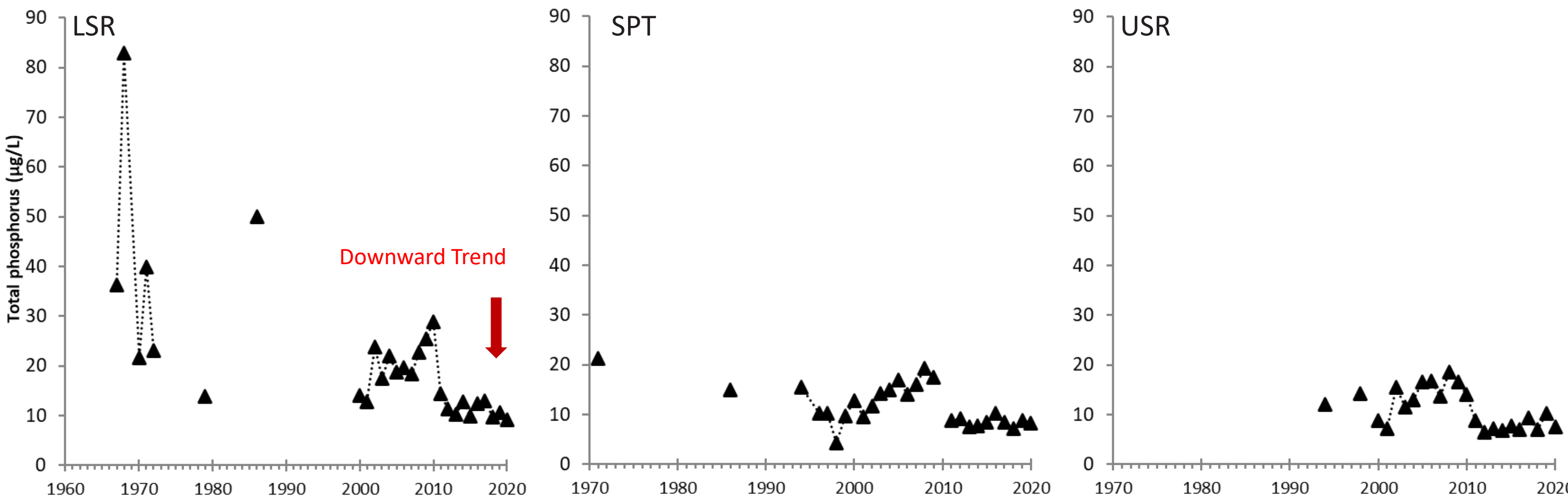
Surface Water Total Phosphorus

Phosphorus is vital to the structure and metabolism of all organisms. In freshwater systems it exists in relatively small amounts compared to other essential nutrients. The addition of extra phosphorus allows algal production to increase greatly because all other essential elements are typically available in access. Weathering of bedrock slowly releases phosphorus into lakes and streams; however, phosphorus can rapidly enter the St. Regis Lakes through fertilizers and poorly maintained septic systems.

Generally speaking, Adirondack lakes of low productivity (oligotrophic) have total phosphorus (TP) concentrations less than 10ug/L, while productive lakes (eutrophic) have concentrations in excess of 20ug/L. Approximately 70% of the lakes in the AWI dataset (n=100) have concentration between 4 and 12ug/L.

Lower St. Regis Lake has experienced a substantial decline in surface water TP since monitoring began in 1967. Concentrations have continued to decline over the last 20 years and are now only 1 to 2ug/L higher than the upper lakes.

Spitfire and Upper St. Regis have similar surface water concentrations of TP, ranging from 8-10ug/L, and have both experienced a decrease in phosphorus availability since monitoring began in the 1990's. Over the last 20 years,the TP concentration in the surface waters has remained stable, with no positive or negative trend in the data.

