Aquatic Ecosystem Sciences LLC

TECHNICAL MEMORANDUM

Upper Klamath Lake 2016 Data Summary Report

Prepared By:

Jacob Kann, Ph.D.
Aquatic Ecosystem Sciences LLC
295 East Main St., Suite 7
Ashland, OR 97520

Prepared For:

Klamath Tribes Natural Resources Department
PO Box 436
Chiloquin, OR 97624

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INTRODUCTION

The Klamath Tribes have been monitoring water quality in Upper Klamath Lake (UKL) since 1990. These data have been described and summarized to varying degrees in a series of reports and manuscripts (e.g., Kann 1998; Kann and Smith 1999; Kann and Welch 2005; Kann 2007 through Kann 2016). The UKL electronic water quality database was previously updated with 2016 data (*see Excel spreadsheet: KlamathTribesUKLWaterQualityData1990-2016_without_QA_6_1_2017.xls*). In addition, several reports provide additional detail and comprehensive analysis of the first 19-20 years of the database (Jassby and Kann 2010; Eldridge et al. 2014). The current 2016 data report is intended to serve as an annual update to the UKL water quality database, including a summary of 2016 data (basic summary statistics and graphical analysis), and limited comparison of inter- annual trends of UKL data collected for the 27 year period between 1990 and 2016.

METHODS

Methods followed the Klamath Tribes established procedures for field collection and laboratory analysis of water quality parameters (see Klamath Tribes 2013a,b for a complete description of these methods). Beginning in 2008 for nutrient parameters and 2009 for Chlorophyll-a (CHL), laboratory analyses transitioned from Aquatic Research, INC. in Seattle WA to the Sprague River Water Quality Laboratory in Chiloquin OR. During the transition period duplicate samples were analyzed by both laboratories to confirm parameter reproducibility. During the 2016 sampling season limnological data (Table 1) were collected approximately biweekly from the end of April through October[1] at 10 standardized stations in UKL and Agency Lake (Figure 1; Figure 2).

Table 1. Limnological parameters sampled in Upper Klamath Lake, 2016.

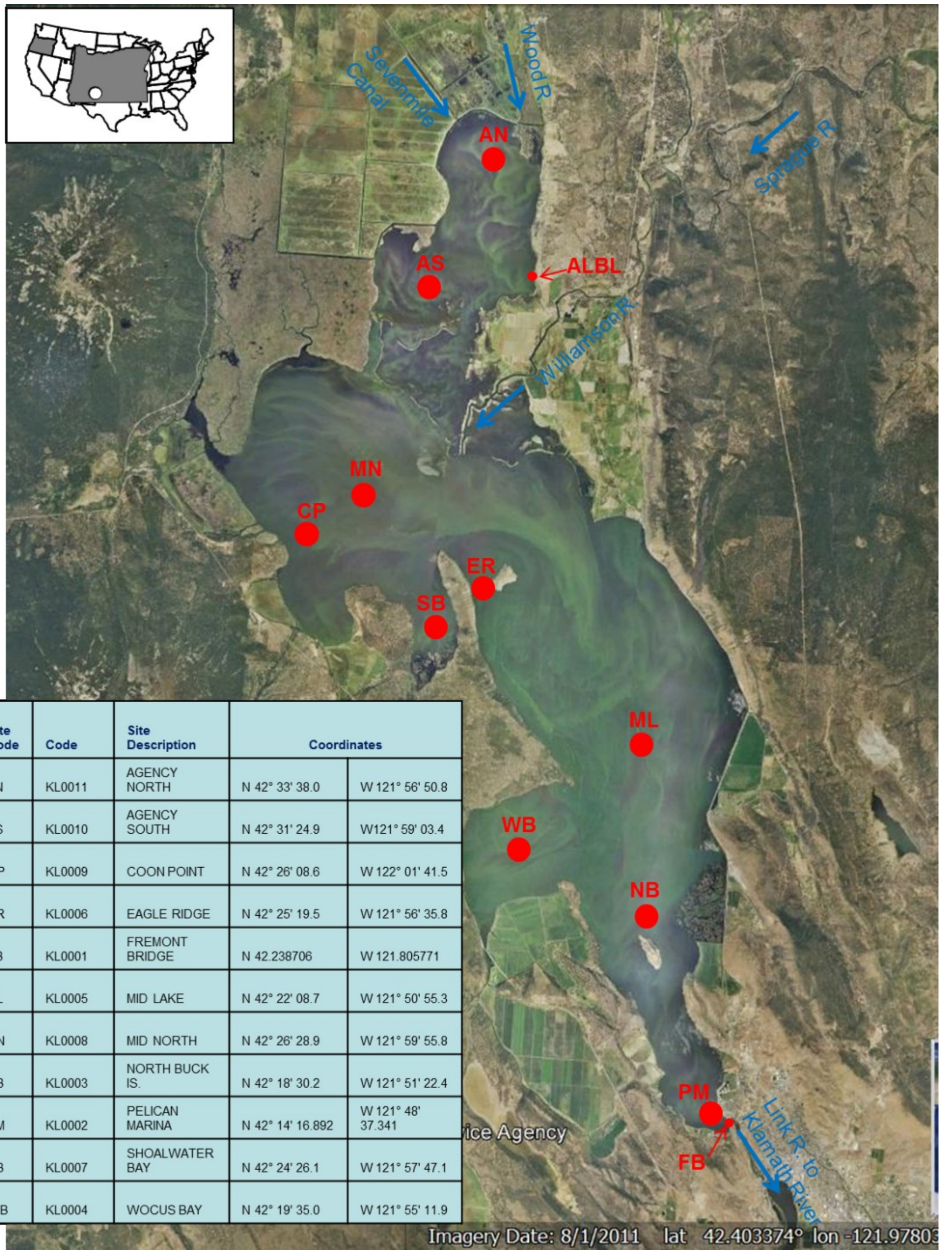
Parameter	Abbreviation/ Unit	Profile [a]	Grab [b]
Temperature	T (ºC)	X	
Dissolved Oxygen	DO (mg/L)	X	
pH	pH	X	
Specific Conductivity	(µSiemens/cm)	X	
Secchi Transparency	Secchi (m)		
Light (Photosynthetically Active Radiation)	PAR ($uEm^{-2}s^{-1}$)	X	
Total Phosphorus	TP (µg/L)		X
Soluble Reactive phosphorus	SRP (µg/L)		X
Total Nitrogen	TN (µg/L)		X
Ammonia Nitrogen	NH_4-N (µg/L)		X
Nitrate-Nitrite Nitrogen	NO_3+ NO_2-N (µg/L)		X
Silica	SiO_2 (µg/L)		X
Chlorophyll *a*	CHL (µg/L)		X
Phytoplankton Species Composition and Biomass[c]	(mm^3/L)		X
Zooplankton Species Composition and Biomass[c]	(mg/L)		X

a Profile = collected with multi-parameter WQ probe at multiple depths in water column
b Grab = depth-integrated water column sample collected with "tube sampler" except for zooplankton which was collected with a Schindler-Patalis Trap
c. Phytoplankton and zooplankton data are compiled in spreadsheets provided separately and are not analyzed herein.

[1] Note that the Fremont Bridge station at the outlet of UKL was sampled prior to April and after October as part of the tributary loading study (see Kann 2015) and based on analyses showing that PM and FB values follow a 1:1 trajectory values for both stations are included here with FB renamed PM for those months (see Figure 2).

Nutrient quality assurance/quality control analyses are contained in data spreadsheets (KlamathTribesUKLWaterQualityData1990-2016_with_QA_6_1_2017.xls and Upper Klamath Lake QA 2016.xlsx) available upon request.

In addition, beginning in 2016 the Klamath Tribes initiated data collection for the cyanotoxin, microcystin. Samples were collected both as surface grab and depth-integrated samples at five locations: ALBL (Agency Lake Boat Launch- surface grab only), PM, ER, MN, and AS. Samples were analyzed at the SRWQL using ELISA methodology for total microcystins[2].



Site Code	Code	Site Description	Coordinates	
AN	KL0011	AGENCY NORTH	N 42° 33' 38.0	W 121° 56' 50.8
AS	KL0010	AGENCY SOUTH	N 42° 31' 24.9	W121° 59' 03.4
CP	KL0009	COON POINT	N 42° 26' 08.6	W 122° 01' 41.5
ER	KL0006	EAGLE RIDGE	N 42° 25' 19.5	W 121° 56' 35.8
FB	KL0001	FREMONT BRIDGE	N 42.238706	W 121.805771
ML	KL0005	MID LAKE	N 42° 22' 08.7	W 121° 50' 55.3
MN	KL0008	MID NORTH	N 42° 26' 28.9	W 121° 59' 55.8
NB	KL0003	NORTH BUCK IS.	N 42° 18' 30.2	W 121° 51' 22.4
PM	KL0002	PELICAN MARINA	N 42° 14' 16.892	W 121° 48' 37.341
SB	KL0007	SHOALWATER BAY	N 42° 24' 26.1	W 121° 57' 47.1
WB	KL0004	WOCUS BAY	N 42° 19' 35.0	W 121° 55' 11.9

Figure 1. Location of Upper Klamath Lake sampling stations, 2016. Google Earth Imagery date 8/1/2011.

[2]EPA Method 546 analyzes for "total" microcystins (MC) and nodularins (NOD) in finished drinking water and in ambient water using enzyme-linked immunosorbent assay (ELISA). The term "Total microcystins and nodularins" is defined as the sum of the congener-independent, intracellular and extracellular microcystin and nodularin that is measurable in a sample.

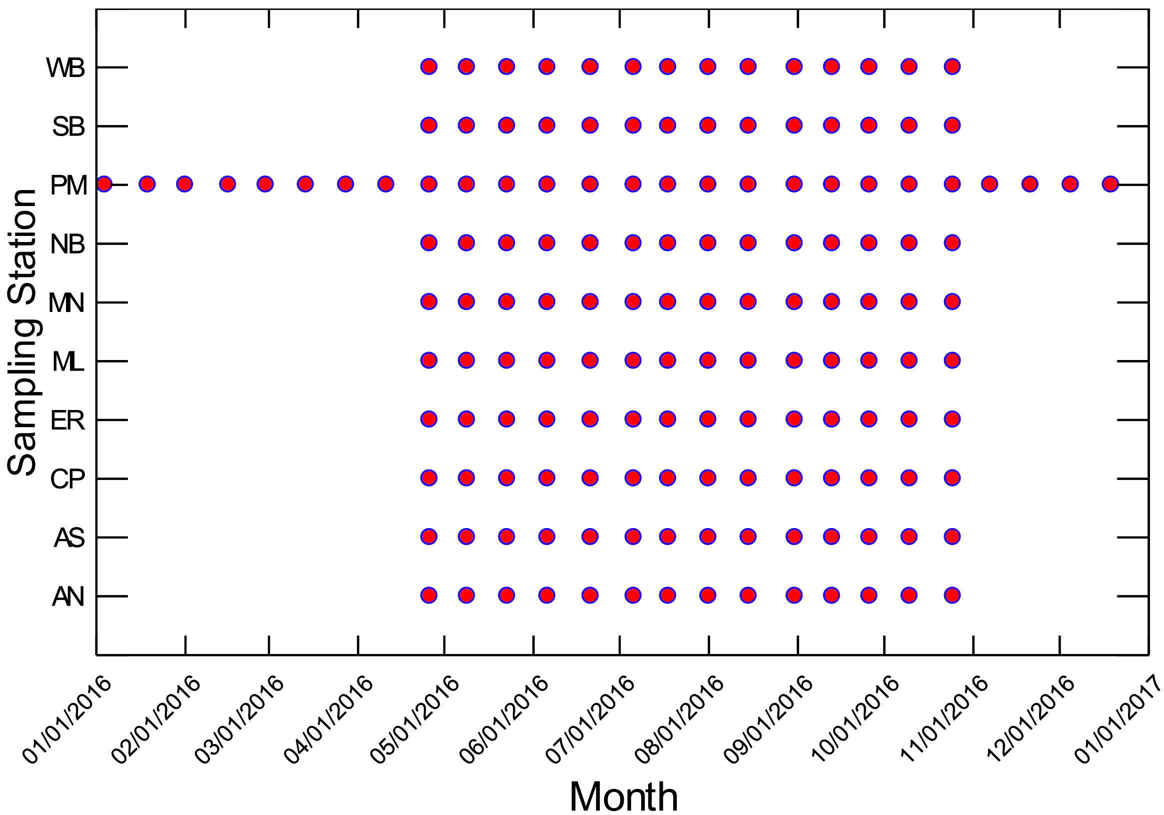


Figure 2. Spatial-temporal sampling matrix for Upper Klamath Lake, 2016.

Due to a gap in 2015 Klamath Tribe data collection[3] between June 11th and July 13th, typically a critical period for bloom development in UKL, data from nearby USGS stations were used to depict conditions during that time period in 2015 (see Kann 2016 for data description).

Data reduction consisted of computation of both lake-wide means on a given sample date and of growing season (June-September sample dates) means. Because of bloom timing differences between Upper Klamath and Agency Lake (e.g., see Kann 1998), lake-wide means and analyses are shown separately for Upper Klamath Lake only and Agency Lake only. Chlorophyll and nutrient data tended to be either normally or log-normally distributed both within a date and seasonally. Based on a comparison of both log transformed ($\log_{10}$ or $\log_{10}(x+1)$) and non-transformed data with the normal distribution using Kolmogorov-Smirnov one-sample tests or the Shapiro-Wilk standard test for normality (*cf.* Systat® 2004), the geometric mean tended to provide the best estimate of lake-wide or seasonal central tendency[4]. Lake-wide variability is shown via boxplots which convey the median, interquartile range and outliers. In addition to median and interquartile values, lake-wide central tendency may be portrayed as a mean and standard error or coefficient of variation (e.g., see Table 2).

[3] Due to reduced Natural Resource Department staffing during that period.

[4] In some cases when the distribution remained significantly different form normal even after transformation, frequency distribution and normal-probability plots indicated that the normality assumption was nonetheless approximately satisfied, especially when compared to untransformed data.

RESULTS/DISCUSSION

Seasonal and Water Column Trends in Profile Water Quality Data (T, DO, and pH)

Water column and seasonal trends in T, DO, and pH are important aspects of water quality dynamics and fish habitat in UKL. Depth-time plots of isotherms and isopleths for these parameters allows both seasonal and depth distribution to be evaluated simultaneously. These are plotted below for two representative stations, ER located in the deep trench area, and MN located in an open-water area in the northern part of the lake (Figure 3; Figure 4)[5]. Similar to 2012-2015 temperature ranged from 11-14 ^{o}C during late-April and early-May at both stations, but then remained low (<14 ^{o}C) in mid-May before increasing sharply in early June to ~21 ^{o}C (which was similar to 2015). Overall this is in contrast to 2011 when temperatures generally remained below 12 ^{o}C into early-June. Temperature then declined in late June before peaking in late-July when temperatures exceeded 22 ^{o}C[6]. Temperatures remained elevated into early August before gradually declining through the remainder of the season (Figure 3; Figure 4).

Unlike 2010 when water column pH initially increased (>9.0) in late-April and early-May (lake observations at that time indicated a massive diatom bloom and further confirmation showed very high biomass of the diatom *Asterionella formosa*), pH in 2016 was similar to 2011-2015 and remained relatively low (<8.5) until late-May before increasing in early-June. By late June most values were >9.5 and values peaked in mid-July. Although in 2015 the depth-time plots indicated that high pH values did not occur until mid to late July (Kann 2016), continuous data collected near the MN station by USGS showed that a large pH increase occurred in mid-June, followed by a large decline[7] and another increase in late July (Figure 5). Overall, 2016 followed a more typical pH pattern than did 2015, increasing in June, peaking in early- to mid-July and then declining for the remainder of the season.

Water column DO values in 2016 were near or slightly below 9 mg/L until early-June and achieved maximum values in late-June (11-14 mg/L) (Figure 3 and Figure 4). This was in contrast to 2015 when seasonal maximum levels occurred in late July (Kann 2016). Lower DO values were observed in August of 2016, and were particularly evident at ER (Figure 3). A plot of the water column mean DO at all stations indicates that ER, CP, AS, and WB tended to have lower values overall during July and August (Figure 6). As noted previously (e.g., Kann 2012), trends in pH and DO can be influenced by temperature and algal dynamics (cool late-spring and early-summer conditions were associated with low algal productivity, a delayed bloom, and moderate bloom decline in 2011). However, 2012 did not fit this trend with algal productivity remaining low in May and June despite water temperatures that were substantially warmer than 2011, indicating that factors other than water temperature also influence algal productivity and subsequent DO and pH dynamics. In 2013 earlier warming did appear to be associated with an earlier bloom peak and coinciding peaks in pH and DO, in 2014, despite mid-May warming, algal biomass remained low until mid-June (see below Figure 9), and in both 2015 and 2016 algal biomass does again appear to increase earlier in June in response to higher June temperatures. As shown below and in earlier data and analytical reports (e.g., Kann 2011; Jassby and Kann 2010), differences in pH and dissolved oxygen can be explained in part by the interaction of both climate and bloom dynamics, which can also be influenced by lake level.

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[5] For reference purposes similar depth-time plots were constructed for these stations for all years of data (1990-2014) and are shown in Appendix I of Kann (2015).

[6] note that isopleths do not accurately capture the June temperature decline- see Figure 9).

[7] See below discussion of mid-June *Aphanizomenon* bloom crash in 2015.

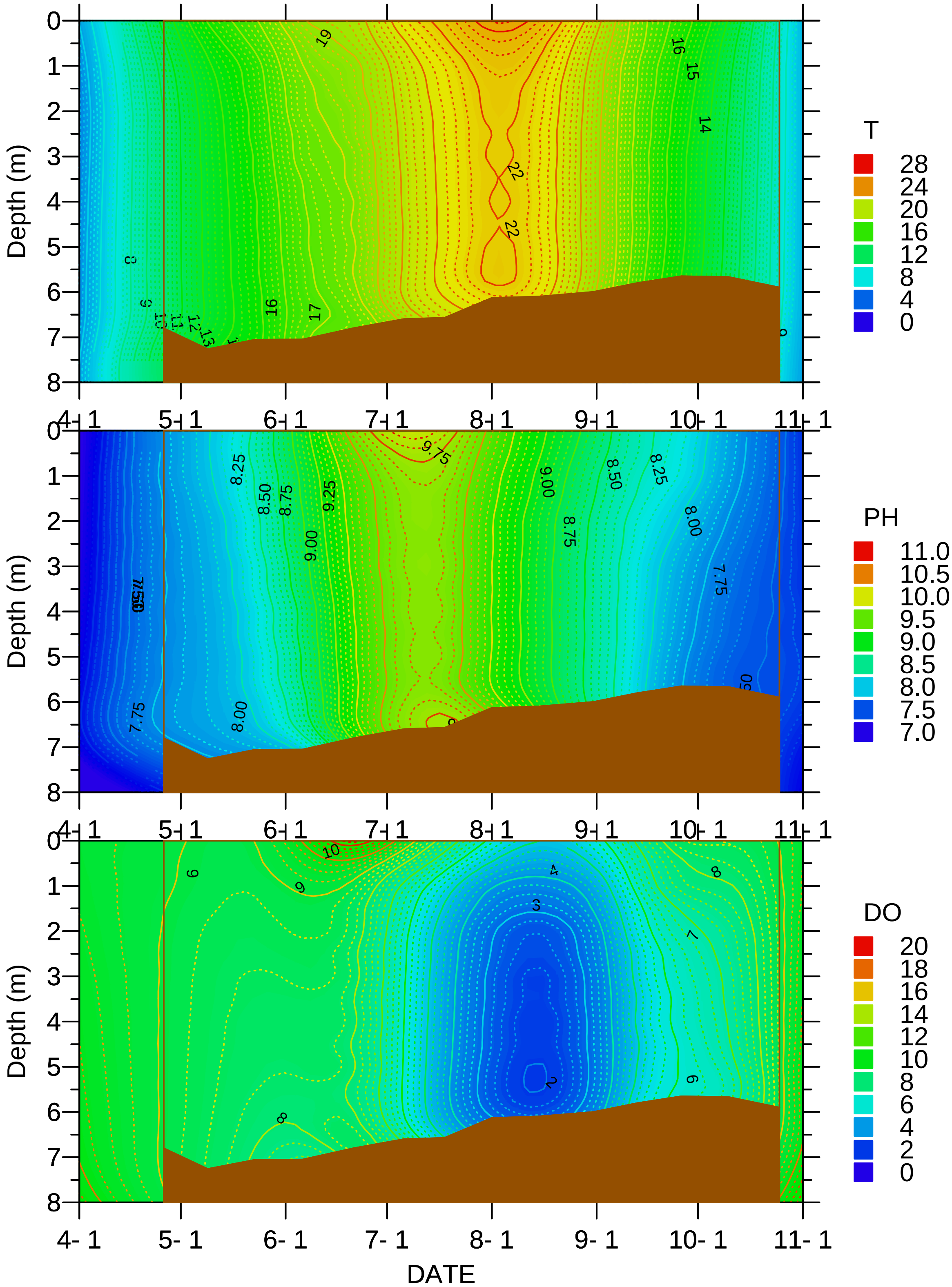


Figure 3. Depth-time distributions of isotherms of T (°C) and isopleths of D.O (mg/L) and pH at UKL station Eagle Ridge (ER), 2016. Note: 1) brown shaded area on the abscissa denotes the bottom profile depth, and 2) contours are not valid outside of vertical brown lines (begin and end dates for seasonal sampling).

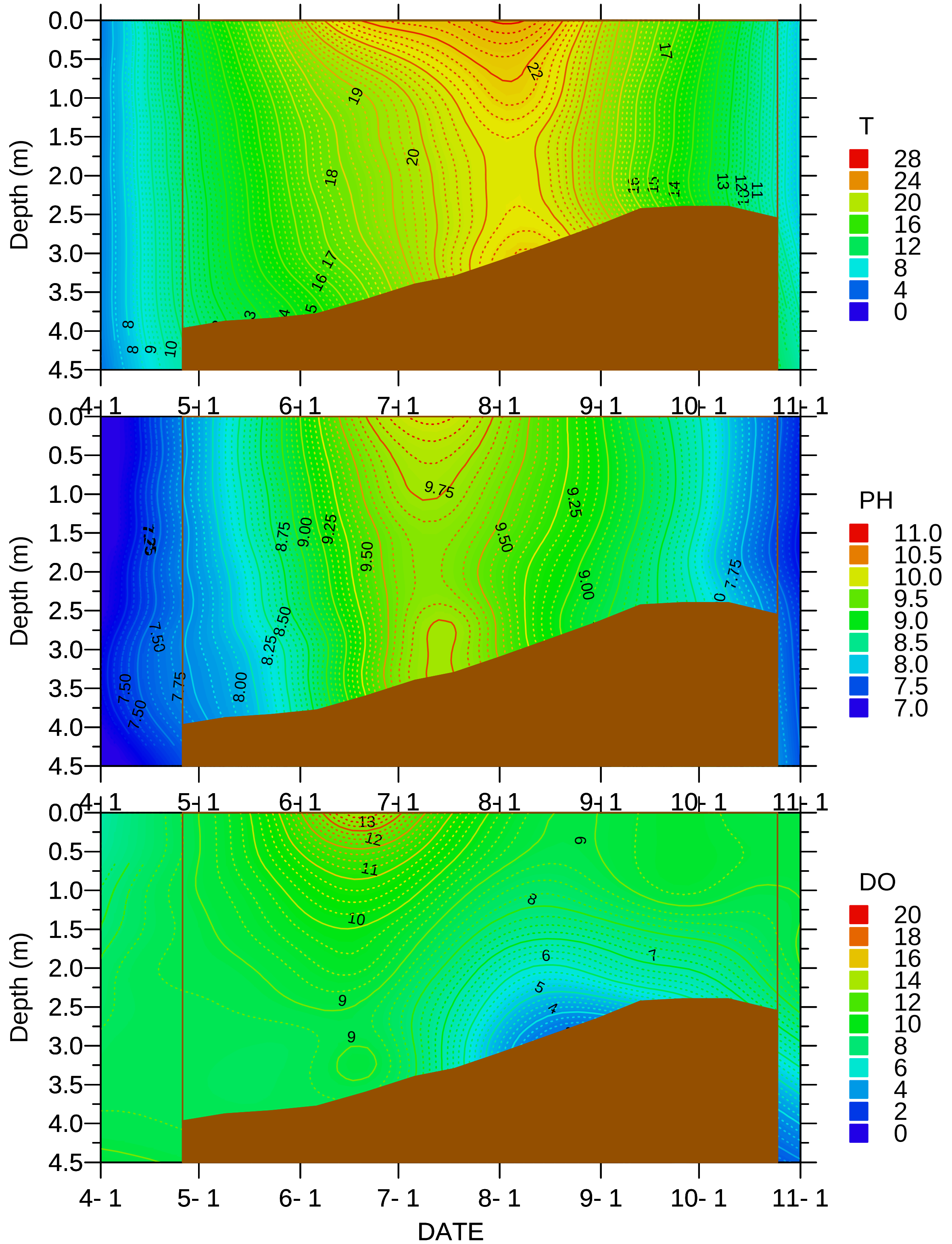


Figure 4. Depth-time distributions of isotherms of T (˚C) and isopleths of D.O (mg/L) and pH at UKL station Mid North (MN), 2016. Note: 1) brown shaded area on the abscissa denotes the bottom profile depth, and 2) contours are not valid outside of vertical brown lines (begin and end dates for seasonal sampling).

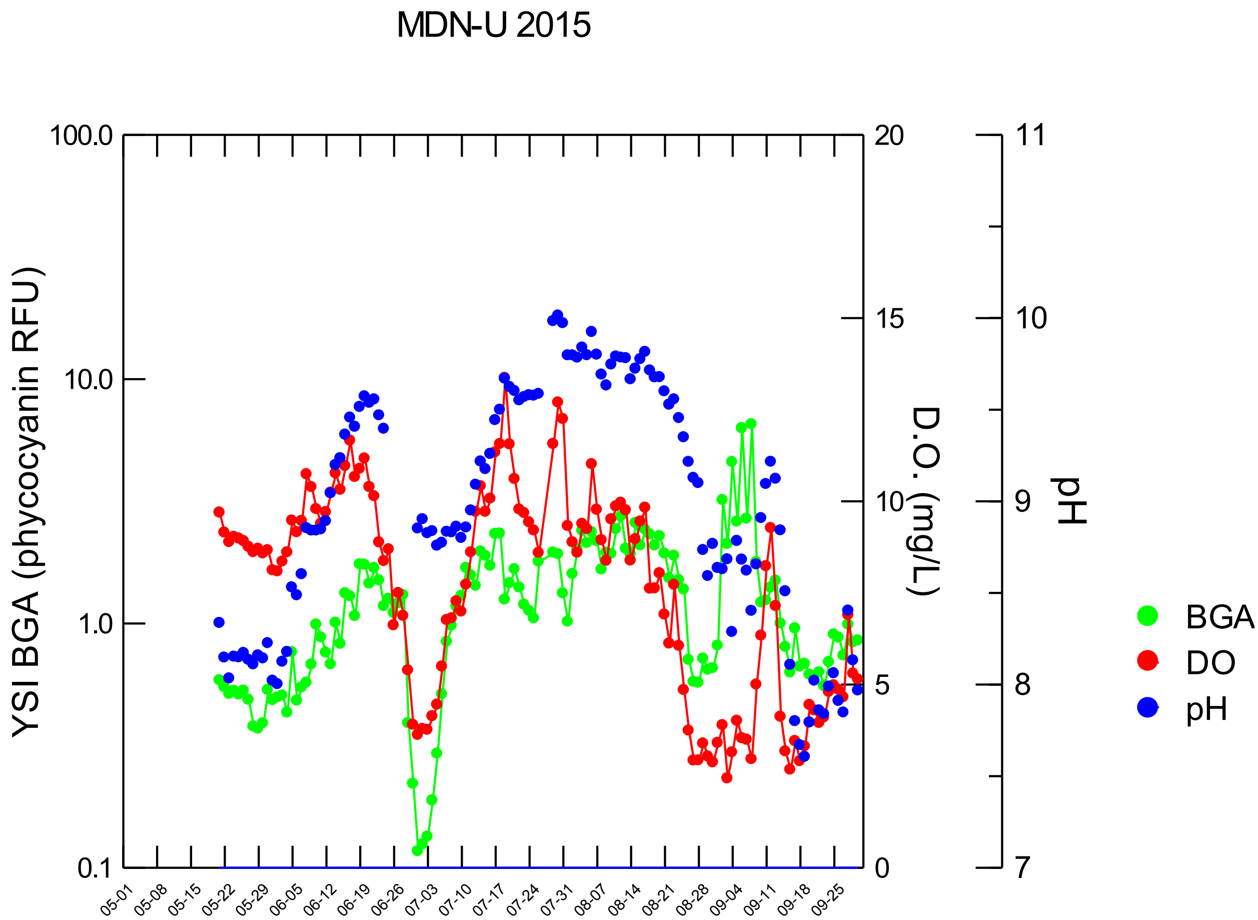


Figure 5. USGS continuous water quality monitoring data from station MDN-U located in the northern portion of UKL in 2015. BGA=phycocyanin pigment indication cyanobacterial biomass. Source: http://waterdata.usgs.gov/nwis/uv/?site_no=422622122004003

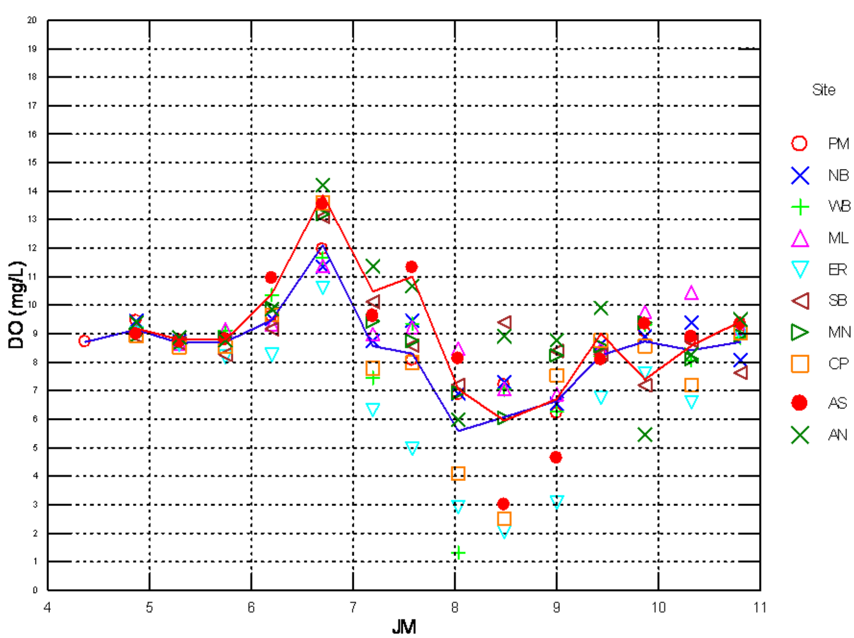


Figure 6. Water column mean dissolved oxygen values in Upper Klamath Lake in 2016.

2016 Station Distributions

The distribution of parameter values for each station for the June-September period (chosen here to encompass the major algal growing season in UKL) are shown in Figure 7 and Figure 8. Although the seasonal timing of water quality has been shown to vary among stations (see below analyses comparing individual stations by date), the season-wide distributions as indicated by the interquartile range (25^{th}-75^{th} percentiles or box hinges in the plots below) tend to overlap for most parameters. In addition, although the timing of sample collection can affect the distribution of these variables (particularly temperature, pH and dissolved oxygen—see Jassby and Kann 2010), the below plots reflect water column means which are less sensitive to the effect of sample timing than are surface values. Nonetheless, as with previous years, certain stations tended to stand out on a seasonal basis. For example, the DO distribution (as indicated by the upper or lower quartile) was skewed higher for AS and AN, and skewed lower for ER and CP (Figure 7). Secchi depth (transparency) was somewhat lower at PM, WB, and SB and higher at AS. These among-station patterns are not always consistent from year-to-year (see Kann 2011-2016).

Stations PM, WB and SB were among the highest with respect to median and/or upper quartile CHL, while the lower quartile value for CHL at AS was among the lowest (Figure 8). However, the inter-quartile CHL range was similar among many other stations. In contrast to 2012 when both AS and AN showed noticeably lower CHL relative to other stations, especially compared to previous years (Kann 2012), the 2016 (and 2015) pattern for AS was more similar to other years. Unlike 2010 and 2011 (but similar to 2012) when the AS and AN stations showed higher upper quartile and median values for TP, UQ values were not high relative to other stations in 2016 (Figure 8). With the exception of SB which was skewed low and AN which was skewed high for SRP, values were similar overall among stations.

Similar to previous years, Agency Lake stations were among the lowest for nitrogen, particularly for TN, but also for NH_4-N and NO_3-N (Figure 8; Table 2). The upper quartile value and interquartile range for TN were highest at WB, ER, and SB. Similar to 2010-15, ER and CP were among the highest for ammonia, but SB was not as high as previous years (NH_4-N; Figure 8; Table 2). WB also showed relatively high NH_4-N in 2016. Un-ionized ammonia also tended to be highest at ER, MN, and CP in 2016 (Figure 8). In previous years it was also high at WB and SB, but not in 2016. NO_3-N was similar among sites, except for ER and AS which had slightly higher values.

Median silica values (~40,000 µg/L)[8] were similar among stations, although medians at the Agency Lake stations were lower and showed a much narrower interquartile range[9] (Figure 8). See below for a description of seasonal silica dynamics.

