Paleolimnological analysis of Nicola Lake, B.C -- Final Report (March 1999).

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BACKGROUND

Nicola Lake was cored on July 20, 1998 by Rick Nordin and Bob Grace. 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. These samples were shipped on ice to Queen's University where they were stored in our coldroom at 4°C. Each container was weighed to determine the total wet weight of sediment then subsampled for ^{210}Pb, diatom and pigment analyses. Twenty intervals (every 2 cm) were subsampled for diatom and pigment analyses, and sixteen intervals for ^{210}Pb analysis. Subsamples for analysis of pigments were sent to Prof. Leavitt at University of Regina. 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. 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 original 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 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 under oil immersion at 1000X magnification using an objective with a numerical aperture of 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

Cluster analysis, which groups similar diatom assemblages, was run on the taxa represented in Fig. 2. Cluster analysis on the diatom assemblage composition was constrained to the depth of the core samples to provide an unbiased assessment of changes in diatom assemblages through time. A squared chord was used to determine similarity between samples in the cluster analysis (Fig.2). Zones were placed based on these analyses to represent distinct groups in diatom assemblages through time (dashed lines on Fig. 2).

Environmental Reconstructions from diatom assemblages

Inferences of total phosphorus downcore were based on a total phosphorus model based on the 111 freshwater lakes from the 219 lakes sampled by Wilson, Cumming & Smol (1996). This model is based on estimates of taxa optima 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 downcore 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 directions of variation do not match, then the diatom-inferred phosphorus reconstructions do not fully represent the changes, if any occurred, in diatom species composition downcore. Presumably, other environmental variables, or interactions between environmental variables, are contributing to the changes in diatom assemblages.

The main direction of variation in the diatom assemblages downcore in Nicola Lake was determined from the first axis scores from a principal components analysis (PCA) ordination using a co-variance matrix and non-transformed species abundance data. A PCA was chosen to represent the main direction of variation in this core since only minor changes in diatom assemblages occurred and thus a linear ordination technique would more effectively capture changes in this core then an approach based on unimodal techniques.

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 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 Nicola Lake shows fluctuations in activity in the upper 10 cms(Fig. 1A). This could be due to changes in sedimentation rates that could cause changes in the dilution of the ^{210}Pb activity or possibly sediment mixing. These fluctuations in ^{210}Pb activity resulted in inferred changes in sedimentation rates (Fig. 1B). In times of low ^{210}Pb activity sedimentation rates were inferred to have increased and vice versa. However, changes in sedimentation rates are best assessed on multiple cores due to the potentially large variation in sedimentation patterns within a basin. Percent organic matter is low throughout the core and fairly stable from approximately 1750 to 1950 (Fig. 1C). Since 1950 percent organic matter has fluctuated between 9 to 13%. 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 to the lake.

Diatom Assemblage Changes and Analyses

Approximately 87 diatom taxa were encounter in the sediment core from Nicola Lake (Appendix C-1). There is little directional change in the floristic composition of diatoms, with the exception of a distinct increase in *Aulacoseira subarctica* starting at approximately 1967 (Fig. 2). This lack of directional change is mirrored by the PCA sample scores (which accounts for 57% of the variation in the core). Dominant taxa throughout the core are *Stephanodiscus parvus* and *Stephanodiscus minutulus,* both of which are indicative of meso- to eutrophic conditions (Fig. 2). Other taxa which reach relatively high abundances include *Fragilaria capucina, Aulacoseira subarctica, Aulacoseira granulata, Fragilaria pinnata, Asterionella formosa* and *Fragilaria crotonensis*. Both *S. parvus* and *S. minutulus* can be classified as generalists to the total phosphorus gradient (i.e. occurs in high abundance over a wide range of TP values), in comparison to other taxa such as *A. formosa* and *F. crotonensis* which have a narrower distribution of high abundances along the TP gradient (information from the 111 B.C. freshwater lake modern-day calibration set). At present our knowledge of the phosphorus optima of *A. subarctica* is based on a relatively small number of occurrences in the modern samples.

Cluster analysis suggests the changes in diatom assemblages through time can be divided into three primary zones (Fig. 2). *S. parvus* and *S. minutulus* fluctuate at relatively high abundances throughout all three zones (10-60%). *F. pinnata, F. crotonensis*, and *A. formosa* fluctuate from approximately 2-3%, up to approx. 10% throughout the core. Whereas, *F. capucina* decreases in Zone A, *A. granulata* is at its highest abundance in Zone B and *A. subarctica* increases in abundance in Zones A and B.

Even though there are changes in the diatom assemblages, inferred total phosphorus (TP) has not changed in a directional fashion since preindustrial times (Fig. 1E). This is not surprising since *S. parvus* and *S. minutulus* are dominant throughout the core as are other meso- to eutrophic taxa. The distinct decrease in *F. capucina* and increase in *A. subarctica* in the upper part of the core suggests, however, that conditions in Nicola Lake may have become slightly more eutrophic.

