

Utah Lake Phytoplankton Assemblage Spatial Patterns: June 2018

Technical Memo

Wasatch Front Water Quality Council

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Introduction

Phytoplankton assemblages are known to vary in Utah Lake spatially and temporally (Richards and Miller 2017; Richards 2018a and 2018b). A limited understanding of this variability can unknowingly influence regulatory decisions; a thorough understanding of this variability is critical for understanding Utah Lake's ecology and food webs, particularly as they pertain to cyanoHABs. This technical memo highlights the large spatial variability of the phytoplankton assemblage in Utah Lake during a one week interval in June, 2018.

Methods

Phytoplankton samples were collected from Utah Lake on June 1st and June 8th, 2018 from several locations: 1) Utah Lake State Park marina; 2) inside and just outside of Lindon Marina; 3) three locations along a transect from Lindon Marina to Pelican Marina; and 4) three locations in Provo Bay (see Tables 1 and 2 and Appendix 4 for details). Samples were collected from elbow deep to surface in 500 ml jars, preserved in Lugol's solution and then taxonomically identified and counted by Rushforth Phycology, Provo, UT. Several statistical analyses were conducted, including non-metric multidimensional scaling (NMS) and descriptive statistics and graphs. In addition, several statistical methods were used to estimate the total number of phytoplankton taxa based on our observed number of taxa (72) including: first order jackknife, second-order jackknife, Chao 2 classic and Chao 2 bias corrected estimators.

Results

Non-metric multidimensional scaling (NMS) of $\log_{10} + 1$ transformed taxa cells mL^{-1} by sites using a Sorenson distance measure resulted in a highly informative 2-dimensional ordination (final stress = 3.99; final instability = 0.0000; at 51 iterations). The first NMS axis resulted in $R^2 = 0.76$ and the second axis = 0.18 for a total $R^2 = 0.94$.

NMS showed that: 1) Provo Bay phytoplankton assemblages (labeled PBC's in Figure 1) were clearly different than the other sites; 2) assemblages along the transect in the main part of Utah Lake (labeled P3/4; P1/4; and LP1/2) were similar to each other but much different than the other sites; 3) assemblages near Lindon Marina were somewhat similar to each other (LMout and LMin); and 4) the assemblage at Utah Lake State Park marina (ULSP) was clearly different than the other assemblages (Figure 1).

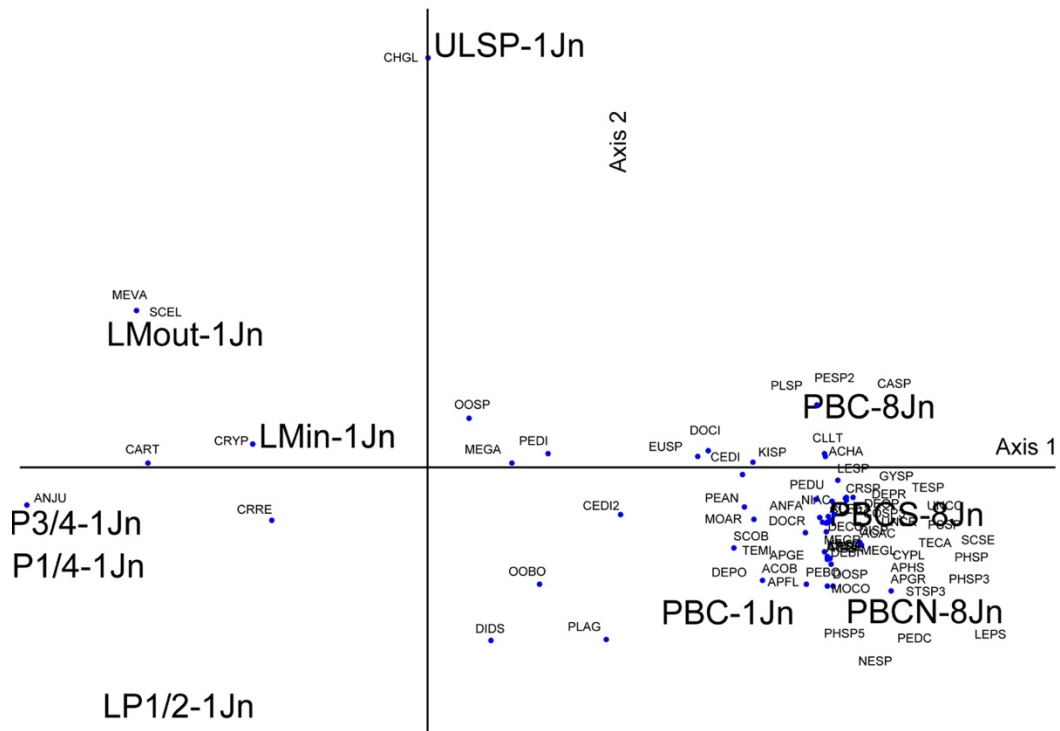


Figure 1. NMS axis 1 and axis 2 Utah Lake phytoplankton taxa by sites in June 2018. Ordinated by cells mL⁻¹. See appendices 1-3 for more ordination information.

Table 1. Summary of % Relative density (cell/mL), Cells/mL, and Biovolume (um³/mL) by Algal Division and sites

SiteCode	Algal Division	% Relative		
		Density	Cells/mL	Biovolume μm ³ /mL
LMO1Jn18	Bacillariophyta	53.1	182.0	223,160.0
	Chlorophyta	19.7	341.6	82,846.4
	Cyanophyta	18.5	394.8	77,775.6
	Euglenophyta	8.8	5.6	36,960.0
LMin1Jn18	Bacillariophyta	2.7	204.4	248,836.0
	Chlorophyta	94.6	5,266.8	8,971,494.0
	Cryptophyta	2.7	44.8	257,331.2
LP11Jn18	Bacillariophyta	62.1	30.8	47,600.0
	Chlorophyta	37.9	148.4	29,080.8
LP21Jn18	Bacillariophyta	8.9	14.0	17,360.0
	Chlorophyta	90.9	364.0	175,828.8

LP31Jn18	Bacillariophyta	68.4	47.6	83,720.0
	Chlorophyta	31.7	316.4	38,780.0
PBC1Jn18	Bacillariophyta	32.3	16,282.0	30,896,600.0
	Chlorophyta	19.1	39,264.4	18,351,471.6
	Cryptophyta	0.0	19.6	23,520.0
	Cyanophyta	48.4	198,660.0	46,228,420.0
ULSP1Jn18	Bacillariophyta	83.3	400.4	971,600.0
	Chlorophyta	1.2	490.0	13,680.8
	Cyanophyta	15.6	921.2	181,476.4

