ASSESSMENT OF CHANGES IN TOTAL PHOSPHORUS IN ROUND LAKE, B.C: A PALEOLIMNOLOGICAL ASSESSMENT (January 2004)

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<u>List of Figures and Appendices:</u>

BACKGROUND

A sediment core was retrieved from Round Lake with a modified K-B corer (internal diameter ~6.35 cm) on March 20, 2003 by Ian Sharpe and A.J. Downie. A 42-cm core was retrieved from the single deep basin. Samples were sectioned into 1.0 cm intervals, which were stored at the Ministry and later shipped to Queen's University where they were stored in our coldroom at 4 °C. All the samples were weighed to determine the total wet weight of sediment prior to subsampling for ^{210}Pb, loss-on-ignition and diatom analyses. Twenty intervals were subsampled for diatoms every one cm from 0 to 10.0 cm, then every two cm from 12 to 28 cm. Fifteen intervals, spaced at 1-cm intervals for the top 5 cm, then 2 cm from 8 to 14 cm, and then 4-8 cm to the bottom of the core, were prepared for ^{210}Pb analysis (see below) and then counted on the gamma counter facilities at PEARL, Queen's University.

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. Twenty-two samples (an additional 7 samples were dried just for percent organic matter analyses) were dried in the freeze drier at PEARL (24 hr. cycle). Dry weight of the sediment and percent water was determined. Dry sediment was then precisely weighed into a plastic tube for gamma spectroscopy for the fifteen ^{210}Pb samples. These samples were then sealed with epoxy and allowed to sit for two weeks in order for ^{214}Bi to equalize for determination of supported ^{210}Pb used in estimating core chronology. Activities of ^{210}Pb, ^{137}Cs and supported ^{210}Pb (via ^{214}Bi) were determined for each sample. These spectra were then used to estimate the chronology of the core.

The activities (in disintegrations per minute/gram) of ^{210}Pb, ^{137}Cs and ^{214}Bi were determined using the procedures outlined in Schelske et al. (1994). These values were converted into picoCuries/gram for use in the Binford program (see below). Unsupported ^{210}Pb was calculated by subtracting supported ^{210}Pb (via ^{214}Bi counts from all samples within each of the cores) from the total ^{210}Pb activity at each level. The sediment chronology and sedimentation rates were calculated using the constant rate of supply (CRS) model (Appleby and Oldfield, 1978) from the estimates of ^{210}Pb activities and estimates of cumulative dry mass (Binford, 1990). See Appendix B for a summary of ^{210}Pb calculations.

Percent organic matter was determined for twenty-two samples, including the fifteen that were ^{210}Pb dated (Appendix A) using standard loss-on-ignition methods (Dean, 1974). Briefly, 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.

Diatom Preparation and Enumeration

Slides for diatom analysis were prepared using standard techniques (Cumming et al. 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 approximately 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 valves were enumerated with a Leica DMRB microscope equipped with DIC optics at 1000X magnification (Numerical Aperature of objective = 1.3). These analyses were based on the references of Krammer and Lange-Bertalot (1986, 1988, 1991a,b), Patrick and Reimer (1966, 1975) and Cumming et al. (1995).

Diatom-based Reconstructions of Total Phosphorus

Inferences of total phosphorus from the diatom assemblages in the core are based on a phosphorus model developed from 111 freshwater lakes from the 219 lakes sampled by Wilson et al. (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 et al. (1995) for several reasons including its better predictive ability and the larger number of samples which provide more analogs for downcore reconstructions.

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

Determination of the Main Direction of Variation

The main direction of variation in the diatom assemblages in the core was determined from the first axis scores from a principal components analysis (PCA) ordination using non-transformed species abundance data (Fig. 1D). A PCA was chosen to represent the main direction of variation of the diatom assemblages in these cores based on the small gradient length (< 1.5 standard deviation units) obtained in an initial detrended correspondence analysis (DCA) ordination.

Analog Analysis of Diatom Assemblages

The reliability of the total phosphorus inferences in the core assumes that the diatom assemblage encountered downcore are well represented in our modern diatom assemblages. To determine if appropriate analogs existed for the core samples, we determined which samples in our present-day dataset of 111 lakes most resembled each of the downcore samples. This determination was based on a squared chord dissimilarity coefficient between all species found in each of the core samples. The best match between downcore and modern samples was compared with the distribution of best match between modern samples. Any downcore samples that were more dissimilar than 80% of the modern distribution were deemed to be a 'poor analog'.

Similarly, any downcore samples that were more dissimilar than 95% of the modern distribution were deemed to have 'no analog' in our present-day dataset. If the downcore assemblages have good representation in modern samples, more confidence can be placed in the reconstruction. If modern analogs do not exist or are poor, then caution must be placed in reconstructions from these downcore samples.

