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Upper Skagit Indian Tribe Baker and Shannon Lake Nutrient Analysis

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COLLEGE OF THE ENVIRONMENT

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Internship Title: Upper Skagit Indian Tribe Baker and Shannon Lake Nutrient Analysis

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Internship Dates: 9/22/2022-12/6/2022

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DATE: 12/6/2022]

Introduction

The Upper Skagit Indian Tribe (USIT) is pursuing the idea of fertilizing both Baker and Shannon Lake in Concrete, WA with the intention to enhance salmon production. Before inputting nutrients into the limnological systems, baseline data must be established to determine the current amount of nutrients within the lakes. The USIT has been contracting with the Institute of Watershed Studies' lab to analyze water samples for this project. The sampling includes testing for 5 different parameters at 10 different sites at each distinct depth from March 2021 to September 2021. My role in the project was to summarize the data set using R to statistically analyze and portray the trends of the nutrient levels found within the two lakes. The goal of the summary is to help guide the USIT in the next steps of this project, whether that be how and where they sample in the future, determining if nutrients are the limiting factor for salmon growth, and if it is a feasible solution for this system.

The USIT helps manage the Puget Sound Energy's Baker River Hatchery on Baker and Shannon Lake. The PSE's Hydroelectric Project places two dams on the Skagit River, creating Shannon Lake and enlarging Baker Lake. The hatchery produces sockeye salmon, and recently the USIT has been curious if the production of salmon could be increased. To increase the production, the food supply must also proportionately increase to sustain a larger population of salmon. Juvenile sockeye salmon mostly consume zooplankton, zooplankton consume phytoplankton, and phytoplankton produce their own energy from photosynthesis and nutrients such as phosphorous and nitrogen. By increasing the nutrients, the populations of phytoplankton and zooplankton would increase due to a more abundant food supply. A larger zooplankton population could sustain a larger salmon population. This is a bottom-top approach to this problem. In open limnological systems returning spawning salmon would die and their carcasses

would input nutrients back into the system. Shannon and Baker Lake are both closed systems due to the two dams that control the waterways; therefore, salmon are unable to leave, let alone return. The USIT would like to determine if there is a lack of nutrients within the lakes limiting their salmon populations. This initial baseline data will help determine if more nutrients are needed.

My intentions with this internship were to gain experience with water sampling in a limnological setting, learn how to manipulate and analyze large data sets with multiple parameters using Excel and R, and gain knowledge of working with governmental organizations trying to solve an ecological problem. Due to windy weather conditions on the lakes, I was unable to participate in the collection of water samples. The wind would have made it almost impossible to anchor the vessel and would have been unsafe. I was given the 2021 data for Baker and Shannon Lakes, my task with this data was to summarize the different concentrations of the parameters, how they varied over time and how they varied between each site.

Prior Experience

My first introduction with R was in ESCI 340, Biostatistical Analysis. This class provided basic knowledge of running statistical analyses on data sets with R, including t-tests, correlations, regressions, etc. This was my first introduction to coding and I found myself enjoying the structure and challenge of learning a new language. After the class was finished, I was left wanting to learn more about R and how to code. The class influenced me to focus more on environmental data analysis and to pursue a career with this as the focus. I reached out to Dr. Strecker and she presented to me this opportunity to work on a real-world project with the USIT and using R and Excel.

My curriculum

I took this internship concurrently with ESCI 361 Water Quality. In this class I was learning about the different parameters that are often looked at when sampling water. This included nutrient levels, dissolved oxygen, temperature, pH, and so on. Though I was not able to sample with the USIT, I was still able to practice collecting water samples within this course. As a class we took water samples of a constructed wetland and ran multiple analyses to determine the quality of the inlet and outlets. We were carrying out a study to determine if the constructed wetland effectively filtered and treated stormwater. At the end of this class, we analyzed the data using Excel and wrote lab reports on our findings. The setup of this study was similar to what I was doing for USIT, just on a smaller scale. This lab report gave me a better understanding of what I needed to be accomplishing for this project. The class complimented the internship well, I was able to learn more about why the USIT wanted to fertilize the lake and why they were analyzing for specific parameters.

R/Excel

For this project, a more comprehensive knowledge of R was necessary to analyze the large data set. As previously mentioned, my experience of R was limited to the brief introduction provided by ESCI 340. This data set included several different parameters and several characteristics of sampling sites. To summarize the data, I needed to learn different ways to subset and manipulate the variables.

In R there are different packages that allow you to manipulate the data. Each package has its own set of tools, vocabulary, and rules that you can apply to any data set. The packages I learned for this project include DPLYR and GGPLOT2. DPLYR allowed me to manipulate the data into smaller data sets. The initial data set I was given included over 200 unique samples.

With DPLYR I could filter the data to only show Baker Lake, the Sample Site, and whichever other parameters I needed. This allowed me to pick and choose what I wanted to include in a graph. I used GGPLOT2 to create specific plots using the subsetted data I made with DPLYR. These plots were intended to help visualize trends in data one would miss by simply looking at a data table.

Learning how to code in R was like learning new language. I had learned some of the basics in ESCI 340, but I needed further comprehension of R. This learning process created a lot of frustrations but learning how to troubleshoot and overcoming errors became easier as I progressed through this project. I found it astounding that simply pasting the error codes into a search engine would help solve 99% of my issues. An example of one of these troubleshooting times was when GGPLOT2 was not categorizing the months chronologically. I did a quick google search, I simply typed in "how to order months with ggplot2", and a plethora of forums addressing the issues were returned. I found that I needed to manually order the months within my pipes using the function "mutate". I also learned that the most common errors were from mistypes and leaving an extra space within the code. But each error code provided me with an opportunity to learn, and instead of getting frustrated I used them to advance my knowledge of R.

I have been using Excel since high school, but I still find that there is more to learn each time I use it. A tool I learned about and relied on heavily for this project was the function of pivot tables. The pivot tables were used to create the summary tables shown in the results section. I would select which variables I want to be in rows and columns and how that data is shown, either the averages, sum, count, standard deviations, and so on. I used the pivot tables to show the averages of each parameter at each sample site from March to September.

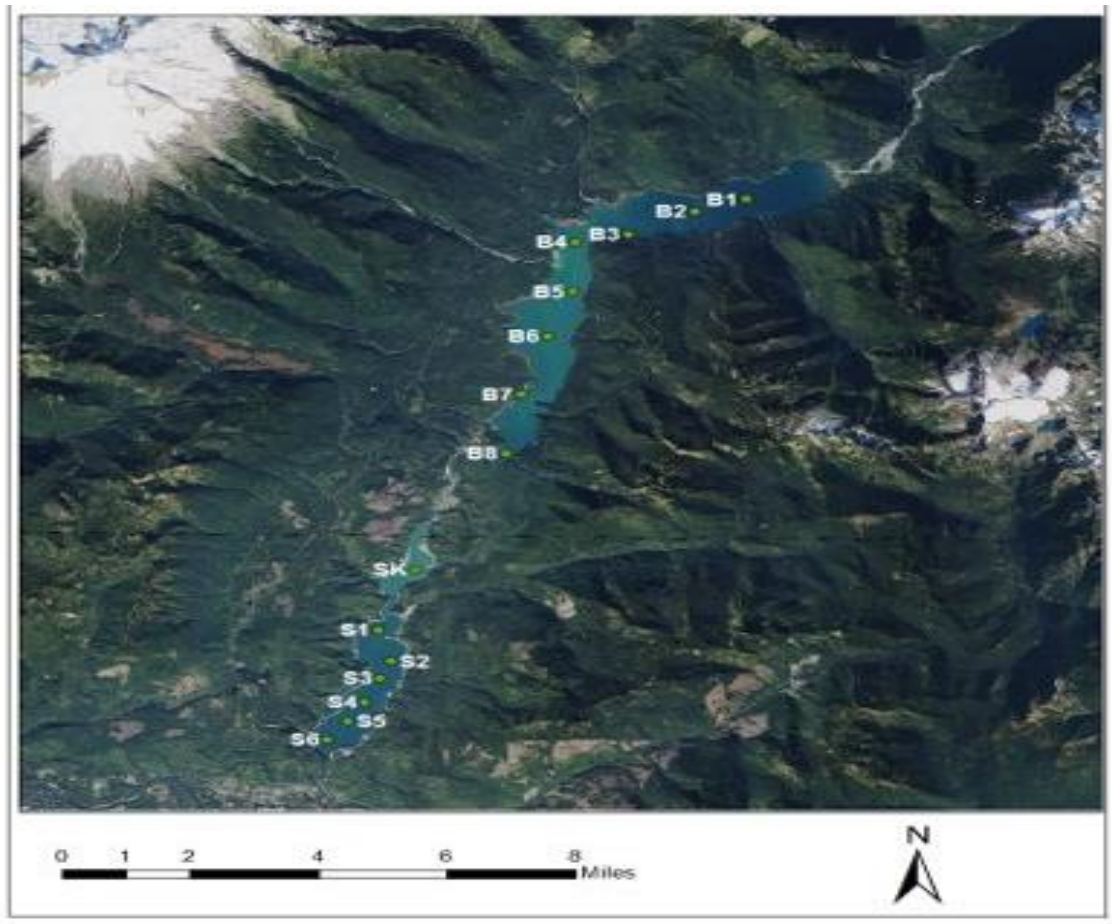
Thursday Meetings

Every Thursday Brian Lanouette (USIT Contact), Dr. Strecker, and I would have a brief meeting concerning progress with this project. During these meetings I was able to touch base with Brian and learn more about what the tribe wanted from this experience. Often there was not much to discuss. I realized I preferred emails to communicate with Brian as it was easier to lay out all the questions I had with greater detail and depth and Brian could return with answers after having time to thoroughly think about them and provide more enhanced guidance.

Friday meetings

Dr. Strecker hosted weekly undergraduate meetings with two other students completing similar projects. During these meetings we would talk about our progress, help troubleshoot any issues, and discuss our higher education goals and life after undergrad. One of the fellow undergrads helped tremendously by providing different R tutorials of the new packages I needed to learn. We all showed interest in attending graduate school and spent a meeting discussing the process of getting into a graduate program and the hidden hoops one must jump through. This was incredibly insightful and helpful towards guiding my future higher education endeavors. We prepared for life after undergrad by bringing in our academic resumes and helping each other fine tune them so they can be most effective and competitive for the professional job search process. During the few years of online classes I felt disconnected from my peers and professors and had not been able to make any educational connections; these meetings helped me feel more a part of the college community.

Baker and Shannon Lake Nutrient Sampling Sites



Data Summary

Table 1. The averages of the Total Nitrate (ug/L) levels measured at each site at Baker Lake from March to September. Standard deviations are included with the average measurement. Data collected by Upper Skagit Indian Tribe.

Average TN (ug/L)							
Months	B1 (n=27)	B2 (n=28)	B3 (n=27)	B4 (n=27)	B6 (n=28)	B7 (n=28)	B8 (n=28)
March	180.57±14.84	155.83±21.76	167.03±34.20	152.57±26.68	151.83±10.97	138.38±3.58	154.25±28.96
April	143.80±6.60	155.73±29.53	146.95±15.84	143.68±11.08	126.63±21.83	141.38±9.77	111.58±23.48
May	179.48±47.61	143.00±12.91	267.08±122.56	113.90±21.26	128.90±27.27	125.68±12.32	132.23±24.84
June	29.75±59.50	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0
July	0.00±0	36.03±72.05	19.70±39.40	0.00±0	0.00±0	0.00±0	91.40±105.56
August	72.20±16.55	105.95±61.37	112.93±47.65	73.38±17.21	98.25±31.86	35.95±41.59	54.70±79.29
September	17.48±34.95	40.13±50.95	45.40±54.27	33.90±67.80	36.05±72.10	13.13±26.25	50.75±66.00

The average TN levels from March to May appear to be decreasing, except for site B3 in May where the concentrations dramatically increase compared to the rest of the sites. June and July see either no concentrations or relatively low concentrations. In August there is an increase in all sites, except for B8 where the concentration decreases through September (Table 1).

Table 2. The averages of the Nitrate/Nitrite (ug/L) levels measured at each site at Baker Lake from March to September. Standard deviations are included with the average measurement. Data collected by Upper Skagit Indian Tribe.

