AQUATIC ECOSYSTEM RESEARCH
A Freshwater Conservation Company

MEMO

Date: July 5th, 2021

To: Heidi Cunnick, Cream Hill Lake Task Force

From: Aquatic Ecosystem Research

Re: Historical Data Analysis of Water Quality

Dear Heidi and Task Force Members,

Thank you for choosing Aquatic Ecosystem Research to assist in your management of Cream Hill Lake. Attached to this letter you will find a summary of the structural features of the dataset, pre-analysis data quality assessments, executed analyses, and our deductions from all tests. We have also provided recommendations about how to improve your water quality monitoring program.

If you have any questions, do not hesitate to contact me a 203-619-3322 or mjunewells@aerlimnology.com.

Sincerely,
AQUATIC ECOSYSTEM RESEARCH

Mark June-Wells, Ph.D
Certified Lake Manager
ESA Certified Ecologist

PURPOSE

Aquatic Ecosystem Research LLC was engaged by the Cream Hill Lake Task Force (CHLTF) to undertake an analysis of water quality data collected by volunteers. The main purpose of this study is to determine whether substantial or concerning changes in water quality have occurred since the first data collection initiative. The secondary and tertiary purposes were to examine the data collection strategy to determine whether more resolution or structure is necessary, and to provide recommendations as they relate to water quality management or data collection, respectively.

INTRODUCTION

Cream Hill Lake (41°53'01.99"N, 73°18'16.36"W) is a 29.5ha waterbody located in Cornwall, CT. The lake is situated in the Housatonic drainage basin and is 338m above sea-level. Cream Hill Lake has maximum depth of 13m and an average depth of 4.78m; it holds an estimated $3.68\text{x}10^8$ gallons of water. Additionally, the lake sits above a mica-schist/gneiss bedrock type comprised of quartz, plagioclase, biotite, muscovite, and sillimanite. The metamorphic bedrock is dark in color and weathers slowly, which contributes relatively low ion and nutrient masses to the waterbody.

Cream Hill Lake management and data collection is overseen by CHLTF; data in some form has been collected and compiled since 1986 at varying intervals. Furthermore, datasets such as dissolved oxygen and temperature data date back to 1986 while the nutrient dataset, which only includes total phosphorus and nitrogen, dates to 2015. The final variable that CHLTF evaluated was Secchi transparency; and, that occurred between 2013 and 2017. This sort of data asymmetry is common to volunteer programs. This understanding of the data is important to determine how to proceed into the future. To that end, Aquatic Ecosystem Research LLC undertook an analysis of the Cream Hill Lake historical dataset and reported results that were ethical regarding any structural limitations.

MATERIALS AND METHODS

Comments on Data Set:
Those data utilized in the proceeding analyses were provided by Cream Hill Lake Task Force to Aquatic Ecosystem Research LLC. Furthermore, AER assumes that the sampling and analyses were conducted in accordance with standard practices and that no data manipulation that could affect data validity has taken place prior to delivery to AER. Finally, we do not accept any liability as it applies to data reliability or validity. All analyses were undertaken with those assumptions.

Additionally, the following comments about the state of the data set were also considered during the analytical process. The first and most obvious shortcoming of the dataset provided to AER was its size; the data set spanned more than 30 years with a maximum of 20 discrete sampling events when all data are considered. That means that there are significant gaps between sampling events, which makes trend analysis difficult to interpret. In conjunction with the limited number of sampling events, the variables assessed throughout the study are asymmetrical with regards to when each variable was collected; in short, some variables were collected during some sampling events and not collected during other events. The final short coming of note is the nature of the timing of sampling events. The timing of sampling events only allows for a limited view of the lake-ecosystem dynamics because in years when more than one sample was taken, those samples were taken in mid-summer and fall; furthermore, when one sample was the sole representative of the year, it was taken in mid-summer or fall. While those data points are important to the assessments of lake systems, they do not give a full view of the dynamic nature of a temperate lake system, which changes significantly throughout the entirety of the year.

