Lake Kapowsin Data Report

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Introduction

University of Washington Tacoma (UWT) staff (Dr. Jim Gawel and undergraduate Christopher Wu) were hired to collect additional water quality data for Lake Kapowsin over a five-month period from June-October 2016. Lake Kapowsin was recently designated Washington's first freshwater aquatic reserve, and Washington Department of Natural Resources (DNR) staff requested additional summertime water quality data for use in informing lake and watershed management decisions. UWT's findings are summarized in this final data report.

Methods

Sampling was conducted by UWT staff once a month from three stations located along the center line of the lake [Figure 1] from June-October 2016. The parameters listed below were collected at each station once a month.

Figure 1: Map of Lake Kapowsin showing UWT sampling locations: Station 1, N46°58.399' W122°13.706'; Station 2, N46°58.867' W122°13.309'; Station 3, N46°59.088' W122°12.687'.

Basic Water Quality Measurements
Vertical profiles of temperature, dissolved oxygen, pH, and specific conductivity were measured using a multi-parameter water quality probe (In Situ SmarTroll MP with RDO probe, calibrated daily prior to use). Secchi depth was also recorded.

Water Sample Collection and Analyses
Water samples for nutrients (dissolved orthophosphate and nitrate/nitrite and total N and P) were collected using a Niskin bottle at two depths, 1 ft depth (top) and ~1 ft from the sediments (bottom), in acid-washed Nalgene bottles. Dissolved nutrient samples were filtered (0.4 µm) in the field. All nutrient samples were stored frozen prior to analysis. Samples for alkalinity, turbidity, total suspended solids (TSS) and chlorophyll *a* were collected only from the 1 ft depth using a Niskin bottle.

Lake alkalinity samples were analyzed using the Gran titration method (Standard Methods 2320 B); turbidity samples were analyzed using a nephelometer (Standard Methods 2130 B); TSS samples were measured using pre-weighed filter paper dried at 105°C (Standard Methods 2540 B); and chlorophyll samples were extracted in 90% acetone and analyzed using the fluorometric method (Standard Methods 10200 H-3). Alkalinity, turbidity, TSS and chlorophyll *a* were analyzed at UWT.

Nutrient samples were analyzed for total N (TKN; EPA 351.2) and total P (ICP-AES; EPA 200.7) by the School of Environmental and Forest Sciences Analytical Service Center. All lake water samples were analyzed for dissolved NO_3^-/NO_2^- (EPA 353.2) and ortho-PO_4^{3-} (EPA 365.1) via discrete nutrient autoanalyzer (Westco SmartChem) at UWT.

Plankton
Phytoplankton samples were collected via duplicate water column tows (near bottom to surface) at each sampling station using an 80 µm-mesh ring net with a removable screened collection cup. Samples were transferred to clean 250 mL Nalgene bottles, fixed with Lugol's solution (1% v/v), and stored on ice for transport to UWT, where they were stored in a refrigerator prior to analysis. Samples were identified to Class (or lower if feasible) under a compound microscope. A drop of the preserved sample was placed on a slide with a coverslip, and >100 organisms were counted (including all in the field of view) to measure percent relative phytoplankton abundance.

Results/Discussion

Water Column
Lake Kapowsin, although shallow (max depth = 30 ft), shows temperature-based stratification from June to September [Figure 2a]. This most likely results from poor light penetration as evidenced by the Secchi depth [Table 1], ranging from 1.8-2.8 m. Secchi depth is most likely depressed by high algal productivity in the

Secchi Depth (m)	Stn. 1	Stn. 2	Stn. 3
6/29/2016	2.1	2.3	2.2
7/27/2016	2.8	2.7	2.4
8/31/2016	2.3	2.4	2.4
9/28/2016	1.8	1.8	1.8
10/21/2016	2.2	2.3	2.4

Table 1: Secchi depth measured in Lake Kapowsin.