Average NO3NO2 (ug/L)							
Month	B1 (n=27)	B2 (n=28)	B3 (n=27)	B4 (n=27)	B6 (n=28)	B7 (n=28)	B8 (n=28)
March	119.73±6.44	120.38±6.85	107.27±9.37	107.73±5.50	103.425±6.54	99.00±5.61	93.89±8.60
April	101.53±5.89	116.50±17.76	99.63±11.55	107.80±16.17	80.00±12/36	75.38±15.82	77.48±19.40
May	53.33±10.02	64.93±34.86	61.23±9.52	58.45±13.14	47.73±16.86	46.85±15.35	43.95±18.71
June	14.68±29.35	16.48±32.95	13.20±26.40	0.00±0	9.15±18.30	10.65±21.30	20.43±40.85
July	0.00±0	29.00±58.00	12.95±25.90	0.00±0	0.00±0	7.23±14.55	24.40±48.80
August	0.00±0	28.85±57.70	14.33±28.65	0.00±0	0.00±0	0.00±0	26.43±52.85
September	19.35±23.19	39.85±58.28	25.30±31.08	8.88±17.75	8.85±17.70	13.18±26.35	30.83±61.65

The nitrate/nitrite levels decreased from March to July for most sites and increased minimally from July to September. Most sites had very minimum or no concentration of nitrate/nitrite during June through August.

Table 3. The averages of the TP (ug/L)levels measured at each site at Baker Lake from March to September, standard deviations of each average are shown. Data collected by Upper Skagit Indian Tribe.

Average TP (ug/L)							
Months	**B1 (n=27)**	**B2 (n=28)**	**B3 (n=27)**	**B4 (n=27)**	**B6 (n=28)**	**B7 (n=28)**	**B8 (n=28)**
March	1.07±1.85	3.10±4.29	2.20±1.92	4.23±1.43	13.85±15.55	5.55±0.83	6.85±1.89
April	0.00±0	3.05±6.10	1.15±2.30	0.00±0	1.93±2.27	0.00±0	1.73±3.45
May	1.98±2.36	1.15±2.30	5.88±2.29	2.98±1.05	3.95±0.54	1.73±2.03	4.05±2.74
June	0.83±1.65	0.00±0	0.85±1.70	4.85±7.60	3.00±2.12	8.75±7.04	2.80±1.90
July	0.00±0	0.00±0	0.00±0	0.00±0	1.65±1.91	0.00±0	0.98±1.95
August	0.00±0	0.00±0	0.93±1.85	0.85±1.70	3.73±4.46	4.05±5.80	2.70±1.81
September	15.70±20.43	6.75±6.29	25.05±23.07	6.48±6.71	10.48±9.69	10.73±6.21	6.13±1.28

Total phosphorous levels during the month of July were between 0 and 2. Most sites followed a trend of decreasing slightly from March to July, and then increasing between August and September.

Table 4. The averages of the Orthophosphate (ug/L)levels measured at each site at Baker Lake from March to September. Standard deviations are included with the average measurement. Data collected by Upper Skagit Indian Tribe.

Average Orthophosphate (ug/L)							
Month	**B1 (n=27)**	**B2 (n=28)**	**B3 (n=27)**	**B4 (n=27)**	**B6 (n=28)**	**B7 (n=28)**	**B8 (n=28)**
March	0.00±0	0.00±0	0.00±0	0.00±0	2.33±4.65	0.00±0	0.00±0
April	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0	0.83±1.65	0.00±0
May	1.08±2.15	0.00±0	3.65±4.41	1.35±2.70	1.28±2.55	0.88±1.75	5.63±5.88
June	0.83±1.65	2.98±2.00	1.88±2.17	1.73±3.45	2.33±2.71	0.93±1.85	2.00±2.33
July	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0	1.75±2.02
August	2.83±2.02	1.78±2.05	1.93±2.32	0.00±0	2.13±2.45	0.75±1.50	0.90±1.80
September	0.75±1.50	0.00±0	1.65±1.91	0.00±0	0.00±0	0.00±0	0.00±0

Average orthophosphate concentrations were low for Baker Lake. During the months of March, April, July, and September, 5-6 sites were depleted of orthophosphates.

Table 5. Average Ammonium (ug/L)levels for each site at Baker from March to September. Standard deviations are included with the average measurement. Data collected by Upper Skagit Indian Tribe.

Average NH4 (ug/L)							
Month	**B1 (n=27)**	**B2 (n=28)**	**B3 (n=27)**	**B4 (n=27)**	**B6 (n=28)**	**B7 (n=28)**	**B8 (n=28)**
March	18.43±6.67	3.08±6.15	10.90±9.46	5.20±9.01	3.25±6.50	5.93±6.64	7.05±8.14
April	2.93±5.85	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0
May	0.00±0	5.90±6.87	3.18±6.35	0.00±0	0.00±0	0.00±0	3.53±7.05
June	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0
July	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0	0.00±0	18.83±21.74
August	0.00±0	7.55±8.78	2.80±5.60	6.55±7.74	23.43±24.10	0.00±0	5.10±10.20
September	2.58±5.15	0.00±0	2.95±5.90	0.00±0	0.00±0	9.40±6.45	9.68±6.70

Average ammonium levels were 0 for the months of April, June, and July (except for B8: 18.83 July and B1: 2.93 in April). Site B6 saw a high increase in NH4 during the month of August, going from no ammonium for 4 months to a dramatic increase to 23.48, then back to 0 in September. All sites had a period of a few months with no ammonium detected.

Table 6. Average levels of Ammonium (ug/L) in Shannon from March to September 2021. Standard deviations are included with the average measurement. Data collected by Upper Skagit Indian Tribe.

Average NH4 (ug/L)			
Month	S1 (n=24)	S4 (n=24)	S6 (n=24)
March	5.45±6.44	2.60±5.20	14.05±2.83
April	12.48±24.95	2.83±5.65	5.43±10.05
June	0.00±0	0.00±0	0.00±0
July	23.25±12.01	30.30±9.67	43.83±12.21
August	24.50±14.62	0.00±0	7.00±8.23
September	3.22±6.45	0.00±0	14.08±4.38

All sites of Shannon Lake had no detectable levels of ammonium during the month of June. S4 had no detectable amounts of ammonium during August and September, while both S1 and S6 had some concentration of ammonium. There was a peak of ammonium at S6 in July, then it dramatically decreased in August. In the month of June, each site saw an increase of ammonium that was considerably higher than their concentrations during the months of March and April.

Table 7. Average concentrations of Orthophosphate (ug/L) in Shannon Lake from March to September 2021. Standard deviations are included with the average measurement Data collected by Upper Skagit Indian Tribe.

Average Orthophosphate (ug/L)			
Month	S1 (n=24)	S4 (n=24)	S6 (n=24)
March	0.00±0	1.30±2.60	0.75±1.50
April	0.00±0	0.85±1.70	2.05±2.38
June	1.18±2.35	0.75±1.50	3.20±2.23
July	0.00±0	0.00±0	0.00±0
August	0.00±0	1.65±1.91	0.85±1.70
September	0.00±0	1.13±2.25	1.70±3.40

Orthophosphate concentrations did not reach above 3.5 at any of the sites. S1 has no detectable levels of orthophosphate for all months except for June at 1.18. S6 saw the highest concentration of orthophosphate during the month of June, and it quickly depleted during July through September.

Table 8. Average concentrations of Total Phosphorous (ug/L) in Shannon Lake from March to September 2021. Standard deviations are included with the average measurement. Data collected by Upper Skagit Indian Tribe.

Average TP (ug/L)			
Month	S1 (n=24)	S4 (n=24)	S6 (n=24)
March	10.10±2.00	9.98±2.93	9.73±1.72
April	8.40±0.84	6.50±1.31	6.50±2.90
June	4.08±2.83	5.13±1.53	4.98±1.81
July	0.00±0	0.00±0	0.00±0
August	7.08±1.28	4.55+0.71	4.50±1.55
September	10.08±5.83	4.93±0.45	5.28±3.93

Average total phosphorous levels decrease from March to June at all three sites, bottom out in July, and increase from August to September.

Table 9. Average concentrations of Nitrate/Nitrite (ug/L) in Shannon Lake from March to September (excluding May) 2021. Standard deviations are included with the average measurement. Data collected by Upper Skagit Indian Tribe.

Average NO3NO2 (ug/L)			
Month	**S1 (n=24)**	**S4 (n=24)**	**S6 (n=24)**
March	114.48±12.73	137.63±17.24	146.50±14.84
April	66.60±40.47	81.33±43.40	94.45±52.02
June	11.20±22.40	27.80±55.60	28.85±57.70
July	0.00±0	31.30±62.60	31.98±63.95
August	0.00±0	24.50±49.00	30.10±60.20
September	0.00±0	28.25±56.60	28.68±57.35

Average levels of nitrate and nitrite are continuously decreasing from March to September. S1 decreases from March to June, then bottom out from July to September.

Table 10. Average levels of Total Nitrogen (ug/L) in Shannon Lake from March to September 2021. Standard deviations are included with the average measurement. Data collected by Upper Skagit Indian Tribe.

Average TN (ug/L)			
Month	S1 (n=24)	S4 (n=24)	S6 (n=24)
March	158.05±20.93	207.35±35.14	207.03±26.22
April	181.50±13.28	157.13±37.36	165.78±57.85
June	58.33±71.16	50.98±62.23	24.80±49.60
July	107.00±82.88	61.53±54.89	58.20±67.20
August	126.13±29.67	115.40±54.86	115.55±47.10
September	12.85±25.70	18.10±36.20	26.28±52.55

Average levels of total nitrogen dropped significantly from April to June. Total nitrogen levels then increase from July to August, then decrease dramatically again from August to September.

Table 11. Max Values of each Parameter from Baker Lake with the Site, Depth, and Month the value occurred. Data collected by Upper Skagit Indian Tribe.

Max Parameter Values of Baker Lake				
Parameter	Site	Depth	Month	Value
TN (ug/L)	B3	ET	May	438.0
TP (ug/L)	B3	HB	September	49.4
Orthophosphate (ug/L)	B8	MM	May	13.9
NH4 (ug/L)	B6	ET	August	55.7
NO3NO2 (ug/L)	B2	EB	April	133.9

Table 12. Max Values of each Parameter from Shannon Lake with the Site, Depth, and Month the value occurred. Data collected by Upper Skagit Indian Tribe.

Max Parameter Values of Shannon Lake				
Parameter	**Site**	**Depth**	**Month**	**Value**
TN (ug/L)	S4	MM	March	255.50
TP (ug/L)	S1	HB	September	18.80
Orthophosphate (ug/L)	S6	HB	September	6.80
NH4 (ug/L)	S6	ET	July	55.80
NO3NO2 (ug/L)	S6	HB	March	167.80

Table 13. Dates of Sampling Baker and Shannon Lakes in 2021. Samples collected by Upper Skagit Indian Tribe.

Baker		**Shannon**	
Month	Day	Month	Day
March	25	March	30
April	29	April	30
May	20	May	NA
June	22	June	23
July	22	July	23
August	26	August	27
September	21	September	20

Figure 14. Sum of Monthly Total Precipitation (in) of 2021 of Concrete PPL Fish Station, WA. Data collected by NOAA Online Weather Data.