Despite these short comings we were able to execute some analyses that provide a historical snapshot of the summer and fall seasons including data trends that describe changes throughout time.

Data Treatment:

To effectively deal with data asymmetry issues, it was necessary to separate the holistic dataset into two different datasets. The first dataset included all nutrient data; those data were collected during October 2015, July 2016, October 2016, August 2017, July 2017, July 2018, July 2020, and October 2020. During all the sampling events, total phosphorus and total nitrogen variables were collected at depths of 1, 7, and 10m. To allow for additional exploratory analyses, we grouped each of the sampling events as either summer or fall. The final nutrient dataset included the variables month, year, depth, total phosphorus (mg/mL), total nitrogen (mg/mL), and season.

The second dataset was constructed from water clarity and vertical profile data (referred to as *Physical Dataset* below). Using those data from vertical profiles (i.e., temperature and dissolved oxygen from the top to the bottom of the water column) AER created a dataset that included variables important to determining temporal changes in the structural features of the lake. For each year and at each depth the RTRM (Relative Thermal Resistance to Mixing) values were calculated. RTRM, which is an assessment of the ability of two different water volumes – that differ in temperature and density – to mix, was calculated using the Relative Thermal Resistance to Mixing (RTRM) formula: $(D_1 - D_2)/(D' - D^o)$, where D_1 is the density of upper water volume, D_2 is the density of the lower water volume, D' is the density of water at 5°C, and D^o is the density of water at 4°C. Utilizing those calculations, AER identified where the greatest RTRM (i.e., thermocline) was located within the water column and to evaluate the size of the epilimnion and hypolimnion. Finally, we included a suite of oxygen variables in this dataset. The second dataset in its final form included the variables month, year, season, Secchi depth, Maximum (Max) RTRM, depth of Max RTRM (thermocline), surface oxygen (mg/mL), Max oxygen (mg/mL), depth of Max oxygen (m), depth of oxygen below 1mg/mL (m), epilimnion size (m), and hypolimnion size (m).

Those two datasets were used independently in subsequent analyses to determine temporal trends.

Statistical Techniques:

To assess the structural features of the constructed datasets we used Shapiro-Wilk Test to evaluate the distribution of each variable. We also transformed variables that did not meet normality assumptions and retested them to evaluate whether normality improved.

To evaluate the dataset and the temporal trends (i.e., by year), both data sets were analyzed using General Linear Models (GLM). Where the datasets permitted, they were evaluated using multiple linear regressions (MLR). That technique was also used to evaluate data trends by depth. To determine whether multivariate models were significant, the F-statistic was used to calculate the p-value and the adjusted multiple r-value was compared to a table of critical values to determine whether multivariate significance was statistically ethical.

When the structural features did not allow for multivariate analysis (i.e., limited data variance), each variable was examined individually using linear regression. To determine whether the univariate models were significant, the F-statistic was used to calculate the p-value and the adjusted r-value was compared to a table of critical values to determine whether univariate significance was statistically ethical.

To compare variables across seasons, univariate T-tests were deployed to determine whether mid-summer or fall variables differed significantly.

Multiple linear regression was used to evaluate whether there were temporal differences among nutrient variables between 2015 and 2020. Furthermore, T-tests were used to compare nutrient variables between the summer and fall seasons. Finally, linear regressions were used to evaluate the temporal differences among physical variables between 1986 and 2017; the physical data set was not large enough to support MLR or seasonal comparisons.

RESULTS AND DISCUSSION

Normality:

