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Inland Lakes Sediment Trends: Sediment Analysis Results for Five Michigan Lakes

Yearly report: 2003-2004

Avalon Lake
Birch Lake
Muskegon Lake
Sand Lake
Shupac Lake

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Introduction

Contaminated sediments can directly impact bottom-dwelling organisms and represent a continuing source of toxic substances in aquatic environments that may impact wildlife and humans through food or water consumption (Catallo et al., 1995). Therefore, an understanding of the trends of toxic chemical (e.g., polychlorinated biphenyls, lead) accumulation in the environment is necessary to assess the current state of Michigan's surface water quality and to identify potential future problems. A common fate of chemicals in a lake is to associate with fine-grained particulate matter and settle to the bottom (Evans and Rigler, 1983). As this deposition occurs over time, sediments in lakes become a chemical tape recorder of the temporal trends of toxic chemicals in the environment as well as of general environmental change over time (von Guten et al., 1997). Sediment trend monitoring is consistent with the framework for statewide surface water quality monitoring outlined in the January 1997 report prepared by the Michigan Department of Environmental Quality entitled, "A Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters". A key goal of the monitoring program is to measure trends in the quality of Michigan's surface waters, and one activity designed to examine these trends is the collection and analysis of high-quality sediment cores. This report details the activities and findings of the fifth year of the sediment trend component of the Strategy, and builds upon the results from the five lakes sampled in 1999 (Year 1)(Simpson *et al.*, 2000), two lakes sampled in 2000 (Year 2) (Yohn et al., 2001), five lakes sampled in 2001 (Year 3) (Yohn *et al.*, 2002) and five lakes sampled in 2002 (Year 4) (Yohn *et al.*, 2003a).

Summary

Sediment cores were collected from five lakes in 2003 to evaluate the spatial and temporal variations in lake sediment quality in Michigan, and as a continuation of the trend monitoring component of the monitoring program (Simpson *et al.*, 2000). Lakes include: Avalon (Montmorency County), Birch (Cass), Muskegon (Muskegon), Sand (Lenawee), and Shupac (Crawford) lakes. Sediment cores were collected from one site in each lake, dated with ^{210}Pb and ^{137}Cs, and analyzed for a suite of metals and organic compounds. Analysis for a suite of metals rather than just target anthropogenic metals (e.g., Pb, Cu) allows for interpretations about the sources for different chemicals. Additionally, porewater was collected from each of the lakes and analyzed for a similar suite of metals. Key findings include:

- Muskegon Lake and Sand Lake exhibited very high sedimentation rates and do not reach background values of anthropogenic elements.
- Sediment concentrations of copper are elevated in Avalon Lake compared to the 2003 study lakes and exhibit a correlation to aluminum suggesting that terrestrial sources are contributing to the sediment copper concentration profile.
- Among the lakes sampled in 2003 Muskegon and Sand lakes have the highest surface sediment concentrations of copper, cadmium, lead and zinc. Lake Cadillac, sampled in 2001, has the highest surface sediment concentrations of all lakes for lead, zinc, and cadmium. Avalon Lake has the highest surface sediment concentrations of copper. Witch Lake has the highest surface sediment concentration of arsenic.
- Birch Lake has high lead and zinc focusing corrected anthropogenic accumulation rates among 2003 study lakes. Whitmore and Paw Paw lakes generally have the highest focusing corrected anthropogenic accumulation rates among all lakes. Cadillac and Houghton lakes having the highest copper accumulation rates.
- Accumulation rates of anthropogenic elements generally increase towards the surface in Avalon Lake. These trends have been observed previously, Lake Cadillac (Yohn *et al.*, 2002) Crystal B (Yohn *et al.*, 2002), Imp (Yohn *et al.*, 2003b) and Round lakes (Yohn *et al.*, 2003b).

Methods

Sediment cores were collected from Avalon (Montmorency County), Birch (Cass), Muskegon (Muskegon), Sand (Lenawee), and Shupac (Crawford) lakes in 2003 (Fig. 1, Table 1). Sediment cores were collected from the deepest portion of each lake using a MC-400 Lake/Shelf Multi-corer deployed from the Monitoring Vessel Nibi. The M/V Nibi was designed to, and has successfully provided access to both major and remote inland lakes throughout Michigan. Collected sediment cores were described and examined for color, texture, and signs of zoobenthos. Cores were then extruded and sectioned at 0.5 cm intervals for the top 8 cm, and at 1 cm intervals for the remainder of the core.

Table 1. Characteristics of study lakes.

Lake	Sampling year	Counties of watershed	Lake area (km^2)	Sampling depth (m)	Watershed area (km^2)
Avalon	2003	Montmorency	1.5	21.3	2
Birch	2003	Cass	1.2	29.6	2.2
Cadillac	2001	Wexford, Missaukee	4.7	8.2	48
Cass	1999	Oakland	5.2	36.6	9.1
Crystal B	2001	Benzie	39.3	49.7	106
Crystal M	2000	Montcalm	2.9	16.8	12
Elk	1999	Grand Traverse, Antrim, Kalkaska	31.3	58.8	217
Gratiot	1999	Keweenaw	5.8	23.8	31
Gull	1999	Kalamazoo, Barry	8.2	33.5	61
Higgins	1999	Roscommon, Missaukee, Crawford	38.9	41.5	108
Houghton	2002	Roscommon	81.2	5.5	450
Hubbard*	2001	Alcona	37.9	29.3	
Imp	2002	Gogebic	0.3	28.0	2.1
Littlefield	2000	Isabella	0.7	21.3	17
Mullett	2001	Cheboygan, Otsego	70.3	35.7	718
Muskegon	2003	Muskegon, Newaygo	16.8	14.5	53
Paw Paw	2001	Berrien, VanBuren	3.7	27.7	30
Round	2002	Luce	7.0	13.7	22
Sand	2003	Lenawee	1.8	17.3	24.5
Shupac	2003	Crawford	0.4	30.4	2.2
Torch	2002	Antrim, Kalkaska	76.0	86.0	198
Whitmore	2001	Washtenaw, Livingston	2.7	20.4	5.6
Witch	2002	Marquette	0.9	31.1	13