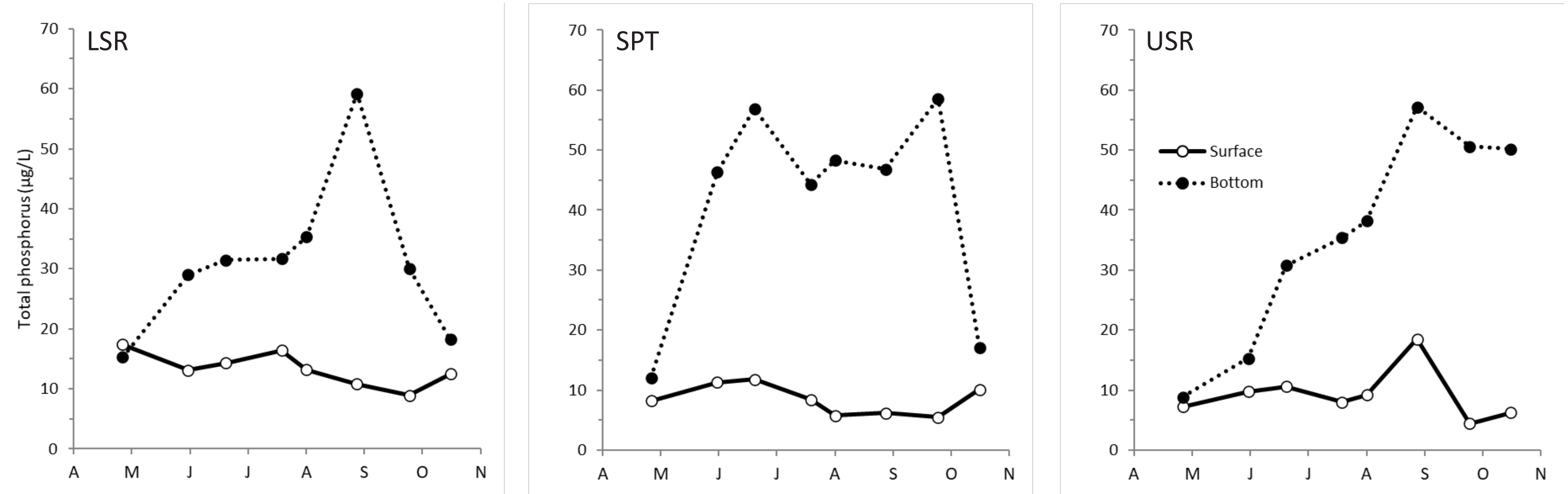


Average total phosphorus concentrations in the surface water of the three lakes in the St. Regis Chain. Lower St. Regis has exhibit a downward trend in TP concentration over the last 20 years (2000-2020).

Bottom Water Total Phosphorus

During the summer months, the deep waters of the Regis lakes are devoid of oxygen. The lack of oxygen has a number of negative effects on the lakes, not least of which is its influence on phosphorus availability. The absence of oxygen increases the solubility of several chemical compounds and allows the release of dissolved reactive phosphorus from the lake sediments, a process referred to as “internal phosphorus loading”.

The sediments in the St. Regis Lakes are rich in organic material and therefore represent a large store of usable phosphorus. Phosphorus concentration slowly builds in the bottom strata of the lakes during the summer months. In the fall, when the lake completely mixes the phosphorus is distributed throughout the water column - often resulting in autumn algal blooms. The defining signature of internal phosphorus loading can been seen in the figures below. During the months of June - October the concentration of total phosphorus is typically six times greater near the bottom than it is at the surface.



Average total phosphorus concentrations in the bottom water of the three lakes in the St. Regis Chain. Phosphorus concentration builds throughout the summer months before it is distributed within the water column during fall turnover (mid October for LSR and SPT, Early November for USR).