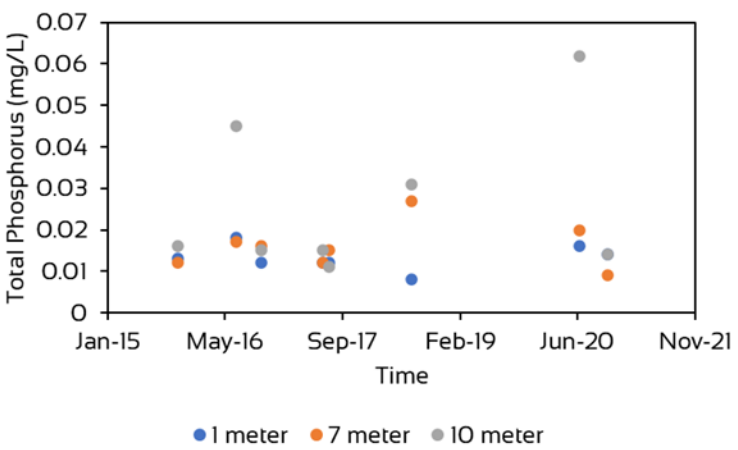
Each of the datasets (i.e., nutrients and physical) were tested for normality by examining each variable individually and analyzing their distribution with the Shapiro-Wilk Test for Normality. When each variable of the nutrient dataset was tested (i.e., total phosphorus and total nitrogen), neither variable conformed to the assumption of normality. Those data were then log-transformed and converted to z-scores then retested using the same test. Neither transformation improved the structural nature of the dataset.

When each variable of the physical data set was tested using the Shapiro-Wilk Test for normality, some variables conformed to the assumption of normality and some variables did not. Those variables that were found to meet the normal distribution were: Secchi depth (m), Max RTRM, surface oxygen (mg/mL), and Max oxygen (mg/mL). Conversely, depth to Max RTRM (m), bottom oxygen (mg/mL), depth of Max oxygen (m), depth to oxygen <1.0mg/mL (m), size of epilimnion (m), and size of hypolimnion (m) were found to violate the assumption of normality. No transformations improved normality in the variables that were found to be of a non-normal distribution.

Despite the outcomes of the normality tests, the decision was made to use parametric statistical strategies because: 1) normality was not the biggest issue with the dataset, 2) parametric approaches are more sensitive, and 3) the results would be cross-referenced with statistical tables to confirm whether any significant finding was statistically ethical (e.g., Critical Values).

Nutrient Dataset:
The dataset containing the variables total phosphorus and total nitrogen was first analyzed as a whole to determine the trend of the system – and the variables – between 2015 and 2020 using Multiple Linear Regression. The resulting model did not differ significantly from random ($F=0.76$, $p<0.48$, $r^2=0.07$). Moreover, the individual variables did not differ significantly over the aforementioned timeframe; total phosphorus did not vary in a significant manner ($t=1.06$, $p<0.30$) and nor did total nitrogen ($t=-0.772$, $p<0.45$). Those results suggest that the nutrient parameters measured during the study period did not change appreciably nor did their trajectories differ from random; overall, the holistic total phosphorus and nitrogen state of the lake has been stable based on the data collected.

The second analysis conducted was designed to look at whether the nutrient state of the lake varied by depth (Fig. 1). That analysis resulted in a system-based model that was not different from random ($F=2.15$, $p<0.14$, $r^2=0.17$); however, the total phosphorus variable did show a significant trend in concentration with depth. Total phosphorus was found to increase with depth in a manner that was significantly different from random ($t=2.07$, $p<0.05$; Fig. 2).



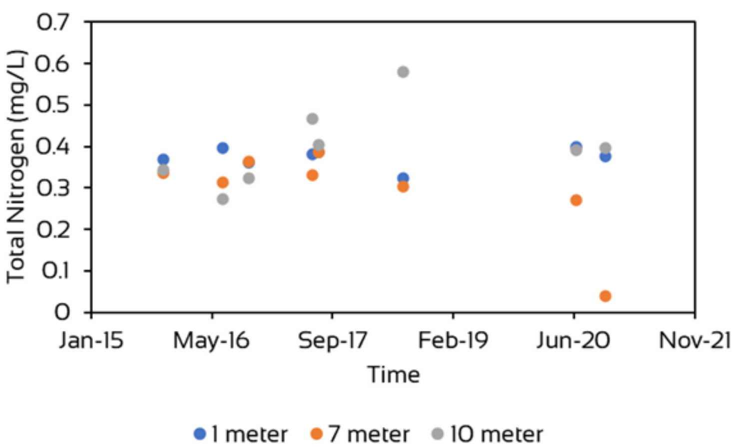


Figure 1. Total phosphorus (top) and total nitrogen concentrations over time by depth.