RESULTS AND DISCUSSION

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

The ^{210}Pb activity of the Round Lake core was very low and showed some diversions from an expected exponential decay with core depth (Fig. 1A), potentially as the result of variations in sediment deposition. At 2cm (estimated date of 1996) there is a decrease in ^{210}Pb activity, which corresponds to a peak in the estimated sedimentation rate and a sharp decline in percent organic matter. The discrete ^{137}Cs peak suggests the core itself was not disturbed (Fig. 2). A distinct peak in ^{137}Cs is a marker for 1963, since 1963 corresponds to the peak in atmospheric testing of nuclear weapons, and consequently fallout of isotopes such as ^{137}Cs. The measured ^{137}Cs peak in the Round Lake core occurs at 8 cm, which has an estimated ^{210}Pb date of 1969. Given that the ^{137}Cs peak may occur slightly off of 8 cm (if all samples could be measured), this is a good match between ^{210}Pb and ^{137}Cs.

Results from the CRS model suggest that sedimentation rates started to increase in the 1950s, with larger increases in the 1980s (Fig. 1B). However, sedimentation rates are best estimated from several cores within a basin because sedimentation rates may vary across a basin. Analysis of organic matter (OM) from the core indicates relatively stable conditions ranging between 26 to 35%, with the exception of the sample at 2 cm (estimated date of 1996) in which OM reaches a low of 20%. Decreases in organic matter can be attributed to several factors including decreased in-lake production of organic matter, decreased inwash of organic matter, or increases in the load of inorganic matter to the lake.

Diatom Assemblage Changes and Analyses

Fifty-one diatom taxa were documented in the core from Round Lake. However, the majority of these taxa are extremely rare. The dominant taxon throughout the past 250 years of the lake's history was *Stephanodiscus parvus*, a meso-eutrophic planktonic taxon. Other sub-dominant taxa include the meso-eutrophic planktonics *Asterionella formosa*, *Fragilaria crotonensis*, *Aulacoseira ambigua* and *Stephanodiscus minutulus.*

Cluster analysis suggests three periods of diatom assemblages in the past 250 years, however the low total sum of squares indicates these changes are small (Fig. 3). The difference in the diatom assemblages found in Zones B and A is based primarily on the presence of rarer taxa such as *Cyclotella bodanica* v. *lemanica*, *Fragilaria pinnata* and *Achnanthes* in Zone B (period prior to 1935), which based on the B.C. lake dataset have slightly lower optima to total phosphorus. However, their abundances are very low, as a consequence because the inferred total phosphorus (TP) values are based on an average weighted by the percent abundance of each taxon there is no change in the estimated TP values between these two zones. A*ulacoseira ambigua* becomes reduced to trace amount around 1984 (Zone a, 0 to 5 cm). This taxon, like the dominants and other sub-dominants, is a meso-eutrophic taxon. However, this taxon flourishes better under more turbulent (windy) conditions. The loss of this taxon in recent sediments may suggest that there has been a change in lake column stability to more stable stratified conditions.

Diatom-inferred total phosphorus (TP) estimates indicate stable mid-summer mesotrophic-eutrophic conditions (TP between 19 to 20 μgL^{-1}, Fig. 1E) during the last 250 years of the lake's history. The correlation between the main direction of variation in taxa (i.e. PCA axis 1 scores) (Fig. 1D) and the log TP inferences is very low ($r = 0.37$) indicating that the small changes seen in the diatom assemblages are not consistent with the small and variable changes seen in the TP estimates. The small changes seen in the diatom assemblages may be related to changes in turbulence or water column stability, or other environmental variables. Analog analysis suggests that all samples had extremely good analogs in the calibration set of modern diatom assemblages (Fig. 1F) providing evidence that the TP inferences are likely reliable.

<u>Summary</u>

In summary, the TP levels of Round Lake have remained stable during the last 250 years at around 20 μgL^{-1}. The diatom flora was dominated by *Stephanodiscus parvus*, meso-eutrophic planktonic, throughout this period. The disappearance in *Aulacoseira ambigua* in the 1980s indicates potential changes in water column stability over the past 20 years.