* A watershed was not delineated for Hubbard Lake.

^{210}Pb was measured on one sub-core from each lake to determine porosity, accumulated dry mass, sedimentation rates, sediment ages and focusing factors (Freshwater Institute in Winnipeg, Manitoba, Canada). Results from all lakes were verified using ^{137}Cs.

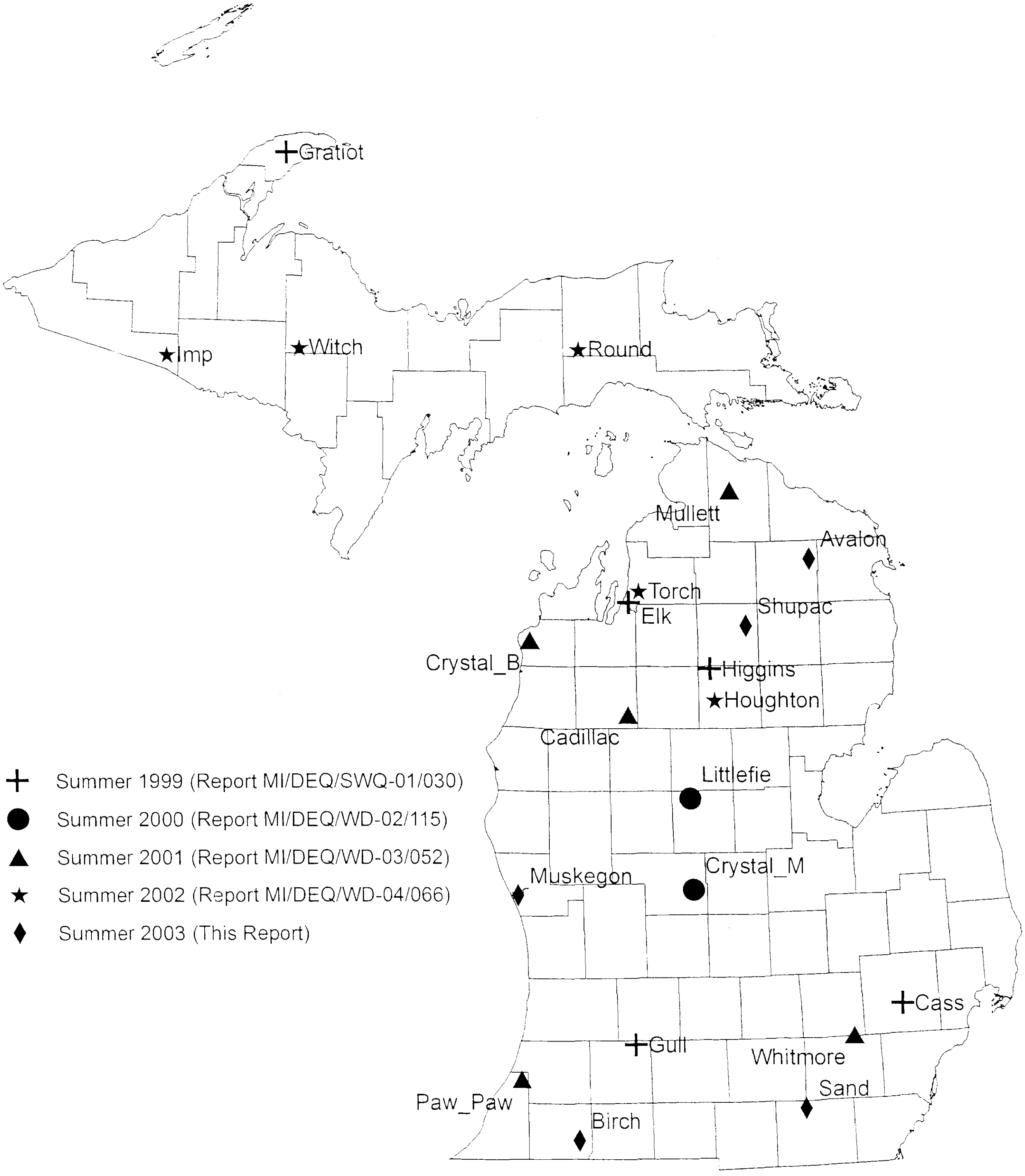


Fig. 1. Michigan lakes sampled in 1999, 2000, 2001, 2002, 2003.