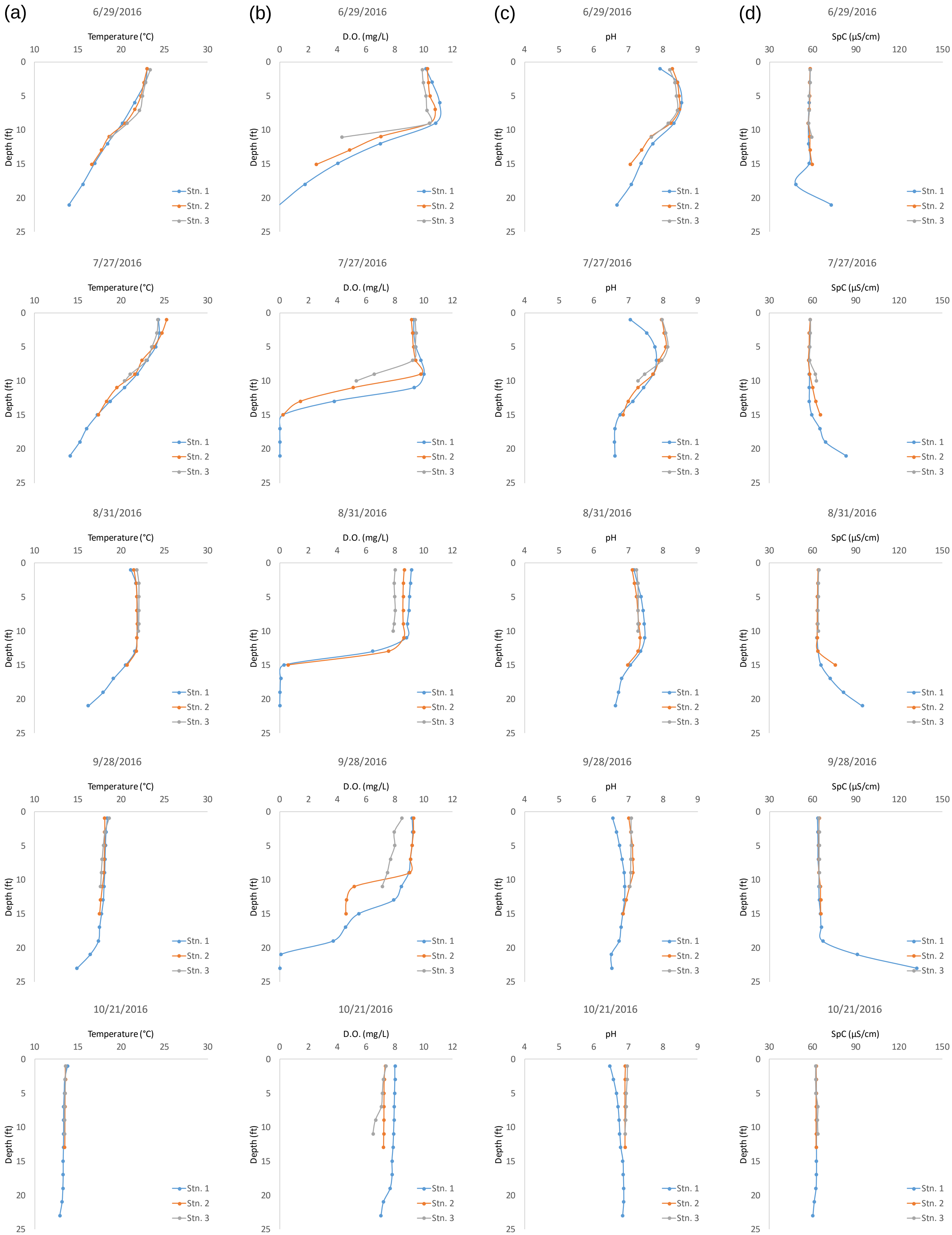

Figure 2: Lake Kapowsin water profiles: (a) temperature, (b) dissolved oxygen, (c) pH and (d) specific conductivity.

lake, as evidenced by elevated chlorophyll *a* concentrations in the water column [Table 2; Figure 3]. High algal productivity and other allochthonous and autochthonous sources feed organic matter to the lake sediments, where bacteria consume available oxygen by aerobic respiration to create anoxic conditions [Figure 2b] and decrease pH [Figure 2c] in the bottom waters. Aided by anoxia in the sediments and bottom waters, bacterial decomposition and reductive dissolution of sediments releases ions into the water column, resulting in increased specific conductivity [Figure 2d].

