2019 and 2020 Pattison Lake Water Quality Report

Prepared by Thurston County Environmental Health Division

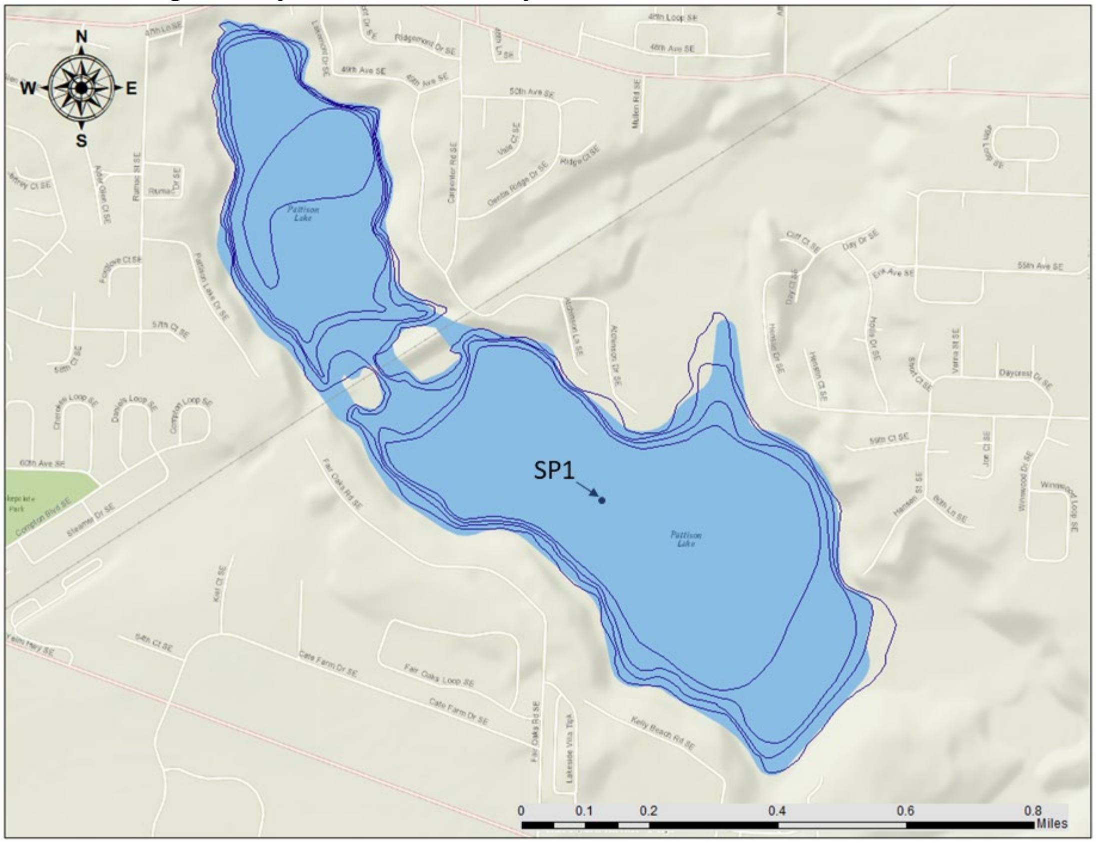


Figure 1. Pattison Lake map showing location of sample site SP1.

PART OF HENDERSON INLET WATERSHED

- **SHORELINE LENGTH**: 6.3 miles
- **LAKE SIZE**: 0.42 square miles (270 acres)
- **BASIN SIZE**: 3.8 square miles
- **MEAN DEPTH**: 4 meters (13 feet)
- **MAXIMUM DEPTH**: 6.7 meters (22 feet)
- **VOLUME**: 3,600 acre-feet

PRIMARY LAND USES:
The watershed is primarily suburban residential with some undeveloped forest cover primarily in wetland areas. The sample site SP1 is in the south basin (Figure 1).

PRIMARY LAKE USE:
Pattison Lake is used for fishing, swimming, and boating (under 5 mph).

PUBLIC ACCESS:
The Washington Department of Fish and Wildlife operates one public boat launch on the east side of the south basin.

GENERAL TOPOGRAPHY:
Pattison Lake is a Puget Sound lowland lake at an elevation of 154 feet above mean sea level. Decades ago, it was divided into two basins, north and south, by placement of fill material for a railroad. Pattison Lake is second in a series of four lakes that begins with Hicks Lake. Hicks Lake drains into Pattison, and Pattison drains to Long Lake. The outlet from Long Lake flows through Lois Lake and ultimately becomes Woodland Creek, a tributary stream to Henderson Inlet.

GENERAL WATER QUALITY:
Fair – In 2019 and 2020 Pattison Lake was classified as eutrophic. Water clarity was below long-term averages in both sampling years. Water quality was further impaired by high levels of nutrients and algal blooms, which interfere with recreation and can produce surface scum and toxins.

DESCRIPTION

Pattison Lake, located in southeast Lacey, is the second lake in a series of four lakes connected by extensive wetlands. The first lake in the chain, Hicks Lake, flows south to Pattison Lake. Pattison Lake is connected to Long Lake by a ditch constructed to float logs many years ago. Water exits Long Lake through a surface outlet at the north end and flows to Lois Lake and Woodland Creek, which discharges into Henderson Inlet in north Thurston County.

Shoreline modifications include a railroad dike, which crosses the lake and separates the two basins, and over 140 private docks (Thurston Regional Planning Council, 2008). In the 1980s, the Federal Clean Lakes Restoration Project was completed. This project included alum treatment, aquatic macrophyte control, and public education. In 1995, effectiveness monitoring showed a 0.001 mg/L increase of whole-lake phosphorus seven years after alum treatment (Welch and Cooke, 1995). Pattison Lake was listed on the 303(d) list for total phosphorus (TP) in 2004, 2008, 2012 and most recently in 2014.

The Washington Department of Fish and Wildlife (WDFW) maintains a public boat ramp on the east side of the south basin. Pattison Lake is stocked with rainbow trout and supports natural populations of largemouth bass, yellow perch, black crappie, and rock bass.

METHODS

In 2019 and 2020, Thurston County Environmental Health (TCEH) conducted monthly monitoring at Pattison Lake from May to October. Figure 1 shows the sample site SP1, located in the deepest part of the lake. Table 1 lists the types of data collected (TCEH, 2009) and Appendix A provides the raw data. The Custer Color Strip (Figure 2) has been used as a reference for water color since the 1990s.

Table 1. List of parameters, units, method, and sampling locations.

Parameter	Units	Method	Sampling Location
Transparency	meters	Secchi Disk	Depth where disk is no longer visible
Color	#1 to #11	Custer Color Strip	Color of water on white portion of Secchi Disk
Vertical Water Quality Profile	• Water Temperature (°C) • Dissolved Oxygen (mg/L) • pH (standard units) • Specific Conductivity (µS/cm)	YSI EXO1 Multi-parameter Sonde	~ 0.5 meter below the water surface to ~ 0.5 meter above the bottom sediments
Total Phosphorus	mg/L	Grab Samples with Kemmerer	Surface Sample: ~ 0.5 meter below the surface Bottom Sample: ~ 0.5 meter above the benthos
Total Nitrogen	mg/L	Grab Samples with Kemmerer	Surface Sample: ~ 0.5 meter below the surface Bottom Sample: ~ 0.5 meter above the benthos
Chlorophyll-a	µg/L	Composite of Multiple Grab Samples	Photic Zone
Phaeophytin-a	µg/L	Composite of Multiple Grab Samples	Photic Zone

Figure 2. TCEH compared water color to the Custer Color Strip.

Quality Assurance and Quality Control (QA/QC)

TCEH collected 10% field replicates and daily trip blanks to assess total variation (3 to 4 lakes sampled each day). The calibration of the Yellow Springs Instrument (YSI) EXO1 was verified before and after each sampling day. See Appendix B for QA/QC data.

RESULTS

Weather Conditions

Weather conditions during the 2019 and 2020 sample season are provided in Table 2.

Table 2. Weather on sample days and the average, minimum, and maximum air temperatures for each month from OLYMPIA RGNL STATION (KOLM) weather station.

Month	2019 Weather on Sample Day	2019 Temperature (° C) Monthly Average (Low/High)	2020 Weather on Sample Day	2020 Temperature (° C) Monthly Average (Low/High)
May	Cloudy, occasional light rain (13° C); 0-5 mph S wind	14.2 (1.1/30.6)	Cloudy (13.3° C); 0-15 mph SW wind	13.3 (0.0/30.6)
June	Cloudy (14° C); 0-9 mph SW wind	15.6 (4.4/33.9)	Cloudy (18.3° C); 0-15 mph SW wind	15.25 (4.4/29.4)
July	Fair, (25° C); 0-7 mph Variable wind	17.8 (6.7/32.2)	Cloudy (17.8° C); 0-10 mph SW wind	17.5 (6.7/36.7)
August	Fair, (22° C); 0-7 mph NNE wind	18.6 (7.2/32.8)	Fair, (17.5° C); 0-8 mph N wind	18 (5.6/37.2)
September	Mostly cloudy (13° C); Calm, 0-3 mph E wind	15.3 (-1.7/27.2)	Rain (16.1° C); 0-20 mph SW wind	17 (5.6/32.8)
October	Cloudy (7° C); Calm, 0-2 E wind	8.3 (-6.1/17.8)	Cloudy (8.3° C); 0-15 W wind	10.9 (-3.3/23.3)

Vertical Water Quality Profiles

During the summer, lakes often stratify into layers based on temperature and density differences.

- Epilimnion: upper warm, circulating strata in contact with the atmosphere
- Metalimnion: middle layer with steep thermal gradient (thermocline)
- Hypolimnion: deepest layer of colder, relatively stagnant water

The vertical water quality profiles illustrate how the water column at the south basin of Pattison Lake changed over the sample seasons in 2019 and 2020 (Figures 3-8).