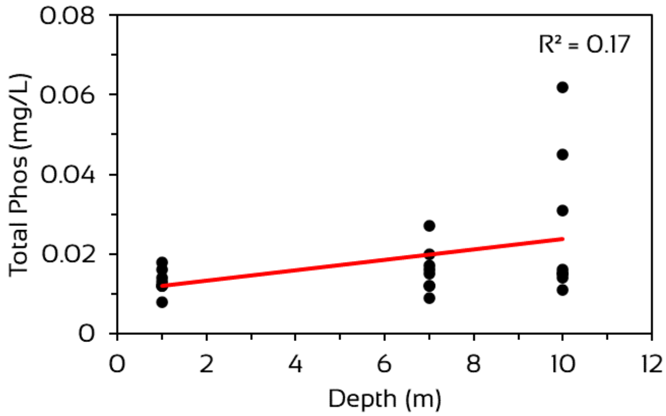


Figure 2. Relationship between total phosphorus and depth at Cream Hill Lake based on data collected between 2015 and 2020.

This finding suggests that there is more phosphorus per unit water-volume as depth increases and is likely a result of dissolution of phosphate from the underlying sediments. This phenomenon is generally associated with deoxygenation of deep waters (i.e., hypolimnion), which causes phosphate to dissociate from other minerals (e.g., iron, manganese, organic material, etc.) and become soluble in the water. Furthermore, asymmetrical heating of the shallow waters results in a phenomenon where mixing between deep waters and surface waters is prevented. That phenomenon is called thermal stratification; the top and bottom waters are no longer mixing, and oxygen is depleted from the deep waters resulting in phosphorus release from the sediments. A holistic view of the Cream Hill Lake dataset suggests that the aforementioned is occurring every year; and, that the bottom sediment could be the major source of phosphorus to the lake. There was not a pattern in the total nitrogen variable when depth was utilized as the constraining variable but that does not mean that there is no difference in nitrogen with depth; it is likely that the ammonia component of the total nitrogen variable would exhibit a similar trend to phosphorus because of its relationship to oxygen concentration.

The third analysis that was conducted on the nutrient dataset was designed to compare the nature of the water chemistry during the summer season (i.e., July) and the fall season (October). Additionally, we also compared the state of the epilimnion, metalimnion, and hypolimnion during both seasons. To compare the aforementioned by season, a Student's T-test was used. When we compared the nutrient status of the whole waterbody by season, the results suggest that the concentration of phosphorus ($t=-2.06$, $p<0.57$) and nitrogen ($t=-1.23$, $p<0.24$) did not differ significantly between 2015 and 2020. When the state of the epilimnion was compared across the summer and fall seasons, resulting statistics suggest that the state of phosphorus ($t=-0.11$, $p<0.92$) and nitrogen ($t=0.61$, $p<0.57$) did not vary significantly between 2015 and 2020. In regard to the metalimnion, the results suggest that phosphorus ($t=-1.80$, $p<0.12$) and nitrogen ($t=-0.71$, $p<0.55$) were not significantly different between the summer and fall seasons. Finally, hypolimnetic phosphorus ($t=-1.87$, $p<0.13$) and nitrogen ($t=-1.27$, $p<0.26$) were not significantly different when the seasons were compared. These results suggest that the summer and fall seasons are similar and that the nutrient status of the lake's layers were stable throughout the study period. However, it should be noted that we do not have any early season data to analyze; early season nutrient data may change the outcome of these pairwise comparisons.

Physical Dataset:

The physical dataset's structure did not allow for the use of multivariate statistical approaches; therefore, univariate approaches were used. Specifically, General Linear Models were utilized to examine each variable individually. The physical data set was too small to allow AER to analyze any differences among seasons; therefore, all analyses were conducted to examine each variable's trend with year as the independent variable.