Sediments were frozen, freeze-dried and digested by nitric acid in a CEM-MDS-81D microwave (Hewitt and Renyolds, 1990). Standard reference material (NIST RM 8704 Buffalo River Sediment) and procedural blanks were processed to test for accuracy and contamination. The concentrated-acid digests were filtered through an acid-washed, e-pure (Barnstead) rinsed 0.40 µm polycarbonate filter. Samples were then analyzed using a Micromass Platform inductively coupled, plasma, mass spectrometer with hexapole technology (ICP-MS-HEX). Sediments were analyzed for a suite of metals and metalloids including Mg, Al, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Sr, Mo, Cd, Ba, Pb, and U.

Another sub-core was sectioned and used for analysis of organic contaminants. There was insufficient material for analysis in the topmost sediments, so the first two sections were combined, and the third and fourth sections were combined. Polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), organochlorine (OC) pesticides (screening only), alkylphenols, and bisphenol A (BPA) were analyzed (Khim *et al.*, 1999a, Khim *et al.*, 1999b). A portion of the sediment was dried at 100°C to determine moisture content.

The fourth sub-core was used for the collection of porewater. The sediment core was squeezed 5-6 cm, forcing water through Porex into syringes placed every 1 cm (10 samples) then 2 cm (18 samples) from the top. The collected water was filtered through an acid washed, DDW rinsed 0.40 µm polycarbonate filter and preserved with nitric acid and gold (for mercury analysis). These solutions were analyzed on the ICP-MS-HEX in a similar fashion as the digested sediments (see the Appendix).

Descriptions of the calculations for data analysis follow this section.

^{210}Pb and sedimentation rates

The radioactive isotope 210-lead (^{210}Pb) was used to date sediments from each lake. Several models exist to determine sediment ages from ^{210}Pb activities, and sediments were dated using the constant flux: constant sedimentation rate model (CF:CS) (Golden et al., 1993), segmented CF:CS (SCF:CS) (Heyvaert et al., 2000), rapid steady state mixing model (RSSM) (Robbins, 1982), and the constant rate of supply model (CRS) (Sanchez-Cabeza et al., 2000). The CF:CS model assumes a constant sedimentation rate throughout the core. The RSSM model also assumes a constant sedimentation rate, but also allows for a mixed zone. The SCF:CS model allows for more than one sedimentation rate, and accounts for the mixed zone. The CRS model determines a different sedimentation rate for each sample. Further description of each of the models may be found in the 2001-2002 year end report (Yohn *et al.*, 2002).

For all models, sediment deeper than the presence of excess ^{210}Pb cannot be dated. Cores from Avalon (15 samples), Birch (15) and Shupac (13) lakes all had samples below the presence of excess ^{210}Pb. Therefore, dates older than this were determined for these lakes by extrapolation, using the assumption that sedimentation rates remain constant below this depth. For the RSSM, CF:CS, and SCF:CS model, the sedimentation rate in the lower portion of the core was used to extrapolate dates. For the CRS model, the average sedimentation rate in the last five samples was used. The sedimentation rate chosen to use for extrapolation has a significant effect on the resulting dates, and all dates older than 1850 should be considered estimations that are reported primarily for graphing purposes.

Sedimentation rates in each lake were determined using all models possible for that lake, and then the models were evaluated to ascertain which was the most appropriate to use in determining sediment ages. There is no consensus as to which model is more appropriate in all cases (Oldfield and Appleby, 1984), and several factors were considered when choosing a model. Visual examination of the ^{210}Pb profile gave some insight into the most appropriate model to be used. The RSSM or CRS models are more appropriate for lakes with large mixing zones, and the SCF:CS or CRS models are more appropriate for lakes with clear changes in sedimentation. Additionally, this study uses two other indicators to determine the most appropriate model to use: profiles of ^{137}Cs activity and stable lead concentration profiles. ^{137}Cs is an artificial radionuclide that was produced by atmospheric testing of nuclear weapons in the late 1950s and early 1960s. The peak level of fallout occurred in 1963, and therefore the peak activity in the sediment should occur in the early 1960s (Walling and Qingping, 1992). The second indicator is the stable lead peak. Stable lead has an historical pattern of deposition that is very consistent among lakes, with lead concentrations increasing from the mid-1800s to the early to mid-1970s, and decreasing to the present. The peak in lead concentrations in the mid-1970s due to the removal of lead from gasoline is consistent enough to use for dating verification (Alfaro-De la Torre and Tessier, 2002, Callender and vanMetre, 1997). Therefore the dating method with both the most appropriate date for the ^{137}Cs peak (1963-64) and stable lead peak (early to mid-1970s) was chosen.

Focusing factors were also determined from ^{210}Pb analysis. Focusing occurs when fine grained sediments in a lake are eroded from higher energy erosional zones near the shore of the lake, transported through transitional zones (where deposition and erosion occur episodically) and deposited in depositional zones (Downing and Rath, 1988, Hakanson, 1977). This process of focusing occurs at different extents among lakes, and must be accounted for using the focusing factor before comparing inventories and accumulation rates among lakes. A complete explanation of the focusing factor can be found in the 2001-2002 year end report (Yohn *et al.*, 2002).

Table 2. Select data from ^{210}Pb analysis, including the model used for dating, mixed depth, sedimentation rate (g/m^2/y), focusing factor (FF) and the age of the oldest section in the sediment core.

