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

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BACKGROUND

Nulki Lake was cored on October 6, 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 as the similarity measure 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 lines 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 that are mainly 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 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 Nulki Lake shows an exponential decay with core depth(Fig. 1A). However, in the absence of any sediment disturbance and/or change in sedimentation rate through time, we would expect a stronger exponential decay of ^{210}Pb with depth. Results from the CRS model suggest that sedimentation rates increased in the early 1900s, followed by a larger increase since c. 1950 (Fig. 1B). The inferred increase in sedimentation rates is temporally consistent with the increase in percent organic matter, c. 1950 (Fig. 1C). The pronounced changes in organic matter (Fig. 1C) in conjunction with pronounced changes in diatom assemblages to a more eutrophic assemblage, suggest that the weakly exponential decay in ^{210}Pb activities with depth is consistent an increase in sedimentation rates in this lake. However, increases in sedimentation rates are best evaluated using multiple cores to avoid erroneous interpretations. The increase in organic matter c. 1950 is a unique change when viewed in the context of the last 300 years of sediment accumulation in this lake (Fig. 1C). 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

Approximately 100 diatom taxa were encounter in the sediment core from Nulki Lake (Appendix C-1). Changes in the diatom assemblages indicate that this lake has become increasing nutrient rich since c. 1950, with the greatest changes in trophic status occurring since the early 1980s (Figs. 2, 1E). Cluster analysis suggests the changes in diatom assemblages through time can be divided into three primary zones (Fig. 2).

Prior to c. 1950 (Fig. 2, Zone C), the diatom assemblage is dominated by taxa with TP optima in the range of 10-15 μg/L, although taxa indicative of a higher trophic status are present (e.g. *Stephanodiscus minutulus*). Circa 1950, there is a marked increase in the abundance of the mesoeutrophic *Aulacoseira ambigua* (Fig. 2, Zone B), as well as increases in other eutrophic taxa including *Stephandiscus hantzschii*. These changes suggest that the lake began to become more nutrient rich at this time (Fig. 1E). In the early 1980s, further increases in *S. hantzschii* and *S. parvus* and declines in the relative abundance of *F. pinnata* suggest that this lake has become increasingly eutrophic (Fig. 2, Zone A; Fig. 1E). These results are consistent with the increases in organic matter and sedimentation rates discussed above.

PCA axis 1 scores (Fig. 1D) accounts for 78% 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 0.84. Thus, the inferred changes in TP are related to the main direction of variation in the diatom assemblages. Futhermore, the diatom assemblages in the core appear to be adequately represented in the modern day samples (Fig. 1F). Based on the above, we feel confident in reliability of the TP inferences provided from the diatom assemblages. In summary, all lines of evidence examined in this report, suggest that this lake has become increasingly nutrient rich since c. 1950, with the greatest changes occurring since the early 1980s.

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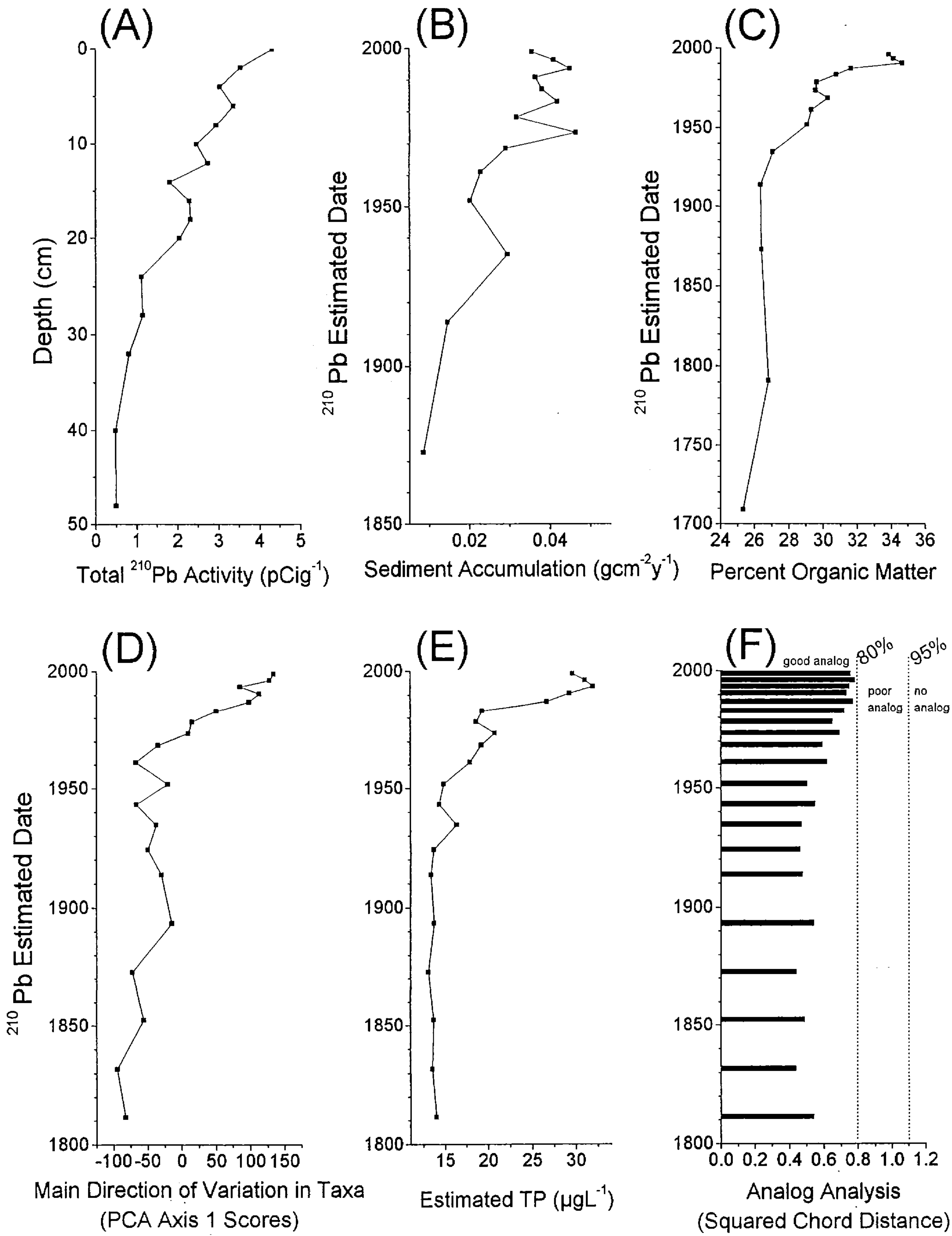
Figure Captions