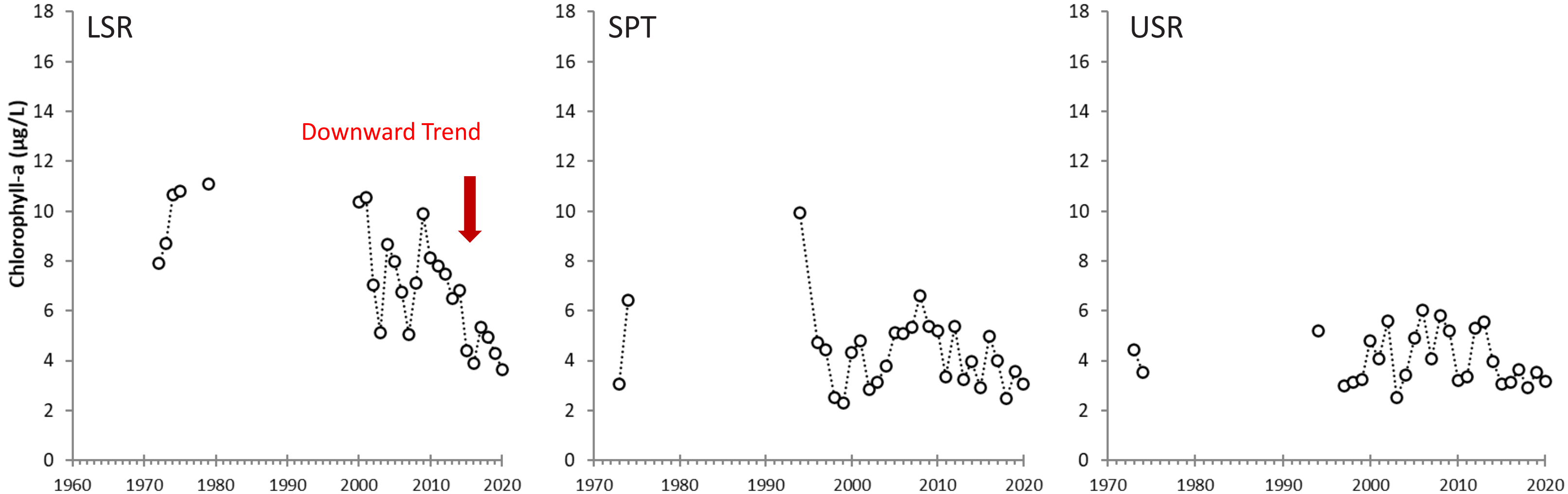
Algal Abundance

Chlorophyll-a is the primary photosynthetic pigment found in algae. Quantifying the abundance or biomass of algae is a difficult undertaking; however, a measurement of chlorophyll is a relatively simple and inexpensive analysis that serves as a surrogate for algal productivity. Major changes in algal biomass (e.g. an algae bloom) are related to changes in the availability of nutrients, primarily phosphorus, silica, or inorganic carbon.

Typically, Adirondack lakes with low algal productivity will have chlorophyll concentrations less than 2ug/L, while highly productive lakes often have concentrations greater than 8ug/L. Of the nearly 100 lakes studied by the AWI, 75% have a chlorophyll concentration of 4ug/L or less.

Lower St. Regis Lake has exhibited a substantial reduction in algal abundance since the 1970's. This downward trend has continued over the last 20 years and the lake now has similar algal abundance as the two upper lakes.

Since 2000, the chlorophyll-a concentration of Spitfire and Upper St. Regis were most often found between 3 and 5 ug/L with no statistical trend detected in the twenty-year dataset.