	Model	Approximate mixed depth (cm)	Sedimentation rate (g/m^2/y)	FF	Oldest section
Avalon	CRS	4 cm	296	1.53	1790[a]
Birch	CRS	2.5 cm	540	1.67	1824[a]
Cadillac	CRS	14 cm	117	1.7	1829[a]
Cass	CF:CS	3 cm	3480	6[c]	1971
Crystal B	CRS	4 cm	624	2.9	1516[a]
Crystal M	CRS	6 cm	465	1.7	1732[a]
Elk	SCF:CS	1 cm	337	2.1	1279[a]
Gratiot	CF:CS	5 cm	255	2.5	1823[a]
Gull	SCF:CS	3 cm	404	1.8	1496[a]
Higgins	CF:CS	3 cm	232	2.0	1729[a]
Houghton	SCF:CS	8 cm	165	1.2	1715[a]
Hubbard	NA	NA	NA	NA	NA
Imp	CRS	3 cm	119	1.5	1745[a]
Littlefield	Pb	NA	444	2.0[b]	1732[a]
Mullett	SCF:CS	4 cm	801	3.6	1708[a]
Muskegon	CF:CS	2.5 cm	1711	2.83[c]	1956
Paw Paw	CF:CS	3 cm	828	2.7[c]	1923
Round	CRS	7 cm	317	2.3	1851
Sand	CRS	0 cm	441	1.78	1864
Shupac	CRS	1 cm	261	1.95	1829[a]
Torch	Pb	0 cm	365	2.4	1493[a]
Whitmore	SCF:CS	6 cm	556	2.8[c]	1887
Witch	CRS	6 cm	269	1.7	1767[a]

a. Estimated dates based on extrapolation

b. A focusing factor could not be calculated for Littlefield Lake, so the average focusing factor of all lakes sampled previously (except Cass Lake) was used.

c. Estimated focusing factor based on extrapolation

Birch Lake had a small mixing zone (2.5 cm) and ^{210}Pb decay that was not log-linear (Fig. 2a). This non-linearity suggests that sedimentation rates varied over time, and that the CF:CS and RSSM models are not appropriate. The SCF:CS model, with five sedimentation rates, placed the ^{137}Cs peak at 1933 and the stable lead peak at 1941. The CRS model placed the ^{137}Cs peak at 1969 (expected 1963), and the stable lead peak at 1975 (expected 1972), therefore the CRS model was used.

Avalon Lake had a mixing zone of 4 cm and a ^{210}Pb decay that was not log linear (Fig 2a). RSSM and CF:CS and SCF:CS models did not adequately describe the ^{210}Pb or ^{137}Cs profiles. The CRS model place the ^{137}Cs peak at 1961 and the stable lead peak at 1974 and was used to date the Birch Lake core.

Muskegon Lake had a 2.5 cm mixed zone (Fig. 2a). The ^{210}Pb profile is nearly log-linear suggesting that sedimentation rates have not changed appreciably over time validating the use of the CF:CS model. Due to the high rate of sedimentation in Muskegon Lake the ^{137}Cs peak could not be used to confirm the dating model. The stable lead however appears to begin its decline in 1971 which suggests that the CF:CS model is adequate.

Shupac Lake had ^{210}Pb activities that were high at the sediment surface (Fig. 2b) and a small mixing zone (1 cm). The ^{210}Pb profile is near log-linear, suggesting the use of CF:CS and RSSM could be appropriate dating models. The CF:CS and RSSM placed the ^{137}Cs peak at 1966 and 1971 respectively whereas the CRS model placed the ^{137}Cs peak at 1961. The stable lead peak in Shupac Lake is bimodal. Using the CRS model the first stable lead peak is placed at 1969 and the second stable lead peak occurs in 1985. The CF:CS and RSSM models place the stable lead peaks more recently. It is evident that a distinct sedimentation rate change occurs during this time period, which may hinder the accurate dating of the Shupac Lake