[8] Median values were ~30,000 µg/L in 2012.
[9] The spatial pattern of lower silica medians and narrower interquartile range at the Agency Lake stations is consistent year-to-year.

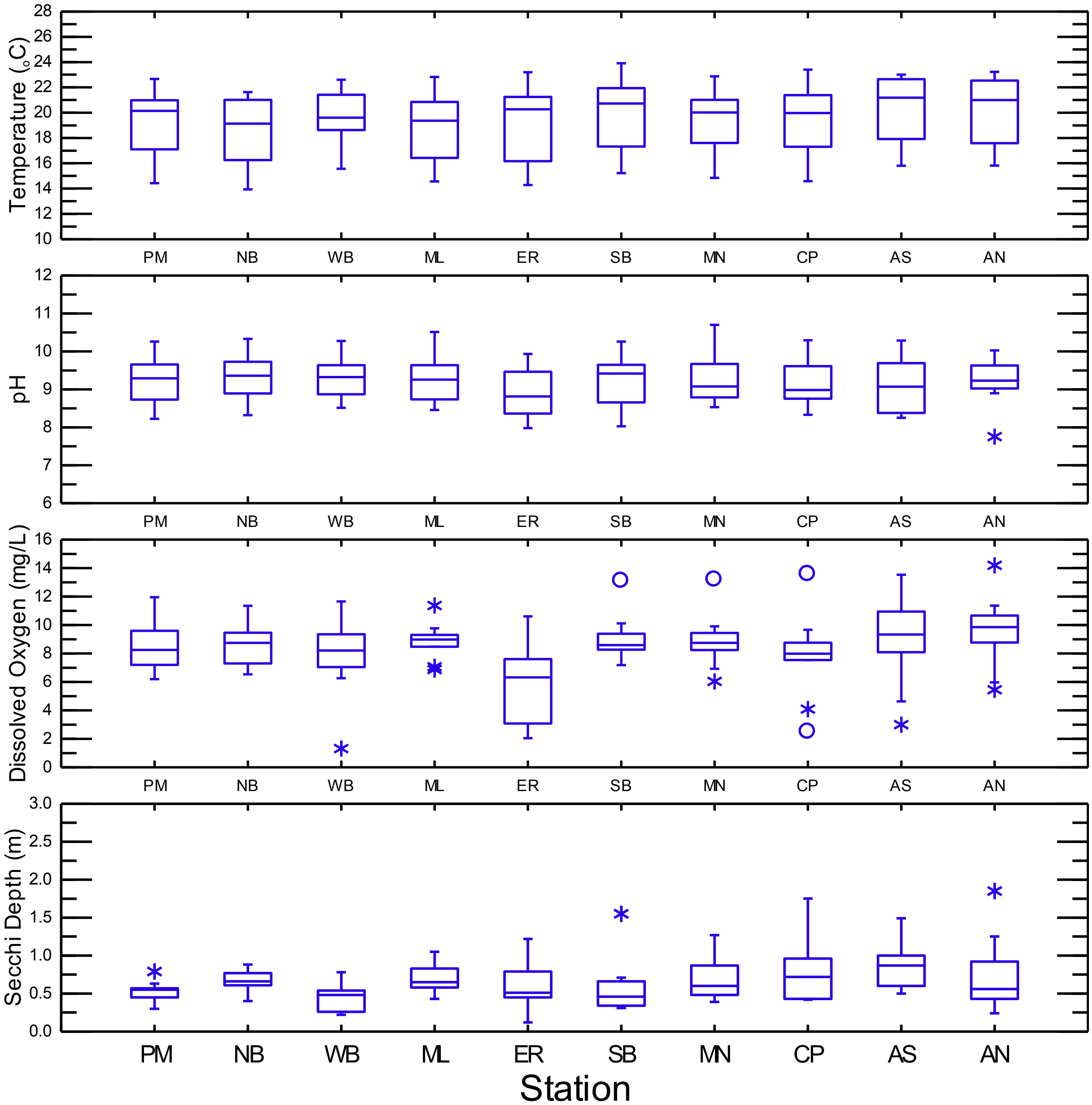


Figure 7. Station distributions of T (˚C), pH, D.O (mg/L), and Secchi depth, June-September, 2016.

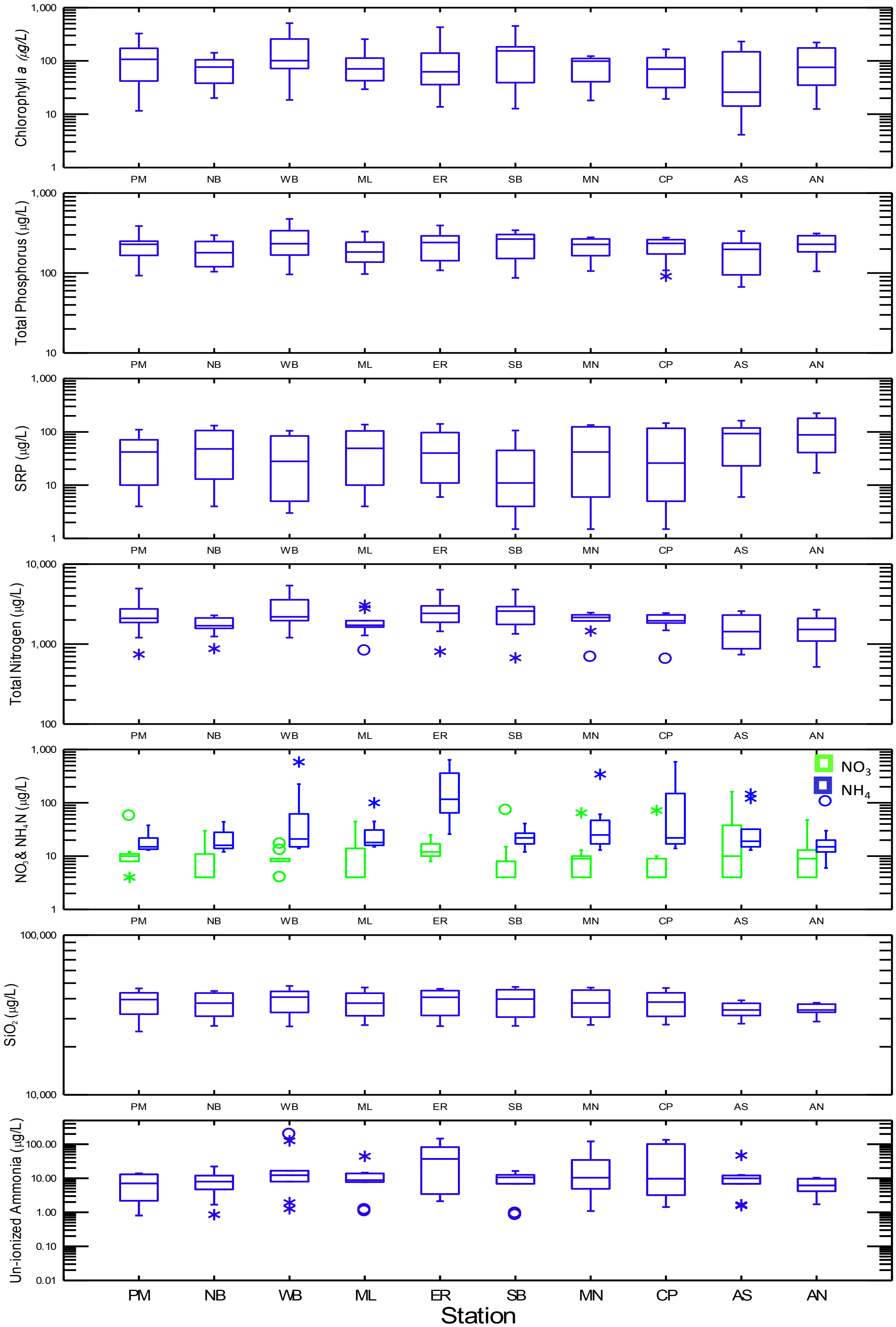


Figure 8. Station distributions of CHL, TP, SRP, TN, NO_3+ NO_2-N, NH_4-N, SiO_2 and un-ionized ammonia, June-September, 2016.

Table 2. Water Column mean summary statistics for each UKL station for the June-September period, 2016 (LQ= Lower Quartile; UQ=Upper Quartile).

Year	Station	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO_3+NO_2 Nitrogen (µg/L)	NH_4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2016	AS	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2016	AS	Median	21.19	9.07	9.34	0.87	26.00	198.00	93.00	1430.00	34000.00	10.00	19.00	9.90
2016	AS	Arithmetic Mean	20.35	9.16	8.73	0.85	78.14	187.78	77.44	1562.67	34166.67	45.00	45.00	12.39
2016	AS	Coefficient of Variation	0.14	0.08	0.38	0.37	1.06	0.52	0.80	0.48	0.13	1.38	1.14	1.10
2016	AS	LQ	17.49	8.36	7.23	0.59	12.19	93.00	19.75	851.00	30675.00	4.00	14.75	5.55
2016	AS	UQ	22.70	9.75	11.04	1.01	149.75	256.25	128.00	2302.50	37825.00	64.00	54.25	12.15
2016	ER	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2016	ER	Median	20.26	8.81	6.32	0.51	62.50	241.00	40.00	2420.00	40800.00	12.00	117.00	36.97
2016	ER	Arithmetic Mean	19.16	8.88	5.84	0.60	131.66	228.78	60.33	2470.44	37844.44	13.33	201.33	53.69
2016	ER	Coefficient of Variation	0.16	0.08	0.48	0.59	1.08	0.44	0.92	0.48	0.20	0.41	1.03	1.10
2016	ER	LQ	16.02	8.28	3.04	0.39	35.20	135.50	10.25	1762.50	30625.00	9.50	57.75	3.30
2016	ER	UQ	21.43	9.53	7.77	0.84	179.75	297.50	106.25	3142.50	45075.00	17.00	361.50	98.19
2016	ML	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2016	ML	Median	19.36	9.26	8.98	0.65	70.90	183.00	49.00	1720.00	37500.00	4.00	18.00	8.85
2016	ML	Arithmetic Mean	18.89	9.29	8.84	0.71	97.31	191.67	56.67	1868.33	37111.11	12.11	30.78	12.59
2016	ML	Coefficient of Variation	0.16	0.08	0.15	0.32	0.84	0.41	0.90	0.37	0.20	1.19	0.90	1.02
2016	ML	LQ	15.98	8.67	8.13	0.55	41.23	127.25	8.75	1542.50	30525.00	4.00	15.75	6.10
2016	ML	UQ	20.99	9.73	9.43	0.88	137.00	250.50	107.25	2167.50	43600.00	17.00	34.50	14.04
2016	MN	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2016	MN	Median	20.01	9.08	8.76	0.60	98.90	228.00	42.00	2150.00	37600.00	9.00	25.00	10.36
2016	MN	Arithmetic Mean	19.39	9.29	8.94	0.69	81.53	207.33	61.50	1954.22	37611.11	14.11	65.00	26.04
2016	MN	Coefficient of Variation	0.15	0.08	0.23	0.41	0.50	0.32	0.96	0.29	0.20	1.37	1.62	1.46
2016	MN	LQ	17.05	8.73	7.91	0.48	37.80	150.50	5.50	1817.50	30400.00	4.00	16.75	4.55

Year	Station	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO_3+NO_2 Nitrogen (µg/L)	NH_4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2016	MN	UQ	21.34	9.71	9.56	0.89	113.50	267.75	125.50	2325.00	45625.00	10.75	50.50	34.73
2016	NB	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2016	NB	Median	19.13	9.36	8.75	0.66	76.50	180.00	48.00	1690.00	37500.00	4.00	16.00	7.96
2016	NB	Arithmetic Mean	18.62	9.30	8.60	0.66	76.93	191.11	57.89	1738.22	36944.44	9.00	21.11	8.76
2016	NB	Coefficient of Variation	0.15	0.07	0.17	0.24	0.58	0.38	0.86	0.27	0.19	1.00	0.51	0.75
2016	NB	LQ	16.06	8.77	7.20	0.57	36.85	116.00	11.25	1487.50	30400.00	4.00	13.75	3.94
2016	NB	UQ	21.13	9.77	9.48	0.78	113.50	249.25	107.50	2140.00	43625.00	12.25	28.50	12.18
2016	PM	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	8.00	8.00
2016	PM	Median	20.15	9.29	8.26	0.55	107.00	229.00	42.00	2100.00	39500.00	10.00	15.00	7.12
2016	PM	Arithmetic Mean	19.20	9.28	8.54	0.54	120.10	214.33	43.11	2362.44	37111.11	13.89	19.00	7.58
2016	PM	Coefficient of Variation	0.16	0.08	0.21	0.25	0.82	0.44	0.85	0.53	0.22	1.18	0.45	0.70
2016	PM	LQ	16.56	8.65	7.12	0.45	38.65	147.75	8.50	1695.00	30250.00	7.00	13.50	2.81
2016	PM	UQ	21.35	9.80	9.61	0.59	176.75	259.00	72.00	2917.50	43825.00	11.25	22.00	13.03
2016	SB	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2016	SB	Median	20.72	9.42	8.59	0.46	154.00	266.00	11.00	2580.00	39800.00	8.00	22.00	10.65
2016	SB	Arithmetic Mean	19.93	9.22	9.05	0.60	146.57	228.33	33.11	2479.00	37844.44	14.22	23.56	9.53
2016	SB	Coefficient of Variation	0.17	0.08	0.20	0.65	0.93	0.42	1.15	0.48	0.21	1.57	0.39	0.59
2016	SB	LQ	16.80	8.60	8.01	0.34	34.45	139.25	3.38	1655.00	30375.00	4.00	16.75	5.41
2016	SB	UQ	22.36	9.69	9.57	0.67	186.50	307.50	53.50	2982.50	45650.00	9.75	28.50	13.21
2016	WB	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2016	WB	Median	19.60	9.32	8.21	0.48	101.00	233.00	28.00	2190.00	40900.00	9.00	21.00	12.31
2016	WB	Arithmetic Mean	19.62	9.29	7.89	0.45	174.47	258.22	43.00	2832.22	38188.89	9.11	108.11	43.01
2016	WB	Coefficient of Variation	0.13	0.07	0.38	0.42	0.91	0.49	1.00	0.54	0.21	0.44	1.76	1.62
2016	WB	LQ	18.07	8.80	6.85	0.26	65.70	158.50	4.75	1790.00	31625.00	7.00	14.75	6.44

Year	Station	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO_3+NO_2 Nitrogen (µg/L)	NH_4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2016	WB	UQ	21.71	9.72	9.61	0.56	268.25	344.75	87.25	3947.50	44475.00	10.00	102.75	44.01
2016	AN	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2016	AN	Median	21.00	9.23	9.86	0.56	75.60	229.00	88.00	1520.00	34000.00	9.00	15.00	6.14
2016	AN	Arithmetic Mean	19.98	9.21	9.46	0.77	100.71	228.00	105.33	1545.67	34100.00	14.89	25.44	6.39
2016	AN	Coefficient of Variation	0.15	0.07	0.28	0.66	0.79	0.36	0.73	0.47	0.10	1.03	1.22	0.52
2016	AN	LQ	17.21	8.99	8.08	0.42	29.85	164.50	39.00	1033.25	32075.00	4.00	11.25	3.71
2016	AN	UQ	22.63	9.71	10.85	1.00	177.75	296.00	181.00	2147.50	37125.00	18.00	22.50	9.74
2016	CP	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2016	CP	Median	19.97	8.99	7.99	0.72	70.00	235.00	26.00	1950.00	38100.00	4.00	22.00	9.70
2016	CP	Arithmetic Mean	19.35	9.14	7.83	0.78	76.84	207.56	61.61	1911.11	37377.78	13.22	133.67	45.51
2016	CP	Coefficient of Variation	0.15	0.07	0.40	0.55	0.66	0.34	1.01	0.30	0.19	1.68	1.48	1.29
2016	CP	LQ	16.91	8.71	6.68	0.43	30.93	156.75	4.75	1742.50	30550.00	4.00	17.00	3.19
2016	CP	UQ	21.44	9.63	8.99	0.98	117.50	265.50	121.50	2320.00	43975.00	9.25	191.75	108.64

Seasonal Chlorophyll Pattern and Climate Interaction

Seasonal differences in algal biomass (CHL) among stations in 2016 show that, unlike both the previous seven years (2008-2014) when early season CHL in Agency Lake was similar to UKL stations through the initial bloom peak, and 2006 (Kann 2011) and 2007 when AS and AN increased earlier and declined earlier in the season relative to UKL stations[10]; early season CHL in Agency Lake was slightly lower than UKL stations early in the season, but was similar during the initial bloom peak (Figure 9). In 2015 AS remained lower through the initial bloom peak (Figure 9). The general trend towards greater similarity between Agency and UKL Lakes in terms of the June algal biomass increase and seasonal maxima and decline in the later years likely reflects greater connectivity between the two lakes due wetland restoration activities on the Williamson Delta Preserve (e.g., Wong et al. 2010; 2011).

As noted in previous annual data reports (Kann 2008 to 2016), water temperature partially explained the early season CHL patterns among the years. Low temperatures coincided with a depressed early-June bloom in 2006, and in 2008 much cooler lake-wide water temperature (median value <7 ^{o}C) in late April and early-May also coincided with low CHL levels. However, it was clear that factors other than temperature were also affecting bloom dynamics in previous years.

For example, in 2010, late-April and early-May CHL was noticeably higher than the previous four years (generally >80 µg/L) due to an unusually large diatom bloom (*Asterionella formosa*) occurring at that time– despite temperatures in a range similar to many of the previous years (Kann 2011). The large 2010 diatom bloom then declined rapidly beginning in mid-May and by early-June, chlorophyll levels were less than 10 µg/L. In contrast, CHL levels in 2011 were only slightly elevated in late-April and early-May (generally <20 µg/L), and except for a decline in mid-May (<7 µg/L), they remained generally less than 20 µg/L (often less than 10 µg/L at many stations) through the end of June (Kann 2012). During this same period in 2011 water column temperature remained very cool (<11 ^{o}C through early June) and although mid-June temperature increased to ~16 ^{o}C in UKL (they were 1-2 deg. warmer in Agency Lake), they only rose slightly, remaining <20 ^{o}C through most of July of 2011 (Kann 2012). In contrast, water temperatures during the previous five years generally exceeded 20 ^{o}C by early-July, if not sooner.

In 2012, the CHL pattern was more similar to 2010, although the spring levels ~30 µg/L were still substantially lower than the ~100 µg/L achieved in 2010. May-June levels were similar, as was the peak which occurred mid to late-July of both 2011 and 2012. Water temperature warmed more rapidly than 2011, and CHL also increased to levels >50 µg/L by early-July. CHL did not undergo a lake-wide decline in August as it did in 2011.

Similar to 2013-2015, spring CHL values were also relatively low (generally <10-15 µg/L) in 2016, and while 2013, 2015, and 2016 2015 increased in late- May/early-June, 2014 values remained low in early-June before increasing in mid- to late-June (Figure 9). 2013-2016 showed relatively rapid increases to values >100-200 µg/L by mid- to late-June, and showed relatively earlier peaks than many previous years. The elevated June values were not necessarily associated with water temperatures that were warmer than other years (~18 ^{o}C in 2013), and in fact both

[10] Between 1990-2007 data tend to show CHL at the Agency L. stations increasing and declining earlier than UKL stations.

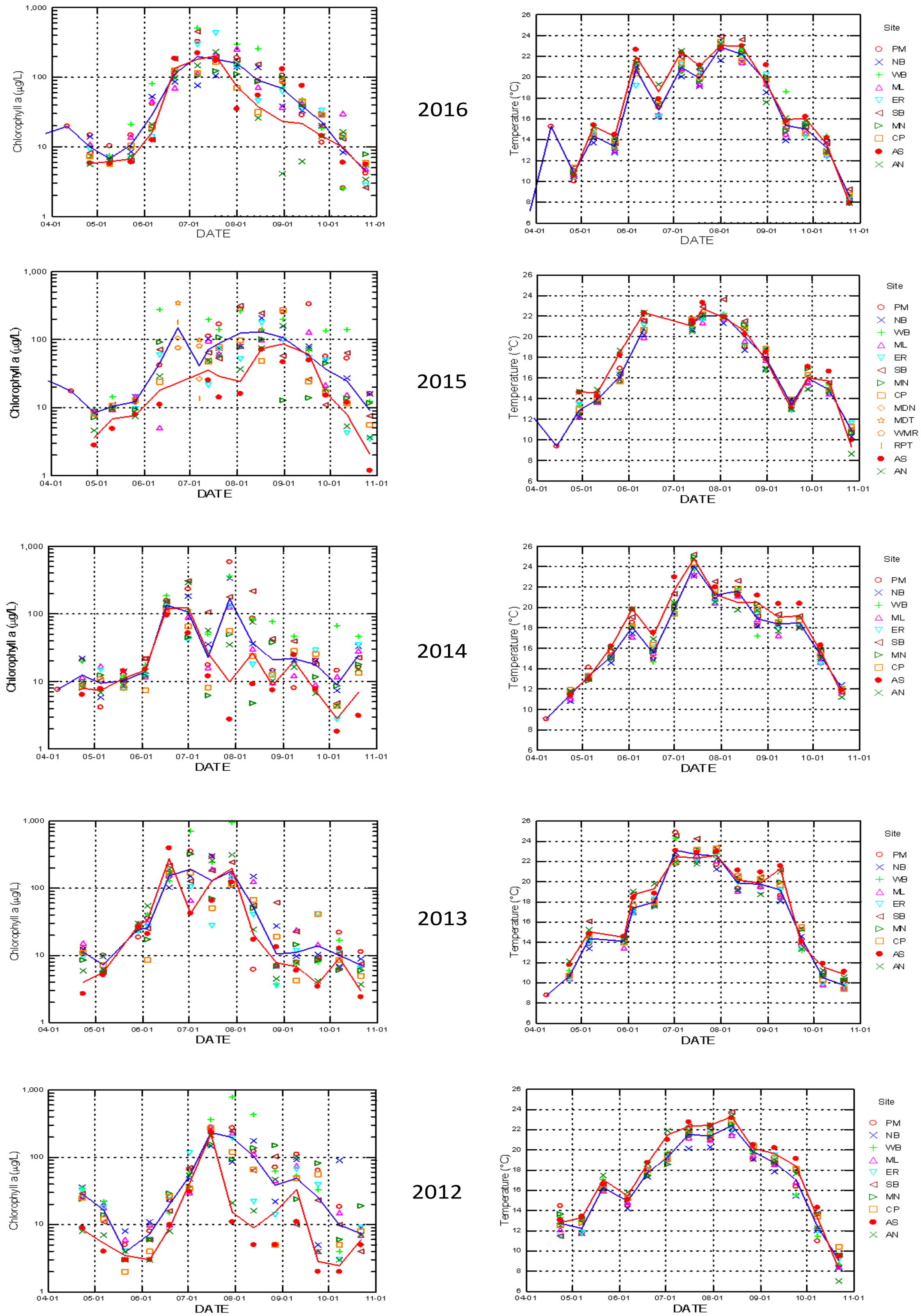


Figure 9. Seasonal CHL and temperature trends for UKL stations, 2012-2016 (blue line shows the median value for UKL-only, red line shows the median value for Agency Lake-only).

2014 and 2016 showed temperature declines in mid-June (Figure 9; (~16 ^{o}C). However, the 2015 Chl increase and peak were clearly associated with warmer June water temperatures.

Somewhat unique to 2015 was the very early CHL decline occurring in late June (Figure 9). This bloom decline is also indicated by the continuous USGS phycocyanin data which shows phycocyanin abruptly declining ~June 20th and rebounding to previous levels on ~July 10th (Figure 5). As noted below, the early bloom was comprised of diazotrophic *Aphanizomenon,* but after the bloom crash and the influx of available nitrogen, non-diazotrophic *Microcystis* dominated. Temperature seemed to directly relate to the onset of the relatively early *Aphanizomenon* bloom, and indirectly to the earlier than usual *Microcystis* bloom in that it was timed to the *Aphanizomenon* crash and the influx of nitrogen[11].

Because water temperature in the above plots is measured biweekly, and due to UKL's shallow depth, a short lag-time is generally observed with respect to equilibrium with ambient air temperatures (e.g., Wood et al. 2006), it is also instructive to evaluate daily air temperatures as another indicator of water column warming.

Previous analyses of daily data obtained from the USBR AgriMet station located near Agency Lake indicated at least partial tracking of May air temperature and CHL levels (Kann 2011; 2012). For example, temperature declines in mid-May of 2006 and 2008 that remained near or below 15 ^{o}C through mid-June were associated with suppressed CHL levels in early-June (Kann 2011). In 2007 and 2009, air temperatures warmed between mid- and late-May and were associated with elevated CHL levels in early June, and in 2010, when temperatures cooled substantially in mid-May and portions of June, CHL also remained suppressed during early and mid-June. Analyses for previous years indicated a threshold temperature of ~15 for *Aphanizomenon* bloom development in Upper Klamath Lake (Kann 1998; Kann 2011). However, as noted previously (Kann 2011) high CHL levels due to spring diatom blooms can be achieved even at temperatures much cooler than 15 ^{o}C. Furthermore, there was an indication that once the 15 ^{o}C threshold was reached, cool temperatures towards the end of June and into July also had an apparent effect on suppressing continuing algal biomass development.

June air temperatures in 2015 clearly fit the trend of warmer temperatures leading to earlier bloom development, with late-May and early June values among the highest of the 2006-2014 period (Figure 10a; Figure 11). Although there was an apparent cooling trend during May-July between 2006 and 2012, this trend reversed itself during 2013-2016 (Figure 11). Early June CHL was somewhat lower in 2016 than in 2015, and although 2016 also showed a rapid May to June temperature increase (Figure 10a), June temperatures were lower overall than they were in 2015 (Figure 11).

Analysis of wind speed as an indicator of the extent of water column mixing showed that the periods directly preceding and during the typical period of June bloom development in previous years tended to show that higher wind speeds were associated with lower algal biomass and vice versa (e.g., Kann 2016). This trend held in 2016 when increased algal biomass was associated with wind speeds among the lowest during late-May and June (Figure 10b).

Also similar to previous 2006-2014 analysis of air temperature and wind speed data that showed wind and temperature to be related such that warm/calm conditions co-occur and that cool/windy

[11]*Microcystis* does not appear in UKL until the *Aphanizomeno*n bloom crash which typically occurs between mid-July and mid-August.

conditions co-occur (Kann 2016), these parameters also tended to co-occur in 2016 (Figure 12). For example, confidence ellipses computed for the period encompassing 10 days prior to and subsequent to June 1st (the typical historical period of initial *Aphanizomenon* increase) show that 2006, 2008, and 2011 (red, green, and maroon ellipses in Figure 12) tended to be cooler and windier than during the same periods in 2009,2013, 2014, 2015, and 2016.

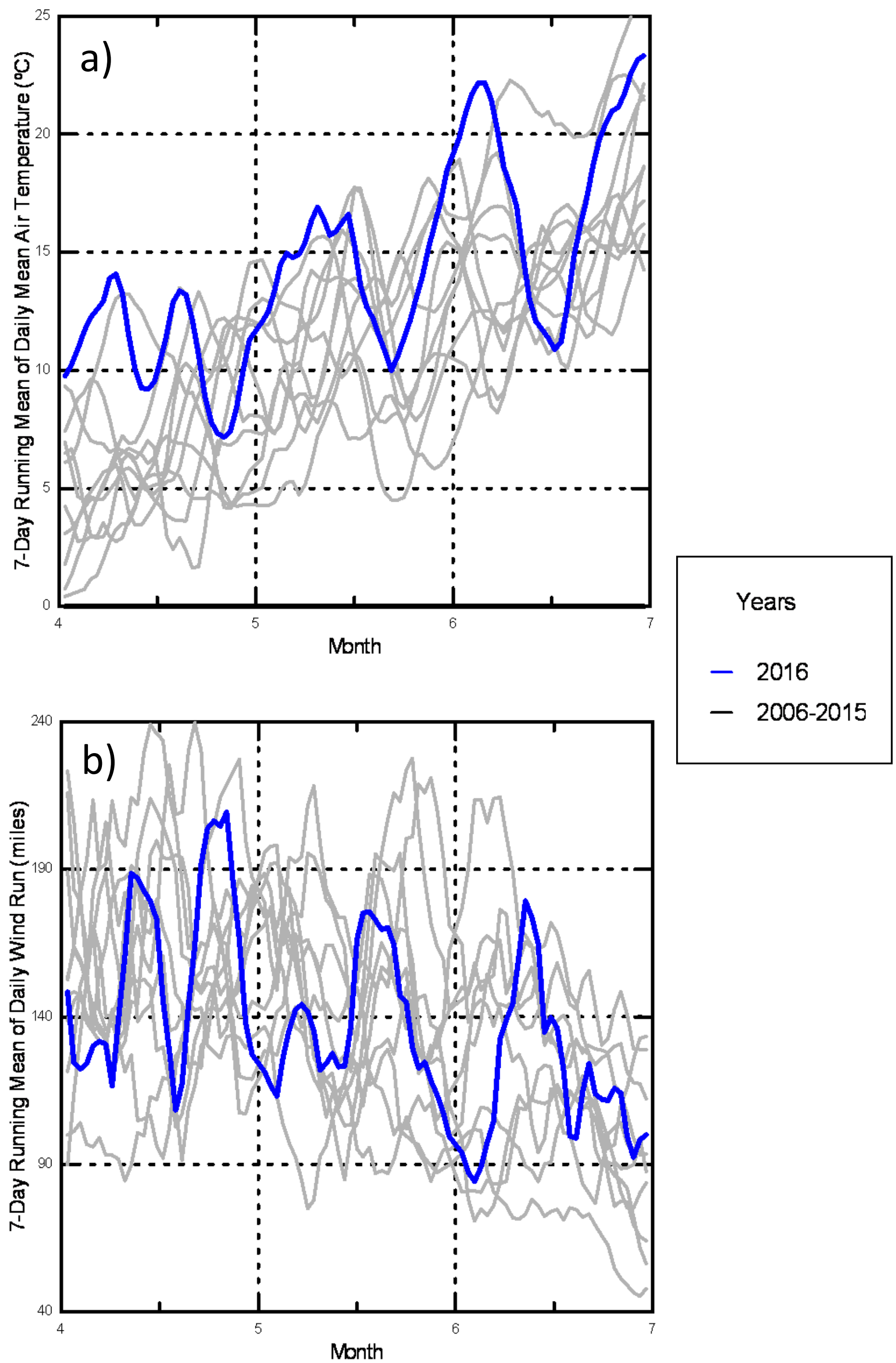


Figure 10. Time series of the 7-day running mean of daily air temperature (a) and 7-day running mean of the daily wind run in miles (b), April-June, 2006-2016. Data are from the Bureau of Reclamation AgriMet station located at Agency Lake (AGKO).

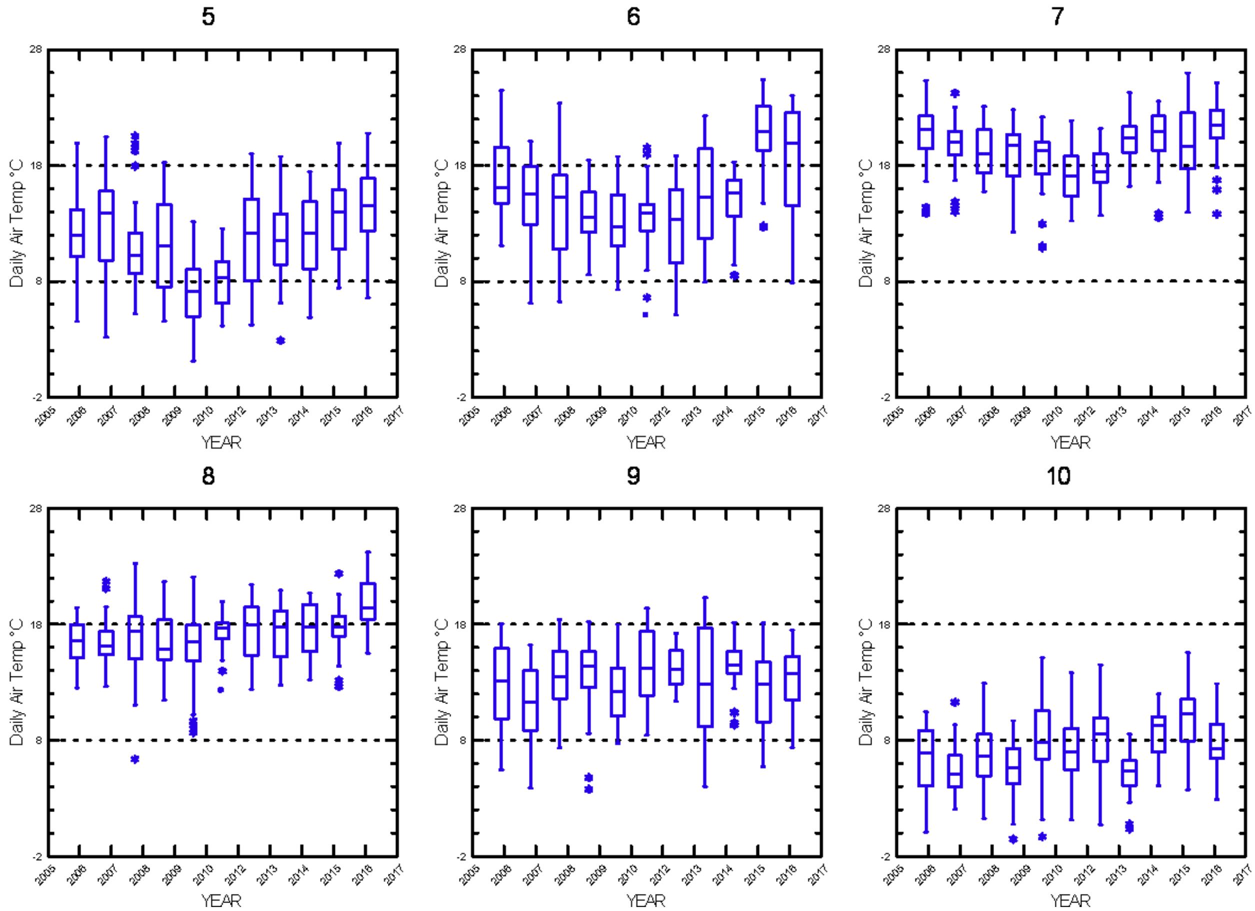


Figure 11. Annual distribution of Agency Lake AgriMet (AGKO) daily air temperatures, May-October, 2006-2016.