Figure 1. Summary diagram for the sediment core from Nulki 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).

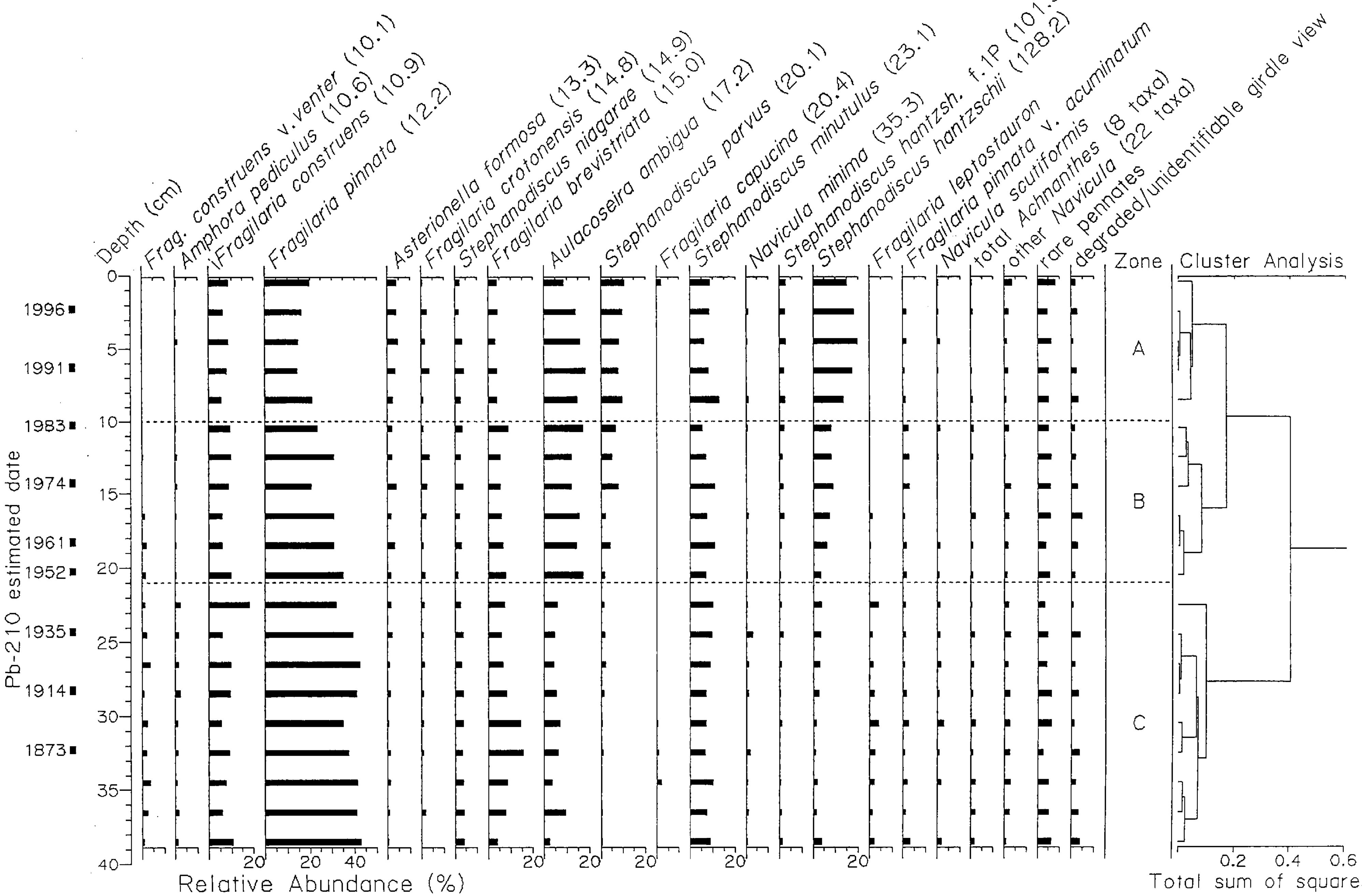
Figure 2. Stratigraphy of the most abundant diatom taxa found in the sediment core from Nulki Lake, B.C. (see Appendix C for a complete list of taxa and the relative percentage data). The diatom taxa are arranged in order of increasing late-summer total phosphorus (TP) optima which is indicated in parentheses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

