ASSESSMENT OF CHANGES IN TOTAL PHOSPHORUS IN KATHLYN LAKE, B.C: A PALEOLIMNOLOGICAL ASSESSMENT (March 2001)

Prepared for: Ian Sharpe, B.C. Ministry of Environment, Lands and Parks

Contractor: Dr. Brian Cumming, Associate Professor
Paleoecological Environmental Assessment and Research Laboratory
Dept. of Biology, Queen's University, Kingston, ON, K7L 3N6,
Ph.: (613) 533-6153; FAX: (613) 533-6617; e-mail: cummingb@biology.queensu.ca

Supplier: Queen's University – Standing Offer KE609-9-4434/001/XSB. Contact person: Sandra Crocker, Office of Research Services, Ph.: (613) 533-6081; FAX: (613) 533-6853

List of Figures and Appendices:

BACKGROUND

Sediment cores were taken from Kathlyn Lake with a modified K-B corer (internal diameter ~6.35 cm) on October 27, 2000. Fourteen samples were shipped to Queen's University where they were stored in our coldroom at 4°C. All the bags were weighed to determine the total wet weight of sediment prior to subsampling for ^{210}Pb analyses. Additionally, we obtained the wet weights of the subsamples from these same intervals that were sent to MYCORE Ltd. for ^{210}Pb analyses. All fourteen intervals were subsampled for diatoms and prepared for ^{210}Pb analysis. The prepared samples (see below) were then sent to MYCORE Ltd. for analyses.

METHODS

210-Pb Dating and Percent Organic Matter

The wet weight of the sediment was determined for all the subsections of the core that were shipped to Queen's. Fourteen subsamples of wet sediment from each core were weighed and oven-dried (24 hr at 105°C) and reweighed to determine percent water and dry weight of the sediment. Samples that were submitted for ^{210}Pb analysis were ground to a fine dust by use of a pestle and redried overnight at 105°C. The weight of this dried sediment was recorded to four decimal places after it was put in a plastic digestion tube. This tube was shipped to MYCORE Ltd. for determination of ^{210}Pb activity.

Percent organic matter for each of the 14 ^{210}Pb samples was determined using standard loss-on-ignition methods (Dean, 1974). A known quantity of dried sediment (recorded to four decimal places) was heated to 550°C for 2 hours. The difference between the dry weight of the sediment and the weight of sediment remaining after ignition was used to estimate the percent of organic matter in each sediment sample.

^{210}Pb activities were estimated from determination of ^{209}Po and a tracer of known activity by alpha spectroscopy. Unsupported ^{210}Pb is calculated by subtracting supported ^{210}Pb (the baseline activity determined from bottom samples of the core) from the total activity at each level. The sediment chronology and sedimentation rates were calculated using the constant rate of supply (CRS) model (Appleby and Oldfield, 1978) from the estimates of ^{210}Pb activities and estimates of cumulative dry mass (Binford, 1990). See Appendix B for a summary of ^{210}Pb calculations (B-1), and the dating output file from the CRS model (B-2).

Diatom Preparation and Enumeration

Slides for diatom analysis were prepared using standard techniques (Cumming, Wilson, Smol and Hall, 1995). Briefly, a small amount of wet sediment was suspended in a 50:50 (molar) mixture of sulfuric and nitric acid in a 20-ml glass vial for 24 hr. prior to being submersed at 70°C in a hot water bath for 5 hr. The remaining sediment material was settled for a period of 24 hr, at which time the acid above the sample was removed. The sample was rinsed with distilled water and allowed to settle once again for 24 hrs. The procedure was repeated approx. 10 times until the sample was acid free (litmus test). The samples were settled onto coverslips in a series of four 100% dilutions, which when dry, were mounted onto glass slides using a high-resolution mounting media called Naphrax®. For each sample, at least 400 diatom taxa were enumerated with a Leica DMRB microscope equipped with DIC optics at 1000X magnification (Numerical Aperature of objective = 1.3). These analyses were based on the references of Krammer and Lange-Bertalot (1986, 1988, 1991a,b), Patrick and Reimer (1966, 1975) and Cumming et al. (1995).

Diatom-based Reconstructions of Total Phosphorus

Inferences of total phosphorus from the diatom assemblages in the core are based on a phosphorus model developed from 111 freshwater lakes from the 219 lakes sampled by Wilson, Cumming & Smol (1996). This model is based on estimates of the optima of taxa from weighted-averaging regression on non-transformed relative percentage data. The coefficient of determination (r^2) of this model is 0.66, and the jackknifed r^2 is 0.47. This model is superior to the earlier models developed by Reavie, Hall & Smol (1995) for several reasons including its better predictive ability and the larger number of samples which provide more analogs for downcore reconstructions.

The total phosphorus inferences (Fig. 1E) were critically assessed to determine: 1) if they tracked the main direction of variation in the diatom species assemblages (Fig. 1D); and 2) to assess if the assemblages encountered in the core are well represented in the modern-day samples (Fig. 1F). If the diatom-based phosphorus reconstructions match the main direction of variation in the diatom assemblages in the core, then we can be fairly confident that the diatoms are tracking changes that are related to phosphorus. If the correlation between the main direction of variation and the diatom-inferred phosphorus values is weak or nonexistent, then other environmental variables (e.g. pH, conductivity, turbulence, etc), or interactions between environmental variables, are likely responsible for the observed changes in diatom assemblages.