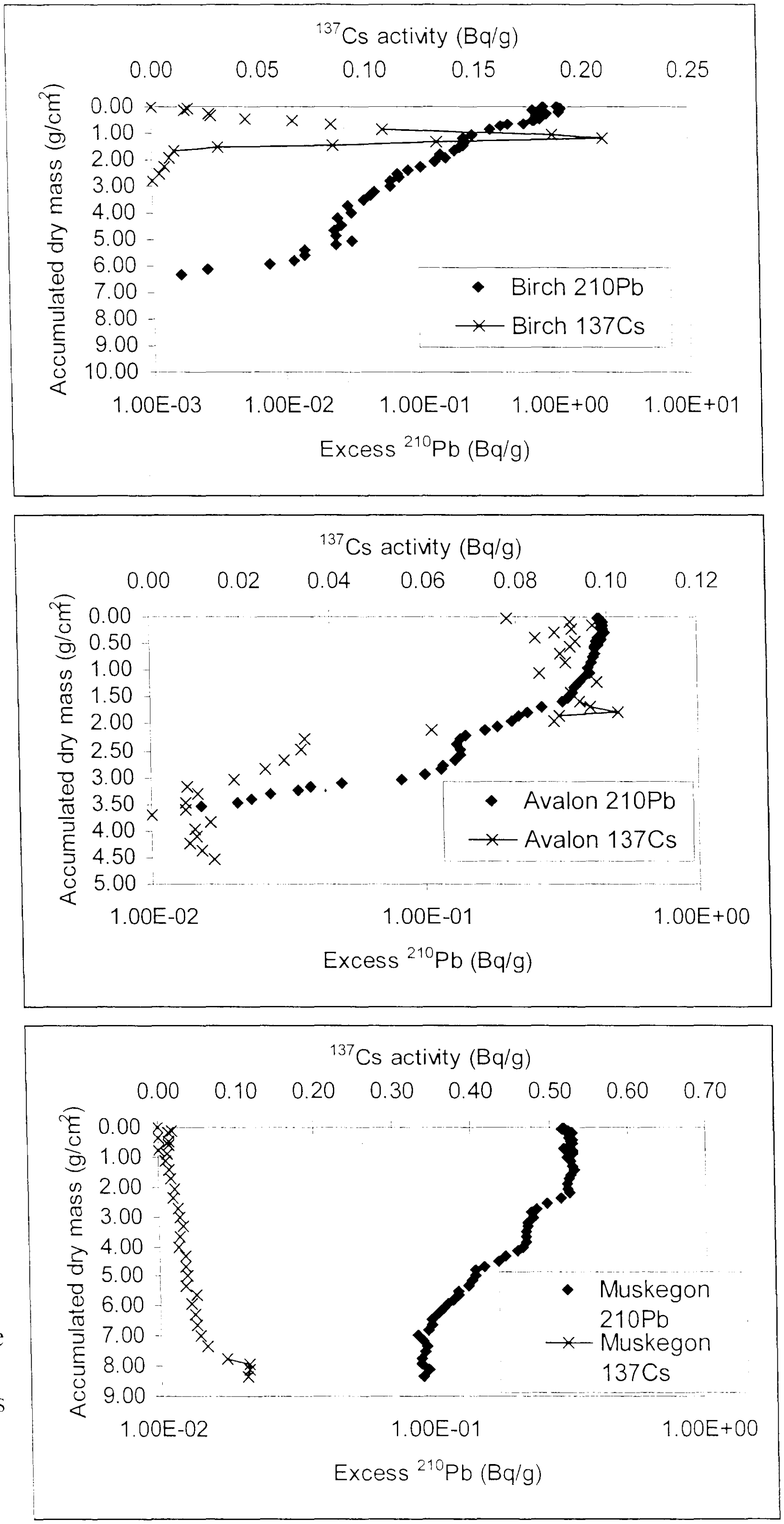


Fig. 2a. ^{137}Cs and ^{210}Pb activities (Bq/g) versus accumulated dry mass in Birch, Avalon, and Muskegon Lakes. ^{137}Cs is plotted on the top scale.

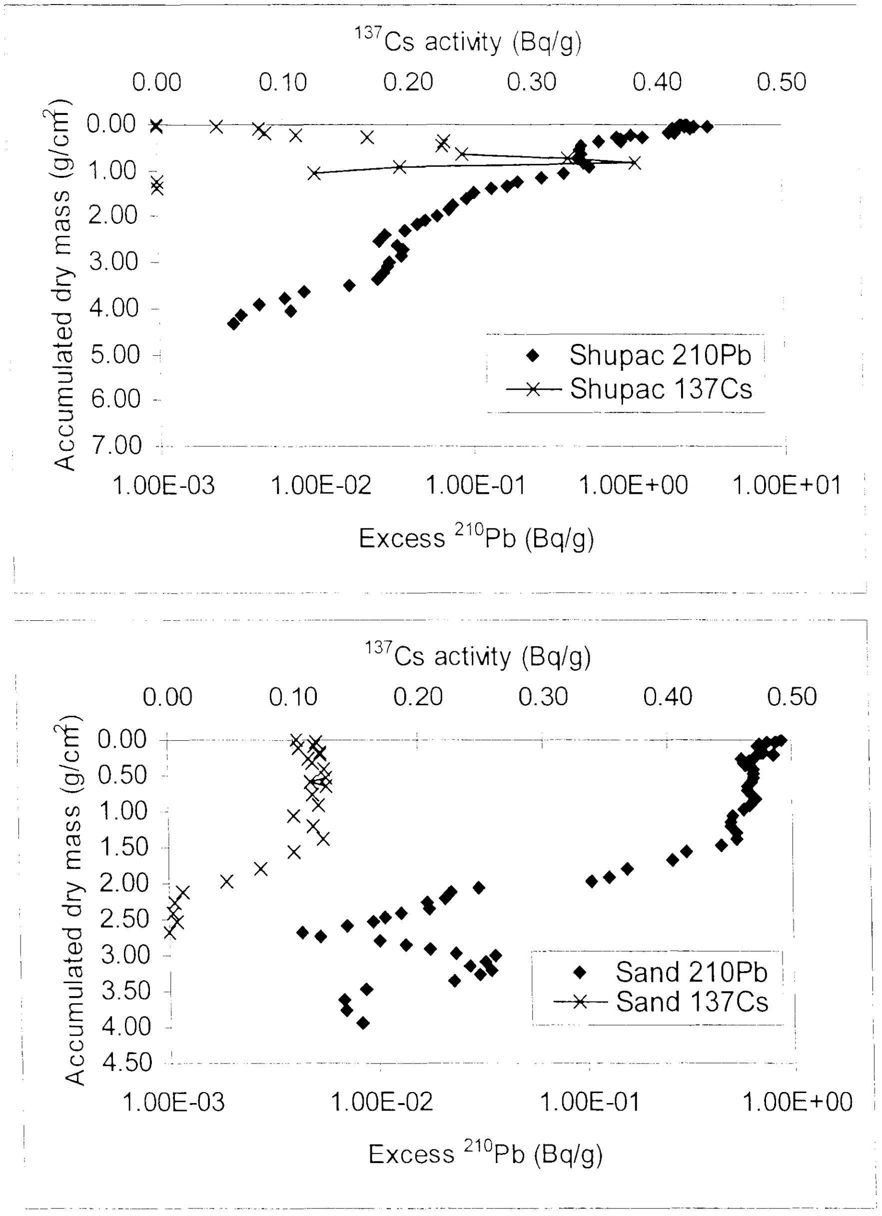


Fig. 2b. ^{137}Cs and ^{210}Pb activities (Bq/cm) versus accumulated dry mass in Shupac and Sand Lakes. ^{137}Cs is plotted on the top scale.

core. The CRS model was used to date this core.