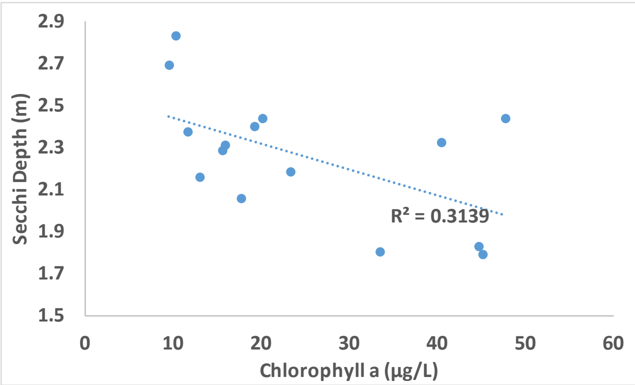

Figure 3: Correlation between chlorophyll a and Secchi depth; water clarity decreases as algal density increases.

This increase in conductivity also signals the release of N and P (as well as Fe, Mn, etc.) from the sediment nutrient reservoir (Wetzel 2001, pp 249). Phosphate readily binds to iron-bearing minerals that precipitate out of the water column under oxic conditions, thus depositing P in the sediments. The reductive dissolution of iron results in the release of phosphate from the sediments (Wetzel 2001, pp 251), as is visible in the higher dissolved and total P concentrations found in the bottom waters relative to the surface waters [Figure 4a and 3b]. Although NO_3^-/NO_2^- concentrations increase near the sediments [Figure 4c], the change is not as pronounced as phosphate and total N levels do not change appreciably [Figure 4d]. NH_4^+ levels, unfortunately, were not analyzed, but would be expected to increase significantly near in bottom waters due to the decomposition of N-containing organic matter in the sediments.

Chlorophyll (µg/L)			
Date	Stn. 1	Stn. 2	Stn. 3
6/29/2016	17.73	15.62	13.00
7/27/2016	10.33	9.57	11.63
8/31/2016	40.53	47.76	19.34
9/28/2016	45.21	44.74	33.49
10/21/2016	23.38	16.00	20.24

Turbidity (NTU)			
Date	Stn. 1	Stn. 2	Stn. 3
6/29/2016	1.72	2.22	1.5
7/27/2016	1.28	1.33	1.42
8/31/2016	2.24	2.45	2.38
9/28/2016	3.75	4.03	3.61
10/21/2016	2.6	2.76	2.48

Total Suspended Solids (mg/L)			
Date	Stn. 1	Stn. 2	Stn. 3
6/29/2016	1.50	4.00	8.84
7/27/2016	2.00	1.30	2.70
8/31/2016	2.50	1.40	3.90
9/28/2016	4.80	3.90	3.90
10/21/2016	1.40	3.92	3.16

Alkalinity (mg $CaCO_3$/L)			
Date	Stn. 1	Stn. 2	Stn. 3
6/29/2016	20.5	19.5	19.6
7/27/2016	22.2	20.7	21.2
8/31/2016	23.7	24.5	23.6
9/28/2016	24.4	24.7	24.6
10/21/2016	23.5	23.4	23.5

Table 2: Chlorophyll *a*, turbidity, TSS and alkalinity measured in surface waters at 3 stations in Lake Kapowsin.

The release of P from the sediments most likely provides a significant internal source of nutrients contributing to lake primary productivity. Lake turbidity is strongly correlated with chlorophyll *a* concentrations [Figure 5; Table 2], meaning that algal production is likely the primary source of turbidity (at least during the summer months) and therefore affects water clarity, thermal stratification and dissolved