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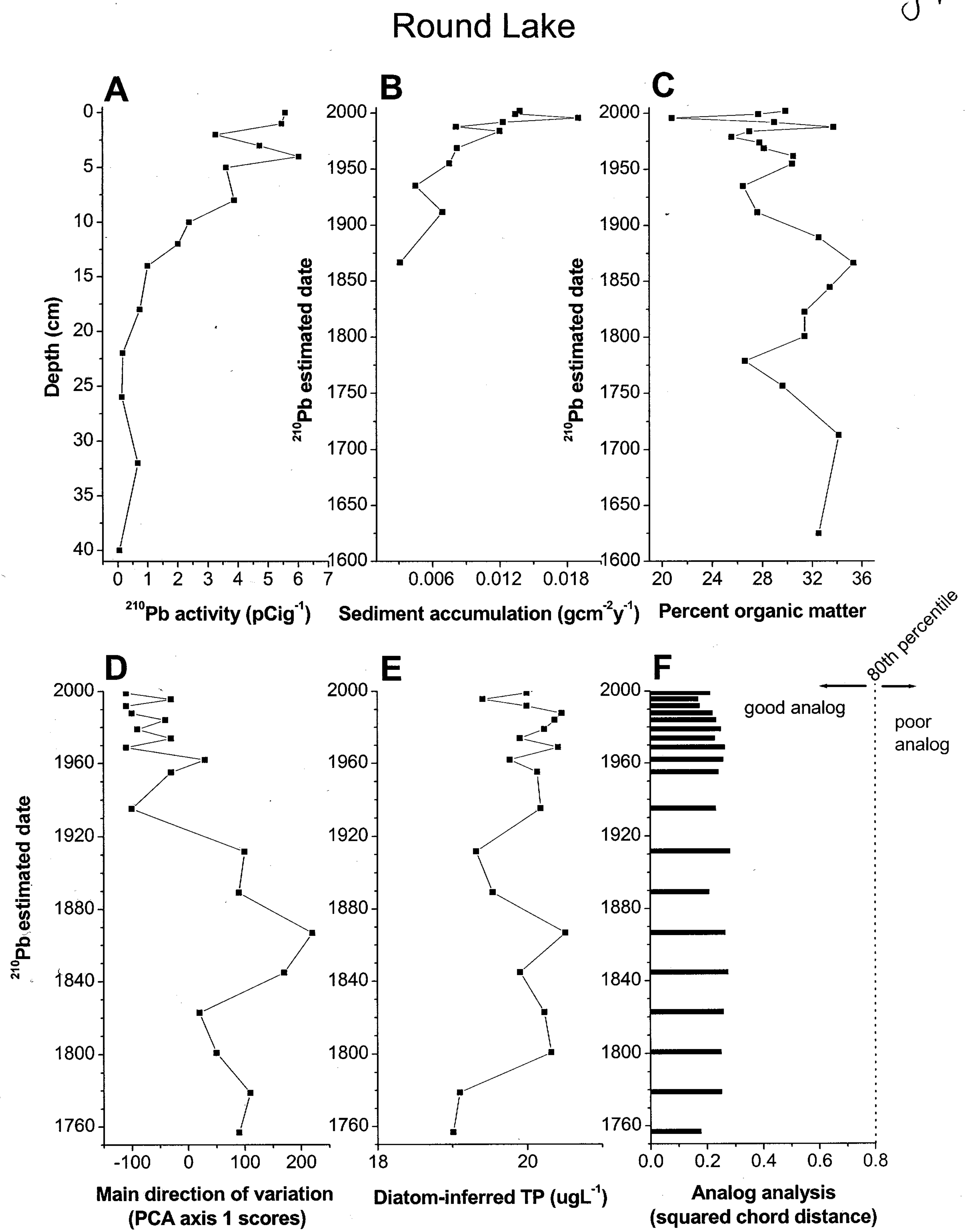
FIGURE CAPTIONS

Figure 1. Summary diagram for Round Lake showing: A) total ^{210}Pb activity; B) the sediment accumulation rate; C) the change in the percent of organic matter in the core; D) the main direction of variation in the diatom assemblage data; E) diatom-based estimated of 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. ^{210}Pb profile and ^{137}Cs profile for Round Lake.

Figure 3. Stratigraphy of the most abundant diatom taxa found in the sediment core from Round Lake, B.C. (see Appendix C-1 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.

Fig. 1



Round Lake
A
B
C
D
E
F
Depth (cm)
210Pb activity (pCig-1)
210Pb estimated date
Sediment accumulation (gcm-2y-1)
Percent organic matter
Main direction of variation
(PCA axis 1 scores)
Diatom-inferred TP (ugL-1)
Analog analysis
(squared chord distance)
80th percentile
good analog
poor
analog