Nulki Lake



(A)
Depth (cm)
Total ^{210}Pb Activity (pCig^{-1})
(B)
^{210}Pb Estimated Date
Sediment Accumulation (gcm^{-2}y^{-1})
(C)
^{210}Pb Estimated Date
Percent Organic Matter
(D)
^{210}Pb Estimated Date
Main Direction of Variation in Taxa
(PCA Axis 1 Scores)
(E)
Estimated TP (μgL^{-1})
(F)
good analog
80%
95%
poor analog
no analog
Analog Analysis
(Squared Chord Distance)

Nulki Lake



Depth (cm)
Frag. construens v.venter (10.1)
Amphora pediculus (10.6)
Fragilaria construens (10.9)
Fragilaria pinnata (12.2)
Asterionella formosa (13.3)
Fragilaria crotonensis (14.8)
Stephanodiscus niagarae (14.9)
Fragilaria brevistriata (15.0)
Aulacoseira ambigua (17.2)
Stephanodiscus parvus (20.1)
Fragilaria capucina (20.4)
Stephanodiscus minutulus (23.1)
Navicula minima (35.3)
Stephanodiscus hantzsh. f.1P (101.9)
Stephanodiscus hantzschii (128.2)
Fragilaria leptostauron
Fragilaria pinnata v. acuminatum
Navicula scutiformis
total Achnanthes (8 taxa)
other Navicula (22 taxa)
rare pennates
degraded/unidentifiable girdle view
Zone
A
B
C
Cluster Analysis
Pb-210 estimated date
1996
1991
1983
1974
1961
1952
1935
1914
1873
Relative Abundance (%)
Total sum of squares

Nulki Lake Summary File

Pb210 and LOI summary

INTTOP (cm)	INTBOT (cm)	Pb210Act (pCi/g)	LOI(550C %organic	estimated AD date	SEDRATE (g/cm2/yr)
0	1	4.3103		1999.0	0.0353
2	2.5	3.5334	33.87	1996.4	0.0408
4	4.5	3.0365	34.15	1993.7	0.0448
6	6.5	3.3675	34.65	1990.8	0.0362
8	8.5	2.9436	31.61	1987.2	0.0380
10	10.5	2.4651	30.76	1983.2	0.0417
12	12.5	2.7352	29.63	1978.5	0.0316
14	14.5	1.8068	29.55	1973.6	0.0462
16	16.5	2.2925	30.27	1968.6	0.0290
18	18.5	2.3138	29.32	1961.2	0.0227
20	20.5	2.0405	29.06	1952.0	0.0201
24	24.5	1.1093	27.06	1934.9	0.0294
28	28.5	1.1457	26.36	1913.9	0.0144
32	32.5	0.8047	26.40	1873.0	0.0084
40	40.5	0.4783	26.80	1791.2	
48	48.5	0.4914	25.30	1709.4	