Sand Lake did not have a readily apparent mixing zone but is characterized by high sedimentation rates in the top half of the core followed by relatively low sedimentation rates in the bottom portions (Fig 2b). Sand Lake also contains an area of the core with a negative slope near 2.5 g/cm^2 indicating very high sedimentation rates or another disturbance in the core. Excess ^{210}Pb activities were found in every section of the core indicating that the sediment has been deposited in the last 150 years. The ^{137}Cs peak is not clearly defined. Dating the core using the CRS model places the highest concentration of stable lead at 1997, however the stable lead concentration profile does appear to peak and remain relatively constant starting in 1985. The CRS model appears to have placed the stable lead peak too recently. The high rate of sedimentation occurs at 2.5 g/cm^2, CRS ^{210}Pb date of 1935. Following this date the stable lead concentration profile increases dramatically. The time of increase and trajectory is concurrent with other inland lakes throughout the State of Michigan. Therefore the CRS model is deemed appropriate to date the Sand Lake core.

Organics

Surface concentrations of organic contaminants in 2003-2004 study lakes are generally highest in Muskegon Lake and lower in Shupac Lake (Table 2). All lakes contain polychlorinated biphenyls (PCBs), pesticides and polyaromatic hydrocarbons (PAHs). Care should be taken in interpreting these results as samples from different lakes are from different ages, dependant on the sedimentation rate. Torch Lake, with a low sedimentation rate, represents older sediments, and might be expected to have higher concentrations of organics.

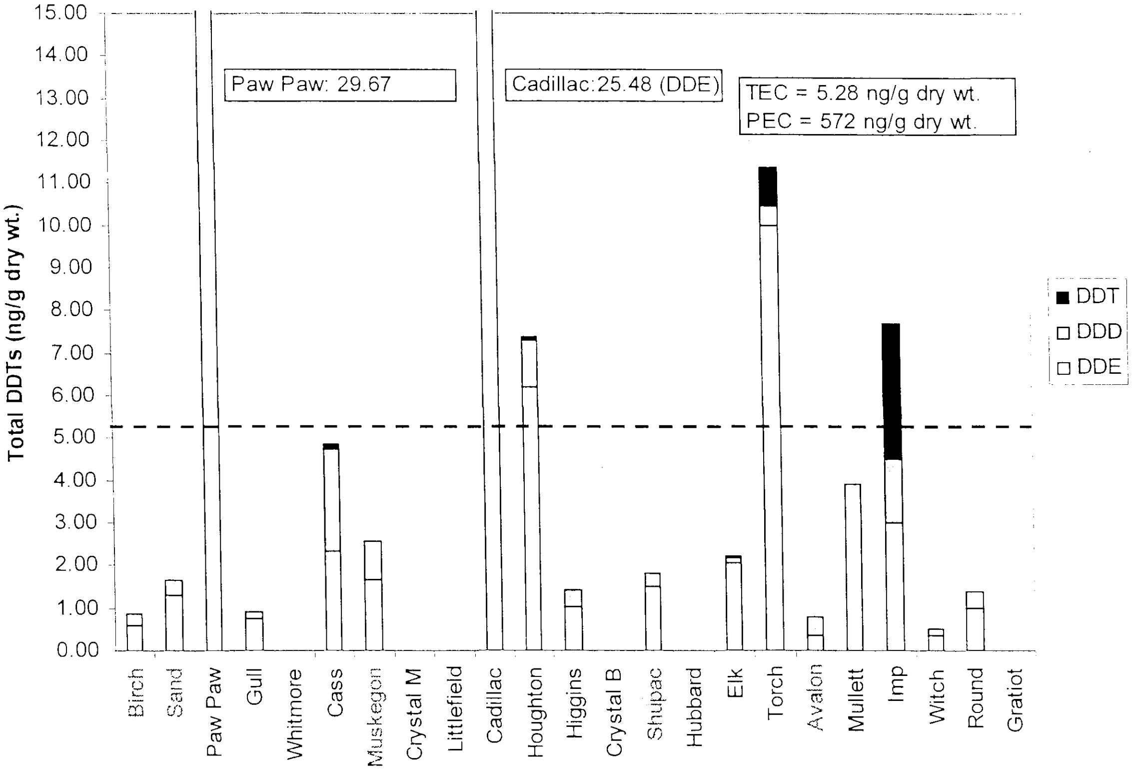


Fig. 3. Concentrations of DDTs from the sediments for sample 1-2 (0-1 cm) and samples 3-4 (1-2 cm) for 23 Michigan lakes. Concentrations are plotted on a log scale. Lakes are plotted from south (Birch) to north (Gratiot). 2003 study lakes are highlighted. Threshold effect concentration (TEC) is plotted as a dashed line.