Fig. 2

Round Lake

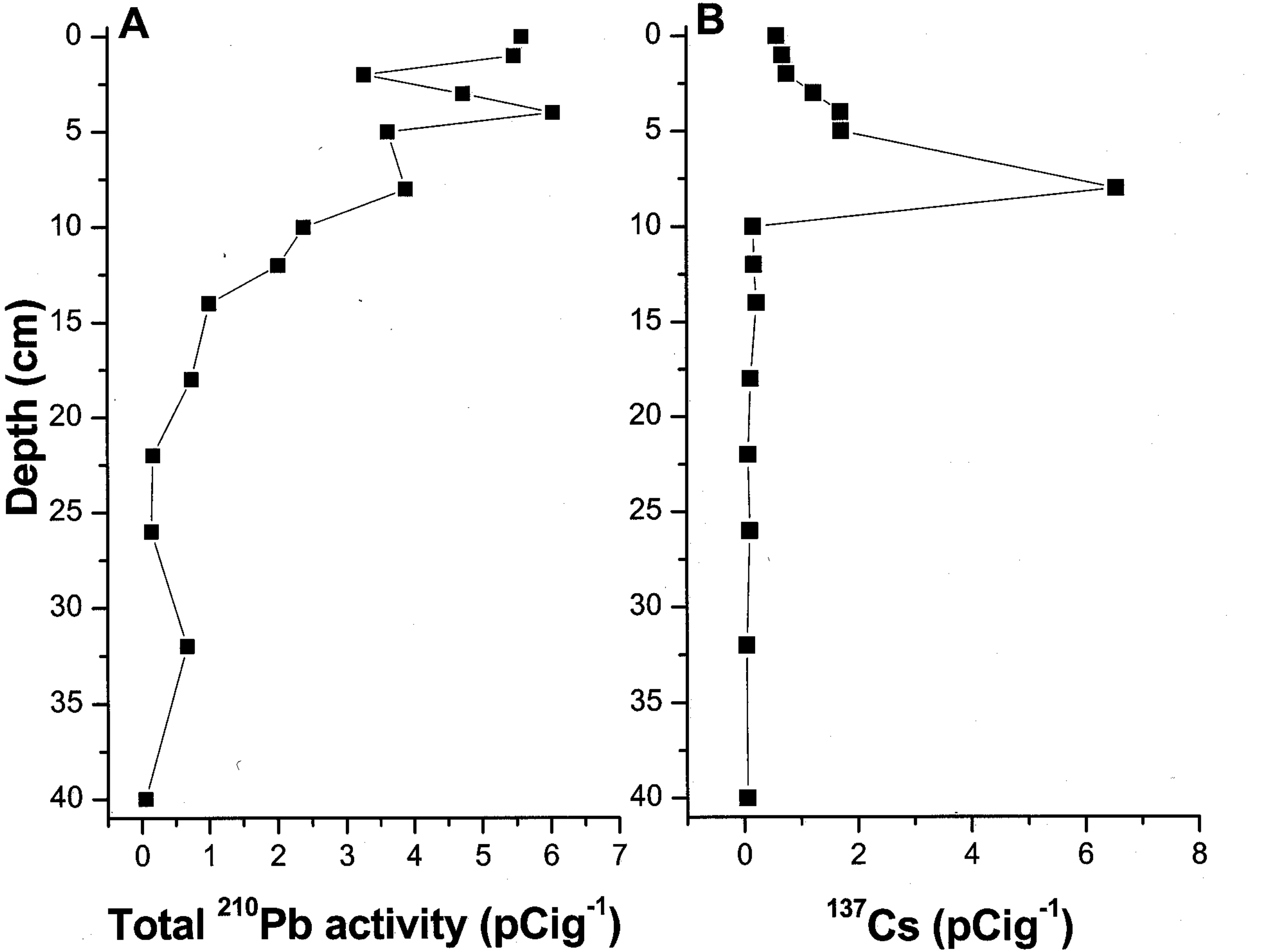
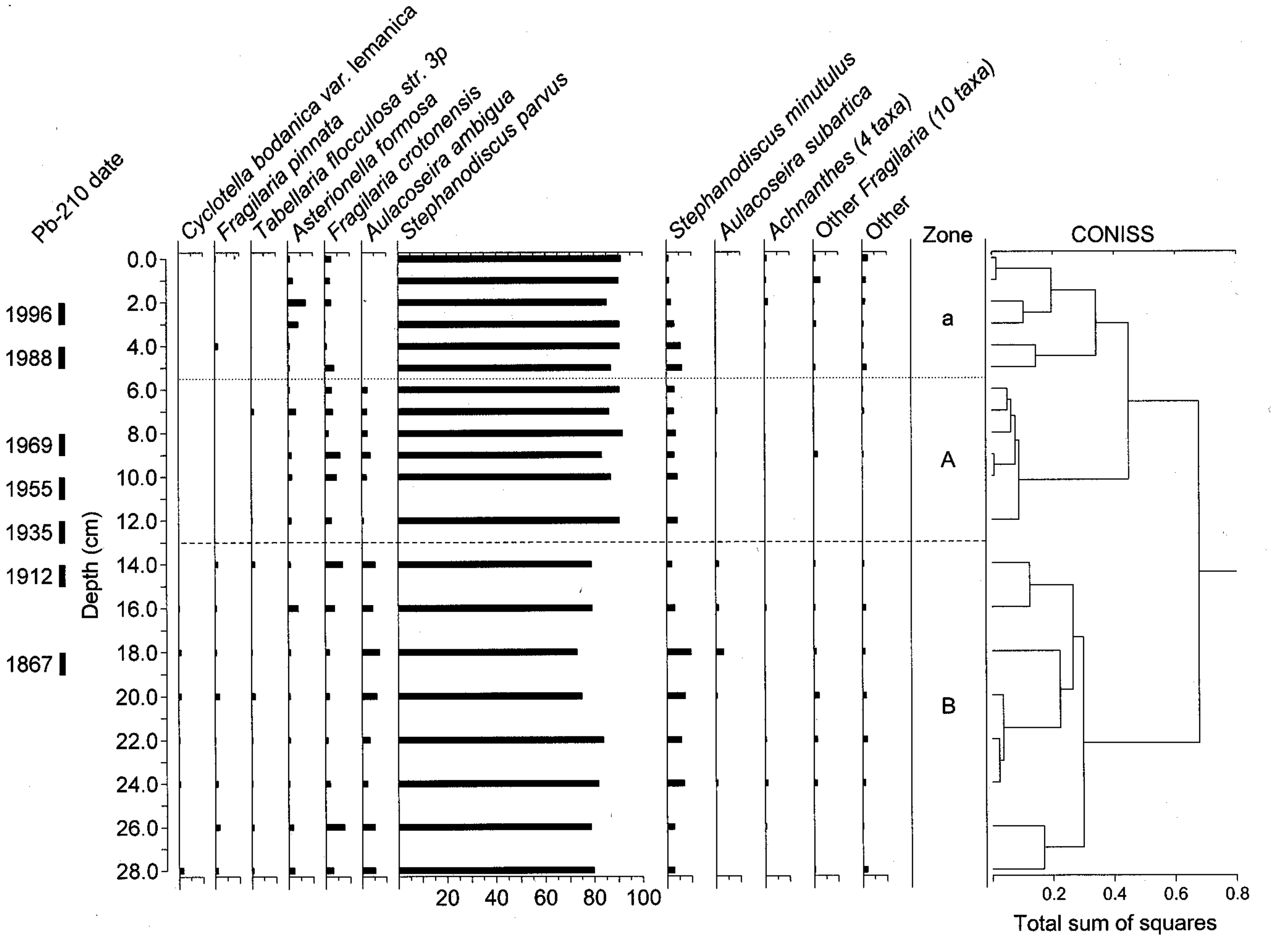