Diatom analyses

Depth (cm) TOP	Depth (cm) BOTTOM	estimated AD date	log TP	TP	PCA Axis 1	minumum sq. chord
0	0.5	1999.0	1.471	29.58	134	0.7556
2	2.5	1996.4	1.491	30.97	128	0.782
4	4.5	1993.7	1.503	31.84	85	0.7495
6	6.5	1990.8	1.465	29.17	113	0.732
8	8.5	1987.2	1.425	26.61	98	0.7688
10	10.5	1983.2	1.285	19.28	50	0.717
12	12.5	1978.5	1.269	18.58	15	0.6494
14	14.5	1973.6	1.316	20.70	9	0.6895
16	16.5	1968.6	1.282	19.14	-35	0.5919
18	18.5	1961.2	1.251	17.82	-68	0.6186
20	20.5	1952.0	1.17	14.79	-21	0.5014
22	22.5	1943.4	1.155	14.29	-67	0.5469
24	24.5	1934.9	1.213	16.33	-38	0.4701
26	26.5	1924.4	1.135	13.65	-50	0.4619
28	28.5	1913.9	1.126	13.37	-30	0.4752
30	30.5	1893.4	1.138	13.74	-15	0.539
32	32.5	1873.0	1.115	13.03	-73	0.4401
34	34.5	1852.5	1.135	13.65	-56	0.4889
36	36.5	1832.1	1.131	13.52	-95	0.4366
38	38.5	1811.6	1.145	13.96	-83	0.5404

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 (%)
Nulki Lake									
65	591	0	1	447	4271	347	0.144	0.158	5.6
66	592	2	3	525	6963	516	0.118	0.130	4.6
67	593	4	5	507	14370	918	0.101	0.112	3.4
68	594	6	7	523	11269	1127	0.112	0.124	3.1
69	595	8	9	617	18139	1455	0.098	0.108	2.7
70	596	10	11	510	5808	319	0.081	0.091	5.8
71	597	12	13	570	12894	910	0.090	0.100	3.4
72	598	14	15	770	17747	1085	0.060	0.066	3.1
73	599	16	17	717	11826	860	0.075	0.084	3.5
74	600	18	19	559	12143	699	0.076	0.085	3.9
75	601	20	20.5	602	12991	706	0.067	0.075	3.9
76	602	24	25	663	5311	174	0.036	0.041	7.7
77	603	28	29	577	6248	184	0.037	0.042	7.5
78	604	32	33	593	6262	130	0.026	0.030	8.9
79	605	40	41	768	13623	222	0.015	0.018	6.8
80	606	48	49	762	7032	118	0.016	0.018	9.3

Back calculate to coring (KRL)

	Section Top (cm)	of Core Bottom (cm)	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)
Nulki L.												
	0	1	100	1	1	99	10	6	87	0.1583	0.1595	0.0057
	2	3	100	1	1	99	10	6	87	0.1298	0.1307	0.0042
	4	5	100	1	1	99	10	6	87	0.1115	0.1124	0.0026
	6	7	100	1	1	99	10	6	87	0.1237	0.1246	0.0027
	8	9	100	1	1	99	10	6	87	0.1081	0.1089	0.0022
	10	11	100	1	1	99	10	6	87	0.0905	0.0912	0.0036
	12	13	100	1	1	99	10	6	87	0.1005	0.1012	0.0025
	14	15	100	1	1	99	10	6	87	0.0664	0.0669	0.0018
	16	17	100	1	1	99	10	6	87	0.0842	0.0848	0.0024
	18	19	100	1	1	99	10	6	87	0.0850	0.0856	0.0024
	20	20.5	100	1	1	99	10	6	87	0.0749	0.0755	0.0022
	24	25	100	1	1	99	10	6	87	0.0407	0.0410	0.0025
	28	29	100	1	1	99	10	6	87	0.0421	0.0424	0.0024
	32	33	100	1	1	99	10	6	87	0.0296	0.0298	0.0020
	40	41	100	1	1	99	10	6	87	0.0176	0.0177	0.0010
	48	49	100	1	1	99	10	6	87	0.0180	0.0182	0.0015

CALCULATIONS FOR INPUT INTO BINFORD PROGRAM

Nulki - 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	0.1595	0.0057	4.3103	0.1547	0.0573
2	2.5	0.1307	0.0042	3.5334	0.1127	0.0558
4	4.5	0.1124	0.0026	3.0365	0.0714	0.0591
6	6.5	0.1246	0.0027	3.3675	0.0725	0.0574
8	8.5	0.1089	0.0022	2.9436	0.0606	0.0769
10	10.5	0.0912	0.0036	2.4651	0.0986	0.0799
12	12.5	0.1012	0.0025	2.7352	0.0685	0.0930
14	14.5	0.0669	0.0018	1.8068	0.0481	0.0908
16	16.5	0.0848	0.0024	2.2925	0.0662	0.0903
18	18.5	0.0856	0.0024	2.3138	0.0654	0.1006
20	20.5	0.0755	0.0022	2.0405	0.0596	0.0958
24	24.5	0.0410	0.0025	1.1093	0.0685	0.1075
28	28.5	0.0424	0.0024	1.1457	0.0642	0.1125
32	32.5	0.0298	0.0020	0.8047	0.0543	0.1219
40	40.5	0.0177	0.0010	0.4783	0.0281	0.1190
48	48.5	0.0182	0.0015	0.4914	0.0395	0.1273
			avg	0.4848	=supported	
			std	0.0093	0.5034	