Organochlorine pesticides in use historically in Michigan include the DDTs; DDT, DDD, and DDE. Total DDTs in the 2003 sample lakes are similar to other Michigan lakes found to contain DDTs (Fig. 3). Distribution of DDTs was also similar, with DDE being the predominant organochlorine pesticide found in sediments of Michigan's inland lakes. Generally, DDTs are highest in northern Michigan lakes and those lakes in highly agricultural areas.

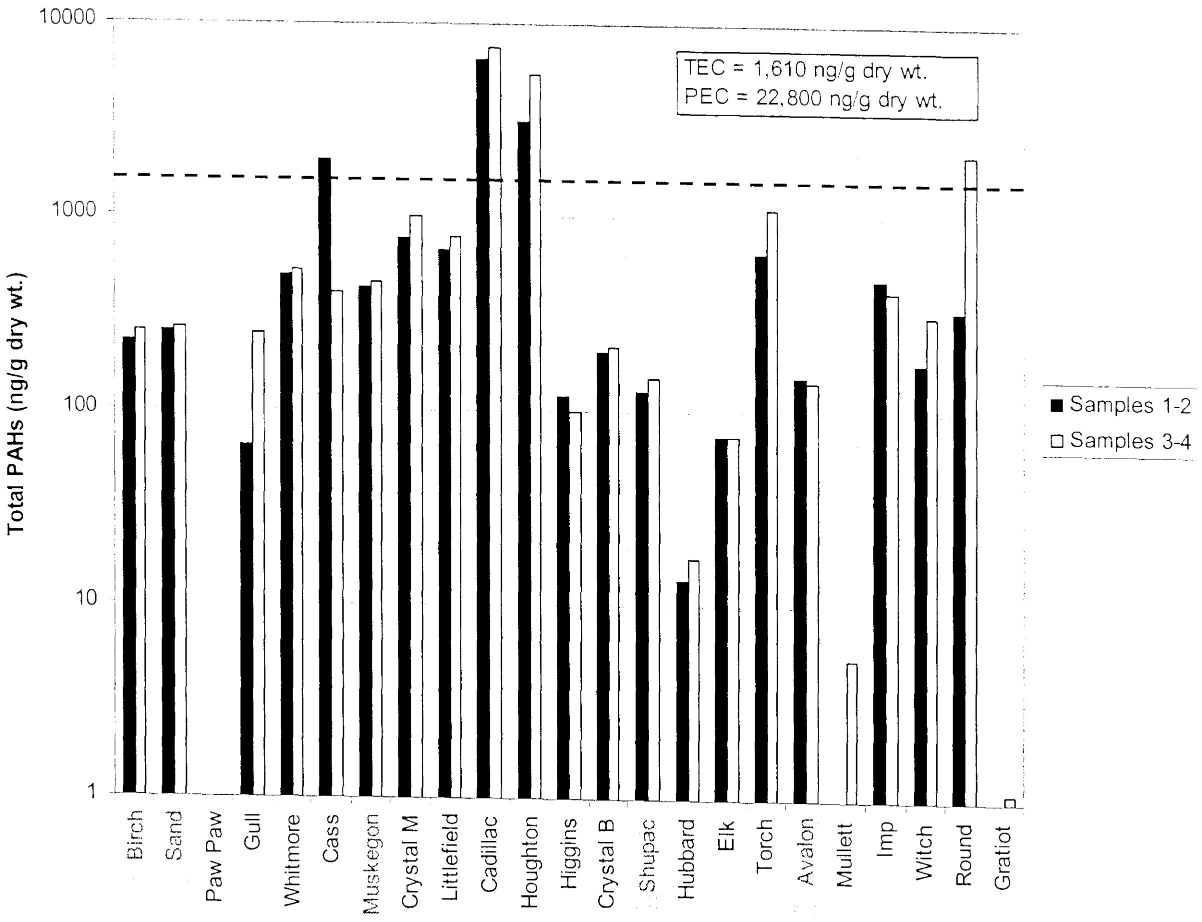


Fig. 4. Concentrations of total PAHs from the sediments for samples 1-2 (0-1 cm) and samples 3-4 (1-2 cm) for 23 Michigan lakes. Concentrations are plotted on a log scale. Lakes are plotted from South (Birch) to North (Gratiot), 2003 study lakes are highlighted. TEC is plotted as a dashed line.

Total dry weight PAH concentrations for the 2003 study lakes are similar to Lower Peninsula lakes sampled previously (Fig. 4). Of the 2003 sample lakes only Avalon Lake showed higher total PAH concentration in the surface sample. Of all the study lakes, Cadillac and Houghton have the highest total PAH concentration. Cass, Cadillac and Houghton lakes have surficial concentrations of total PAHs above the TEC.

Congener sum PCB concentrations for the 2003 study lakes are similar to other study lakes (Fig. 5). Of the 2003 study lakes Muskegon Lake has the highest PCB congener sum concentration and has higher concentrations in the surficial sediment than in the lower sediment fraction. Distribution of PCBs in lakes does not appear to follow a south to north spatial trend. Conversely, all Upper Peninsula lakes studied to date are contaminated with PCBs, the highest concentration of the congener sum of PCBs (surficial sediment) was found in Imp Lake.

