Paleolimnological analysis of Culculz Lake, B.C -- Final Report (March 2000)

Contractor: Dr. Brian Cumming, Assistant 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, Contact person: Dr. Bruce Hutchinson, Office of Research Services, Ph.: (613) 533-6081; FAX: (613) 533-6853

List of Figures and Appendices:

BACKGROUND

Culculz Lake was cored on October 5, 1999 by Rick Nordin and Bruce Carmichael. The core was retrieved using a modified K-B corer (internal diameter ~ 6.35 cm) from the deep basin. On shore the core was sectioned into 0.5-cm intervals into 120-ml plastic containers. Every other sample was shipped on ice to Queen's University where they were stored in our coldroom at 4°C. The containers were weighed to determine the total wet weight of sediment prior to subsampling for ^{210}Pb analyses. Twenty intervals (every 2 cm) were subsampled for diatom and sixteen intervals for ^{210}Pb analysis. Prepared samples for ^{210}Pb analysis (see below) were sent to MYCORE Ltd.

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. Sixteen 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 tared plastic digestion tube for determination of ^{210}Pb activity that was shipped to MYCORE Ltd.

Percent organic matter for each of the 16 ^{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 summaries of ^{210}Pb analyses by MYCORE (B-1), summary of ^{210}Pb calculations (B-1,2), and output from the CRS model (B-3).

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).

Cluster Analysis

A depth-constrained cluster analysis was run on the diatom assemblages in the core to provide an unbiased assessment of changes in diatom assemblages through time. A squared chord distance was used as the similarity coefficient between samples in the cluster analysis. Zones based on this clustering algorithm were placed on the diatom stratigraphy to represent zones of similar diatom assemblages (dashed line on Fig. 2).

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 reconstruction matches the main direction of variation in the diatom assemblages downcore, then we can be fairly confident that the diatoms are tracking changes correlated 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 (i.e. other environmental variables besides changes in phosphorus are responsible for the observed changes).

Determination of the Main Direction of Variation

The main direction of variation in the diatom assemblages downcore 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 sd units) obtained in an initial detrended correspondence analysis(DCA) ordination.

Analog Analysis of Diatom Assemblages

The reliability of the downcore total phosphorus inferences 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 sample that was more dissimilar than 80% of the modern distribution were deemed to be a 'poor analog'. Similarly, any downcore sample that was 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 Culculz Lake shows the expected exponential decay with core depth with the exception of a small decrease in activity at the top of the core (Fig. 1A). Overall, the ^{210}Pb profile from this lake indicates an intact an undisturbed sediment core was obtained from this lake and that sedimentation rates have been relatively slow (~1mm/yr). Furthermore, only small variations in sedimentation rates and changes in organic matter have occurred over the time period represented by this core (Figs. 1B, 1C). The results of the time/depth calculations can be found in Appendix B3. The most likely explanations for the decrease in ^{210}Pb activity at the top of the core include: a minor increase in sedimentation rate that could cause a slight dilution of the ^{210}Pb activity, and/or sediment mixing. The CRS model assumes that decreases in ^{210}Pb activities are due to dilution from increased sedimentation (Fig. 1B). In summary, the variations in both sedimentation rates and changes in organic matter are small and variable throughout this core (Figs. 1B and 1C).

Diatom Assemblage Changes and Analyses

Approximately 100 diatom taxa were encountered in the sediment core from Culculz Lake (Appendix C-1). Changes in the diatom assemblages indicate that this lake has only undergone minor changes in species composition over the last 300 years. Cluster analysis suggests the changes in diatom assemblages through time can be divided into two primary zones (Fig. 2).

Prior to c. 1865 (Fig. 2, Zone B), the diatom assemblage is dominated by eutrophic planktonic taxa (e.g. *Stephanodiscus minutulus, S. parvus*, and *S. hantzschii*). Consequently, inference of pre-1900 TP values range from ~23 to 34 µg/L. Since c. 1865, there have been decreases in the abundance of *S.* parvus, and small increases in the abundance of *Asterionella formosa*, *Fragilaria crotonensis*, *F. capucina*, and *S. hantzschii* (Fig. 2, Zone A). These floristic changes suggest that the lake has varied in nutrient status over the last 150 years, but no more than prior to human settlement (Fig. 1E).

PCA axis 1 scores (Fig. 1D) account for 54% of the variation in diatom taxa in this core. The coefficient of determination between the PCA axis 1 scores (Fig. 1D) and the log TP inferences (Fig. 1E) is low ($r^2 = 0.43$). Thus, the inferred changes in TP are only weakly related to the main direction of variation in the diatom assemblages. Based on the good representation of the core diatom assemblages in the modern day samples (Fig. 1F), the TP inferences are likely reliable. In summary, this lake has historically had high concentrations of phosphorus and the recent changes are within the range observed over the past 300 years.

References:

Appleby, P.G. & F. Oldfield. 1978. The calculation of lead-210 dates assuming a constant rate of supply of unsupported ^{210}Pb to the sediment. *Catena* 5: 1-8.

Binford, M.W. 1990. Calculation and uncertainty analysis of ^{210}Pb dates for PIRLA project lakes sediment cores. *Journal of Paleolimnology* 3: 253-267.