Fig. 3

Round Lake



Appendix A

Summary File Round Lake

Pb210 and LOI summary
* = extrapoloted dates

INTTOP (cm)	INTBOT (cm)	137Cs (pCig-1)	Pb210Act (pCi/g)	Time Top	Standard deviation Top	Time Bottom	Standard deviation Bottom	estimated AD date	SEDRATE (g/cm2/yr)
0	1	0.5778	5.5716	0	1.44	2.27	1.49	2002.1	0.0138
1	2	0.6798	5.4601	2.27	1.49	5.95	1.56	1999.1	0.0134
2	3	0.7512	3.2597	5.95	1.56	9.17	1.63	1995.7	0.019
3	4	1.2268	4.7224	9.17	1.63	13.52	1.74	1991.9	0.0123
4	5	1.7002	6.0305	13.52	1.74	17.3	1.87	1987.8	0.0081
5	6	1.7103	3.6094	17.3	1.87	21.22	2.01	1984.0	0.012
8	9	6.5562	3.8813	31.15	2.44	37.73	2.8	1968.8	0.0082
10	11	0.1678	2.3793	44.57	3.33	51.69	3.96	1955.1	0.0075
12	13	0.1773	2.0141	61.15	5.13	75.11	7.46	1935.1	0.0045
14	15	0.2238	1.0030	87.26	10.59	95.88	13.26	1911.7	0.0069
18	19	0.1181	0.7388	128.63	30.24	144.44	47.39	1866.7	0.0031
22	23	0.0706	0.1670						
26	27	0.1013	0.1454						
32	33	0.0488	0.6722						
40	41	0.0550	0.0534						

INTTOP (cm)	INTBOT (cm)	estimated AD date	LOI(550C) %organic
0	1	2002.1	29.86
1	2	1999.1	27.69
2	3	1995.7	20.79
3	4	1991.9	28.97
4	5	1987.8	33.74
5	6	1984.0	26.97
6	7	1978.9	25.56
7	8	1973.9	27.79
8	9	1968.8	28.14
9	10	1962.0	30.49
10	11	1955.1	30.39
12	13	1935.1	26.48
14	15	1911.7	27.61
16	17	1889.2	32.55
18	19	1866.7	35.36
20	21	1844.7	33.43
22	23	1822.8	31.42
24	25	1800.8	31.41
26	27	1778.8	26.62
28	29	1756.8	29.62
32	33	1712.9	34.16
40	41	1625.0	32.52

Diatom analyses

Depth (cm TOP	Depth (cm BOTTOM	estimated AD date	log TP	TP	PCA Axis 1	ANALOG min. sq.chord
0	1	2002.1	1.306	20.23	-120	0.2276
1	2	1999.1	1.301	20.00	-110	0.2114
2	3	1995.7	1.288	19.41	-30	0.1703
3	4	1991.9	1.301	20.00	-110	0.1740
4	5	1987.8	1.311	20.46	-100	0.2200
5	6	1984.0	1.309	20.37	-40	0.2325
6	7	1978.9	1.306	20.23	-90	0.2497
7	8	1973.9	1.299	19.91	-30	0.2287
8	9	1968.8	1.310	20.42	-110	0.2639
9	10	1962.0	1.296	19.77	30	0.2580
10	11	1955.1	1.304	20.14	-30	0.2414
12	13	1935.1	1.305	20.18	-100	0.2321
14	15	1911.7	1.286	19.32	100	0.2821
16	17	1889.2	1.291	19.54	90	0.2082
18	19	1866.7	1.312	20.51	220	0.2656
20	21	1844.7	1.299	19.91	170	0.2747
22	23	1822.8	1.306	20.23	20	0.2592
24	25	1800.8	1.308	20.32	50	0.2504
26	27	1778.8	1.281	19.10	110	0.2511
28	29	1756.8	1.279	19.01	90	0.1786