Determination of the Main Direction of Variation

The main direction of variation in the diatom assemblages in the cores was determined from the first axis scores from a principal components analysis (PCA) ordination using non-transformed species abundance data. A PCA was chosen to represent the main direction of variation of the diatom assemblages in this core based on the small gradient length (< 1.5 standard deviation units) obtained in an initial detrended correspondence analysis (DCA) ordination.

Analog Analysis of Diatom Assemblages

The reliability of the total phosphorus inferences in the core assumes that the diatom assemblages encountered downcore are well represented in our modern diatom assemblages. To determine if appropriate analogs existed for the core samples, we determined which samples in our present-day dataset of 111 lakes most resembled each of the downcore samples. This determination was based on a squared chord dissimilarity coefficient between all species found in each of the core samples. The best match between downcore and modern samples was compared with the distribution of best match between modern samples. Any downcore samples that were more dissimilar than 80% of the modern distribution were deemed to be a 'poor analog'. Similarly, any downcore samples that were more dissimilar than 95% of the modern distribution were deemed to have 'no analog' in our present-day dataset. If the downcore assemblages have good representation in modern samples, more confidence can be placed in the reconstruction. If modern analogs do not exist or are poor, then caution must be placed in reconstructions from these downcore samples.

RESULTS AND DISCUSSION

^{210}Pb Profile, Sedimentation Rates and Organic Matter

The ^{210}Pb profile from Kathlyn Lake shows an ~exponential decay with core depth (Fig. 1A). Results from the CRS model suggest, with the exception of the bottommost two points, that sedimentation rates have not varied much over the past 100 years (Fig. 1B). Inferences of sedimentation rates become increasingly (exponentially) difficult with depth due to the nature of ^{210}Pb calculations. Thus, estimates of changes in sedimentation rates are best evaluated using multiple cores to avoid erroneous interpretations. The increase in organic matter starting ~1900 from ~2-3% to 12% at the top of the core (Fig. 1C) is an unique change when viewed in the context of the last 200 years of sediment accumulation in this lake. Increases in organic matter can be attributed to several factors including increased in-lake production of organic matter, increased inwash of organic matter, or decreases in the load of inorganic matter of the lake.

Diatom Assemblage Changes and Analyses

One-hundred and sixty-four diatom taxa were encounter in the sediment core from Kathyln Lake (Appendix C). Cluster analysis suggests the changes in diatom assemblages through time can be divided into two primary zones, before and after 1945. Since 1945 (Zone A, Fig. 2), the diatom assemblages shows an unprecedented increase in the mesoeutrophic planktonic taxon *Asterionella formosa,* from a plankton dominated by the oligotrophic planktonic taxon, *Cyclotella stelligera*. There is also a small post-1945 increase in the mesoeutrophic planktonic taxon, *Tabellaria floculosa* (Fig. 2). Prior to 1945, the diatom assemblage is also dominanted by a diversity of benthic taxa, many of which have a wide tolerance to total phosphorus in our modern calibration set, with TP optima in the mesotrophic range. Consequently, inferences of TP from the diatom assemblages show a much more complex pattern (Fig. 1E) than the main direction of variation in the diatom assemblages (Fig. 1D). Thus, it is not surprising that the correlation between the PCA axis 1 scores (Fig. 1D) and the log TP inferences (Fig. 1E) is low ($r = 0.45$, $p < 0.05$).

In summary, the predominance of eutrophic planktonic diatoms in the post-1945 sediments, in combination with declines in many benthic taxa (e.g. *F. construens*, *F. pinnata*), and an overall increase in organic matter, suggest that the trophic status of this lake has increased slightly over the past 50 years. However, because many benthic taxa are mesotrophic and have wide tolerances to TP, the TP inference doesn't exhibit as large as change as would be expected if we only considered the planktonic taxa. Thus, the inferred magnitude of TP change since 1945 is likely an underestimate.