Cumming, B.F., S.E. Wilson, R.I. Hall & J.P. Smol. 1995. Diatoms from British Columbia (Canada) Lakes and their Relationship to Salinity, Nutrients and Other Limnological Variables (with 248 figures, 6 tables and 1041 photos on 60 plates). *Bibliotheca Diatomologica*: 31. Stuttgart, Germany. 207 pp.

Dean, W.E. 1974. Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: comparison with other methods. *Journal of Sedimentary Petrology* 44: 242-248.

Krammer, K. & H. Lange-Bertalot. 1986. Bacillariophyceae. 1. Teil: Naviculaceae. In H. Ettl, G. Gärtner, J. Gerloff, H. Heynig & D. Mollenhauer (eds.), Süßwasserflora von Mitteleuropa, Band 2/1, Gustav Fischer Verlag, Stuttgart/New York, 876 pp.

Krammer, K. & H. Lange-Bertalot. 1988. Bacillariophyceae. 2. Teil: Bacillariaceae, Epithemiaceae, Surirellaceae. In H. Ettl, G. Gärtner, J. Gerloff, H. Heynig & D. Mollenhauer (eds.), Süßwasserflora von Mitteleuropa, Band 2/2, Gustav Fischer Verlag, Stuttgart/New York, 596 pp.

Krammer, K. & H. Lange-Bertalot. 1991a. Bacillariophyceae. 3. Teil: Centrales, Fragilariaceae, Eunotiaceae. In H. Ettl, G. Gärtner, J. Gerloff, H. Heynig & D. Mollenhauer (eds.), Süßwasserflora von Mitteleuropa, Band 2/3, Gustav Fischer Verlag, Stuttgart/Jena, 576 pp.

Krammer, K. & H. Lange-Bertalot. 1991b. Bacillariophyceae. 4. Teil: Achnanthaceae Kritische Ergänzungen zu Navicula (Lineolatae) und Gomphonema. In H. Ettl, G. Gärtner, J. Gerloff, H. Heynig & D. Mollenhauer (eds.), Süßwasserflora von Mitteleuropa, Band 2/4, Gustav Fischer Verlag, Stuttgart/Jena, 437 pp.

Patrick, R. & C. Reimer. 1966. The diatoms of the United States exclusive of Alaska and Hawaii. Vol. 1. The Academy of Natural Sciences of Philadelphia, Philadelphia, Monograph 13, 668 pp.

Patrick, R. & C. Reimer. 1975. The diatoms of the United States exclusive of Alaska and Hawaii. Vol. 2, Part 1. The Academy of Natural Sciences of Philadelphia, Philadelphia, Monograph 13, 213 pp.

Reavie, E.D., J.P. Smol & N.B. Carmichael. 1995. Postsettlement eutrophication histories of six British Columbia (Canada) lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 52: 2388-2401.

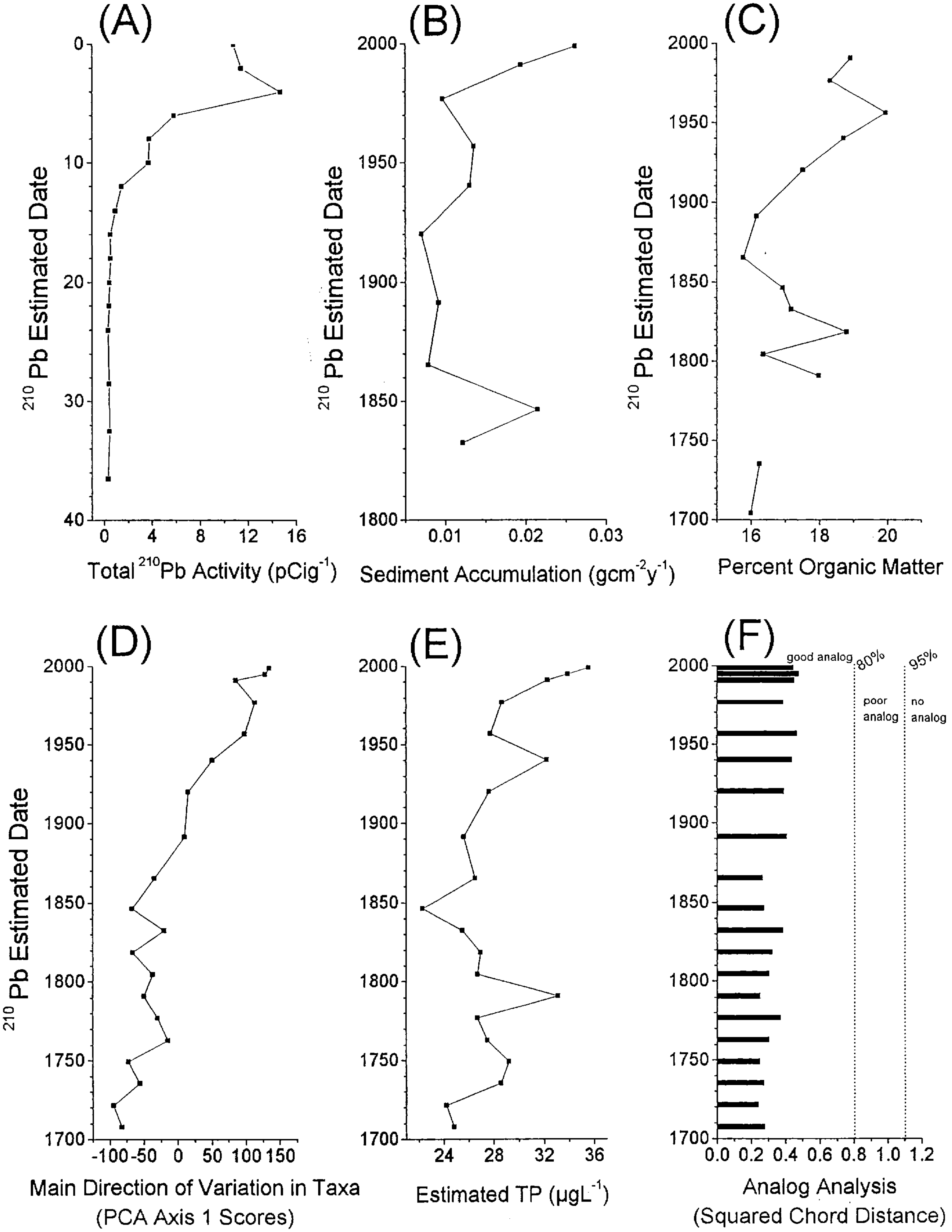
S.E. Wilson, B.F. Cumming & J.P. Smol. 1996. Assessing the reliability of salinity inference models from diatom assemblages: An examination of a 219 lake dataset from western North America. *Canadian Journal of Fisheries and Aquatic Sciences* 53: 1580-1594.