Overall, years showing lower wind speed and warmer temperatures tend to be associated with higher early- and mid-June CHL than the other years. For example, during 2011the late-May to early-June period was among the coolest and windiest of the six years portrayed (Figure 12), and as noted above also showed relatively low algal biomass levels. Both the 2013 and 2014 earlier bloom years were associated with warmer and calmer conditions during the late-May to early-June period. In this case, 2015 stands out as one of the calmest and warmest during the late-May to early June period. Early June of 2016 was also relatively calm and warm.

These climate data indicate that cooler and well mixed conditions during the usual early season bloom development period (e.g., Kann and Welch 2005) contribute to variability in year-to-year bloom development. Multivariate analyses performed on the longer 1990-2009 data set also showed that wind and temperature, along with lake elevation were determinants of CHL levels in UKL (Jassby and Kann 2010). As noted below these factors also interact with varying year-to-year variability in nutrient concentrations.

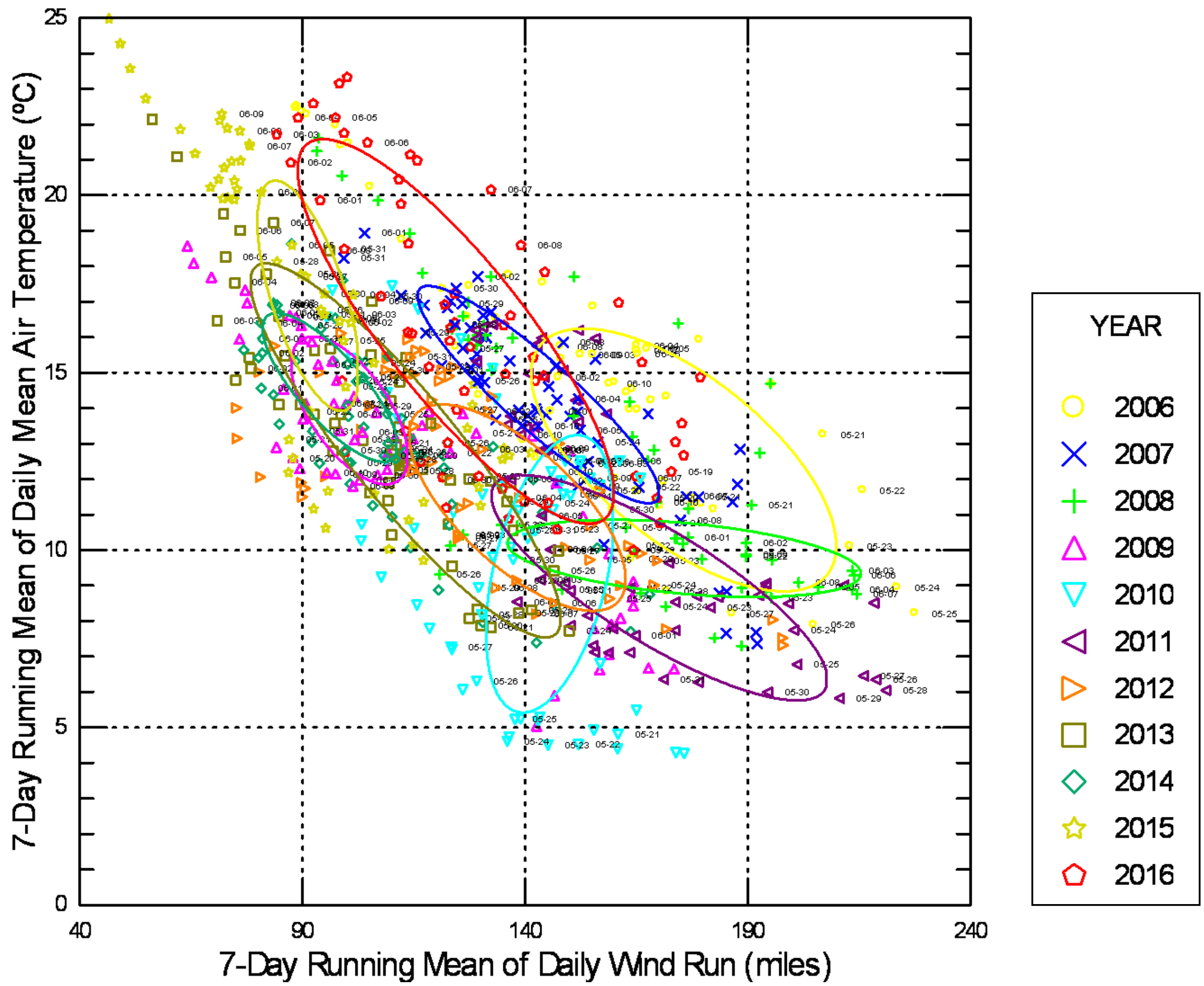


Figure 12. Scatter plot of the 7-day running mean of the daily wind run (miles) vs. 7-day running mean of daily air temperature (°C) during May and June. Data are from the Bureau of Reclamation AgriMet station located at Agency Lake (AGKO). Data labels are day of the month. Confidence ellipses are drawn for dates occurring during the last 10 days of May and first 10 days of June; confidence ellipses are centered on the sample means of the x and y variables where the unbiased sample standard deviations of x and y determine its major axes and the sample covariance between x and y, its orientation (Systat 2013).

Basic statistics for monthly distributions over all sampling years are shown in Appendix 1. Peak water temperatures occurred in August of 2016 (this is in contrast to some earlier years when the July median was higher) (Figure 13). Monthly distributions for pH in 2016 showed a progressive seasonal increase with seasonal maxima occurring in July that coincided with lower Secchi depth (indicating reduced transparency) and highest CHL distributions (Figure 14). Similar to 2012 through 2015, lower DO occurred during August in 2016, and although the timing of low DO was similar to other years, August DO was relatively low compared to many previous years.

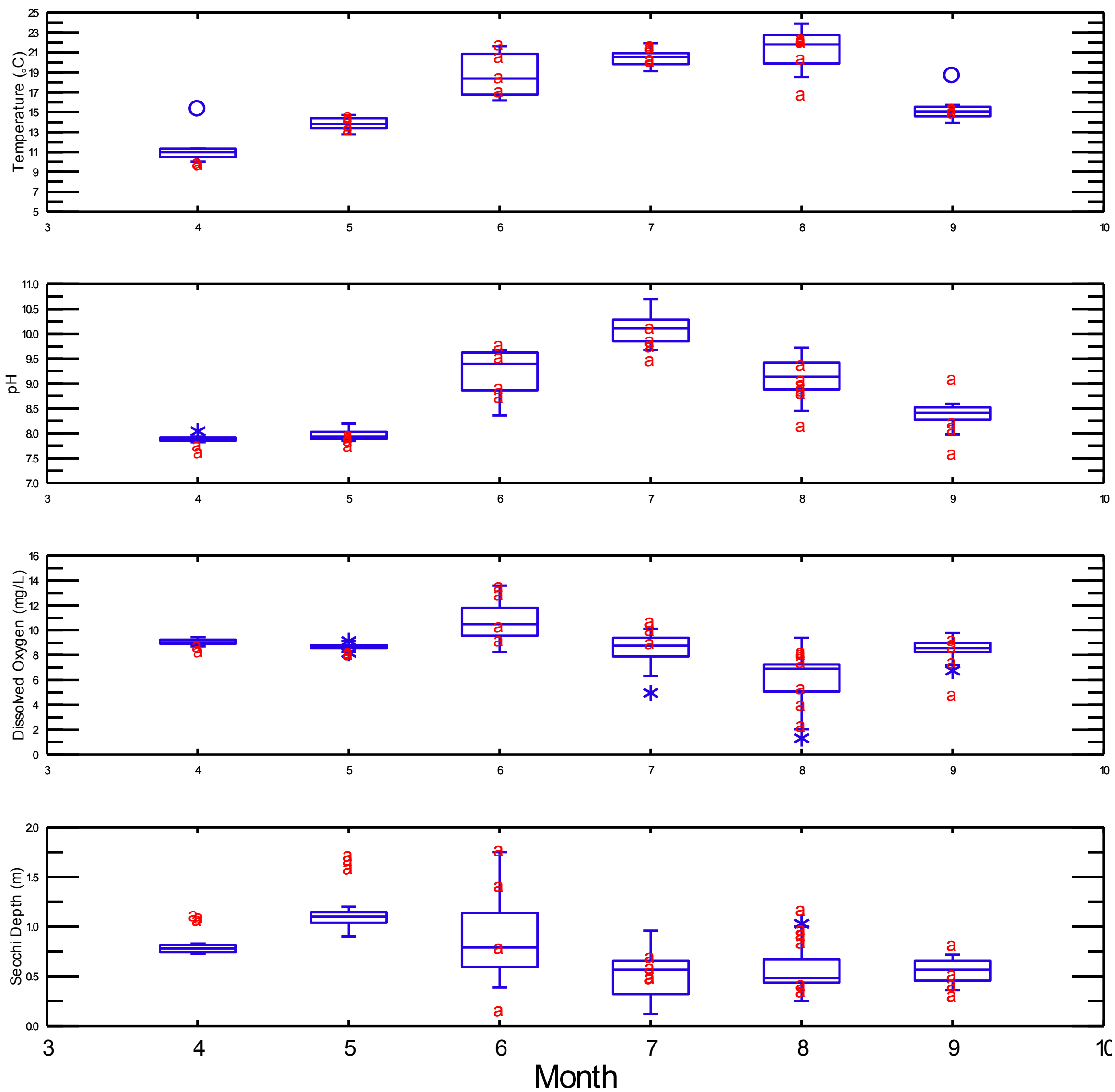


Figure 13. Monthly distributions of T (˚C), pH, D.O (mg/L), and Secchi depth, 2016 (symbol "a" denotes values for Agency Lake plotted separately from the box plot distribution).

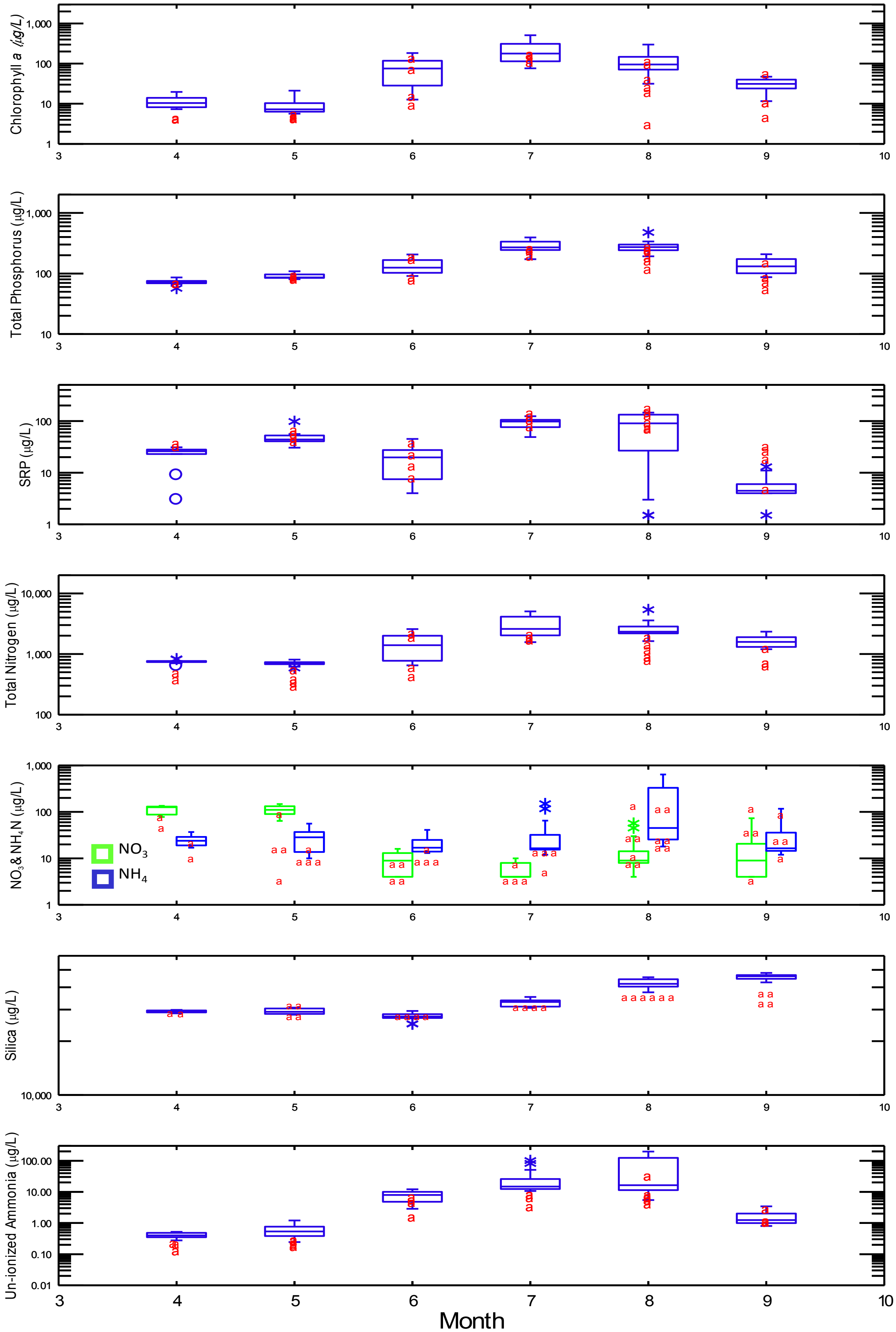


Figure 14. Monthly distributions of CHL, TP, SRP, TN, NO_3+ NO_2-N, NH_4-N, SiO_2 and un-ionized ammonia, 2016 (symbol "a" denotes values for Agency Lake plotted separately from the box plot distribution).

Because the CHL decline in 2016 was not as pronounced as other years, the typical bimodal CHL peak as indicated by the monthly box plots was not as obvious as in other years (Figure 14). TP tended to follow the initial trend in CHL, but then remains elevated even while the bloom declines. SRP was elevated in April and May before declining during the period of algal biomass increase (indicating uptake), before peaking in July during the bloom peak and decline. TN increased during June, with values then peaking in July and remaining somewhat constant through the season. Coinciding with the decline of the *Aphanizomenon* bloom, NH_4-N increased in August (this was in contrast to 2015 when ammonia increased during the June bloom decline), and NO_3-N also increased in August (Figure 14; Figure 15).

A further look at the 2016 time-series with respect to CHL and dissolved nutrients on a lake-wide basis (Figure 16; which includes June dates for USGS stations in 2015) shows that, as in other years, SRP at the UKL stations generally remained low through the initial June CHL peak before increasing during the algal biomass decline in early July (Figure 15 and Appendix III). As noted previously, there is evidence that SRP is limiting the early season bloom in UKL, especially since SRP values remain suppressed even when internal sources of phosphorus are increasing during that time period (Kann 2010; Walker et al. 2012).

In 2016 and most previous years, TIN (the sum of NH_4-N and NO_3-N) levels were relatively low during the period leading up to and a the onset the annual *Aphanizomenon* growth period (Figure 16). TIN began to increase in late-July as algal biomass began to decline (Figure 16), but then decreased again in mid-September before increasing in October. As in earlier years, SRP in 2016 tended to decline into the fall months. Unlike 2011 when TIN declined in the fall, values of TIN also increased in 2016 (values continued to increase in 2012-2105 as well). Spring and fall TIN tended to show an increased proportion of NO_3-N, while summer TIN was comprised predominantly of NH_4-N (Figure 16). However, similar to 2015, fall NH_4-N values were high relative to other years. The contrast between 2015 and 2016 provides a good illustration of the effect of bloom phenology, particularly bloom onset, peak and decline, on nutrient parameters.

In previous years April TN:TP values were >15, which was associated with diatom blooms observed in spring (Kann 2012). However, in 2015 April TN:TP ratios were closer to 10 (Figure 16), but were back to ~15 in 2016. In most years the TN:TP and TIN:SRP ratios declined in May and June during the period preceding the rise of nitrogen-fixing *Aphanizomenon* in UKL (TN:TP ratios were generally lower than 10 and TIN:SRP<2.5) (Figure 16). April and early May TIN:SRP ratios were notably higher in 2016 than they were in 2015. Relatively low May-June TN:TP and TIN:SRP ratios in 2015 (TN:TP <10; TIN:SRP<1) also seemed to be associated with an earlier *Aphanizomenon*-associated algal biomass rise (Figure 16). Although TIN:SRP ratios typically increase in August as TIN levels rise (as they did in 2016), this occurred in late June of 2015 due to the early *Aphanizomenon* decline and subsequent remineralization of organic N to inorganic N. Also unique to 2015 was an unusually early and large boom of *Microcystis aeruginosa* which followed the decline in *Aphanizomenon* and increase in TIN (Figure 17). Although *Microcystis* typically follows the decline in *Aphanizomenon* and rise in TIN in UKL (Kann 2015; Eldridge et al. 2012), this usually happens in late-July or August as it did in 2014 (Figure 16; Figure 17). The cause of the early bloom decline in 2015 is uncertain; however, it may be related to the warm/calm conditions causing early and rapid *Aphanizomenon* growth rate and subsequent light limitation due to self- shading. In that regard, climate favored the early onset of both bloom species, but a source of TIN was still associated with the onset of the non-diazotrophic *Microcystis*. Relatively early blooms occurred in both 2013 and 2014 (Figure 16) that were also associated with warmer late spring conditions (Figure 12).

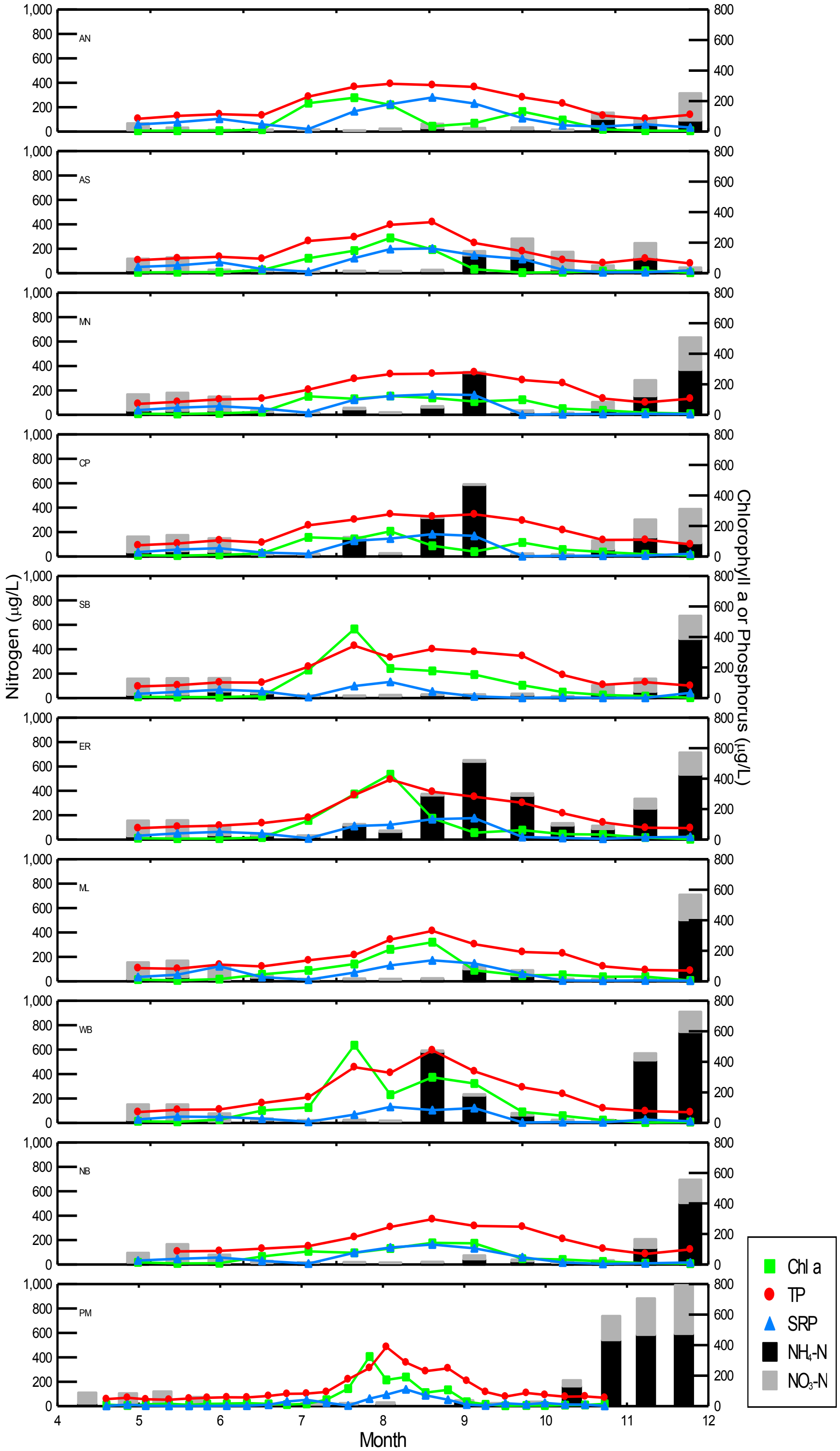


Figure 15. Chlorophyll, SRP, and TIN time-series for UKL and Agency Lake Stations, 2016.

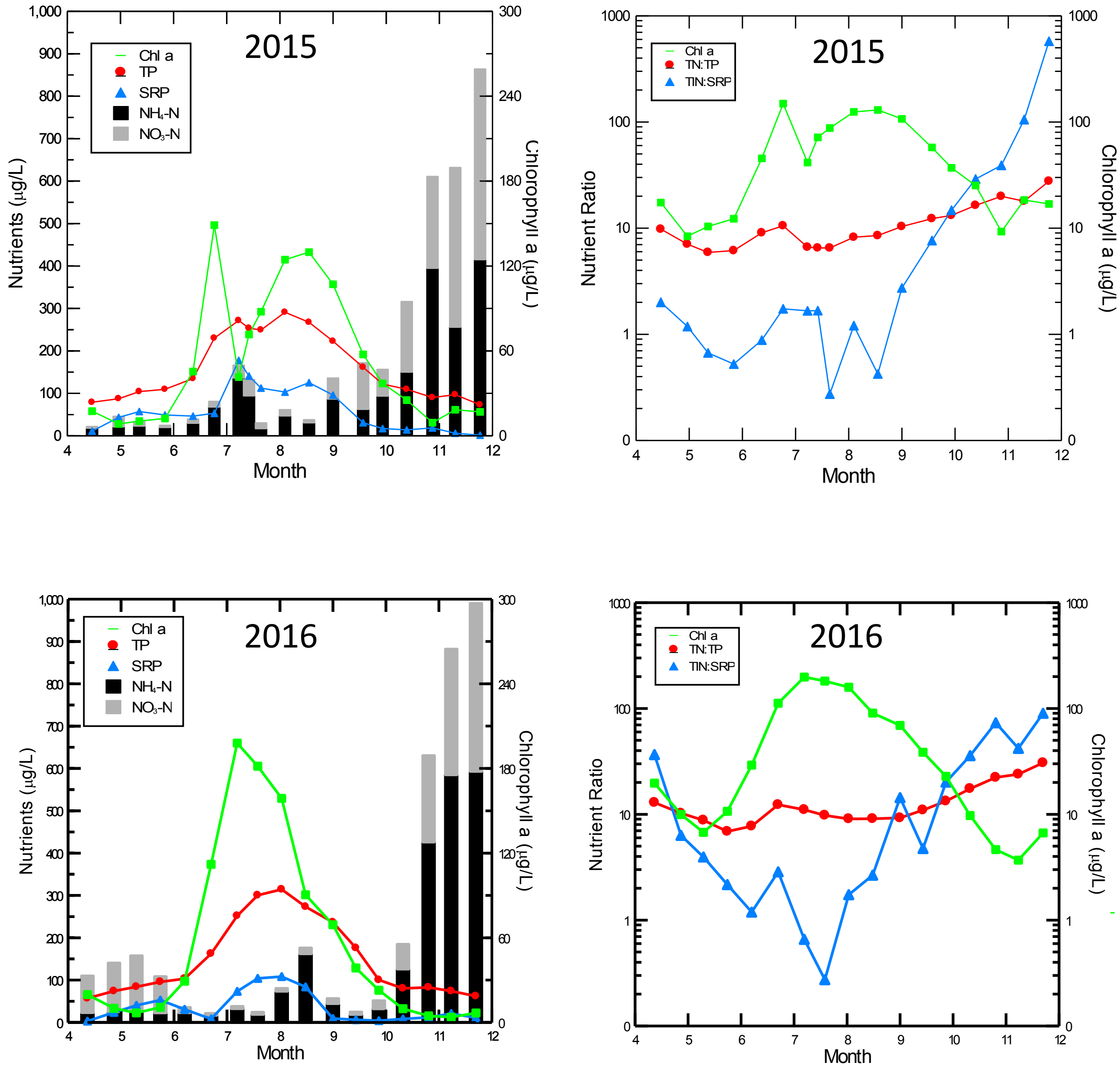
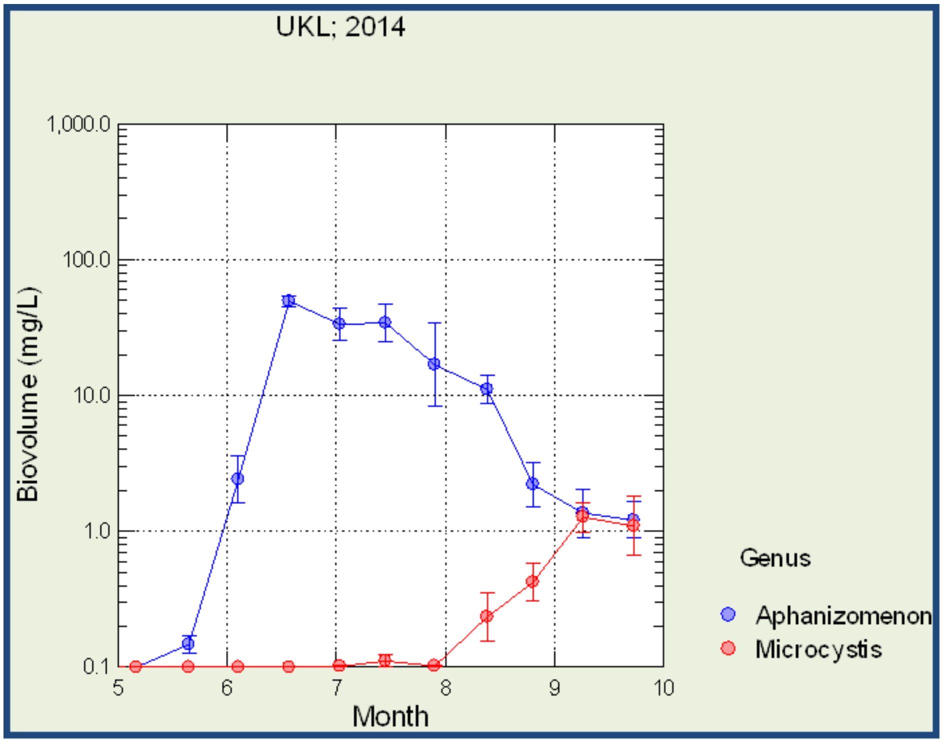


Figure 16. Lake-wide mean Chlorophyll, SRP, TIN, and nutrient ratio time-series for UKL Stations, 2015-2016.



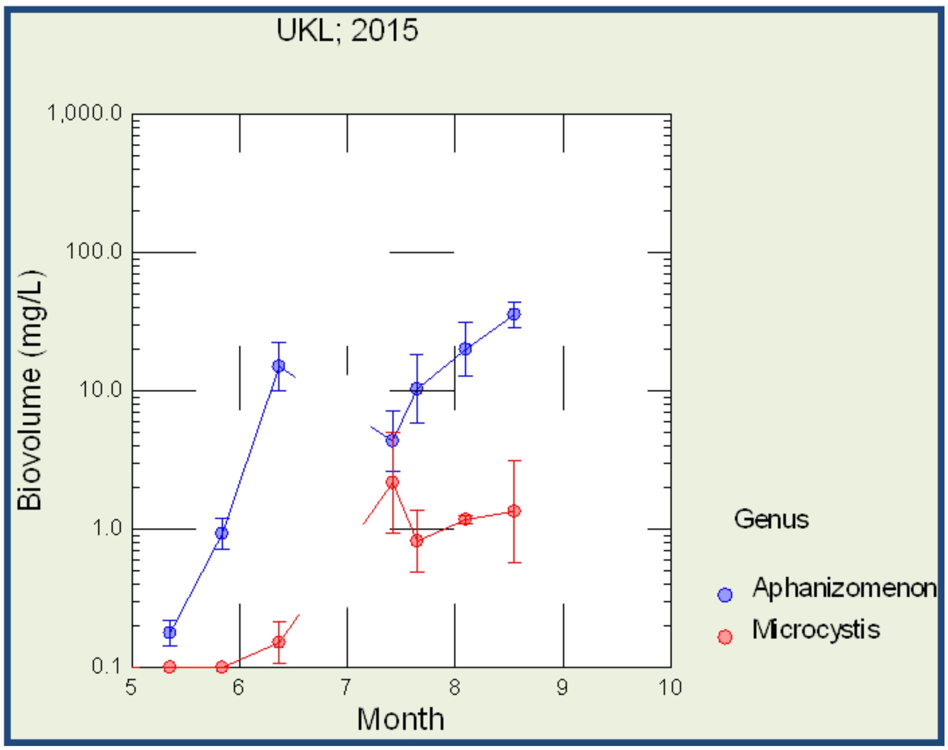


Figure 17. Biovolume of *Aphanizomenon and Microcystis* in UKL, 2014-2015. See Kann et al. 2014 for methodology.

Silica showed declining and lowest seasonal values April-June, and a substantial increase beginning in July, with elevated values continuing through mid-September (Figure 14; Appendix III). These trends are likely tied to silica uptake during spring diatom blooms, and subsequent summer sediment recycling and lack of uptake due to diatom decline during periods of *Aphanizomenon* dominance. Time series graphs in Appendix III indicate that the silica increase is concomitant with initial large CHL and TP increases in July, and that silica concentration increases (>45,000 µg/L) continue into September before gradually declining in the fall, and continue to decline to seasonal lows in the spring. The Agency Lake sites showed a more muted pattern with somewhat higher values in the spring compared to other stations, and the magnitude of summer increases were less pronounced, especially at AN (Appendix III). Silica values in the spring and early summer of 2013 and 2014 were noticeably higher (>25,000 µg/L) than in 2012 when they were ~15,000 µg/L (Kann 2013). The reason for this is not yet clear, but TP values were also higher during this period in 2013 and 2014. Silica values in 2015 were again lower and similar to those in 2012 (Appendix III; Figure 18), but values in 2016 were higher and similar to 2013 and 2014. Trends at the outflow station (Figure 18), which include winter data, show the seasonal silica trend that includes a spring depression likely due to diatom uptake. The outflow data also clearly show the relatively high TIN occurring in the fall of both 2015 and 2016 (especially when compared to 2014), as well as the seasonal spring depression of TIN in the period preceding the rise in CHL due to diazotrophic *Aphanizomenon*.