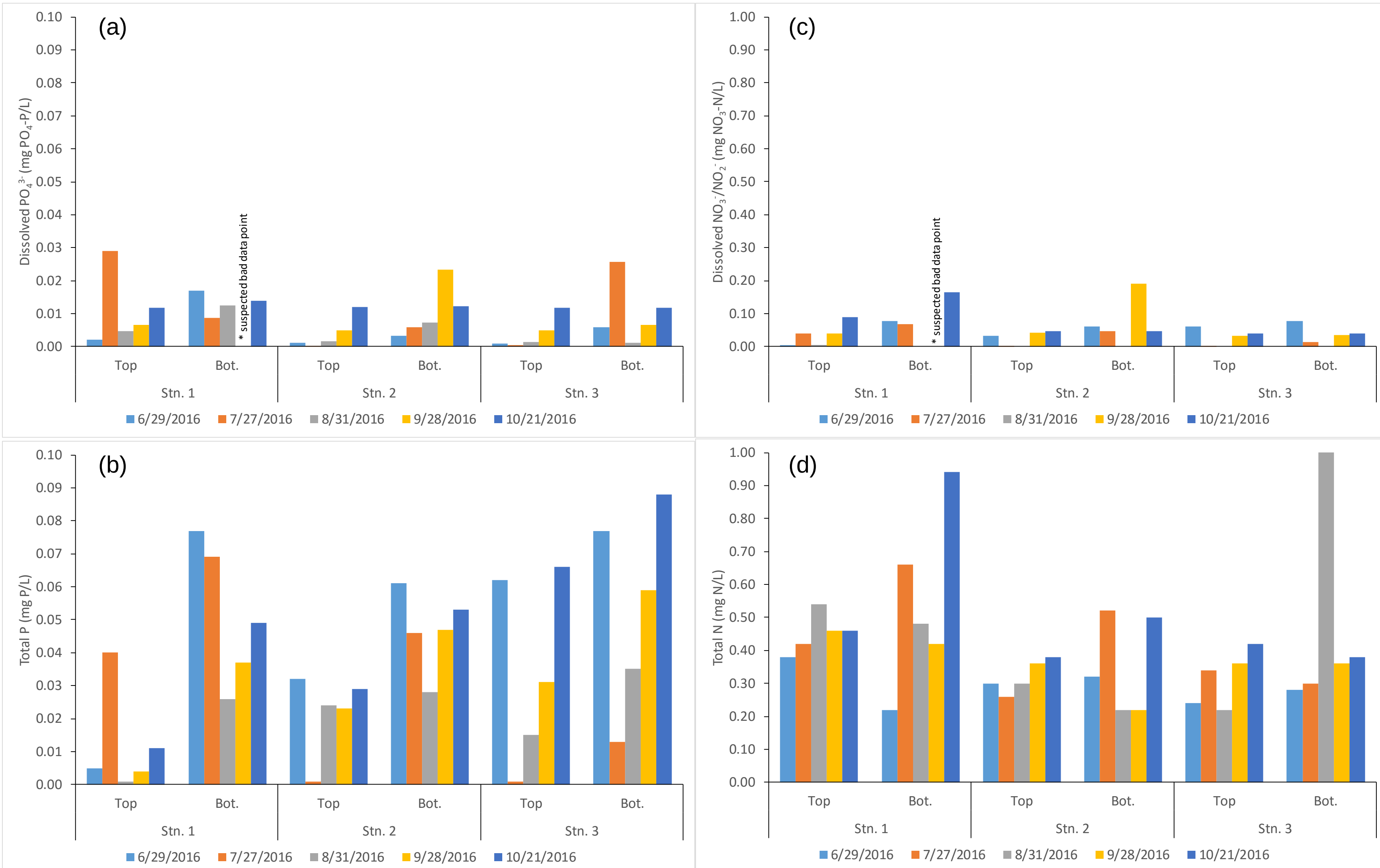

Figure 4: Nutrient concentrations in Lake Kapowsin water column, top (1 ft) and bottom (~1 ft above sediments): (a) soluble reactive phosphorus, (b) total P, (c) dissolved nitrate/nitrate, and (d) total N.