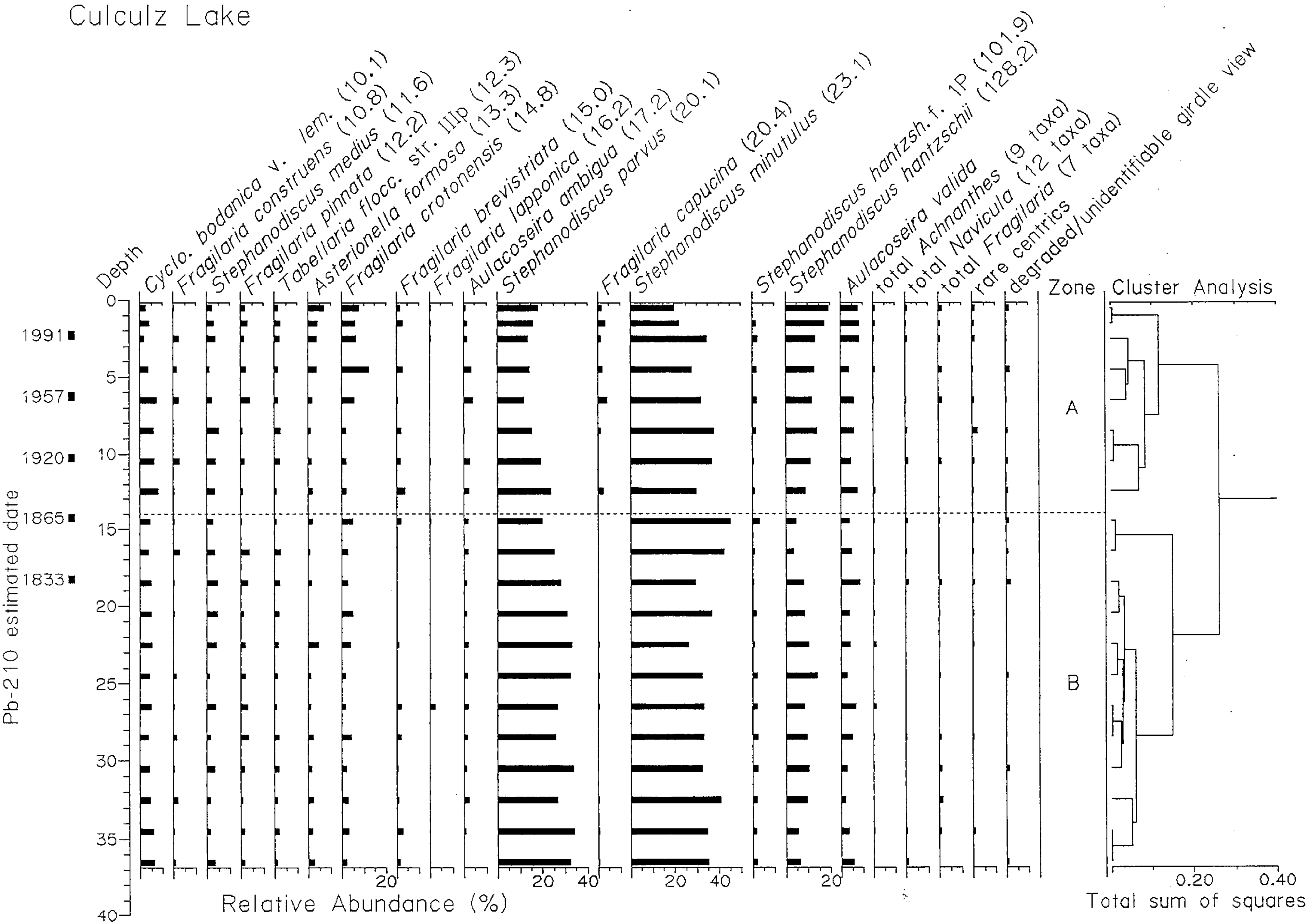
Figure Captions

Figure 1. Summary diagram for the sediment core from Culculz Lake showing: A) total ^{210}Pb activity from which the chronology of the core is based; 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 dominant diatom taxa in the sediment core from Culculz Lake, B.C. (see Appendix C 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 are indicated in parentheses for those taxa with known optima. The dotted lines separate the stratigraphy into two zones that were identified by a cluster analysis on the diatom assemblage composition that was constrained to the depth of the core samples (see text for details).

Culculz Lake




Culculz Lake
Depth
Cyclo. bodanica v. lem. (10.1)
Fragilaria construens (10.8)
Stephanodiscus medius (11.6)
Fragilaria pinnata (12.2)
Tabellaria flocc. str. IIIp (12.3)
Asterionella formosa (13.3)
Fragilaria crotonensis (14.8)
Fragilaria brevistriata (15.0)
Fragilaria lapponica (16.2)
Aulacoseira ambigua (17.2)
Stephanodiscus parvus (20.1)
Fragilaria capucina (20.4)
Stephanodiscus minutulus (23.1)
Stephanodiscus hantzsh. f. 1P (101.9)
Stephanodiscus hantzschii (128.2)
Aulacoseira valida
total Achnanthes (9 taxa)
total Navicula (12 taxa)
total Fragilaria (7 taxa)
rare centrics
degraded/unidentifiable girdle view
Zone
Cluster Analysis
Pb-210 estimated date
1991
1957
1920
1865
1833
0
5
10
15
20
25
30
35
40
20
20
40
20
40
20
Relative Abundance (%)
A
B
0.20
0.40
Total sum of squares