Year	March	April	May	June	July	August	September
2021	3.12	1.75	2.85	1.26	0	1.16	6.74

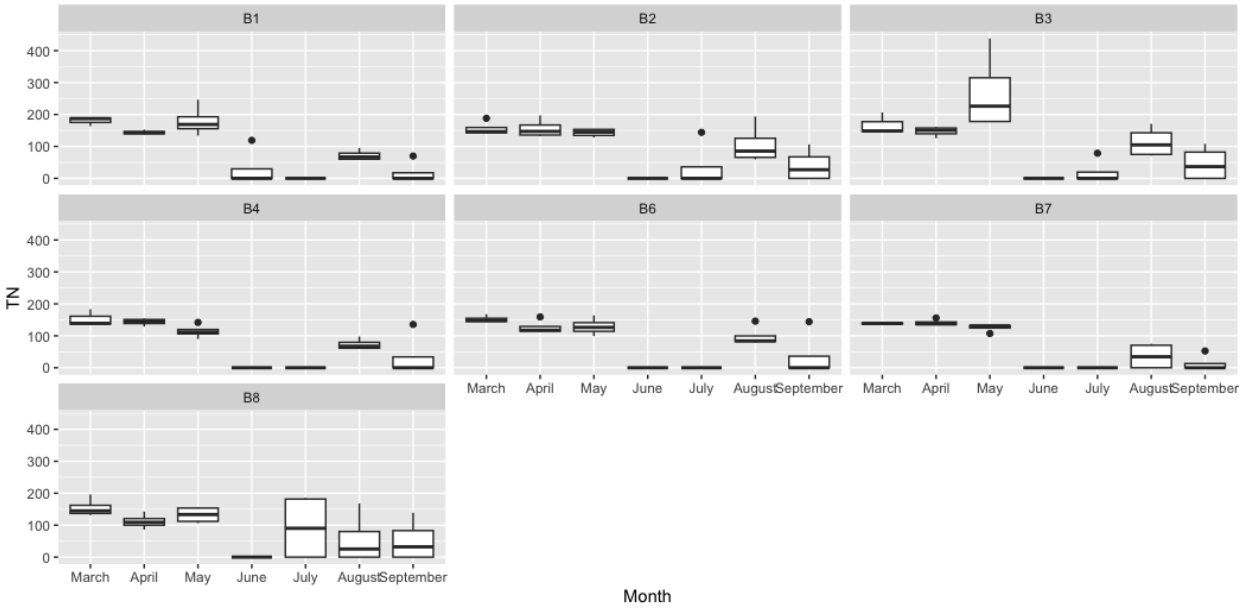


Figure 1. Boxplot of Average Levels of Total Nitrogen (ug/L) at each Site* in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*B1: n=27, B2: n=28, B3: n=27, B4: n=27, B6: n=28, B7: n=28, B8: n=28

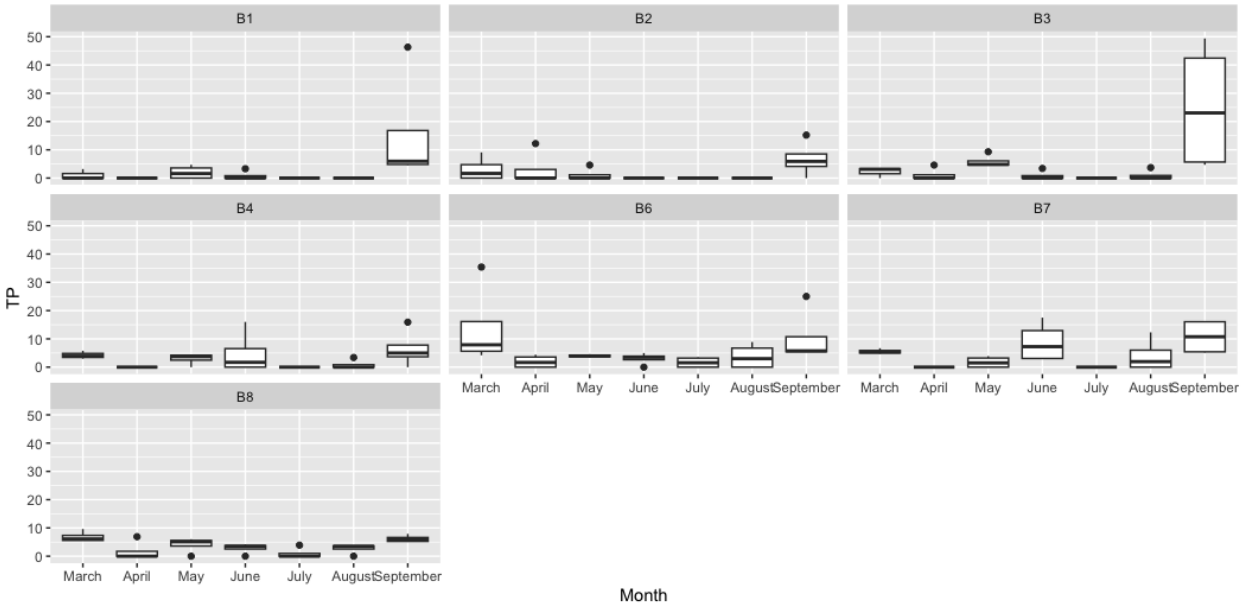


Figure 2. Boxplot of Average Total Phosphorous (ug/L) at each Site in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.

*B1: n=27, B2: n=28, B3: n=27, B4: n=27, B6: n=28, B7: n=28, B8: n=28

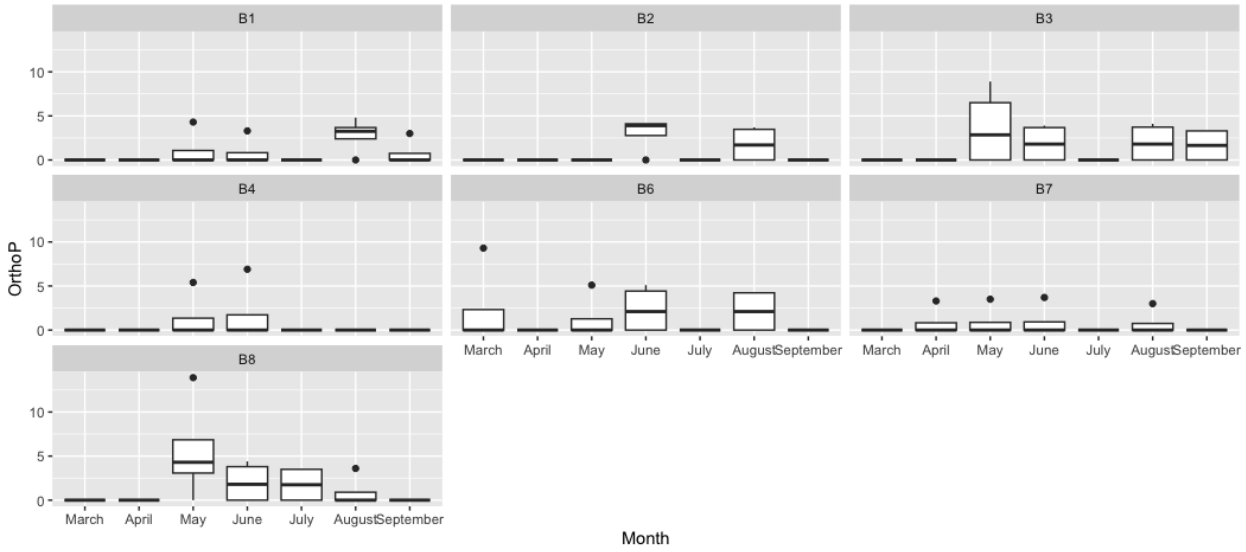


Figure 3. Boxplot of Average Orthophosphate (ug/L) levels at each Site* in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*B1: n=27, B2: n=28, B3: n=27, B4: n=27, B6: n=28, B7: n=28, B8: n=28

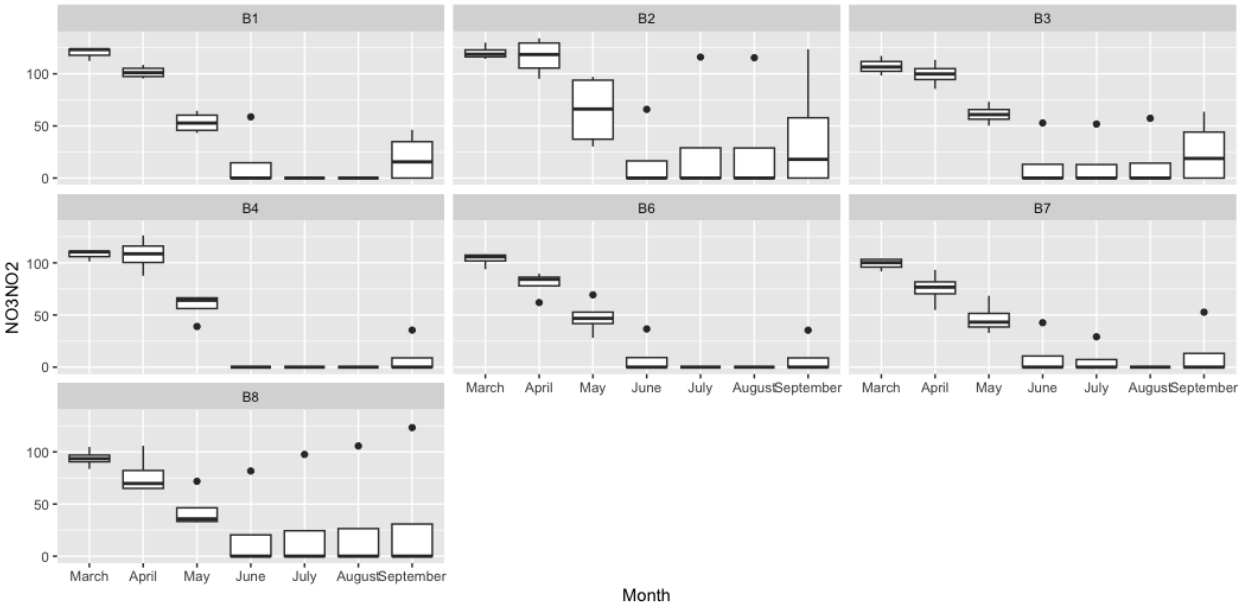


Figure 4. Boxplot of Average Nitrate/Nitrite (ug/L) levels of each Site* in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.

*B1: n=27, B2: n=28, B3: n=27, B4: n=27, B6: n=28, B7: n=28, B8: n=28

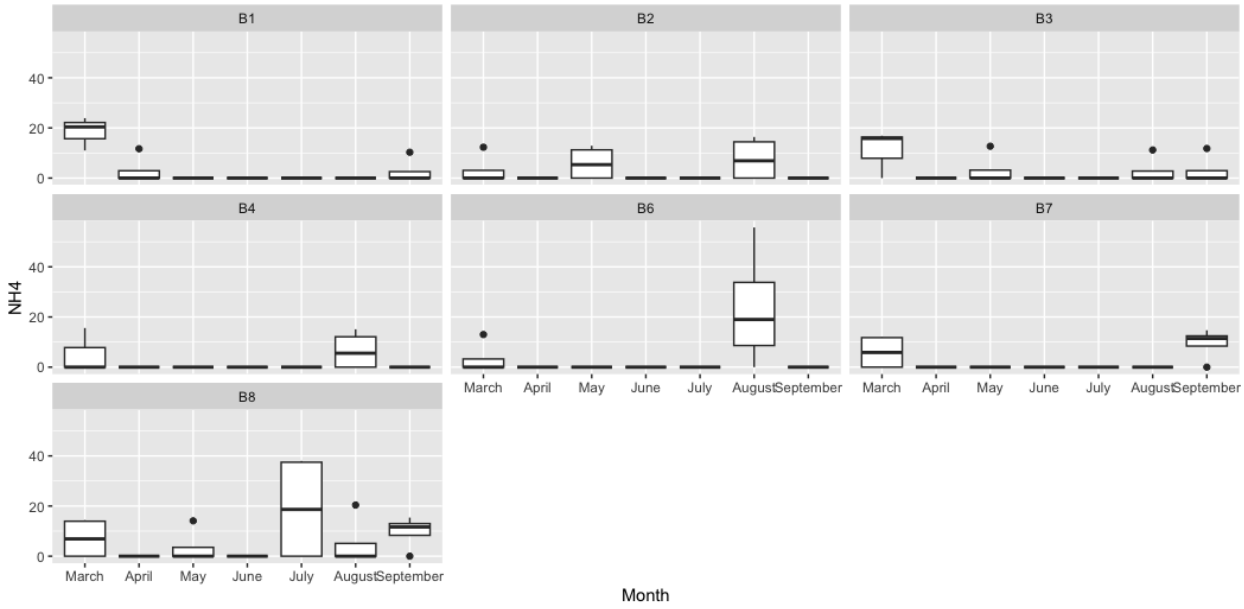


Figure 5. Boxplot of Average Ammonium (ug/L) levels at each Site* in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.