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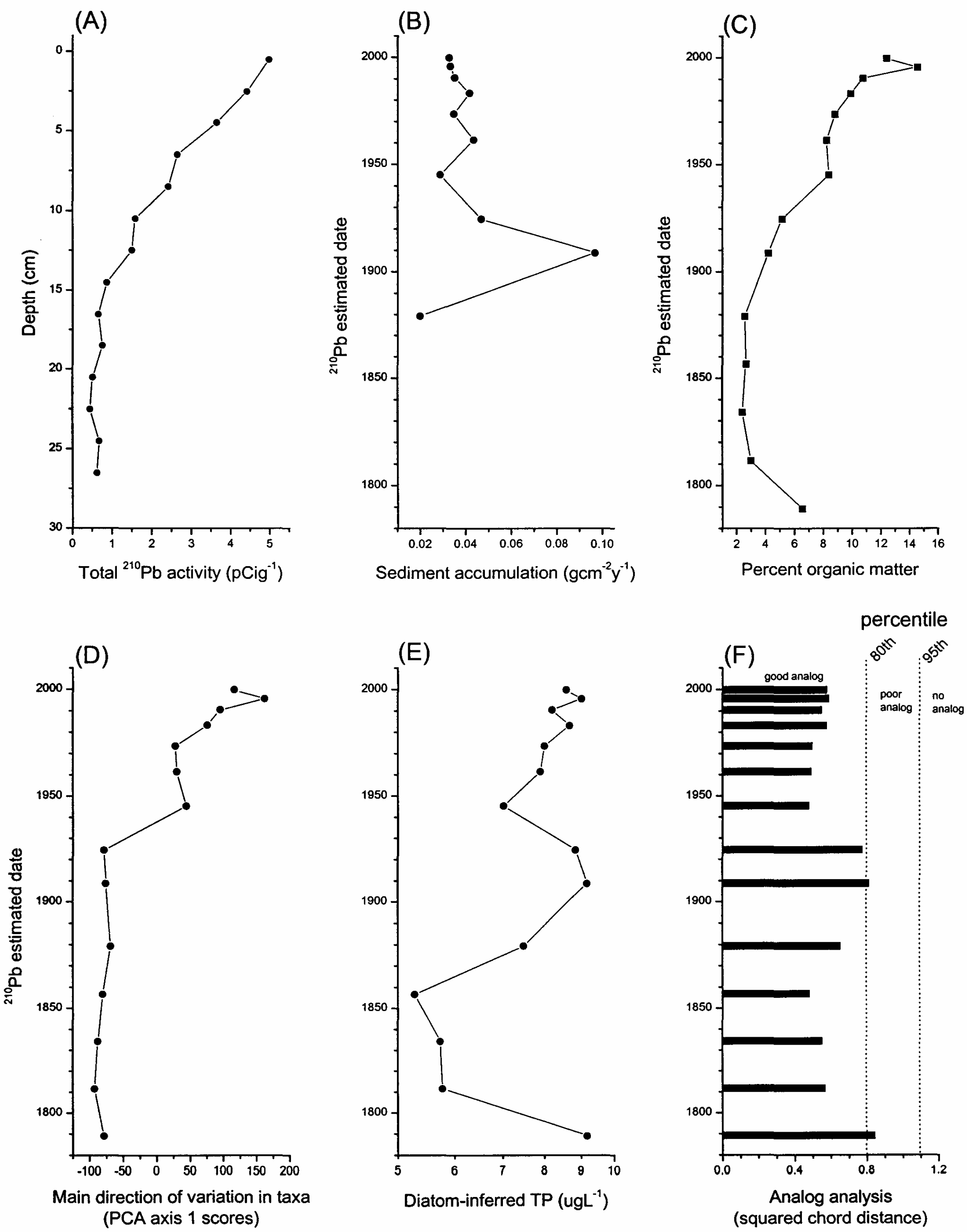
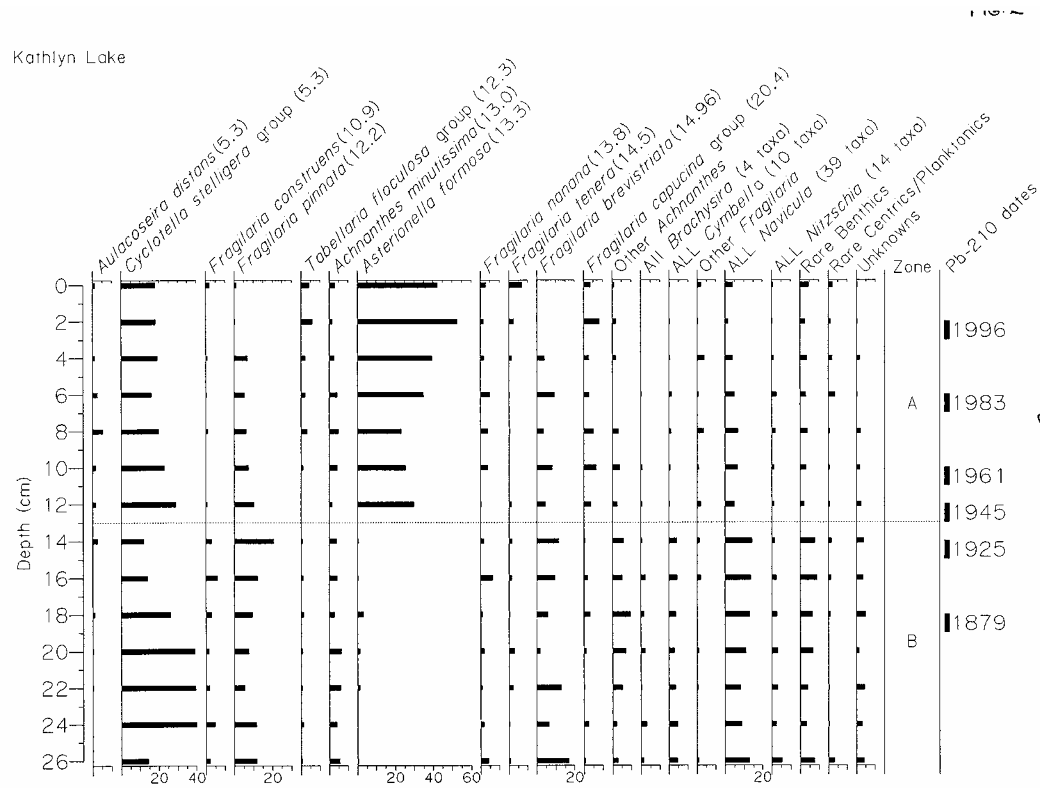
FIGURE CAPTIONS

Figure 1. Summary diagram for the sediment core from Kathlyn Lake showing: A) total ^{210}Pb activity; B) the sediment accumulation rate; C) the change in the percent of organic matter in the core; D) the main direction of variation in the diatom assemblage data; E) diatom-based estimated late-summer total phosphorus; and F) analog analysis showing the dissimilarity between present-day and downcore samples (any sample that has a squared chord distance > 0.8 was determined to be a poor analog, whereas any sample with a squared chord distance greater than 1.1 was determined to have no analog in the modern dataset).