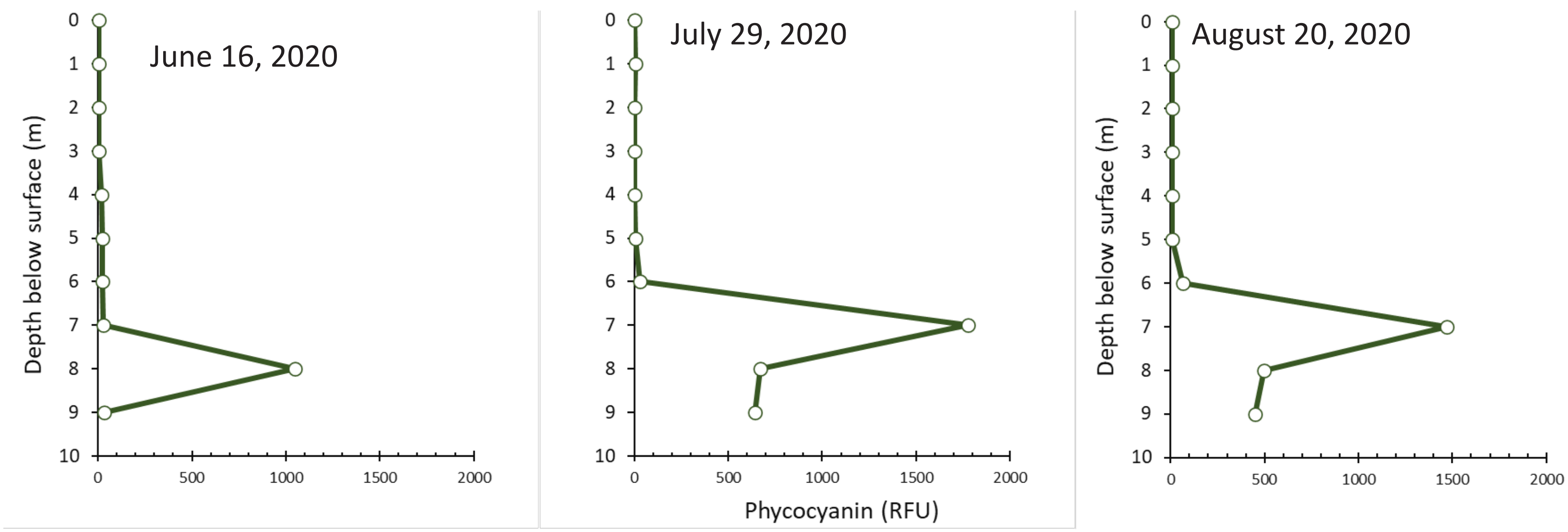


Average chlorophyll-a concentrations in the surface water of the three lakes in the St. Regis Chain. Lower St. Regis Lake has experienced a substantial reduction in algal biomass since 2000.

Cyanobacteria Abundance

Cyanobacteria, also known as blue-green algae, are common in lakes and ponds around the world. They are native to Adirondack lakes and fill important ecological roles related to photosynthesis and nitrogen fixation. Lake managers are concerned about cyanobacteria due to the tremendous impacts they can have on water quality under very high densities. The introduction of excess phosphorus to a lake may result in widespread blooms of cyanobacteria, which have the capacity to produce toxins and are aesthetically unpleasing.

Although all of the lakes have had issues at one time or another, the concentration of cyanobacteria is exceptionally high in the bottom water of Spitfire Lake from mid-July to early September. The species *Planktothrix* thrives in the bottom stratum of Spitfire Lake because they are able to photosynthesis at very low light levels, require anoxic conditions to fix nitrogen, and have an adequate supply of phosphorus. Typically, this bloom remains hidden from site at a depth of 7-8 meters. Occasionally, the entire population rises to the surface and forms dense green balls on the top of the water. This species also exists in Lower and Upper St. Regis, but is relatively rare compared to the population size in Spitfire.



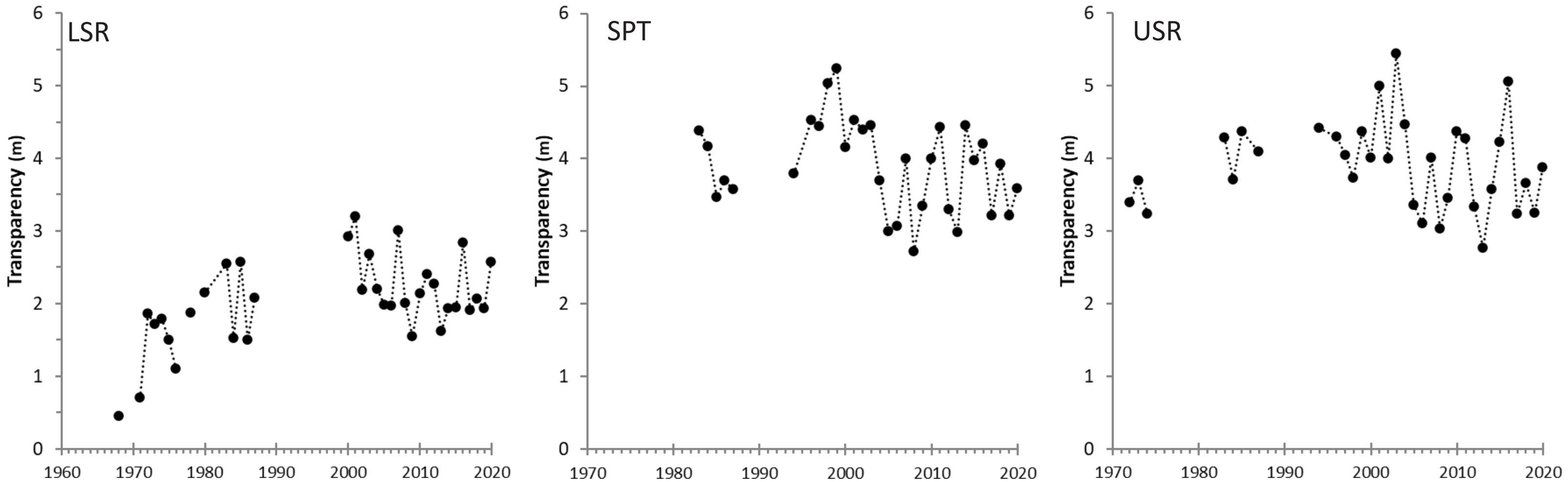
Development of the typical bloom of Planktothris in the water column of Spitfire Lake using a surragote measure of phycocyanin (accessory pigment).The population typically remains in the hypoloimnion, where anoxic water and high phosphorus concentration create the ideal habitat for this species.