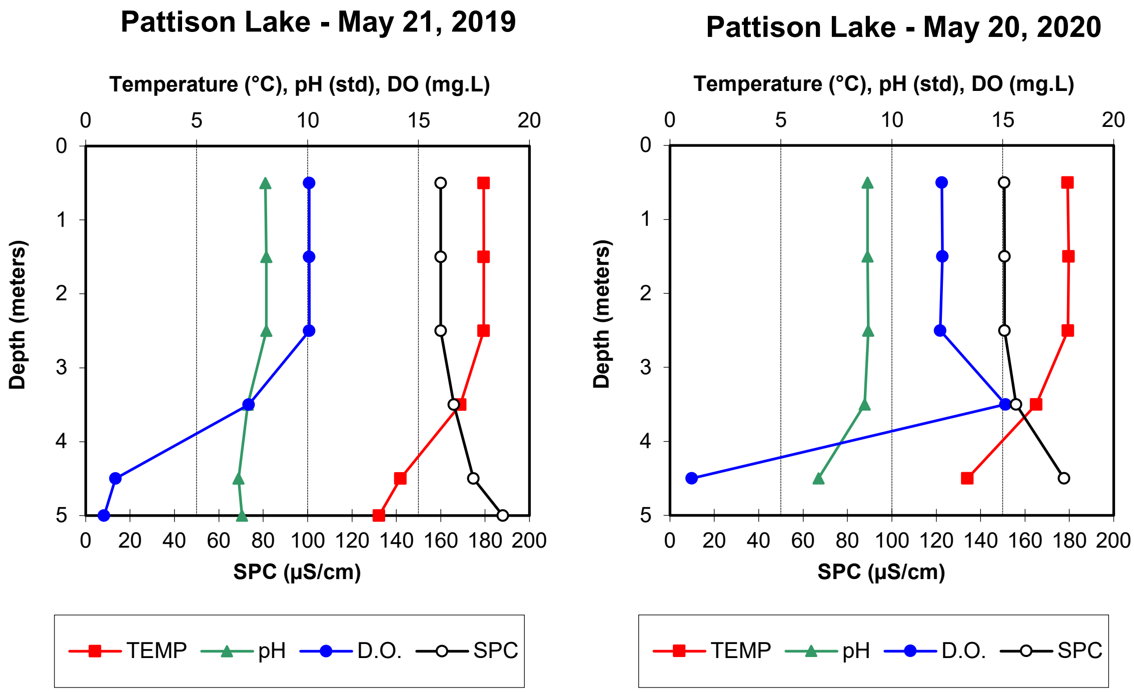


Figure 3. Vertical water quality profiles for SP1 collected during May 2019 and 2020.

In May 2019, the lake was beginning to stratify, but the layers were not yet well defined.

- May Epilimnion – Mean Temperature 17.9°C; Mean DO 10.1 mg/L
- May Hypolimnion – Mean Temperature 13.7°C; Mean DO 1.1 mg/L

In May 2020, the dissolved oxygen (DO) profile had a positive heterograde curve. The water column was sufficiently transparent to permit photosynthesis in deeper water, where excess oxygen accumulated due to the reduced mixing of the water column (Wetzel, 1983).

- May Epilimnion – Mean Temperature 17.9°C; Mean DO 12.2 mg/L
- May Hypolimnion – Temperature 13.4°C; Mean DO 0.99 mg/L

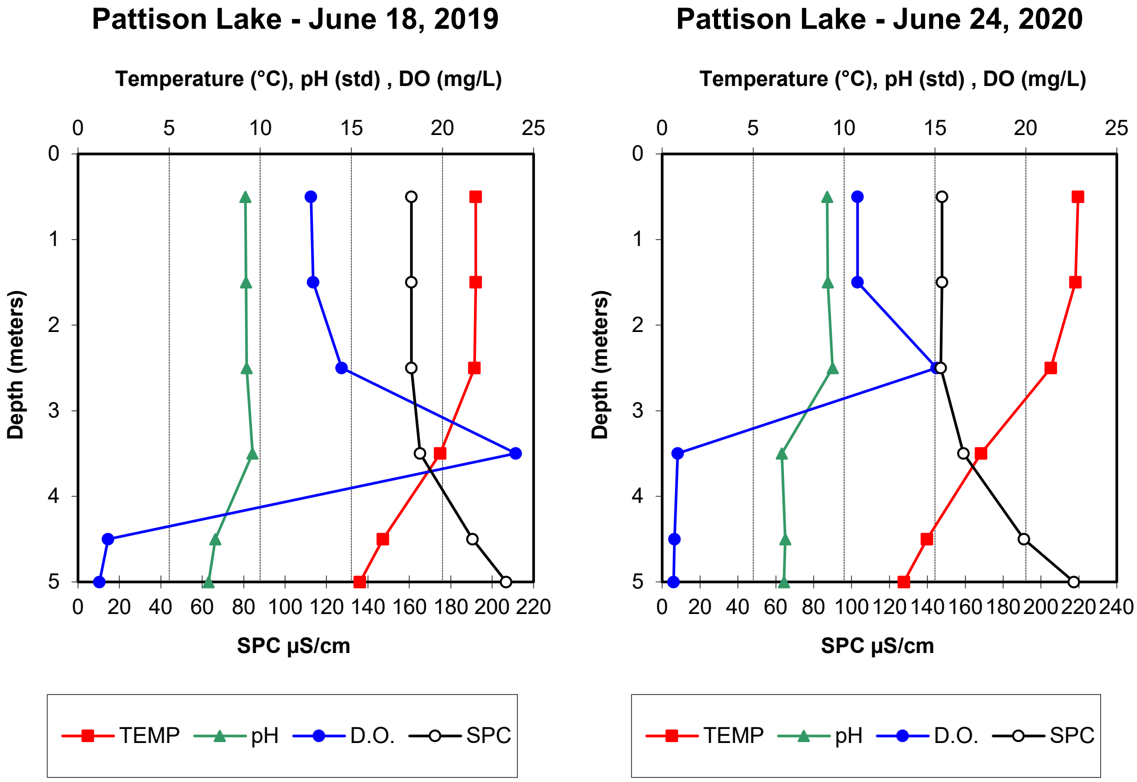


Figure 4. Vertical water quality profiles for SP1 collected during June 2019 and 2020.

In June 2019 and 2020, the average daily air temperature increased, heating the surface layer, the epilimnion. This heat was retained because the overnight air temperature remained warmer, as well (Table 2). The cooler dense water sank and had higher levels of DO.

June 2019:

- June Epilimnion – Mean Temperature 21.8°C; Mean DO 13.4 mg/L
- June Hypolimnion – Mean Temperature 16.1°C; Mean DO 1.4 mg/L

June 2020:

- June Epilimnion – Mean Temperature 22.3°C; Mean DO 12.2 mg/L
- June Hypolimnion – Mean Temperature 13.9°C; Mean DO 0.7 mg/L

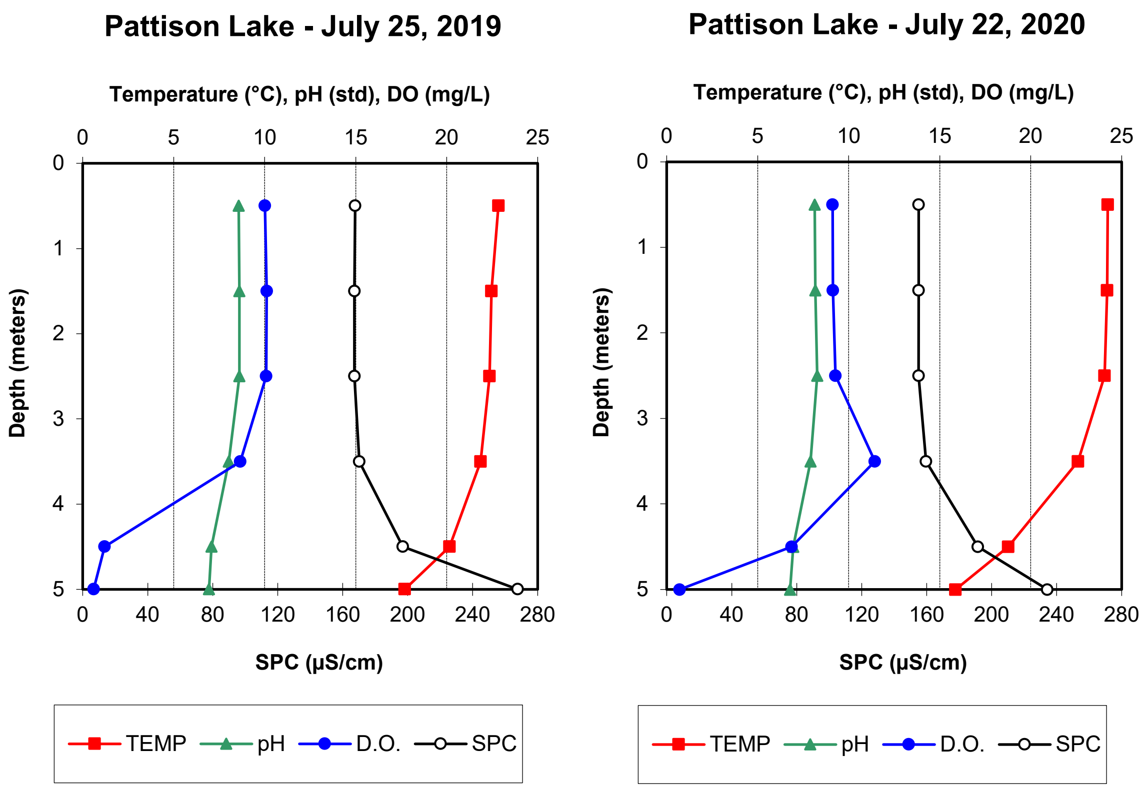


Figure 5. Vertical water quality profiles for SP1 collected during July 2019 and 2020.

The average air temperature was higher in July of 2019 and 2020 (Table 2), likewise water temperatures in the epilimnion increased to the summer peak. Due to the relative shallow nature of Pattison lake, this warmer water reached almost to the bottom, reducing the temperature difference between the stratified layers. In July 2020 there was a slight positive heterograde curve seen in the DO.