The results of the analyses associated with each variable – except for depth to oxygen below 1mg/mL - were found to not differ significantly from random. Despite the detection of a significant pattern in the variable "depth to oxygen below 1mg/mL", we assert that this is likely a Type I error (i.e., false positive) based on the following. Firstly, there were a total of 6 data-points; five of them were calculated to be 8m and one was calculated to be 6m. Secondly, a single data point with a different value was recorded in 1986; oxygen sensors and analytical techniques have significantly improved since then. Additionally, the subsequent year that oxygen concentrations were measured after 1986 was 2013. With that in mind, the difference in precision of equipment could have a marked impact on the dataset. Even if this is a false positive, it is a positive finding that suggests that the total volume of water that is enriched with oxygen has improved since 1986.

Finally, within the physical data set an interesting correlation was found during the evaluation of the dataset. AER found that there was strong correlation between Secchi depth and depth to maximum oxygen. When these two variables were analyzed to determine if the trend was significantly different from random, the results suggest that there was not a significant relationship at the 95% significance level; nor was the r^2 value in concordance with the critical value for the level of significance. However, the relationship was found to be significant – with an appropriate critical value – at the 90% significance level. We assert that this relationship is indeed important despite not meeting the customary significance limit; the lack of significance at the 95% level is likely due to the small nature of the dataset. Therefore, this relationship is something that should be monitored in the future because it suggests that the water clarity of the lake (i.e., Secchi transparency) is tightly tied to the lake stratum with the highest oxygen concentration, which suggests that the planktonic algal community is concentrated in a single stratum of the lake and creating an oxygen rich environment in that layer. Furthermore, the dense concentration of algae at a specific layer is the major factor controlling water clarity; where the algae are densely layered has been – and likely will continue to be – the limit of clarity in Cream Hill Lake. For full results see Appendix 1.

CONCLUSION

Based on the mid-summer and fall season data that were provided to Aquatic Ecosystem Research, the Cream Hill Lake system falls within the early mesotrophic to mesotrophic range. If water clarity were considered alone, the lake would be classified as oligotrophic; however, when all available data are considered, we believe that the early mesotrophic to mesotrophic tropic status is more appropriate. The reason for this assertion is associated with the mid-summer and fall total phosphorus and total nitrogen concentrations. Those data averages fall within a range that is considered mesotrophic (Table 1).

Table 1. Trophic classification criteria used by the Connecticut Experimental Agricultural Station (Frink and Norvell, 1984) and the CT DEP (1991) to assess the trophic status of Connecticut lakes. The categories range from oligotrophic or least productive to highly eutrophic or most productive.

Trophic Category	Total Phosphorus (μg / L)	Total Nitrogen (μg / L)	Summer Chlorophyll-*a* (μg / L)	Summer Secchi Disk Transparency (m)
Oligotrophic	0 - 10	0 - 200	0 - 2	>6
Early Mesotrophic	10 - 15	200 - 300	2 - 5	4 - 6
Mesotrophic	15 - 25	300 - 500	5 - 10	3 - 4
Late Mesotrophic	25 - 30	500 - 600	10 - 15	2 - 3
Eutrophic	30 - 50	600 - 1000	15 - 30	1 - 2
Highly Eutrophic	> 50	> 1000	> 30	0 - 1

Overall, the Cream Hill Lake nutrient and physical data trends appear to be stable over the entirety of the study period. Additionally, there were no major differences found between the summer and the fall period; the available dataset suggests that the lake is in good health. The major issue with this analysis was the size and symmetry of the data collection initiatives. While all data and analysis are associated with good conditions, the abridged and asymmetrical natures of the dataset do not afford AER the ability to evaluate seasonal trends or how those seasonal trends vary overtime. Furthermore, while we were able to detect some signs of internal loading of phosphorus from the sediments of the lake, we were unable to determine whether there were early season watershed influences on the lake and how the watershed might be affecting the state of water quality throughout the season. In short, it is imperative to improve the nature of the data collection initiative to allow for a true analysis of seasonal and yearly trends.