BINFORD FILE INPUTS FOR CALCULATIONS OF DATES AND SEDIMENTATION RATES

Nulki
C1
16.00
0.0093

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	4.3103	3.8255	0.0573	0.342	0.0000	0.0573	0.1547
2.0000	2.5000	3.5334	3.0485	0.0558	0.339	0.1114	0.1393	0.1127
4.0000	4.5000	3.0365	2.5517	0.0591	0.341	0.2240	0.2536	0.0714
6.0000	6.5000	3.3675	2.8827	0.0574	0.347	0.3457	0.3744	0.0725
8.0000	8.5000	2.9436	2.4588	0.0769	0.316	0.4843	0.5228	0.0606
10.0000	10.5000	2.4651	1.9802	0.0799	0.308	0.6328	0.6728	0.0986
12.0000	12.5000	2.7352	2.2504	0.0930	0.296	0.7959	0.8423	0.0685
14.0000	14.5000	1.8068	1.3220	0.0908	0.296	0.9811	1.0265	0.0481
16.0000	16.5000	2.2925	1.8077	0.0903	0.303	1.1607	1.2059	0.0662
18.0000	18.5000	2.3138	1.8290	0.1006	0.293	1.3422	1.3925	0.0654
20.0000	20.5000	2.0405	1.5557	0.0958	0.291	1.5311	1.5790	0.0596
24.0000	24.5000	1.1093	0.6245	0.1075	0.271	1.9187	1.9725	0.0685
28.0000	28.5000	1.1457	0.6609	0.1125	0.264	2.3897	2.4460	0.0642
32.0000	32.5000	0.8047	0.3199	0.1219	0.264	2.8216	2.8826	0.0543
40.0000	40.5000	0.4783	0.0000	0.1190	0.268	3.7160	3.7755	0.0281
48.0000	48.5000	0.4914	0.0000	0.1273	0.253	4.7066	4.7702	0.0395

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pb210.bat

C:\PB210>pb210

C:\PB210>ECHO OFF
HIT CTRL-PRTSC, THEN RETURN FOR HARD COPY OUTPUT
HIT RETURN FOR SCREEN OUTPUT
Press any key to continue . . .
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YOU ARE ANALYZING CORE C1 FROM LAKE Nulki

THE DATA ARE:

INTTOP	INTBOT	PB210ACT	UNSUPACT	RHO	PERCORG	CUMMASST	CUMMASSB	SDACT
0.0	1.0	4.31030	3.82550	0.05730	0.340	0.0000	0.0573	0.1547
2.0	2.5	3.53340	3.04850	0.05580	0.330	0.1114	0.1393	0.1127
4.0	4.5	3.03650	2.55170	0.05910	0.340	0.2240	0.2536	0.0714
6.0	6.5	3.36750	2.88270	0.05740	0.340	0.3457	0.3744	0.0725
8.0	8.5	2.94360	2.45880	0.07690	0.310	0.4843	0.5228	0.0606
10.0	10.5	2.46510	1.98020	0.07990	0.300	0.6328	0.6728	0.0986
12.0	12.5	2.73520	2.25040	0.09300	0.290	0.7959	0.8423	0.0685
14.0	14.5	1.80680	1.32200	0.09080	0.290	0.9811	1.0265	0.0481
16.0	16.5	2.29250	1.80770	0.09030	0.300	1.1607	1.2059	0.0662
18.0	18.5	2.31380	1.82900	0.10060	0.290	1.3422	1.3925	0.0654
20.0	20.5	2.04050	1.55570	0.09580	0.290	1.5311	1.5790	0.0596
24.0	24.5	1.10930	0.62450	0.10750	0.270	1.9187	1.9725	0.0685
28.0	28.5	1.14570	0.66090	0.11250	0.260	2.3897	2.4460	0.0642
32.0	32.5	0.80470	0.31990	0.12190	0.260	2.8216	2.8826	0.0543
40.0	40.5	0.47830	0.00000	0.11900	0.260	3.7160	3.7755	0.0281
48.0	48.5	0.49140	0.00000	0.12730	0.250	4.7066	4.7702	0.0395