July 2019:

- July Epilimnion – Mean Temperature 22.6°C; Mean DO 10.1 mg/L
- July Hypolimnion – Mean Temperature 18.9°C; Mean DO 0.9 mg/L

July 2020:

- July Epilimnion – Mean Temperature 24.2°C; Mean DO 9.2 mg/L
- July Hypolimnion – Mean Temperature 17.3°C; Mean DO 0.7 mg/L

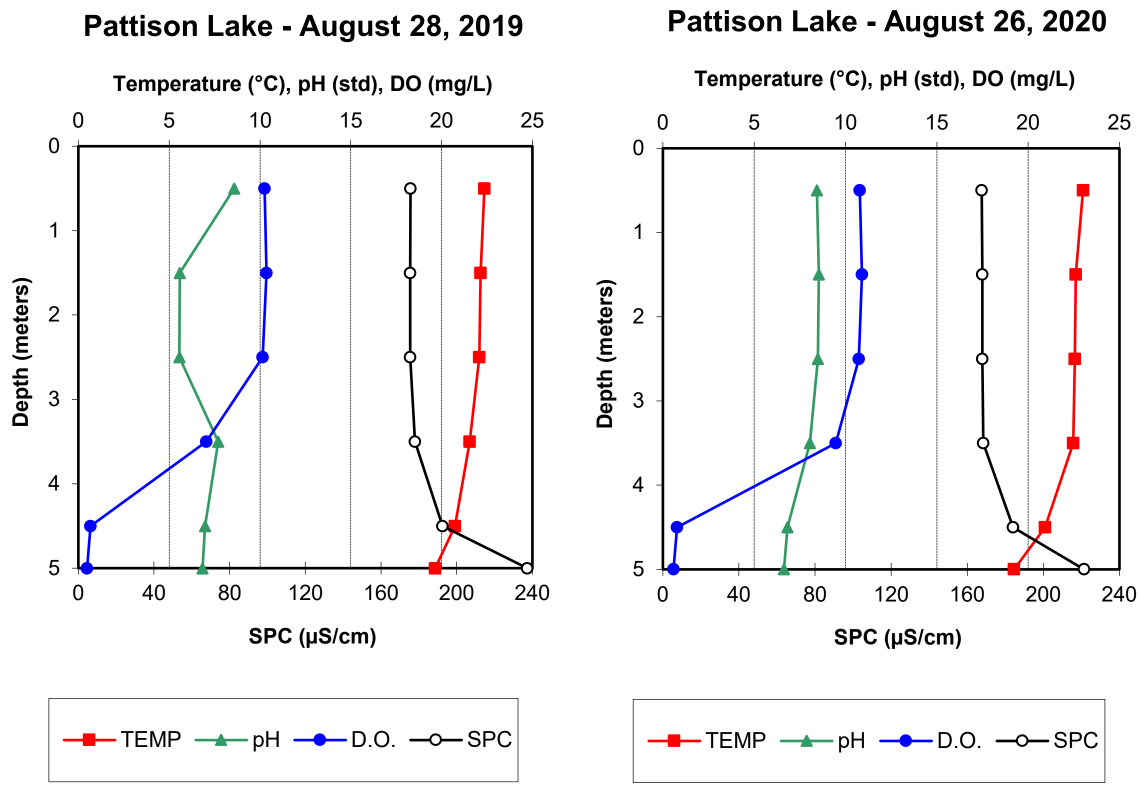


Figure 6. Vertical water quality profiles for SP1 collected during August 2019 and 2020.

The average air temperature peaked in August of 2019 and 2020, while winds increased, reducing the temperature difference between the surface and bottom. The average temperature difference between epilimnion and hypolimnion fell from 3.7 to 2°C (2019) and 6.9 to 2.5°C (2020). Water layers began to mix.

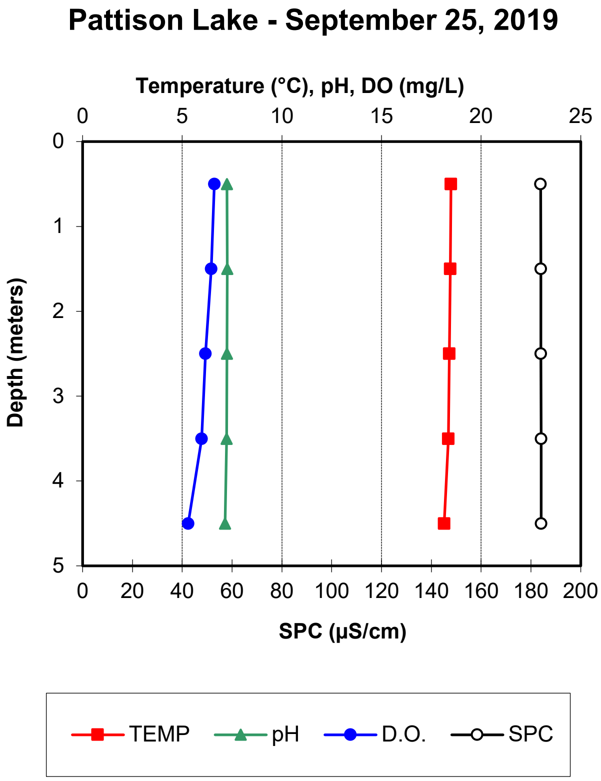
August 2019:

- August Epilimnion – Mean Temperature 22.2°C; Mean DO 10.3 mg/L
- August Hypolimnion – Mean Temperature 20.2°C; Mean DO 0.6 mg/L

August 2019:

- August Epilimnion – Mean Temperature 22.7°C; Mean DO 10.8 mg/L
- August Hypolimnion – Mean Temperature 20.1°C; Mean DO 0.7 mg/L

The DO profile during thermal stratification in July and August was clinograde curve. Oxygen consuming processes or flow of low oxygen groundwater produced anoxic conditions in the hypolimnion. The epilimnion had a higher DO because this layer gained oxygen from the atmosphere and photosynthesis.



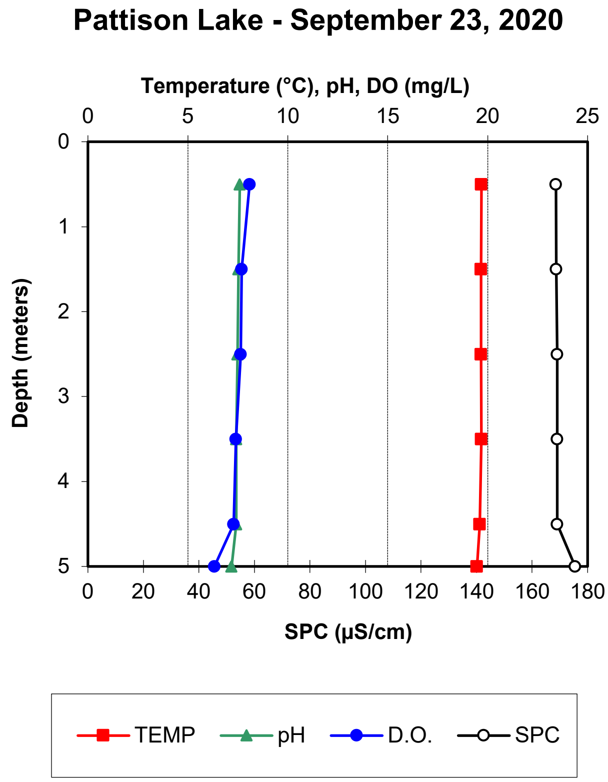


Figure 7. Vertical water quality profiles from SP1 collected during September 2019 and 2020.

In September of 2019 and 2020, average air temperatures declined, especially overnight. This caused Pattison Lake to turn over, resulting in water layers mixing, as can be seen in Figure 7.

September 2019:

- September Photic Zone (Secchi Depth 3.05 meters) – Mean Temperature 18.4°C; DO 6.3 mg/L
- September Bottom Measurement (5 meters) – Temperature 18.1°C; DO 5.3 mg/L

September 2020 secchi depth was limited while Pattison turned over. This led to mixing layers of water and only slightly different from surface to bottom temperature (0.2°C).

- September Top Measurement (0.5 meters) – Temperature 19.7°C; DO 8.1 mg/L
- September Bottom Measurement (5 meters) – Temperature 19.5°C; DO 6.8 mg/L

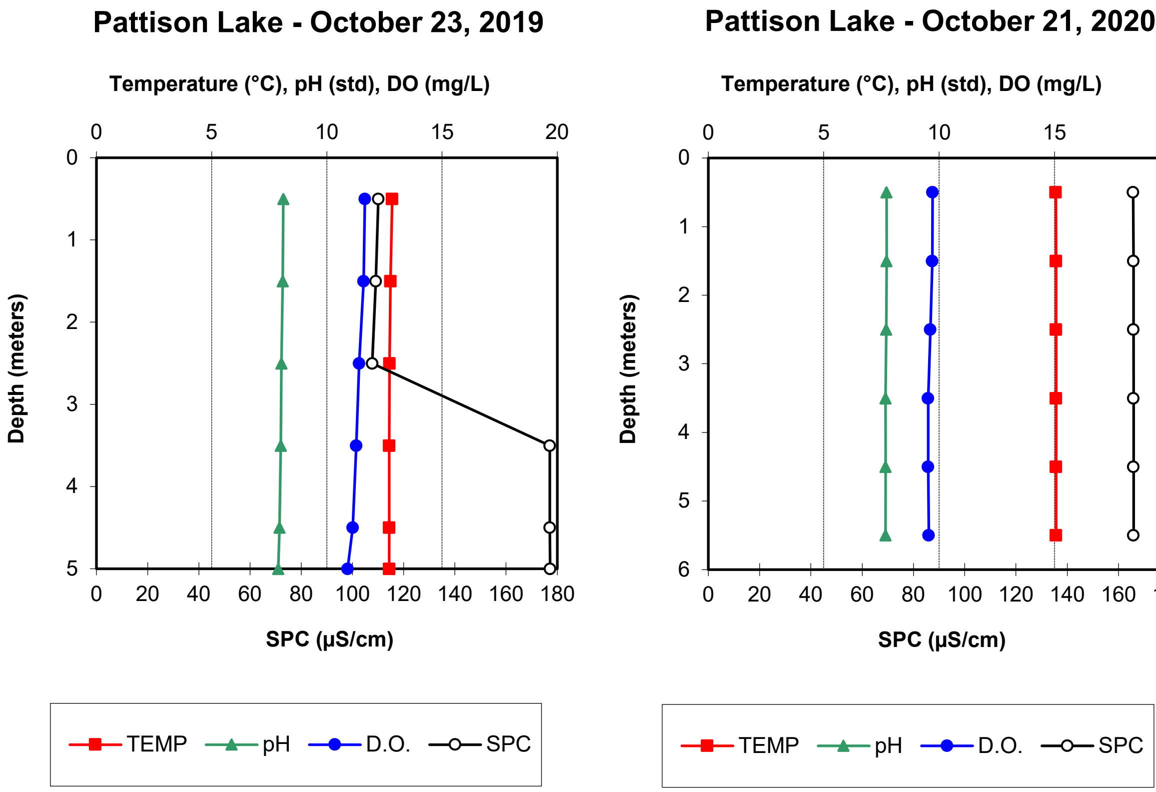


Figure 8. Vertical water quality profiles from SP1 collected during September and October 2018.

In October 2019 and 2020, fall arrived with colder weather. The surface water continued to cool and sink, diminishing temperature variation in the water column.

2019

- October Photic Zone (Secchi Depth 1.2 meters) – Temperature 12.8°C; DO 11.7 mg/L
- October Bottom Measurement (5.0 meters) – Temperature 12.7°C; DO 10.9 mg/L

2020

- October Photic Zone (Secchi Depth 0.9 meters) – Temperature 15.1°C; DO 9.7 mg/L
- October Bottom Measurement (5.5 meters) – Temperature 15.1°C; DO 6.6 mg/L

Water Transparency and Color

Transparency of water to light has been used to approximate turbidity and phytoplankton populations. Secchi depth is closely correlated with the percentage of light transmission through water. The depth at which the Secchi disk is no longer visible approximates 10% of surface light, however suspended particles in the water affect accuracy. The health department recommends visibility of at least 1.2 meters, or four feet, at public swimming beaches.