RECOMMENDATIONS

The following are Aquatic Ecosystem Research LLC's recommendations for future water quality analysis. Here we provide two options for monitoring the system: 1) A volunteer-based program and 2) a professionally executed program.

Firstly, it is important to structure the data collection initiatives in a manner that affords the Task Force the ability to analyze the system over a longer time period. Secondly, it is important to expand the number of variables that are evaluated during the data collection events. Both of these goals can be easily achieved in either of the frameworks provided below.

Before describing the different practical strategies, the proceeding variables and temporal structures should be adopted no matter what data collection approach is selected.

- Variables:
  - Class 1 – Vertical Profiles
    - These variables should be collected at 0.5m and at every meter from the surface to the bottom.
      - Dissolved Oxygen (mg/mL)
      - Temperature (C)
      - pH (SU)
      - Specific Conductance (us/cm)
  - Class 2 – Nutrient Data
    - These variables should be collected at 0.5m below the surface and 0.5m above the sediment-water interface. It is optional whether to collect these data at middle depths.
      - Alkalinity
      - Total Phosphorus (mg/L)
      - Total Kjeldahl Nitrogen (mg/mL)
      - Ammonia (mg/mL)
      - Nitrite/Nitrate (mg/mL)
      - Iron (mg/mL)
      - Calcium (mg/mL)
      - Magnesium (mg/mL)
      - Chloride (mg/mL)
  - Class 3 – Physical and Biological Variables
    - These variables are collected at specific depths within the water column or are measurements associated with water clarity.
      - Secchi Depth (m)
      - Algal Community
        - Diversity Sample – Concentrated Net Sample
        - Quantitative Sample – Integrated Tube Sample

The aforementioned variables should be collected within one of the following temporal structures:

- Basic Timeframe:
  - This design is structured to evaluate early, middle, and late recreational season dynamics of the lake.
    - Months:
      - May
      - July
      - September

- Recommended Timeframe:
  - This design is structured to evaluate the entirety of the recreational season. This is the design that is most well balanced in regards to cost vs. value of data.
    - Months:
      - May
      - June
      - July
      - August
      - September
      - October
- Extended Timeframe:
  - This design is structured to evaluate a longer period of the recreational season and to evaluate the influences of the early and late season flushing/mixing events on the lake system. This design is common when lake communities are having significant water quality issues.
    - Months:
      - April
      - May
      - June
      - July
      - August
      - September
      - October
      - November

The following are the two different approaches available for data collection.

- Trained Volunteers:
  - Aquatic Ecosystem Research LLC will identify and source all equipment as well as establish a relationship with a local analytical laboratory.
    - Cost of equipment will be paid for by the Task Force.
  - Aquatic Ecosystem Research LLC personnel will develop a standard operating procedure and train resident-volunteers how to execute the study design.
  - Associated Costs:
    - The cost required for startup will depend on the current equipment inventory of the Task Force; here we present costs for all equipment.
      - Class 1 Variables:
        - YSI Multimeter or similar: $3,500.00
      - Class 2 Variables:
        - Van Dorn Horizontal Sample: $500.00 - $700.00
        - Associated Laboratory Cost per event: $150.00
      - Class 3 Variables:
        - Secchi Disc: $50.00
        - Net Sampler: $200.00
        - Integrated Sampler: $100.00
        - Algae Enumeration Costs per event: $175.00

        - Sourcing and Training:
            - Location and Sourcing of Equipment: $500.00
            - Onsite training: $1,000.00
        - Optional and ongoing costs of analysis and reporting:
            - $2,500.00/yr

- Aquatic Ecosystem Research Professional Monitoring:
    - AER will execute all sampling events, delivery of samples to the lab, analysis of all algae samples, analysis of all yearly data, and provide a yearly report.
        - $1,200.00/event at one sample site.
            - $1,500.00/event at two sample sites.
        - $2,500 for the yearly report.