SiteCode	Algal Division	% Relative	Cells/mL	Biovolume
		Density		$\mu\text{m}^3/\text{mL}$
PBCS8Jn18	Bacillariophyta	37.8	12,801.6	20,031,564.0
	Chlorophyta	5.1	10,880.8	2,662,795.8
	Cryptophyta	1.3	165.2	643,552.0
	Cyanophyta	55.7	144,438.0	29,464,164.2
	Dinophyta	0.2	98.0	106,820.0
PBC8Jn18	Bacillariophyta	57.0	10,385.2	13,918,240.0
	Chlorophyta	22.5	65,013.2	5,514,927.6
	Cryptophyta	1.7	212.8	408,038.4
	Cyanophyta	15.3	20,932.8	3,767,030.4
	Dinophyta	2.4	67.2	599,323.2
	Euglenophyta	0.9	33.6	221,760.0
PBCN8Ju18	Bacillariophyta	18.6	18,309.2	19,800,704.0
	Chlorophyta	6.8	34,636.0	7,573,109.6
	Cryptophyta	0.5	277.2	510,764.8
	Cyanophyta	73.3	358,414.0	78,373,222.2
	Dinophyta	0.0	30.8	33,572.0
	Euglenophyta	0.5	92.4	572,880.0

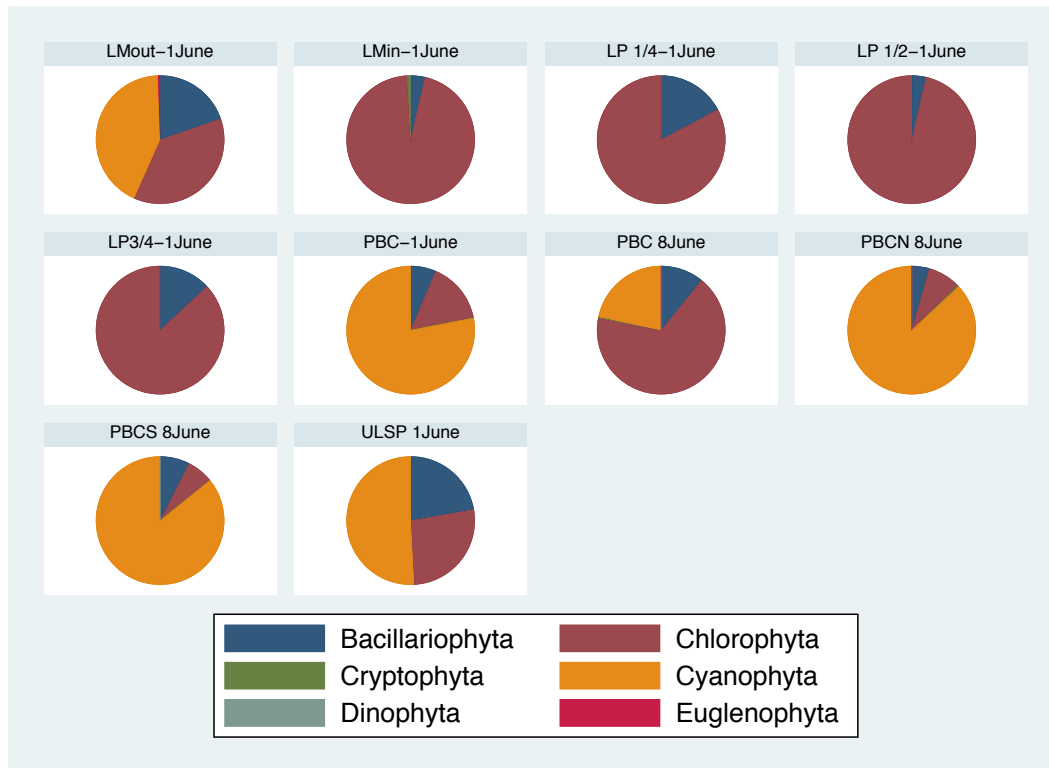


Figure 2. Breakdown of phytoplankton assemblages by algal divisions for the sites in June 2018.

Table 2. Descriptive statistics of cells/ mL Algal Divisions, total cells/mL, and four diversity measures: Shannon diversity (*h*); Evenness (*e*); taxa richness (*s*); and effective number of taxa (*ent*).

site	Bacillariophyta	Chlorophyta	Cryptophyta	Cyanophyta	Dinophyta	Euglenophyta	Total Cells	<i>h</i>	<i>e</i>	<i>s</i>	<i>ent</i>
LMO1Jn18	182	341.6	0	394.8	0	5.6	924	1.4	0.64	9	4
LMin1Jn18	204	5266.8	44.8	0	0	0	5,516	0.34	0.15	9	1
LP11Jn18	31	148.4	0	0	0	0	179.2	1.68	0.94	6	5
LP21Jn18	14	364	0	0	0	0	378	2.06	0.99	8	8
LP31Jn18	48	316.4	0	0	0	0	364	1.56	0.97	5	5
PBC1Jn18	16282	39264.4	19.6	198660	0	0	254,226	2.01	0.56	37	7
ULSP1Jn18	400	490	0	921.2	0	0	1,811.6	0.69	0.43	5	2
PBCS8Jn18	12802	10881	165	144438	98	0	168,383.6	2.16	0.59	38	9
PBC8Jn18	10385	65013	213	20933	67	34	96,644.8	2.12	0.63	29	8
PBCN8Ju18	18309	34636	277	358414	31	92	411,759.6	2.18	0.56	48	9