Color can reveal information about a lake's nutrient load, algal growth, water quality and surrounding landscape. High concentrations of algae cause the water color to appear green, golden, or red. Weather, rocks and soil, land use practices, and types of trees and plants influence dissolved and suspended materials in the lake. Tannins and lignins, naturally occurring organic compounds from decomposition, can color the water yellow to brown.

Figures 9 and 10 show the Secchi depth (bar length), color (color of the bar), and chlorophyll-a concentration (dashed line) at SP1 for 2019 and 2020.

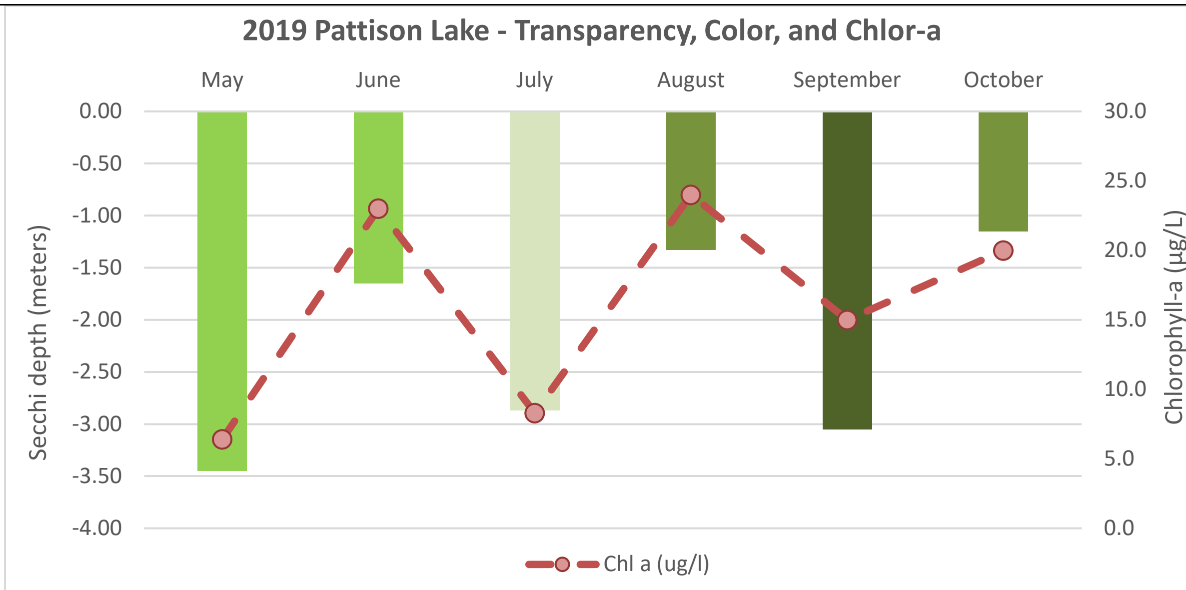


Figure 9. Water color, Secchi depths, and chlorophyll-a concentrations at SP1 in 2019.

In 2019, transparency was lowest in October (1.15 meters) and highest in May (3.45 meters). The mean transparency for the sample season was 2.25 meters. Secchi depth was negatively correlated with the chlorophyll-a concentration. Productivity, as measured by the chlorophyll-a concentration, was lowest (mean 9.9 µg/L) in May, July, and September, when the mean Secchi depth was 3.2 meters. In June, August and October water clarity was reduced (mean Secchi depth 1.4 meters) when the chlorophyll-a concentration increased (mean 22.3 µg/L).

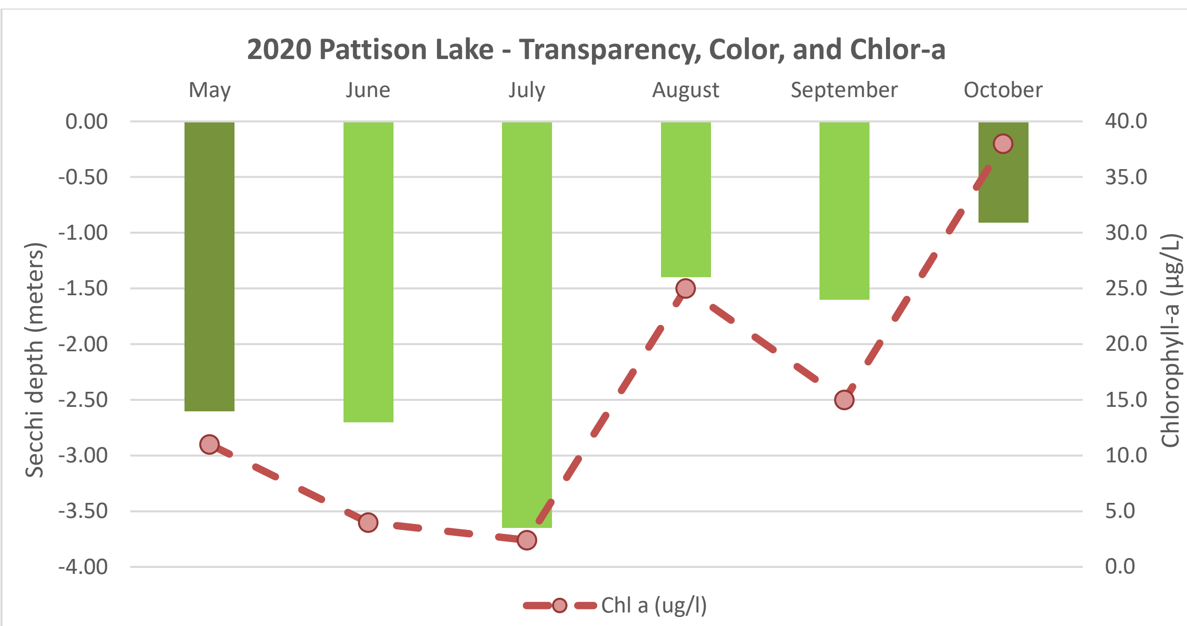


Figure 10. Water color, Secchi depths, and chlorophyll-a concentrations at SP1 in 2020.

In 2020, transparency was lowest in October (0.91 meters) and highest in July (3.65 meters). The mean transparency for the sample season was 2.14 meters. Secchi depth was negatively correlated with the chlorophyll-a concentration. Productivity, as measured by the chlorophyll-a concentration, was lowest (mean 5.8 µg/L) in May through July, when the mean Secchi depth was 2.98 meters. From August through October water clarity was reduced (mean Secchi depth 1.3 meters) when the chlorophyll-a concentration increased (mean 26.0 µg/L).

In both 2019 and 2020, the color of the water (shown as the bar color in Figures 9 and 10) is based on the reference Custer Color Strip shown in Figure 2. Lake color was likely affected by changes in the algae and cyanobacteria communities; phytoplankton identification would provide more information about productivity and phytoplankton assemblages.

Figure 11 shows the annual average transparency (Secchi depth) compared to the long-term average (LTA). Positive values reflect transparency better than the long-term average. Transparency was lower than the long-term average of 2.32 meters in both 2019 (by 0.07 meters) and 2020 (by 0.18 meters).

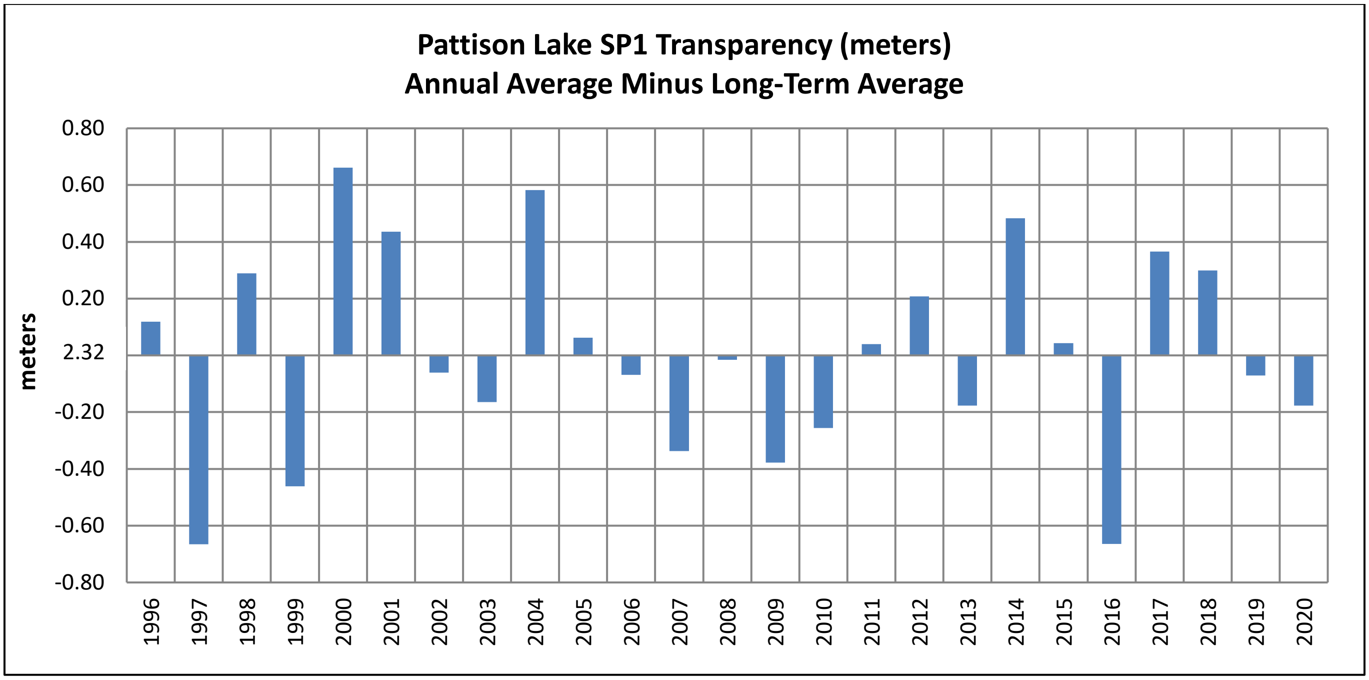


Figure 11. Transparency at SP1 compared to the long-term average (LTA) from 1996 to 2020.

Productivity

Pigments

Chlorophyll-a pigment is present in algae and cyanobacteria and is widely used to assess the abundance of phytoplankton in suspension. Phaeophytin is also a pigment, but it is not active in photosynthesis. It is a breakdown product of chlorophyll and is present in dead suspended material (Moss, 1967). Phaeophytin absorbs light in the same region of the spectrum as chlorophyll-a, and, if present can interfere with acquiring an accurate chlorophyll-a value. The ratio of chlorophyll-a to phaeophytin-a has been used as an indicator of the physiological condition of phytoplankton in the sample. Phaeopigments have been reported to contribute 16 to 60% of the measured chlorophyll-a content (Marker et al., 1980).