APPENDIX 1. STATISTICAL ANALYSES

Physical Dataset – Descriptive Statistics

Descriptive Stats Overall	Secchi	Max RTRM	Depth MRTRM	Surf O	Bot O	Max O2	D Max O2	TD O Low	Epi Sz	Hypo Sz
Avg.	6.54	96.18	5.50	8.85	0.09	10.81	4.00	7.67	3.33	3.50
SD	0.71	9.91	1.22	0.27	0.04	1.83	3.10	0.82	1.97	0.55
N	5	6	6	6	6	6	4	6	6	6
SE	0.32	4.05	0.50	0.11	0.02	0.75	1.55	0.33	0.80	0.22
Conf 95	0.62	7.93	0.98	0.22	0.03	1.46	3.04	0.65	1.57	0.44
Ubound	7.16	104.11	6.48	9.07	0.12	12.27	7.04	8.32	4.91	3.94
Lbound	5.92	88.25	4.52	8.63	0.06	9.35	0.96	7.01	1.76	3.06

Descriptive Stats Fall	Secchi	Max RTRM	Depth MRTRM	Surf O	Bot O	Max O2	D Max O2	TD O Low	Epi Sz	Hypo Sz
Avg.	6.50	91.15	6.50	8.95	0.10	10.92	3.00	8.00	5.50	3.00
SD	4.60	15.69	2.12	0.21	0.01	2.99	4.24	0.00	2.12	0.00
N	2	2	2	2	2	2	2	2	2	2
SE	3.25	11.094	1.5	0.15	0.005	2.115	3	0	1.5	0
Conf 95	6.37	21.74	2.94	0.29	0.01	4.15	5.88	0.00	2.94	0.00
Ubound										
Lbound										

Descriptive Stats Summer	Secchi	Max RTRM	Depth MRTRM	Surf O	Bot O	Max O2	D Max O2	TD O Low	Epi Sz	Hypo Sz
Avg.	6.55	98.701	5	8.8	0.085	10.7575	4.5	7.5	2.25	3.75
SD	3.44	51.30	2.58	4.55	0.06	5.69	3.29	3.95	1.22	1.97
N	4	4	4	4	4	4	4	4	4	4
SE	1.72	25.65	1.29	2.28	0.03	2.85	1.64	1.97	0.61	0.99
Conf 95	3.37	50.27	2.53	4.46	0.06	5.58	3.22	3.87	1.20	1.94
Ubound										
Lbound										

Nutrient Dataset – Descriptive Statistics

Overall	TP	TN
Ave	0.01841667	0.35467917
SD	0.01219735	0.09233366
N	24	24
SE	0.00248977	0.01884753
Conf 95	0.00487987	0.03694048
Ubound	0.02329653	0.39161965
Lbound	0.0135368	0.31773869

By Fall	TP	TN
Ave	0.01344444	0.32292222
SD	0.00677899	0.17196957
N	9	9
SE	0.00225966	0.05732319
Conf 95	0.00442886	0.11235139
Ubound	0.0178733	0.43527361
Lbound	0.00901559	0.21057083

By Summer	TP	TN
Ave	0.0214	0.37373333
SD	0.01560605	0.19489371
N	15	15
SE	0.00402947	0.05032134
Conf 95	0.00789761	0.09862801
Ubound	0.02929761	0.47236135
Lbound	0.01350239	0.27510532

By Year	2020		2018		2017		2016		2015	
	TP	TN	TP	TN	TP	TN	TP	TN	TP	TN
Ave	0.023	0.312	0.022	0.402	0.013	0.393	0.021	0.338	0.014	0.349
SD	0.014	0.153	0.008	0.143	0.006	0.175	0.011	0.151	0.005	0.118
N	6	6	3	3	6	6	6	6	3	3
SE	0.006	0.062	0.005	0.083	0.002	0.071	0.004	0.062	0.003	0.068
Conf 95	0.011	0.122	0.009	0.162	0.005	0.140	0.009	0.121	0.005	0.134
Ubound	0.024	0.275	0.018	0.306	0.010	0.315	0.019	0.272	0.010	0.252
Lbound	0.012	0.189	0.013	0.240	0.008	0.253	0.012	0.218	0.008	0.216