STANDARD DEVIATION OF SUPPORTED PB-210 = 0.0093

Pb-210 dates for Lake Nulki core C1

INTTOP	INTBOT	MIDINT	TTOP	SDTTOP	TBOT	SDTBOT	SEDRATE	SDSEDRT	SUMTOP
0.0	1.0	0.5	0.00	0.28	1.62	0.28	0.0353	0.0068	4.4447
2.0	2.5	2.2	3.13	0.28	3.81	0.28	0.0408	0.0069	4.0319
4.0	4.5	4.2	5.83	0.29	6.49	0.30	0.0448	0.0064	3.7065
6.0	6.5	6.2	8.66	0.31	9.45	0.31	0.0362	0.0055	3.3940
8.0	8.5	8.2	12.14	0.33	13.15	0.33	0.0380	0.0056	3.0458
10.0	10.5	10.2	16.11	0.35	17.07	0.35	0.0417	0.0082	2.6915
12.0	12.5	12.2	20.62	0.38	22.09	0.39	0.0316	0.0057	2.3385
14.0	14.5	14.2	25.76	0.42	26.74	0.43	0.0462	0.0075	1.9930
16.0	16.5	16.2	30.45	0.47	32.01	0.49	0.0290	0.0060	1.7222
18.0	18.5	18.2	37.55	0.56	39.76	0.59	0.0227	0.0054	1.3805
20.0	20.5	20.2	46.66	0.71	49.04	0.75	0.0201	0.0054	1.0396
24.0	24.5	24.2	64.01	1.09	65.84	1.13	0.0294	0.0104	0.6057
28.0	28.5	28.2	84.02	1.76	87.93	1.94	0.0144	0.0073	0.3247
32.0	32.5	32.2	123.22	5.01	130.53	6.13	0.0084	0.0082	0.0958