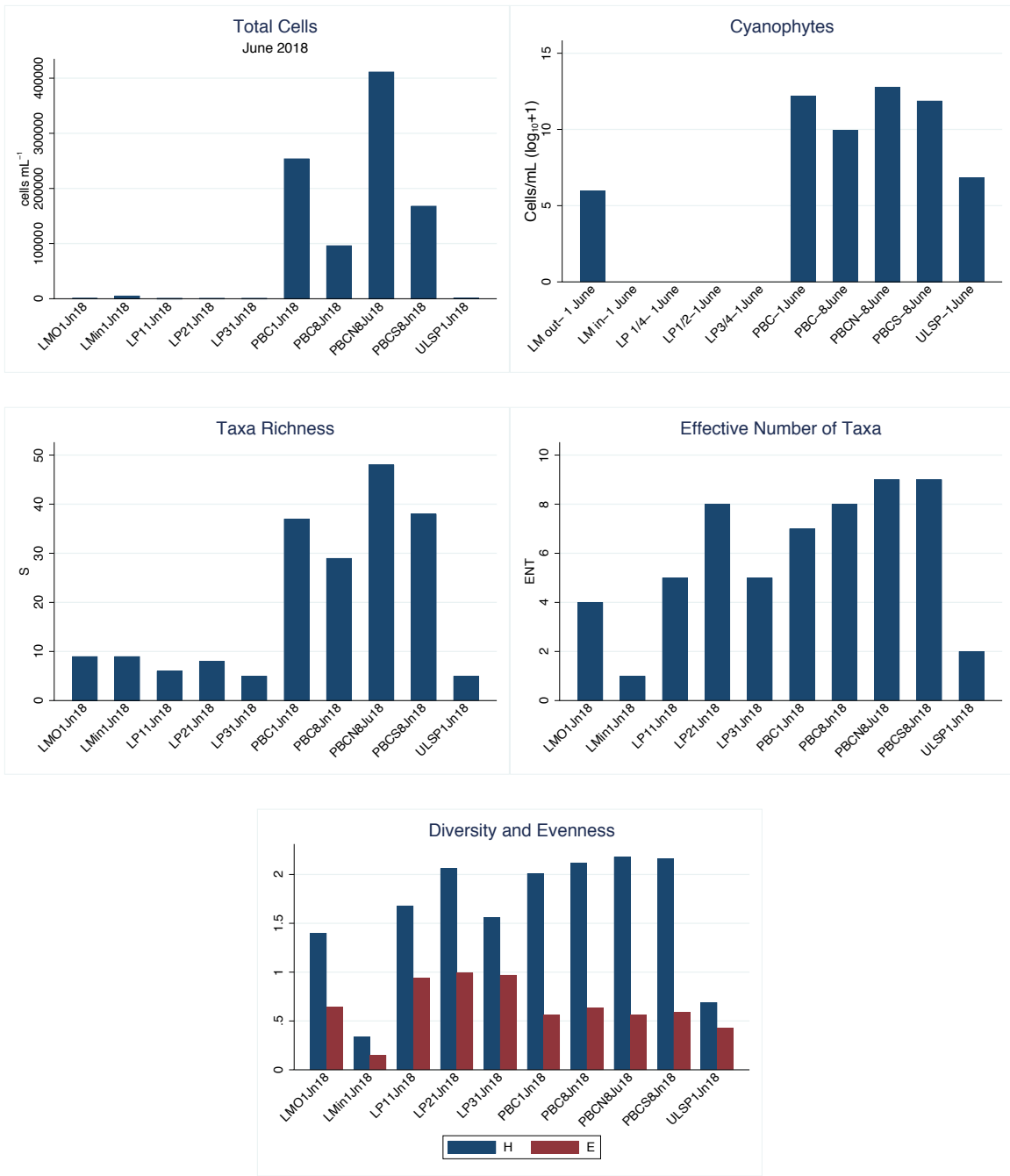


Figure 3. Relationships of several phytoplankton assemblage metrics between sites, June 2018.

Taxa Diversity

The total number of phytoplankton taxa collected in our one week sampling interval in June 2018 in Utah Lake was 72. Which, in our experience is a very high diversity. Of these, 26 taxa had only one occurrence and 11 had only two occurrences in the samples or about 51% of the taxa were what we consider uncommon.

Estimates of the actual number of taxa in this period were between 95 (first-order jackknife estimator) to 118 (upper 95% CI for the Chao 2 estimator). Using these estimates, about 100 different phytoplankton taxa occurred in elbow deep water in Utah Lake during this time period. Likely many more taxa occurred at depths > elbow deep (approximately 50 to 60 cm).

Discussion

The Provo Bay phytoplankton assemblage was clearly different than the other sections of the lake sampled in June 2018. The Provo Bay assemblage had substantially greater cell counts and taxa richness, and greater diversity than most other locations suggesting that the bay is highly productive and diverse and should not be considered impaired, at least during June 2018, and based on our other research not at other times of year, as well. The Bay should also be managed separately from the main part of the lake, as should the marinas. The main part of Utah Lake had very low cell counts, richness and diversity, suggesting that most of the lake has relatively poorer primary production than Provo Bay and the sheltered marinas, however concurrently collected zooplankton data have not been analyzed and zooplankton abundances may have reduced phytoplankton abundance and diversity in the main part of the lake. The Utah Lake State Park marina sample site was dredged just prior to our sampling event, which explains why the phytoplankton assemblage was so different than others and why taxa richness was very low. In addition, the coefficient of variation for the four Provo Bay samples total cells/mL = 0.58 suggesting that even within a small area of the lake and within a one week period; cell counts can vary substantially. As we are continuing to document, sheltered shallow locations (e.g. Lindon Marina, Provo Bay) have more productivity and diversity. These findings will be helpful in our continued research.

Literature Cited

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Appendices

Appendix 1. NMS axis 1 and 2 coordinates for sites

LMO1Jn18	-0.75819	0.40853
LMin1Jn1	-0.45524	0.06108
LP11Jn18	-1.03012	-0.23085
LP21Jn18	-0.84402	-0.67063
LP31Jn18	-1.04249	-0.09554
PBC1Jn18	0.86890	-0.29284
ULSP1Jn1	-0.00009	1.06395
PBCS8Jn1	1.05031	-0.08677
PBC8Jn18	1.00857	0.16258
PBCN8Ju1	1.20236	-0.31951

Appendix 2. NMS axis 1 and 3 coordinates for phytoplankton taxa

ANJU	-1.04249	-0.09554
ACGR	1.03658	-0.23659
ACHA	1.03081	0.02971
ACAC	1.12505	-0.20118
ACOB	0.86890	-0.29284
ACPE	1.04325	-0.13678
ANFA	0.97912	-0.16764
APFL	0.86890	-0.29284
APSP	1.03644	-0.23350
APGE	0.86890	-0.29284
APGR	1.20236	-0.31951
APHS	1.20236	-0.31951
CART	-0.72687	0.01288
CASP	1.00857	0.16258
CEDI	0.81735	-0.01645
CEDI2	0.49982	-0.12011
CRRE	-0.40470	-0.13722
CHGL	-0.00009	1.06395
CLLO	1.04331	-0.13819
CLLT	1.02944	0.03791
COSP3	1.03492	-0.14453
CRRE	1.03872	-0.23480

CRSP	1.08527	-0.08475
CRYP	-0.45524	0.06108
CYPL	1.20236	-0.31951
DEBI	1.04570	-0.25098
DECO	1.03388	-0.16587
DEOP	1.03956	-0.12595
DEPO	0.86890	-0.29284
DEPR	1.08546	-0.07609
DISP	1.12018	-0.19371
DIDS	0.16422	-0.44826
DOCI	0.72860	0.04406
DOSP	1.05086	-0.30739
DOCR	1.02449	-0.14038
EUSP	0.69932	0.02970
GYSF	1.08291	-0.08000
KILU	1.03642	-0.22948
KISP	0.84361	0.01364
LESP	1.06390	-0.03316
LEPS	1.20236	-0.31951
MEGR	1.02883	-0.21880
MEGA	0.21696	0.01263
MEGL	1.04407	-0.23601
MEVA	-0.75819	0.40853
MOAR	0.84594	-0.13285
MOCO	1.03754	-0.30633
NESP	1.20236	-0.31951
NIAC	1.01642	-0.12826
OBOO	0.29015	-0.30088
OOSP	0.10748	0.12766
PEBO	0.98125	-0.30183
PEDU	1.00702	-0.08137
PEDC	1.20236	-0.31951
PEAN	0.82262	-0.10058
PEDI	0.31220	0.03816
PESP2	1.00857	0.16258
PHSP	1.20236	-0.31951
PHSP3	1.20236	-0.31951
PHSP5	1.20236	-0.31951
PLAG	0.46382	-0.44623
PLSP	1.00857	0.16258

PSSP	1.05031	-0.08677
SCOB	0.79523	-0.20719
SCEL	-0.75819	0.40853
SCSE	1.03773	-0.14022
STSP3	1.20236	-0.31951
TECA	1.20236	-0.31951
TEMI	0.86890	-0.29284
TESP	1.10430	-0.07556
UNCC	1.05031	-0.08677
UNCR	1.05386	-0.12060

Appendix 3. Correlations between taxon and NMS axes. Negative values = left side of axis 1 and bottom section of axis 2. Taxa names are in Appendix 4.