*B1: n=27, B2: n=28, B3: n=27, B4: n=27, B6: n=28, B7: n=28, B8: n=28

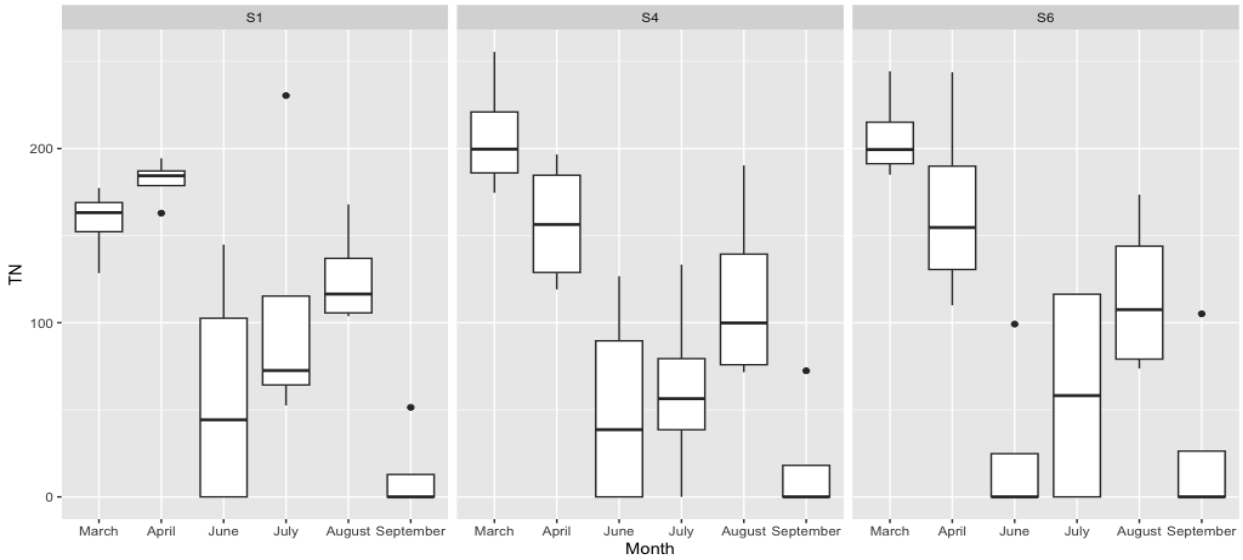


Figure 6. Boxplot of Average Total Nitrogen (ug/L) levels at each Site* in Shannon Lake from March to September (excluding May) 2021. Data collected by Upper Skagit Indian Tribe.
* S1: n=24, S4: n=24, S6: n=24

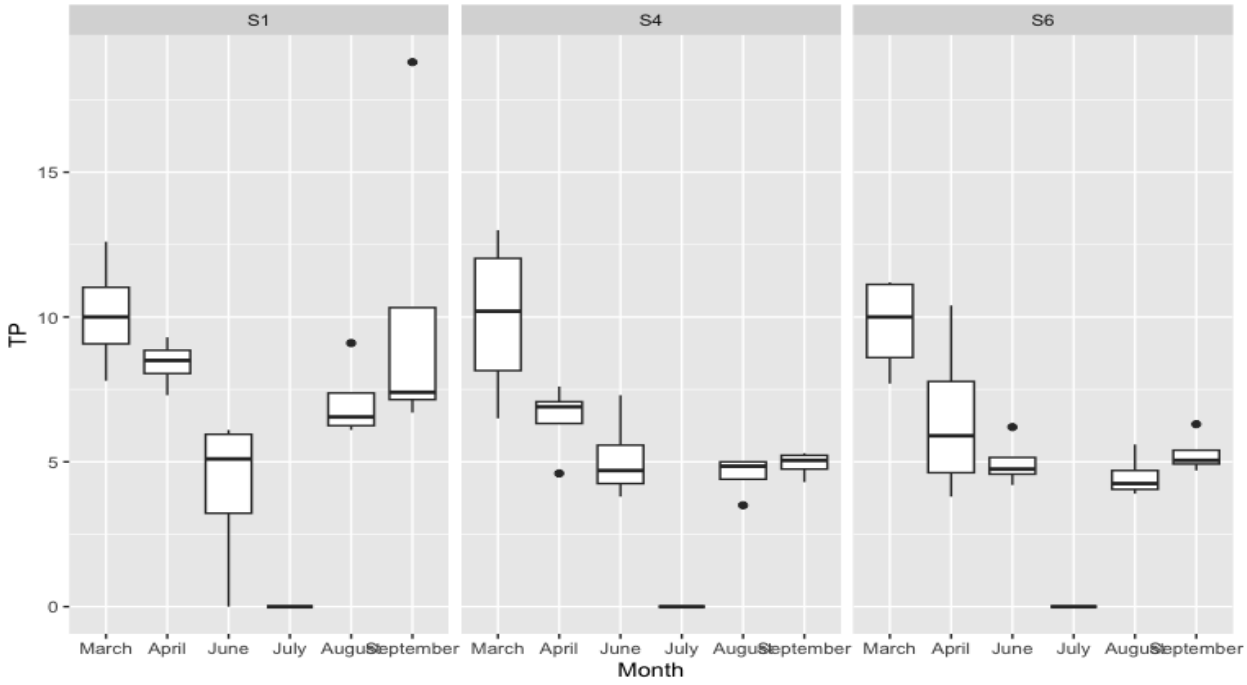


Figure 7. Boxplot of Average Total Phosphorous (ug/L) Levels at each Site* in Shannon Lake from March to September (excluding May) 2021. Data collected by Upper Skagit Indian Tribe.
* S1: n=24, S4: n=24, S6: n=24

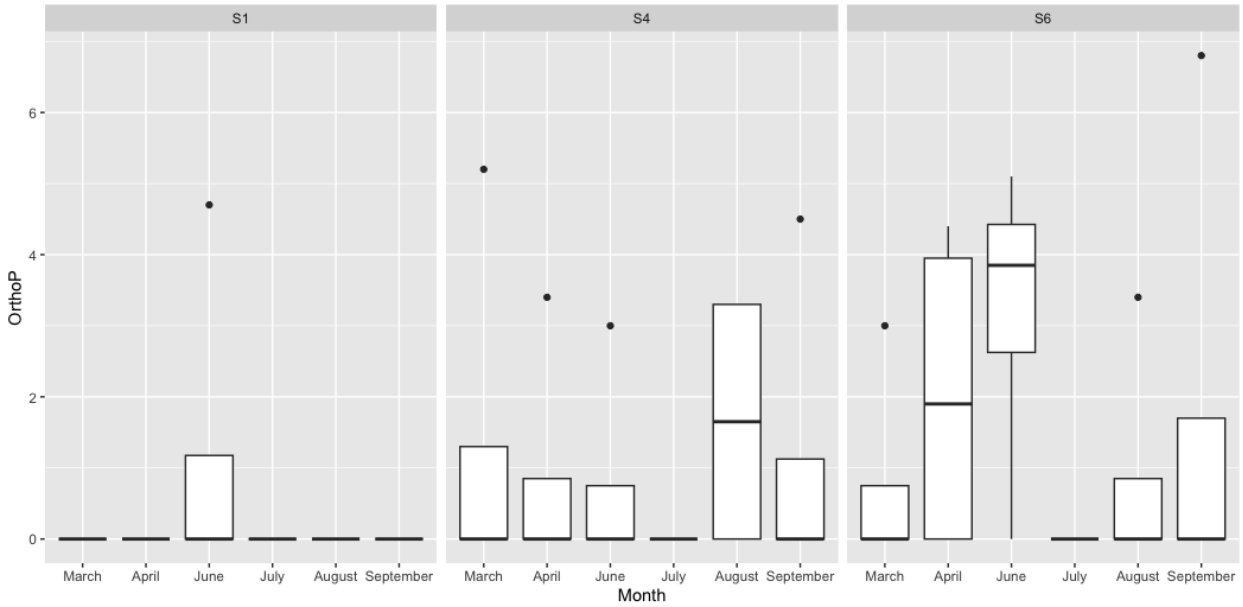


Figure 8. Boxplot of Average Orthophosphate (ug/L) levels at each Site* in Shannon Lake from March to September (excluding May) 2021. Data collected by Upper Skagit Indian Tribe.
* S1: n=24, S4: n=24, S6: n=24

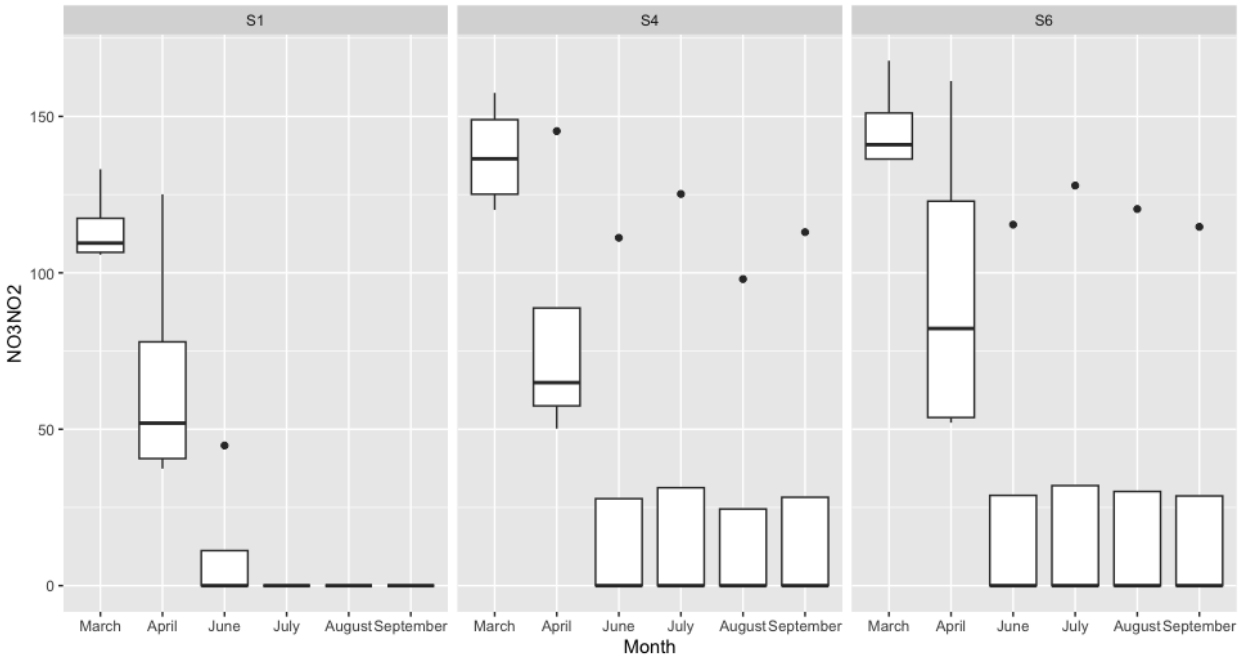


Figure 9. Boxplot of Average Nitrate/Nitrite (ug/L) Levels at each Site* in Shannon Lake from March to September (excluding May) 2021. Data collected by Upper Skagit Indian Tribe.
* S1: n=24, S4: n=24, S6: n=24

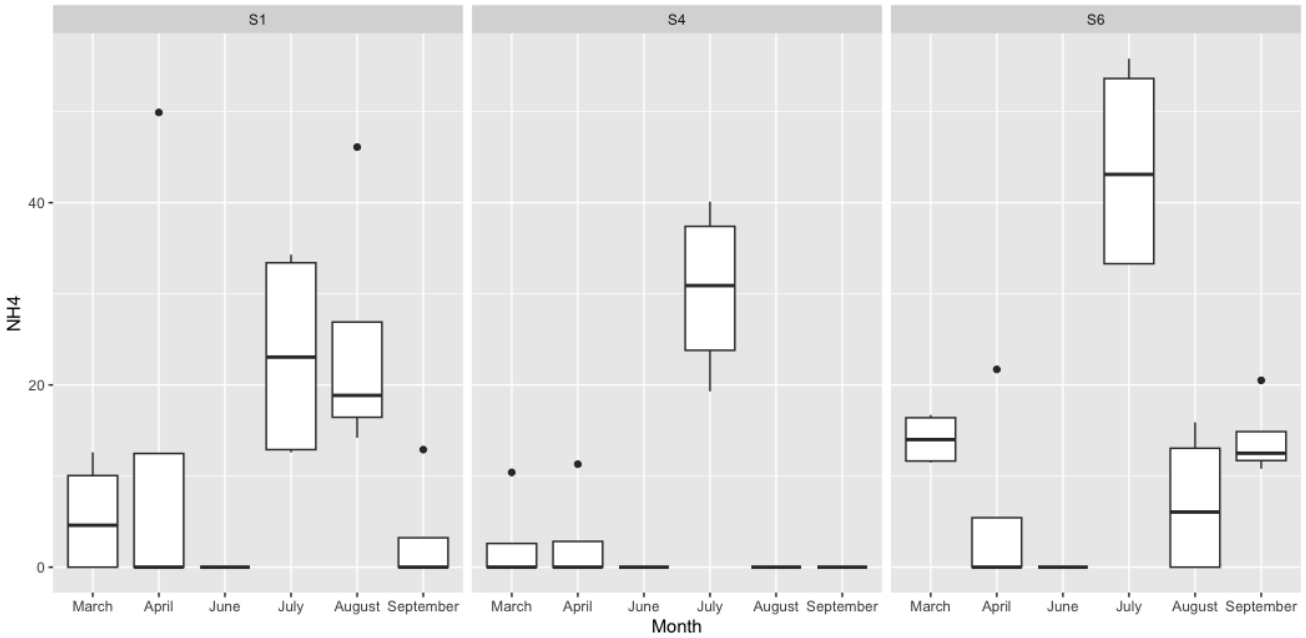


Figure 10. Boxplot of Average Ammonium (ug/L) Levels at each Site* in Shannon Lake from March to September (excluding May) 2021. Data collected by Upper Skagit Indian Tribe.
* S1: n=24, S4: n=24, S6: n=24