Water Transparency

Transparency, or clarity, is a measurement of light penetration through the water. Many factors can influence transparency, including algal abundance, dissolved chemicals, and suspended material. Low transparency is not necessarily a cause for concern, especially in the Adirondacks, where dissolved organic material from wetlands can have a large impact on light penetration. Across the region, transparency typically ranges from 1 meter in depth to as high as 8 meters.

Approximately 60% of the lakes studied by the AWI have transparency depths between 2 and 4 meters.

The most important feature of transparency is the long-term trend, which is indicative of a change in the components of the water. Lower St. Regis has the least amount of transparency, owning largely to the wetlands that comprise over 13% of its watershed. The clarity of the lake has improved significantly since the late 1960's and early 1970's, when transparency was typically 1 meter or less. Over the last 20 years the transparency has typically fluctuated between 2 and 3 meters with no significant trend. The transparency of Spitfire and the Upper Lake are similar, and have typically ranged from 3 to 5 meters in depth. Neither Spitfire of Upper St. Regis have exhibited a statistical change in transparency over the last 20 years.

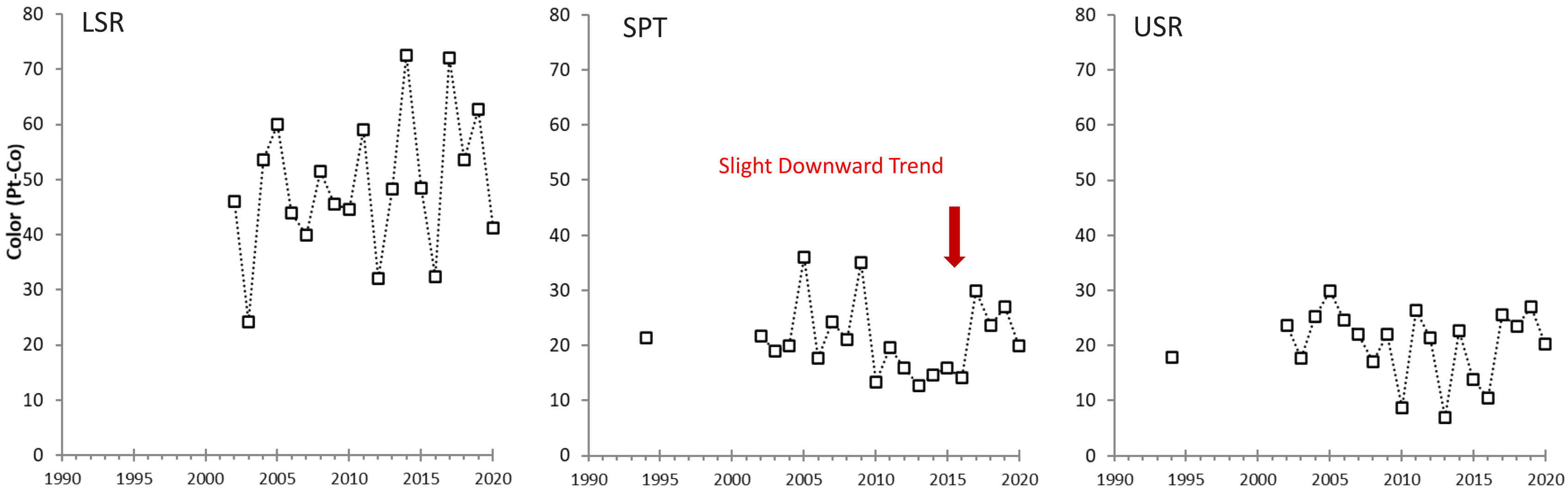


Average transparency depth for the three lakes in the St. Regis Chain. None of the lakes have experienced a statistical change in transparency depth over the last 20 years (2000-2020).