Figure 2. Stratigraphy of the most abundant diatom taxa found in the sediment core from Kathlyn Lake, B.C. (see Appendix B for a complete list of taxa and the relative percentage data). The diatom taxa are arranged in order of increasing late-summer total phosphorus (TP) optima which is indicated in parentheses for those taxa with known optima.

Kathlyn Lake





Kathlyn Lake
Aulacoseira distans(5.3)
Cyclotella stelligera group (5.3)
Fragilaria construens(10.9)
Fragilaria pinnata(12.2)
Tabellaria flocculosa group (12.3)
Achnanthes minutissima(13.0)
Asterionella formosa(13.3)
Fragilaria nanana(13.8)
Fragilaria tenera(14.5)
Fragilaria brevistriata(14.96)
Fragilaria capucina group (20.4)
Other Achnanthes
All Brachysira (4 taxa)
ALL Cymbella (10 taxa)
Other Fragilaria
ALL Navicula (39 taxa)
ALL Nitzschia (14 taxa)
Rare Benthics
Rare Centrics/Planktonics
Unknowns
Zone
Pb-210 dates
Depth (cm)
A
B
1996
1983
1961
1945
1925
1879

Summary File Kathlyn Lake

Pb210 and LOI summary

* = extrapoloted dates

INTTOP (cm)	INTBOT (cm)	Pb210Act (pCi/g)	LOI(550C) %organic	estimated AD date	SEDRATE (g/cm2/yr)
0	1	4.9930	12.42	1999.8	0.0329
2	3	4.4275	14.58	1995.8	0.0334
4	5	3.6589	10.77	1990.5	0.0353
6	7	2.6526	9.92	1983.3	0.0418
8	9	2.4233	8.83	1973.6	0.0349
10	11	1.5879	8.24	1961.4	0.0435
12	13	1.5109	8.38	1945.3	0.0288
14	15	0.8736	5.14	1924.5	0.0468
16	17	0.6607	4.21	1908.9	0.0969
18	19	0.7630	2.58	1879.4	0.02
20	21	0.5178	2.66	*1856.9	
22	23	0.4537	2.42	*1834.3	
24	25	0.6870	3.01	*1811.7	
26	27	0.6292	6.55	*1789.2	

Diatom analyses

Depth (cm) TOP	Depth (cm BOTTOM	estimated AD date	log TP	TP	PCA Axis 1	ANALOG min. sq.chord
0	1	1999.8	0.934	8.59	117	0.5767
2	3	1995.8	0.955	9.02	163	0.5892
4	5	1990.5	0.914	8.20	96	0.5483
6	7	1983.3	0.939	8.69	77	0.5768
8	9	1973.6	0.904	8.02	29	0.4955
10	11	1961.4	0.898	7.91	31	0.4896
12	13	1945.3	0.847	7.03	45	0.478
14	15	1924.5	0.947	8.85	-78	0.773
16	17	1908.9	0.963	9.18	-75	0.8116
18	19	1879.4	0.875	7.50	-68	0.6512
20	21	1856.9	0.723	5.28	-80	0.4799
22	23	1834.3	0.759	5.74	-87	0.5511
24	25	1811.7	0.762	5.78	-92	0.5682
26	27	1789.2	0.963	9.18	-78	0.8424

CALCULATIONS FOR INPUT INTO BINFORD PROGRAM

Kathlyn L. - Pb210

INTTOP (cm)	INTBOT (cm)	Back calculated to coring Pb-210 (Bq/g) activity	Std dev (Bg/g)	Pb210 activity (pCig-1)	Std dev (pCig-1)	Rho (g cm-3)
0	1	0.184741	0.006731	4.9930	0.1819	0.0666
2	3	0.163816	0.003539	4.4275	0.0956	0.0656
4	5	0.13538	0.003729	3.6589	0.1008	0.1224
6	7	0.098147	0.003177	2.6526	0.0859	0.1587
8	9	0.089663	0.002858	2.4233	0.0773	0.2117
10	11	0.058753	0.002485	1.5879	0.0672	0.2624
12	13	0.055903	0.00146	1.5109	0.0395	0.3049
14	15	0.032324	0.001453	0.8736	0.0393	0.4541
16	17	0.024446	0.001146	0.6607	0.0310	0.5385
18	19	0.02823	0.001477	0.7630	0.0399	0.5750
20	21	0.019157	0.001027	0.5178	0.0277	0.5698
22	23	0.016786	0.000872	0.4537	0.0236	0.7096
24	25	0.025417	0.001477	0.6870	0.0399	0.4361
26	27	0.023279	0.001183	0.6292	0.0320	0.3708
			avg	0.571887	=supported	
			stds	0.10556	0.677447	