The correlation between the reconstructed TP and the main direction of variation in taxa(represented by PCA axis 1 scores) is 0.6 when all 20 points are considered, which suggests that some of the changes seen in the diatom assemblages are related to changes in inferred total phosphorus. All samples have good analogs (Fig.1F). Diatom-inferred salinity has increased slightly since approximately 1960 (see Appendix A) and thus climate and potentially associated changes in lake level may account for some of the variation seen in the diatom assemblages. The correlation between estimated total phosphorus and salinity is 0.73, with both variables increasing slightly in more recent sediments, suggesting that some of the phosphorus changes may be linked to climatic changes.

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Figure Captions

Figure 1. Summary diagram for the sediment core from Nicola 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. Diatom stratigraphy of the diatom taxa that were present in at least ~2% relative abundance in the sediment core from Nicola 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 optima which is indicated in parentheses for those taxa with known optima. The dotted lines separate the stratigraphy into three zones that were identified by a cluster analysis on the diatom assemblage composition that was constrained to the depth of the core samples.

FIGURE 1

Nicola Lake, British Columbia

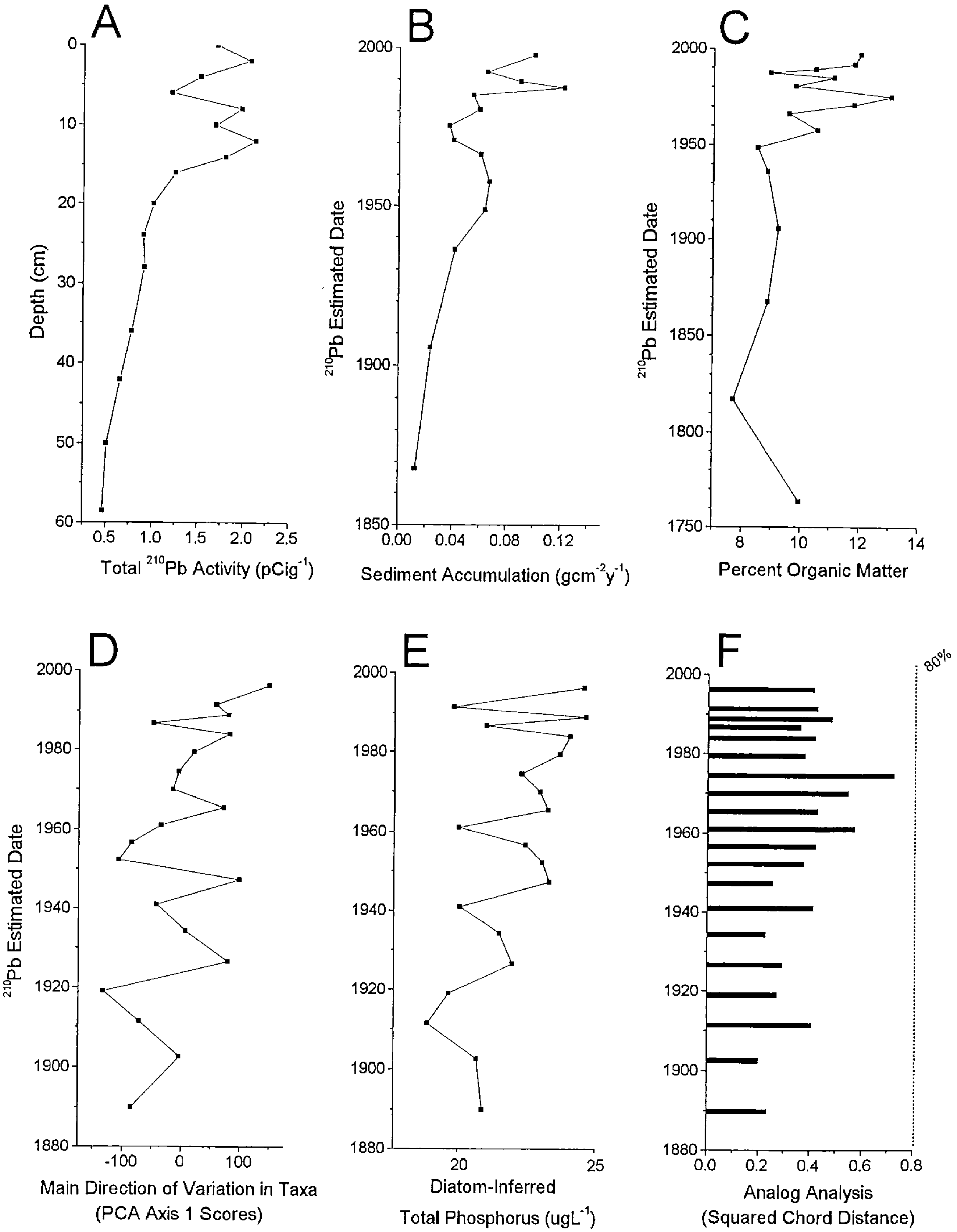
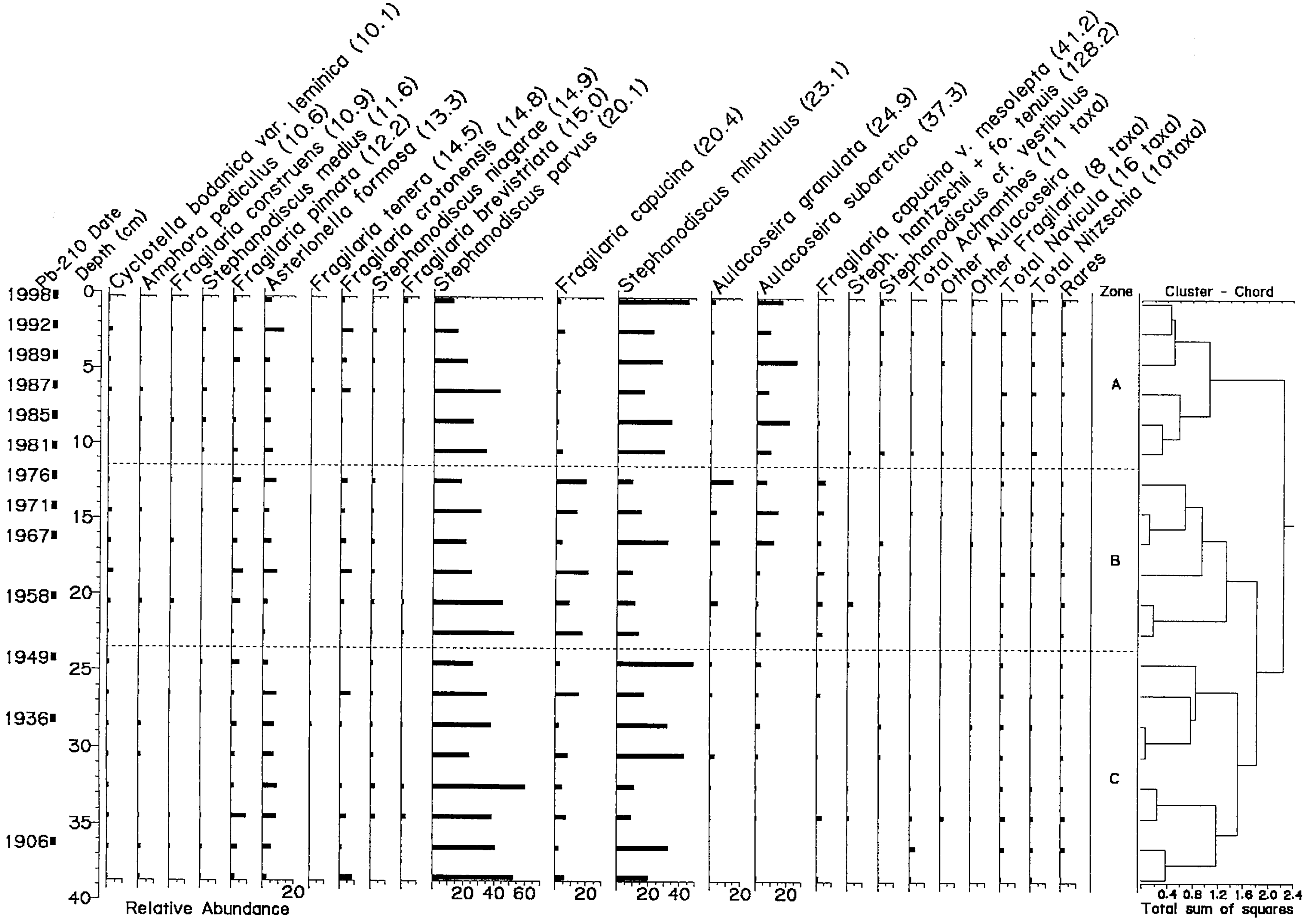