Taxon	Axis 1	Taxon	Axis 2
CART	-0.65	OOBO	-0.489
CRRE	-0.523	DIDS	-0.487
ANJU	-0.389	PLAG	-0.472
MEVA	-0.283	SCOB	-0.444
SCEL	-0.283	DEBI	-0.356
CRYP	-0.17	CRRE	-0.351
CHGL	0	ACGR	-0.343
OOSP	0.071	MEGL	-0.342
DIDS	0.09	CRRE	-0.34
MEGA	0.198	DOSP	-0.339
OOBO	0.239	MOCO	-0.339
PLAG	0.248	APSP	-0.338
ACOB	0.325	KILU	-0.332
APFL	0.325	PEBO	-0.314
APGE	0.325	MEGR	-0.312
DEPO	0.325	DECO	-0.293
TEMI	0.325	CEDI2	-0.291
CASP	0.377	MOAR	-0.276
PESP2	0.377	COSP3	-0.261
PLSP	0.377	DOCR	-0.253
PSSP	0.392	SCSE	-0.253
UNCC	0.392	CLLO	-0.248
APGR	0.449	ACPE	-0.245
APHS	0.449	APGR	-0.236

CYPL	0.449	APHS	-0.236
LEPS	0.449	CYPL	-0.236
NESP	0.449	LEPS	-0.236
PEDC	0.449	NESP	-0.236
PHSP	0.449	PEDC	-0.236
PHSP3	0.449	PHSP	-0.236
PHSP5	0.449	PHSP3	-0.236
STSP3	0.449	PHSP5	-0.236
TECA	0.449	STSP3	-0.236
EUSP	0.492	TECA	-0.236
PEBO	0.517	NIAC	-0.228
ANFA	0.533	DEOP	-0.227
ACHA	0.576	ACAC	-0.223
CLLT	0.577	ACOB	-0.216
MOCO	0.581	APFL	-0.216
DOSP	0.586	APGE	-0.216
CEDI2	0.612	DEPO	-0.216
TESP	0.619	TEMI	-0.216
DISP	0.625	DISP	-0.214
ACAC	0.63	PEAN	-0.214
LESP	0.739	UNCR	-0.21
MEGR	0.742	ANFA	-0.181
DEBI	0.751	PEDU	-0.135
KISP	0.755	CRSP	-0.122
ACGR	0.759	GYSP	-0.115
KILU	0.759	DEPR	-0.11
APSP	0.76	TESP	-0.084
CRRE	0.762	ANJU	-0.071
MEGL	0.765	PSSP	-0.064
GYSP	0.784	UNCC	-0.064
CRSP	0.788	LESP	-0.046
DEPR	0.796	CEDI	-0.039
PEDU	0.844	CART	0.023
SCOB	0.862	MEGA	0.023
PEAN	0.884	KISP	0.024
MOAR	0.887	ACHA	0.033
NIAC	0.914	EUSP	0.041
PEDI	0.918	CLLT	0.042
DOCI	0.919	CRYP	0.045

DECO	0.922		DOCI	0.11
UNCR	0.93		CASP	0.12
DOCR	0.932		PESP2	0.12
ACPE	0.944		PLSP	0.12
COSP3	0.944		OOSP	0.166
DEOP	0.946		PEDI	0.222
SCSE	0.946		MEVA	0.302
CLLO	0.948		SCEL	0.302
CEDI	0.984		CHGL	0.786

Appendix 4. Phytoplankton results with additional descriptive statistics and information from Rushforth Phycology, Provo, UT.

Site Name	Date	Site Code	Taxon	Taxa Code	Algal Division	% Relative Density	Cells/mL	Biovolume $\mu\text{m}^3/\text{mL}$
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Actinastrum gracillimum</i> Smith	ACGR	Chlorophyta	0.1	224	31584
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Actinastrum hantzschii</i> Lagerheim	ACHA	Chlorophyta	0	386.4	19320
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Acutodesmus acuminatus</i> (Lagerheim) Tsarenko	ACAC	Chlorophyta	0.3	638.4	141086.4
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Acutodesmus pectinatus</i> (Meyen) Tsarenko	ACPE	Chlorophyta	0.1	201.6	50400
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Ankistrodesmus falcatus</i> (Corda) Ralfs	ANFA	Chlorophyta	0	86.8	4904.2
Provo Bay, Center South	6/8/18	PBCS8Jn18	Aphanocapsa species	APSP	Cyanophyta	0.9	3458	497952
Provo Bay, Center South	6/8/18	PBCS8Jn18	centric diatoms species	CEDI	Bacillariophyta	4.4	2326.8	2326800
Provo Bay, Center South	6/8/18	PBCS8Jn18	centric diatoms species 2	CEDI2	Bacillariophyta	2.9	3880.8	1552320
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Closteriopsis longissima</i> (Lemmermann) Lemmermann	CLLO	Chlorophyta	0.1	98	69776
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Closteriopsis longissima</i> var. <i>tropica</i> West & West	CLLT	Chlorophyta	0.1	33.6	33600
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Cosmarium</i> species 3	COSP3	Chlorophyta	0	33.6	2688
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Cricigeniella rectangularis</i> (Nägeli) Komárek (= <i>Willea rectangularis</i> (A.Braun) D.M.John, M.J.Wynne & P.M.Tsarenko)	CRRE	Chlorophyta	0.1	537.6	43008
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Cryptomonas</i> species	CRSP	Cryptophyta	1.1	98	562912
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Desmodesmus bicellularis</i> (R. Chodat) An, Friedl & Hegewald	DEBI	Chlorophyta	0	61.6	1016.4
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Desmodesmus communis</i> (Hegewald) Hegewald	DECO	Chlorophyta	0.7	772.8	367080
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Desmodesmus opoliensis</i> (Richter) Hegewald	DEOP	Chlorophyta	0.2	392	98000
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Desmodesmus protuberans</i> (Fritsch & Rich) Hegewald	DEPR	Chlorophyta	0.8	1041.6	437472
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Didymogenes</i> species	DISP	Chlorophyta	0.1	128.8	38640
Provo Bay, Center South	6/8/18	PBCS8Jn18	<i>Dolichospermum circinalis</i> Brébisson ex Borne & Flahault)	DOCI	Cyanophyta	48.5	130152.4	25640022.8