BINFORD FILE INPUTS FOR CALCULATIONS OF DATES AND SEDIMENTATION RATES

Kathlyn
C1
14.00
0.1056

INTTOP (cm)	INTBOT (cm)	Pb210 Total (pCig-1)	Pb210 Unsup. (pCig-1)	Rho (g cm-3)	OM proportion	CUMTOP (g cm-2)	CUMBOT (g cm-2)	std Pb210 (pCig-1)
0.0000	1.0000	4.9930	4.4211	0.0666	0.1242	0.0000	0.0666	0.1819
2.0000	3.0000	4.4275	3.8556	0.0656	0.1458	0.0672	0.1328	0.0956
4.0000	5.0000	3.6589	3.0870	0.1224	0.1077	0.1044	0.2268	0.1008
6.0000	7.0000	2.6526	2.0807	0.1587	0.0992	0.2086	0.3673	0.0859
8.0000	9.0000	2.4233	1.8514	0.2117	0.0883	0.3409	0.5526	0.0773
10.0000	11.0000	1.5879	1.0160	0.2624	0.0824	0.5272	0.7896	0.0672
12.0000	13.0000	1.5109	0.9390	0.3049	0.0838	0.7683	1.0733	0.0395
14.0000	15.0000	0.8736	0.3017	0.4541	0.0514	0.9987	1.4528	0.0393
16.0000	17.0000	0.6607	0.0888	0.5385	0.0421	1.4106	1.9491	0.0310
18.0000	19.0000	0.7630	0.1911	0.5750	0.0258	1.9309	2.5059	0.0399
20.0000	21.0000	0.5178	0.0000	0.5698	0.0266	2.5085	3.0782	0.0277
22.0000	23.0000	0.4537	0.0000	0.7096	0.0242	3.0083	3.7179	0.0236
24.0000	25.0000	0.6870	0.0000	0.4361	0.0301	3.8546	4.2907	0.0399
26.0000	27.0000	0.6292	0.0000	0.3708	0.0655	4.3233	4.6941	0.0320

YOU ARE ANALYZING CORE C1 FROM LAKE Kathlyn

THE DATA ARE:

INTTOP	INTBOT	PB210ACT	UNSUPACT	RHO	PERCORG	CUMMASST	CUMMASSB	SDACT
0.0	1.0	4.99300	4.42110	0.06660	0.120	0.0000	0.0666	0.1819
2.0	3.0	4.42750	3.85560	0.06560	0.140	0.0672	0.1328	0.0956
4.0	5.0	3.65890	3.08700	0.12240	0.100	0.1044	0.2268	0.1008
6.0	7.0	2.65260	2.08070	0.15870	0.090	0.2086	0.3673	0.0859
8.0	9.0	2.42330	1.85140	0.21170	0.080	0.3409	0.5526	0.0773
10.0	11.0	1.58790	1.01600	0.26240	0.080	0.5272	0.7896	0.0672
12.0	13.0	1.51090	0.93900	0.30490	0.080	0.7683	1.0733	0.0395
14.0	15.0	0.87360	0.30170	0.45410	0.050	0.9987	1.4528	0.0393
16.0	17.0	0.66070	0.08880	0.53850	0.040	1.4106	1.9491	0.0310
18.0	19.0	0.76300	0.19110	0.57500	0.020	1.9309	2.5059	0.0399
20.0	21.0	0.51780	0.00000	0.56980	0.020	2.5085	3.0782	0.0277
22.0	23.0	0.45370	0.00000	0.70960	0.020	3.0083	3.7179	0.0236
24.0	25.0	0.68700	0.00000	0.43610	0.030	3.8546	4.2907	0.0399
26.0	27.0	0.62920	0.00000	0.37080	0.060	4.3233	4.6941	0.0320

STANDARD DEVIATION OF SUPPORTED PB-210 = 0.1056

Pb-210 dates for Lake Kathlyn core C1

INTTOP	INTBOT	MIDINT	TTOP	SDTTOP	TBOT	SDTBOT	SEDRATE	SDSEDRT	SUMTOP
0.0	1.0	0.5	0.00	1.80	2.02	1.85	0.0329	0.0081	4.8245
2.0	3.0	2.5	4.02	1.92	5.99	1.98	0.0334	0.0079	4.2569
4.0	5.0	4.5	8.58	2.08	12.05	2.23	0.0353	0.0090	3.6928
6.0	7.0	6.5	15.67	2.41	19.47	2.61	0.0418	0.0112	2.9614
8.0	9.0	8.5	24.20	2.92	30.28	3.39	0.0349	0.0113	2.2710
10.0	11.0	10.5	36.38	3.99	42.43	4.67	0.0435	0.0159	1.5538
12.0	13.0	12.5	50.19	5.81	60.88	7.86	0.0288	0.0149	1.0109
14.0	15.0	14.5	71.41	10.68	81.19	13.78	0.0468	0.0289	0.5220
16.0	17.0	16.5	89.17	17.14	94.74	18.92	0.0969	0.0665	0.3003
18.0	19.0	18.5	105.98	25.62	136.86	59.53	0.0200	0.0299	0.1779

Execution terminated : 0

C:\PB210>

Appendix C

athlyn Lake - Analyst: Kate Laird
calibration code sheet (164 taxa)

Diatom Relative Abundances (%)