Culculz Lake Summary File

Pb210 and LOI summary
(x-missing LOI values)

INTTOP (cm)	INTBOT (cm)	Pb210Act (pCi/g)	estimated AD date	LOI(550C %organic	SEDRATE (g/cm2/yr)
0	0.5	10.7882	1999.1	x	0.0261
2	2.5	11.4020	1991.2	18.92	0.0193
4	4.5	14.6764	1977.0	18.32	0.0096
6	6.5	5.8084	1956.9	19.96	0.0135
8	8.5	3.7621	1940.5	18.71	0.0130
10	10.5	3.7281	1920.4	17.52	0.0070
12	12.5	1.4258	1891.5	16.16	0.0091
14	14.5	0.9227	1865.4	15.77	0.0078
16	16.5	0.4887	1846.5	16.92	0.0214
18	18.5	0.5048	1832.6	17.16	0.0121
20	20.5	0.4357	1818.7	18.80	
22	22.5	0.3918	1804.9	16.35	
24	24.5	0.3066	1791.0	17.98	
28.5	29	0.3718	1759.8	x	
32.5	33	0.4468	1735.5	16.24	
36.5	37	0.3209	1704.3	15.98	

Diatom analyses

Depth (c TOP	Depth (c BOTTOM	estimated AD date	log TP	TP	PCA Axis 1	minumum sq. chord
0	0.5	1999.1	1.55	35.56	134	0.448
1	1.5	1995.1	1.53	33.88	128	0.4772
2	2.5	1991.2	1.51	32.28	85	0.4495
4	4.5	1977.0	1.46	28.64	113	0.3838
6	6.5	1956.9	1.44	27.73	98	0.4657
8	8.5	1940.5	1.51	32.21	50	0.4352
10	10.5	1920.4	1.44	27.61	15	0.3896
12	12.5	1891.5	1.41	25.59	9	0.4076
14	14.5	1865.4	1.42	26.49	-35	0.2654
16	16.5	1846.5	1.35	22.28	-68	0.2724
18	18.5	1832.6	1.41	25.47	-21	0.3846
20	20.5	1818.7	1.43	26.92	-67	0.3224
22	22.5	1804.9	1.43	26.67	-38	0.304
24	24.5	1791.0	1.52	33.11	-50	0.2508
26	26.5	1777.1	1.43	26.67	-30	0.37
28	28.5	1763.2	1.44	27.48	-15	0.302
30	30.5	1749.4	1.47	29.17	-73	0.2486
32	32.5	1735.5	1.46	28.58	-56	0.2738
34	34.5	1721.6	1.38	24.21	-95	0.2393
36	36.5	1707.8	1.40	24.83	-83	0.2751