Water Color

The observed color of a lake is a result of light being scattered upwards after selective absorption by water molecules as well as dissolved (metallic ions, organic acids) and suspended materials (silt, plant pigments). For example, lakes rich in dissolved organic matter and humic compounds, such as Lower St. Regis, absorb shorter wavelengths of light, such as green and blue, and scatter the longer wavelengths of red and yellow, thus the lakes appears brown in color. Analysis of color can provide us with information about the quantity of dissolved organic matter (DOM) in the water. Approximately 60% of the lakes studied by the AWI posses color values between 15 and 35 PtCo units.

The intensity of the water color is driven mainly by the amount of precipitation moving through the watershed and is highly variable between years. Lower St. Regis has the highest amount of color because it has the largest watershed and greatest proportion of wetlands. The color values of Spitfire and Upper St. Regis are very similar, and typically range between 10 and 35 PtCo units. Despite the variability between years, we did detect a slight, yet statistically significant decrease in the average color of Spitfire over the last 20 years.

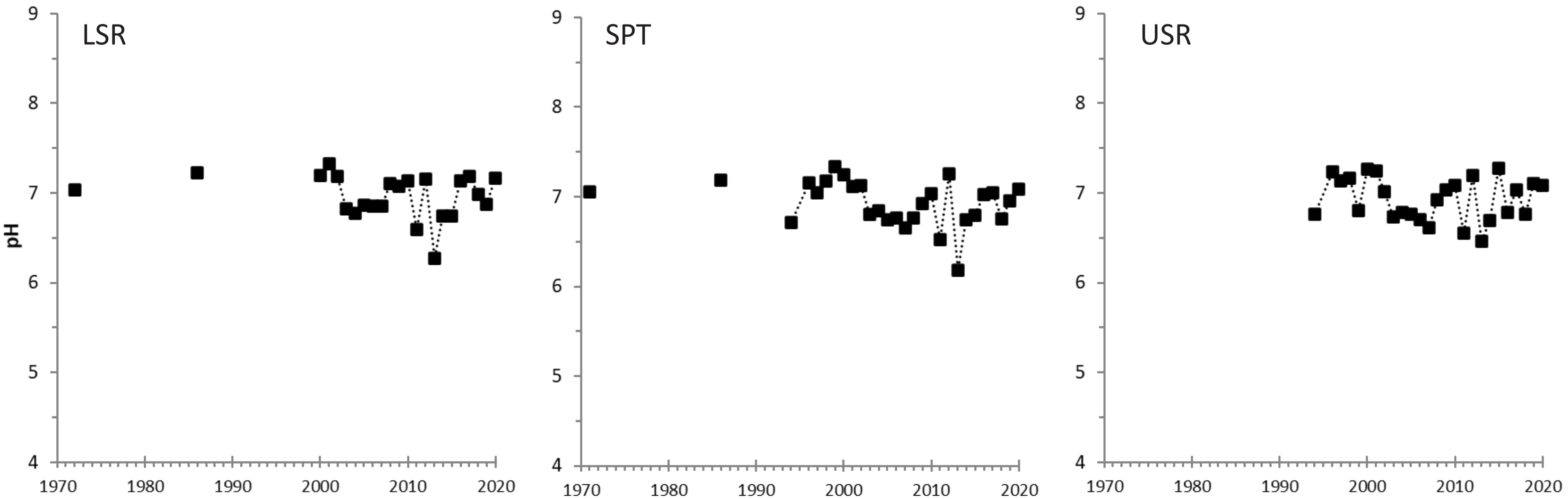


Average color values in the surface water of the three lakes in the St. Regis Chain. The color of Spitfire Lake has experienced a slight, yet statistically significant decrease since 2000.

Acidity Indicators - pH

In chemistry, pH is used to communicate the acidity of a solution. Technically pH is a surrogate measure of the concentration of hydrogen ions in water (acidity). Hydrogen ions are very active, and their interaction with other molecules determines the solubility and biological activity of gases, nutrients, and heavy metals; thus pH is considered a master variable for its influence on chemical processes and aquatic life. pH exists on a logarithmic scale from 0-14, with 7 being neutral. pH values less than 7 indicate increasing acidity, whereas pH values greater than 7 indicate increasingly alkaline conditions. Because pH exists on a logarithmic scale a decrease in 1 pH unit represents a 10 fold increase in hydrogen ion activity. Lakes can become acidified when they are influenced by organic acids from wetlands and bogs or when acidic precipitation falls on a poorly buffered watershed. In the Adirondacks, lakes are considered threatened if the pH falls below 6, and critically impaired if the pH falls below 5.