Productivity Data

Figures 12 shows that in 2019, three months (June, August, and October) had high concentration of chlorophyll-a. Transparency was lowest these months (Figure 9); water clarity was negatively correlated to productivity. The concentration of DO at the surface was highest in June (12.78 mg/L) and lowest in September (6.61 mg/L). The ratio of chlorophyll-a to phaeophytin-a peaked in June, indicating a breakdown of chlorophyll-a during that month, and lowest in October.

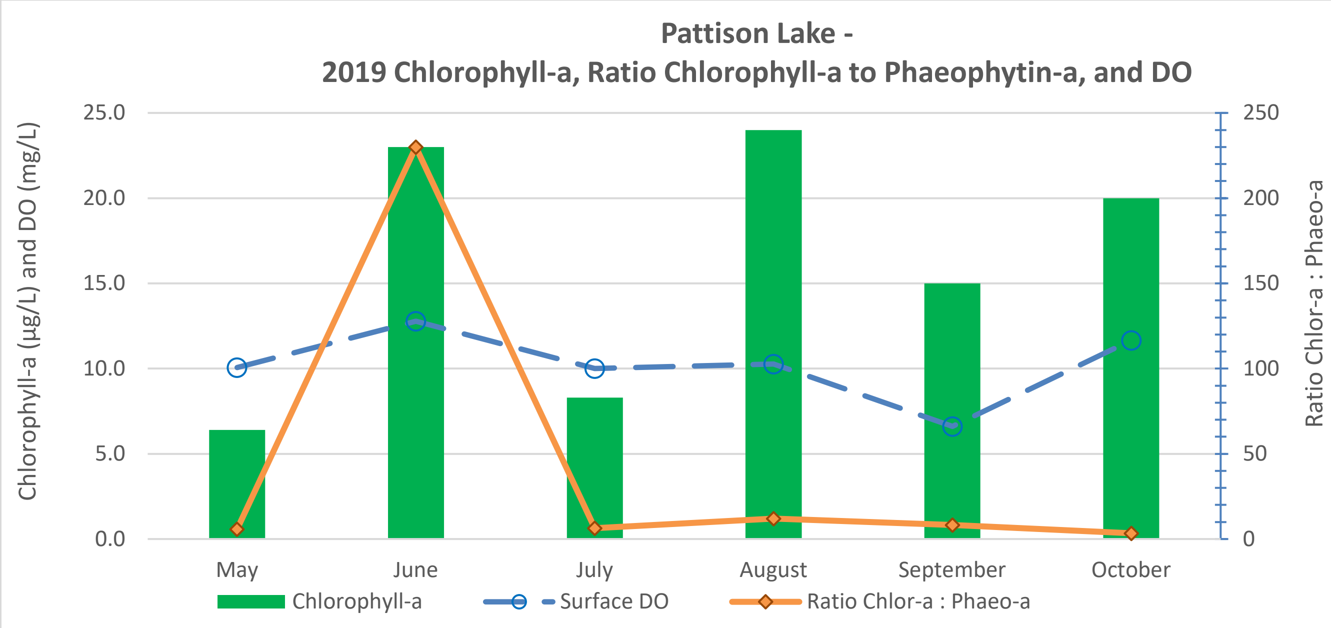


Figure 12. Chlorophyll-a concentration, ratio of chlorophyll-a to phaeophytin-a pigments and DO concentration in the photic zone or epilimnion collected at SP1 in 2019.

Figure 13 shows that the highest concentration of chlorophyll-a occurred after turnover in October 2020 (38.0 µg/L). The ratio of chlorophyll-a to phaeophytin-a peaked in August, indicating a breakdown of chlorophyll-a during that month. Surface DO remained relatively stable throughout the sampling season, with a maximum of 12.25 mg/L in May and minimum of 8.09 mg/L in September.

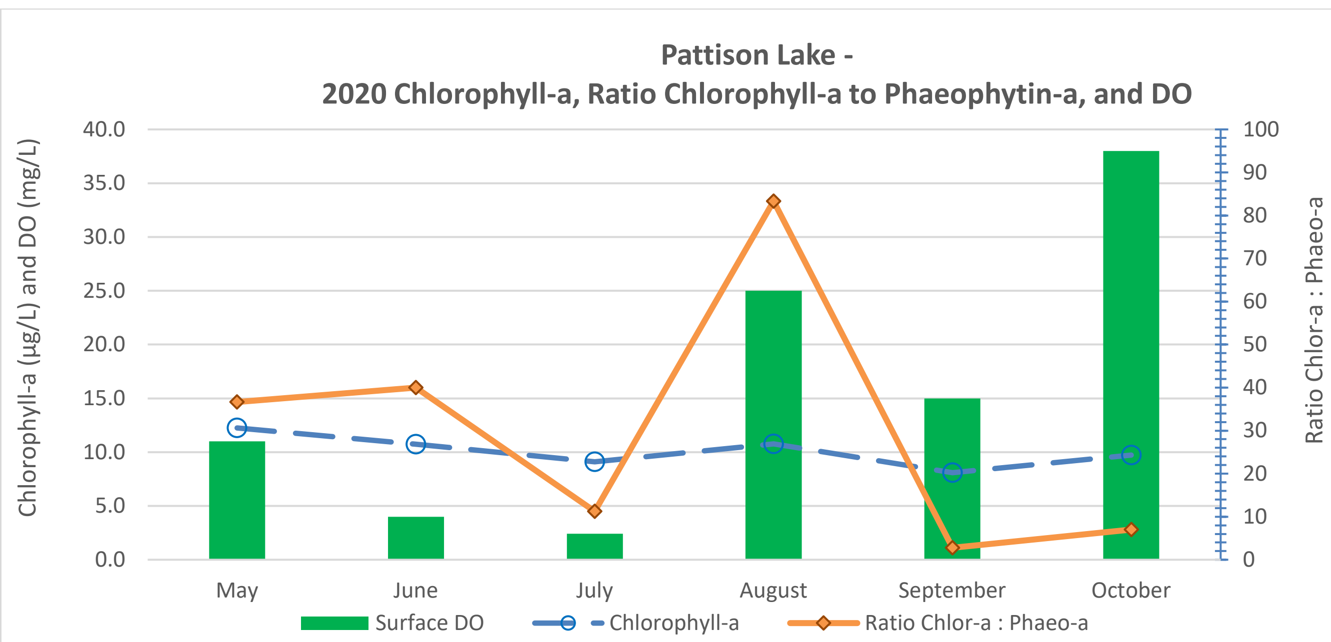


Figure 13. Chlorophyll-a concentration, ratio of chlorophyll-a to phaeophytin-a pigments and DO concentration in the photic zone or epilimnion collected at SP1 in 2020.

Nutrients

Surface Nutrients

Inorganic nutrients, particularly the elements phosphorus and nitrogen, are vital for algal nutrition and cellular constituents. Over enrichment of surface waters leads to excessive production of autotrophs, especially algae and cyanobacteria (Correll, 1998). Figures 14 and 15 shows the total phosphorus (TP) and total nitrogen (TN) present in the surface waters at SP1.

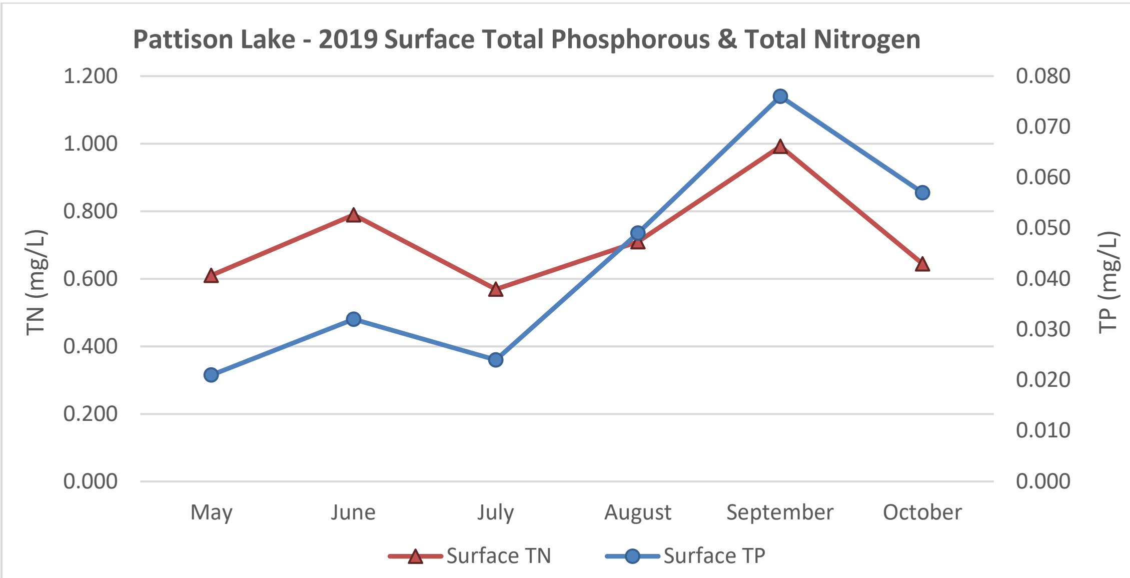


Figure 14. 2019 surface concentration of TP and TN at SP1.

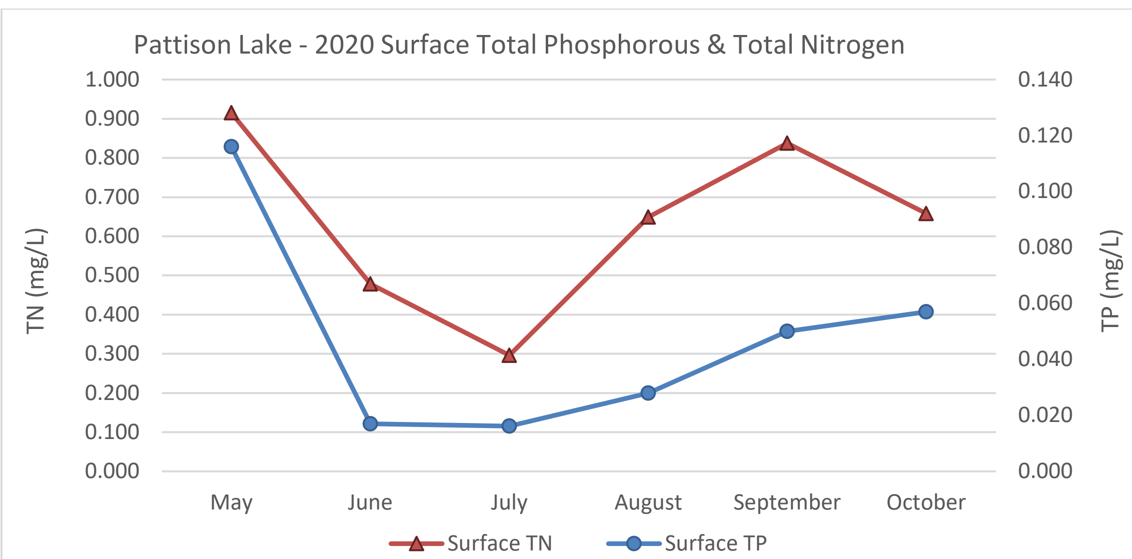


Figure 15. 2020 surface concentration of TP and TN at SP1.