Depth (cm) - samples in 1 cm intervals

Taxon	Code	0	2	4	6	8	10	12	14	16	18	20	22	24	26
Achnanthes altaica	ac alta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.24	0.00	0.00	0.00	0.00
Achnanthes chlidanos	ac chli	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
Achnanthes curtissima	ac curt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes cf. daonensis	ac daon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.00
Achnanthes didyma	ac didy	0.00	0.00	0.00	0.00	0.24	0.22	0.00	0.25	1.18	0.47	0.00	1.19	0.00	0.45
Achnanthes flexella	ac flex	0.00	0.00	0.00	0.00	0.00	0.45	0.22	0.00	0.00	0.24	0.00	0.00	0.00	0.00
Achnanthes holstii	ac hols	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
Achnanthes impexiformis	ac impe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.48	0.48	0.25	0.00
Achnanthes lacus-vulcani	ac lacv	0.00	0.00	0.00	0.00	1.19	0.00	1.08	0.98	1.41	1.42	0.97	0.71	0.00	0.00
Achnanthes lanceolata	ac lanc	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00
Achnanthes lanceolata var. dubia	ac la.d	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes lanceolata spp. freq.	AC LA.F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.00
Achnanthes laterostrata	ac late	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.23
Achnanthes marginulata	ac marg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.42	0.97	0.71	0.00	0.00
Achnanthes minutissima	AC MINU	2.91	1.47	2.53	4.13	4.76	4.27	1.52	3.93	4.00	2.61	6.28	5.94	3.92	5.42
Achnanthes nodosa	ac nodo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.47	0.00	0.00	0.00	0.00	0.00
Achnanthes oestrupii	ac oest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00
Achnanthes pusilla	AC PUSI	0.00	0.98	1.38	0.00	1.19	2.92	1.08	1.47	0.94	1.66	1.45	0.00	0.74	0.00
Achnanthes rosenstockii	AC ROSE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.45
Achnanthes subatomoides	AC SUBA	0.73	0.00	0.00	0.00	0.00	0.00	0.22	0.74	0.71	0.47	1.45	0.24	0.25	0.23
Achnanthes ventralis	ac vent	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.49	0.00	0.47	0.00	0.00	0.00	0.45
Achnanthes spp.	ac spp.	0.24	0.00	0.00	0.23	0.71	0.22	0.00	0.49	0.00	1.18	0.72	1.66	0.25	0.23
Amphipleura krieg.	ap krie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Amphipleura pellucida	ap pell	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Amphora libyca	AM LIBY	0.00	0.00	0.00	0.00	0.00	0.22	0.22	0.25	0.71	0.00	0.24	0.00	0.00	0.45
Amphora pediculus	AM PEDI	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asterionella formosa	AS FORM	42.23	52.81	39.40	34.86	23.10	25.39	29.93	0.49	0.24	3.08	1.45	1.19	0.25	0.45
Aulacoseira ambigua	AU AMBI	0.00	0.00	0.69	0.23	0.00	0.00	0.22	0.49	1.18	0.95	0.00	0.00	0.00	1.13
Aulacoseira distans	AU DIST	1.21	0.00	1.15	2.52	5.24	1.57	1.74	2.46	0.00	0.95	0.24	0.24	0.00	0.00
Aulacoseira cf. nygaardii	au nyga	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13
Aulacoseira perglabra	au perg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68
Aulacoseira spp.	au spp.	0.00	0.24	0.23	0.00	0.00	0.22	0.22	0.49	0.24	0.00	0.00	0.24	0.00	0.00
Brachysira brebissonii	br breb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00
Brachysira garrensis	br garr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.25	0.00
Brachysira neoexilis	br neox	0.00	0.00	0.23	0.46	0.00	0.90	0.65	0.49	1.65	1.42	2.42	0.48	2.94	1.58
Caloneis undulata	ca undu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00
Caloneis spp.	ca spp.	0.00	0.00	0.00	0.46	0.00	0.00	0.00	1.23	0.47	1.42	0.97	0.00	0.25	1.13
Chaetoceros cyst	CH MUEL	0.73	0.73	1.84	0.69	0.00	0.00	0.43	0.00	0.24	0.00	0.00	0.00	0.00	0.23
Cocconeis placentula	CO PLAC	0.00	0.24	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cocconeis placentula var. euglypta	CO PL.E	0.49	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cocconeis spp.	co spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.25	0.00
Cyclotella bodanica var.lemanica	CY BO.L	2.18	0.98	0.92	1.83	0.71	0.00	0.22	0.49	0.00	0.00	0.00	0.24	0.49	0.23
Cyclotella stelligera group	CY STEL	17.96	18.09	19.12	16.06	19.76	22.70	29.07	11.79	14.12	26.07	39.13	39.43	39.95	14.45
Cymbella cesatii	CM CESA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.24	0.00	0.00	1.35
Cymbella cymbiformis var. nonpunctata	CM CY.N	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella gaeumannii	cm gaeu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	1.18	0.47	1.21	0.48	1.23	0.45
Cymbella gracilis	cm grac	0.00	0.49	0.00	0.46	0.00	0.22	0.00	0.98	1.65	0.71	0.00	0.00	1.47	0.68
Cymbella incerta	cm ince	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.24	0.25	0.00
Cymbella microcephala	CM MICR	0.00	0.00	0.46	0.46	0.00	0.22	0.22	1.97	0.24	0.24	0.24	0.24	0.00	1.13
Cymbella minuta	CM MINU	0.00	0.00	0.00	0.46	0.71	0.22	0.00	0.49	0.47	1.42	0.72	0.71	0.49	0.00
Cymbella naviculiformis	cm navi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00
Cymbella perpusilla	cm perp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.48	0.00	0.00