FIGURE 2

Nicola Lake, B.C.



APPENDIX A

Nicola Lake - Summary File

Pb210 and LOI summary

INTTOP (cm)	INTBOT (cm)	Pb210ACt (pCi/g)	LOI(550C) %organics	Estimated AD-DATE	SEDRATE (g/cm2/yr)
0	0.5	1.6999	12.00	1997.7	0.1001
2	2.5	2.0698	11.81	1992.3	0.0650
4	4.5	1.5232	10.48	1989.3	0.0901
6	6.5	1.2069	8.93	1987.3	0.1219
8	8.5	1.9736	11.11	1985.0	0.0549
10	10.5	1.6866	9.80	1980.7	0.0596
12	12.5	2.1246	13.05	1975.6	0.0373
14	14.5	1.8008	11.79	1971.1	0.0404
16	16.5	1.2462	9.58	1966.6	0.0606
20	20.5	1.0124	10.55	1957.9	0.0667
24	24.5	0.9029	8.50	1948.8	0.0636
28	28.5	0.9153	8.87	1936.2	0.0417
36	36.5	0.7776	9.23	1905.8	0.0238
42	42.5	0.6552	8.88	1867.8	0.0125
50	50.5	0.5070	7.70	1817.2	
58.5	59	0.4628	9.98	1763.4	