D-1

Sample Number	Disk #	Section Top (cm)	of Core Bottom (cm)	Sample Weight used (mg)	209 Po Counts	210 Po Counts	210 Po Meas (Bq/g)	210 Po (Bq/g)	Precisn 1 STD (%)
Culculz lake									
17	531	0	0.5	544	7851	2490	0.359	0.397	2.3
18	532	2	2.5	704	4985	2132	0.379	0.420	2.6
19	533	4	4.5	415	6940	1738	0.374	0.540	2.7
20	534	6	6.5	693	3567	765	0.193	0.214	4.0
21	535	8	8.5	754	3295	498	0.125	0.138	4.8
22	536	10	10.5	828	2961	487	0.124	0.137	4.9
23	537	12	12.5	788	4370	280	0.047	0.052	6.2
24	538	14	14.5	806	3830	151	0.031	0.034	8.3
25	539	16	16.5	713	3998	76	0.016	0.018	11.6
26	540	18	18.5	569	10173	156	0.017	0.019	8.1
27	541	20	20.5	725	9794	164	0.014	0.016	7.9
28	542	22	22.5	741	13581	209	0.013	0.014	7.0
29	543	24	24.5	924	7488	111	0.010	0.011	9.6
30	544	28.5	29	877	6330	108	0.012	0.014	9.7
31	545	32.5	33	658	32389	388	0.011	0.016	5.1
32	546	36.5	37	966	7744	125	0.010	0.012	9.0

	Section Top (cm)	of Core Bottom (cm)	Back calculate to coring (KRL) Date Po Sample Extra (year)	(month)	(day)	Date of coring (year)	(month)	(day)	Time since coring (days)	Decay Corr. to Extractn (Bq/g)	Decay Corr. to Coring (Bg/g)	Std dev (Bg/g)
Culcluz L.												
	0	0.5	99	12	10	99	10	5	66	0.397	0.3992	0.0059
	2	2.5	99	12	10	99	10	5	66	0.420	0.4219	0.0077
	4	4.5	99	12	10	99	10	5	66	0.540	0.5430	0.0084
	6	6.5	99	12	10	99	10	5	66	0.214	0.2149	0.0065
	8	8.5	99	12	10	99	10	5	66	0.138	0.1392	0.0054
	10	10.5	99	12	10	99	10	5	66	0.137	0.1379	0.0057
	12	12.5	99	12	10	99	10	5	66	0.052	0.0528	0.0028
	14	14.5	99	12	10	99	10	5	66	0.034	0.0341	0.0025
	16	16.5	99	12	10	99	10	5	66	0.018	0.0181	0.0018
	18	18.5	99	12	10	99	10	5	66	0.019	0.0187	0.0011
	20	20.5	99	12	10	99	10	5	66	0.016	0.0161	0.0011
	22	22.5	99	12	10	99	10	5	66	0.014	0.0145	0.0009
	24	24.5	99	12	10	99	10	5	66	0.011	0.0113	0.0010
	28.5	29	99	12	10	99	10	5	66	0.014	0.0138	0.0012
	32.5	33	99	12	10	99	10	5	66	0.016	0.0165	0.0007
	36.5	37	99	12	10	99	10	5	66	0.012	0.0119	0.0010

CALCULATIONS FOR INPUT INTO BINFORD PROGRAM

Culculz - 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	0.5	0.3992	0.0059	10.7882	0.1595	0.0803
2	2.5	0.4219	0.0077	11.4020	0.2072	0.0967
4	4.5	0.5430	0.0084	14.6764	0.2268	0.0967
6	6.5	0.2149	0.0065	5.8084	0.1748	0.1313
8	8.5	0.1392	0.0054	3.7621	0.1464	0.0839
10	10.5	0.1379	0.0057	3.7281	0.1537	0.1104
12	12.5	0.0528	0.0028	1.4258	0.0756	0.1115
14	14.5	0.0341	0.0025	0.9227	0.0674	0.1080
16	16.5	0.0181	0.0018	0.4887	0.0473	0.1065
18	18.5	0.0187	0.0011	0.5048	0.0305	0.1172
20	20.5	0.0161	0.0011	0.4357	0.0290	0.1199
22	22.5	0.0145	0.0009	0.3918	0.0233	0.1305
24	24.5	0.0113	0.0010	0.3066	0.0280	0.1434
28.5	29	0.0138	0.0012	0.3718	0.0335	0.1459
32.5	33	0.0165	0.0007	0.4468	0.0184	0.1428
36.5	37	0.0119	0.0010	0.3209	0.0282	0.1487
			avg	0.3789	=supported	
			stds	0.0577	0.4943	