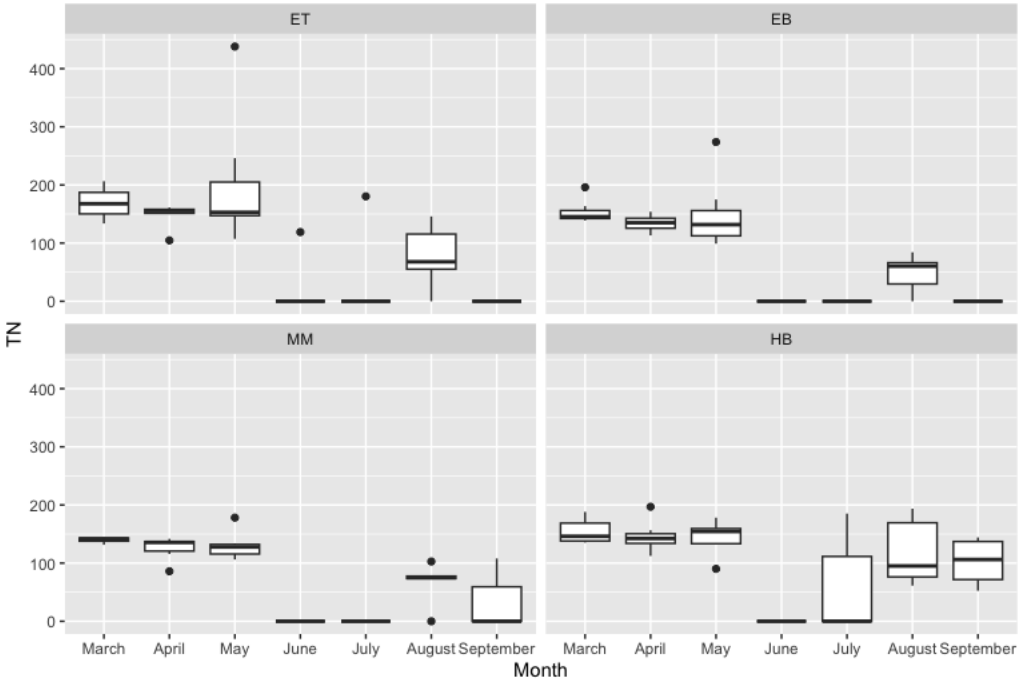


Figure 11. Boxplot of Average levels of Total Nitrogen (ug/L) at each Depth* in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=49, EB: n=46, HB: n=49, MM: n=49

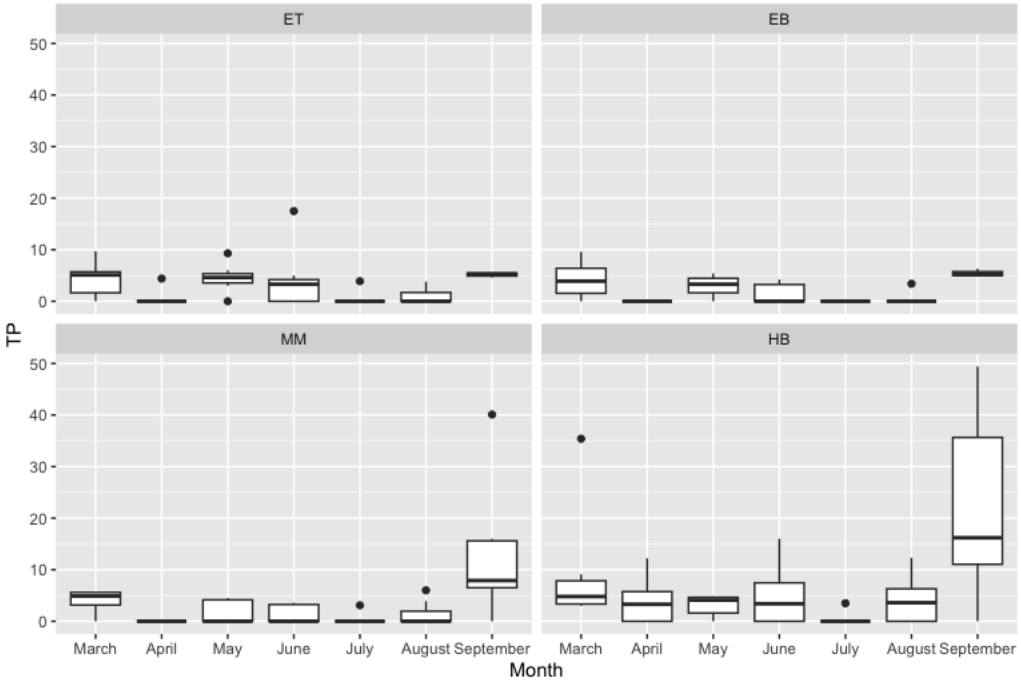


Figure 12. Boxplot of Average levels of Total Phosphorous (ug/L) at each Depth* in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=49, EB: n=46, HB: n=49, MM: n=49

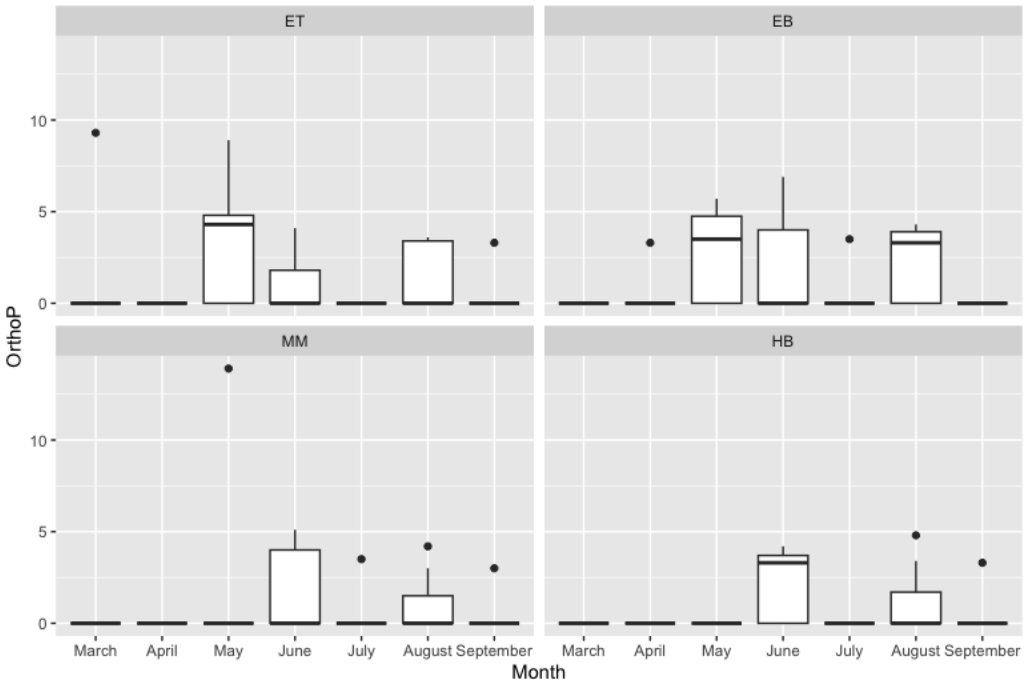


Figure 13. Boxplot of Average levels of Orthophosphate (ug/L) at each Depth* in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=49, EB: n=46, HB: n=49, MM: n=49

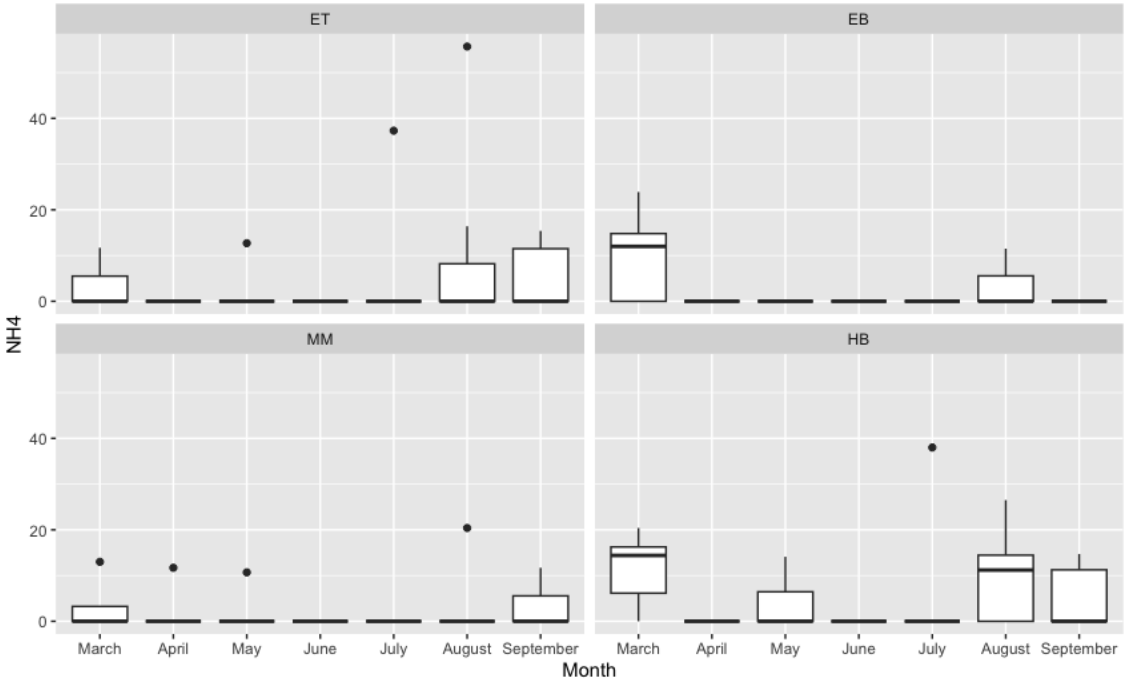


Figure 14. Boxplot of Average levels of Ammonium (ug/L) at each Depth* in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=49, EB: n=46, HB: n=49, MM: n=49

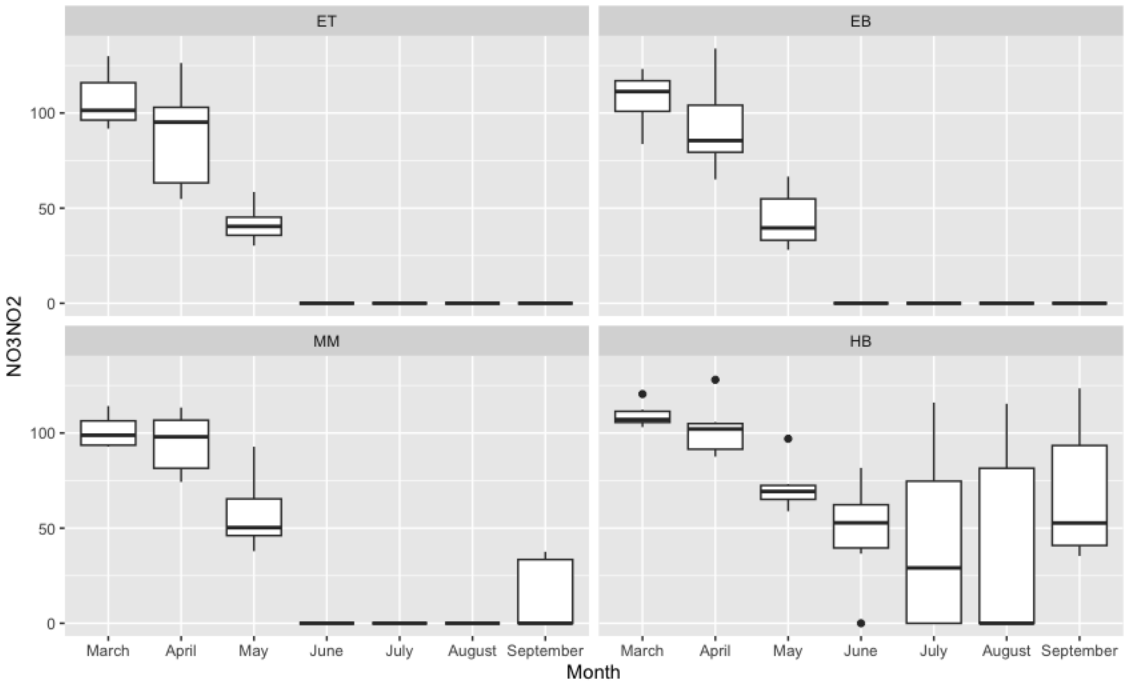


Figure 15. Boxplot of Average levels of Nitrate/Nitrite (ug/L) at each Depth* in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=49, EB: n=46, HB: n=49, MM: n=49