Diatom analyses summary

Depth(cm TOP	Depth(cm BOTTOM	Estimated AD-DATE	LogTP	TP (ug/L)	Logsalinit	salinity (mg/L)	PCA AX1	111Lakes minimum sq. chord
0.5	1	1996.3	1.389	24.49	2.194	156.3	147	0.412
2.5	3	1991.6	1.297	19.82	2.157	143.5	57	0.4246
4.5	5	1988.8	1.39	24.55	2.216	164.4	79	0.4795
6.5	7	1986.7	1.32	20.89	2.145	139.6	-49	0.3594
8.5	9	1983.9	1.379	23.93	2.192	155.6	80	0.4166
10.5	11	1979.4	1.372	23.55	2.166	146.6	20	0.3758
12.5	13	1974.5	1.345	22.13	2.152	141.9	-6	0.7224
14.5	15	1970.0	1.358	22.80	2.171	148.3	-16	0.5462
16.5	17	1965.5	1.364	23.12	2.159	144.2	71	0.4277
18.5	19	1961.1	1.301	20.00	2.163	145.5	-36	0.5705
20.5	21	1956.7	1.348	22.28	2.107	127.9	-86	0.4204
22.5	23	1952.2	1.36	22.91	2.144	139.3	-107	0.3749
24.5	25	1947.3	1.365	23.17	2.148	140.6	98	0.2554
26.5	27	1941.0	1.302	20.04	2.13	134.9	-43	0.4106
28.5	29	1934.3	1.33	21.38	2.129	134.6	6	0.2268
30.5	31	1926.7	1.339	21.83	2.142	138.7	79	0.2926
32.5	33	1919.1	1.294	19.68	2.09	123.0	-133	0.271
34.5	35	1911.5	1.279	19.01	2.094	124.2	-72	0.4052
36.5	37	1902.6	1.314	20.61	2.134	136.1	-4	0.1982
38.5	39	1890.0	1.318	20.80	2.11	128.8	-86	0.2342

APPENDIX B-1

SUMMARY PB210 ANALYSES BY MYCORE - NICOLA LAKE

Sample Number	Disk #	Section Top	of Cor Bottom	Sample Weight used	209 Po Counts	210 Po Counts	210 Po Meas	210 Po	Precisn 1 STD
		(cm)	(cm)	(mg)			(Bq/g)	(Bq/g)	(%)
Nicola Lake, B.C.									
33	481	0.0	0.5	1066	6665	726	0.062	0.063	3.9
34	482	2.0	2.5	993	5423	670	0.075	0.076	4.1
35	483	4.0	4.5	1025	4094	388	0.055	0.056	5.3
36	484	6.0	6.5	1044	3347	256	0.044	0.044	6.5
37	485	8.0	8.5	998	3978	471	0.071	0.073	4.9
38	486	10.0	10.5	1092	5928	653	0.061	0.062	4.1
39	487	12.0	12.5	999	5534	699	0.076	0.078	4.0
40	488	14.0	14.5	1016	6744	738	0.065	0.066	3.9
41	489	16.0	16.5	1038	7458	577	0.045	0.046	4.3
42	490	20.0	20.5	1046	7307	465	0.036	0.037	4.8
43	491	24.0	24.5	1049	6606	376	0.032	0.033	5.3
44	492	28.0	28.5	1054	6880	395	0.033	0.034	5.2
45	493	36.0	36.5	1028	4351	205	0.028	0.029	7.1
46	494	42.0	42.5	1048	5286	216	0.023	0.024	6.9
47	495	50.0	50.5	1115	3537	112	0.017	0.019	9.6
48	496	58.5	59.0	1055	3474	95	0.015	0.017	10.4
REPEAT COUNTING									
35	483	4.0	4.5	1025	3017	278	0.054	0.060	6.3
36	484	6.0	6.5	1044	2737	151	0.032	0.035	8.4
37	485	8.0	8.5	998	2397	258	0.065	0.072	6.6
38	486	10.0	10.5	1092	2155	231	0.059	0.066	6.9
39	487	12.0	12.5	999	4555	535	0.071	0.081	4.6
40	488	14.0	14.5	1016	4475	399	0.053	0.060	5.2