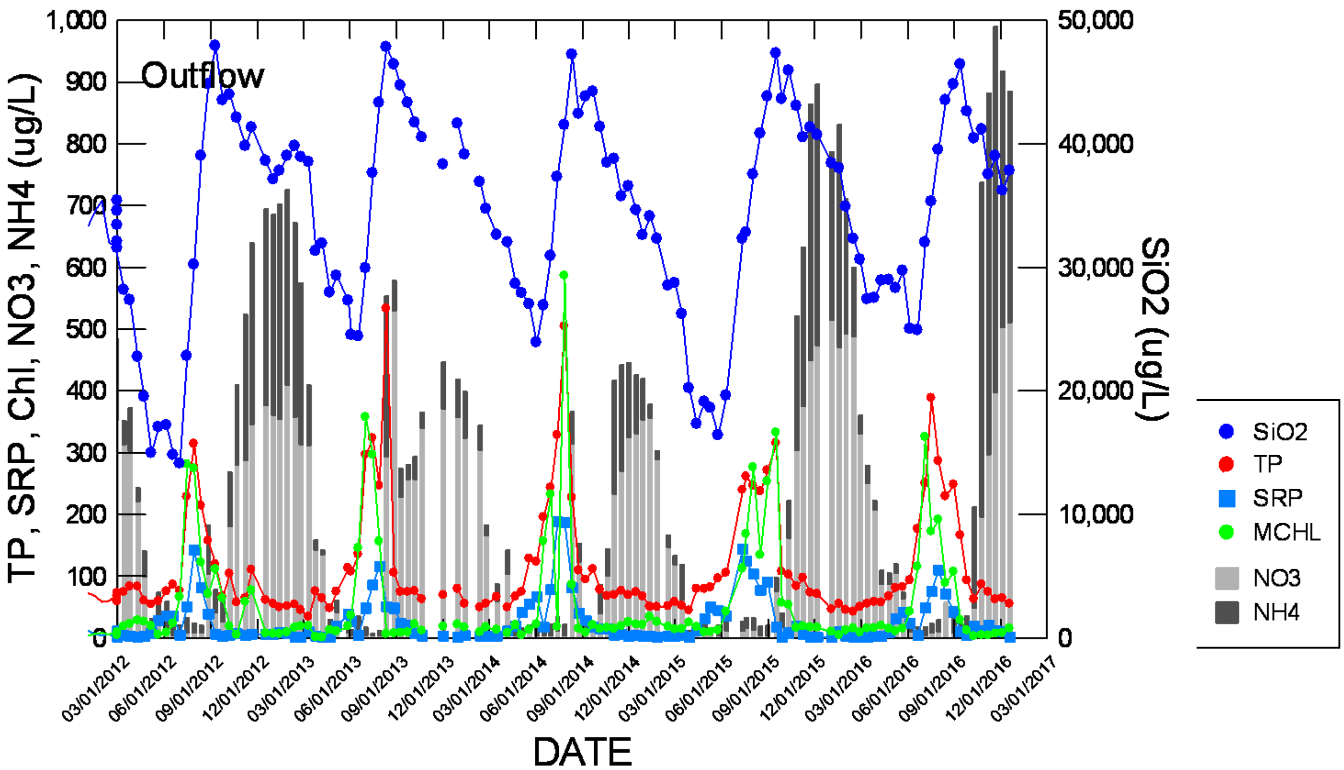


Figure 18. Outflow Chlorophyll, SRP, TIN (nitrate and ammonia), and silica time-series, 2012 -2016.

In 2009, chlorophyll to TP ratios greater than 1 (which indicate potential P limitation- see Kann 2010) were observed at a high frequency in June during the initial bloom increase; in 2010 CHL: TP ratios >1 occurred in April, part of May, July, and part of September (Kann 2011), and in 2012 the frequency of CHL: TP ratios >1 was similar to 2011, occurring at a high frequency only in July (Kann 2013). In 2013 both June and July showed an increased frequency of CHL:TP >1 but in 2014 a relatively low frequency of CHL: TP ratios >1 occurred, with only a few stations in June and July above 1 (Kann 2014; Kann 2015). Interestingly, 2015 and now 2016 also showed (Figure 19) a relatively low frequency of CHL: TP ratios >1; 5 stations in July (Figure 19).

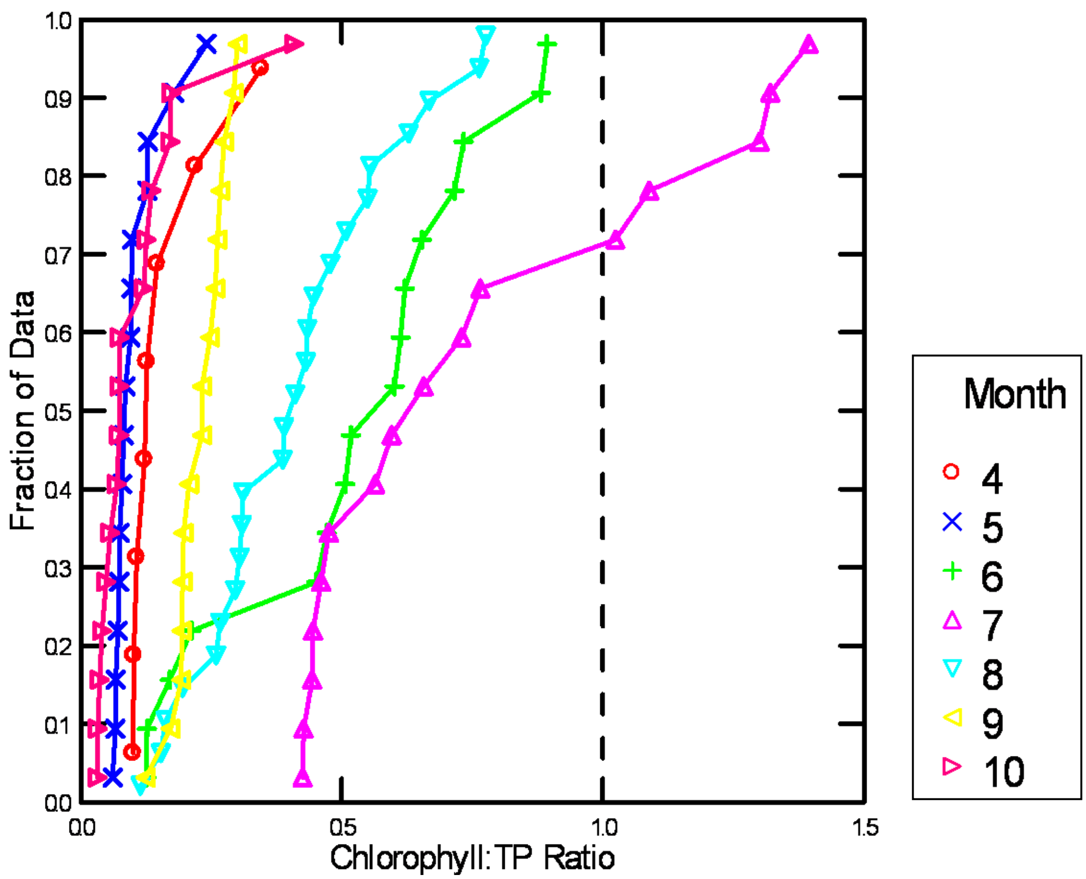


Figure 19. Quantile plot (cumulative frequency) of April-October chlorophyll to TP ratios in Upper Klamath Lake, 2016.

The underwater light environment is another factor that can influence both bloom dynamics and other water quality parameters, especially those that are photosynthetically driven. Although not discussed in detail here, a plot of photic zone depth (defined as the depth where 99% of incident light is absorbed as computed from extinction coefficients) relative to the maximum depth at UKL and Agency Lake stations shows that, as in other years, despite the shallow nature of the system that the photic zone depth was at times shallower than maximum depth in 2015 (Figure 20; occurring when the blue line is above red line). The typical UKL pattern shows a relatively shallow photic zone during the spring diatom bloom, a deeper photic zone that extends the depth of the water column during much of May and early-June, a shallower photic zone during late-June to mid-July algal blooms, a decline (i.e., deeper photic zone- although not as extreme as the May decline) during August bloom declines, and finally another shallow photic zone period during bloom rebound in late-August and September (Kann 2010-2016). The 2016 pattern was generally similar to other years; however, the percentage of the water column outside of the photic zone tended to be somewhat higher than previous years (e.g., does not have sufficient light for photosynthesis; Figure 21).

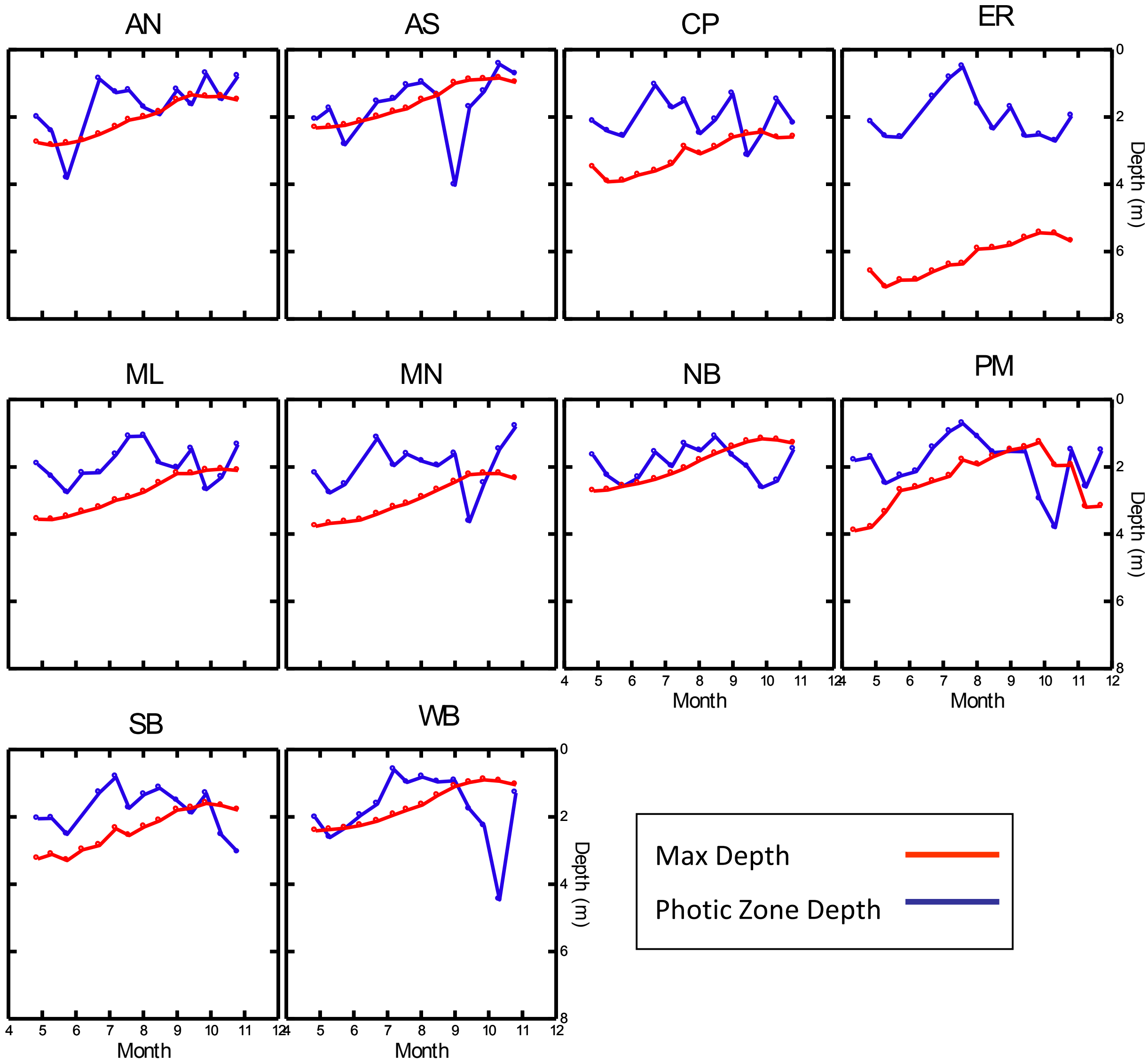


Figure 20. Photic zone depth and maximum depth at UKL and Agency Lake stations in 2016 (periods when the blue line is shallower than the red line indicate that a portion of the water column is not within the photic zone.

Light limitation was more apparent at the deeper ER station which showed a greater percentage of the water column to be light limited. To the extent that underwater light is influenced by seasonal algal dynamics (in concert with ambient light and the interaction with lake depth), decreases in available light during the early spring were likely influenced by diatom blooms (e.g., Kann 2011). These light decreases are generally followed by a “clear water” phase in May (with some variability in timing) as the diatoms decline (Kann 2014). In 2012, a reduced photic zone occurred in early-spring, with a “clear water” phase occurring in late-May, and although the photic zone was again reduced in early June, the lake was then relatively clear again in late-June prior to a sharp decrease in transparency in mid-July (Kann 2013). In both 2013 and 2014 there was a “clear water” phase in early June which preceded the algal biomass increase in July, and in 2015 and 2016 a mid-May to early-June increase in clarity preceded the June algal biomass increase (Figure 21).

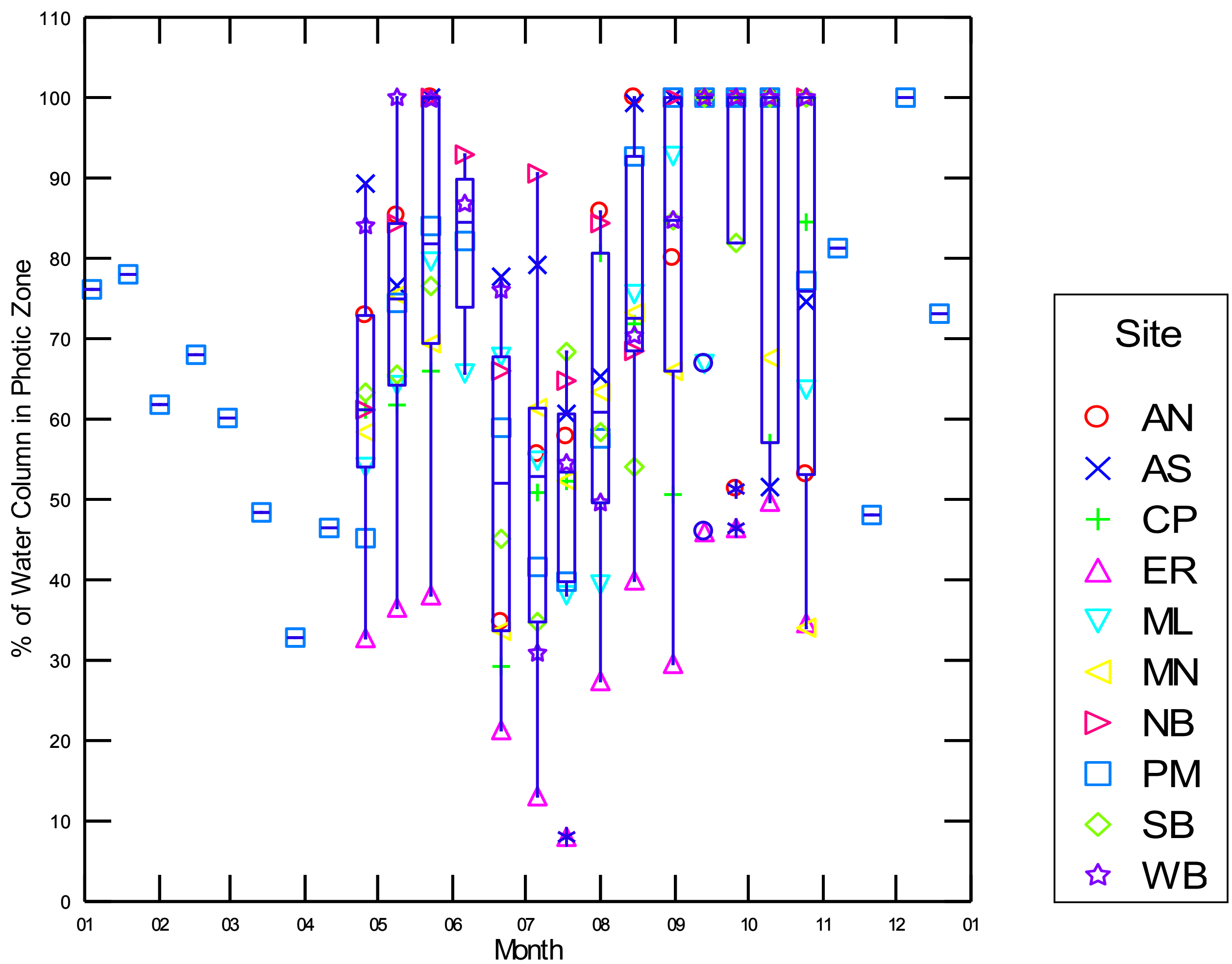


Figure 21. Percent of the water column in the photic zone for UKL and Agency Lake Stations, 2016.

As is typical for many shallow lake ecosystems, the concentration of nutrients, their ratios, the underwater light climate, and climatic variables (e.g., temperature and wind speed) are important determinants of annual bloom dynamics of *Aphanizomenon* in UKL. During the 2010 and 2009 growing seasons (see Kann 2010; 2011) it appears that the late-spring decline in TN:TP (indicating more nitrogen limiting conditions), a later (June as opposed to May) "clear water" phase (nitrogen fixation generally has a high energy/light requirement) and cooler May-June temperatures were important determinants of *Aphanizomenon* bloom timing. Likewise, relatively high TIN concentrations and high TIN:SRP ratios, a late "clear water" phase, generally cooler and windier conditions during late-May and early-June, and cool temperatures in July apparently influenced bloom dynamics in 2011. The bloom pattern in 2012 fell somewhere in between the 2009-2010 and 2011 pattern, with declining TIN:SRP ratios and a "clear water" phase also preceding the summer *Aphanizomenon* increase.

The 2013-2016 bloom initiation patterns were also characterized declining TIN:SRP ratios and a "clear water" phase, as well as by warmer/calmer climatic conditions. In particular, 2015 experienced an early bloom and unusually early bloom crash (decline) of *Aphanizomenon* that was followed by an unusually early *Microcystis* bloom. As shown by Jassby and Kann (2010), lake level and climate interact to determine bloom magnitude during the early season.

As noted above, this report serves as an annual data summary, and additional multivariate modelling is beyond the current scope. However, it is recommended that the interaction among these variables as well as other controlling factors such as lake level and hydrodynamic patterns be further explored further with additional multivariate statistical analyses using the long-term dataset.

Comparison of 2016 to Previous 1990-2015 Data

To facilitate inter-annual comparisons of the major water quality variables, lake-wide means and medians were computed for UKL-only and Agency Lake-only. The distributions for the June-September period are shown in Figure 23 to Figure 26, and summary statistics in Tables 3 and 4. Similar to 2015, despite early season temperature values that were relatively high, the overall June-September lower quartile in 2016 was relatively low, as was the upper quartile (Figure 23). Dissimilar to 2010-2014 when the June-Sep UKL pH distributions were among the lowest for the period of record, values in both 2015 and 2016 were again in the range of many previous years (Figure 23; Table 3). In contrast to 2011 when median DO concentration was higher than all other years for the period of record, median DO in 2012 and 2013 were among the lowest despite the lack of a large bloom decline, and 2014-2016 were intermediate. Secchi disk transparency followed that of the photic zone indication of less water column light, with the interquartile range among the lowest for the period of record (Figure 22).

As expected due to its controlling effect on pH, median and lower quartile CHL in 2014 (as in 2013) also tended to be among the lowest for the period of record, but rebounded in 2015 and 2016 (Figure 24). Overall CHL levels were lower for the 2010-2014 period compared to the earlier period. TP in 2016 was relatively high compared to other years, but SRP in 2016 was among the lowest for median and lower quartile[12] (Figure 24). While TN was low between 2010 and 2014, and followed the trend in TP and CHL during those years, TN increased in 2015 and

[12] in contrast 2014-2015 were among the highest

2016. However, values were still comparatively low 2015 and 2016 despite the rebound in CHL and pH in those years. For the 27 years of record, the ammonia distribution was similar from 1990-1995, was elevated from 1996-2002, and then decreased to pre-1996 levels during the past 14 years (2003-2016). The ammonia and nitrate distributions were low overall in 2016.   Inter-annual silica variability is indicated, with 2009 and 2010 showing reduced lower quartile values, possibly due to enhanced diatom blooms in spring of those years (Figure 24). Silica values in 2013-2016 were similar, and showed the highest median, upper and lower quartiles, and inter-quartile range compared to the previous five years. As expected given lower pH values in recent years, un-ionized ammonia was notably lower during 2010-2014 (especially lower quartile values), but rebounded somewhat in 2015 and 2016.

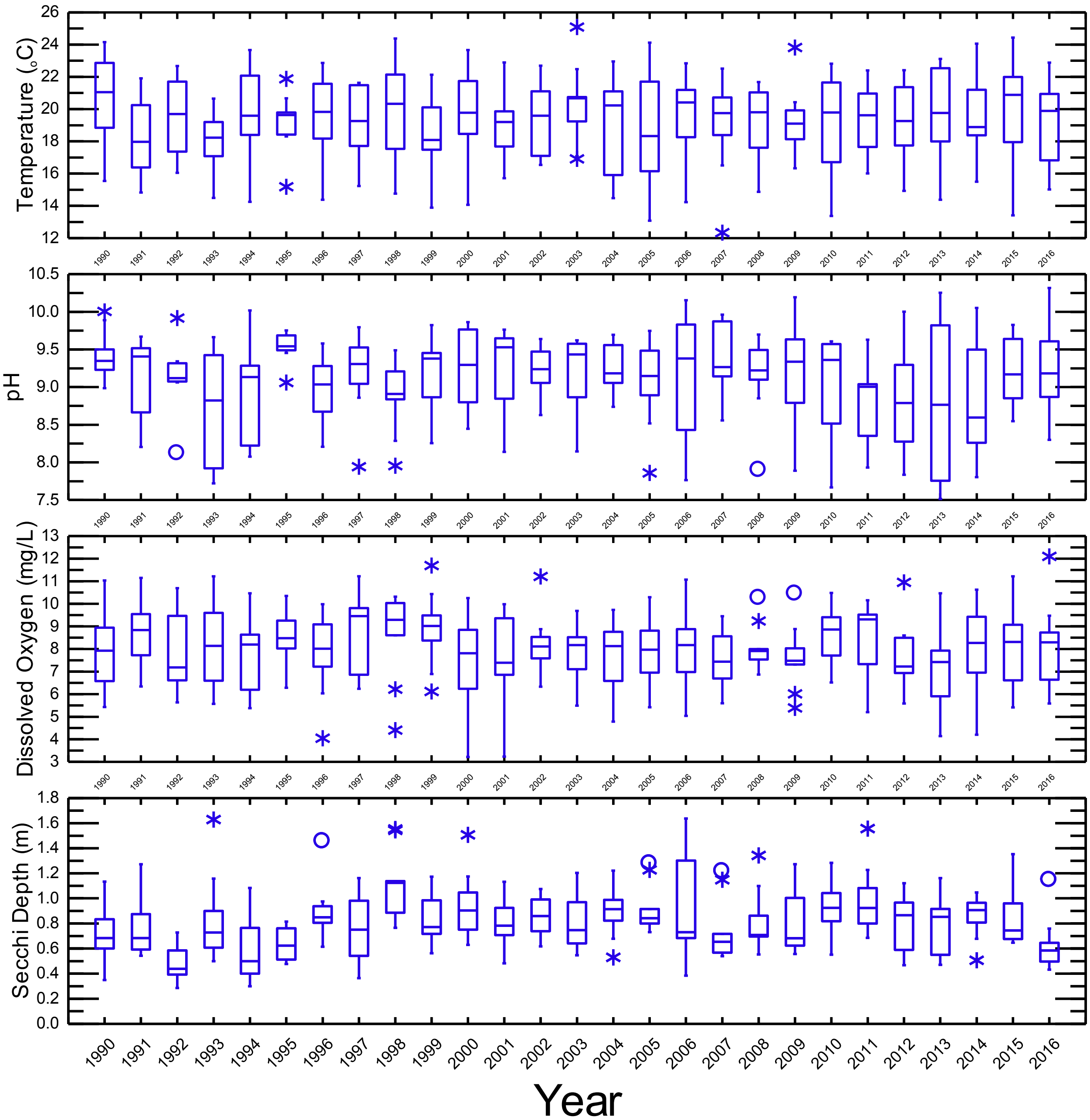


Figure 23. June-September distribution of UKL-only lake-wide means for T (˚C), pH, D.O (mg/L), and Secchi depth, 1990-2016.

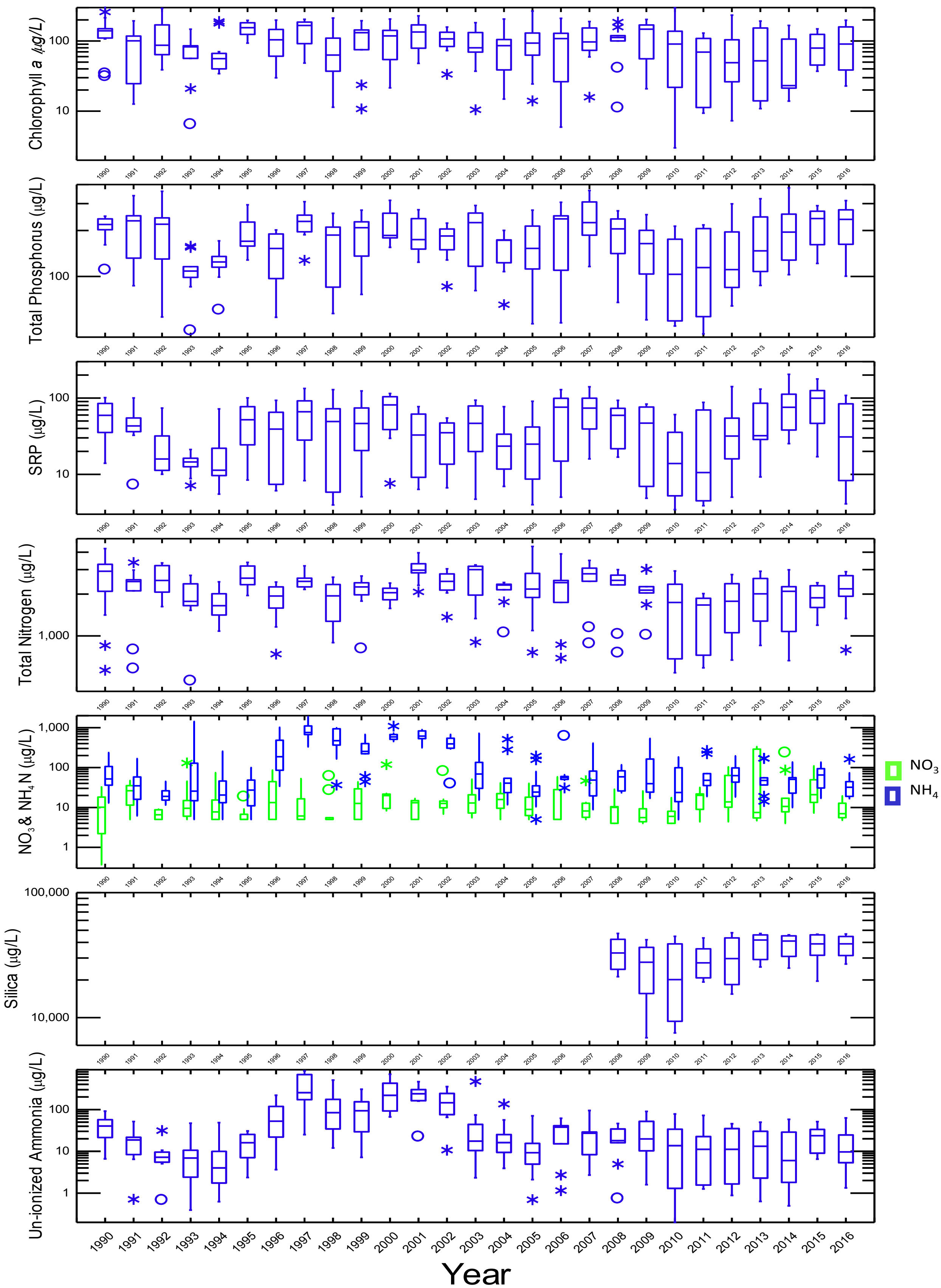


Figure 24. June-September distribution of UKL-only lake-wide means for CHL, TP, SRP, TN, NO_3+ NO_2-N, SiO_2 and NH_4-N, 1990-2016.

Table 3. Summary statistics for June-September UKL-only lake-wide means, 1990-2016 (LQ= Lower Quartile; UQ=Upper Quartile).

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1990	N of Cases	14.00	14.00	14.00	14.00	13.00	13.00	13.00	13.00	0.00	10.00	11.00	11.00
1990	Median	21.05	9.35	7.93	0.68	139.91	219.19	59.35	2916.12		9.04	51.96	49.74
1990	Arithmetic Mean	20.71	9.41	8.00	0.72	136.77	208.35	60.66	2642.61		11.11	84.68	53.95
1990	Coefficient of Variation	0.12	0.03	0.21	0.36	0.45	0.19	0.50	0.43		1.00	0.87	0.54
1990	LQ	18.84	9.23	6.58	0.60	109.49	192.81	33.76	1922.61		1.66	34.39	37.30
1990	UQ	22.86	9.50	8.94	0.83	155.99	239.41	87.34	3379.41		18.25	123.58	72.62
1991	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	3.00	7.00	7.00
1991	Median	17.97	9.41	8.84	0.68	100.53	231.59	43.11	2459.31		26.34	34.97	28.76
1991	Arithmetic Mean	18.11	9.17	8.66	0.77	95.58	202.44	47.32	2171.56		26.12	52.31	35.16
1991	Coefficient of Variation	0.13	0.06	0.16	0.32	0.70	0.43	0.54	0.42		0.80	1.09	0.90
1991	LQ	16.38	8.66	7.65	0.59	24.61	122.06	35.32	1780.00		10.33	14.30	12.70
1991	UQ	20.36	9.54	9.56	0.91	135.47	255.72	57.90	2643.12		41.86	73.10	56.67
1992	N of Cases	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.00	8.00	8.00	8.00
1992	Median	19.69	9.12	7.19	0.44	87.18	220.07	16.04	2530.52		6.57	18.98	9.79
1992	Arithmetic Mean	19.53	9.13	7.86	0.48	122.76	200.16	25.32	2571.30		6.83	22.22	13.34
1992	Coefficient of Variation	0.13	0.05	0.23	0.30	0.71	0.47	0.85	0.26		0.27	0.48	0.77
1992	LQ	17.36	9.07	6.61	0.39	64.57	130.27	11.31	2065.52		5.00	15.44	6.89
1992	UQ	21.70	9.32	9.47	0.59	173.82	242.27	32.00	3201.93		8.74	26.27	20.30
1993	N of Cases	10.00	10.00	10.00	10.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
1993	Median	18.22	8.82	8.14	0.73	82.63	108.59	14.54	1772.42		9.54	25.68	15.28
1993	Arithmetic Mean	17.91	8.77	8.21	0.83	74.91	109.72	14.21	1841.27		25.90	234.53	37.61
1993	Coefficient of Variation	0.12	0.08	0.23	0.41	0.60	0.31	0.31	0.35		1.58	2.01	2.09
1993	LQ	17.08	7.92	6.60	0.61	47.66	95.38	11.64	1619.51		5.76	12.60	2.07
1993	UQ	19.20	9.43	9.60	0.90	96.19	125.74	16.58	2374.96		22.52	211.36	20.07
1994	N of Cases	10.00	10.00	10.00	9.00	13.00	14.00	14.00	14.00	0.00	14.00	15.00	10.00
1994	Median	19.59	9.13	8.20	0.50	56.00	124.50	11.36	1650.00		7.74	20.51	4.57
1994	Arithmetic Mean	19.61	8.96	7.82	0.59	72.48	123.44	18.30	1734.58		15.84	51.59	10.71
1994	Coefficient of Variation	0.16	0.08	0.21	0.43	0.70	0.21	0.96	0.22		1.26	1.35	1.53
1994	LQ	18.40	8.22	6.20	0.40	39.82	115.00	9.65	1413.48		5.00	13.09	1.90
1994	UQ	22.08	9.28	8.64	0.77	67.64	135.29	22.00	2010.00		15.39	46.50	9.95
1995	N of Cases	9.00	9.00	9.00	8.00	8.00	8.00	8.00	8.00	0.00	8.00	8.00	8.00
1995	Median	19.64	9.54	8.48	0.62	155.27	170.13	52.78	2608.21		5.00	27.92	29.91
1995	Arithmetic Mean	19.16	9.53	8.56	0.64	152.04	192.23	52.74	2697.85		7.22	34.94	31.33
1995	Coefficient of Variation	0.10	0.02	0.14	0.21	0.24	0.29	0.62	0.19		0.67	0.89	0.65
1995	LQ	18.39	9.48	7.96	0.51	125.43	158.26	26.25	2335.87		5.00	11.04	17.08