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Execution terminated : 0

C:\PB210>
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C-1

Nulki Lake -- Analyst Joe Bennett (Dec. 1999) **Diatom Relative Abundances (%)**

Depth (cm) - samples in 0.5 cm intervals

taxa	code	0.5	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	38.5
Achnanthes clevi	ac clev	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.88	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00
Achnanthes conspicua	AC CONS	0.00	0.00	0.00	0.00	0.00	0.00	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	0.00
Achnanthes chilandos	ac chil	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	0.23	0.00	0.00
Achnanthes exigua	AC EXIG	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.22	0.00	0.00	0.70	0.00	0.00
Achnanthes jouracense	ac jour	0.18	0.20	0.00	0.00	0.45	0.00	0.37	0.00	0.44	0.00	0.42	0.22	0.21	1.15	0.22	1.12	0.45	0.47	0.23	0.00
Achnanthes lanceolata var. dubia	ac la.d	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	0.67	0.00	0.00	0.00	0.00
Achnanthes minutissima	AC MINU	0.00	0.00	0.00	0.40	0.00	1.18	0.19	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.69	1.09
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	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.43
Amphora libyca	AM LIBY	0.00	0.00	0.00	0.20	0.00	0.24	0.19	0.72	0.88	0.43	0.21	0.22	0.21	0.00	0.22	0.00	0.00	0.23	0.00	1.52
Amphora pediculus	AM PEDI	0.18	0.41	0.85	0.00	0.00	0.24	0.74	0.48	0.22	0.21	0.21	2.00	1.47	1.39	2.02	1.12	1.12	0.70	1.62	1.09
Amphora veneta	AM VENE	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	0.22
Asterionella formosa	AS FORM	3.69	3.67	4.66	3.16	2.03	1.90	1.86	3.86	1.32	2.99	1.46	1.56	1.68	0.46	0.90	0.22	1.12	0.94	0.46	0.22
Aulacoseira ambigua	AU AMBI	8.30	13.88	15.89	18.18	14.67	16.82	11.87	11.84	15.57	14.32	17.15	5.56	4.42	4.16	5.17	6.74	6.07	3.52	9.24	2.39
Cocconeis neodiminuta	co neod	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.21	0.63	0.22	0.00	0.00	0.00	0.00	0.00	0.23	0.23	0.22
Cocconeis placentula	CO PLAC	1.11	1.22	1.06	0.79	0.23	0.71	1.86	0.00	1.75	1.07	0.63	0.44	1.05	0.92	0.45	0.22	0.45	1.17	0.92	0.22
Cocconeis placentula var. euglypta	CO PL.E	0.37	0.00	0.21	0.40	0.23	0.00	0.19	0.48	0.00	0.43	0.21	0.89	0.63	0.00	0.22	1.12	0.22	0.47	0.46	0.22
Cocconeis placentula var. lineata	CO PL.L	0.37	0.00	0.00	0.00	0.45	0.00	0.74	0.24	0.22	0.00	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cyclostephanos cf. invisitatus	CS INVI	0.55	0.41	0.21	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	0.00	0.00
Cyclotella bodanica var. leminica	CY BO.L	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	0.22
Cymbella cesatii	CM CESA	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	0.23	0.00	0.00
Cymbella cf. incerta	cm ince	0.18	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
Cymbella cistula	CM CIST	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	0.00	0.00
Cymbella cymbiformis var. nonpunctata	CM CY.N	0.18	0.20	0.42	0.59	0.00	0.71	0.19	0.00	0.44	0.00	0.00	0.22	0.63	0.23	0.90	0.67	0.00	0.70	0.00	0.00
Cymbella ehrenbergii	cm ehm	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	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella microcephala	CM MICR	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	0.22	0.00	0.00	0.00	0.00
Cymbella minuta	CM MINU	0.18	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	0.00	0.00	0.00
Cymbella muelleri	CM MUEL	0.18	0.41	0.00	0.59	0.00	0.24	0.19	0.72	0.44	0.00	0.42	0.00	0.42	0.00	0.00	0.67	0.00	0.23	0.00	0.43
Denticula keutzingii	DE KUET	0.00	0.00	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
Diploneis elliptica	di elli	0.18	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
Epithemia adnata	EP ADNA	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.46	0.00	0.22	0.67	0.00	0.00	0.43
Epithemia sorex	ep sore	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	0.22	0.00	0.00	0.00	0.00
Fragilaria 2 PIRLA	fr 2pir	0.00	0.00	0.00	0.00	0.00	0.47	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
Fragilaria brevistriata	FR BREV	3.87	4.08	3.18	3.95	3.84	9.00	5.57	5.56	5.92	6.41	7.95	7.33	5.89	6.70	8.31	14.38	15.51	6.69	7.85	3.69
Fragilaria capucina	FR CAPU	2.03	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.21	0.21	0.22	0.00	0.23	0.00	0.45	0.90	1.88	0.23	0.00
Fragilaria construens	FR CONS	8.67	6.12	6.47	7.71	5.64	9.24	9.65	8.70	5.92	5.77	9.83	17.78	5.68	9.70	9.21	5.62	8.99	7.51	6.00	10.63
Fragilaria crotonensis var. binodis	FR CO.B	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	0.67	0.45	0.00	0.00	0.00	0.43
Fragilaria construens var. venter	FR CO.V	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	1.10	1.92	1.46	1.33	2.11	3.46	0.90	2.47	2.02	3.52	2.31	0.87
Fragilaria crotonensis	FR CROT	0.55	2.45	1.48	3.36	0.90	0.95	3.34	2.42	1.97	0.85	1.46	1.11	0.63	1.15	0.90	0.90	0.90	0.00	1.62	0.00
Fragilaria cyclopum	FR CYCL	0.37	0.61	0.64	0.20	0.45	0.47	0.37	0.72	0.00	0.00	0.00	0.00	0.00	0.23	0.45	0.00	0.00	0.00	0.00	0.00
Fragilaria lapponica	FR LAPP	0.55	0.41	1.27	0.40	0.68	1.18	0.93	1.45	0.00	0.21	1.46	0.44	0.84	1.39	0.45	0.90	0.22	0.70	1.39	1.74
Fragilaria leptostauron	fr lept	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.64	0.00	3.78	1.26	1.62	2.02	3.82	2.25	1.88	1.39	2.17
Fragilaria parasitica	FR PARA	0.00	0.20	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00
Fragilaria pinnata	FR PINN	19.74	16.12	14.62	14.23	20.89	23.22	30.80	20.77	30.70	30.56	35.15	32.00	39.37	42.49	40.67	34.83	37.30	41.08	40.65	42.73
Fragilaria pinnata var. acuminatum	fr pi.a	0.00	1.43	1.48	0.59	0.90	2.37	2.41	2.42	0.66	1.50	1.26	0.89	1.05	0.69	1.57	2.25	0.67	1.88	0.92	3.04
Fragilaria pinnata var. lancettula	FR PI.L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.44	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00
Fragilaria tenera	FR TENE	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	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria ulna	FR ULNA	0.18	0.41	0.00	0.00	0.45	0.24	0.19	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.22