SUMMARY PB210 CALCULATIONS FOR DETERMINING DATES - NICOLA LAKE

			Back calculate to coring (KRL)										
	Section Top	of Core Bottom	Date Po Sample Extracte			Date of coring			Time since coring	Decay Corr. to Extractn	Decay Corr. to Coring	Sample Weight used	Std dev
	(cm)	(cm)	(year)	(month)	(day)	(year)	(month)	(day)	(days)	(Bq/g)	(Bg/g)	(g)	(Bg/g)
Nicola Lake													
	0.0	0.5	98	10	1	98	7	20	73	0.0625	0.0629	1.066	0.0024
	2.0	2.5	98	10	1	98	7	20	73	0.0761	0.0766	0.993	0.0029
	4.0	4.5	98	10	1	98	7	20	73	0.0560	0.0564	1.025	0.0029
	6.0	6.5	98	10	1	98	7	20	73	0.0444	0.0447	1.044	0.0029
	8.0	8.5	98	10	1	98	7	20	73	0.0726	0.0730	0.998	0.0034
	10.0	10.5	98	10	1	98	7	20	73	0.0620	0.0624	1.092	0.0026
	12.0	12.5	98	10	1	98	7	20	73	0.0781	0.0786	0.999	0.0030
	14.0	14.5	98	10	1	98	7	20	73	0.0662	0.0666	1.016	0.0025
	16.0	16.5	98	10	1	98	7	20	73	0.0458	0.0461	1.038	0.0020
	20.0	20.5	98	10	1	98	7	20	73	0.0372	0.0375	1.046	0.0018
	24.0	24.5	98	10	1	98	7	20	73	0.0332	0.0334	1.049	0.0018
	28.0	28.5	98	10	1	98	7	20	73	0.0337	0.0339	1.054	0.0017
	36.0	36.5	98	10	1	98	7	20	73	0.0286	0.0288	1.028	0.0020
	42.0	42.5	98	10	1	98	7	20	73	0.0241	0.0242	1.048	0.0017
	50.0	50.5	98	10	1	98	7	20	73	0.0186	0.0188	1.115	0.0019
	58.5	59.0	98	10	1	98	7	20	73	0.0170	0.0171	1.055	0.0018
repeats Nicola													
	4.0	4.5	98	10	1	98	7	20	73	0.0596	0.0600	1.025	0.0036
	6.0	6.5	98	10	1	98	7	20	73	0.0350	0.0353	1.044	0.0029
	8.0	8.5	98	10	1	98	7	20	73	0.0722	0.0727	0.998	0.0045
	10.0	10.5	98	10	1	98	7	20	73	0.0657	0.0661	1.092	0.0045
	12.0	12.5	98	10	1	98	7	20	73	0.0807	0.0812	0.999	0.0035
	14.0	14.5	98	10	1	98	7	20	73	0.0603	0.0606	1.016	0.0031

APPENDIX B-2

CALCULATIONS FOR INPUT INTO BINFORD PROGRAM

Nicola
Pb210

		Back calculated to coring				
INTTOP (cm)	INTBOT (cm)	Pb-210 (Bq/g) activity	Std dev (Bg/g)	Pb210 activity (pCig-1)	Std dev (pCig-1)	Rho (g cm-3)
0.0	0.5	0.0629	0.0024	1.6999	0.0651	0.3598
2.0	2.5	0.0766	0.0029	2.0698	0.0797	0.1183
4.0	4.5	0.0564	0.0029	1.5232	0.0783	0.1148
6.0	6.5	0.0447	0.0029	1.2069	0.0771	0.0874
8.0	8.5	0.0730	0.0034	1.9736	0.0908	0.0974
10.0	10.5	0.0624	0.0026	1.6866	0.0690	0.1521
12.0	12.5	0.0786	0.0030	2.1246	0.0803	0.0941
14.0	14.5	0.0666	0.0025	1.8008	0.0668	0.0801
16.0	16.5	0.0461	0.0020	1.2462	0.0529	0.1572
20.0	20.5	0.0375	0.0018	1.0124	0.0480	0.1165
24.0	24.5	0.0334	0.0018	0.9029	0.0477	0.1853
28.0	28.5	0.0339	0.0017	0.9153	0.0473	0.1429
36.0	36.5	0.0288	0.0020	0.7776	0.0551	0.1033
42.0	42.5	0.0242	0.0017	0.6552	0.0456	0.1277
50.0	50.5	0.0188	0.0019	0.5070	0.0506	0.1826
58.5	59.0	0.0171	0.0018	0.4628	0.0488	0.1930
			avg	0.484878	=supported Pb210	
			stds	0.031294	0.547466	

BINFORD FILE FOR CALCULATION OF DATES AND SEDIMENTATION RATES

Nicola Lake
C1
16
0.0313

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)
0.0	0.5	1.6999	1.2150	0.3598	0.12	0.0000	0.1799	0.0651
2.0	2.5	2.0698	1.5849	0.1183	0.12	0.3711	0.4303	0.0797
4.0	4.5	1.5232	1.0383	0.1148	0.10	0.5817	0.6390	0.0783
6.0	6.5	1.2069	0.7221	0.0874	0.09	0.7791	0.8228	0.0771
8.0	8.5	1.9736	1.4888	0.0974	0.11	0.9739	1.0226	0.0908
10.0	10.5	1.6866	1.2017	0.1521	0.10	1.2121	1.2882	0.0690
12.0	12.5	2.1246	1.6397	0.0941	0.13	1.4678	1.5149	0.0803
14.0	14.5	1.8008	1.3159	0.0801	0.12	1.6457	1.6857	0.0668
16.0	16.5	1.2462	0.7613	0.1572	0.10	1.8520	1.9306	0.0529
20.0	20.5	1.0124	0.5275	0.1165	0.11	2.3765	2.4347	0.0480
24.0	24.5	0.9029	0.4180	0.1853	0.09	2.8945	2.9871	0.0477
28.0	28.5	0.9153	0.4304	0.1429	0.09	3.5185	3.5899	0.0473
36.0	36.5	0.7776	0.2927	0.1033	0.09	4.5510	4.6026	0.0551
42.0	42.5	0.6552	0.1703	0.1277	0.09	5.3049	5.3688	0.0456
50.0	50.5	0.5070	0.0000	0.1826	0.08	6.5699	6.6612	0.0506
58.5	59.0	0.4628	0.0000	0.1930	0.10	8.1648	8.2613	0.0488