Cymbella spp.	cm spp.	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.47	0.24	0.71	1.23	0.90
Denticula kuetzingii	DE KUET	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00
Diatoma mesodon	di meso	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00
Diatoma tenue var. elongatum	DI TE.E	0.00	0.00	0.00	0.00	0.48	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diatoma vulgaris	di vulg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00
Diatoma spp.	di spp.	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.45
Diploneis elliptica	dp elli	0.00	0.00	0.00	0.00	0.71	0.00	0.00	1.47	1.41	0.47	0.24	0.24	0.00	0.00
Diploneis finnica	dp finn	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.24	0.00	0.00	0.24	0.00	0.00
Diploneis spp.	dp spp.	0.00	0.00	0.00	0.23	0.00	0.45	0.43	0.49	0.71	0.47	0.00	0.48	0.00	0.90
Eunotia bilunaris	eu bilu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.97	0.24	0.00	0.00
Eunotia incisa	eu inci	0.00	0.00	0.23	0.00	0.00	0.00	0.22	0.25	0.24	0.00	0.00	0.00	0.00	0.00
Eunotia intermedia	eu inte	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Eunotia microcephala	eu micr	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eunotia muscicola	eu musc	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eunotia subarcuatoides	eu suba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
Eunotia spp.	eu spp.	0.00	0.73	0.00	0.46	0.00	0.67	0.43	0.74	0.94	0.71	0.72	0.48	0.98	0.00
Fragilaria arcus	fr arcu	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00
Fragilaria brevistriata	FR BREV	0.00	0.00	4.15	9.40	3.57	8.09	4.56	11.55	9.65	5.92	1.69	13.06	6.37	16.93
Fragilaria capucina (includes var. rumpens)	FR CAPU	0.24	3.91	0.46	1.15	2.86	2.25	0.87	0.25	0.00	1.66	0.97	0.24	0.98	0.00
Fragilaria capucina var. gracilis	FR CA.G	2.91	4.40	2.07	1.61	2.38	4.27	2.82	0.49	1.88	1.66	0.24	0.00	1.47	0.68
Fragilaria capucina var. mesolepta	FR CA.M	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria construens	FR CONS	1.94	0.00	0.92	0.46	0.95	0.00	0.65	3.19	5.88	3.08	1.45	1.90	4.66	2.26
Fragilaria crotonensis	FR CROT	0.49	0.00	2.30	0.46	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria lapponica	FR LAPP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Fragilaria nanana	FR NANA	2.67	1.47	1.61	5.05	3.81	3.82	0.22	1.72	6.35	0.95	1.93	0.71	1.72	4.06
Fragilaria parasitica	FR PARA	0.00	0.00	0.46	0.00	0.95	0.22	0.22	0.49	0.00	0.00	0.00	0.48	0.00	0.68
Fragilaria pinnata	FR PINN	1.21	0.49	6.91	5.28	6.19	7.42	10.20	20.64	12.00	9.24	7.49	5.23	11.52	11.74
Fragilaria pinnata var. lancettula	FR PI.L	0.24	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria tenera	FR TENE	7.28	2.93	1.38	0.46	0.71	0.22	1.95	1.72	1.41	0.47	2.90	2.14	0.25	0.68
Fragilaria ulna	FR ULNA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria spp.	fr spp.	0.73	0.00	0.69	0.23	1.19	0.22	1.30	0.25	1.88	0.00	0.97	0.00	0.00	0.00
Frustulia rhomboides	fu rhom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.71	0.00	0.00
Frustulia rhomboides var. crassinervia	fu rh.c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.48	0.00	0.00	0.00
Frustulia spp.	fr spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00
Gomphonema parvulum	GO PARV	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00
Gomphonema subtile	go subt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90
Gomphonema spp.	go spp.	1.46	0.49	0.92	0.69	0.00	1.12	0.22	0.25	0.00	0.00	0.97	0.00	0.25	0.45
Gyrosigma acuminatum	gy acum	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hantzschia amphioxys	HA AMPH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00
Mer. circulare	me circ	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mer. circulare var. constrictum	me ci.c	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula angusta	na angu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.25	0.00
Navicula begerii	na berg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
Navicula bryophila	na bryo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00
Navicula capitata	NA CA.C	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula cocconeiformis	na cocc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Navicula contenta	na cont	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula cryptocephala	NA CCEP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	1.18	0.48	0.00	0.49	0.00
Navicula cryptotenella	NA CRYP	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.48	0.98	0.00
Navicula cryptotenella fo. 1	NA CRY1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.48	0.00	0.00	0.00
Navicula cf. detenta	na dete	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.21	0.24	0.25	0.00
Navicula difficillima	na diff	0.00	0.00	0.23	0.00	0.00	0.45	0.22	0.00	0.00	0.24	0.00	0.00	0.00	0.00
Navicula evanida	na evan	0.00	0.00	0.00	1.15	0.24	0.45	0.22	1.23	0.24	0.47	0.72	0.24	0.49	0.00
Navicula explanata	na expl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.00
Navicula jaernefeltii	na jaer	0.00	0.00	0.46	0.46	0.00	0.00	0.65	0.49	0.94	0.71	0.48	0.48	0.00	0.00