			Wacklin, Hoffmann & Komárek (= Anabaena flosaquae)					
Provo Bay, Center South	6/8/18	PBCS8Jn18	Dolichospermum crassum (Lemmermann) Wacklin, Hoffmann & Komárek (= Anabaena spiroides var. crassa)	DOCR	Cyanophyta	6.2	4435.2	3282048
Provo Bay, Center South	6/8/18	PBCS8Jn18	Gymnodinium species	GYSP	Dinophyta	0.2	98	106820
Provo Bay, Center South	6/8/18	PBCS8Jn18	Kirchneriella lunaris (Kirchner) Möbius (= Kirchneriella lunata)	KILU	Chlorophyta	0	1545.6	13910.4
Provo Bay, Center South	6/8/18	PBCS8Jn18	Kirchneriella species	KISP	Chlorophyta	0	1545.6	18547.2
Provo Bay, Center South	6/8/18	PBCS8Jn18	Leptolyngbya species	LESP	Cyanophyta	0.1	3928.4	31427.2
Provo Bay, Center South	6/8/18	PBCS8Jn18	Melosira granulata (= Aulacoseira granulata (Ehrenb.) Simonsen)	MEGR	Bacillariophyta	0.1	168	64512
Provo Bay, Center South	6/8/18	PBCS8Jn18	Melosira granulata var. angustissima (= Aulacoseira granulata var. angustissima (O.Müll.) Simonsen)	MEGA	Bacillariophyta	0	92.4	12012
Provo Bay, Center South	6/8/18	PBCS8Jn18	Merismopedia glauca (Ehrenberg) Kützing	MEGL	Cyanophyta	0	1909.6	5728.8
Provo Bay, Center South	6/8/18	PBCS8Jn18	Monoraphidium arcuatum (= Ankistrodesmus arcuatus Korshikov}	MOAR	Chlorophyta	0	72.8	4368
Provo Bay, Center South	6/8/18	PBCS8Jn18	Nitzschia acicularis (Kützing) Smith	NIAC	Bacillariophyta	23.3	4838.4	12337920
Provo Bay, Center South	6/8/18	PBCS8Jn18	Oocystis borgei Snow	OBOO	Chlorophyta	0.1	123.2	55440
Provo Bay, Center South	6/8/18	PBCS8Jn18	Pediastrum duplex	PEDU	Chlorophyta	0	616	6160
Provo Bay, Center South	6/8/18	PBCS8Jn18	Pediastrum angulosum Ehrenberg ex Meneghini	PEAN	Chlorophyta	1.6	1638	820638
Provo Bay, Center South	6/8/18	PBCS8Jn18	pennate diatoms	PEDI	Bacillariophyta	7.1	1495.2	3738000
Provo Bay, Center South	6/8/18	PBCS8Jn18	Pseudanabaena species	PSSP	Cyanophyta	0	554.4	6985.4
Provo Bay, Center South	6/8/18	PBCS8Jn18	Scenedesmus obtusus Meyen	SCOB	Chlorophyta	0.6	515.2	330243.2
Provo Bay, Center South	6/8/18	PBCS8Jn18	Schroederia setigera (Schroder) Lemmermann	SCSE	Chlorophyta	0.1	64.4	38446.8
Provo Bay, Center South	6/8/18	PBCS8Jn18	Unknown colonial chlorophyte	UNCC	Chlorophyta	0.1	123.2	36467.2
Provo Bay, Center South	6/8/18	PBCS8Jn18	Unknown cryptomonad	UNCR	Cryptophyta	0.2	67.2	80640
						100.10	168,383.60	52,908,896.00
Provo Bay Center	6/8/18	PBC8Jn18	Actinastrum hantzschii Lagerheim	ACHA	Chlorophyta	0	184.8	9240

Provo Bay Center	6/8/18	PBC8Jn18	<i>Acutodesmus pectinatus</i> (Meyen) Tsarenko	ACPE	Chlorophyta	0.5	515.2	128800
Provo Bay Center	6/8/18	PBC8Jn18	Calothrix species	CASP	Cyanophyta	1.6	862.4	400153.6
Provo Bay Center	6/8/18	PBC8Jn18	centric diatoms species	CEDI	Bacillariophyta	12.8	3122	3122000
Provo Bay Center	6/8/18	PBC8Jn18	centric diatoms species 2	CEDI2	Bacillariophyta	5.9	3581.2	1432480
Provo Bay Center	6/8/18	PBC8Jn18	<i>Closteriopsis longissima</i> (Lemmermann) Lemmermann	CLLO	Chlorophyta	0.2	67.2	47846.4
Provo Bay Center	6/8/18	PBC8Jn18	<i>Closteriopsis longissima</i> var. <i>tropica</i> West & West	CLLT	Chlorophyta	0.1	33.6	33600
Provo Bay Center	6/8/18	PBC8Jn18	<i>Cosmarium</i> species 3	COSP3	Chlorophyta	0	33.6	2688
Provo Bay Center	6/8/18	PBC8Jn18	<i>Cryptomonas</i> species	CRSP	Cryptophyta	0.8	33.6	192998.4
Provo Bay Center	6/8/18	PBC8Jn18	<i>Desmodesmus communis</i> (Hegewald) Hegewald	DECO	Chlorophyta	1	515.2	244720
Provo Bay Center	6/8/18	PBC8Jn18	<i>Desmodesmus opoliensis</i> (Richter) Hegewald	DEOP	Chlorophyta	0.4	392	98000
Provo Bay Center	6/8/18	PBC8Jn18	<i>Desmodesmus protuberans</i> (Fritsch & Rich) Hegewald	DEPR	Chlorophyta	2.9	1668.8	700896
Provo Bay Center	6/8/18	PBC8Jn18	Dolichospermum circinalis Brébisson ex Bornet & Flahault) Wacklin, Hoffmann & Komárek (= Anabaena flosaquae)	DOCI	Cyanophyta	4.9	6053.6	1192559.2
Provo Bay Center	6/8/18	PBC8Jn18	Dolichospermum crassum (Lemmermann) Wacklin, Hoffmann & Komárek (= Anabaena spiroides var. crassa)	DOCR	Cyanophyta	6.7	2217.6	1641024
Provo Bay Center	6/8/18	PBC8Jn18	<i>Euglena</i> species	EUSP	Euglenophyta	0.9	33.6	221760
Provo Bay Center	6/8/18	PBC8Jn18	<i>Gymnodinium</i> species	GYSB	Dinophyta	0.1	33.6	36624
Provo Bay Center	6/8/18	PBC8Jn18	Leptolyngbya species	LESP	Cyanophyta	0.1	4099.2	32793.6
Provo Bay Center	6/8/18	PBC8Jn18	<i>Monoraphidium arcuatum</i> (= <i>Ankistrodesmus arcuatus</i> Korshikov)	MOAR	Chlorophyta	0	33.6	2016
Provo Bay Center	6/8/18	PBC8Jn18	<i>Nitzschia acicularis</i> (Kützing) Smith	NIAC	Bacillariophyta	33.1	3175.2	8096760
Provo Bay Center	6/8/18	PBC8Jn18	<i>Oocystis</i> species	OOSP	Chlorophyta	1.6	1064	395808
Provo Bay Center	6/8/18	PBC8Jn18	<i>Pediastrum duplex</i>	PEDU	Chlorophyta	2.2	54040	540400
Provo Bay Center	6/8/18	PBC8Jn18	<i>Pediastrum angulosum</i> Ehrenberg ex Meneghini	PEAN	Chlorophyta	12	5838	2924838
Provo Bay Center	6/8/18	PBC8Jn18	pennate diatoms	PEDI	Bacillariophyta	5.2	506.8	1267000
Provo Bay Center	6/8/18	PBC8Jn18	<i>Peridinium</i> species 2	PESP2	Dinophyta	2.3	33.6	562699.2