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1995	UQ	20.01	9.69	9.28	0.76	182.09	228.96	77.54	3183.11		7.07	48.65	46.51
1996	N of Cases	10.00	10.00	10.00	7.00	10.00	10.00	10.00	10.00	0.00	10.00	10.00	10.00
1996	Median	19.83	9.04	8.01	0.85	104.18	153.62	39.76	1936.19		14.21	196.35	54.04
1996	Arithmetic Mean	19.57	8.96	7.79	0.92	106.37	142.58	41.08	1818.78		26.87	331.45	83.87
1996	Coefficient of Variation	0.13	0.05	0.22	0.29	0.52	0.38	0.83	0.30		1.00	0.97	0.89
1996	LQ	18.17	8.67	7.22	0.79	60.72	96.88	7.39	1584.47		5.00	85.37	22.82
1996	UQ	21.57	9.28	9.09	0.96	146.00	189.91	65.00	2251.72		44.41	483.08	130.41
1997	N of Cases	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.00	8.00	8.00	8.00
1997	Median	19.26	9.31	9.46	0.75	167.50	229.62	66.08	2468.43		6.12	761.29	302.12
1997	Arithmetic Mean	19.22	9.19	8.72	0.76	143.07	224.18	65.61	2499.46		15.58	916.03	482.15
1997	Coefficient of Variation	0.12	0.06	0.21	0.36	0.40	0.24	0.63	0.13		1.20	0.52	0.79
1997	LQ	17.72	9.04	6.86	0.54	92.06	196.59	33.43	2252.51		5.00	669.32	237.43
1997	UQ	21.49	9.53	9.81	0.98	186.38	252.14	91.95	2603.33		22.35	1124.56	843.47
1998	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
1998	Median	20.33	8.91	9.29	1.13	63.03	186.78	49.21	1940.22		5.00	471.70	170.54
1998	Arithmetic Mean	19.91	8.88	8.58	1.11	86.09	163.71	48.41	1824.37		13.73	583.04	194.93
1998	Coefficient of Variation	0.17	0.06	0.23	0.26	0.74	0.44	0.93	0.35		1.38	0.63	0.95
1998	LQ	17.02	8.70	8.01	0.88	36.69	84.01	5.69	1205.65		5.00	315.01	64.57
1998	UQ	22.38	9.25	10.09	1.24	119.87	214.91	76.42	2352.78		10.88	947.26	259.38
1999	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
1999	Median	18.09	9.38	9.02	0.77	131.26	208.76	46.45	2248.65		12.65	254.15	120.34
1999	Arithmetic Mean	18.23	9.14	8.89	0.84	109.09	188.11	52.47	2114.62		18.10	306.96	154.92
1999	Coefficient of Variation	0.15	0.06	0.19	0.24	0.61	0.34	0.75	0.27		0.86	0.68	1.02
1999	LQ	16.70	8.72	8.00	0.71	62.20	135.08	17.08	1924.75		5.00	181.69	28.94
1999	UQ	20.25	9.54	9.73	1.01	154.63	234.77	77.09	2461.33		31.93	435.01	237.68
2000	N of Cases	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.00	8.00	8.00	8.00
2000	Median	19.77	9.30	7.81	0.90	118.76	185.90	81.25	2043.25		19.76	586.91	259.86
2000	Arithmetic Mean	19.71	9.25	7.41	0.94	109.61	215.01	71.72	2013.85		28.57	636.96	334.35
2000	Coefficient of Variation	0.15	0.06	0.29	0.30	0.56	0.26	0.55	0.14		1.29	0.32	0.78
2000	LQ	18.46	8.80	6.24	0.75	64.58	178.94	40.01	1820.30		9.53	511.00	107.67
2000	UQ	21.74	9.77	8.85	1.05	141.52	259.88	104.46	2204.64		21.60	674.46	550.45
2001	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
2001	Median	19.20	9.53	7.39	0.78	134.25	174.45	32.80	2967.38		13.15	613.56	264.73
2001	Arithmetic Mean	18.80	9.22	7.36	0.82	132.75	193.42	35.26	2989.51		10.97	645.49	275.94
2001	Coefficient of Variation	0.12	0.06	0.29	0.24	0.49	0.28	0.75	0.19		0.44	0.33	0.46
2001	LQ	17.27	8.83	6.47	0.70	74.75	150.88	8.67	2708.62		5.00	492.95	226.57
2001	UQ	19.92	9.65	9.39	0.95	180.28	246.18	61.93	3357.25		14.95	846.60	330.29

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2002	N of Cases	8.00	8.00	7.00	8.00	8.00	8.00	8.00	8.00	0.00	8.00	8.00	8.00
2002	Median	19.58	9.24	8.11	0.86	107.35	184.20	35.55	2469.07		12.62	397.24	168.12
2002	Arithmetic Mean	19.35	9.23	8.27	0.86	105.59	173.91	32.55	2400.61		20.28	400.99	181.82
2002	Coefficient of Variation	0.12	0.03	0.19	0.19	0.39	0.26	0.57	0.22		1.22	0.50	0.64
2002	LQ	17.10	9.06	7.37	0.74	84.35	151.48	16.57	2138.12		10.04	304.52	106.34
2002	UQ	21.10	9.47	8.71	0.99	134.81	205.05	47.33	2794.86		14.53	545.95	260.60
2003	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
2003	Median	20.67	9.43	8.17	0.75	80.14	225.38	46.59	2999.79		12.96	69.05	24.13
2003	Arithmetic Mean	20.33	9.17	7.82	0.81	90.60	204.23	48.72	2475.04		17.34	141.92	93.82
2003	Coefficient of Variation	0.12	0.06	0.16	0.30	0.58	0.39	0.68	0.36		0.81	1.57	1.92
2003	LQ	18.70	8.81	7.03	0.62	61.33	114.97	18.11	1807.83		6.97	27.56	11.92
2003	UQ	21.18	9.58	8.55	1.01	133.04	266.88	79.19	3175.81		21.11	142.99	82.03
2004	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
2004	Median	20.23	9.18	8.13	0.91	85.86	172.70	23.46	2317.70		15.80	40.70	19.60
2004	Arithmetic Mean	19.32	9.24	7.74	0.89	85.13	148.75	29.12	2114.16		17.58	113.56	37.21
2004	Coefficient of Variation	0.16	0.04	0.20	0.22	0.68	0.29	0.78	0.21		0.63	1.50	1.18
2004	LQ	15.88	9.01	6.57	0.79	36.82	119.24	11.12	2049.98		9.17	21.98	11.36
2004	UQ	21.45	9.57	8.77	1.00	109.72	173.87	38.02	2351.32		22.99	110.88	41.50
2005	N of Cases	18.00	18.00	18.00	9.00	16.00	18.00	18.00	18.00	0.00	18.00	18.00	18.00
2005	Median	18.33	9.15	7.97	0.84	93.21	152.78	25.05	2170.00		9.01	24.35	10.01
2005	Arithmetic Mean	18.83	9.12	8.00	0.92	98.71	159.61	29.73	2332.41		12.71	44.29	16.28
2005	Coefficient of Variation	0.19	0.05	0.17	0.22	0.63	0.39	0.81	0.37		0.73	1.16	1.16
2005	LQ	16.15	8.89	6.95	0.79	63.07	112.00	8.67	1890.00		6.26	19.00	4.96
2005	UQ	21.71	9.48	8.82	0.99	130.41	213.87	41.72	2815.04		18.00	35.00	22.54
2006	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
2006	Median	20.41	9.38	8.18	0.73	108.17	238.28	75.75	2416.32		5.00	56.32	51.18
2006	Arithmetic Mean	19.72	9.20	8.09	0.93	95.78	198.39	61.54	2256.01		17.43	115.02	50.83
2006	Coefficient of Variation	0.14	0.09	0.21	0.48	0.69	0.46	0.73	0.48		1.06	1.63	0.69
2006	LQ	18.20	8.38	6.98	0.66	24.62	102.89	14.71	1522.98		5.00	49.80	24.29
2006	UQ	21.52	9.91	9.01	1.36	129.45	255.16	99.37	2786.70		28.47	61.46	87.43
2007	N of Cases	9.00	9.00	9.00	9.00	8.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
2007	Median	19.75	9.27	7.44	0.65	97.06	225.51	73.65	2794.14		8.15	48.50	41.77
2007	Arithmetic Mean	19.06	9.40	7.62	0.74	107.39	234.89	72.75	2513.64		12.76	85.22	40.27
2007	Coefficient of Variation	0.16	0.05	0.17	0.35	0.53	0.37	0.59	0.36		1.03	1.45	0.89
2007	LQ	17.92	9.12	6.59	0.56	75.46	169.52	35.68	2139.40		5.50	17.24	11.41
2007	UQ	21.10	9.89	8.68	0.83	154.20	309.70	103.45	3115.55		12.88	82.48	53.26
2008	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2008	Median	19.80	9.22	7.91	0.71	111.99	205.13	59.36	2507.32	32887.50	10.01	58.58	25.07

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO_3+NO_2 Nitrogen (µg/L)	NH_4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2008	Arithmetic Mean	18.96	9.15	8.08	0.82	105.56	182.18	53.51	2232.80	33625.40	9.84	57.74	32.38
2008	Coefficient of Variation	0.14	0.06	0.13	0.31	0.50	0.41	0.56	0.35	0.30	0.79	0.58	0.78
2008	LQ	17.06	9.04	7.48	0.68	85.60	123.19	20.68	2000.96	23581.25	4.00	25.81	13.70
2008	UQ	21.19	9.52	8.31	0.92	128.68	238.97	76.65	2756.35	43150.00	10.87	84.29	55.86
2009	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2009	Median	19.10	9.34	7.48	0.68	147.50	164.22	46.84	2132.77	27725.00	5.58	39.40	27.06
2009	Arithmetic Mean	19.13	9.21	7.66	0.93	122.96	156.53	44.24	2161.99	25734.86	9.13	134.19	52.41
2009	Coefficient of Variation	0.12	0.08	0.19	0.48	0.54	0.45	0.78	0.29	0.50	0.82	1.31	1.12
2009	LQ	17.69	8.71	6.99	0.64	53.04	95.42	6.47	1945.76	14155.31	4.29	23.93	11.32
2009	UQ	20.05	9.70	8.24	1.10	170.90	210.68	77.79	2448.61	37043.75	11.20	193.68	81.25
2010	N of Cases	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
2010	Median	19.79	9.36	8.86	0.93	92.16	112.18	16.83	1763.03	20712.50	5.98	24.28	14.66
2010	Arithmetic Mean	18.94	9.06	8.70	0.91	103.13	118.10	22.14	1657.01	24208.00	7.28	55.53	25.16
2010	Coefficient of Variation	0.17	0.07	0.14	0.23	0.88	0.58	0.89	0.51	0.61	0.62	1.14	1.18
2010	LQ	16.71	8.52	7.71	0.82	21.80	51.18	5.24	684.12	9335.00	4.00	13.98	1.42
2010	UQ	21.65	9.57	9.41	1.04	137.66	175.45	35.58	2353.14	38887.50	8.00	98.97	44.36
2011	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2011	Median	19.28	9.00	9.32	0.92	69.55	114.37	10.55	1667.95	27450.00	20.10	48.04	12.71
2011	Arithmetic Mean	18.37	8.83	8.46	0.98	62.43	126.99	30.98	1412.90	29198.61	17.07	87.56	24.71
2011	Coefficient of Variation	0.20	0.07	0.20	0.29	0.80	0.58	1.16	0.41	0.30	0.57	1.04	1.13
2011	LQ	16.47	8.27	7.20	0.77	11.16	52.67	4.40	708.98	20687.50	7.97	31.32	1.59
2011	UQ	20.93	9.19	9.65	1.12	109.69	208.13	71.79	1870.02	36443.75	23.29	108.55	34.74
2012	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2012	Median	19.26	8.79	7.22	0.87	49.12	110.94	31.75	1773.10	29675.00	13.80	62.93	15.10
2012	Arithmetic Mean	19.21	8.81	7.77	0.80	81.07	153.46	50.31	1661.52	30586.11	32.98	75.09	26.58
2012	Coefficient of Variation	0.13	0.09	0.20	0.28	1.01	0.56	0.94	0.47	0.44	1.08	0.72	1.04
2012	LQ	17.57	8.18	6.87	0.57	24.69	83.09	15.61	967.17	17653.13	9.58	39.74	1.61
2012	UQ	21.41	9.39	8.52	0.97	127.30	211.93	70.08	2391.86	44068.75	63.80	101.75	45.63
2013	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2013	Median	19.75	8.77	7.42	0.85	52.14	147.13	32.11	2007.96	41762.50	7.49	47.42	15.74
2013	Arithmetic Mean	19.66	8.89	7.28	0.77	85.61	183.01	58.04	1910.94	38059.72	115.75	67.29	29.94
2013	Coefficient of Variation	0.15	0.12	0.27	0.31	0.91	0.50	0.75	0.37	0.24	1.30	0.89	1.12
2013	LQ	17.84	7.72	5.77	0.54	13.32	104.21	28.30	1263.73	28328.13	5.43	32.28	2.02
2013	UQ	22.58	9.86	8.24	0.92	160.24	256.50	93.01	2593.92	46150.00	296.73	83.79	62.31
2014	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2014	Median	18.89	8.60	8.27	0.91	23.13	195.25	75.72	2091.89	41025.00	10.59	50.71	6.10
2014	Arithmetic Mean	19.56	8.87	8.02	0.86	60.43	212.26	89.56	1824.00	37950.00	43.64	52.45	29.24
2014	Coefficient of Variation	0.13	0.09	0.24	0.20	0.98	0.52	0.73	0.43	0.22	1.74	0.78	1.30

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2014	LQ	18.29	8.19	6.93	0.78	20.45	122.73	35.63	1075.28	29843.75	7.68	22.24	2.15
2014	UQ	21.30	9.56	9.50	0.98	113.43	287.08	128.87	2359.74	45206.25	34.37	65.98	49.43
2015	N of Cases	10.00	10.00	10.00	8.00	10.00	10.00	10.00	10.00	8.00	10.00	10.00	10.00
2015	Median	20.88	9.17	8.32	0.74	79.65	239.73	99.46	1881.01	38956.25	22.29	65.06	35.77
2015	Arithmetic Mean	19.90	9.20	8.04	0.85	85.10	220.39	90.23	1902.42	37362.50	34.89	66.53	37.12
2015	Coefficient of Variation	0.16	0.05	0.22	0.29	0.48	0.27	0.58	0.21	0.25	0.92	0.55	0.70
2015	LQ	17.96	8.85	6.61	0.68	45.42	161.56	46.48	1601.55	31531.25	13.39	30.68	12.23
2015	UQ	21.99	9.64	9.07	0.96	124.47	267.43	125.19	2294.81	45956.25	49.36	93.71	51.42
2016	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2016	Median	19.89	9.18	8.30	0.59	90.50	236.56	30.88	2179.46	38962.50	6.98	32.10	11.82
2016	Arithmetic Mean	19.27	9.21	8.19	0.63	100.08	213.14	47.59	2125.37	37504.17	9.66	46.83	26.94
2016	Coefficient of Variation	0.15	0.07	0.24	0.35	0.67	0.38	0.93	0.33	0.20	0.53	1.00	1.17
2016	LQ	16.46	8.76	6.50	0.49	36.24	147.55	7.81	1779.75	30593.75	5.47	18.84	4.81
2016	UQ	21.25	9.68	8.91	0.67	164.49	280.13	88.94	2738.10	44637.50	13.04	51.69	44.44

Although for Agency Lake in 2013 both pH and DO were noticeably lower compared to many previous years, median values (LQ values were higher) in both 2014 and 2015 were low for pH but intermediate for DO. For 2016 pH was skewed high and DO low (Figure 25; Table 4). Lower quartile and median values of CHL in Agency Lake in 2014 were also among the lowest for the period of record, and while 2015 and 2016 values rebounded they were still somewhat low relative to previous years (Figure 26; Table 4). However, TP, SRP, and TN values were intermediate in 2016. NO_3-NO_2-N was similar to other years, and NH_4-N tended to follow the overall 25 year cyclical pattern described above (Figure 26). Both Agency and UKL Lakes continued to show several periods of apparent sub-decadal cyclical increases and decreases for nutrient parameters over the period of record (Figure 24 and Figure 26). Inter-annual silica variability and overall values in Agency Lake are lower relative to UKL.

2016 Microcystin Sampling

Beginning in 2016 the Klamath Tribes initiated data collection for the cyanotoxin, microcystin. A total of 91 samples were collected, with 13 surface grabs (SG) at Agency Lake Boat Launch (ALBL), and 11 each of depth-integrated and SG samples at stations PM, ER, MN, and AS. Seasonal trends indicated low values in June (<0.5 µg/L), with several stations then exceeding 1 1 µg/L in early-July (Figure 27). The SG sample at ER (KL0006) exceeded the recent draft EPA recreational criteria of 4 µg/L[13] in early July, a level which the Oregon Health Authority (OHA) intends to adopt in coming years. Overall values then declined in mid-July and early-August, before rebounding in mid-August in the SG samples at MN (KL0008) and ALBL to levels greatly exceeding the OHA public health advisory level of 10 µg/L[14] (Figure 27). Station ALBL then continued to exceed either the OHA or EPA public health advisory levels through late October, with maximum values in August and September 2 orders of magnitude higher than the OHA advisory level (Figure 27). In addition, the SG sample at ER (KL0006) again exceeded the recent draft EPA recreational criteria of 4 µg/L in early-October. With the exception of AS (KL0010) concentrations of 2.9 µg/L and 1.8 µg/L in late September and late-October, remaining stations were generally <1 µg/L.

SUMMARY

With the addition of 2016 data, the UKL water quality/limnological database now includes 27 years of data and includes the years 1990-2016. Given the dynamic and variable nature of shallow, high productivity lakes such as UKL, a long-term monitoring program is essential for assessing change relative to management programs, as well as for understanding lake dynamics.

For example, as noted in earlier reports, ongoing wetland restoration is occurring in vast areas of the periphery of UKL (e.g., Wong et al. 2010; 2011), riparian and nutrient management plans (e.g., Oregon 1010 and TMDL plans) have been developed, and water use plans have been implemented (e.g., KBRT Wood River Valley programs).

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[13] Draft Human Health Recreational Ambient Water Quality Criteria and/or Swimming Advisories for Microcystins and Cylindrospermopsin. https://www.epa.gov/sites/production/files/2016-12/documents/draft-hh-rec-ambient-water-swimming-document.pdf

[14] http://public.health.oregon.gov/HealthyEnvironments/Recreation/HarmfulAlgaeBlooms/Documents/HABPublic-HealthAdvisoryGuidelines.pdf

Continued monitoring is recommended to accommodate the restoration time-frame (restoration of ecological function can be a multi-decade process) for Klamath Basin activities and to increase statistical power (sample size) for multi-variable analyses. Such a long-term database allows for statistical time series or trend analysis, as well as multi-variable assessment of the relationship between controlling variables (e.g., climate) and important water quality parameters (e.g., see Jassby and Kann 2010).

Further analysis (beyond the scope of the current data summary report) of the noticeable differences in algal biomass (CHL), as well as other water quality parameters among years will provide an opportunity to gain further insight into annual controlling factors of bloom dynamics. Additional multivariate analyses, time-series and trend analyses such as Seasonal Kendal Tests, as well as integration with current lake literature on shallow lakes and *Aphanizomenon* bloom dynamics are recommended. The analysis of the long-term Upper Klamath Lake phytoplankton and zooplankton datasets will also significantly aid in understanding annual water quality variability. A comprehensive statistical analysis of the type provided in Jassby and Kann (2010) is recommended at five year intervals[15].

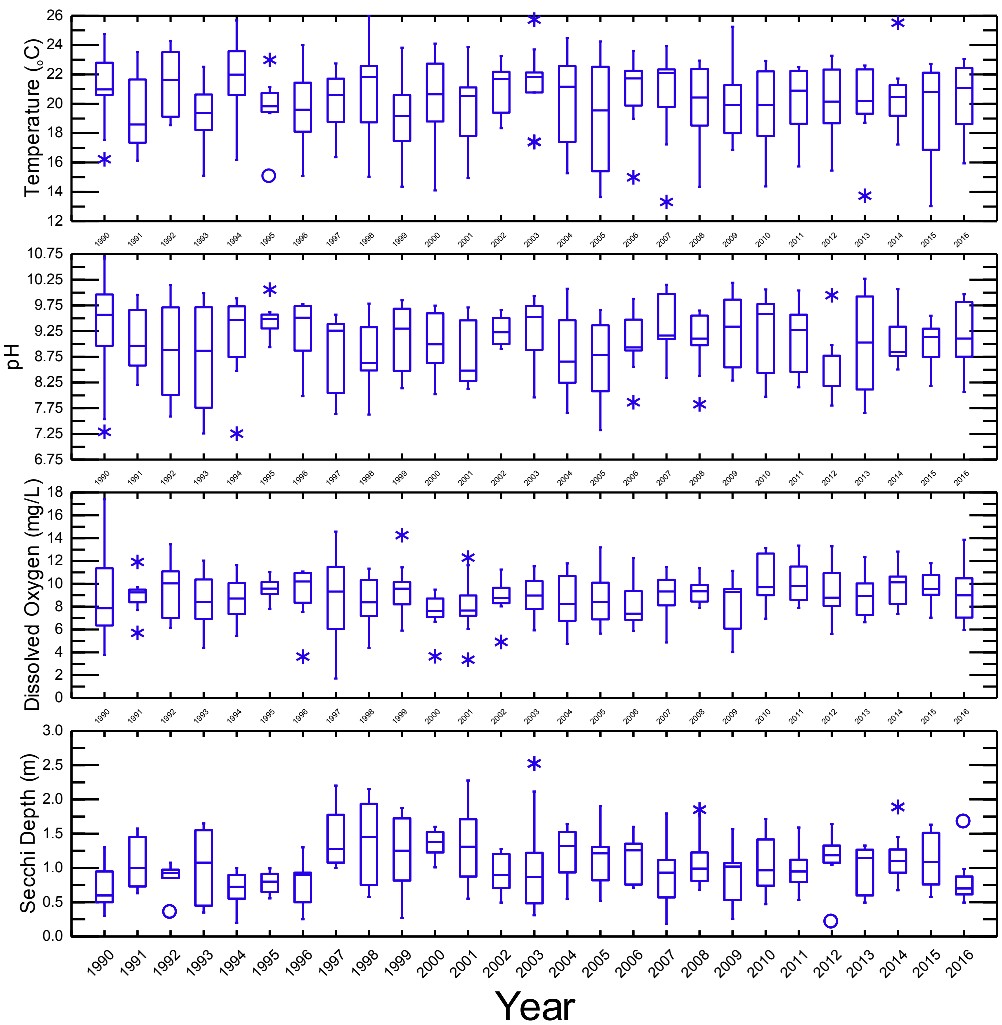

Figure 25. June-September distribution of Agency Lake means for T (˚C), pH, D.O (mg/L), and Secchi depth, 1990-2016.

[15] The next 5-year interval occurred with the addition of 2014 sampling data.

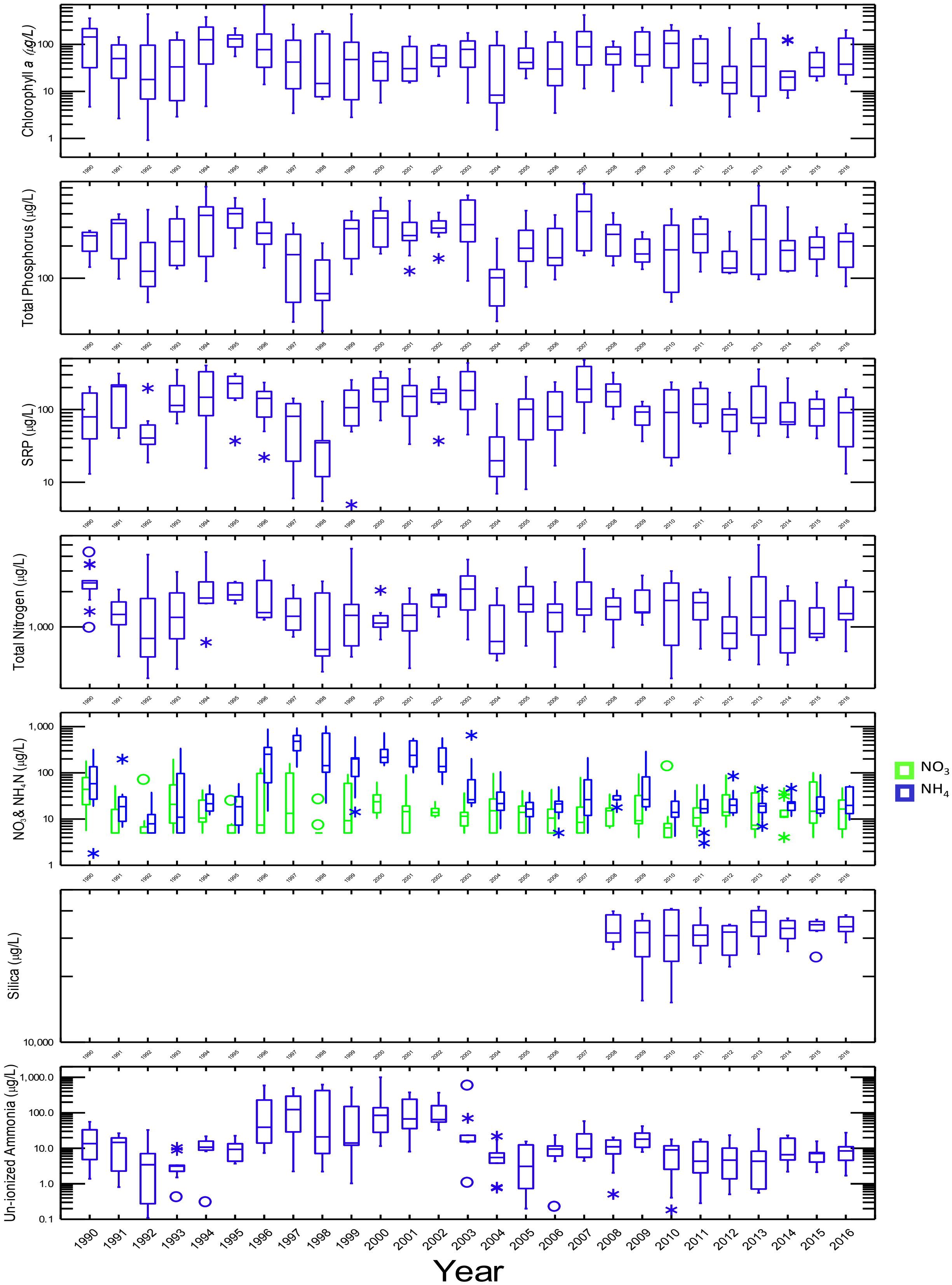

Figure 26. June-September distribution of Agency Lake means for CHL, TP, SRP, TN, NO_3+ NO_2-N, SiO_2 and NH_4-N, 1990-2016.

Table 4. Summary statistics for June-September Agency Lake means, 1990-2016 (LQ=Lower Quartile; UQ=Upper Quartile).

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1990	N of Cases	14.00	14.00	14.00	11.00	13.00	13.00	13.00	13.00	0.00	9.00	11.00	11.00
1990	Median	20.98	9.57	7.87	0.60	143.08	249.00	79.00	2374.00		20.50	58.20	13.60
1990	Arithmetic Mean	21.07	9.31	9.04	0.75	150.55	222.79	99.07	2411.14		41.20	95.25	20.32
1990	Coefficient of Variation	0.11	0.11	0.45	0.42	0.76	0.23	0.73	0.37		1.41	1.04	0.89
1990	LQ	20.60	8.97	6.35	0.50	31.86	178.35	34.88	2008.88		0.00	25.74	4.56
1990	UQ	22.80	9.97	11.36	0.98	224.12	270.39	172.35	2706.25		55.00	135.95	33.72
1991	N of Cases	9.00	8.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	3.00	7.00	6.00
1991	Median	18.59	8.96	9.26	1.00	50.03	325.57	205.94	1276.40		5.00	18.62	14.69
1991	Arithmetic Mean	19.16	9.07	8.94	1.04	56.33	270.59	175.19	1327.97		20.72	43.14	13.11
1991	Coefficient of Variation	0.14	0.07	0.19	0.36	0.88	0.44	0.59	0.39		1.31	1.60	0.76
1991	LQ	17.22	8.58	8.22	0.71	15.34	139.72	55.14	986.82		5.00	8.30	2.29
1991	UQ	21.79	9.66	9.56	1.46	97.38	359.05	237.57	1731.54		40.37	32.25	19.61
1992	N of Cases	8.00	8.00	8.00	8.00	8.00	7.00	8.00	7.00	0.00	8.00	8.00	8.00
1992	Median	21.64	8.88	10.04	0.93	19.44	115.94	40.54	797.33		5.00	7.96	3.51
1992	Arithmetic Mean	21.42	8.87	9.49	0.87	85.73	180.21	60.74	1419.28		13.59	11.72	7.06
1992	Coefficient of Variation	0.11	0.11	0.27	0.26	1.73	0.83	0.93	0.93		1.67	0.93	1.57
1992	LQ	19.12	8.01	7.01	0.85	7.04	80.68	33.32	502.55		5.00	5.00	0.28
1992	UQ	23.52	9.71	11.10	0.98	96.75	293.05	61.80	1755.67		7.05	12.74	7.89
1993	N of Cases	10.00	10.00	10.00	10.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
1993	Median	19.36	8.87	8.41	1.08	33.18	220.62	113.59	1206.83		20.82	11.00	3.13
1993	Arithmetic Mean	19.20	8.78	8.30	1.05	66.52	255.56	160.11	1450.52		53.98	70.24	4.01
1993	Coefficient of Variation	0.12	0.12	0.31	0.53	1.03	0.51	0.60	0.58		1.33	1.58	0.85
1993	LQ	18.21	7.76	6.94	0.45	6.03	130.69	88.27	761.51		7.37	5.00	2.06
1993	UQ	20.63	9.72	10.38	1.55	127.62	370.71	219.71	2053.15		80.96	108.06	4.71
1994	N of Cases	8.00	8.00	8.00	6.00	7.00	7.00	7.00	7.00	0.00	7.00	7.00	7.00
1994	Median	21.98	9.47	8.71	0.73	125.21	386.48	147.26	1763.64		10.49	21.52	10.69
1994	Arithmetic Mean	21.77	9.13	8.67	0.68	157.85	350.57	198.76	2155.59		18.42	26.79	11.89
1994	Coefficient of Variation	0.13	0.10	0.23	0.42	0.90	0.65	0.77	0.57		0.79	0.58	0.61
1994	LQ	20.59	8.75	7.36	0.55	35.24	153.50	82.14	1583.72		8.11	14.60	8.56
1994	UQ	23.58	9.73	10.06	0.90	273.76	497.74	335.16	2893.88		30.85	37.30	18.17
1995	N of	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.00	8.00	8.00	8.00

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
	Cases												
1995	Median	19.83	9.49	9.59	0.80	130.64	401.30	227.86	1878.00		5.00	19.12	9.46
1995	Arithmetic Mean	19.75	9.47	9.57	0.78	128.89	383.50	207.81	1988.93		8.04	22.13	10.12
1995	Coefficient of Variation	0.11	0.03	0.10	0.21	0.41	0.32	0.45	0.18		0.84	0.81	0.65
1995	LQ	19.45	9.30	9.12	0.65	88.51	305.29	143.33	1695.69		5.00	7.38	4.35
1995	UQ	20.73	9.57	10.16	0.92	157.91	449.69	286.58	2376.43		7.38	30.68	13.48
1996	N of Cases	8.00	8.00	8.00	6.00	8.00	8.00	8.00	8.00	0.00	8.00	8.00	8.00
1996	Median	19.59	9.51	10.21	0.90	78.50	264.50	143.00	1325.00		8.00	254.75	39.28
1996	Arithmetic Mean	19.67	9.25	9.22	0.80	158.81	285.88	133.88	1871.88		44.13	279.56	146.11
1996	Coefficient of Variation	0.14	0.07	0.28	0.46	1.38	0.45	0.52	0.52		1.22	0.99	1.40
1996	LQ	18.10	8.87	8.35	0.50	36.75	208.00	87.00	1202.50		5.00	61.00	14.04
1996	UQ	21.44	9.74	10.95	0.93	175.50	333.50	177.00	2545.00		99.50	359.50	232.62
1997	N of Cases	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.00	8.00	8.00	8.00
1997	Median	20.60	9.26	9.33	1.28	46.00	166.87	82.29	1234.47		13.34	484.99	133.72
1997	Arithmetic Mean	20.15	8.83	8.75	1.43	80.09	167.01	76.94	1376.63		50.75	494.31	176.95
1997	Coefficient of Variation	0.11	0.09	0.47	0.33	1.16	0.65	0.68	0.40		1.25	0.51	0.99
1997	LQ	18.76	8.05	6.05	1.08	11.85	60.50	30.50	941.50		5.00	318.70	30.41
1997	UQ	21.71	9.39	11.50	1.78	128.64	257.59	120.75	1782.20		103.65	643.42	293.73
1998	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
1998	Median	21.81	8.63	8.38	1.45	14.72	71.87	34.89	642.61		5.00	143.00	20.91
1998	Arithmetic Mean	20.84	8.80	8.56	1.39	66.86	107.95	37.72	1144.32		7.64	353.18	186.92
1998	Coefficient of Variation	0.17	0.08	0.27	0.45	1.23	0.62	1.01	0.73		0.93	1.10	1.42
1998	LQ	18.20	8.36	7.03	0.72	7.50	58.27	10.72	546.42		5.00	90.90	6.33
1998	UQ	22.99	9.40	10.39	1.97	167.49	160.77	42.39	2027.35		5.58	749.69	456.80
1999	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
1999	Median	19.16	9.30	9.58	1.25	47.43	290.27	105.99	1253.28		9.25	200.23	14.13
1999	Arithmetic Mean	19.10	9.11	9.52	1.21	91.12	254.03	125.02	1514.63		28.37	198.27	117.60
1999	Coefficient of Variation	0.15	0.08	0.26	0.47	1.52	0.46	0.67	0.83		1.16	0.89	1.46
1999	LQ	17.01	8.44	7.88	0.80	5.88	145.70	57.15	656.95		5.00	69.71	11.75
1999	UQ	20.80	9.72	10.48	1.75	116.44	354.19	190.65	1619.39		59.67	238.88	172.83
2000	N of Cases	8.00	8.00	8.00	7.00	8.00	8.00	8.00	8.00	0.00	8.00	8.00	8.00
2000	Median	20.65	9.00	7.61	1.38	44.37	365.07	190.38	1079.10		23.87	221.26	84.75
2000	Arithmetic Mean	20.32	9.03	7.49	1.36	42.42	339.48	197.98	1184.70		26.98	286.67	192.21
2000	Coefficient of Variation	0.16	0.07	0.24	0.16	0.61	0.42	0.46	0.32		0.64	0.67	1.74
2000	LQ	18.80	8.63	7.08	1.21	21.49	195.95	128.15	996.04		13.77	167.08	28.72
2000	UQ	22.73	9.60	8.71	1.53	66.41	428.97	272.41	1249.00		34.06	321.15	146.91