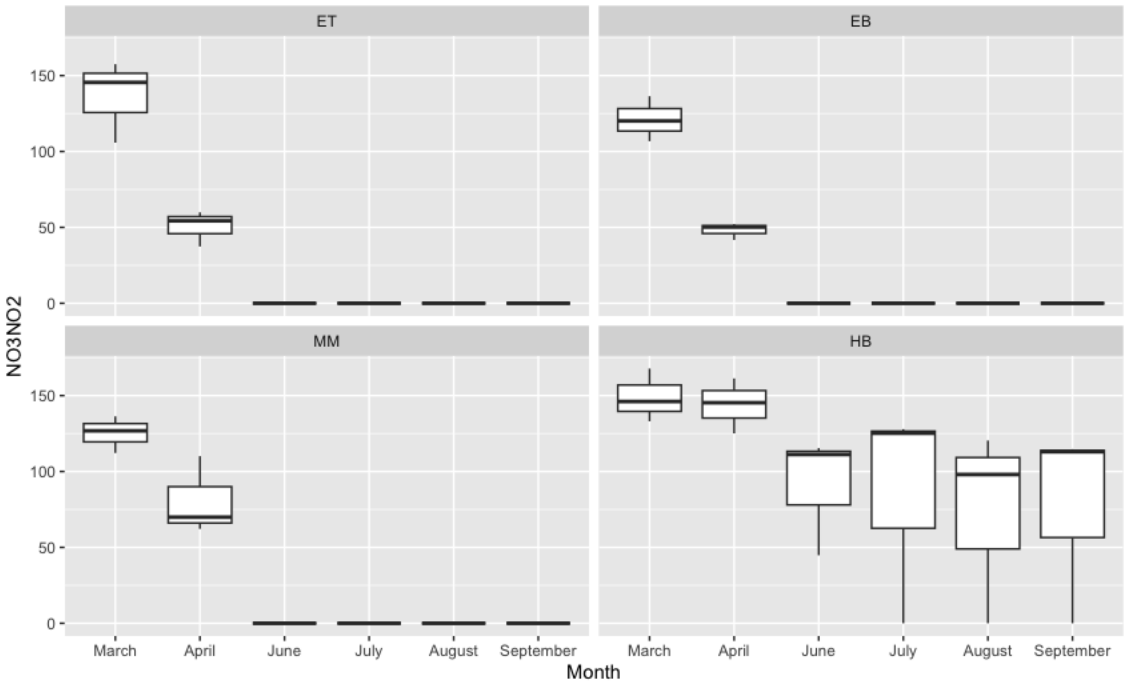


Figure 16. Boxplot of Average levels Nitrate/Nitrite (ug/L) at each Depth* in Shannon Lake March to September (excluding May) 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=18, EB: n=18, MM: n=18, HB: n=18

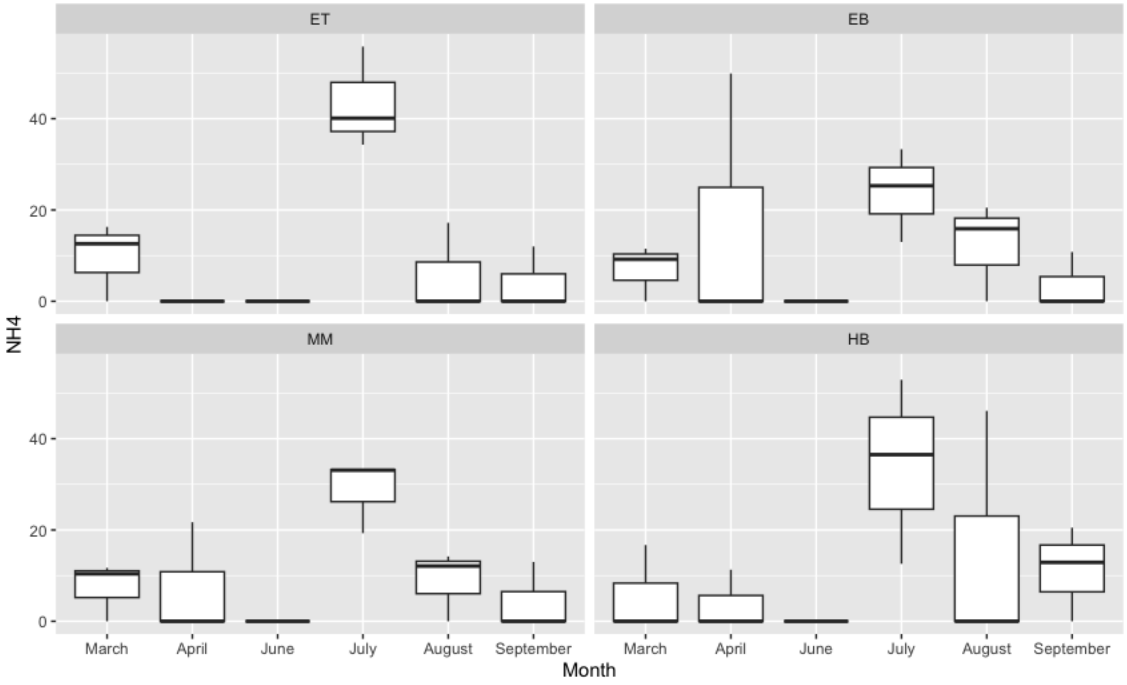


Figure 17. Boxplot of Average levels of Ammonium (ug/L) at each Depth* in Shannon Lake March to September (excluding May) 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=18, EB: n=18, MM: n=18, HB: n=18

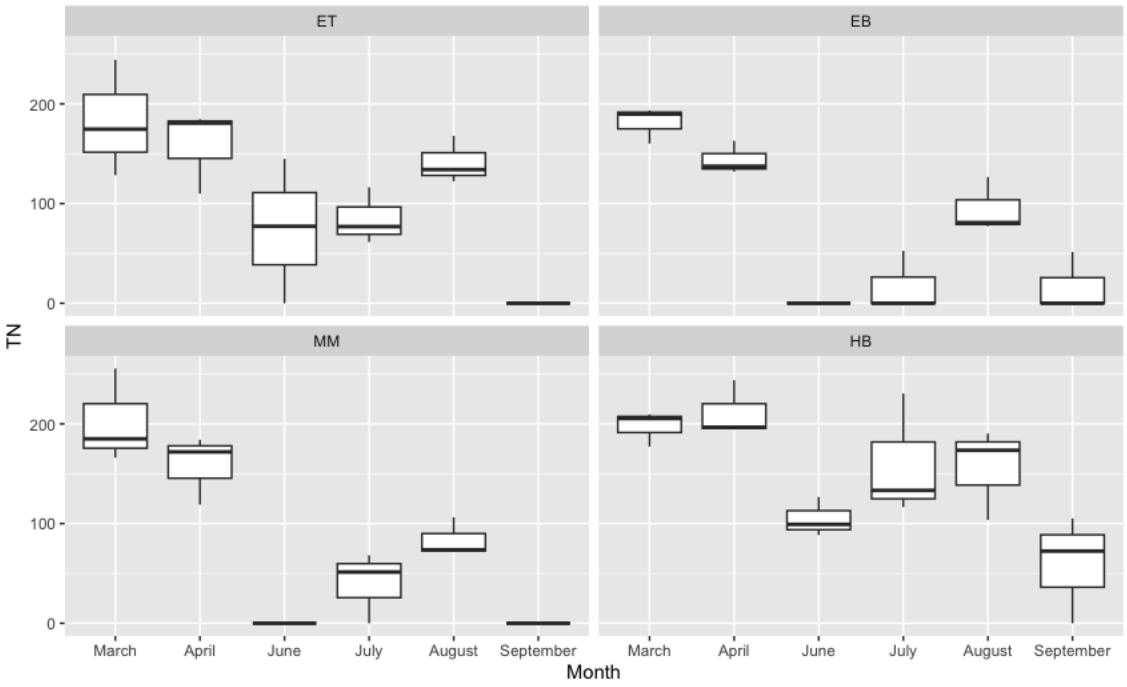


Figure 16. Boxplot of Average levels of Total Nitrogen (ug/L) at each Depth* in Shannon Lake March to September (excluding May) 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=18, EB: n=18, MM: n=18, HB: n=18

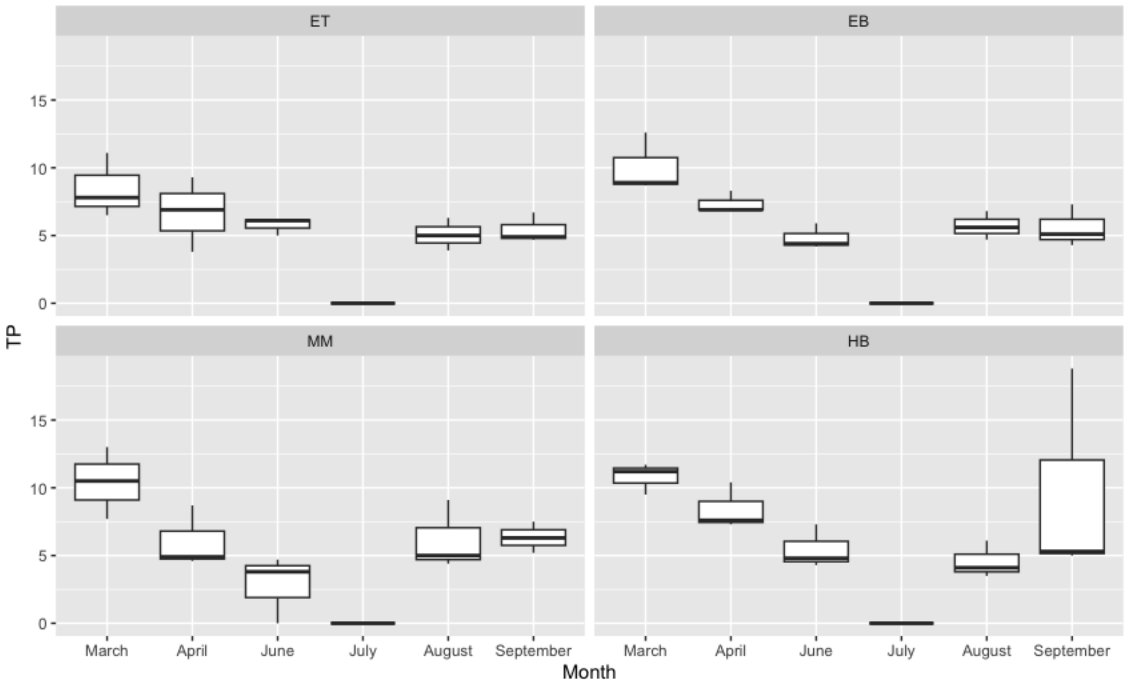


Figure 19. Boxplot of Average levels of Total Phosphorous (ug/L) at each Depth* in Shannon Lake March to September (excluding May) 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=18, EB: n=18, MM: n=18, HB: n=18