All of the lakes in the St. Regis chain are considered circumneutral, with pH values between 6.5 and 7.5 pH units. The acidity of the lake chain has been stable since monitoring began, with no statistical trend detected in any of the lakes.



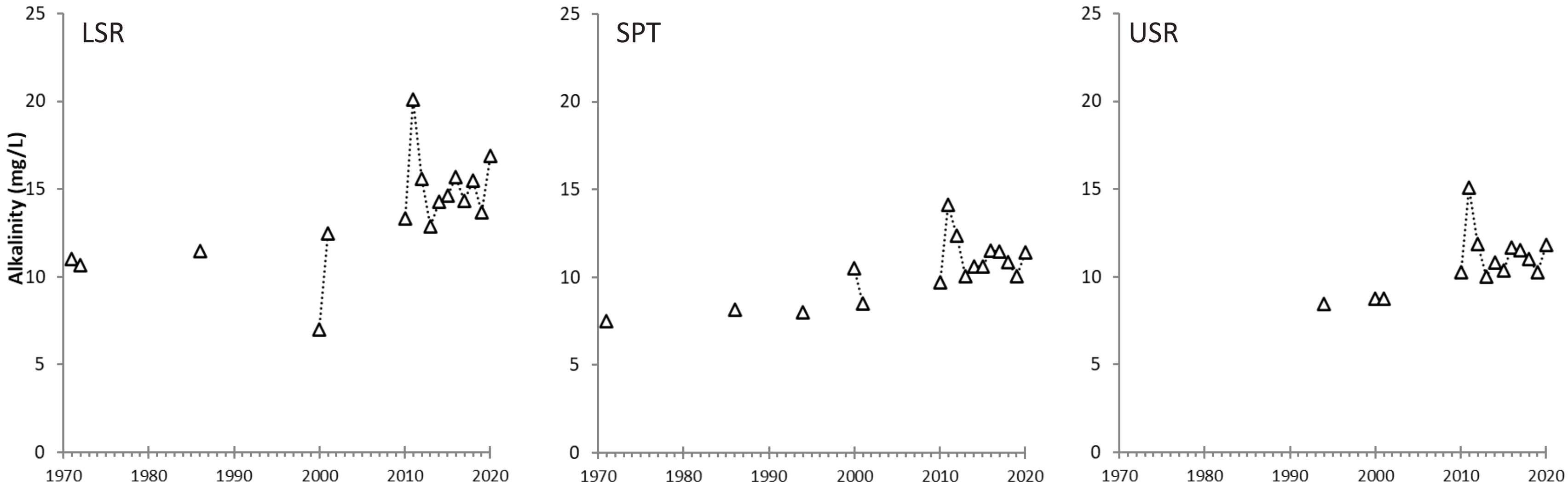
Average pH values in the surface water of the three lakes in the St. Regis Chain. The lakes have a neutral pH and have not exhibited any historical trend in acidity.

Acidity Indicators - Alkalinity

Alkalinity is the capacity of a water body to neutralize acids and thereby resist changes in pH. The alkalinity of a lake plays a major role in whether or not a lake is impacted by acid deposition. Alkalinity is a function of the amount of calcium carbonate in the water which is derived mainly from the watershed. Many Adirondack lakes exist on granitic bedrock that has a slow rate of calcium carbonate generation, and therefore lower acid neutralizing ability. The opposite is true for lakes that exist on bedrock derived from ancient ocean deposits, such as limestone or dolomite. Soil depth also plays a role in acid neutralizing capacity, with deeper soils offering more buffering ability than shallower soils.

Lakes with less than 2mg/L of alkalinity are considered extremely sensitive to acid deposition, while lakes containing alkalinity in the range of 10-25mg/L have low sensitivity to acidification.

The St. Regis Lakes have not been negatively influenced by acid deposition because the water has adequate levels of alkalinity. The alkalinity concentration of Lower St. Regis typically fluctuated between 12 and 18mg/L. The concentrations for Spitfire and Upper St. Regis are similar, and have typically ranged between 10 and 12mg/L. No statistical change in alkalinity has been detected over the last 20 years.