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2001	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
2001	Median	20.53	8.48	7.66	1.31	30.50	250.63	151.42	1255.53		14.49	238.44	67.26
2001	Arithmetic Mean	19.69	8.81	8.13	1.34	58.58	288.10	171.68	1309.84		21.11	305.57	140.63
2001	Coefficient of Variation	0.14	0.07	0.33	0.45	0.91	0.45	0.70	0.42		1.27	0.61	1.01
2001	LQ	17.51	8.26	6.92	0.84	16.38	209.26	71.48	918.62		5.00	128.18	34.62
2001	UQ	21.36	9.47	9.65	1.82	101.47	358.49	246.32	1697.26		20.87	503.58	266.23
2002	N of Cases	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	0.00	7.00	7.00	7.00
2002	Median	21.68	9.23	8.75	0.90	51.31	293.49	166.81	1844.52		13.83	137.48	64.44
2002	Arithmetic Mean	20.92	9.26	8.69	0.93	60.78	298.17	158.99	1698.46		15.14	236.42	132.13
2002	Coefficient of Variation	0.09	0.03	0.23	0.33	0.55	0.30	0.47	0.18		0.30	0.79	0.96
2002	LQ	19.12	8.97	8.17	0.70	32.54	255.49	122.31	1458.87		11.60	104.04	52.84
2002	UQ	22.38	9.55	9.74	1.22	93.43	372.35	190.87	1901.93		17.77	348.78	208.04
2003	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
2003	Median	21.82	9.52	8.97	0.87	78.09	316.90	182.25	2102.31		11.49	26.25	15.87
2003	Arithmetic Mean	21.40	9.28	9.08	1.08	83.50	364.72	227.76	2078.22		14.80	121.38	83.61
2003	Coefficient of Variation	0.13	0.07	0.20	0.71	0.69	0.53	0.63	0.49		0.79	1.70	2.21
2003	LQ	19.93	8.89	7.78	0.47	30.43	205.84	99.21	1251.60		6.59	22.43	15.11
2003	UQ	22.53	9.75	10.56	1.44	124.77	548.65	346.83	2821.06		18.71	103.41	34.99
2004	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
2004	Median	21.15	8.66	8.22	1.32	8.33	100.96	19.78	750.92		15.12	21.72	5.50
2004	Arithmetic Mean	20.44	8.79	8.35	1.21	47.37	106.35	38.37	1105.13		29.37	37.19	7.62
2004	Coefficient of Variation	0.17	0.10	0.29	0.34	1.38	0.63	1.09	0.57		1.20	0.92	0.95
2004	LQ	17.00	8.18	6.48	0.86	5.39	54.48	11.46	583.94		5.00	13.58	3.06
2004	UQ	22.98	9.57	10.78	1.54	96.45	138.00	56.27	1593.94		41.32	49.42	9.90
2005	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
2005	Median	19.55	8.78	8.41	1.22	41.00	190.41	100.51	1557.31		14.00	16.49	3.09
2005	Arithmetic Mean	19.40	8.70	8.57	1.13	68.45	218.19	119.23	1783.30		17.13	18.36	5.73
2005	Coefficient of Variation	0.21	0.10	0.29	0.36	0.88	0.55	0.83	0.46		0.83	0.52	1.09
2005	LQ	15.40	8.01	6.63	0.81	29.23	129.20	36.31	1233.49		5.00	10.94	0.60
2005	UQ	22.90	9.42	10.38	1.33	99.87	303.57	171.04	2305.18		24.42	23.44	12.59
2006	N of Cases	9.00	9.00	9.00	8.00	9.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
2006	Median	21.72	8.93	7.39	1.26	29.85	155.48	80.00	1327.04		10.49	21.23	9.53
2006	Arithmetic Mean	20.80	9.00	8.25	1.13	60.15	205.80	115.70	1303.05		13.40	22.23	9.92
2006	Coefficient of Variation	0.13	0.07	0.27	0.30	1.05	0.52	0.71	0.50		0.93	0.60	0.71
2006	LQ	19.65	8.79	6.61	0.76	12.66	131.10	50.57	838.71		5.00	13.13	5.63

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2006	UQ	22.58	9.49	9.67	1.36	113.49	304.08	188.71	1685.76		17.15	27.16	12.98
2007	N of Cases	9.00	9.00	9.00	9.00	8.00	9.00	9.00	9.00	0.00	9.00	9.00	9.00
2007	Median	22.11	9.17	9.34	0.93	88.88	420.62	189.40	1421.53		8.49	26.35	9.76
2007	Arithmetic Mean	20.54	9.38	8.91	0.90	133.76	403.15	256.31	2144.51		18.08	55.92	17.13
2007	Coefficient of Variation	0.17	0.07	0.24	0.55	1.03	0.56	0.63	0.62		1.31	1.24	1.02
2007	LQ	19.15	9.03	7.70	0.50	37.29	176.70	120.12	1216.27		5.00	11.69	5.31
2007	UQ	22.71	10.00	10.40	1.15	192.54	615.24	406.12	2797.03		19.48	83.68	25.57
2008	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2008	Median	20.43	9.10	9.34	0.99	61.74	257.04	175.24	1488.79	31650.00	15.16	26.39	11.04
2008	Arithmetic Mean	19.82	9.07	9.22	1.12	62.58	263.09	180.20	1419.34	33200.00	14.86	28.71	10.66
2008	Coefficient of Variation	0.16	0.07	0.12	0.39	0.63	0.40	0.46	0.35	0.16	0.62	0.25	0.65
2008	LQ	17.82	8.83	8.31	0.81	31.57	157.22	107.18	1041.79	28550.00	7.06	25.78	5.74
2008	UQ	22.44	9.56	9.93	1.37	94.48	339.81	235.17	1799.78	38612.50	18.53	33.13	17.42
2009	N of Cases	8.00	8.00	8.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	8.00
2009	Median	19.92	9.34	9.29	1.02	60.51	168.71	92.19	1341.10	31800.00	9.25	26.57	18.09
2009	Arithmetic Mean	20.06	9.25	8.13	0.91	100.17	185.56	86.34	1645.39	30156.11	25.56	65.84	20.57
2009	Coefficient of Variation	0.14	0.08	0.30	0.48	0.81	0.30	0.39	0.36	0.27	1.16	1.33	0.61
2009	LQ	17.99	8.54	6.08	0.51	30.34	138.99	58.18	1286.60	24037.50	7.87	18.31	11.08
2009	UQ	21.28	9.86	9.56	1.17	184.49	234.36	114.28	2130.33	36487.50	37.03	83.35	28.03
2010	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2010	Median	19.91	9.58	9.70	0.97	104.72	184.34	91.24	1681.73	30850.00	6.42	14.00	9.01
2010	Arithmetic Mean	19.35	9.20	10.51	1.04	116.02	221.85	109.63	1644.39	30183.33	20.72	17.62	8.07
2010	Coefficient of Variation	0.17	0.09	0.21	0.45	0.85	0.67	0.84	0.58	0.33	2.12	0.65	0.83
2010	LQ	16.97	8.42	9.00	0.68	25.72	72.13	21.60	643.19	22137.50	4.00	10.12	2.03
2010	UQ	22.28	9.83	12.73	1.49	205.09	338.46	196.30	2430.56	40500.00	8.81	24.79	12.90
2011	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2011	Median	20.24	9.28	9.81	0.95	39.24	257.77	117.79	1608.54	30950.00	10.62	16.75	4.33
2011	Arithmetic Mean	19.22	9.08	10.18	0.97	62.00	250.33	131.29	1513.48	31150.00	16.05	21.57	8.42
2011	Coefficient of Variation	0.20	0.07	0.18	0.32	0.94	0.40	0.54	0.34	0.20	0.98	0.74	0.89
2011	LQ	17.55	8.42	8.54	0.76	15.32	163.67	64.51	1105.81	26662.50	6.90	11.52	1.65
2011	UQ	22.22	9.61	11.69	1.13	130.15	358.92	201.92	1993.21	35525.00	18.84	28.03	15.85
2012	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2012	Median	20.15	8.77	8.78	1.19	15.25	124.30	84.79	882.80	32000.00	14.17	19.90	4.63
2012	Arithmetic Mean	20.21	8.62	9.18	1.15	39.37	155.38	85.33	1118.69	29850.00	27.61	28.00	8.04
2012	Coefficient of Variation	0.12	0.07	0.27	0.35	1.79	0.38	0.52	0.64	0.17	0.98	0.84	1.12

Year	Parameter	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Total Phosphorus (µg/L)	Soluble Reactive Phosphorus (µg/L)	Total Nitrogen (µg/L)	Silica (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2012	LQ	18.60	8.14	7.65	1.07	7.46	112.82	48.96	637.14	24587.50	11.59	13.28	1.16
2012	UQ	22.37	8.82	11.16	1.37	35.73	191.62	107.78	1386.92	34250.00	38.32	30.51	13.23
2013	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2013	Median	20.19	9.03	8.92	1.15	33.96	230.84	77.35	1210.22	35550.00	7.37	19.12	4.33
2013	Arithmetic Mean	20.06	8.99	8.97	0.96	79.85	298.63	142.38	1917.22	35027.78	19.09	20.60	8.99
2013	Coefficient of Variation	0.14	0.11	0.22	0.37	1.24	0.77	0.80	0.77	0.17	0.95	0.55	1.32
2013	LQ	19.17	8.05	7.25	0.58	7.62	106.44	61.50	790.49	29850.00	5.55	12.77	0.69
2013	UQ	22.38	10.01	10.38	1.27	146.77	492.74	226.11	2708.23	40412.50	36.96	24.36	11.71
2014	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2014	Median	20.46	8.85	10.13	1.10	20.04	182.02	67.27	972.22	33250.00	11.37	21.98	6.60
2014	Arithmetic Mean	20.52	9.09	9.74	1.16	39.81	201.27	104.51	1198.82	32655.56	15.24	23.60	10.98
2014	Coefficient of Variation	0.11	0.06	0.17	0.31	1.18	0.55	0.69	0.56	0.12	0.74	0.52	0.77
2014	LQ	19.14	8.72	8.22	0.91	10.15	116.87	59.93	600.59	29450.00	9.25	14.89	4.35
2014	UQ	21.38	9.51	10.67	1.32	50.17	232.09	132.39	1784.48	36112.50	19.33	28.02	20.06
2015	N of Cases	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
2015	Median	20.80	9.13	9.56	1.09	32.30	193.96	102.29	877.89	34550.00	14.91	16.15	7.13
2015	Arithmetic Mean	19.41	9.01	9.70	1.12	42.97	197.99	102.25	1183.26	33331.25	34.76	28.32	6.99
2015	Coefficient of Variation	0.18	0.05	0.15	0.38	0.62	0.32	0.47	0.48	0.12	1.04	0.97	0.59
2015	LQ	16.86	8.75	9.04	0.76	21.15	152.97	59.90	815.86	32550.00	8.54	13.46	4.23
2015	UQ	22.12	9.30	10.77	1.51	66.94	242.89	137.88	1459.64	35775.00	63.45	32.73	7.61
2016	N of Cases	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
2016	Median	21.07	9.11	9.00	0.70	37.85	219.82	90.47	1298.53	33850.00	16.49	19.71	8.45
2016	Arithmetic Mean	20.16	9.18	9.09	0.81	78.56	205.42	89.63	1525.78	34133.33	19.33	27.47	9.39
2016	Coefficient of Variation	0.14	0.07	0.28	0.44	0.95	0.43	0.77	0.44	0.11	0.84	0.66	0.81
2016	LQ	17.96	8.74	6.96	0.60	20.85	120.03	26.67	1069.75	31300.00	5.55	13.11	4.15
2016	UQ	22.57	9.85	10.61	0.90	146.62	275.97	152.69	2218.77	37675.00	29.98	50.15	11.11

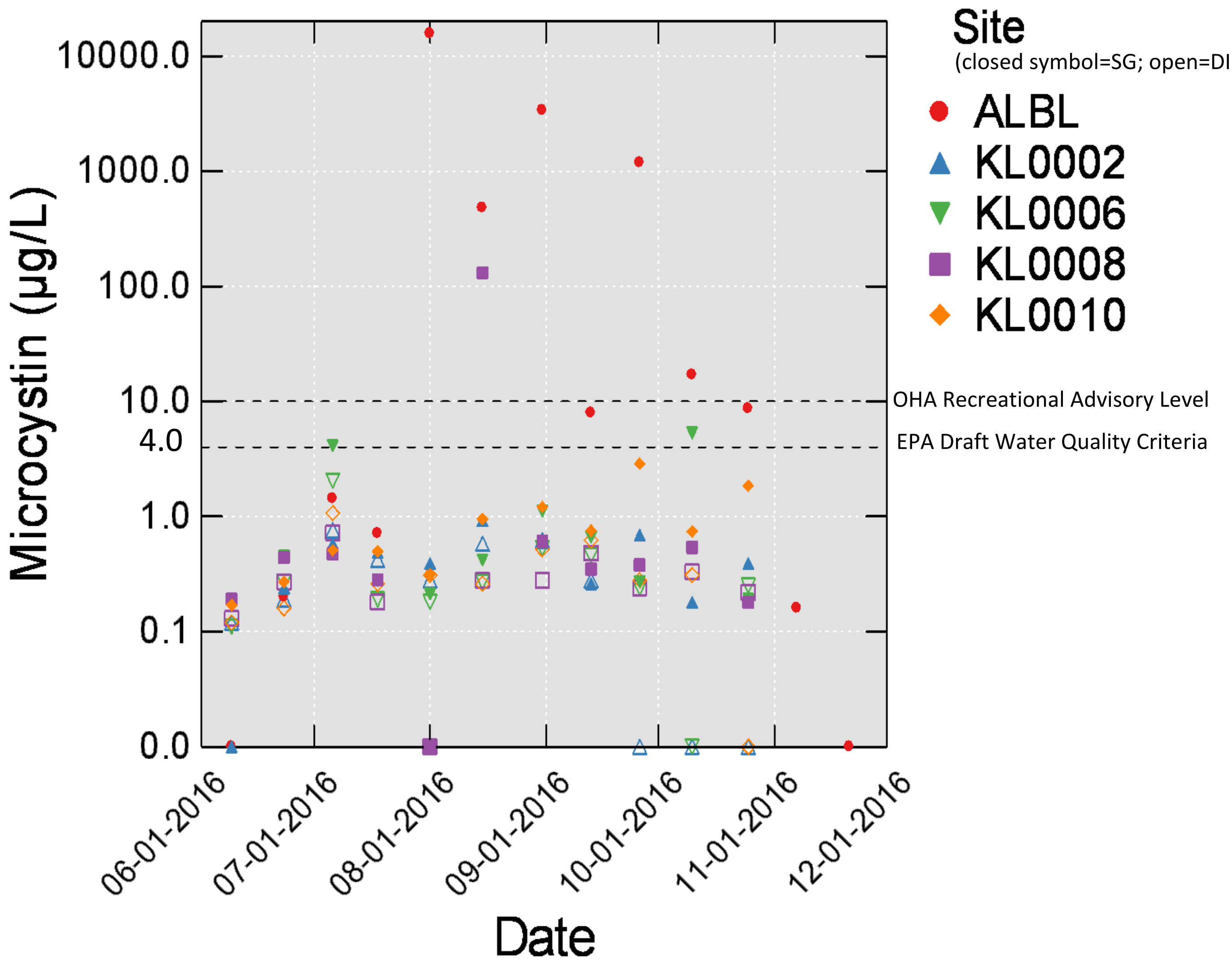

Figure 27. Microcystin concentration in Upper Klamath and Agency Lakes, 2016.

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APPENDIX I: Summary statistics of monthly distributions for the June-September period, Upper Klamath Lake Stations; 1990-2016 (LQ= Lower Quartile; UQ=Upper Quartile).

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1990	6	N of Cases	13	13	13	12	11	11	12	11	2	2	2
1990	6	Median	16.13	9.18	8.86	1	59.88	119	17	795	25	62.15	50.15
1990	6	Arithmetic Mean	17.91	9.34	9.15	0.93	97.13	131.42	19.65	1110.97	25	62.15	50.15
1990	6	Coefficient of Variation	0.15	0.05	0.17	0.35	1.13	0.29	0.41	0.6	0.17	0.32	0.3
1990	6	LQ	15.58	8.94	8.09	0.75	31.11	108.25	14.5	678.5	22	47.9	39.69
1990	6	UQ	20.8	9.64	9.77	1.2	117.34	140.5	20	1649	28	76.4	60.62
1990	7	N of Cases	17	17	17	15	15	15	15	15	8	15	15
1990	7	Median	22.23	9.42	7.12	0.5	138.06	215	67	2347	14.05	47	32.98
1990	7	Arithmetic Mean	22.4	9.48	7.3	0.61	169.95	222.47	66.13	2660.73	12.96	95.26	48.84
1990	7	Coefficient of Variation	0.04	0.03	0.3	0.46	0.62	0.24	0.36	0.41	0.85	1.04	0.88
1990	7	LQ	21.73	9.27	6.29	0.4	95.14	193.75	52.5	2172.5	2.8	31.23	20.85
1990	7	UQ	23.08	9.65	8.9	0.86	277.74	246.5	81	3373	19	128.63	61.97
1990	8	N of Cases	9	9	9	9	9	9	9	9	9	9	9
1990	8	Median	23.3	9.28	7.82	0.5	191.16	240.9	95.3	3428.4	20.6	100.1	48.42
1990	8	Arithmetic Mean	22.12	9.24	7.41	0.73	201.19	242.78	94.21	3897.02	16.83	96.11	38.4
1990	8	Coefficient of Variation	0.12	0.02	0.27	0.71	0.72	0.33	0.14	0.48	0.95	0.94	0.87
1990	8	LQ	19.14	9.04	5.27	0.35	82.45	171.4	87.43	2533.4	0	13.8	5.65
1990	8	UQ	23.49	9.37	9.05	1	276.12	306.93	103.65	4316.88	29.33	159	68.97
1990	9	N of Cases	15	15	15	15	13	13	13	13	13	13	13
1990	9	Median	18.2	9.37	9.62	0.6	146.91	228	59.4	3428.2	0	85.6	44.77
1990	9	Arithmetic Mean	18.49	9.41	8.88	0.71	164.34	235.71	67.61	3478.16	6.14	175.25	65.65
1990	9	Coefficient of Variation	0.06	0.03	0.29	0.47	0.83	0.23	0.33	0.3	1.96	1.08	0.85
1990	9	LQ	17.68	9.24	6.81	0.43	76.11	201.2	52.38	2818.95	0	35.93	20.55
1990	9	UQ	19.13	9.6	10.91	0.98	235.41	251.16	72.88	3593.58	9.13	269.46	105.02
1991	6	N of Cases	16	16	16	16	14	14	14	14	14	7	7
1991	6	Median	15.85	8.43	8.08	0.85	16.82	88.7	19.45	680.97	46.5	5	0.61
1991	6	Arithmetic Mean	15.64	8.42	8.14	0.79	19.43	90.42	22.38	691.38	50.46	7.14	0.75
1991	6	Coefficient of Variation	0.05	0.03	0.1	0.7	0.5	0.13	0.73	0.18	0.76	0.79	0.58
1991	6	LQ	14.93	8.17	7.38	0.35	12.39	83	7	593.31	16	5	0.48
1991	6	UQ	16.34	8.62	8.91	1.2	24.34	94.5	39.25	802	73.5	5	0.81
1991	7	N of Cases	12	12	12	12	10	10	10	10	3	10	10
1991	7	Median	19.86	9.43	8.91	0.68	106.91	154.5	40.47	2271.19	5	60.5	40.33
1991	7	Arithmetic Mean	19.51	9.49	8.79	0.7	118.29	161.83	37.28	2476.27	5	139.65	71.88
1991	7	Coefficient of	0.06	0.02	0.24	0.42	0.52	0.21	0.39	0.29	0	1.3	1.11

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
		Variation											
1991	7	LQ	18.42	9.37	7.57	0.5	77	141.3	23.5	2136.1	5	31	20.71
1991	7	UQ	20.32	9.67	10.45	0.8	138.77	176	48.5	2445.53	5	207.5	125.14
1991	8	N of Cases	22	18	22	24	21	21	21	21	0	21	18
1991	8	Median	20.34	9.28	9.18	0.66	126.02	241	55	2638		29	10.09
1991	8	Arithmetic Mean	20.05	9.14	8.56	0.71	140.23	256.93	65	2934.13		80.6	21.56
1991	8	Coefficient of Variation	0.09	0.06	0.24	0.64	0.88	0.27	0.47	0.46		1.19	0.99
1991	8	LQ	18.26	8.71	6.71	0.46	38.9	211.88	41	2004.75		16.33	8.11
1991	8	UQ	21.76	9.59	10.11	1.05	196.12	297	99	3387.25		153.88	37.99
1991	9	N of Cases	15	15	15	15	14	14	13	14	0	7	7
1991	9	Median	16.3	9.59	9.03	0.72	133.81	271.5	56.8	2384.8		18	12.69
1991	9	Arithmetic Mean	16.59	9.57	8.76	0.75	186.95	311.78	63.3	2894.41		111.57	28.76
1991	9	Coefficient of Variation	0.06	0.03	0.2	0.47	1.08	0.44	0.35	0.41		2.03	1.16
1991	9	LQ	15.89	9.47	7.68	0.51	87.79	219.19	46.62	2068.2		13	9.32
1991	9	UQ	17.48	9.77	9.9	1	172.75	333.9	78.98	3939.4		51.5	31.16
1992	6	N of Cases	14	14	14	14	14	14	14	14	14	14	14
1992	6	Median	18.21	9.61	10.07	0.4	247.58	162	15	2625	5	33.5	22.26
1992	6	Arithmetic Mean	18.24	9.63	10.15	0.51	257.75	195.18	14.14	2874.29	5	32.86	20.55
1992	6	Coefficient of Variation	0.14	0.04	0.13	0.63	0.7	0.55	0.31	0.42	0	0.52	0.63
1992	6	LQ	15.95	9.34	9.22	0.3	96.1	121	10	1960	5	15	8.18
1992	6	UQ	20.33	9.94	10.9	0.6	377.7	271	18	3600	5	49	31.18
1992	7	N of Cases	21	21	21	21	21	18	21	18	21	21	21
1992	7	Median	21.05	9.3	7.28	0.6	125.9	246	41.5	2835	5	12	5.68
1992	7	Arithmetic Mean	20.3	9.15	6.82	0.57	159.64	299.08	49.95	3095.83	9.26	147.26	16.96
1992	7	Coefficient of Variation	0.11	0.04	0.36	0.47	0.87	0.35	0.76	0.31	1.42	2.9	1.43
1992	7	LQ	18	9.06	5.71	0.3	67.5	217	25	2420	5	5	2.44
1992	7	UQ	21.71	9.35	8.81	0.8	220.35	379	59.75	3635	7.63	49.5	18.37
1992	8	N of Cases	14	14	14	14	14	14	14	14	14	14	14
1992	8	Median	20.62	9.15	8.66	0.3	72.38	121	11.25	2362.5	6.25	19	6.33
1992	8	Arithmetic Mean	20.82	9.12	8.23	0.36	75.7	137.61	11.57	2443.93	7.68	21	6.89
1992	8	Coefficient of Variation	0.1	0.02	0.28	0.26	0.37	0.66	0.25	0.23	0.41	0.84	0.63
1992	8	LQ	19.45	9.01	6.93	0.3	49.3	54	9	1980	5	5	2.22
1992	8	UQ	22.65	9.22	9.89	0.4	99.9	212	14	2880	10.5	23	11.24
1992	9	N of Cases	7	7	7	7	6	7	7	7	7	7	7
1992	9	Median	17.45	7.97	5.12	0.4	40.55	136	13	1620	5	12.5	0.39
1992	9	Arithmetic Mean	17.24	8.12	5.63	0.39	43.21	134.57	14.43	1639.29	15.57	13.21	0.96

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1992	9	Coefficient of Variation	0.04	0.06	0.16	0.23	0.46	0.2	0.3	0.15	1.44	0.55	1.53
1992	9	LQ	16.82	7.75	4.95	0.3	34.05	113.63	11.5	1482.5	5	6.75	0.19
1992	9	UQ	17.61	8.57	6.31	0.48	58.4	154.38	18.25	1811.25	15.5	16.5	0.88
1993	6	N of Cases	21	21	21	21	21	21	21	21	21	21	21
1993	6	Median	17.26	8.68	9.65	0.9	65	89	8.5	1660	5	5	0.65
1993	6	Arithmetic Mean	16.76	8.62	9.75	1.05	67.2	81.48	10.69	1498.4	5.67	13.38	1.28
1993	6	Coefficient of Variation	0.11	0.08	0.14	0.46	0.87	0.42	0.52	0.6	0.39	1	0.77
1993	6	LQ	14.71	7.77	8.47	0.64	6.7	46.75	7	518.38	5	5	0.53
1993	6	UQ	18.36	9.35	10.93	1.4	114.38	102.38	12.25	2252.5	5	16	2.29
1993	7	N of Cases	15	15	15	15	14	14	14	14	14	14	14
1993	7	Median	18.23	9.31	8.37	0.8	109	121.25	14	1870	5	12.75	7.44
1993	7	Arithmetic Mean	18.29	9.38	8.42	0.65	140.07	138.93	13.29	2350.71	9.96	55.39	19.32
1993	7	Coefficient of Variation	0.03	0.03	0.16	0.39	0.71	0.36	0.18	0.52	1.04	1.77	1.69
1993	7	LQ	17.78	9.16	7.83	0.5	71	97	11	1590	5	5	2.3
1993	7	UQ	18.8	9.65	9.44	0.8	150	175	15	2330	15	45	14.05
1993	8	N of Cases	14	14	14	14	14	14	14	14	14	14	14
1993	8	Median	18.91	8.93	7.6	0.73	84.5	137	19	1790	14.25	32	7.66
1993	8	Arithmetic Mean	18.86	8.8	6.95	0.67	99.93	141.25	19.21	1786.07	14.93	173.96	17.46
1993	8	Coefficient of Variation	0.1	0.05	0.28	0.36	0.62	0.34	0.29	0.24	0.67	1.35	1.44
1993	8	LQ	17.37	8.55	5.15	0.5	71.5	100	14	1490	10	5	1.93
1993	8	UQ	20.66	9.12	8.67	0.8	125	159	22	2250	16	332	25.23
1993	9	N of Cases	14	14	14	14	14	14	14	14	14	14	14
1993	9	Median	18.07	7.99	6.21	1.05	34	105.25	17.5	1785	126.5	662	17.21
1993	9	Arithmetic Mean	17.74	7.92	5.92	0.99	63.22	114.04	17.75	2482.14	126.68	1253.5	130.53
1993	9	Coefficient of Variation	0.17	0.08	0.43	0.36	1.63	0.49	0.39	0.77	0.86	1.26	2.97
1993	9	LQ	14.87	7.29	4.18	0.8	18	79	14	1595	35	473	5.59
1993	9	UQ	20.64	8.45	7.96	1.2	58	122	18.5	2740	178	1012.5	42.13
1994	6	N of Cases	14	14	14	14	14	14	14	14	14	14	14
1994	6	Median	16.87	9.55	9.83	0.73	103.25	85.5	5	1525	5	7.75	3.82
1994	6	Arithmetic Mean	16.96	9.55	10.04	0.71	134.43	80.79	6.32	1846.14	5	9.5	4.09
1994	6	Coefficient of Variation	0.09	0.04	0.09	0.21	0.58	0.3	0.37	0.54	0	0.58	0.25
1994	6	LQ	15.67	9.25	9.49	0.6	69	60	5	1020	5	5	3.22
1994	6	UQ	18.15	9.92	10.91	0.8	186.5	94	7	2330	5	12	4.65
1994	7	N of Cases	11	11	11	10	11	11	11	11	11	11	11
1994	7	Median	20.79	9.93	8.4	1.03	109	159	33	2010	11	13	9.34
1994	7	Arithmetic Mean	21.12	9.71	7.75	0.86	149.32	150.18	43.5	2238.64	16	53.86	20.12

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1994	7	Coefficient of Variation	0.09	0.05	0.18	0.4	0.68	0.22	0.52	0.28	1.22	1.97	1.33
1994	7	LQ	19.25	9.29	6.68	0.5	67.75	117.25	26	1697.5	8.13	5	4.2
1994	7	UQ	23.26	10.04	8.61	1.1	212.38	181.13	68	2692.5	13.63	45.5	24.25
1994	8	N of Cases	15	15	15	14	15	15	15	15	15	15	14
1994	8	Median	21.42	8.72	6.19	0.4	56	143	11.5	1940	5	20	5.9
1994	8	Arithmetic Mean	21.28	8.82	5.88	0.44	60.7	151.8	14.3	1957	18.57	44.63	11.83
1994	8	Coefficient of Variation	0.07	0.04	0.28	0.23	0.22	0.15	0.43	0.13	1.26	1.37	1.82
1994	8	LQ	21.08	8.6	5.3	0.4	51.5	132.88	10.25	1740	5	10.13	1.58
1994	8	UQ	22.13	9.14	6.52	0.5	67.75	175.75	16	2185	22	44.5	8.7
1994	9	N of Cases	15	15	15	15	19	20	20	20	20	21	15
1994	9	Median	18.7	8.15	7.83	0.4	40	119	10	1435	5	19	0.78
1994	9	Arithmetic Mean	17.81	8.12	7.88	0.38	39.42	118.75	9.83	1471	8.55	43.95	1.17
1994	9	Coefficient of Variation	0.13	0.03	0.14	0.15	0.28	0.09	0.16	0.11	1.16	1.37	0.72
1994	9	LQ	15.61	7.97	7.21	0.33	30	113.5	9	1370	5	14.5	0.56
1994	9	UQ	19.27	8.3	8.52	0.4	48.13	124.5	11	1580	7.5	43.88	1.54
1995	6	N of Cases	14	14	14	14	14	14	14	14	14	14	14
1995	6	Median	17	9.59	10.19	0.64	200	126.25	11.5	2110	10	9	5.6
1995	6	Arithmetic Mean	17.45	9.6	9.85	0.6	273.86	178.11	12.57	2869.64	12.04	26.82	16.13
1995	6	Coefficient of Variation	0.14	0.02	0.11	0.39	1.05	1.01	0.38	0.69	0.66	1.59	1.55
1995	6	LQ	15.19	9.52	9.49	0.49	179	111	8	1850	5	5	2.44
1995	6	UQ	19.29	9.69	10.7	0.8	249	158	16	3020	17	25	17
1995	7	N of Cases	14	14	14	14	14	14	14	14	14	14	14
1995	7	Median	21.01	9.66	8.83	0.58	150.25	164.5	47.5	2300	5	5	3.91
1995	7	Arithmetic Mean	20.75	9.65	8.54	0.59	164.75	167.29	46.82	2403.93	21.36	43.29	21.3
1995	7	Coefficient of Variation	0.06	0.02	0.2	0.42	0.36	0.19	0.47	0.23	2.87	2.5	2.35
1995	7	LQ	19.71	9.43	8.4	0.46	114	139	30	2005	5	5	3.36
1995	7	UQ	21.84	9.85	9.22	0.79	205	184	64	2580	5	14	7.37
1995	8	N of Cases	17	17	17	14	14	14	14	14	14	14	14
1995	8	Median	20.18	9.59	8.83	0.69	144.25	174.5	66	2622.5	5	29	17.27
1995	8	Arithmetic Mean	19.89	9.54	8.3	0.7	141.71	196.82	66.14	2716.43	5	83.89	41.39
1995	8	Coefficient of Variation	0.06	0.03	0.24	0.53	0.5	0.56	0.19	0.33	0	1.29	1.2
1995	8	LQ	19.01	9.35	7.71	0.41	79	145	59	2200	5	11	7.5
1995	8	UQ	20.78	9.74	9.66	1.02	187	186	75.5	3115	5	146	66.33
1995	9	N of Cases	14	14	14	14	14	14	14	14	14	14	14
1995	9	Median	18.47	9.33	8.08	0.59	154.5	287	91.5	3392.5	5	41.5	18.84
1995	9	Arithmetic Mean	18.66	9.27	7.38	0.65	152	287.93	98.04	3337.14	5	188.79	46.51