By Depth	@ 1 Meter		@ 7 Meters		@ 10 Meters	
	TP	TN	TP	TN	TP	TN
Ave	0.0131	0.3739	0.0160	0.2929	0.0261	0.3973
SD	0.0065	0.1805	0.0083	0.1532	0.0162	0.1982
N	8	8	8	8	8	8
SE	0.0023	0.0638	0.0029	0.0541	0.0057	0.0701
Conf 95	0.0045	0.1251	0.0058	0.1061	0.0112	0.1374
Ubound	0.0177	0.4990	0.0218	0.3990	0.0373	0.5346
Lbound	0.0086	0.2488	0.0102	0.1868	0.0149	0.2599

Multivariate Linear Regression and T-Test Analyses of Nutrient Dataset

Nutrients

MLR Year_X_TP,TN

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2017.888	1.518	1328.887	<2e-16	***
TP	32.637	30.793	1.06	0.301	
TN	-3.141	4.068	-0.772	0.449	

F	0.7599
DF	2,21
p	0.4801
r2	0.06749

MLR Depth_X_TP,TN

Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	4.276	3.103	1.378	0.1827
TP	130.321	62.932	2.071	**0.0509**
TN	-1.907	8.313	-0.229	0.8208

F	2.146
DF	2,21
p	0.1419
r2	0.1697

T-Test Season TP

t	df	p
-2.0564	15.067	0.5749

T-Test Season TN

t	df	p
-1.2255	13.2	0.2418

Epi x Season TN

t	df	p
-0.61004	4.9333	0.5688

Mid x Season TN

t	df	p
-0.70723	2.1409	0.5485

Bot x Season	TN					
	t		df		p	
		-1.268		5.2373		0.2582
Epi x Season	TP					
	t		df		p	
		-0.10889		4.8096		0.9177
Mid x Season	TP					
	t		df		p	
		-1.7976		5.9261		0.123
Bot x Season	TP					
	t		df		p	
		-1.8745		4.0296		0.1336

Univariate Analyses of Physical Dataset

Physical LM

	Estimate Std.	Error	t value	Pr(>|t|)	
(Intercept)	1909.898	40.941	46.65	2.17E-05	***
Secchi	15.276	6.231	2.452	0.0915	.
F	6.011				
r2	0.6671				
df	1,3				

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2055.6467	53.834	38.185	2.81E-06	***
Max.RTRM	-0.4711	0.5572	-0.845	0.445	
F	0.7148				
r2	0.1516				
df	1,4				

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2004.467	27.319	73.372	2.07E-07	***
Depth.MRTRM	1.067	4.868	0.219	0.837	
F	0.04802				
r2	0.01186				
df	1,4				

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1771.97	152.89	11.59	0.000317	***
Surf.O	26.93	17.27	1.56	0.19385	
F	2.443				
r2	0.3782				
df	1,4				

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2014.78	14.22	141.69	1.49E-08	***
Bot.O	-50.32	148.93	-0.338	0.752	
F	0.01142				
r2	0.02775				
df	1,4				

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1963.228	26.896	72.993	2.11E-07	***
Max.O2	4.358	2.459	1.772	0.151	
F	3.14				
r2	0.4398				
df	1,4				

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1999.5	6.775	295.111	7.91E-10	***
D.Max.O2	2.708	1.383	1.958	0.122	
F	3.835				
r2	0.4895				
df	1,4				

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1898.4	6.2578	303.37	7.08E-10	***
TD.O.Low	14.6	0.8124	17.97	**5.64E-05**	***
F	323				
r2	0.9878				
df	1,4				

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2010.62069	11.54548	174.148	6.52E-09	***
Epi.Sz	-0.08621	3.04957	-0.028	0.979	
F	0.0007991				
r2	0.0001997				
df	1,4				

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2038.33	36.04	56.563	5.85E-07	***
Hypo.Sz	-8	10.19	-0.785	0.476	
F	0.616				
r2	0.1335				
df	1,4				