BINFORD FILE INPUTS FOR CALCULATIONS OF DATES AND SEDIMENTATION RATES

Culcluz
C1
16.00
0.0577

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	0.5000	10.7882	10.4093	0.0803	0.186	0.0000	0.0402	0.1595
2.0000	2.5000	11.4020	11.0231	0.0967	0.189	0.1810	0.2293	0.2072
4.0000	4.5000	14.6764	14.2974	0.0967	0.183	0.3764	0.4247	0.2268
6.0000	6.5000	5.8084	5.4295	0.1313	0.200	0.5959	0.6615	0.1748
8.0000	8.5000	3.7621	3.3832	0.0839	0.187	0.8303	0.8723	0.1464
10.0000	10.5000	3.7281	3.3492	0.1104	0.175	1.0388	1.0940	0.1537
12.0000	12.5000	1.4258	1.0468	0.1115	0.162	1.2664	1.3221	0.0756
14.0000	14.5000	0.9227	0.5438	0.1080	0.158	1.4833	1.5373	0.0674
16.0000	16.5000	0.4887	0.1098	0.1065	0.169	1.7157	1.7689	0.0473
18.0000	18.5000	0.5048	0.1259	0.1172	0.172	1.9429	2.0015	0.0305
20.0000	20.5000	0.4357	0.0000	0.1199	0.188	2.1845	2.2444	0.0290
22.0000	22.5000	0.3918	0.0000	0.1305	0.164	2.4305	2.4957	0.0233
24.0000	24.5000	0.3066	0.0000	0.1434	0.180	2.7072	2.7789	0.0280
28.5000	29.0000	0.3718	0.0000	0.1459	0.171	3.3567	3.4297	0.0335
32.5000	33.0000	0.4468	0.0000	0.1428	0.162	3.9188	3.9901	0.0184
36.5000	37.0000	0.3209	0.0000	0.1487	0.160	4.4910	4.5654	0.0282

```
C:\PB210>ECHO OFF
HIT CTRL-PRTSC, THEN RETURN FOR HARD COPY OUTPUT
HIT RETURN FOR SCREEN OUTPUT
Press any key to continue . . .


YOU ARE ANALYZING CORE C1              FROM LAKE Culcluz

THE DATA ARE:
INTTOP  INTBOT  PB210ACT  UNSUPACT   RHO     PERCORG CUMMASST  CUMMASSB   SDACT
 0.0     0.5    10.78820  10.40930  0.08030   0.180   0.0000    0.0402   0.1595
 2.0     2.5    11.40200  11.02310  0.09670   0.180   0.1810    0.2293   0.2072
 4.0     4.5    14.67640  14.29740  0.09670   0.180   0.3764    0.4247   0.2268
 6.0     6.5     5.80840   5.42950  0.13130   0.200   0.5959    0.6615   0.1748
 8.0     8.5     3.76210   3.38320  0.08390   0.180   0.8303    0.8723   0.1464
10.0    10.5     3.72810   3.34920  0.11040   0.170   1.0388    1.0940   0.1537
12.0    12.5     1.42580   1.04680  0.11150   0.160   1.2664    1.3221   0.0756
14.0    14.5     0.92270   0.54380  0.10800   0.150   1.4833    1.5373   0.0674
16.0    16.5     0.48870   0.10980  0.10650   0.160   1.7157    1.7689   0.0473
18.0    18.5     0.50480   0.12590  0.11720   0.170   1.9429    2.0015   0.0305
20.0    20.5     0.43570   0.00000  0.11990   0.180   2.1845    2.2444   0.0290
22.0    22.5     0.39180   0.00000  0.13050   0.160   2.4305    2.4957   0.0233
24.0    24.5     0.30660   0.00000  0.14340   0.180   2.7072    2.7789   0.0280
28.5    29.0     0.37180   0.00000  0.14590   0.170   3.3567    3.4297   0.0335
32.5    33.0     0.44680   0.00000  0.14280   0.160   3.9188    3.9901   0.0184
36.5    37.0     0.32090   0.00000  0.14870   0.160   4.4910    4.5654   0.0282

STANDARD DEVIATION OF SUPPORTED PB-210 =  0.0577


Pb-210 dates for Lake Culcluz              core C1

INTTOP  INTBOT  MIDINT   TTOP   SDTTOP   TBOT   SDTBOT  SEDRATE  SDSEDRT  SUMTOP
 0.0     0.5     0.2     0.00    0.19    1.54    0.20   0.0261   0.0037   8.9393
 2.0     2.5     2.2     7.39    0.21    9.89    0.22   0.0193   0.0035   7.1020
 4.0     4.5     4.2    20.35    0.26   25.41    0.28   0.0096   0.0024   4.7429
 6.0     6.5     6.2    40.47    0.38   45.34    0.40   0.0135   0.0040   2.5351
 8.0     8.5     8.2    57.76    0.52   61.00    0.55   0.0130   0.0046   1.4798
10.0    10.5    10.2    75.54    0.79   83.41    0.91   0.0070   0.0037   0.8505
12.0    12.5    12.2   105.32    1.61  111.44    1.85   0.0091   0.0057   0.3364
14.0    14.5    14.2   130.96    3.20  137.88    3.76   0.0078   0.0072   0.1514
16.0    16.5    16.2   152.12    5.53  154.61    5.71   0.0214   0.0220   0.0784
18.0    18.5    18.2   164.82    7.43  169.65    8.21   0.0121   0.0152   0.0528
Execution terminated : 0

C:\PB210>ed
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C-1

Culculz Lake - Dec 99   Analyst: Joe Bennett

Diatom Relative Abundances (%)

Depth (cm) - samples in 0.5 cm intervals

taxa	code	0.5	1.5	2.5	4.5	6.5	8.5	10.5	12.5	14.5	16.5	18.5	20.5	22.5	24.5	26.5	28.5	30.5	32.5	34.5	36.5
Achnanthes acares	ac acar	0.43	0.00	0.00	0.19	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	0.00	0.00	0.00
Achnanthes amoena	ac amoe	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	0.42	0.00	0.00	0.00	0.00	0.00