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1995	9	Coefficient of Variation	0.03	0.04	0.32	0.42	0.43	0.3	0.33	0.27	0	1.28	1.05
1995	9	LQ	18.36	9.01	5.25	0.46	120	206	75	2555	5	18	8.96
1995	9	UQ	18.88	9.53	9.29	0.84	198	341	126.5	4220	5	330	74.85
1996	6	N of Cases	10	10	10	5	10	10	10	10	10	10	10
1996	6	Median	17.65	8.6	8.2	0.8	54	58.5	7.5	869.5	5	232.5	36.36
1996	6	Arithmetic Mean	17.92	8.63	8.37	0.83	60.95	63.05	7.6	971.95	8.4	274	67.17
1996	6	Coefficient of Variation	0.08	0.05	0.1	0.13	0.59	0.28	0.13	0.34	0.94	0.84	1.19
1996	6	LQ	16.6	8.21	7.79	0.73	30	52	7	750	5	63	3.55
1996	6	UQ	19.27	9.09	9.05	0.94	95	66	8	1170	5	489	112.52
1996	7	N of Cases	10	10	10	8	10	10	10	10	10	10	10
1996	7	Median	21.72	9.42	8.98	0.84	138.5	115.25	6	1740	5	194	96.53
1996	7	Arithmetic Mean	22.22	9.43	9.18	0.8	154.75	118.4	6.55	1849.5	5	265.95	123.48
1996	7	Coefficient of Variation	0.06	0.02	0.16	0.4	0.48	0.28	0.15	0.33	0	0.96	0.89
1996	7	LQ	21.04	9.31	8.47	0.57	100	102	6	1580	5	31	19.58
1996	7	UQ	23.47	9.5	9.73	1.05	199	124	7	1870	5	482	227
1996	8	N of Cases	10	10	10	7	10	10	10	10	10	10	10
1996	8	Median	20.28	8.94	7.05	0.76	94	188.5	58.5	2165	26	242.5	73.94
1996	8	Arithmetic Mean	20.18	9	7.2	0.83	106.74	181.3	66.1	2129	43.4	451.4	93.71
1996	8	Coefficient of Variation	0.05	0.04	0.27	0.3	0.63	0.16	0.39	0.21	0.86	0.85	0.54
1996	8	LQ	19.51	8.7	5.99	0.64	60	166	50	1910	22	122	54.4
1996	8	UQ	20.48	9.37	8.75	1.09	154	202	89	2440	51	791	128.57
1996	9	N of Cases	10	10	10	8	10	10	10	10	10	10	10
1996	9	Median	15.76	8.8	7.87	1.13	83.5	182.5	71	2010	20.5	180.5	26.58
1996	9	Arithmetic Mean	16.28	8.81	8.1	1.15	115.6	190	73.8	2141.5	36.1	211.4	28.16
1996	9	Coefficient of Variation	0.13	0.03	0.16	0.38	0.72	0.2	0.33	0.33	1.21	0.83	0.6
1996	9	LQ	14.76	8.65	7.12	0.8	69	165	61	1780	5	47	14.04
1996	9	UQ	18.68	9.05	9.18	1.34	119	214	78	2350	48	324	41.45
1997	6	N of Cases	7	7	7	6	7	7	7	7	7	7	7
1997	6	Median	18.93	9.55	9.64	0.5	197	123	9	2190	5	298	163.65
1997	6	Arithmetic Mean	18.7	9.5	9.46	0.52	218.71	133.93	8.57	2312.14	5	394.86	219.21
1997	6	Coefficient of Variation	0.03	0.02	0.12	0.41	0.45	0.36	0.29	0.3	0	0.64	0.77
1997	6	LQ	18.48	9.37	8.52	0.4	182	101.13	6.5	1983.75	5	271.75	153.65
1997	6	UQ	18.98	9.63	10.55	0.7	211.25	150.75	10.5	2462.5	5	518.25	240.12
1997	7	N of Cases	23	23	23	21	23	23	23	23	23	23	23
1997	7	Median	21.13	9.54	9.06	0.51	190	225	56	2240	5	1680	664.94
1997	7	Arithmetic Mean	20.04	9.53	8.51	0.54	267.48	271.3	56.7	2782.39	6.74	1666.33	912.4

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1997	7	Coefficient of Variation	0.11	0.03	0.28	0.53	1.05	0.61	0.6	0.58	0.69	0.88	0.74
1997	7	LQ	17.13	9.3	6.32	0.32	129.5	183.5	27	1895	5	773.75	400.59
1997	7	UQ	21.79	9.76	10.24	0.8	291.25	319	82	3247.5	5	1937.5	1452.47
1997	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
1997	8	Median	20.26	8.55	6.57	1.15	64.25	242.75	112.5	2650	46.5	853.5	72.78
1997	8	Arithmetic Mean	20.44	8.4	6.81	1.08	131.1	269.69	116.59	3276.88	55.47	836.13	143.6
1997	8	Coefficient of Variation	0.07	0.07	0.28	0.34	1.79	0.48	0.34	0.72	0.65	0.44	1.72
1997	8	LQ	19.39	7.8	5.16	0.88	34	201.5	82.5	2355	23	619	20.5
1997	8	UQ	21.23	8.82	7.7	1.3	114.5	280.75	146.5	3170	84.5	979.75	138.66
1997	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
1997	9	Median	17.5	9.29	10.37	0.85	155	205.5	68.5	2065	5	597	233.42
1997	9	Arithmetic Mean	17.24	9.28	10.5	0.9	172.59	220.34	67.65	2337.19	6.28	757.5	302.12
1997	9	Coefficient of Variation	0.13	0.02	0.17	0.37	0.81	0.33	0.21	0.36	0.72	0.62	0.71
1997	9	LQ	15.12	9.2	9.4	0.68	58.5	164.5	58.25	1665	5	471.5	150.92
1997	9	UQ	19.25	9.4	11.9	1.18	227	277	82	2945	5	902	396.34
1998	6	N of Cases	24	24	24	24	24	24	24	24	24	24	24
1998	6	Median	17.43	8.86	9.7	1.18	45	62	6	906.5	5	302.5	54.86
1998	6	Arithmetic Mean	17.26	8.87	9.61	1.13	62.63	82.63	7.58	1123.58	5	360.23	93.68
1998	6	Coefficient of Variation	0.12	0.03	0.12	0.34	0.65	0.56	0.54	0.43	0	0.61	1.29
1998	6	LQ	15.57	8.71	9.18	0.93	34.75	49.75	5	828	5	187	29.72
1998	6	UQ	19.27	9.01	10.08	1.25	77.5	101	9.25	1322.5	5	454	102.64
1998	7	N of Cases	15	15	15	15	15	15	15	15	15	15	15
1998	7	Median	23.87	9.39	8.1	0.75	172	193.5	49	2330	5	963	450.85
1998	7	Arithmetic Mean	23.33	9.34	8	0.82	192.1	206.97	41.43	2500.67	5	957.03	499.29
1998	7	Coefficient of Variation	0.05	0.03	0.33	0.57	0.43	0.27	0.92	0.26	0	0.31	0.39
1998	7	LQ	22.22	9.13	6.18	0.55	124.63	159	4	2071.25	5	647.88	352.75
1998	7	UQ	24.49	9.49	10.08	0.94	243.25	257.5	72.88	2662.5	5	1173.75	647.07
1998	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
1998	8	Median	21.68	8.15	6.81	1.82	13	224.5	111.5	2220	55	1004.75	59.28
1998	8	Arithmetic Mean	21.72	8.12	6.58	1.55	82.4	246.91	113.28	2555.63	62.28	1122.09	127.56
1998	8	Coefficient of Variation	0.07	0.04	0.49	0.43	1.97	0.38	0.34	0.49	1.1	0.59	1.97
1998	8	LQ	20.37	7.79	3.45	1.14	6.38	191	80	2065	15.5	826	21.74
1998	8	UQ	23.22	8.23	8.46	2	50	248.5	146.5	2475	79.5	1090	70.59
1998	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
1998	9	Median	18.94	9.28	9.97	1.01	92.5	181.5	55.5	1847.5	5	287.5	89.23
1998	9	Arithmetic Mean	18.74	9.2	9.46	0.91	115.41	198.09	63	1883.59	5.69	279.72	107.45

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
1998	9	Coefficient of Variation	0.18	0.03	0.17	0.26	0.52	0.34	0.39	0.3	0.33	0.88	0.97
1998	9	LQ	15.32	9.04	8.67	0.73	72	162.25	48.5	1490	5	24	7.59
1998	9	UQ	21.77	9.38	10.5	1.13	156	221.5	70.5	2230	5	501.25	182.5
1999	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
1999	6	Median	16.79	8.76	10.07	1.05	46	87.75	12	1112.5	5	238.5	32.83
1999	6	Arithmetic Mean	16.91	8.83	10.48	0.93	95.44	111.78	13.78	1361.03	5	275.25	88.83
1999	6	Coefficient of Variation	0.16	0.07	0.14	0.43	1.25	0.59	0.55	0.55	0	0.68	1.54
1999	6	LQ	14.34	8.26	9.12	0.7	22.5	74.25	6.5	750.5	5	153	9.48
1999	6	UQ	19.4	9.39	11.43	1.09	126.75	118.5	21	1930	5	309.5	131.93
1999	7	N of Cases	15	15	15	15	15	15	15	15	15	15	15
1999	7	Median	20.06	9.82	9.05	0.57	223	177.5	29	2310	5	233	161.82
1999	7	Arithmetic Mean	19.48	9.8	9.06	0.63	224.03	193.9	27.53	2719	9.53	393.2	279.94
1999	7	Coefficient of Variation	0.07	0.02	0.19	0.56	0.57	0.44	0.85	0.38	0.58	0.91	0.99
1999	7	LQ	18.26	9.65	8.67	0.32	125	138	5	1912.5	5	150.75	108.38
1999	7	UQ	20.79	9.9	10.26	0.87	299.13	222.5	48.75	3377.5	15.25	549	372.41
1999	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
1999	8	Median	21.12	9.42	7.63	0.74	142.5	234.5	81	2405	11	165	67.81
1999	8	Arithmetic Mean	21.12	9.43	7.63	0.74	183.13	285.41	80.47	2626.25	12.94	431.94	245.72
1999	8	Coefficient of Variation	0.06	0.02	0.24	0.44	0.88	0.44	0.12	0.48	0.99	1.32	1.45
1999	8	LQ	20.15	9.3	6.13	0.53	76	187	74.5	1855	5	61	26.92
1999	8	UQ	22.33	9.58	8.89	1.02	232.5	357.5	84.75	3040	14	641	359.04
1999	9	N of Cases	24	24	24	24	24	24	24	24	24	24	24
1999	9	Median	17.09	8.74	8.65	1.15	46.5	190.5	66.5	2020	43	363.5	32.51
1999	9	Arithmetic Mean	16.41	8.7	8.53	0.99	74.03	209.48	79.02	2244.38	45.71	405.35	58.42
1999	9	Coefficient of Variation	0.12	0.04	0.26	0.37	1.16	0.44	0.46	0.33	0.64	0.8	1.23
1999	9	LQ	14.73	8.42	6.85	0.65	24	152	52	1805	16	91.5	12.63
1999	9	UQ	17.97	9	10.38	1.3	97.5	216	113.5	2400	61	740.5	58.12
2000	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2000	6	Median	20.47	9.81	9.42	0.61	183	172.5	8.5	2275	14.25	733.5	540.53
2000	6	Arithmetic Mean	20.09	9.77	9.1	0.66	203.09	184.72	21.59	2322.5	17.78	929.59	617.91
2000	6	Coefficient of Variation	0.12	0.03	0.17	0.42	0.62	0.4	0.98	0.34	0.98	0.58	0.6
2000	6	LQ	17.57	9.6	7.98	0.43	106.25	124	7	1602.5	5	606.5	436.15
2000	6	UQ	21.9	9.98	10.23	0.88	271	227	32.5	2947.5	21.5	1355	718.17
2000	7	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2000	7	Median	21.13	9.64	7.48	0.99	96.5	228	91.5	1605	10	521.25	314.78
2000	7	Arithmetic Mean	20.94	9.64	7.54	0.9	164.69	369.25	90.88	2012.25	9.56	706.5	476.78

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2000	7	Coefficient of Variation	0.03	0.03	0.18	0.5	1.02	1.2	0.14	0.57	0.22	0.75	0.95
2000	7	LQ	20.24	9.45	6.9	0.55	69.75	206.25	87.5	1390	10	368	229.27
2000	7	UQ	21.56	9.82	8.15	1.22	189	321	96.5	2295	10.25	927	481.09
2000	8	N of Cases	16	16	16	10	16	16	16	16	16	16	16
2000	8	Median	21.49	8.49	4.47	1.35	21.25	226	141.25	2277.5	66.5	870	79.33
2000	8	Arithmetic Mean	21.26	8.52	4.58	1.44	34.16	224.91	129	2240.31	76.22	778.31	92.43
2000	8	Coefficient of Variation	0.12	0.04	0.43	0.22	1.16	0.27	0.34	0.22	0.85	0.42	0.52
2000	8	LQ	18.54	8.34	2.89	1.2	17	183.5	118.25	1920	18.5	570	57.65
2000	8	UQ	23.47	8.68	6.14	1.75	37	262.75	158	2460	134	970.5	124.51
2000	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2000	9	Median	16.7	9.1	8.58	0.8	116	189	67	1680	18.25	484	116.02
2000	9	Arithmetic Mean	16.55	9.08	8.43	0.87	135.34	182.22	64.5	1899.69	23.88	496	150.28
2000	9	Coefficient of Variation	0.16	0.03	0.19	0.28	0.64	0.11	0.25	0.34	0.6	0.35	0.69
2000	9	LQ	14.25	8.92	7.37	0.69	68.5	163.5	51	1445	13.25	357.5	79.61
2000	9	UQ	18.69	9.29	9.84	1.14	170.75	200.75	75.5	2160	29	604.75	188.41
2001	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2001	6	Median	16.64	9.62	9.34	0.57	160.25	132	7	2490	5	501.5	258
2001	6	Arithmetic Mean	16.87	9.59	9.42	0.6	187.38	145.09	6.84	2565.63	5	498.53	269.94
2001	6	Coefficient of Variation	0.08	0.02	0.1	0.3	0.4	0.4	0.12	0.28	0	0.51	0.57
2001	6	LQ	15.91	9.49	8.84	0.54	134	101.5	6	1900	5	253.5	160.93
2001	6	UQ	17.57	9.71	9.65	0.73	233.5	162.5	7	2942.5	5	645.25	332.7
2001	7	N of Cases	24	24	24	24	24	24	24	24	24	24	24
2001	7	Median	19.66	9.68	7.9	0.73	193.5	247.5	59	3340	13	623	356.18
2001	7	Arithmetic Mean	19.59	9.68	8.18	0.74	200.6	234.4	45.38	3330.08	12.77	614.31	384.17
2001	7	Coefficient of Variation	0.03	0.02	0.2	0.43	0.45	0.31	0.61	0.3	0.2	0.51	0.5
2001	7	LQ	19.22	9.55	7.32	0.55	135	179	11.5	2545	11.5	347.5	268.49
2001	7	UQ	19.94	9.83	9.38	0.93	240.5	279.5	66	3890	14.5	716	481.92
2001	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2001	8	Median	22.17	8.94	5.51	0.85	75.25	226.5	70.75	3120	8	861	231.1
2001	8	Arithmetic Mean	21.49	8.91	5.35	0.95	84.88	238.5	66.72	3387.81	10.63	934	253.38
2001	8	Coefficient of Variation	0.08	0.04	0.51	0.49	0.72	0.32	0.63	0.27	0.7	0.42	0.54
2001	8	LQ	19.81	8.75	3.63	0.61	41	175	31.75	2862.5	5	676.5	137.7
2001	8	UQ	22.94	9.14	8.08	1.31	120.25	302.5	98.5	3820	14.5	1115	363.27
2001	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2001	9	Median	16.72	8.74	6.67	1.09	82.5	165	31	2765	13.25	970	93.57
2001	9	Arithmetic Mean	16.85	8.49	6.09	1.03	102.69	168.03	36.34	2894.38	17.59	878.84	142.18

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2001	9	Coefficient of Variation	0.06	0.08	0.38	0.4	0.69	0.3	0.62	0.3	0.58	0.58	1.66
2001	9	LQ	16.01	7.91	3.69	0.75	60	132	16.75	2285	11.5	419.5	19.61
2001	9	UQ	17.85	8.99	7.99	1.33	140.25	195.5	57.75	3690	25	1165	102.73
2002	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2002	6	Median	19.53	9.25	9.24	0.72	142	101	6.5	1847.5	6.25	249	125.25
2002	6	Arithmetic Mean	19.4	9.23	9.71	0.76	168.09	122.25	7.22	1786.22	8	381.56	192.2
2002	6	Coefficient of Variation	0.1	0.03	0.19	0.44	0.73	0.65	0.36	0.35	0.45	1.02	1.04
2002	6	LQ	17.49	9.08	8.55	0.56	90.25	74.25	5.5	1382.5	5	43.5	9.09
2002	6	UQ	20.75	9.43	11.21	1.04	209	127.5	8.5	2155	10	660	349.9
2002	7	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2002	7	Median	21.79	9.61	7.34	0.75	147.5	177.5	41	2435	11	398.75	265.97
2002	7	Arithmetic Mean	21.7	9.58	7.17	0.78	138.91	189.81	42.44	2345	18.34	416.78	260.6
2002	7	Coefficient of Variation	0.05	0.02	0.25	0.3	0.42	0.24	0.45	0.18	1.28	0.35	0.37
2002	7	LQ	20.95	9.5	5.97	0.59	81.5	160.25	30	2130	10	321.5	188.59
2002	7	UQ	22.66	9.69	8.36	0.97	186	207.5	55.25	2600	13.25	510.5	333.05
2002	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2002	8	Median	19.59	8.96	8.38	0.85	77	174	39	2745	54.75	585.25	111.89
2002	8	Arithmetic Mean	19.75	8.85	8.02	0.96	89.77	205.88	47.19	2830.31	70.59	590.75	153.35
2002	8	Coefficient of Variation	0.08	0.06	0.28	0.4	0.8	0.32	0.62	0.26	1.11	0.38	0.77
2002	8	LQ	18.57	8.59	6.69	0.69	40.25	158	30.5	2285	11	439	57.92
2002	8	UQ	20.83	9.21	9.68	1.21	134.5	249.5	61.5	2962.5	87.5	701	218.11
2002	9	N of Cases	16	16	8	16	16	16	16	16	16	16	16
2002	9	Median	16.46	9.27	8.88	0.89	98	190.25	45.5	2652.5	12	309.5	86.52
2002	9	Arithmetic Mean	16.54	9.24	8.11	0.93	110.66	213.56	44.84	2922.5	12.5	336.69	121.11
2002	9	Coefficient of Variation	0.05	0.02	0.15	0.35	0.58	0.32	0.37	0.28	0.17	0.45	0.62
2002	9	LQ	15.91	9.12	6.88	0.69	77.5	151	31.5	2270	11	205.75	64.49
2002	9	UQ	17.14	9.43	9	1.1	136	267	57.5	3600	13.25	449	165.94
2003	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2003	6	Median	20.08	8.4	8.02	1.24	16	90.75	18.5	1000	15.25	69.5	5.42
2003	6	Arithmetic Mean	19.98	8.4	8.16	1.16	28.9	102.16	16.91	1187.03	35.88	62.19	7.51
2003	6	Coefficient of Variation	0.05	0.04	0.1	0.17	1.04	0.47	0.33	0.44	0.83	0.34	0.91
2003	6	LQ	19.1	8.15	7.72	0.99	11.5	68.75	11.75	793.5	12	53.5	2.31
2003	6	UQ	20.6	8.59	8.24	1.28	34	112.5	21	1507.5	63	75.75	9.75
2003	7	N of Cases	24	24	24	24	24	24	24	24	24	24	24
2003	7	Median	22.55	9.5	8.43	0.69	82.5	212	45	2785	9	380	73.13
2003	7	Arithmetic Mean	22.74	9.34	7.43	0.8	108.06	213.4	54.35	2843.96	8.69	448.54	217.97

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2003	7	Coefficient of Variation	0.08	0.05	0.38	0.55	0.85	0.41	0.95	0.33	0.44	1.29	1.55
2003	7	LQ	20.86	9.37	6.19	0.56	49.75	142	5	2235	5	23.75	13.51
2003	7	UQ	24.51	9.57	9.47	0.99	148	280	86	3325	12	720	284.82
2003	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2003	8	Median	20.53	9.51	8.52	0.58	176	261.5	73.5	3045	13.5	16	8.48
2003	8	Arithmetic Mean	20.39	9.51	8.35	0.6	167.75	274.75	75.47	3124.06	13.59	43.25	17.37
2003	8	Coefficient of Variation	0.03	0.02	0.2	0.32	0.34	0.23	0.21	0.16	0.68	2.57	1.99
2003	8	LQ	20.09	9.44	7.91	0.48	139.5	234.75	69	2870	5	11	6.92
2003	8	UQ	20.73	9.62	8.93	0.67	200.5	306.5	79.5	3505	19.25	23.25	12.77
2003	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2003	9	Median	17.08	9.4	7.19	0.69	93.5	216.5	63.5	2480	16.5	151.25	29.58
2003	9	Arithmetic Mean	16.99	9.34	7.56	0.69	138.69	271.88	59.44	3064.69	29.38	177.63	70.34
2003	9	Coefficient of Variation	0.04	0.04	0.27	0.45	1.35	0.66	0.51	0.61	0.92	1.15	1.33
2003	9	LQ	16.41	9.11	5.89	0.42	74.5	180.5	32	2047.5	12.25	33.5	14.77
2003	9	UQ	17.56	9.58	8.97	0.87	118	290	74	3060	41.75	241	108.62
2004	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2004	6	Median	17.41	9.31	9.02	0.96	65.5	69.5	7.5	1325	5	21.5	4.36
2004	6	Arithmetic Mean	17.35	9.25	9.27	0.83	89.53	94.56	8.19	1448	7.38	27.41	11.09
2004	6	Coefficient of Variation	0.17	0.04	0.09	0.31	0.82	0.62	0.21	0.41	0.38	0.84	1.35
2004	6	LQ	14.55	8.85	8.75	0.71	40	60.5	7	1035	5	13	3.36
2004	6	UQ	20.02	9.6	9.81	1	109	101	9.5	1570	10	35.5	7.69
2004	7	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2004	7	Median	21.69	9.63	7.38	0.66	132.25	172.5	30.5	2120	16	22	13.38
2004	7	Arithmetic Mean	21.68	9.63	7.12	0.72	187.5	187.81	28.94	2456.88	25.69	32.66	19.56
2004	7	Coefficient of Variation	0.05	0.02	0.17	0.49	0.9	0.51	0.56	0.44	0.88	0.98	0.85
2004	7	LQ	20.97	9.54	6.35	0.49	103.5	131.5	14	1745	9.75	12	8.59
2004	7	UQ	22.71	9.72	8.15	0.76	210.5	194.75	41	2525	41	38	24.32
2004	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2004	8	Median	21.93	9.03	5.86	0.95	80.5	178.25	56	2450	29.5	159	37.25
2004	8	Arithmetic Mean	22.03	9.03	5.69	1.02	76.88	191.34	65.88	2410	35.41	206.13	48.79
2004	8	Coefficient of Variation	0.05	0.05	0.31	0.33	0.72	0.26	0.33	0.14	0.63	0.92	0.69
2004	8	LQ	21.17	8.86	4.22	0.76	28.5	170	48	2130	20.25	42.5	19.14
2004	8	UQ	23.05	9.35	6.77	1.26	108.25	195	88.5	2660	41.5	342	82.33
2004	9	N of Cases	24	24	24	24	24	24	24	24	24	24	24
2004	9	Median	16.24	9.14	8.49	1.04	51	140.5	24.5	2030	14.5	105	24.95
2004	9	Arithmetic Mean	17.25	9.11	8.51	0.96	81.54	155.15	26.69	2447.08	16.81	226.94	58.68

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2004	9	Coefficient of Variation	0.12	0.02	0.17	0.29	1.33	0.38	0.75	0.45	0.9	1.11	1.2
2004	9	LQ	15.57	8.99	7.8	0.84	15.5	122	10.5	1860	9	22.5	9.34
2004	9	UQ	19.44	9.26	9.24	1.13	74	177.5	32.5	2575	20	418	106.88
2005	6	N of Cases	19	19	19	16	19	19	19	19	19	19	19
2005	6	Median	15.94	9.07	9.73	0.97	61	84	6	1410	5	27	3.81
2005	6	Arithmetic Mean	15.73	8.96	9.7	0.87	58.79	92.58	6.84	1403.74	8.53	24.53	6.24
2005	6	Coefficient of Variation	0.08	0.04	0.09	0.42	0.53	0.44	0.43	0.3	0.54	0.43	0.77
2005	6	LQ	14.46	8.73	9.48	0.75	29.25	63.25	5	990	5	15.25	2.27
2005	6	UQ	16.72	9.22	10.17	1.11	71.75	114.25	7	1815	11	33	11.21
2005	7	N of Cases	18	18	18	16	17	18	18	18	18	18	18
2005	7	Median	22.01	9.45	7.17	1.02	59	175.5	36	2090	7.5	69	36.67
2005	7	Arithmetic Mean	22.38	9.41	6.77	1.04	75.78	184.39	36.94	2431.67	10.17	111.44	48.8
2005	7	Coefficient of Variation	0.07	0.03	0.26	0.49	0.96	0.41	0.82	0.37	0.61	1.12	0.9
2005	7	LQ	21.09	9.23	5.76	0.58	19.75	124	8	1890	5	15	10.16
2005	7	UQ	23.72	9.6	8.12	1.4	101.75	260	53	3150	14	137	74.08
2005	8	N of Cases	25	25	25	23	24	25	25	25	25	25	25
2005	8	Median	21.12	9.33	7.58	0.88	108	195	52	2470	13	19	8.99
2005	8	Arithmetic Mean	20.88	9.16	7.34	0.94	131.27	205.32	55.94	2835.6	17.54	128.12	20.6
2005	8	Coefficient of Variation	0.1	0.06	0.23	0.51	0.78	0.34	0.58	0.38	0.77	1.68	1.02
2005	8	LQ	19.2	9.06	6.57	0.64	54.5	150.75	32.63	2047.5	5	8.75	5.08
2005	8	UQ	22.4	9.48	8.63	1.22	172	227.5	70.75	3417.5	25.75	133	31.34
2005	9	N of Cases	18	18	18	16	18	18	18	18	18	18	18
2005	9	Median	14.08	8.9	8.12	0.72	139.5	194	40.5	2870	10	57.5	8.39
2005	9	Arithmetic Mean	14.16	8.92	8.13	0.79	137.17	198.28	39.61	2978.33	10.72	91.78	14.46
2005	9	Coefficient of Variation	0.1	0.02	0.13	0.23	0.47	0.24	0.42	0.21	0.61	1.04	0.92
2005	9	LQ	13.25	8.79	7.28	0.67	89	162	27	2510	5	23	4.56
2005	9	UQ	15.06	9.07	8.82	0.97	169	237	52	3290	14	113	18.66
2006	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2006	6	Median	18.32	7.99	7.24	1.61	12	54	15	714.5	22.5	53	1.76
2006	6	Arithmetic Mean	18.14	7.99	7.34	1.59	13.24	74.19	15	793.13	22.75	58	1.98
2006	6	Coefficient of Variation	0.04	0.03	0.06	0.11	0.65	0.74	0.27	0.23	0.38	0.38	0.48
2006	6	LQ	17.52	7.75	6.96	1.46	5.6	49.5	12.5	674	18.5	47	1.33
2006	6	UQ	18.73	8.22	7.79	1.73	20	59	17.5	919	27	72.5	2.62
2006	7	N of Cases	24	24	24	24	24	24	24	24	24	24	24
2006	7	Median	22.23	9.33	7.39	0.88	111.5	187.5	48	2065	20	101.5	31.97
2006	7	Arithmetic Mean	22.18	9.11	7.13	0.94	110.88	212.08	59.58	2192.08	40.5	288.67	56.42

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2006	7	Coefficient of Variation	0.04	0.06	0.3	0.4	1	0.56	0.92	0.43	1.19	1.28	0.84
2006	7	LQ	21.57	8.81	5.26	0.73	36.5	134.5	7	1825	5	41	24.96
2006	7	UQ	22.84	9.53	9.24	1.21	137	242.5	115.5	2340	61.5	534	66.2
2006	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2006	8	Median	20.67	9.71	8.3	0.71	99	246	94.5	3160	5	30	18.02
2006	8	Arithmetic Mean	20.67	9.75	8.53	0.66	147.25	269.44	90.19	3386.25	5	118.88	71.44
2006	8	Coefficient of Variation	0.04	0.04	0.17	0.42	0.85	0.4	0.25	0.46	0	1.8	1.6
2006	8	LQ	20.13	9.37	7.7	0.4	76	198	68.5	1975	5	14	8.6
2006	8	UQ	21.23	10.17	9.68	0.91	177	292.5	104.5	4565	5	79	55.4
2006	9	N of Cases	16	16	16	12	16	16	16	16	16	16	16
2006	9	Median	16.95	9.98	10.04	0.6	142.5	255	94	2500	5	61.5	37.33
2006	9	Arithmetic Mean	16.66	9.99	9.84	0.58	200.31	287.38	94.06	3389.38	5	95.13	70.68
2006	9	Coefficient of Variation	0.16	0.02	0.21	0.57	1	0.42	0.43	0.63	0	1.08	1.12
2006	9	LQ	14.07	9.8	8.3	0.32	89	230.5	77	2385	5	26.5	17.38
2006	9	UQ	18.97	10.16	11.28	0.84	224	299.5	99.5	3515	5	146.5	99.99
2007	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2007	6	Median	17.8	8.93	8.62	1.19	27.5	116	35.5	899	5	19.5	3.15
2007	6	Arithmetic Mean	17.86	8.81	8.45	1.18	51.06	127.19	32.63	1100.88	30.44	28.31	4.17
2007	6	Coefficient of Variation	0.08	0.04	0.14	0.31	1.46	0.54	0.52	0.59	0.98	0.86	0.84
2007	6	LQ	16.65	8.58	7.38	1.01	13	91.5	16	800	5	8.5	1.95
2007	6	UQ	18.97	9.04	9.61	1.46	56.5	123	48	1070	63	45	5.13
2007	7	N of Cases	24	24	24	24	24	24	24	24	24	24	24
2007	7	Median	21.79	9.92	7.31	0.62	140.5	302.5	111	3065	5	23	18.1
2007	7	Arithmetic Mean	21.54	9.92	7.29	0.6	160.38	312.38	93.96	3012.5	8.17	51.88	39.57
2007	7	Coefficient of Variation	0.06	0.01	0.25	0.38	0.48	0.35	0.55	0.26	0.59	1.19	1.19
2007	7	LQ	20.14	9.88	5.88	0.4	100.5	254.5	27.5	2355	5	5	4.36
2007	7	UQ	22.6	10.01	8.73	0.75	222.5	361	133.5	3660	13	69	50.9
2007	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2007	8	Median	20.32	9.39	7.33	0.61	122	256	105.5	2660	5	32	20.15
2007	8	Arithmetic Mean	20.24	9.41	6.49	0.62	135.13	292.88	101.06	3244.38	8.5	99.63	42.59
2007	8	Coefficient of Variation	0.04	0.02	0.26	0.48	0.57	0.32	0.22	0.4	0.52	1.03	0.91
2007	8	LQ	19.48	9.26	5.03	0.44	68	236	87.5	2415	5	20	11.65
2007	8	UQ	21.03	9.57	7.75	0.84	202.5	304	115.5	3935	12	197.5	76.68
2007	9	N of Cases	16	16	16	16	8	16	16	16	16	16	16
2007	9	Median	15.03	9.23	9.15	0.66	88	199.25	49.52	2665.87	13	295.22	73.51
2007	9	Arithmetic Mean	15.36	9.18	8.41	0.63	123.25	209.28	63.45	2872.7	15.76	343.1	75.09

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2007	9	Coefficient of Variation	0.21	0.03	0.22	0.2	0.7	0.21	0.59	0.23	0.75	1.01	0.74
2007	9	LQ	12.5	9.04	7.39	0.51	85	177.98	39.42	2414.04	5.01	77	33.2
2008	9	UQ	18.46	9.34	9.52	0.74	150.5	245	83.5	3172.43	19.99	481.75	115.76
2008	6	N of Cases	23	23	23	23	23	23	23	23	23	23	23
2008	6	Median	17.78	8.95	9.23	1.03	48	77	18	1120	4	25	5.1
2008	6	Arithmetic Mean	18.28	8.82	9.19	1	66.8	101.83	18.83	1488.48	13.39	30.26	7.8
2008	6	Coefficient of Variation	0.16	0.08	0.12	0.37	1.08	0.68	0.2	0.67	1.27	0.42	0.94
2008	6	LQ	15.24	8.05	8.19	0.71	13.5	59	17	737	4	20.25	0.88
2008	6	UQ	21.29	9.51	10.22	1.34	94	121	21.5	1902.5	18.25	36	14.27
2008	7	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2008	7	Median	21.22	9.61	8.02	0.73	160	199.5	54	2600	6.5	19.5	14.23
2008	7	Arithmetic Mean	21.34	9.6	7.99	0.66	260.63	199.63	57.75	2603.75	7.13	93.19	43.24
2008	7	Coefficient of Variation	0.05	0.03	0.22	0.4	1.03	0.26	0.37	0.34	0.46	1.66	1.3
2008	7	LQ	20.63	9.43	6.77	0.5	130.5	164	42	1855	4	16.5	11.79
2008	7	UQ	21.45	9.79	9.16	0.89	259.5	230.5	68.5	3035	10	76.5	49.1
2008	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2008	8	Median	20.22	9.27	7.2	0.8	101.5	230	94	2870	9	153	67.67
2008	8	Arithmetic Mean	20.28	9.26	7.24	0.78	140.94	267.88	92.75	2891.88	9.81	190	61.24
2008	8	Coefficient of Variation	0.04	0.03	0.27	0.26	0.8	0.35	0.25	0.35	0.74	1.08	0.74
2008	8	LQ	19.63	9.15	6.58	0.7	61.5	209.5	82	2070	4	25	12.18
2008	8	UQ	21.03	9.44	8.36	0.94	191	297.5	108.5	3405	13	287	99.88
2008	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2008	9	Median	16.55	9.31	8.39	0.7	98	197.5	66	2475	10	35	12.02
2008	9	Arithmetic Mean	16.51	9.16	7.42	0.71	155.13	253.44	72.44	3116.25	10.69	314.25	29.99
2008	9	Coefficient of Variation	0.08	0.06	0.32	0.33	1.28	0.51	0.45	0.59	0.32	2.61	1.19
2008	9	LQ	15.56	9.04	5.99	0.62	64	180.5	53.5	2055	9	23	10.35
2008	9	UQ	17.55	9.48	9.05	0.89	159	267	84.5	3255	12	151.5	31.54
2009	6	N of Cases	24	24	24	24	23	24	24	24	24	24	24
2009	6	Median	18.41	9.29	8.35	0.86	95.36	67.5	6	1670	4	18.5	7.66
2009	6	Arithmetic Mean	18.96	9.09	8.29	0.9	135.88	82.21	5.75	1735.04	4.54	25.58	8.7
2009	6	Coefficient of Variation	0.07	0.06	0.11	0.35	0.78	0.57	0.29	0.52	0.44	0.72	0.81
2009	6	LQ	18.1	8.77	7.54	0.74	60	46	4	986.5	4	12.5	2.44
2009	6	UQ	19.68	9.42	8.98	1.1	176.03	99	7	1990	4	28.5	10.87
2009	7	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2009	7	Median	21.77	8.47	5.73	1.51	45.34	159.5	60	2175	20.5	456	35.97
2009	7	Arithmetic Mean	21.78	8.34	5.7	1.61	49.92	156.75	71.81	2080.63	28.56	558.75	41.41