In 2019, concentrations of surface TN and TP peaked when the water column began to mix in September. The concentration of TP in surface waters was lowest in May, when the lake was starting to stratify. Thermal stratification reduced internal loading to surface waters from June to August; changes in the phytoplankton community and external sources likely affect nutrient levels during stratification.

In 2020, the concentration of surface TN and TP was highest in May and then saw a dramatic reduction in the early summer. Thermal stratification reduced internal loading to surface waters in June and July; changes in the phytoplankton community and external sources likely affect nutrient levels during stratification. As temperatures began to cool and the water column began mixing in September, concentrations of both nutrients increased.

Total Phosphorus

Compared to the rich supply of other elements required for nutrition or structure, phosphorus is the least abundant and most commonly limits biological productivity. Lakes in this region experience undesirable algae growth when the annual average surface phosphorus level reaches 0.030 mg/L (Gillion, 1983). Washington adopted numeric action values in the state water quality standards to protect lakes. The action level for the Puget Lowlands ecoregion is 0.020 mg/L (WAC, 2019). Figures 16 and 17 displays the TP concentration at SP1.

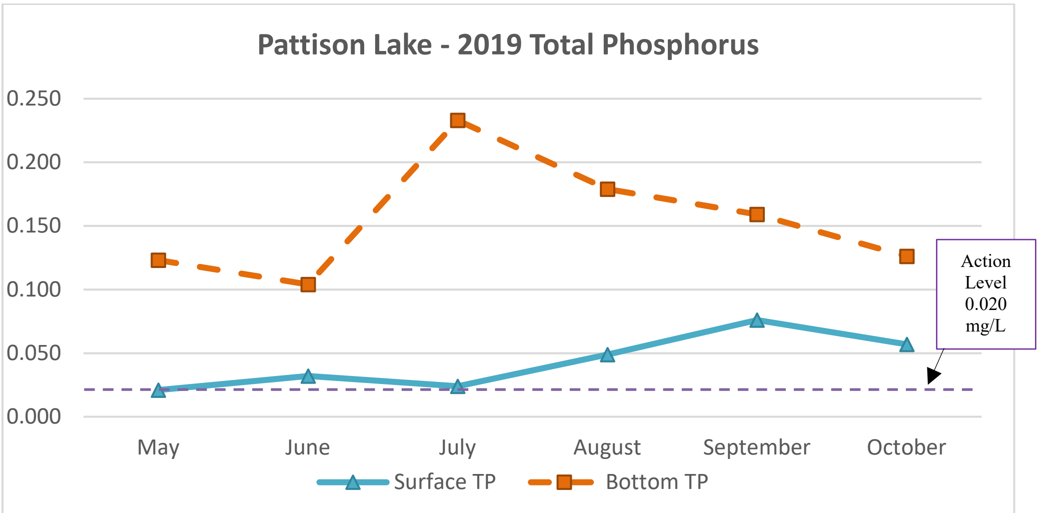


Figure 16. Concentration of Total Phosphorus at the surface and bottom at SP1 in 2019.

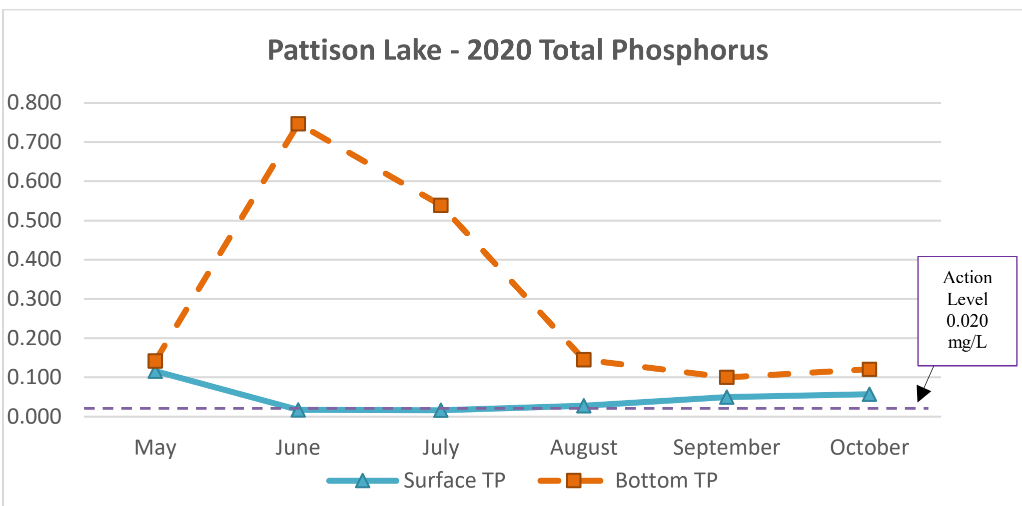


Figure 17. Concentration of Total Phosphorus at the surface and bottom at SP1 in 2020.

At SP1, the 2019 TP concentration was:

- TP Surface Mean 0.043 mg/L
- TP Surface Median 0.041 mg/L
- TP Surface Std Dev 0.020 mg/L
- TP Bottom Mean 0.111 mg/L
- TP Bottom Median 0.093 mg/L
- TP Bottom Std Dev 0.049 mg/L

At SP1, the 2020 TP concentration was:

- TP Surface Mean 0.047 mg/L
- TP Surface Median 0.039 mg/L
- TP Surface Std Dev 0.034 mg/L
- TP Bottom Mean 0.252 mg/L
- TP Bottom Median 0.091 mg/L
- TP Bottom Std Dev 0.273 mg/L

In 2019, the concentration of TP at the bottom was highest during July and August. In 2020, the bottom TP concentration was highest in June and July. Three defined layers were recognizable in the vertical profiles during those months (Figures 4-6) indicating thermal stratification. During stratification, the hypolimnion was mostly stagnant, not mixing with the oxygenated water above. At the same time, oxygen in the hypolimnion was consumed by redox processes like decomposition. Due to the lack of oxygen near the bottom, phosphorus stored in the sediments was released into the water column. This phosphorus accumulated in the hypolimnion, until turn-over later in September, when the water column mixed.

Figure 18 displays the average annual concentration of total phosphorus at SP1 from 1996 to 2020. The mean annual surface TP has been above the state action level (dashed line at 0.020 mg/L) 96% of the sample seasons. Alum was applied at Pattison Lake in 1983 to reduce internal loading of phosphorus.

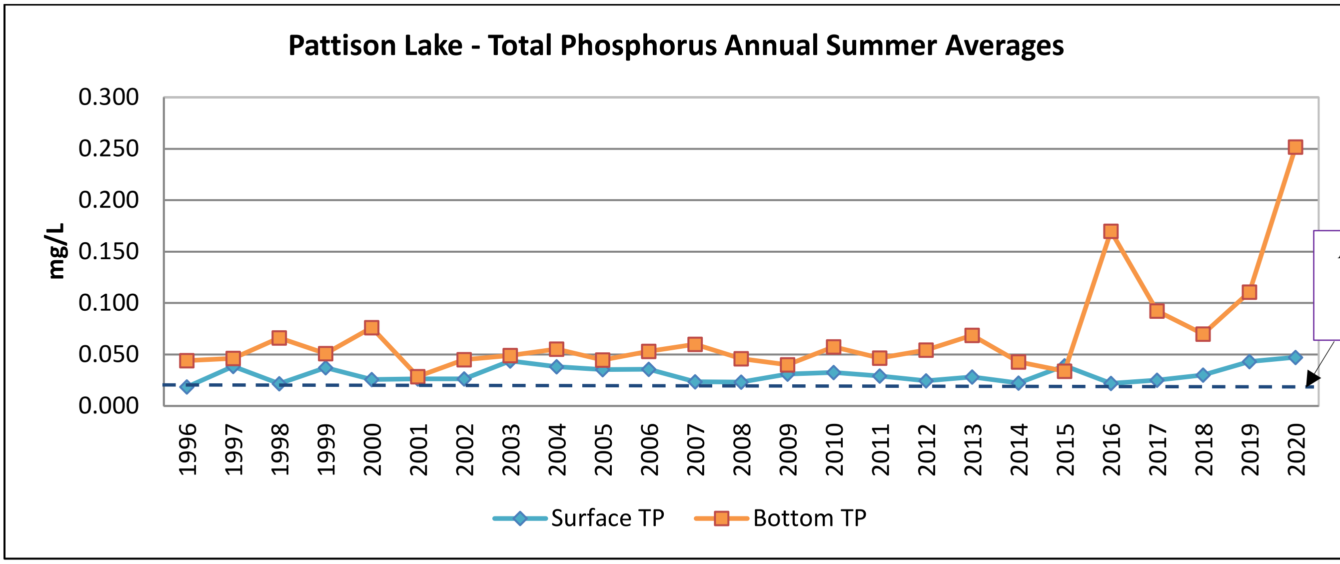


Figure 18. Average Annual Total Phosphorus at SP1 from 1996 to 2020.

For this 25-year period:

- TP Surface Mean 0.031 mg/L
- TP Surface Median 0.029 mg/L
- TP Surface Std Dev 0.008 mg/L
- TP Bottom Mean 0.068 mg/L
- TP Bottom Median 0.053 mg/L
- TP Bottom Std Dev 0.047 mg/L

The long-term average annual concentration of total phosphorus at SP1 from 1996 to 2020 is 0.0.31 mg/L for surface TP and 0.068 mg/L for bottom TP. In 2019 and 2020, surface TP was above the long-term average, at 0.043mg/L and 0.047 mg/L respectively. In 2019 and 2020, bottom TP was also above the long-term average, at 0.111 mg/L and 0.252 mg/L respectively.

Nitrogen

Nitrogen is also limiting to lake productivity, but supplies are more readily augmented by inputs from external sources. The State of Washington does not have established action or cleanup levels for surface total nitrogen. Figures 19 and 20 show the 2019 and 2020 TN concentrations for SP1.