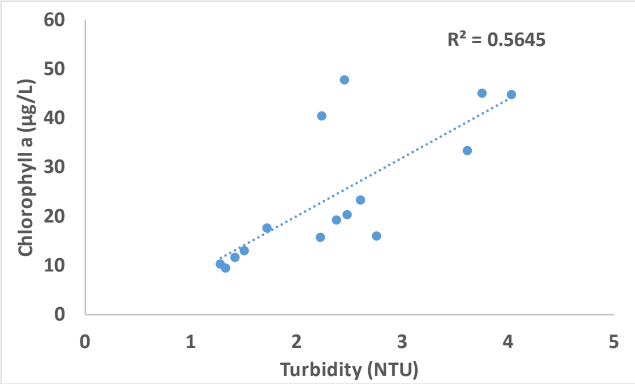

Figure 5: Correlation between chlorophyll *a* and turbidity.

oxygen levels in the lake. Phytoplankton populations are dominated by cyanobacteria [Table 3] throughout the summer (*Anabaena* and *Woronichinia sp.*). However, TN:TP ratios (on mass basis) in surface waters average almost 100, suggesting significant P-limitation, which often is thought to select against cyanobacteria dominance (Kolzau et al. 2014). It is possible that elevated TP (Downing and McCauley 1992) or light limitation (Kolzau et al. 2014) may benefit cyanobacteria in Lake Kapowsin in relation to other plankton groups, negating the usefulness of the TN:TP ratio as a predictor. Some cyanobacteria species are known to create cyanotoxins under certain environmental conditions (somewhat poorly understood), and thus it may be important to monitor for these toxins as part of an ongoing management plan to protect public health (Wetzel 2001, pp 383-384).

Phytoplankton Relative Abundance															
	6/29/2016			7/27/2016			8/31/2016			9/28/2016			10/21/2016		
	Stn. 1	Stn. 2	Stn. 3	Stn. 1	Stn. 2	Stn. 3	Stn. 1	Stn. 2	Stn. 3	Stn. 1	Stn. 2	Stn. 3	Stn. 1	Stn. 2	Stn. 3
Anabaena	67%	23%	59%	56%	53%	39%	62%	71%	48%	77%	87%	81%	49%	46%	41%
Asterionella	7%	6%	9%	22%	18%	28%	0%	0%	0%	1%	1%	1%	15%	15%	9%
Fragilaria	11%	44%	11%	9%	12%	7%	0%	0%	0%	0%	0%	1%	0%	1%	0%
Dinobryon	2%	4%	4%	2%	4%	5%	26%	17%	39%	13%	8%	11%	14%	17%	21%
Woronichinia	13%	18%	14%	11%	12%	19%	10%	12%	11%	4%	4%	5%	15%	13%	19%
Staurastrum	2%	3%	2%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Ceratium	0%	2%	1%	1%	1%	1%	1%	0%	2%	4%	0%	2%	7%	8%	9%

Table 3: Average (n = 2) phytoplankton abundance (%) in vertical net tows collected from 3 stations in Lake Kapowsin.

Overall, Lake Kapowsin is classified as mesotrophic to eutrophic based on average chlorophyll *a* [TSI(CHL) = 62], Secchi depth [TSI(SD) = 48], TP [TSI(TP) = 49] and TN [TSI(TN) = 40] values (Carlson 1977). This means the lake has relatively high primary productivity, leading to higher levels of autochthonous organic matter, higher turbidity, enhanced summer stratification, high biological oxygen demand, and low oxygen levels in the bottom waters. The persistence of the anoxic bottom layer overlain by warmer waters will limit the use of the lake by cold water fish species, but overall lake productivity should benefit warm water species.

Works Cited

Carlson, R.E. 1977. A trophic state index for lakes. *Limnology and Oceanography*, 22: 361-369.

Downing, J.A., and E. McCauley. 1992. The nitrogen:phosphorus relationship in lakes. *Limnology and Oceanography*, 37: 936:945.

Kolzau, S., C. Wiedner, J. Rücker, J. Köhler, A. Köhler, and A.M. Dolan. 2014. Seasonal patterns of nitrogen and phosphorus limitation in four German lakes and the predictability of limitation status from ambient nutrient conditions. *PLoS One*, 9: e96065.

Wetzel, R.G. 2001. *Limnology: Lake and River Ecosystems*, 3rd Ed. Academic Press, San Diego, CA.