Regression Output:		
Constant		5187.66
Std Err of Y Est		97.81264
R Squared		0.149551
No. of Observations		20
Degrees of Freedom		18
X Coefficient(s)	-3990.43	
Std Err of Coef.	2242.914	

Appendix B-1

Round- 210Pb ROI data **Cored on March 20, 2003** **GAMMA COUNTER**

Top Int (cm)	Bot Int (cm)	Mid pt	Date counted	counting ti (s)	mass g/dry wt	hieght in tube (mm)	Bkgr RO11	210-Pb RO12	Bkgr RO13	Bkgr RO14	226-Ra RO15	Bkgr RO16	Bkgr RO17	137-Cs RO18	Bkgr RO19
0	1	0.5	27 Nov 03	80000	0.69	22.48	300	964	288	80	213	78	64	246	61
1	2	1.5	28 Nov 03	80000	1.0081	32.27	355	1114	303	95	253	70	79	344	80
2	3	2.5	29 Nov 03	80000	1.1851	29.22	350	984	300	89	229	97	85	394	60
3	4	3.5	30 Nov 03	80000	0.9003	31.86	353	1052	344	85	234	77	73	456	84
4	5	4.5	1 Dec 03	80000	0.8222	32.76	317	1056	330	95	216	71	86	530	70
5	6	5.5	2 Dec 03	80000	0.8504	31.53	315	878	306	83	210	87	71	540	74
8	9	8.5	4 Dec 03	80000	0.8379	34.11	315	889	314	70	227	62	138	1687	107
10	11	10.5	5 Dec 03	80000	0.8793	33.64	306	762	289	77	184	72	73	186	73
12	13	12.5	6 Dec 03	80000	0.8626	32.5	309	721	271	86	184	82	70	168	56
14	15	14,5	8 Dec 03	80000	0.8767	33.4	338	695	289	74	202	71	54	172	65
18	19	18.5	9 Dec 03	80000	0.8643	33.62	269	580	263	74	200	68	54	144	62
22	23	22.5	11 Dec 03	80000	0.8627	34.29	307	597	306	80	199	71	52	126	57
26	27	26.5	12 Dec 03	80000	0.8542	32.81	290	569	273	79	202	73	76	128	74
32	33	32.5	13 Dec 03	80000	0.8608	33.73	267	570	260	92	180	76	63	108	55
40	41	40.5	14 Dec 03	80000	0.7658	34.02	296	575	280	78	178	83	52	108	66

Top Int (cm)	Bot Int (cm)	corrected for efficiency & density **210Pb (dpm/g)**	**214Bi (dpm/g)**	corrected for sampling date **137Cs (dpm/g)**	210Pb error 1 std. dev. (dpm/g)	214Bi error 1 std. dev. (dpm/g)	137Cs error 1 std. dev. (dpm/g)	corrected for efficiency & density **210Pb (dps/g)**	**214Bi (dps/g)**	corrected for sampling date **137Cs (dps/g)**	210Pb error 1 std. dev. (dps/g)	214Bi error 1 std. dev. (dps/g)	137Cs error 1 std. dev. (dps/g)
0	1	12.369	0.893	1.283	0.638	0.120	0.117	0.2061	0.0149	0.0214	0.0106	0.0020	0.0019
1	2	12.121	1.284	1.509	0.568	0.137	0.111	0.2020	0.0214	0.0252	0.0095	0.0023	0.0018
2	3	7.237	0.380	1.668	0.396	0.058	0.106	0.1206	0.0063	0.0278	0.0066	0.0010	0.0018
3	4	10.484	1.106	2.723	0.556	0.130	0.157	0.1747	0.0184	0.0454	0.0093	0.0022	0.0026
4	5	13.388	0.729	3.775	0.662	0.103	0.195	0.2231	0.0122	0.0629	0.0110	0.0017	0.0033
5	6	8.013	0.480	3.797	0.500	0.076	0.191	0.1335	0.0080	0.0633	0.0083	0.0013	0.0032
8	9	8.616	1.737	14.555	0.534	0.178	0.383	0.1436	0.0289	0.2426	0.0089	0.0030	0.0064
10	11	5.282	0.370	0.373	0.409	0.063	0.059	0.0880	0.0062	0.0062	0.0068	0.0010	0.0010
12	13	4.471	-0.034	0.394	0.377	0.009	0.061	0.0745	-0.0006	0.0066	0.0063	0.0001	0.0010
14	15	2.227	0.838	0.497	0.270	0.111	0.068	0.0371	0.0140	0.0083	0.0045	0.0018	0.0011
18	19	1.640	0.874	0.262	0.237	0.115	0.050	0.0273	0.0146	0.0044	0.0039	0.0019	0.0008
22	23	-0.371	0.664	0.157	0.093	0.096	0.038	-0.0062	0.0111	0.0026	0.0015	0.0016	0.0006
26	27	0.323	0.702	-0.225	0.132	0.099	0.048	0.0054	0.0117	-0.0037	0.0022	0.0017	0.0008
32	33	1.492	-0.122	-0.108	0.228	0.035	0.034	0.0249	-0.0020	-0.0018	0.0038	0.0006	0.0006
40	41	0.119	-0.015	-0.122	0.119	0.004	0.039	0.0020	-0.0002	-0.0020	0.0020	0.0001	0.0006