OUTPUT FROM BINFORD PROGRAM

APPENDIX B-3

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YOU ARE ANALYZING CORE C1                   FROM LAKE Nicola Lake

THE DATA ARE:
INTTOP  INTBOT  PB210ACT  UNSUPACT   RHO      PERCORG  CUMMASST  CUMMASSB  SDACT
  0.0     0.5   1.69990   1.21500   0.35980   0.120    0.0000    0.1799   0.0651
  2.0     2.5   2.06980   1.58490   0.11830   0.120    0.3711    0.4303   0.0797
  4.0     4.5   1.52320   1.03830   0.11480   0.100    0.5817    0.6390   0.0783
  6.0     6.5   1.20690   0.72210   0.08740   0.090    0.7791    0.8228   0.0771
  8.0     8.5   1.97360   1.48880   0.09740   0.110    0.9739    1.0226   0.0908
 10.0    10.5   1.68660   1.20170   0.15210   0.100    1.2121    1.2882   0.0690
 12.0    12.5   2.12460   1.63970   0.09410   0.130    1.4678    1.5149   0.0803
 14.0    14.5   1.80080   1.31590   0.08010   0.120    1.6457    1.6857   0.0668
 16.0    16.5   1.24620   0.76130   0.15720   0.100    1.8520    1.9306   0.0529
 20.0    20.5   1.01240   0.52750   0.11650   0.110    2.3765    2.4347   0.0480
 24.0    24.5   0.90290   0.41800   0.18530   0.090    2.8945    2.9871   0.0477
 28.0    28.5   0.91530   0.43040   0.14290   0.090    3.5185    3.5899   0.0473
 36.0    36.5   0.77760   0.29270   0.10330   0.090    4.5510    4.6026   0.0551
 42.0    42.5   0.65520   0.17030   0.12770   0.090    5.3049    5.3688   0.0456
 50.0    50.5   0.50700   0.00000   0.18260   0.080    6.5699    6.6612   0.0506
 58.5    59.0   0.46280   0.00000   0.19300   0.100    8.1648    8.2613   0.0488

STANDARD DEVIATION OF SUPPORTED PB-210 =  0.0313


Pb-210 dates for Lake Nicola Lake        core C1

INTTOP  INTBOT  MIDINT   TTOP   SDTTOP   TBOT   SDTBOT  SEDRATE  SDSEDRT  SUMTOP
  0.0     0.5    0.2     0.00   0.54     1.80   0.54    0.1001   0.0139   4.0148
  2.0     2.5    2.2     5.78   0.57     6.69   0.58    0.0650   0.0107   3.3538
  4.0     4.5    4.2     9.00   0.60     9.63   0.60    0.0901   0.0153   3.0339
  6.0     6.5    6.2    11.09   0.62    11.45   0.62    0.1219   0.0211   2.8420
  8.0     8.5    8.2    13.19   0.64    14.07   0.65    0.0549   0.0107   2.6628
 10.0    10.5   10.2    17.26   0.69    18.54   0.71    0.0596   0.0111   2.3455
 12.0    12.5   12.2    22.35   0.77    23.61   0.79    0.0373   0.0082   2.0019
 14.0    14.5   14.2    26.99   0.85    27.98   0.87    0.0404   0.0088   1.7323
 16.0    16.5   16.2    31.38   0.95    32.68   0.98    0.0606   0.0128   1.5110
 20.0    20.5   20.2    40.28   1.16    41.15   1.19    0.0667   0.0155   1.1455
 24.0    24.5   24.2    49.01   1.43    50.47   1.48    0.0636   0.0170   0.8727
 28.0    28.5   28.2    61.48   1.95    63.19   2.04    0.0417   0.0139   0.5919
 36.0    36.5   36.2    91.71   4.07    93.89   4.33    0.0238   0.0138   0.2309
 42.0    42.5   42.2   128.22  11.18   133.32  12.97    0.0125   0.0142   0.0741
Execution terminated : 0

C:\pb210>
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APPENDIX C

NICOLA LAKE - DIATOM RELATIVE ABUNDANCES (%)