Provo Bay Center	6/8/18	PBC8Jn18	Planktothrix species	PLSP	Cyanophyta	2	7700	500500
Provo Bay Center	6/8/18	PBC8Jn18	Scenedesmus obtusus Meyen	SCOB	Chlorophyta	1.5	560	358960
Provo Bay Center	6/8/18	PBC8Jn18	Schroederia setigera (Schröder) Lemmermann	SCSE	Chlorophyta	0.1	33.6	20059.2
Provo Bay Center	6/8/18	PBC8Jn18	Tetraëdron species	TESP	Chlorophyta	0	33.6	7056
Provo Bay Center	6/8/18	PBC8Jn18	Unknown cryptomonad	UNCR	Cryptophyta	0.9	179.2	215040
TOTAL						99.80	96,644.80	24,429,319.60
Provo Bay Center, North	6/8/18	PBCN8Ju18	Actinastrum gracillimum Smith	ACGR	Chlorophyta	0	291.2	41059.2
Provo Bay Center, North	6/8/18	PBCN8Ju18	Acutodesmus acuminatus (Lagerheim) Tsarenko	ACAC	Chlorophyta	0.1	515.2	113859.2
Provo Bay Center, North	6/8/18	PBCN8Ju18	Acutodesmus pectinatus (Meyen) Tsarenko	ACPE	Chlorophyta	0.3	1164.8	291200
Provo Bay Center, North	6/8/18	PBCN8Ju18	Aphanocapsa species	APSP	Cyanophyta	0.4	2926	421344
Provo Bay Center, North	6/8/18	PBCN8Ju18	Aphanocapsa grevillei (Berkeley) Rabenhorst	APGR	Cyanophyta	0.2	1820	262080
Provo Bay Center, North	6/8/18	PBCN8Ju18	Aphanothece species	APHS	Cyanophyta	0	2002	12612.6
Provo Bay Center, North	6/8/18	PBCN8Ju18	centric diatoms species	CEDI	Bacillariophyta	2.6	2738.4	2738400
Provo Bay Center, North	6/8/18	PBCN8Ju18	centric diatoms species 2	CEDI2	Bacillariophyta	3.9	10388	4155200
Provo Bay Center, North	6/8/18	PBCN8Ju18	Closteriopsis longissima (Lemmermann) Lemmermann	CLLO	Chlorophyta	0.1	145.6	103667.2
Provo Bay Center, North	6/8/18	PBCN8Ju18	Cosmarium species 3	COSP3	Chlorophyta	0	58.8	4704
Provo Bay Center, North	6/8/18	PBCN8Ju18	Cricigeniella rectangularis (Nägeli) Komárek (= Willea rectangularis (A.Braun) D.M.John, M.J.Wynne & P.M.Tsarenko)	CRRE	Chlorophyta	0	627.2	50176
Provo Bay Center, North	6/8/18	PBCN8Ju18	Cryptomonas species	CRSP	Cryptophyta	0.2	39.2	225164.8
Provo Bay Center, North	6/8/18	PBCN8Ju18	Cyanodictyon planctonicum Mayer	CYPL	Cyanophyta	0.1	5208	62496
Provo Bay Center, North	6/8/18	PBCN8Ju18	Desmodesmus bicellularis (R. Chodat) An, Friedl & Hegewald	DEBI	Chlorophyta	0	593.6	9794.4
Provo Bay Center, North	6/8/18	PBCN8Ju18	Desmodesmus communis (Hegewald) Hegewald	DECO	Chlorophyta	4.5	10214.4	4851840
Provo Bay Center, North	6/8/18	PBCN8Ju18	Desmodesmus opoliensis (Richter) Hegewald	DEOP	Chlorophyta	0.1	358.4	89600
Provo Bay Center, North	6/8/18	PBCN8Ju18	Desmodesmus protuberans (Fritsch & Rich) Hegewald	DEPR	Chlorophyta	0.4	1064	446880