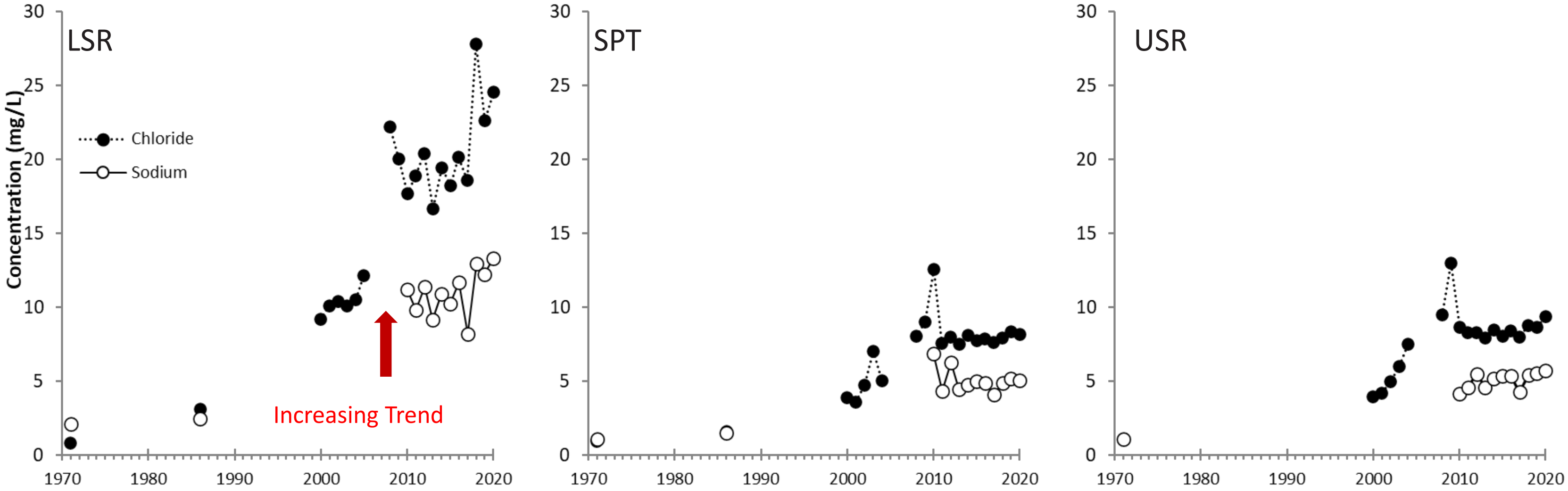
Average alkalinity values in the surface water of the three lakes in the St. Regis Chain. The lakes have adequate acid neutralizing capacity to resit changes in pH typically caused by acid deposition. No statistical change in alkalinity has been detected over the last 20 years (2000-2020).

Road Salt Indicators - Chloride and Sodium

Wide spread use of road salt over the last several decades has significantly increased the concentration of sodium and chloride in the environment. Adirondack roads receive over 200,000 tons of road deicers each year, with an average application rate of 36 tons/lane-mile on state roads.

Adirondack lakes have naturally low concentrations of sodium and chloride, with typical values near 0.5 and 0.2mg/L, respectively. Lakes with salted roads in their watershed have been found to contain up to 250 times more chloride than unimpaired lakes. We consider lakes with less than 1.0mg/L of chloride to have insignificant road salt influence, and lakes with greater than 20mg/L to have a high amount of road salt influence.

The greatest impact is in Lower St. Regis where chloride has been as high at 27mg/L, or 135 times greater than background levels. The salt content of the lake has increased drastically since monitoring began, and has continued to increase of the last 20 years. A large proportion of the salt load to the lower lake is from the Paul Smith's College Campus. Spitfire and Upper St. Regis are also impacted by road runoff and have chloride concentrations between 8 and 9mg/L, or approximately 42 times higher than background levels. Neither of the upper lakes have experienced concentration changes over the last 20 years.



THANK YOU

FOR PROTECTING CLEAN WATER & HEALTHY WATERSHEDS

Our mission is simply to protect clean water. We couldn't achieve this goal without the dedication of our partners like you. We are grateful to you, our St. Regis neighbors, for your commitment to protecting our lakes and working side by side with AWI's scientists and stewards to safeguard our waterways. Learn more about our work at adkwatershed.org or email us at adk.stewards@gmail.com.