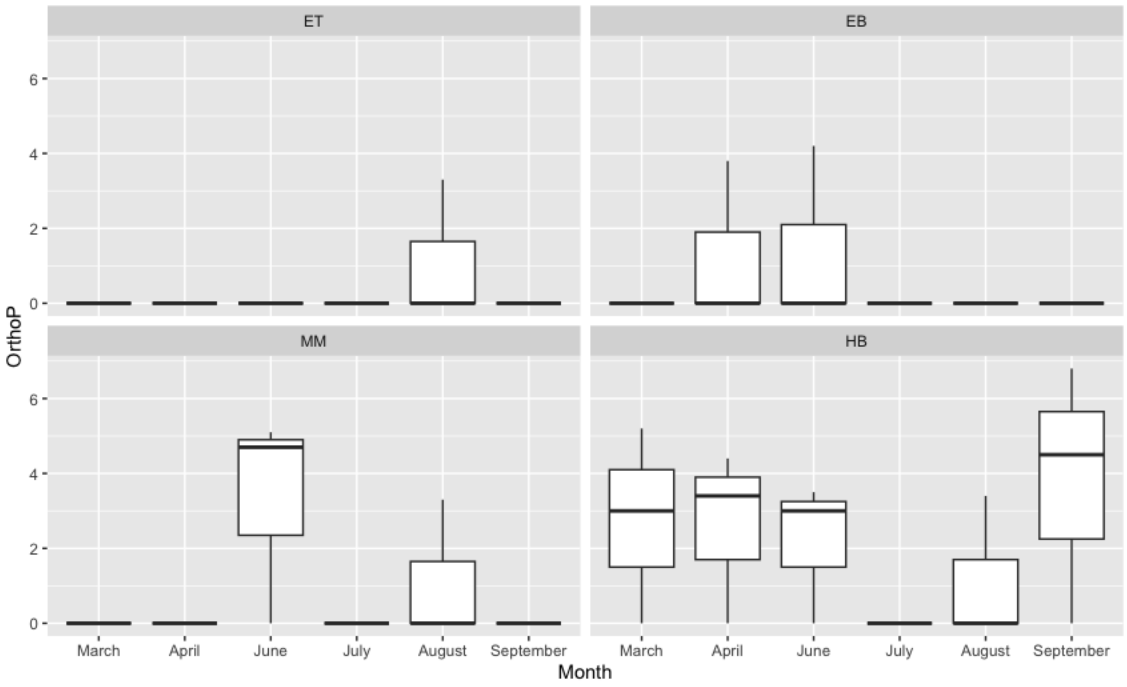


Figure 20. Boxplot of Average levels Orthophosphate (ug/L) at each Depth* in Shannon Lake March to September (excluding May) 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=18, EB: n=18, MM: n=18, HB: n=18

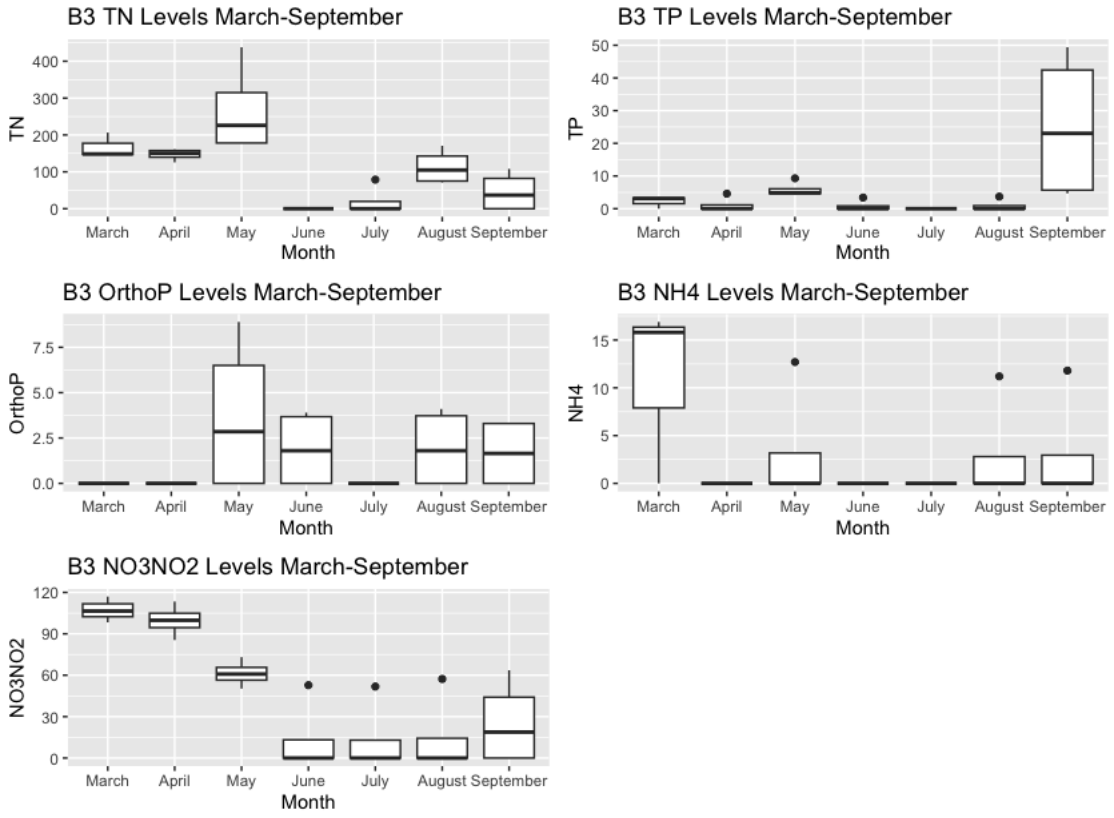


Figure 21. Boxplots of Average Levels of Total Phosphorus (ug/L) *, Total Nitrogen, Orthophosphate, Nitrate/Nitrite, and Ammonium of Site B3 on Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*TP: n=27, TN: n=27, OrthoP: n=27. NO3NO2: n=27, NH4: n=27

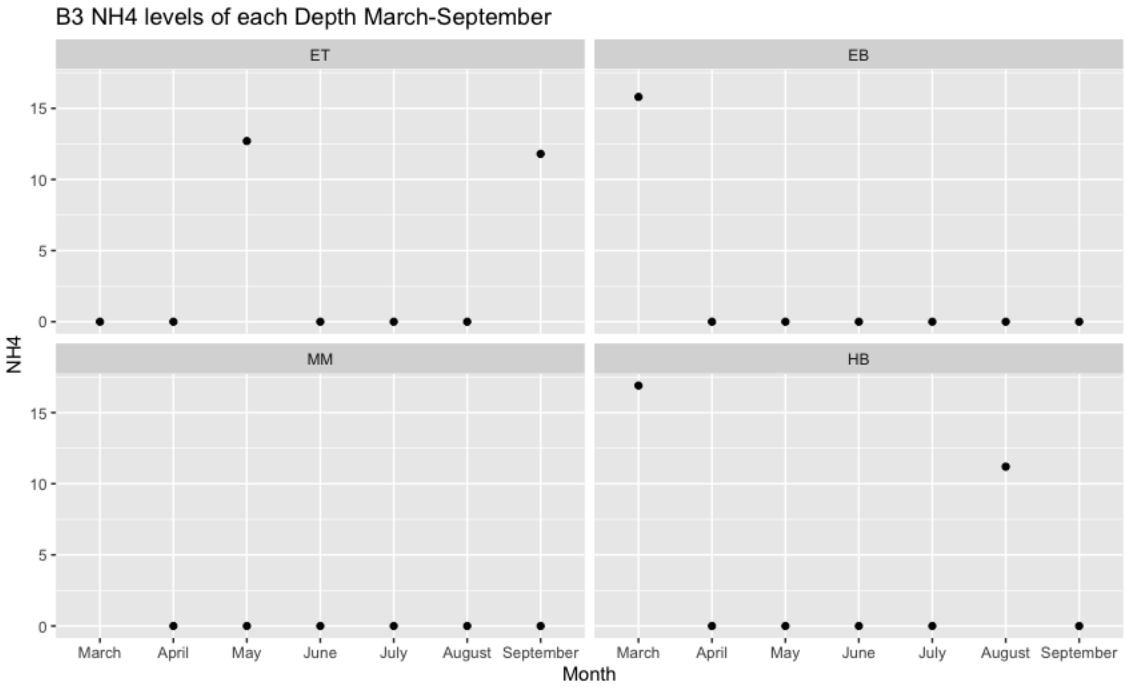


Figure 22. Levels of Ammonium of Site B3 at the Surface (ET)*, Bottom of the Epilimnion (EB), Metalimnion (MM), and the Hypolimnion (HB) in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=7, EB: n=6, MM: n=7, HB: n=7

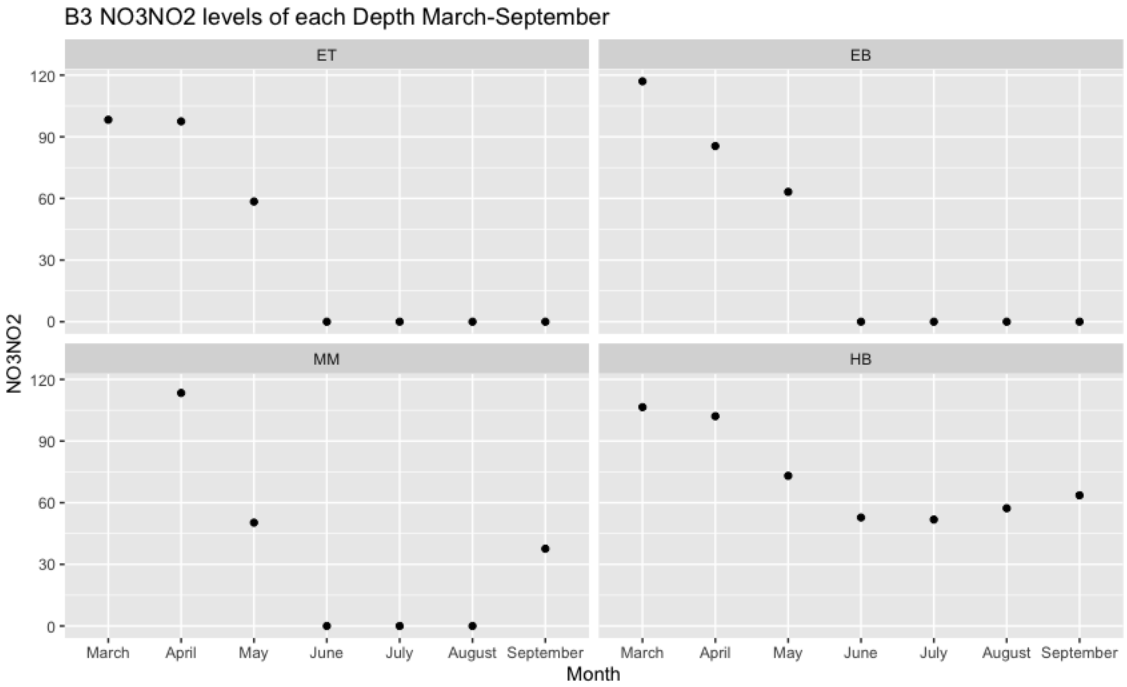


Figure 23. Levels of Nitrate/Nitrite (ug/L) of Site B3 at the Surface (ET)*, Bottom of the Epilimnion (EB), Metalimnion (MM), and the Hypolimnion (HB) in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=7, EB: n=6, MM: n=7, HB: n=7

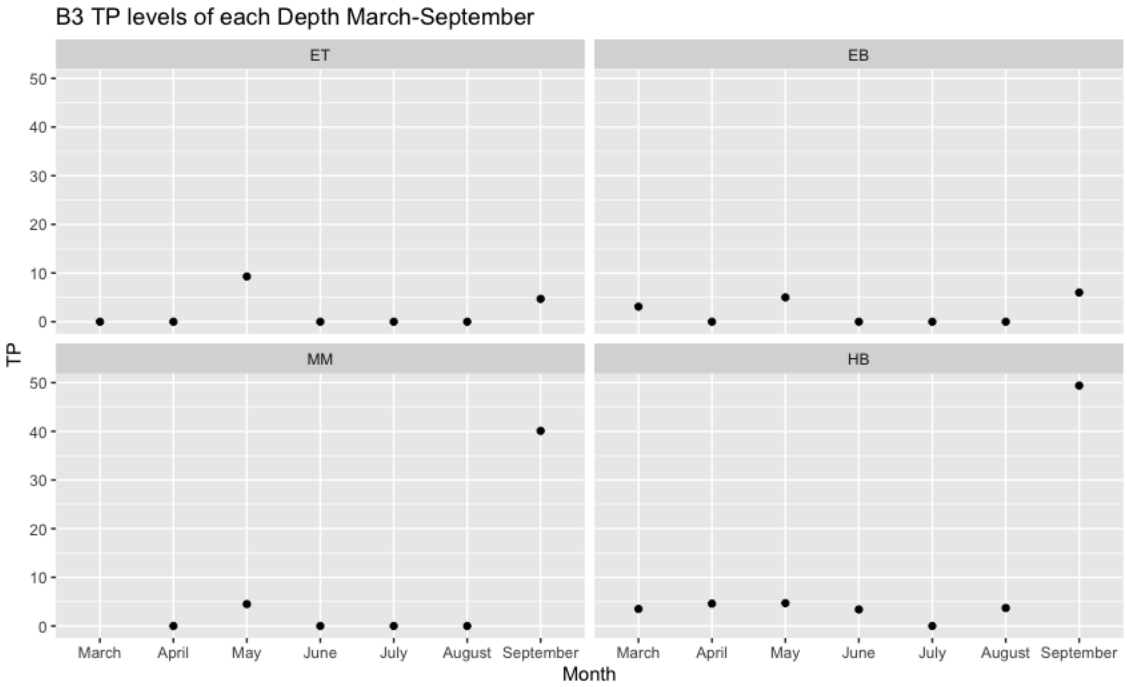


Figure 24. Levels of Total Phosphorus (ug/L) of Site B3 at the Surface (ET)*, Bottom of the Epilimnion (EB), Metalimnion (MM), and the Hypolimnion (HB) in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=7, EB: n=6, MM: n=7, HB: n=7