Navicula joubaudii	na joub	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.47	0.71	0.00	1.19	0.74	0.00
Navicula krasskei	na kras	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00
Navicula laevissima	NA LAEV	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.23
Navicula lapidosa	na lapi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Navicula mediocomvexa	na medc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00
Navicula medioris	na medi	0.00	0.00	0.23	1.15	0.00	0.00	0.43	0.98	0.00	0.24	0.00	0.00	0.00	0.00
Navicula minima	NA MINI	0.00	0.00	0.00	0.00	1.43	0.22	0.87	0.74	3.29	1.42	0.24	0.71	0.49	1.13
Navicula oblonga	NA OBLO	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula porifera	na pori	0.00	0.00	0.00	0.00	0.00	0.22	0.43	0.49	0.47	0.00	0.00	0.00	0.00	0.00
Navicula pseudoscutiformis	na psec	0.00	0.00	0.00	0.23	0.48	0.22	0.22	0.98	0.00	0.00	0.48	0.00	0.00	0.90
Navicula pseudoventralis	NA PSVE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
Navicula pupula	NA PUPU	0.24	0.73	0.00	0.00	0.00	0.00	0.00	0.49	0.47	0.47	0.97	0.00	0.00	0.68
Navicula radiosa	NA RADI	0.24	0.49	0.46	0.00	0.71	0.00	0.00	0.25	0.00	0.00	0.24	0.48	0.74	0.00
Navicula rotunda	na rotu	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula schmassmannii	na schm	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.72	0.71	0.49	0.00
Navicula subminuscula	NA SUBM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.23
Navicula submuralis	na sumu	0.00	0.00	0.00	0.46	2.14	0.90	0.43	0.49	0.24	0.00	0.97	0.00	0.74	2.71
Navicula subrotundata	na subr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00
Navicula subtilissima	na subt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.24	0.25	0.00
Navicula trivialis	NA TRIV	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula aff. utermoehlii	NA UTER	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.45
Navicula varicestriata	na vari	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
Navicula vitiosa	na viti	0.00	0.00	0.00	0.00	0.48	0.67	0.65	0.25	0.47	0.71	0.72	0.71	0.00	0.45
Navicula sp. (BC, PI23, F1)	na pi23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Navicula spp.	na spp.	2.43	0.00	1.61	1.15	1.19	2.25	0.87	4.67	8.35	5.45	2.90	2.38	2.21	4.06
Neidium affine	ne affi	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia amphibia	NI AMPH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90
Nitzschia cf. bacillum	NI BACI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	1.58
Nitzschia diss. var. media	ni di.m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.00
Nitzschia fonticola	NI CFFO	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00
Nitzschia frustulum	NI FRUS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.25	0.00
Nitzschia graciliformis	NI GRFO	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia linearis var. subtilis	ni li.s	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00
Nitzschia palea	NI PALE	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia palea var. tenuir.	NI PA.T	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.49	0.00
Nitzschia perminuta	NI PERM	0.00	0.00	0.00	0.46	0.24	0.00	0.43	0.49	0.47	1.90	0.24	0.95	0.49	0.45
Nitzschia recta	NI RECT	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia subacicularis	ni suba	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
Nitzschia tubicola	ni tubi	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.23
Nitzschia spp.	ni spp.	0.24	0.49	0.46	0.92	0.95	0.67	0.65	0.74	1.65	0.24	1.45	1.43	0.98	1.58
Pinnularia borealis var. rec.	PI BO.R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00
Pinnularia interrupta	PI INTE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.95	0.00	0.00	0.00	0.00
Pinnularia microstauron	PI MICR	0.00	0.00	0.00	0.23	0.24	0.22	0.22	0.74	0.71	1.42	0.72	0.00	0.49	0.00
Pinnularia nodosa	pi nodo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.45
Pinnularia spp.	pi spp.	0.73	0.24	0.23	0.00	0.00	0.00	0.00	0.00	1.18	0.24	0.00	0.00	0.25	0.90
Rhopalodia gibba	RH GIBB	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stauroneis anceps fo. gracilis	SR AN.G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.23
Stauroneis phoen.	sr phoe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.23
Stauroneis prominula	st prom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stenopterobia delicatissima	st deli	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.23
Surirella spp.	su spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.47	0.24	0.24	0.24	0.25	0.00
Synedra acus var. angustissima	sy ac.a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00
Tabellaria flocculosa group	TA FL3P	4.13	5.87	2.07	2.06	3.33	0.90	0.00	0.74	0.94	0.71	0.72	0.48	0.98	0.45
Tabellaria spp.	ta spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.25	0.00
Central area unknown	ca unk	0.24	0.24	1.15	0.46	0.71	1.57	0.87	1.97	1.41	1.66	1.21	1.43	0.74	1.58
Pennate unknown	pe unk	0.00	0.00	0.69	0.00	1.43	0.45	1.74	1.97	2.35	3.32	0.24	3.09	2.45	2.26
Centric unknown	ce unk	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45