Appendix B-2

Round Lake - Pb210

CALCULATIONS FOR INPUT INTO BINFORD PROGRAM

1 dps= 1Becquerrel

INTTOP (cm)	INTBOT (cm)	Pb-210 (dps/g) activity	Std dev Pb-210 (dps/g)	214Bi (dps/g)	137Cs (dps/g)	137Cs (pCig-1)	Pb210 activity (pCig-1)	Std dev Pb-210 (pCig-1)	214Bi (pCig-1)	Rho (g cm-3)
0	1	0.206149	0.010631	0.014879	0.021377	0.5778	5.5716	0.2873	0.4021	0.0314
1	2	0.202022	0.009461	0.021406	0.025152	0.6798	5.4601	0.2557	0.5785	0.0492
2	3	0.12061	0.006599	0.00634	0.027794	0.7512	3.2597	0.1784	0.1714	0.0609
3	4	0.174728	0.009274	0.018432	0.04539	1.2268	4.7224	0.2506	0.4982	0.0537
4	5	0.223127	0.011033	0.012151	0.062909	1.7002	6.0305	0.2982	0.3284	0.0304
5	6	0.133546	0.00833	0.008005	0.063281	1.7103	3.6094	0.2251	0.2163	0.0470
8	9	0.143608	0.008906	0.028949	0.242581	6.5562	3.8813	0.2407	0.7824	0.0539
10	11	0.088034	0.006812	0.006168	0.006209	0.1678	2.3793	0.1841	0.1667	0.0533
12	13	0.07452	0.006276	0.000568	0.00656	0.1773	2.0141	0.1696	0.0153	0.0625
14	15	0.037111	0.0045	0.013964	0.008282	0.2238	1.0030	0.1216	0.3774	0.0591
18	19	0.027336	0.003946	0.014563	0.004369	0.1181	0.7388	0.1066	0.3936	0.0488
22	23	0.006179	0.001545	0.011069	0.002611	0.0706	0.1670	0.0418	0.2992	0.0513
26	27	0.005381	0.002197	0.011703	0.003748	0.1013	0.1454	0.0594	0.3163	0.0739
32	33	0.024873	0.003793	0.002027	0.001805	0.0488	0.6722	0.1025	0.0548	0.0680
40	41	0.001976	0.001976	0.000243	0.002036	0.0550	0.0534	0.0534	0.0066	0.0756
									0.307145	
									0.214414	

BINFORD FILE INPUTS FOR CALCULATIONS OF DATES AND SEDIMENTATION RATES

Round
C1
15.00
0.2144

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	1	5.5716	5.1694	0.0314	0.2986	0.0000	0.0314	0.2873
1	2	5.4601	4.8815	0.0492	0.2769	0.0314	0.0807	0.2557
2	3	3.2597	3.0884	0.0609	0.2079	0.0807	0.1415	0.1784
3	4	4.7224	4.2242	0.0537	0.2897	0.1415	0.1952	0.2506
4	5	6.0305	5.7021	0.0304	0.3374	0.1952	0.2256	0.2982
5	6	3.6094	3.3930	0.0470	0.2697	0.2256	0.2726	0.2251
8	9	3.8813	3.0989	0.0539	0.2814	0.3367	0.3906	0.2407
10	11	2.3793	2.2126	0.0533	0.3039	0.4402	0.4935	0.1841
12	13	2.0141	1.9987	0.0625	0.2648	0.5497	0.6122	0.1696
14	15	1.0030	0.6256	0.0591	0.2761	0.6750	0.7341	0.1216
18	19	0.7388	0.3452	0.0488	0.3536	0.8875	0.9363	0.1066
22	23	0.1670	0.0000	0.0513	0.3142	1.0955	1.1468	0.0418
26	27	0.1454	0.0000	0.0739	0.2662	1.3532	1.4271	0.0594
32	33	0.6722	0.0000	0.0680	0.3416	1.7821	1.8500	0.1025
40	41	0.0534	0.0000	0.0756	0.3252	2.3626	2.4381	0.0534

Because of the high variability in 214Bi I used individual counts to substract from the total 210Pb to get supported as opposed to the calculated average above

see Appendix A for summary of output from the Binford 210Pb program (CRS model).