Sample Depth

Taxa	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 calcar	0.00	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
Achnanthes clevei	0.00	0.00	0.00	0.00	0.23	0.23	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00
Achnanthes conspicua	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.38	0.00	0.23	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49
Achnanthes exigua	0.00	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	0.49	0.00	0.00	0.00	0.00
Achnanthes joursacense	0.00	0.24	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	0.00	0.00	0.00	0.67	0.24
Achnanthes lanceolata	0.00	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	0.00
Achnanthes lanceolata var. dubia	0.00	0.00	0.00	0.72	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.22	0.00
Achnanthes lanceolata spp. freq	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.57	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00
Achnanthes minutissima	0.00	0.98	0.23	0.24	0.00	0.00	0.22	0.00	0.00	0.46	0.00	0.46	0.00	0.73	0.00	0.24	0.45	1.02	1.33	0.00
Achnanthes ziegleri	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	0.00	0.00	0.22	0.00
Achnanthes spp.	0.24	0.73	0.00	0.00	0.23	1.15	0.44	0.00	0.00	0.00	0.00	0.00	0.25	0.24	0.43	0.00	0.00	0.41	1.33	0.24
Amphora inariensis	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	0.00	0.00	0.00	0.00
Amphora libyca	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	0.00	0.00	0.00	0.00	0.00
Amphora pediculus	0.00	0.24	0.45	1.43	0.92	0.46	0.22	0.95	0.46	0.23	1.21	0.23	0.00	0.49	1.30	1.22	0.00	0.20	1.33	0.73
Amphora thumensis	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asterionella formosa	4.36	12.20	2.95	3.34	3.68	5.08	7.51	2.86	4.87	8.31	2.67	1.14	3.22	8.29	6.91	7.09	9.15	8.57	5.10	2.68
Aulacoseira ambigua	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.57	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.49	0.67	2.24	0.00	0.00
Aulacoseira granulata	2.42	1.22	0.91	0.72	0.92	0.23	15.01	3.62	5.80	0.92	4.61	0.46	0.99	1.46	0.00	3.18	0.22	0.41	0.00	0.49
Aulacoseira subarctica	16.95	9.02	26.14	7.88	21.38	9.47	6.62	14.10	11.60	2.31	1.46	2.73	3.47	1.71	3.02	1.71	0.45	0.61	0.22	0.73
Aulacoseira valve	0.73	0.98	1.59	0.24	0.92	1.39	0.66	0.76	0.46	0.00	0.24	0.23	0.99	0.00	0.22	0.00	0.00	0.20	0.00	0.00
Cocconeis placentula var. euglypta	0.73	0.24	0.45	0.24	0.00	0.23	0.44	0.38	0.23	0.69	0.73	0.68	0.00	0.00	0.22	0.00	0.00	0.20	0.44	0.49
Cocconeis placentula var. lineata	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.38	0.00	0.00	0.00	0.23	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cocconeis placentula var. placentula	0.00	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	0.20	0.00	0.00
Cyclotella bodanica var. leminica	0.24	1.71	0.68	1.43	0.46	0.00	0.44	1.71	1.39	2.77	1.46	0.46	0.99	0.73	0.65	0.98	0.67	0.61	0.67	0.49
Cyclotella ocelatta	0.00	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
Cymbella minuta	0.00	0.00	0.00	0.48	0.23	0.23	0.44	0.00	0.46	0.23	0.00	0.23	0.25	0.00	0.00	0.00	0.00	0.20	0.00	0.00
Cymbella muelleri	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.24	0.22	0.20	0.22	0.00
Cymbella silesiaca	0.73	0.49	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.25	0.00	0.00	0.00	0.45	0.20	0.22	0.00
Cymbella sinuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.25	0.24	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella sp (PL45)	0.00	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	0.44	0.00
Cymbella spp.	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	0.00	0.20	0.00	0.00
Denticula kuetzingii	0.00	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	0.49	0.00	0.41	0.00	0.00
Epithemia sorex	0.00	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	0.00	0.00	0.00	0.00	0.00	0.00
Fragilaria brevistriata	2.91	1.22	0.68	0.48	0.69	0.00	0.44	0.00	0.00	0.00	1.46	1.37	0.00	0.00	0.86	0.24	1.79	3.06	0.44	0.00
Fragilaria capucina	1.94	4.39	1.59	1.91	0.92	3.70	19.43	13.33	3.71	21.02	8.25	16.86	2.23	14.88	2.16	7.82	4.02	6.53	2.00	5.85
Fragilaria capucina cf. var. gracilis	1.45	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	0.65	0.00	0.00	0.00	0.00	0.00
Fragilaria capucina var. mesolepta	0.24	0.73	0.45	0.24	1.15	0.23	5.30	4.00	2.09	4.62	3.16	3.42	0.74	2.44	0.22	0.73	0.00	3.67	0.00	1.22
Fragilaria construens	0.24	0.49	0.00	0.24	1.15	0.00	0.44	0.00	1.16	0.00	2.18	0.00	0.00	0.49	0.00	0.00	0.00	0.41	0.44	0.00
Fragilaria crotonensis	1.94	7.07	2.73	5.73	0.46	0.23	4.19	2.29	3.25	6.93	2.43	0.46	0.00	6.83	1.30	0.24	1.34	3.67	1.33	8.29
Fragilaria lapponica	0.00	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.50	0.00	0.43	0.24	0.45	0.00	0.00	0.00
Fragilaria leptostauron	0.00	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	0.41	0.00	0.00
Fragilaria mazamaensis	0.00	0.24	0.23	0.48	0.00	0.69	0.00	0.00	0.00	0.00	0.24	0.00	0.25	0.24	0.00	0.24	0.00	0.20	0.00	0.24