In 2019, the TN concentrations at SP1 were:

- TN Surface Mean 0.719 mg/L
- TN Surface Median 0.677 mg/L
- TN Surface Std Dev 0.141 mg/L
- TN Bottom Mean 1.204 mg/L
- TN Bottom Median 1.275 mg/L
- TN Bottom Std Dev 0.376 mg/L

In 2020, the TN concentrations at SP1 were:

- TN Surface Mean 0.639 mg/L
- TN Surface Median 0.654 mg/L
- TN Surface Std Dev 0.208 mg/L
- TN Bottom Mean 1.394 mg/L
- TN Bottom Median 0.974 mg/L
- TN Bottom Std Dev 0.899 mg/L

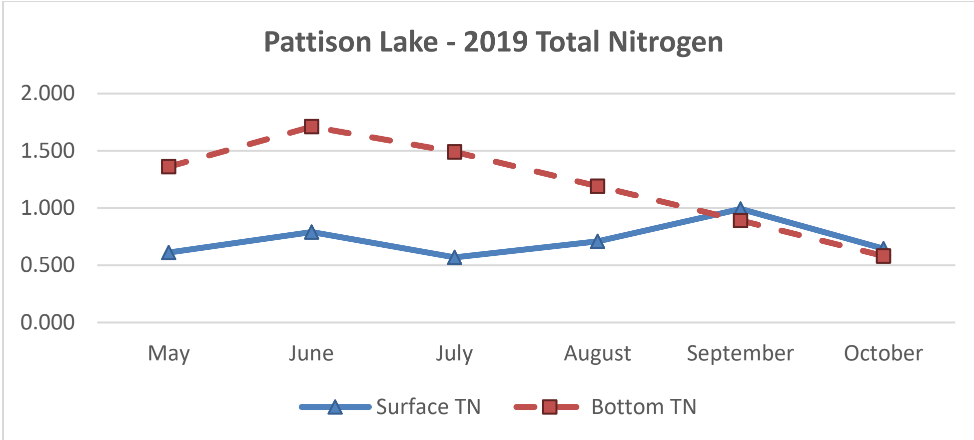


Figure 19. Concentration of Total Nitrogen at the surface and bottom at SP1 in 2019.

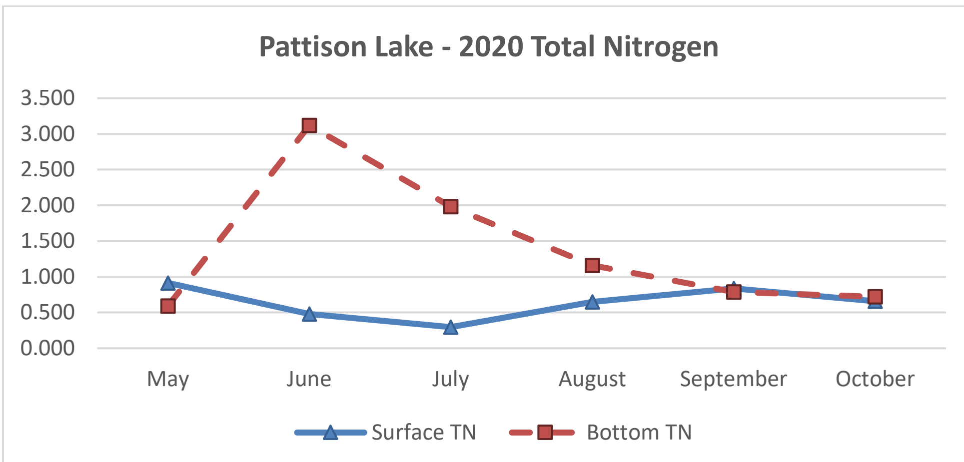


Figure 20. Concentration of Total Nitrogen at the surface and bottom at SP1 in 2020.

Figures 21 displays the average annual concentrations for total nitrogen from 1996 to 2020. The TN concentration for the 25-year period of record was:

- TN Surface Mean 0.689 mg/L
- TN Surface Median 0.665 mg/L
- TN Surface Std Dev 0.137 mg/L
- TN Bottom Mean 0.838 mg/L
- TN Bottom Median 0.789 mg/L
- TN Bottom Std Dev 0.256 mg/L

The total nitrogen concentration was higher at the bottom in June of both 2019 and 2020 because the hypolimnion was hypoxic during stratification; ammonia-nitrogen was released from the bottom sediments and accumulated in the hypolimnion. The Surface? TN concentration was slightly higher that what? in September while the lake turned over in both 2019 and 2020.

Figure 21 displays the average annual concentration of total nitrogen at SP1 from 1996 to 2020, with the long-term average being 0.689 mg/L for surface TN and 0.838 mg/L for bottom TN. In 2019, surface and bottom TN were above the long-term average (0.719 mg/L and 1.204 mg/L respectively). In 2020, surface TN was below the long-term average at 0.639 mg/L, while bottom TN continued to be above the average at 1.394 mg/L.

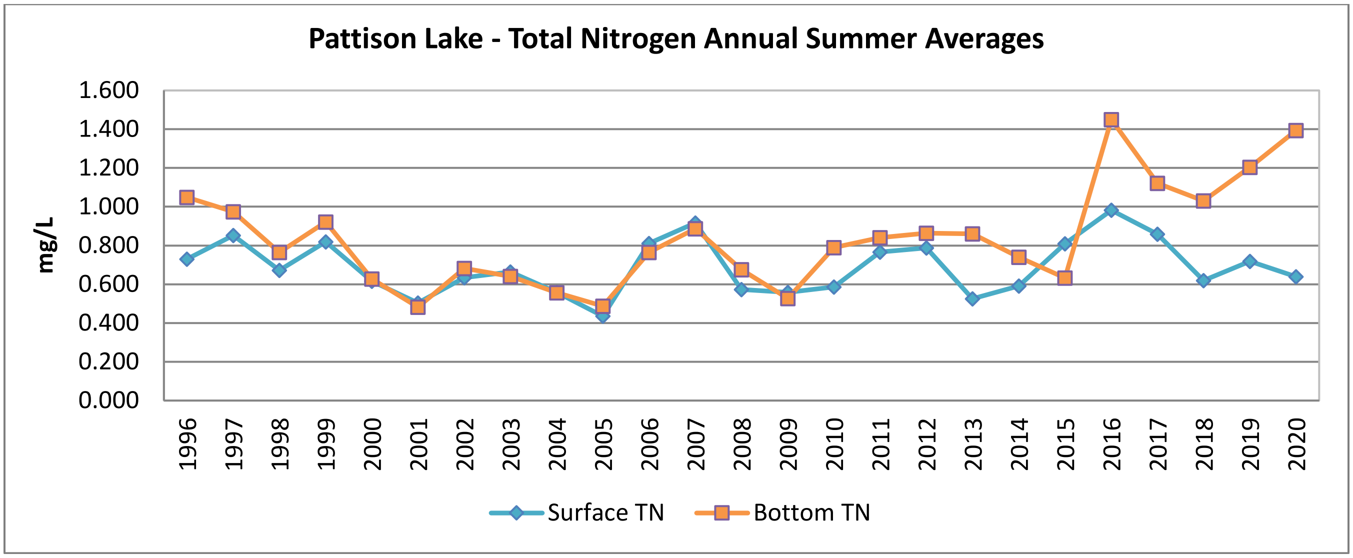


Figure 21. Average Annual Total Nitrogen at SP1 from 1996 to 2020.

Nitrogen to Phosphorus Ratios

To prevent dominance by cyanobacteria (blue-green algae), the TN to TP ratio (TN:TP) should be above 10:1 (Moore and Hicks, 2004). Figures 22 shows the TN to TP ratio at SP1. Pattison Lake has been phosphorus limited since 1996 but the ratio has been decreasing since 2016.

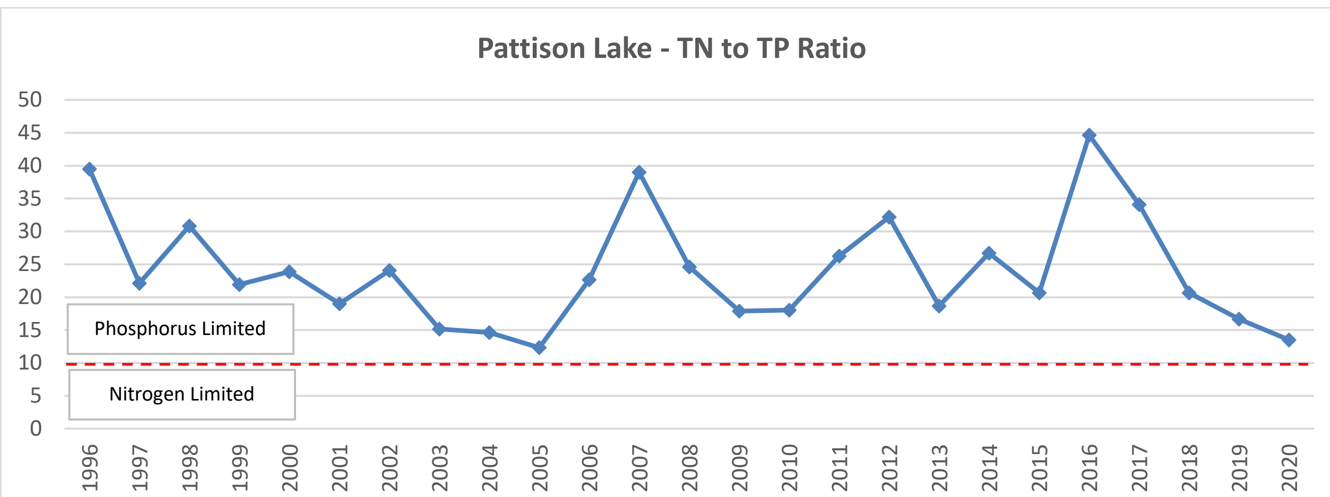


Figure 22. TN:TP at SP1 from 1996 to 2020.

Algae

In 2019, TCEH collected and sent out for testing three samples for algal toxins. These samples were collected in September and October. None of the samples exceeded the Washington State Toxic Algae Advisory Levels.

In 2020, TCEH collected and sent out for testing nine samples for algal toxins. These samples were collected in August and September. Two samples, one at the end of August and one at the beginning of September, exceeded the Washington State Toxic Algae Advisory Levels for microcystin and warning signs were posted at Pattison Lake.

Trophic State Indices (TSI)

The most used method to classify lakes is called the Carlson's Trophic State Index (Carlson, 1977). Based on the productivity, this method uses three index variables: transparency (Secchi disk depth), chlorophyll-a, and phosphorus concentrations. Table 3 provides the index values for each trophic classification.

Table 3. Trophic State Index variables.