Appendix C

Round Lake - January 2004 (Analyst: Dr. KR Laird) **Percent abundance of diatom taxa**

Top of 1 cm interval

Taxa	0	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	22	24	26	28
Achnanthes conspicua	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	0.00	0.00	0.45	0.00
Achnanthes lanceolata spp. freq.	0.00	0.00	0.00	0.00	0.00	0.00	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
Achnanthes minutissima	0.47	0.25	1.43	0.24	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.49	0.00	0.00
Achnanthes spp.	0.23	0.25	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	0.23	0.00	0.00	0.00	0.00
Amphora pediculus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.73
Asterionella formosa	0.70	1.97	7.16	4.13	0.69	0.65	0.72	3.14	0.47	1.43	1.47	1.21	0.91	4.13	0.97	0.70	0.74	0.49	1.81	2.43
Aulacoseira ambigua	0.00	0.00	0.20	0.00	0.00	0.00	2.42	2.10	2.36	3.58	1.97	0.73	5.48	4.59	7.28	6.07	3.22	2.19	5.22	5.35
Aulacoseira granulata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.23	0.00	0.00	0.00	0.00
Aulacoseira subartica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.24	0.00	0.00	1.14	1.15	3.16	0.47	0.00	0.73	0.23	0.00
Cocconeis placentula var. euglypta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
Cocconeis placentula var. linearis	0.00	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Craticula ambigua	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	0.00	0.00	0.00	0.00	0.00	0.00
Cyclotella bodanica var. lemanica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.46	0.97	1.17	0.50	0.73	0.00	1.95
Epithemia adnata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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
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	0.00	0.00	0.00	0.00	0.00	0.00	0.49
Fragilaria brevistriata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Fragilaria capucina	0.00	1.48	0.00	0.73	0.00	0.00	0.00	0.00	0.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.49
Fragilaria capucina v. mesolepta	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	0.47	0.00	0.00	0.00	0.00
Fragilaria construens	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
Fragilaria crotonensis	2.56	1.97	2.45	0.24	0.69	3.67	2.66	3.14	1.42	6.21	4.67	2.66	7.08	3.90	1.70	1.64	0.99	1.95	7.71	3.16
Fragilaria cyclopum	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	0.46	0.00	0.93	0.99	0.49	0.00	0.00
Fragilaria lata	0.00	0.00	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 nanana	0.93	1.48	0.41	0.00	0.00	0.65	0.24	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Fragilaria pinnata	0.47	0.00	0.00	0.24	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	0.69	0.73	1.87	0.25	1.22	1.81	1.22
Fragilaria tenera	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	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	0.23	0.00	0.24	0.00	0.00
Fragilaria spp.	0.00	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	0.97	0.00	0.25	0.24	0.00	0.00
Gomphonema angustum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.24
Navicula cf. cryptotenella	0.00	0.00	0.00	0.00	0.00	0.86	0.00	0.00	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 cryptotenella fo. 1	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	0.00	0.00	0.00	0.00	0.00
Navicula minima	0.00	0.00	0.00	0.00	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	0.24	0.00	0.00
Navicula radiosa	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	0.00
Navicula subhamulata	0.00	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	0.00	0.00	0.00	0.00	0.00	0.00
Navicula submuralis	0.00	0.00	0.00	0.49	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
Navicula subrotundata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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
Navicula spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.23	0.99	0.49	0.00	0.00
Nitzschia amphibia	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	0.00	0.00	0.00	0.00
Nitzschia cf. bacillum	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	0.46	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia dissapata v. med.	0.47	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	0.49
Nitzschia frustulum	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitzschia palea	0.00	0.00	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	0.00	0.00	0.00	0.00	0.00
Nitzschia cf. paleaceae	0.47	0.49	0.00	0.00	0.46	0.22	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
Nitzschia spp.	0.00	0.00	0.00	0.00	0.00	0.00	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
Stauroneis anceps fo. gracilis	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	0.00	0.00	0.00
Stephanodiscus medius	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
Stephanodiscus cf. minutulus	0.93	0.99	1.84	3.16	5.77	6.26	3.14	2.94	3.78	3.10	4.42	4.36	2.05	3.44	9.95	7.48	5.94	7.06	2.95	2.92
Stephanodiscus parvus	91.14	90.15	85.28	90.53	90.53	87.04	90.58	86.16	91.96	83.29	86.98	90.56	79.00	79.13	73.06	75.00	83.91	81.75	78.68	79.81
Tabellaria flocculosa var. linearis	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tabellaria flocculosa str. 3p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	1.37	0.00	0.24	1.64	0.50	0.49	0.91	0.73
Central area unknown	0.00	0.00	0.00	0.00	0.00	0.00	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
Centric unknown	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00