Fragilaria pinnata	1.45	5.37	3.41	0.95	1.61	2.31	4.64	3.05	2.78	6.47	4.61	1.14	4.46	1.22	2.81	1.96	1.56	8.78	3.55	2.20
Fragilaria pinnata var. intercedens	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	0.00	0.00	0.00	0.00	0.00
Fragilaria tenera	0.00	0.00	1.14	2.39	0.23	0.23	0.00	0.38	0.23	0.00	0.00	0.00	0.50	0.49	1.08	0.00	0.00	0.00	0.00	0.00
Fragilaria ulna	0.00	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	0.49	0.00	0.00	0.00	0.00
Fragilaria ulna var. acus	0.00	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	0.00	0.00	0.00	0.00	0.00
Fragilaria spp.	0.00	0.00	0.00	0.00	0.00	0.23	0.66	0.57	0.93	0.00	0.24	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.24
Gomphonema angustum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.23	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.41	0.22	0.00
Gomphonema parvulum	0.00	0.00	0.00	0.00	0.00	0.00	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
Gomphonema spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.49	0.00	0.24	0.22	0.41	0.00	0.00
Mastogloia smithii var. lacustris	0.00	0.00	0.00	0.24	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
Navicula clementis	0.00	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	0.41	0.00	0.00
Navicula cryptonella	0.00	0.00	0.00	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	0.00	0.44	0.00
Navicula cryptonella fo. 1	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	0.00	0.00	0.00	0.00	0.00
Navicula diluviana	0.00	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00
Navicula indifferens	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula af. minuscula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.00	0.43	0.00	0.00	0.41	0.00	0.00
Navicula minima	0.00	0.73	0.23	0.48	0.00	0.00	0.22	0.57	0.00	0.00	0.73	0.00	0.00	0.49	0.65	0.98	0.00	0.00	0.00	0.00
Navicula pseudoventralis	0.00	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	0.43	0.00	0.45	0.00	0.00	0.00
Navicula pupula	0.00	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	0.44	0.00
Navicula schoenfeldii	0.00	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	0.41	0.00	0.00
Navicula scutelloides	0.00	0.00	0.23	0.24	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	0.22	0.00
Navicula tripunctata	0.00	0.00	0.00	0.00	0.00	0.23	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
Navicula aff. utermoehlii	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	0.41	0.00	0.00
Navicula veneta	0.00	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	0.00	0.00	0.00	0.00	0.00
Navicula vitabunda	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navicula spp.	0.24	1.46	0.00	0.72	1.15	1.15	0.88	0.19	0.23	1.15	0.24	1.14	0.74	1.46	0.65	0.24	0.89	1.22	0.89	0.24
Nitzschia acicularis	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.19	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia amphibia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia bacillum	0.00	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	0.41	0.44	0.00
Nitzschia dissipata	0.48	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.22	0.20	0.00	0.49
Nitzschia frustulum	0.00	0.98	0.45	0.72	0.00	0.00	0.44	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.43	0.00	0.45	0.00	0.67	0.49
Nitzschia inconspicua	0.00	0.00	0.00	0.00	0.00	0.23	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
Nitzschia palea	0.48	0.49	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	0.00	0.00
Nitzschia paleacea	0.00	0.00	0.68	0.24	0.46	1.15	0.44	0.19	0.00	0.69	0.49	0.00	0.00	0.00	0.22	0.00	0.00	0.61	0.44	0.00
Nitzschia sp. 1 PISCES	0.00	0.00	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	0.00	0.00	0.00	0.00
Nitzschia spp.	0.48	0.24	0.00	0.48	0.00	0.92	0.44	0.19	0.00	0.92	0.00	0.00	0.00	0.49	0.43	0.00	0.00	0.00	0.00	0.00
Stephanodiscus hantzschii	0.00	0.73	0.00	0.48	0.23	0.92	0.22	0.00	0.23	0.46	0.24	0.23	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00
Stephanodiscus hantzschii fo. tenuis	0.24	0.24	0.91	0.24	0.00	0.23	0.22	0.19	0.70	0.46	2.91	0.46	1.24	0.24	0.22	0.24	0.67	1.22	0.22	0.00
Stephanodiscus medius	0.24	1.46	0.91	2.39	2.07	0.69	0.00	0.19	0.00	0.00	0.00	0.00	0.74	0.49	0.00	0.00	0.00	0.20	0.67	0.24
Stephanodiscus minutulus	45.04	22.68	27.95	16.71	34.25	29.79	9.27	14.86	32.02	9.70	10.92	13.90	49.26	17.32	32.18	42.79	11.38	8.98	32.59	19.76
Stephanodiscus niagarae	0.73	2.44	1.36	1.19	0.23	0.23	1.55	1.33	1.62	1.62	1.94	0.46	0.99	1.22	1.30	1.71	3.13	3.06	0.22	0.24
Stephanodiscus parvus	12.59	15.37	21.59	42.72	25.52	34.18	18.10	30.86	21.35	24.94	44.90	52.62	25.99	35.61	38.23	23.96	60.27	38.37	40.80	52.93
Stephanodiscus cf. vestibulus	2.42	2.44	1.36	0.95	0.00	3.00	0.22	0.19	2.32	1.39	0.49	0.91	0.74	0.98	1.94	1.22	0.22	0.20	0.00	0.73
Girdle view unknown	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	0.00	0.49	0.45	0.00	0.67	0.00
Pennate undiff.	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.19	0.00	0.23	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00