Achnanthes bioretii	ac bior	0.00	0.19	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	0.00	0.00	0.00	0.00
Achnanthes clevi	ac clev	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes daonensis	ac daon	0.00	0.00	0.22	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	0.00	0.00	0.00
Achnanthes jouracense	ac jour	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes lanceolata spp. frequentissima	AC LA.F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achnanthes minutissima	AC MINU	0.21	0.57	0.00	0.38	0.21	0.00	0.00	0.24	0.20	0.19	0.00	0.00	0.42	0.00	0.42	0.00	0.22	0.00	0.21	0.00
Achnanthes ziegleri	AC ZIEG	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Amphora libyca	AM LIBY	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.24
Amphora pediculus	AM PEDI	0.43	0.38	0.00	0.75	0.42	0.24	0.22	0.95	0.40	0.39	0.21	0.00	0.00	0.00	0.21	0.84	0.44	0.00	0.42	0.00
Asterionella formosa	AS FORM	6.85	4.02	3.53	3.57	1.69	0.97	1.34	1.90	1.78	0.58	1.25	0.00	4.25	1.15	1.05	2.30	1.33	2.30	1.69	2.42
Aulacoseira ambigua	AU AMBI	0.64	1.53	1.55	3.38	4.02	0.48	2.67	2.38	1.78	1.74	1.25	1.05	1.91	1.53	1.90	1.67	1.33	2.09	0.85	0.00
Aulacoseira granulata	AU GRAN	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	0.00	0.21	0.00	0.00	0.00	0.00
Aulacoseira valida	au valid	7.71	8.62	8.61	3.57	5.92	6.05	4.23	7.36	3.75	4.83	8.52	3.77	3.82	2.49	6.75	5.23	2.44	1.88	3.17	5.31
Cocconeis placentula var. euglypta	CO PL.E	0.43	0.19	0.44	0.00	0.21	0.00	0.00	0.00	0.20	0.19	0.21	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.21	0.00
Cocconeis placentula var. lineata	CO PL.L	0.00	0.19	0.00	0.00	0.00	0.24	0.00	0.00	0.20	0.19	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Cyclotella bodanica var. lemnica	CY BO.L	2.57	4.21	1.77	3.57	7.40	6.05	6.24	8.31	4.35	3.86	4.78	4.61	5.10	4.21	4.85	3.56	4.00	4.38	5.92	6.28
Cyclotella kuetzingiana	cy kuet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cyclotella meneghiniana	CY MENE	0.00	0.38	0.00	0.19	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	0.00	0.00	0.00
Cyclotella ocellata	cy ocel	0.00	0.19	0.66	0.00	0.21	1.21	0.45	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
Cyclotella stelligera	CY STEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella cymbiformis var. nonpunctata	CM CY.N	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.42	0.19	0.00	0.00	0.22	0.00	0.00	0.00
Cymbella minuta	CM MINU	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.44	0.21	0.00	0.00
Cymbella muelleri	CM MUE	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	0.21	0.00	0.00	0.00	0.00	0.24
Cymbella naviculiformis	cm navi	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella sp (PL45)	CM SP.3	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.42	0.00	0.00	0.00	0.00
Epithemia adnata	EP ADNA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Epithemia sorex	ep sore	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria 6 PIRLA	fr 6pir	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00
Fragilaria brevistriata	FR BREV	1.71	2.68	0.00	2.63	0.42	1.94	1.56	3.80	1.78	0.00	0.00	0.00	0.64	0.19	1.90	1.88	0.44	0.84	2.54	0.97
Fragilaria capucina	FR CAPU	1.50	3.26	1.10	1.88	4.02	1.21	0.00	2.14	0.20	0.00	0.00	0.00	0.21	0.38	0.21	0.00	0.00	0.21	0.21	0.24
Fragilaria capucina var. rumpens	fr ca*r	0.43	0.00	0.00	0.19	0.21	0.00	0.22	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	0.21	0.00	2.21	1.32	2.33	0.24	2.67	0.24	0.40	2.51	0.42	0.42	0.00	1.15	0.42	1.26	0.22	1.88	0.42	0.72
Fragilaria crotonensis	FR CROT	7.92	5.75	6.18	12.41	5.50	1.94	1.78	1.90	4.74	2.51	2.49	4.61	3.82	1.53	1.48	3.97	1.78	2.51	2.75	1.69
Fragilaria cyclopum	FR CYCL	0.43	0.00	0.22	0.56	0.00	0.00	0.00	0.00	0.20	0.00	0.42	0.00	0.21	0.19	0.00	0.21	0.00	0.21	0.00	0.00
Fragilaria lapponica	FR LAPP	0.43	0.38	0.44	0.19	0.00	0.00	0.45	0.00	0.40	0.00	0.00	0.00	0.00	0.38	2.11	0.00	0.00	0.00	0.00	0.00
Fragilaria nanana	FR NANA	0.43	0.19	0.00	0.75	0.42	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00
Fragilaria parasitica	FR PARA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria pinnata	FR PINN	1.93	2.87	1.32	2.07	4.23	0.73	1.34	0.71	0.40	3.47	2.91	1.05	1.70	1.72	2.74	3.35	1.56	0.84	1.48	1.45
Fragilaria tenera	FR TENE	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria ulna	FR ULNA	0.00	0.19	0.22	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.42	0.42	0.00