TSI Value	Trophic State	Productivity
0 to 40	oligotrophic	Low
41 to 50	mesotrophic	Medium
> 50	eutrophic	High

For SP1, the TSI results were:

- 2019 Chlorophyll-a: 58 eutrophic
- 2019 Total Phosphorus: 58 eutrophic
- 2019 Secchi Disk: 48 mesotrophic
- 2019 Average TSI: 55 - eutrophic

- 2020 Chlorophyll-a: 58 eutrophic
- 2020 Total Phosphorus: 60 eutrophic
- 2020 Secchi Disk: 49 mesotrophic
- 2020 Average TSI: 56 - eutrophic

Based on the chlorophyll-a concentration, SP1 has been classified as eutrophic 96% of the last 25 sample seasons (Figure 20). Since 1996, SP1 has been classified as eutrophic 76% of the years for TP concentration and 12% of the years for Secchi depth

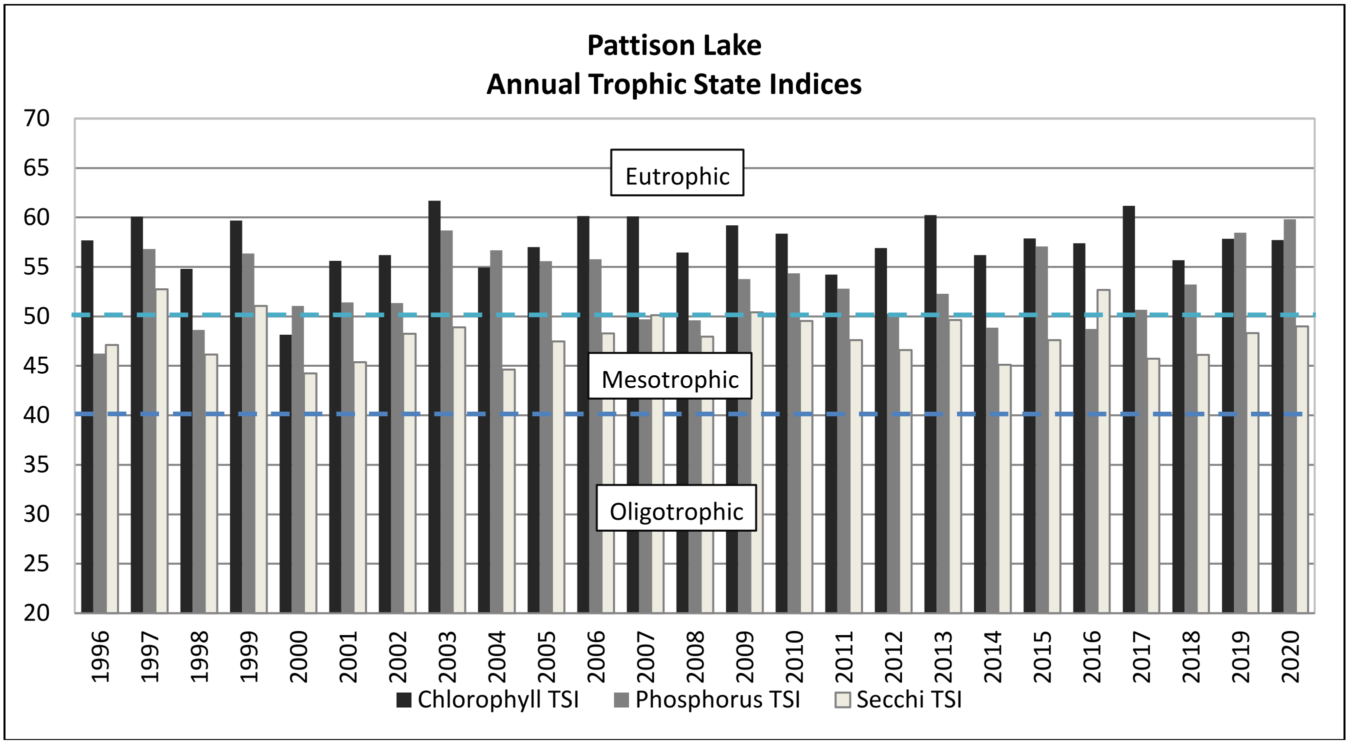


Figure 4. SP1 Trophic State Index from 1996 to 2020.

SUMMARY

Thermal Stratification

In 2019 and 2020, the water column at Pattison Lake began to stratify in May. Three distinct layers were apparent in June, July, and August. Pattison Lake turned-over in September and remained fully mixed in October.

Water Clarity and Transparency

In 2019 and 2020, transparency at SP1 was lower than the long-term average, 0.07 meters lower in 2019 and 0.18 meters lower in 2020. Transparency ranged from 1.15 to 3.45 meters (in 2019) and 0.91 to 3.65 meters (in 2020). In both sampling years, transparency was negatively correlated to the concentration of chlorophyll-a.

Chlorophyll-a and Productivity

In 2019, the mean concentration of chlorophyll-a was 16.1 µg/L (range 6.4 to 24.0 µg/L). The highest productivity occurred in June, August, and October. In 2020, the mean concentration of chlorophyll-a was 15.9 µg/L (range 4.0 to 38.0 µg/L). The highest productivity occurred in August and October.

In 2019, algal blooms with scum were reported in September and October. TCEH sampled Pattison Lake three times for toxic algae. The Washington State advisory level was not exceeded by any of the samples. In 2020, algal blooms with scum were reported in August and September. TCEH sampled Pattison Lake nine times for toxic algae. The Washington State advisory level for microcystin was exceeded by two samples on August 31st and September 14th, 2020. An advisory was posted by TCEH to warn local lake users.

Nutrient Concentrations

In 2019 and 2020, both surface and bottom TP were above the long-term averages.
In 2019, surface and bottom TN were above the long-term average. In 2020, surface TN was below the long-term average, while bottom TN continued to be above the average.

Classified as Eutrophic

In 2019 and 2020, the Pattison Lake site SP1 continued to be classified as eutrophic based on an average of the three TSI variables.

DATA SOURCES:

Thurston County Community Planning and Economic Development
(360) 786-2075 or
https://www.thurstoncountywa.gov/planning/Pages/water-gateway.aspx

Thurston County Environmental Health
(360) 867-2626 or
https://www.co.thurston.wa.us/health/ehrp/annualreport.html

For correction, questions, and suggestions, contact the author of the 2019-2020 report:
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FUNDING SOURCE:

Thurston County funded monitoring in 2019 and 2020.

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Appendices

Appendix A. Raw Data
Appendix B. Quality Assurance/Quality Control

Appendix A. Raw data

Table A-1 Raw data collected at the Pattison Lake site SP1 2019.

Site INFO		Profile													Samples					
						Temp (C)		pH		DO (m/l)		Conductivity (Sp)			TP		TN		Composite Sample	
Date	Time	Total Depth (m)	Secchi (m)	Water Color	Bottom Profile Depth (m)	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Bottom Sample Depth (m)	Surface	Bottom	Surface	Bottom	Chl a	Phae a
5/21/2019	9:00	5.1	3.45	6	5.0	17.941	13.222	8.100	7.040	10.07	0.83	160.0	188.0	5	0.021	0.102	0.610	1.360	6.4	1.1
6/18/2019	10:36	5.13	1.65	6	5.0	21.825	15.474	9.19	7.17	12.78	1.18	161.0	206.8	4.75	0.032	0.072	0.789	1.710	23.0	<0.1
7/25/2019	11:05	5.09	2.87	2	5.0	22.842	17.693	8.58	6.94	10.01	0.60	167.6	267.8	4.5	0.024	0.209	0.569	1.490	8.3	1.3
8/28/2019	10:05	5.21	1.33	3	5.0	22.358	19.648	8.58	6.83	10.26	0.48	175.6	237.3	5	0.049	0.130	0.710	1.190	24.0	2.0
9/25/2019	10:22	5.05	3.05	4	4.5	18.487	18.146	7.25	7.15	6.61	5.30	183.9	184.1	4.50	0.076	0.083	0.992	0.890	15.0	1.8
10/23/2019	10:57	5.15	1.15	3	5.0	12.835	12.704	8.11	7.89	11.65	10.90	110.1	177.2	4.50	0.057	0.069	0.644	0.581	20.0	5.9

Table A-2 Raw data collected at the Pattison Lake site SP1 2020.

Site INFO		Profile													Samples					
						Temp (C)		pH		DO (m/l)		Conductivity (Sp)			TP		TN		Composite Sample	
Date	Time	Total Depth (m)	Secchi (m)	Water Color	Bottom Profile Depth (m)	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Bottom Sample Depth (m)	Surface	Bottom	Surface	Bottom	Chl a	Phae a
5/20/2020	10:07	5.1	2.60	3	4.5	17.926	13.410	8.91	6.69	12.25	0.99	150.7	177.6	4.6	0.116	0.026	0.915	0.593	11.0	0.3
6/24/2020	12:25	5.3	2.70	6	5.0	22.871	13.288	9.08	6.70	10.75	0.63	147.7	217.4	5.0	0.017	0.730	0.478	3.120	4.0	0.1
7/22/2020	13:21	5.23	3.65	6	5.0	24.234	15.876	8.14	6.78	9.11	0.72	155.1	234.3	4.7	0.016	0.523	0.296	1.985	2.403	0.214
8/26/2020	12:20	5.24	1.40	6	5.0	23.005	19.232	8.43	6.63	10.78	0.58	167.6	221.4	5.0	0.028	0.117	0.649	1.160	25.0	0.3
9/23/2020	13:00	5.3	1.60	6	5.0	19.690	19.468	7.60	7.19	8.09	6.33	168.6	175.5	4.8	0.050	0.050	0.838	0.787	15.0	5.4
10/21/2020	13:24	5.7	0.91	3	5.5	15.062	15.077	7.72	7.68	9.72	9.55	165.7	165.9	5.2	0.057	0.064	0.658	0.722	38.0	5.4

Appendix B. Quality Assurance/Quality Control

Tables B-1 and B-2 provides the amount of instrument drift for specific conductivity, dissolved oxygen (collected with optical sensor), and pH. TCEH collected 15% field replicates and blanks for TP, TN. Chlorophyll-a, and Phaeophytin-a.

Table B-1. Instrument drift for Pattison Lake sample days in 2019.

Date	Time	Percent Difference		
		DO	SPC	pH (7)
6/19/2019	7:20	0.10	0.3	0.00
7/26/2019	16:20	0.09	6.62	0.43
8/29/2019	7:30	0.26	0.33	0.29
9/26/2019	13:30	0.57	0.12	0.14
10/24/2019	13:15	0.03	0.91	0.57
Median Percent Difference:		0.25	0.34	0.14
Mean Percent Difference:		0.45	1.15	0.25

Table B-2. Instrument drift for Pattison Lake sample days in 2020.

Date	Time	Percent Difference		
		DO	SPC	pH (7)
5/21/2020	13:00	0.82	0.39	1.43
6/26/2020	9:45	0.52	3.83	0.86
7/23/2020	17:30	0.10	0.11	0.14
8/27/2020	13:10	0.21	0.49	0.29
9/23/2020	15:40	0.54	0.09	0.86
10/22/2020	-	0.17	0.15	0.14
Median Percent Difference:		0.28	0.13	0.43
Mean Percent Difference:		0.63	0.61	0.56