Provo Bay Center, North	6/8/18	PBCN8Ju18	Didymogenes species	DISP	Chlorophyta	0	61.6	18480
Provo Bay Center, North	6/8/18	PBCN8Ju18	Dolichospermum circinalis Brébisson ex Bornet & Flahault) Wacklin, Hoffmann & Komárek (= Anabaena flosaquae)	DOCI	Cyanophyta	51.9	281755.6	55505853.2
Provo Bay Center, North	6/8/18	PBCN8Ju18	Dolichospermum species	DOSP	Cyanophyta	0.7	2819.6	704900
Provo Bay Center, North	6/8/18	PBCN8Ju18	Dolichospermum crassum (Lemmermann) Wacklin, Hoffmann & Komárek (= Anabaena spiroides var. crassa)	DOCR	Cyanophyta	1.4	2032.8	1504272
Provo Bay Center, North	6/8/18	PBCN8Ju18	Euglena species	EUSP	Euglenophyta	0.2	30.8	203280
Provo Bay Center, North	6/8/18	PBCN8Ju18	Gymnodinium species	GYSP	Dinophyta	0	30.8	33572
Provo Bay Center, North	6/8/18	PBCN8Ju18	Kirchneriella lunaris (Kirchner) Möbius (= Kirchneriella lunata)	KILU	Chlorophyta	0	739.2	6652.8
Provo Bay Center, North	6/8/18	PBCN8Ju18	Kirchneriella species	KISP	Chlorophyta	0.2	15792	189504
Provo Bay Center, North	6/8/18	PBCN8Ju18	Lepocinclus species	LESP	Euglenophyta	0.3	61.6	369600
Provo Bay Center, North	6/8/18	PBCN8Ju18	Leptolyngbya species	LEPS	Cyanophyta	0	3757.6	30060.8
Provo Bay Center, North	6/8/18	PBCN8Ju18	Melosira granulata var. angustissima (= Aulacoseira granulata var. angustissima (O.Müll.) Simonsen)	MEGR	Bacillariophyta	0	30.8	4004
Provo Bay Center, North	6/8/18	PBCN8Ju18	Merismopedia glauca (Ehrenberg) Kützing	MEGL	Cyanophyta	0	3819.2	11457.6
Provo Bay Center, North	6/8/18	PBCN8Ju18	Monoraphidium arcuatum (= Ankistrodesmus arcuatus Korshikov)	MOAR	Chlorophyta	0	495.6	29736
Provo Bay Center, North	6/8/18	PBCN8Ju18	Monoraphidium contortum (Thuret) Komárková-Legnerová	MOCO	Chlorophyta	0	61.6	4004
Provo Bay Center, North	6/8/18	PBCN8Ju18	Nephrocytium species	NESP	Chlorophyta	0	154	27874
Provo Bay Center, North	6/8/18	PBCN8Ju18	Nitzschia acicularis (Kützing) Smith	NIAC	Bacillariophyta	1.1	462	1178100
Provo Bay Center, North	6/8/18	PBCN8Ju18	Pediastrum boryanum (= Pseudopediastrum boryanum (Turpin) Hegewald)	PEBO	Chlorophyta	0.1	95.2	90440
Provo Bay Center, North	6/8/18	PBCN8Ju18	Pediastrum duplex	PEDU	Chlorophyta	0	56	560
Provo Bay Center, North	6/8/18	PBCN8Ju18	Pediastrum duplex var. clathratum Meyen	PEDC	Chlorophyta	0	78.4	22344
Provo Bay Center, North	6/8/18	PBCN8Ju18	Pediastrum angulosum Ehrenberg ex Meneghini	PEAN	Chlorophyta	0.3	672	336672
Provo Bay Center, North	6/8/18	PBCN8Ju18	pennate diatoms	PEDI	Bacillariophyta	11	4690	11725000
Provo Bay Center, North	6/8/18	PBCN8Ju18	Phormidium species	PHSP	Cyanophyta	6.1	15582	6466530
Provo Bay Center, North	6/8/18	PBCN8Ju18	Phormidium species 3	PHSP3	Cyanophyta	9	19219.2	9609600

Provo Bay Center, North	6/8/18	PBCN8Ju18	Phormidium species 5	PHSP5	Cyanophyta	2.8	7616	3008320
Provo Bay Center, North	6/8/18	PBCN8Ju18	Planktothrix agardhii (Gomont) Anagnostidis & Komárek	PLAG	Cyanophyta	0.7	9856	773696
Provo Bay Center, North	6/8/18	PBCN8Ju18	Scenedesmus obtusus Meyen	SCOB	Chlorophyta	0.7	1187.2	760995.2
Provo Bay Center, North	6/8/18	PBCN8Ju18	Schroederia setigera (Schröder) Lemmermann	SCSE	Chlorophyta	0	58.8	35103.6
Provo Bay Center, North	6/8/18	PBCN8Ju18	Staurastrum species 3	STSP3	Chlorophyta	0	30.8	33880
Provo Bay Center, North	6/8/18	PBCN8Ju18	Tetraëdron caudatum (Corda) Hansgirg	TECA	Chlorophyta	0	89.6	7616
Provo Bay Center, North	6/8/18	PBCN8Ju18	Tetraëdron species	TESP	Chlorophyta	0	30.8	6468
Provo Bay Center, North	6/8/18	PBCN8Ju18	Unknown cryptomonad	UNCR	Cryptophyta	0.3	238	285600
						99.70	411,759.60	106,864,252.60
Site Name	Date		Shannon-Wiener Index		Species Evenness	Species Richness	Total # of Taxa in Stand	ENT
Provo Bay, Center South	6/8/18		2.16		0.59	4.23	38	8.671137658
Provo Bay Center	6/8/18		2.12		0.63	3.25	29	8.331137488
Provo Bay Center, North	6/8/18		2.18		0.56	5.04	48	8.846306259

Site Name	Date	Site Code	Taxon	Taxa Code	Algal Division	% Relative Density	Cells/mL	Biovolume $\mu\text{m}^3/\text{mL}$
Lindon Marina Out	6/1/18	LMO1Jn18	Carteria globosa Korsikov	CART	Chlorophyta	8.3	140	35000
Lindon Marina Out	6/1/18	LMO1Jn18	Cricigeniella rectangularis (Nägeli) Komárek (= Willea rectangularis (A.Braun) D.M.John, M.J.Wynne & P.M.Tsarenko)		Chlorophyta	2.6	134.4	10752
Lindon Marina Out	6/1/18	LMO1Jn18	Dolichospermum circinalis Brébisson ex Bornet & Flahault) Wacklin, Hoffmann & Komárek (= Anabaena flosaquae)	DOCI	Cyanophyta	18.5	394.8	77775.6
Lindon Marina Out	6/1/18	LMO1Jn18	Euglena species	EUSP	Euglenophyta	8.8	5.6	36960