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2009	7	Coefficient of Variation	0.1	0.09	0.32	0.39	0.91	0.2	0.55	0.18	0.81	0.75	0.71
2009	7	LQ	19.66	7.63	4.6	1.09	16.26	136	40.5	1740	13	247.5	14.44
2009	7	UQ	23.61	8.92	7.02	2.04	60.45	171	97	2330	38.5	902.5	57.93
2009	8	N of Cases	15	15	15	16	16	16	16	16	16	16	15
2009	8	Median	19.58	9.69	8.94	0.68	166.89	191.5	41	2115	6	22	11.78
2009	8	Arithmetic Mean	19.53	9.74	8.87	0.62	186.03	195.38	48.06	2353.13	6.69	68.19	46.51
2009	8	Coefficient of Variation	0.03	0.06	0.29	0.41	0.45	0.27	0.57	0.32	0.45	2.02	2.06
2009	8	LQ	19.1	9.2	7.88	0.48	132.42	154.5	26.5	1855	4	17	8.14
2009	8	UQ	20.1	10.25	10.8	0.8	229.95	212.5	69	2800	9	35	22.8
2009	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2009	9	Median	16.48	9.81	7.79	0.57	174.81	240.5	90.5	2810	4	121	86.29
2009	9	Arithmetic Mean	16.35	9.77	7.39	0.62	182.81	251.44	82.06	3103.13	7.69	265.69	137.16
2009	9	Coefficient of Variation	0.05	0.02	0.17	0.28	0.33	0.19	0.25	0.27	0.74	1.44	1
2009	9	LQ	15.82	9.66	6.58	0.48	142.87	218	69	2470	4	33	22.56
2009	9	UQ	17.02	9.92	8.19	0.77	223.45	279.5	96	3670	10	379.5	231.07
2010	6	N of Cases	24	24	24	24	24	24	24	24	24	24	24
2010	6	Median	16.6	8.35	8.51	1.07	12.35	47.5	4	602.5	4	9.5	0.44
2010	6	Arithmetic Mean	16.86	8.22	8.67	1.1	14.05	50	5.17	623.67	5.33	11.79	0.7
2010	6	Coefficient of Variation	0.18	0.05	0.07	0.27	1.05	0.22	0.69	0.19	0.36	0.59	1
2010	6	LQ	13.52	7.7	8.13	0.98	3.3	44	3	546.5	4	6.5	0.22
2010	6	UQ	20.1	8.55	9.16	1.2	15.75	54.5	6	641.5	8	17	0.77
2010	7	N of Cases	20	20	20	20	20	20	20	20	20	20	20
2010	7	Median	22.3	9.51	9.11	0.99	106.5	81.5	8	1660	4	29	15.26
2010	7	Arithmetic Mean	22.05	9.51	8.37	0.92	121.06	107.6	20	1778.6	5.6	83.25	42.83
2010	7	Coefficient of Variation	0.04	0.02	0.23	0.38	0.57	0.57	1.09	0.39	0.78	1.26	1.12
2010	7	LQ	21.35	9.4	6.8	0.64	60.1	67	5.5	1370	4	14	9.37
2010	7	UQ	22.87	9.67	9.61	1.14	148.5	152.5	26.5	2125	4	153	87.45
2010	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2010	8	Median	20.39	9.42	8.62	0.71	135	180.5	45.5	2120	9.5	42.5	21.75
2010	8	Arithmetic Mean	20.36	9.23	8.53	0.81	153.48	184.25	52.5	2305	17.56	174.75	37.22
2010	8	Coefficient of Variation	0.08	0.05	0.18	0.47	0.73	0.18	0.51	0.27	1.25	1.35	0.83
2010	8	LQ	19.24	8.93	7.75	0.52	80.85	162.5	39	1920	4	25	13.98
2010	8	UQ	21.7	9.58	9.84	0.96	189.5	199.5	70.5	2640	19.5	289	66.19
2010	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2010	9	Median	15.9	9.5	8.98	0.74	214.5	175.5	30.5	2420	9	31	17.87
2010	9	Arithmetic Mean	15.91	9.46	9.03	0.69	215.6	206.31	34	2851.88	11.38	123.69	31.76

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2010	9	Coefficient of Variation	0.07	0.03	0.26	0.38	0.59	0.46	0.47	0.45	1	1.96	0.85
2010	9	LQ	15.02	9.37	7.84	0.56	112	147	25.5	2225	4	27	14.08
2010	9	UQ	16.9	9.64	10.86	0.81	284	221	36.5	2905	11.5	98.5	39.55
2011	6	N of Cases	24	24	24	24	24	24	24	24	24	24	24
2011	6	Median	16.06	8.06	8.35	1.05	12.6	48	5	655	14	49.5	1.43
2011	6	Arithmetic Mean	15.25	8.1	8.37	1.17	13.51	49.29	5.19	665.67	18.46	49.29	1.47
2011	6	Coefficient of Variation	0.24	0.03	0.12	0.26	0.39	0.31	0.4	0.21	0.6	0.53	0.45
2011	6	LQ	10.63	7.98	7.86	0.95	9.28	41.5	4	605	10	36	0.94
2011	6	UQ	18.97	8.26	9.32	1.5	15.55	52	6.5	698	27	68	2
2011	7	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2011	7	Median	20.09	9.59	10.19	0.77	115	97	7	1665	4	23	13.73
2011	7	Arithmetic Mean	19.79	9.63	9.84	0.76	136.04	106.5	7.81	1743.13	4.94	32.75	19.34
2011	7	Coefficient of Variation	0.06	0.02	0.14	0.22	0.54	0.28	0.54	0.28	0.41	0.93	0.81
2011	7	LQ	18.58	9.49	8.91	0.71	96.65	88	4	1500	4	17	11.65
2011	7	UQ	20.84	9.73	10.49	0.83	166.5	121.5	9.5	1805	4	36	22.37
2011	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2011	8	Median	21.98	9.05	7.45	1.03	42.5	205.5	70.5	1870	19	114	47.37
2011	8	Arithmetic Mean	21.71	9.03	7.26	1.01	84.51	218.13	74.88	2091.88	25.25	200.13	55.06
2011	8	Coefficient of Variation	0.05	0.05	0.35	0.46	1.5	0.3	0.19	0.48	0.79	0.97	0.8
2011	8	LQ	21.38	8.85	5.52	0.78	8.45	184	64	1525	15.5	49	19.14
2011	8	UQ	22.51	9.28	9.62	1.41	81.45	227.5	83	2285	26	291.5	74.05
2011	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2011	9	Median	18.12	8.98	8.84	0.79	86.55	187	34.5	1660	23.5	165.5	27.65
2011	9	Arithmetic Mean	18.29	8.91	8.42	0.89	93.19	185.88	52.25	1771.88	30.69	171.81	34.56
2011	9	Coefficient of Variation	0.1	0.03	0.28	0.35	0.64	0.22	0.79	0.27	0.77	0.81	0.81
2011	9	LQ	16.7	8.72	6.42	0.65	51.3	144.5	13.5	1525	14	39.5	9.68
2011	9	UQ	20.08	9.11	10.34	1.01	115.5	210.5	96	1890	42.5	279	62.31
2012	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2012	6	Median	16.37	8.13	8.45	1.03	10.5	80	31.5	687	6	24	1.03
2012	6	Arithmetic Mean	16.33	8.1	8.44	1.04	14.38	82.06	31.31	692.38	11.31	36.44	1.15
2012	6	Coefficient of Variation	0.09	0.04	0.04	0.12	0.59	0.13	0.14	0.13	0.86	0.72	0.44
2012	6	LQ	15.06	7.82	8.19	0.94	7	72.5	28.5	622	4	17.5	0.77
2012	6	UQ	17.77	8.33	8.72	1.15	23.5	87.5	34.5	734	18.5	50	1.53
2012	7	N of Cases	24	24	24	24	24	24	24	24	24	24	24
2012	7	Median	21.14	9.65	8.67	0.58	152	182.5	49	1975	9	38	23.02
2012	7	Arithmetic Mean	20.73	9.62	8.71	0.63	184.71	201.88	67.63	2180.25	10.75	63.67	39.14

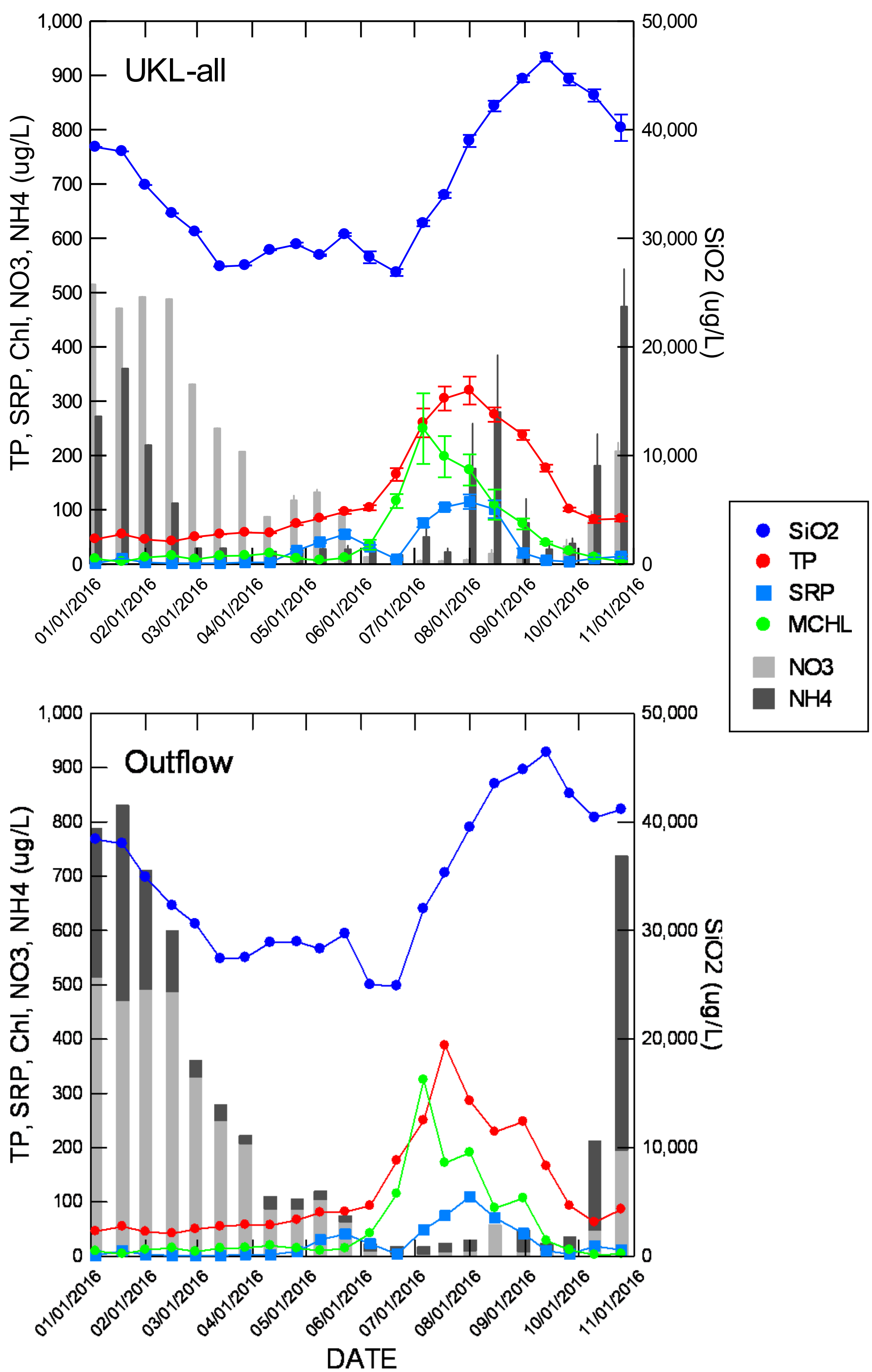
Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2012	7	Coefficient of Variation	0.06	0.04	0.24	0.54	0.87	0.54	0.82	0.59	0.42	1.01	1.02
2012	7	LQ	19.52	9.29	6.77	0.4	68	100.5	20	1155	8.5	25	15.54
2012	7	UQ	21.76	9.93	10.56	0.91	258	274.5	138	2770	12	69	45.75
2012	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2012	8	Median	20.98	9.09	6.7	0.8	68.5	223	91.5	2085	34.5	113.5	33.53
2012	8	Arithmetic Mean	21.13	9.04	6.41	0.78	100.19	239.13	95.19	2243.13	42.69	265.75	55.28
2012	8	Coefficient of Variation	0.07	0.05	0.46	0.38	1.02	0.39	0.44	0.3	0.91	1.07	0.88
2012	8	LQ	19.89	8.86	4.12	0.58	33.5	173.5	73	1980	13	57.5	24.91
2012	8	UQ	22.41	9.37	9.18	1.04	130	276	133	2260	56.5	467	72.26
2012	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2012	9	Median	18.13	8.03	7.5	0.81	51	92	7.5	1520	78.5	100.5	3.05
2012	9	Arithmetic Mean	17.89	8.08	7.04	0.85	49.19	88.38	13.25	1523.75	96.69	137	4.47
2012	9	Coefficient of Variation	0.07	0.06	0.22	0.25	0.65	0.3	1.02	0.24	0.54	0.97	0.78
2012	9	LQ	17.35	7.72	5.87	0.73	23.5	63	4	1175	61.5	34.5	1.72
2012	9	UQ	18.64	8.37	7.91	1.02	70.5	114.5	18	1715	147	206	6.82
2013	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2013	6	Median	17.61	9.33	9.55	0.66	71.9	128	19.5	1365	8.5	16	6.56
2013	6	Arithmetic Mean	17.69	9.29	9.82	0.72	92.24	128.5	21.31	1448.25	7.75	19.25	9.1
2013	6	Coefficient of Variation	0.03	0.06	0.09	0.32	0.76	0.21	0.6	0.44	0.31	0.75	1.19
2013	6	LQ	17.21	8.8	9.06	0.54	28.9	102.5	9	911.5	6	11.5	2.08
2013	6	UQ	18.12	9.82	10.43	0.89	158	155.5	32.5	2025	9	22	11.78
2013	7	N of Cases	24	24	24	24	24	24	24	24	24	24	24
2013	7	Median	22.62	9.98	8.36	0.55	154	274.5	112.5	2510	4	59.5	49.28
2013	7	Arithmetic Mean	22.78	9.97	7.74	0.53	223.74	297.63	105.42	2987.08	5.67	94.04	71.66
2013	7	Coefficient of Variation	0.04	0.03	0.22	0.43	0.94	0.38	0.35	0.56	0.57	1.09	1.05
2013	7	LQ	22.06	9.79	6.55	0.34	110	240	72.5	2180	4	13.5	11.74
2013	7	UQ	23.25	10.2	8.84	0.67	270.5	320.5	138	3335	6	159	125.89
2013	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2013	8	Median	19.98	8.05	5.02	0.92	33.85	174	49.5	1805	208.5	262	7.76
2013	8	Arithmetic Mean	19.81	8.13	4.76	1.04	42.98	187.75	62.28	1891.25	225.06	286.06	17.44
2013	8	Coefficient of Variation	0.03	0.09	0.51	0.26	1.02	0.58	0.51	0.22	0.75	0.91	1.25
2013	8	LQ	19.38	7.5	2.32	0.89	6.96	110	45	1505	69.5	71	3.75
2013	8	UQ	20.31	8.78	6.25	1.25	58.35	221	97	2270	343.5	394.5	27.11
2013	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2013	9	Median	16.79	7.65	6.71	0.89	10.01	89	31.5	1235	326.5	55	0.57
2013	9	Arithmetic Mean	16.78	7.64	6.6	0.89	15.22	91.13	30.13	1256.25	314.25	51.75	0.69

Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2013	9	Coefficient of Variation	0.16	0.03	0.2	0.17	0.75	0.12	0.32	0.11	0.25	0.5	0.57
2013	9	LQ	14.23	7.52	5.8	0.8	8.17	85	22	1155	249	36	0.46
2013	9	UQ	18.87	7.81	7.69	1.02	18.6	98.5	37	1335	372	58	0.71
2014	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2014	6	Median	16.73	9.03	9.52	0.71	66.9	160.5	58.5	1313.5	4	11	4.08
2014	6	Arithmetic Mean	16.78	9	9.64	0.78	75.69	163.19	57.94	1384.25	6.94	19.94	3.87
2014	6	Coefficient of Variation	0.09	0.09	0.12	0.41	0.87	0.22	0.36	0.54	0.66	0.77	0.64
2014	6	LQ	15.62	8.27	8.63	0.51	12.5	131.5	43.5	671.5	4	9.5	1.57
2014	6	UQ	18.09	9.71	10.74	1.07	128	196.5	75	2070	11.5	31	5.84
2014	7	N of Cases	24	24	24	24	24	24	24	24	24	24	24
2014	7	Median	21.33	9.76	9.34	0.66	77.4	339.5	180.5	2335	9	75.5	45.42
2014	7	Arithmetic Mean	21.71	9.67	8.7	0.79	132.02	336.13	160.88	2812.08	10.83	138.79	73.34
2014	7	Coefficient of Variation	0.09	0.04	0.31	0.4	1.08	0.29	0.31	0.42	0.83	1.15	1.04
2014	7	LQ	20.23	9.31	7.26	0.55	38.3	252	112.5	1995	4	17.5	14.19
2014	7	UQ	23.49	9.96	10.61	1.05	180.5	394	195	3180	13	214.5	98.92
2014	8	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2014	8	Median	20.76	8.19	6.2	0.92	27.2	177	66.5	1560	174.5	64.5	5.39
2014	8	Arithmetic Mean	20.24	8.28	5.52	0.93	45.04	195.38	85.44	1883.75	192.88	159.5	16.21
2014	8	Coefficient of Variation	0.08	0.06	0.42	0.27	1.18	0.42	0.57	0.4	0.63	1.36	1.5
2014	8	LQ	18.98	7.95	3.74	0.75	13.4	128.5	48.5	1395	94	32	1.11
2014	8	UQ	21.49	8.7	7.53	1.05	59.7	233.5	130	2205	308.5	119.5	18.58
2014	9	N of Cases	16	16	16	16	15	16	16	16	16	16	16
2014	9	Median	18.42	7.99	7.79	1.02	20.5	109	30	1130	15	20.5	0.95
2014	9	Arithmetic Mean	18.43	8.14	7.87	1	22.19	106.25	28.63	1105.06	18.13	24.63	1.5
2014	9	Coefficient of Variation	0.03	0.05	0.11	0.16	0.49	0.16	0.33	0.22	0.48	0.64	1.07
2014	9	LQ	18.09	7.82	7.37	0.9	13.63	95	24.5	983	11.5	14.5	0.5
2014	9	UQ	18.78	8.49	8.25	1.12	27.65	114	34.5	1205	21	28.5	2.15
2015	6	N of Cases	12	12	12	8	12	12	12	12	12	12	12
2015	6	Median	20.84	8.95	8.73	1.43	73.45	139.5	53.5	1340	12	36.5	8.58
2015	6	Arithmetic Mean	20.86	9.05	9.16	1.35	108.38	177.42	50	1804.58	12.04	47.17	19.68
2015	6	Coefficient of Variation	0.03	0.05	0.13	0.35	0.97	0.52	0.23	0.68	0.43	0.75	1.29
2015	6	LQ	20.52	8.79	8.23	1.08	35.45	129	43	1011.5	9.5	30	6.42
2015	6	UQ	21.33	9.46	10.4	1.54	142	196.5	57	2265	16.25	48.5	21.88
2015	7	N of Cases	20	20	20	16	20	20	20	20	20	20	20
2015	7	Median	21.72	9.28	10.04	0.85	75.85	254	126	1580	16.5	20	11.95
2015	7	Arithmetic Mean	22.21	9.25	9.41	0.96	83.08	259.2	137.8	1715.25	32.85	139.93	36.29

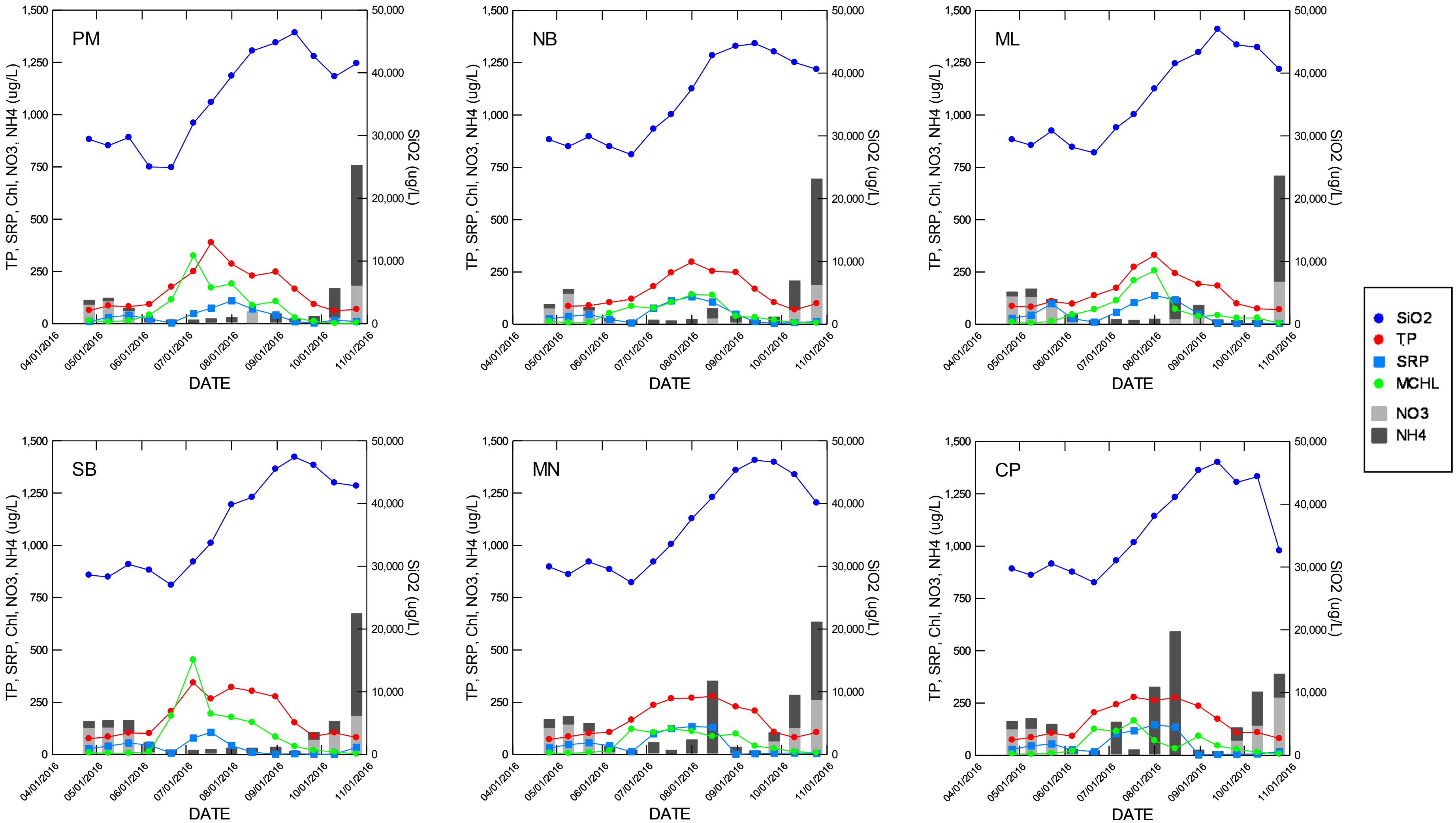
Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2015	7	Coefficient of Variation	0.06	0.04	0.27	0.28	0.56	0.18	0.22	0.33	0.84	1.39	1.22
2015	7	LQ	21.42	8.91	8.43	0.75	50.2	225.5	115.5	1435	12	16	10.25
2015	7	UQ	22.56	9.53	11.12	1.25	105.5	280.5	160.5	1775	55.5	183	45.61
2015	8	N of Cases	24	24	24	24	24	24	24	24	24	24	24
2015	8	Median	19.88	9.78	8.13	0.57	118.5	255	114.5	2220	12.5	23	16.44
2015	8	Arithmetic Mean	20.02	9.62	7.35	0.67	147.53	266.25	113.46	2392.08	42.63	108.04	51.52
2015	8	Coefficient of Variation	0.1	0.04	0.32	0.43	0.58	0.25	0.31	0.35	1.95	1.34	1.32
2015	8	LQ	18.71	9.41	5.27	0.45	79.8	234.5	87	1810	9	17	11.95
2015	8	UQ	21.84	9.86	9.19	0.87	225	281	140	2675	29.5	183.5	68.57
2015	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2015	9	Median	14.41	8.65	6.25	0.77	49.05	124	29	1550	77	80.5	6.37
2015	9	Arithmetic Mean	14.69	8.61	6.56	0.74	69.52	149.38	27.47	1891.25	122.56	159.75	15.58
2015	9	Coefficient of Variation	0.1	0.06	0.26	0.3	1.14	0.41	0.47	0.41	0.87	1.97	1.45
2015	9	LQ	13.6	8.25	5.22	0.55	22.9	107	19	1465	38.5	25.5	3.55
2015	9	UQ	16.08	9.15	8.08	0.84	74.65	172.5	36.5	2040	176.5	127	21.42
2016	6	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2016	6	Median	18.38	9.39	10.48	0.79	75.8	125	20	1415	9	17	7.96
2016	6	Arithmetic Mean	18.78	9.25	10.79	0.88	75.86	134.31	20.44	1412.13	8.94	20.88	7.61
2016	6	Coefficient of Variation	0.11	0.05	0.15	0.45	0.66	0.29	0.67	0.48	0.5	0.41	0.38
2016	6	LQ	16.76	8.87	9.56	0.6	30.65	102.5	7.5	773	4	14	4.8
2016	6	UQ	20.86	9.62	11.81	1.14	118	166.5	27.5	2000	13	25	10.03
2016	7	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2016	7	Median	20.54	10.11	8.75	0.57	178.5	270	98	2600	4	16.5	14.78
2016	7	Arithmetic Mean	20.42	10.11	8.43	0.55	223.59	282.44	90.44	3023.75	5.75	36	27.31
2016	7	Coefficient of Variation	0.04	0.03	0.16	0.48	0.62	0.23	0.25	0.41	0.42	1.14	1
2016	7	LQ	19.84	9.85	7.89	0.32	114	244	76	2030	4	15.5	12.33
2016	7	UQ	20.93	10.29	9.4	0.66	312	335.5	105.5	4175	8	34.5	27.06
2016	8	N of Cases	24	24	24	24	24	24	24	24	24	23	23
2016	8	Median	21.8	9.14	6.89	0.48	95.2	273	90.5	2335	9	45	16.41
2016	8	Arithmetic Mean	21.54	9.15	6.1	0.56	118.92	277.46	78.77	2556.67	13.96	172.78	55.12
2016	8	Coefficient of Variation	0.07	0.04	0.36	0.41	0.61	0.2	0.68	0.29	0.95	1.21	1.12
2016	8	LQ	19.89	8.88	5.07	0.44	70.95	242	29.5	2190	8	25.25	10.91
2016	8	UQ	22.74	9.42	7.25	0.67	148	300	132.5	2845	14.5	336.5	124.89
2016	9	N of Cases	16	16	16	16	16	16	16	16	16	16	16
2016	9	Median	15.07	8.42	8.57	0.57	31.25	132.5	4.5	1585	9	16.5	1.24
2016	9	Arithmetic Mean	15.19	8.36	8.49	0.56	31.47	138.69	5.66	1638.13	20.06	32.5	1.65

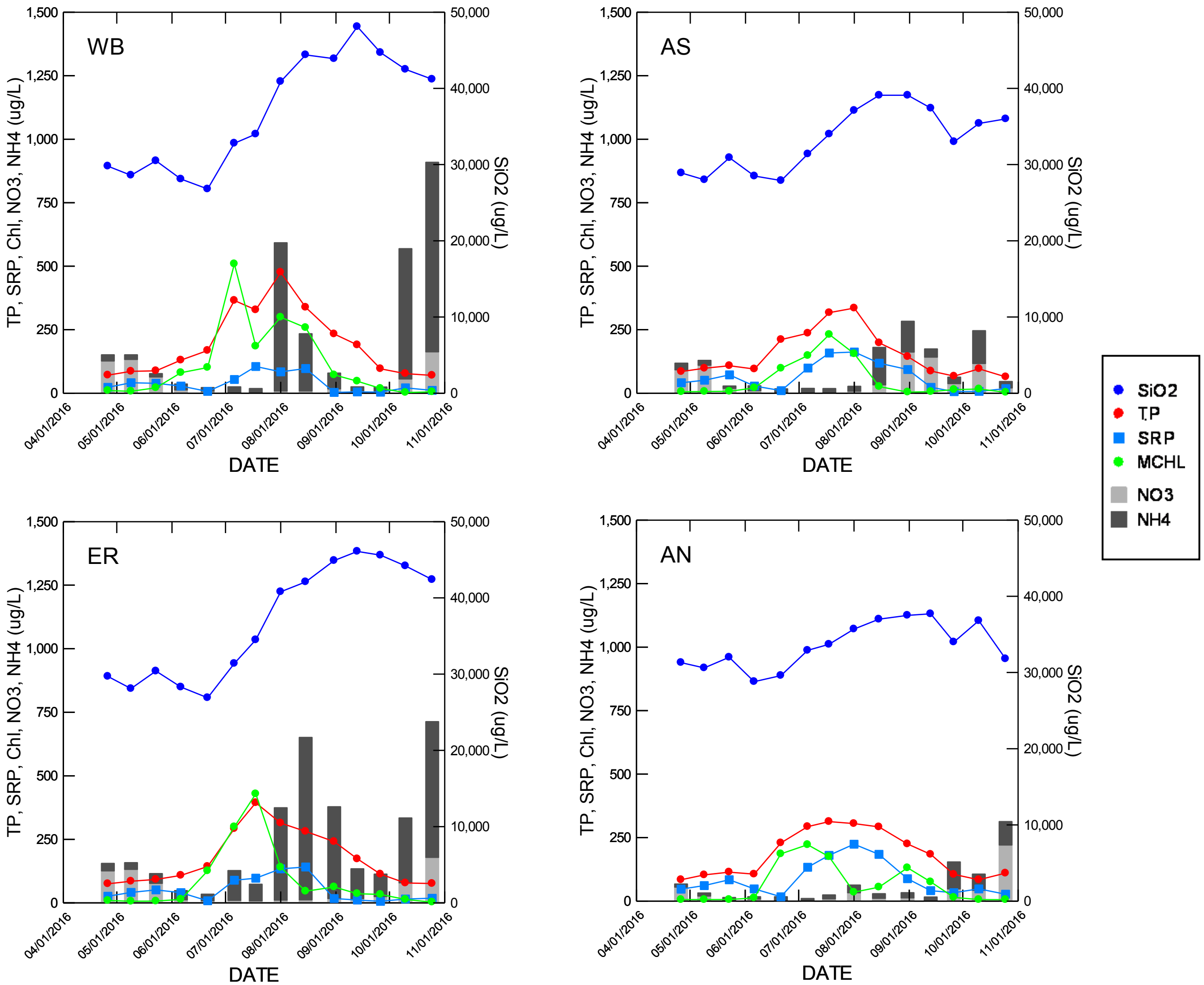
Year	Month	Parameter	Temp-erature (°C)	pH	Dissolved Oxygen (mg/L)	Secchi Depth (m)	Chloro-phyll a (µg/L)	Total Phos-phorus (µg/L)	Soluble Reactive Phos-phorus (µg/L)	Total Nitrogen (µg/L)	NO3+NO2 Nitrogen (µg/L)	NH4 Nitrogen (µg/L)	Un-ionized Ammonia (µg/L)
2016	9	Coefficient of Variation	0.07	0.02	0.09	0.21	0.32	0.3	0.54	0.21	1.27	0.94	0.56
2016	9	LQ	14.58	8.27	8.23	0.46	24.4	101	4	1310	4	14.5	1
2016	9	UQ	15.53	8.52	9	0.66	39.9	173	6	1895	21	36	2.02

APPENDIX II: 2016 Seasonal trends in silica and other nutrient parameters in UKL and UKL Outflow (lake-wide mean shown with standard error).



2016 Seasonal trends in silica and other nutrient parameters by station in UKL




WB
AS
ER
AN
TP, SRP, Chl, NO3, NH4 (ug/L)
SiO2 (ug/L)
DATE
0
250
500
750
1,000
1,250
1,500
10,000
20,000
30,000
40,000
50,000
04/01/2016
05/01/2016
06/01/2016
07/01/2016
08/01/2016
09/01/2016
10/01/2016
11/01/2016
SiO2
TP
SRP
MCHL
NO3
NH4