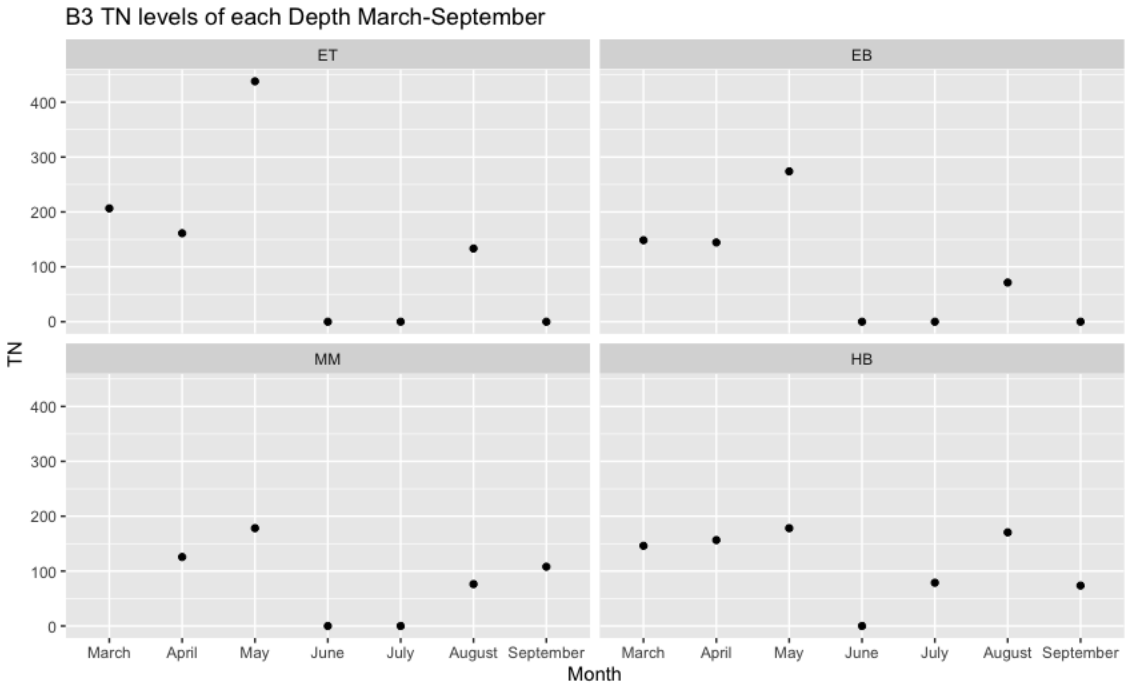


Figure 25. Levels of Total Nitrogen (ug/L) of Site B3 at the Surface (ET)*, Bottom of the Epilimnion (EB), Metalimnion (MM), and the Hypolimnion (HB) in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=7, EB: n=6, MM: n=7, HB: n=7

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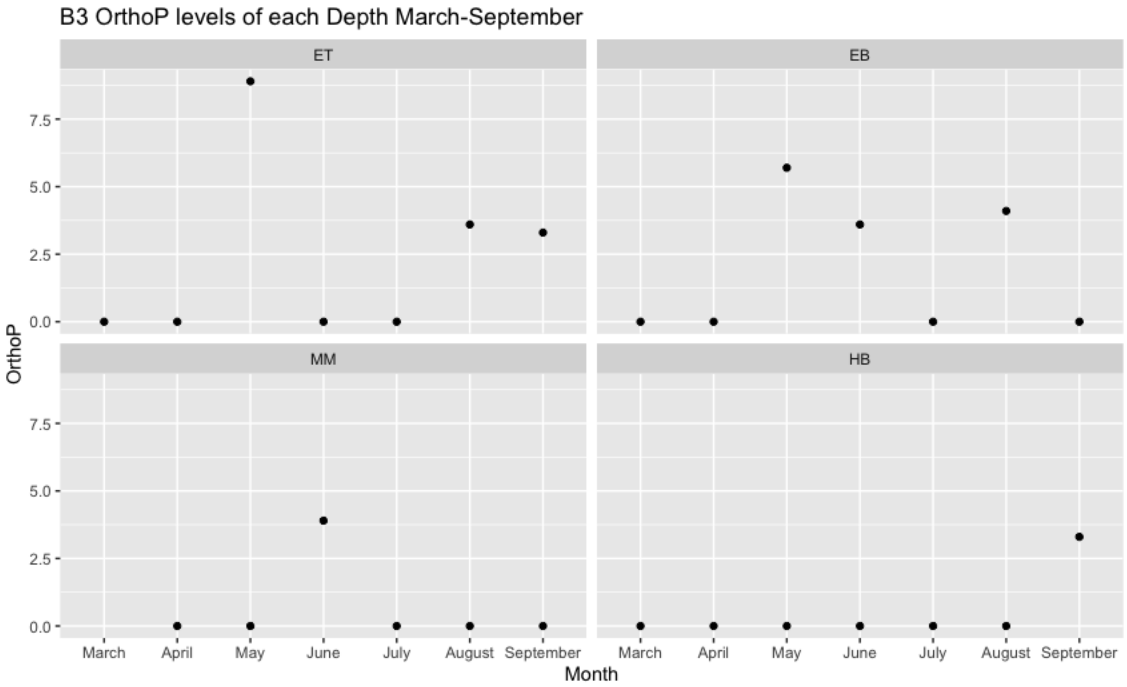

Figure 26. Levels of Orthophosphate (ug/L) of Site B3 at the Surface (ET)*, Bottom of the Epilimnion (EB), Metalimnion (MM), and the Hypolimnion (HB) in Baker Lake from March to September 2021. Data collected by Upper Skagit Indian Tribe.
*ET: n=7, EB: n=6, MM: n=7, HB: n=7

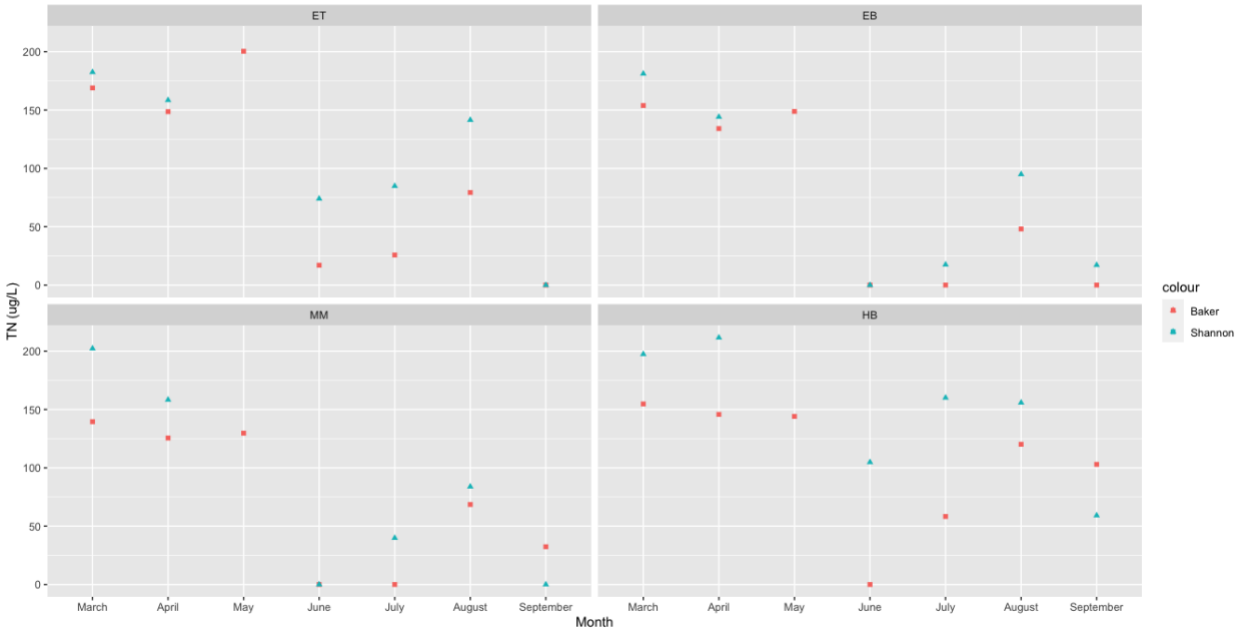

Figure 27. Levels of Total Nitrogen (ug/L) in Baker* and Shannon** Lakes from March to September 2021 (excluding May for Shannon Lake). Data Collected by Upper Skagit Indian Tribe.

*ET: n=49, EB: n=49, MM: n=46, HB: n=49

**ET: n=18, EB: n=18, MM: n=18, HB: n=18

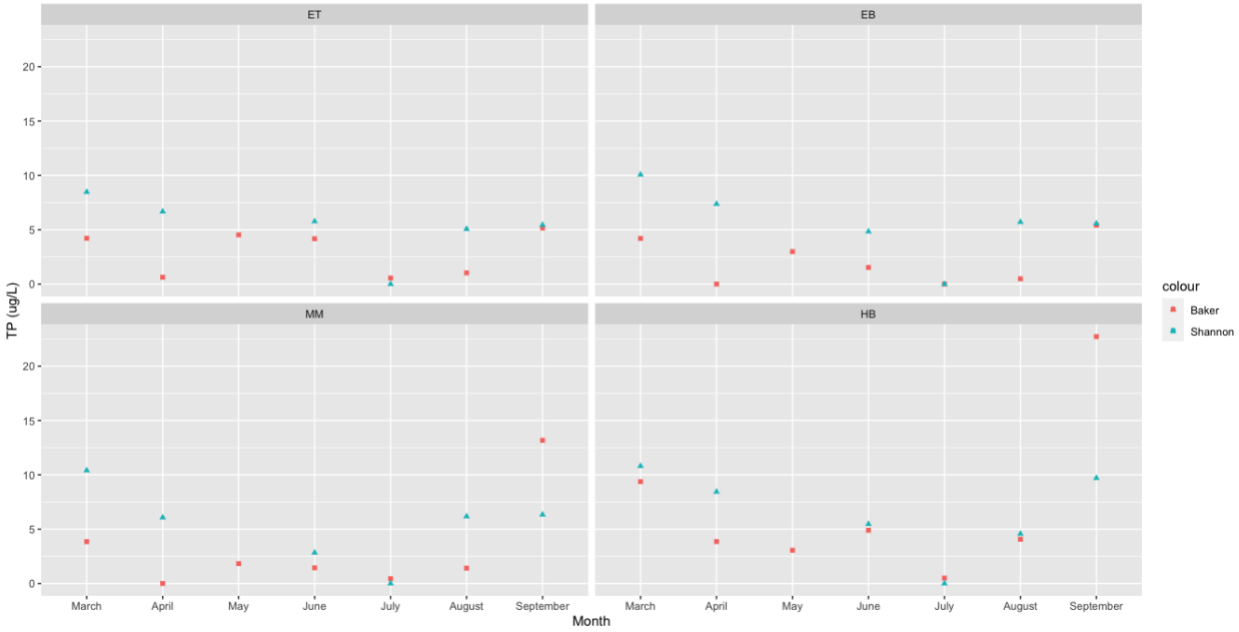

Figure 28. Levels of Total Phosphate (ug/L) in Baker* and Shannon** Lakes from March to September 2021 (excluding May for Shannon Lake). Data Collected by Upper Skagit Indian Tribe.

*ET: n=49, EB: n=49, MM: n=46, HB: n=49

**ET: n=18, EB: n=18, MM: n=18, HB: n=18