L-P ¼	6/1/18	LP31Jn18	Ankyra judayi (= Schroederia judayi (Smith) Fott)	ANJU	Chlorophyta	7.8	16.8	9576
L-P ¼	6/1/18	LP31Jn18	Carteria globosa Korsikov	CART	Chlorophyta	6.3	30.8	7700
L-P ¼	6/1/18	LP31Jn18	centric diatoms species 2	CEDI2	Bacillariophyta	5.5	16.8	6720
L-P ¼	6/1/18	LP31Jn18	Cricigeniella rectangularis (Nägeli) Komárek (= Willea rectangularis (A.Braun) D.M.John, M.J.Wynne & P.M.Tsarenko)	CRRE	Chlorophyta	17.6	268.8	21504
L-P ¼	6/1/18	LP31Jn18	pennate diatoms	PEDI	Bacillariophyta	62.9	30.8	77000
Provo Bay, Center	6/1/18	PBC1Jn18	Actinastrum gracillimum Smith	ACGR	Chlorophyta	0.1	425.6	60009.6
Provo Bay, Center	6/1/18	PBC1Jn18	Acutodesmus obliquus (Turpin) Hegewald & Hanagata	ACOB	Chlorophyta	0.1	515.2	128800
Provo Bay, Center	6/1/18	PBC1Jn18	Acutodesmus pectinatus (Meyen) Tsarenko	ACPE	Chlorophyta	0.1	224	56000
Provo Bay, Center	6/1/18	PBC1Jn18	Ankistrodesmus falcatus (Corda) Ralfs	ANFA	Chlorophyta	0	16.8	949.2
Provo Bay, Center	6/1/18	PBC1Jn18	Aphanizomenon flosaquae Ralfs ex Bornet & Flahault	APFL	Cyanophyta	2.1	1024.8	2011682
Provo Bay, Center	6/1/18	PBC1Jn18	Aphanocapsa species	APSP	Cyanophyta	0.8	5320	766080
Provo Bay, Center	6/1/18	PBC1Jn18	Aphanocapsa grevillei (Berkeley) Rabenhorst	APGE	Cyanophyta	0.2	1092	157248
Provo Bay, Center	6/1/18	PBC1Jn18	centric diatoms species	CEDI	Bacillariophyta	1.7	1643.6	1643600
Provo Bay, Center	6/1/18	PBC1Jn18	centric diatoms species 2	CEDI2	Bacillariophyta	1.5	3547.6	1419040
Provo Bay, Center	6/1/18	PBC1Jn18	Closteriopsis longissima (Lemmermann) Lemmermann	CLLO	Chlorophyta	0	47.6	33891.2
Provo Bay, Center	6/1/18	PBC1Jn18	Cosmarium species 3	COSP3	Chlorophyta	0	47.6	3808
Provo Bay, Center	6/1/18	PBC1Jn18	Cricigeniella rectangularis (Nägeli) Komárek (= Willea rectangularis (A.Braun) D.M.John, M.J.Wynne & P.M.Tsarenko)	CRRE	Chlorophyta	0.1	761.6	60928
Provo Bay, Center	6/1/18	PBC1Jn18	Desmodesmus bicellularis (R. Chodat) An, Friedl & Hegewald	DEBI	Chlorophyta	0	319.2	5266.8
Provo Bay, Center	6/1/18	PBC1Jn18	Desmodesmus communis (Hegewald) Hegewald	DECO	Chlorophyta	4.6	9240	4389000
Provo Bay, Center	6/1/18	PBC1Jn18	Desmodesmus opoliensis (Richter) Hegewald	DEOP	Chlorophyta	0	134.4	33600
Provo Bay, Center	6/1/18	PBC1Jn18	Desmodesmus protuberans (Fritsch & Rich) Hegewald	DEPO	Chlorophyta	0.2	358.4	150528
Provo Bay, Center	6/1/18	PBC1Jn18	Didymogenes species	DIDS	Chlorophyta	0	33.6	10080
Provo Bay, Center	6/1/18	PBC1Jn18	Dolichospermum circinalis Brébisson ex Bornet & Flahault) Wacklin, Hoffmann & Komárek (= Anabaena flosaquae)	DOCI	Cyanophyta	36.5	177133.6	34895319
Provo Bay, Center	6/1/18	PBC1Jn18	Dolichospermum species	DOSP	Cyanophyta	0.2	744.8	186200
Provo Bay, Center	6/1/18	PBC1Jn18	Dolichospermum crassum (Lemmermann) Wacklin, Hoffmann & Komárek (= Anabaena spiroides var. crassa)	DOCR	Cyanophyta	8.6	11088	8205120
Provo Bay, Center	6/1/18	PBC1Jn18	Kirchneriella lunaris (Kirchner) Möbius (= Kirchneriella lunata)	KILU	Chlorophyta	0	1276.8	11491.2
Provo Bay, Center	6/1/18	PBC1Jn18	Kirchneriella species	KISP	Chlorophyta	0	3561.6	42739.2
Provo Bay, Center	6/1/18	PBC1Jn18	Melosira granulata (= Aulacoseira granulata (Ehrenb.) Simonsen)	MEGR	Bacillariophyta	0	84	32256
Provo Bay, Center	6/1/18	PBC1Jn18	Melosira granulata var. angustissima (= Aulacoseira granulata var. angustissima (O.Müll.) Simonsen)	MEGA	Bacillariophyta	0	100.8	13104
Provo Bay, Center	6/1/18	PBC1Jn18	Merismopedia glauca (Ehrenberg) Kützing	MEGL	Cyanophyta	0	2256.8	6770.4
Provo Bay, Center	6/1/18	PBC1Jn18	Monoraphidium arcuatum (= Ankistrodesmus arcuatus Korshikov)	MOAR	Chlorophyta	0	56	3360

Provo Bay, Center	6/1/18	PBC1Jn18	Monoraphidium contortum (Thuret) Komárková-Legnerová	MOCO	Chlorophyta	0	56	3640
Provo Bay, Center	6/1/18	PBC1Jn18	Nitzschia acicularis (Kützinger) Smith	NIAC	Bacillariophyta	28	10472	26703600
Provo Bay, Center	6/1/18	PBC1Jn18	Oocystis borgei Snow	OBOO	Chlorophyta	1.1	2408	1083600
Provo Bay, Center	6/1/18	PBC1Jn18	Pediastrum boryanum (= Pseudopediastrum boryanum (Turpin) Hegewald)	PEBO	Chlorophyta	8	7996.8	7596960
Provo Bay, Center	6/1/18	PBC1Jn18	Pediastrum duplex	PEDU	Chlorophyta	0	2576	25760
Provo Bay, Center	6/1/18	PBC1Jn18	Pediastrum angulosum Ehrenberg ex Meneghini	PEAN	Chlorophyta	4.5	8610	4313610
Provo Bay, Center	6/1/18	PBC1Jn18	pennate diatoms	PEDI	Bacillariophyta	1.1	434	1085000
Provo Bay, Center	6/1/18	PBC1Jn18	Scenedesmus obtusus Meyen	SCOB	Chlorophyta	0.3	448	287168
Provo Bay, Center	6/1/18	PBC1Jn18	Schroederia setigera (Schröder) Lemmermann	SCSE	Chlorophyta	0	39.2	23402.4
Provo Bay, Center	6/1/18	PBC1Jn18	Tetraëdron minimum (Braun) Hansgirg	TEMI	Chlorophyta	0	112	26880
Provo Bay, Center	6/1/18	PBC1Jn18	Unknown cryptomonad	UNCR	Cryptophyta	0	19.6	23520
Provo Marina	6/1/18	ULSP1Jn18	centric diatoms species	CEDI	Bacillariophyta	1.7	19.6	19600
Provo Marina	6/1/18	ULSP1Jn18	Chlamydomonas globosa Snow	CHGL	Chlorophyta	0.7	19.6	8036
Provo Marina	6/1/18	ULSP1Jn18	Dolichospermum circinalis Brébisson ex Bornet & Flahault) Wacklin, Hoffmann & Komárek (= Anabaena flosaquae)	DOCI	Cyanophyta	15.6	921.2	181476.4
Provo Marina	6/1/18	ULSP1Jn18	Kirchneriella species	KISP	Chlorophyta	0.5	470.4	5644.8
Provo Marina	6/1/18	ULSP1Jn18	pennate diatoms	PEDI	Bacillariophyta	81.6	380.8	952000