Fragilaria ulna var. acus	FR UL.A	0.21	0.19	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.42	0.44	0.00	0.00	0.00
Gomphonema angustum	GO ANG	0.86	0.19	0.00	0.38	0.00	0.00	0.22	0.24	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gomphonema cf. aquaemineralis	GO AQU	0.00	0.00	0.00	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	0.00	0.00	0.00
Gomphonema sp. (#8-12, pl. 43)	GO SP.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Melosira undulata	me undu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Meridion circulare	mr circ	0.00	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	0.00	0.00	0.00	0.00	0.00
Navicula capitata var. hungarica	NA CA.H	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	0.00	0.00	0.00	0.00	0.00	0.24
Navicula cryptocephala	NA CCEP	0.00	0.00	0.00	0.00	0.00	0.00	0.45	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 cryptonella	NA CRYP	0.00	0.00	0.00	0.00	0.21	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	0.00
Navicula cf. minuscula	NA MINU	0.43	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	0.00	0.00	0.00	0.00	0.00
Navicula pseudoventralis	NA PSVE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula pupula	NA PUPU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula radiosa	NA RADI	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	0.00	0.00	0.00	0.00	0.00	0.24
Navicula scutelloides	na scte	0.21	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	0.00	0.00	0.00	0.00	0.00
Navicula scutiformis	na scut	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	0.00	0.21	0.00	0.00	0.21	0.00
Navicula sp. 1PISCES	NA SP.1	0.00	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	0.00	0.00	0.00	0.00	0.00
Navicula submuralis	na sbmu	0.00	0.19	0.44	0.00	0.00	0.24	0.45	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula veneta	NA VENE	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia amphibia	NI AMPH	0.00	0.00	0.00	0.19	0.00	0.00	0.45	0.48	0.40	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia bacillum	NI BACI	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.21	0.21	0.00
Nitzschia cf. fonticola	NI CFFO	0.00	0.00	0.00	0.00	0.00	0.00	0.45	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
Nitzschia frustulum	NI FRUS	0.21	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	0.00	0.00	0.00	0.00	0.00
Nitzschia liebetruthii fo. 1 PISCES	NI LI.1	0.21	0.00	0.22	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia liebetruthii fo. 2 PISCES	NI LI.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pinnularia microstauron	PI MICR	0.00	0.00	0.00	0.19	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	0.00	0.00
Rhopalodia gibba	RH GIBB	0.00	0.00	0.00	0.38	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	0.00	0.00	0.00
Stephanodiscus alpinus	st alpi	0.43	0.00	0.44	0.00	0.21	0.73	0.00	0.00	0.20	0.00	0.21	0.21	0.00	0.00	0.00	0.21	0.00	0.00	0.42	0.00
Stephanodiscus hantzschii	ST HANT	19.27	17.24	13.25	12.97	11.63	14.04	11.14	8.79	4.74	3.67	8.11	8.39	10.19	13.98	8.23	9.41	10.22	9.60	5.29	6.04
Stephanodiscus hantzschii fo. 1PISCES	ST HA.1	0.21	1.53	2.21	1.88	2.11	1.69	0.67	0.95	2.96	0.77	0.62	1.47	0.85	2.11	2.11	2.30	2.44	1.88	1.69	1.93
Stephanodiscus medius	ST MEDI	2.14	2.87	3.53	0.94	2.11	5.33	3.79	3.33	2.37	3.28	4.57	4.40	4.03	1.15	3.80	1.46	3.11	1.25	1.27	3.38
Stephanodiscus minutulus	ST MINU	19.70	22.22	34.44	27.63	31.92	37.53	36.53	29.69	45.06	42.28	29.11	36.27	26.33	32.18	32.91	32.85	32.22	40.71	34.46	34.78
Stephanodiscus niagarae	ST NIAG	0.64	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stephanodiscus cf. oregonicus	ST OREG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stephanodiscus parvus	ST PARV	17.99	15.90	13.47	14.10	11.63	15.25	19.15	23.52	19.76	25.10	28.07	30.61	32.91	32.18	26.79	25.94	33.78	26.72	34.04	32.37
Synedra cf. incisa	sy inci	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.38	0.21	0.00	0.00	0.00	0.21	0.00
Tabellaria flocculosa trs. IIIp	TA FL3P	1.50	2.68	2.21	1.50	1.48	2.66	2.23	0.48	0.79	2.51	2.29	1.89	1.49	1.15	0.84	1.88	1.78	1.04	1.90	0.97
degraded/unidentifiable girdle view	deg/grd	1.50	0.38	0.22	1.69	0.42	0.48	0.45	0.48	0.79	0.77	1.87	0.00	0.00	0.77	0.00	0.00	0.89	0.00	0.00	0.48