Fragilaria ulna var. acus	FR UL.A	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.23	0.00
Gomphonema angustum	GO ANG	0.74	0.41	0.42	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.45	0.00	0.00	0.47	0.23	0.22
Gomphonema cf. aquaemineralis	GO AQU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gomphonema cf. olivaceum	go oliv	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	0.22	0.00	0.00	0.00
Gomphonema parvulum	GO PAR	0.74	0.00	0.00	0.00	0.00	0.00	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	0.00
Gomphonema sp. (#8-12, pl. 43)	GO SP.2	0.00	0.00	0.00	0.20	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00
Gomphonema sp. 1 PISCES	GO SP.1	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Gyrosigma acuminatum	gy acum	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	0.22	0.00	0.00	0.00	0.00
Navicula aurora	na auro	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	0.45	0.00	0.00	0.00
Navicula capitata var. capitata	NA CA.C	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	0.00	0.00	0.45	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	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula cryptocephala	NA CCEP	0.92	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 cryptonella	NA CRYP	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.72	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 explanta	na expl	0.00	0.41	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	0.00	0.00
Navicula ignora var. palustris	na igvp	0.55	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 laevissima	NA LAEV	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.21	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.22
Navicula cf. lapidosa	na lapi	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
Navicula menisculus	na menu	0.00	0.00	0.00	0.00	0.00	0.00	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	0.00
Navicula minima	NA MINI	0.00	1.02	0.42	0.00	0.90	0.47	0.00	0.24	1.10	0.00	0.42	0.44	2.74	0.92	0.90	0.22	1.57	0.47	1.15	0.43
Navicula cf. minuscula	NA MINU	0.18	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula oblonga	NA OBLO	0.18	0.00	0.21	0.40	0.23	0.47	0.00	0.00	0.00	0.21	0.00	0.22	0.00	0.00	0.22	0.90	0.45	0.70	0.46	0.43
Navicula pseudoventralis	NA PSVE	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula pupula	NA PUPU	0.65	0.41	0.42	0.40	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.23	0.22	0.45	0.22	0.00	0.46	0.22
Navicula radiosa	NA RADI	0.00	0.00	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
Navicula schaderl	na scha	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	0.47	0.00	0.00
Navicula scutiformis	na scut	0.37	0.41	1.27	0.59	0.23	1.18	0.56	0.00	0.22	1.28	0.63	1.33	1.05	1.62	0.90	2.92	0.67	1.64	0.23	2.17
Navicula sp. 2PISCES	na sp.2	0.00	0.00	0.00	0.00	0.00	0.47	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 sp. pl. 20	na pl20	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	0.00	0.00
Navicula sp. pl. 23	na pl23	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	0.22	0.00	0.00	0.00	0.00
Navicula submuralis	na sbmu	0.37	0.00	0.00	0.00	0.45	0.71	0.37	0.48	0.66	1.07	0.63	1.56	0.63	1.15	1.12	0.22	0.67	0.47	1.15	0.00
Navicula subminuscula	NA SUBM	0.74	0.00	0.21	0.40	0.00	0.00	0.19	0.48	0.00	0.00	0.00	0.00	0.63	0.00	0.22	0.00	0.45	0.94	0.00	0.00
Navicula vitabunda	NA VITA	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	0.45	0.00	0.00	0.00	0.00	0.00
Nedium ampliatum	NE AMPL	0.18	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	0.45	0.00	0.23	0.00
Nitzschia amphibia	NI AMPH	0.55	0.00	0.64	0.20	0.23	0.00	0.37	0.48	0.22	0.00	0.21	0.00	0.42	0.00	0.45	0.22	0.00	0.00	0.00	0.00
Nitzschia angustata	ni angu	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
Nitzschia bacillum	NI BACI	0.37	0.00	0.00	0.40	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.45	0.00	0.00	0.00	0.00	0.00
Nitzschia dissipata var. media	ni ds.m	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
Nitzschia frustulum	NI FRUS	0.00	0.00	0.42	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 gracilis	NI GRAC	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00
Nitzschia liebetruthii fo. 1 PISCES	NI LI.1	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	0.22	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	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00
Nitzschia palea	NI PALE	0.18	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
Pinnularia interrupta	PI INTE	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pinnularia microstauron	PI MICR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00
Pinularia maior	pi maio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stephanodiscus hantzschii	ST HANT	14.94	18.16	19.49	17.19	13.32	8.06	7.79	8.70	7.02	6.20	3.35	3.78	3.16	3.00	2.47	1.35	1.12	1.64	1.39	3.47
Stephanodiscus hantzschii fo. 1PISCES	ST HA.1	2.58	2.45	2.75	1.78	2.48	1.90	1.11	1.69	1.75	0.85	0.42	0.67	1.68	0.92	0.22	0.90	0.00	0.23	0.92	1.30
Stephanodiscus medius	ST MEDI	0.00	0.82	0.21	0.20	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
Stephanodiscus minutulus	ST MINU	8.67	8.37	5.93	8.10	12.87	5.21	6.86	10.63	7.24	10.68	6.90	10.00	8.68	8.78	6.97	6.74	6.52	9.86	7.39	8.68
Stephanodiscus niagarae	ST NIAG	2.03	1.63	3.39	3.95	2.48	3.32	2.60	3.62	1.97	2.99	1.46	2.67	3.58	2.77	3.60	3.60	3.37	3.52	4.16	4.12
Stephanodiscus parvus	ST PARV	10.52	9.59	8.05	7.51	9.71	6.40	5.01	7.73	1.97	4.06	1.88	1.33	1.89	2.08	1.35	0.45	0.90	0.00	0.69	0.65
Surirella tenera	sur ten	0.00	0.00	0.00	0.40	0.23	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
Synedra cf. incisa	sy inci	0.74	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	0.00	0.00	0.00	0.00	0.00
degraded/unidentifiable girdle view	deg/grd	2.03	2.65	0.85	2.37	2.93	1.66	2.04	2.66	4.61	2.56	1.67	0.89	4.00	1.39	3.15	1.12	3.60	2.11	3.00	3.90