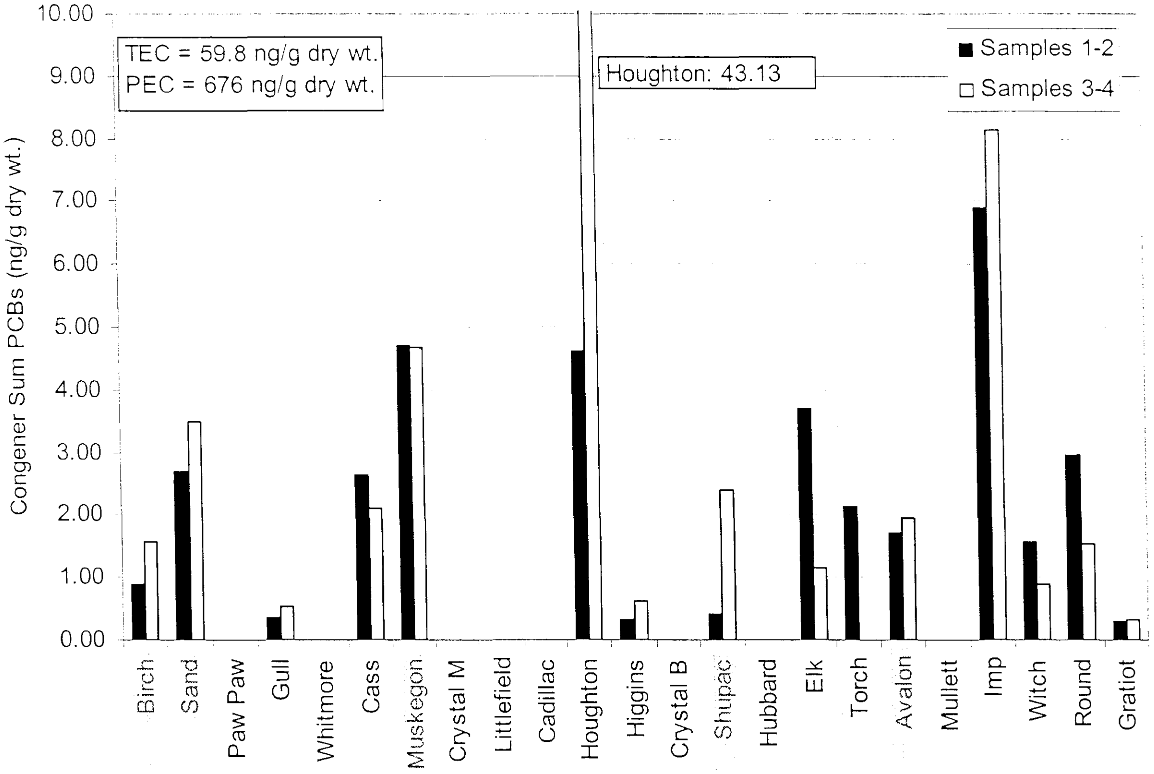


Fig. 5. Congener sum concentrations of PCBs from the sediments for samples 1-2 (0-1 cm) and samples 3-4 (1-2 cm) for 23 Michigan lakes. Lakes are plotted from South (Birch) to North (Gratiot), 2003 study lakes are highlighted.

Table 3. Concentrations (ng/g dry wt) of various organic compounds for five Michigan Lakes.

	Shupac 1	Shupac 2	Sand 1	Sand 2	Birch 1	Birch 2	Muskegon 1	Muskegon 2	Avalon 1	Avalon 2
cm depth[1]	0 - 1	1 - 2	0 - 1	1 - 2	0 - 1	1 - 2	0 - 1	1 - 2	0 - 1	1 - 2
Age[2]	2003	2001	2003	2001	2002	2000	2003	2003	2002	2001
Total polychlorinated biphenyls (PCBs)	0.4	2.4	2.7	3.5	0.89	1.58	4.70	4.68	1.71	1.95
Total polyaromatic hydrocarbons (PAHs)	126.6	149.8	252.0	262.0	225.03	254.57	429.87	459.48	153.69	143.80
Acenaphthalene	0.54	1.52	1.75	1.77	1.48	1.7	2.64	2.85	1.01	1.01
Acenaphthene	0.98	1.27	2.05	1.65	0.86	1.13	4.56	4.62	0.41	0.55
Fluorene	2.05	4.34	5.12	5.69	1.97	2.55	5.07	5.42	3.70	3.88
Phenanthrene	8.19	12.59	24.84	24.61	19.44	19.95	36.79	38.97	15.66	14.77
Anthracene	4.69	1.94	3.88	3.83	2.68	3.27	7.24	7.64	1.80	1.67
Fluoranthene	13	18.73	40.01	36.18	37.37	40.99	60.77	64.88	22.99	23.08
Pyrene	13.64	15.49	32.8	31.22	31.02	34.01	60.56	65.09	18.21	18.24
Benzo-A-anthracene	7.65	6.38	14.18	9.37	12.75	14.23	27.57	25.76	5.67	5.89
Chrysene	12.21	16.39	25.53	27.97	24.75	30.58	52.03	54.51	8.33	7.99
Benzo-B-fluoranthene	12.83	31.88	31.03	41.81	38.33	42.33	56.30	60.31	28.89	29.03
Benzo-K-fluoranthene	22.72	8.29	20.2	18.04	10.81	13.43	28.96	31.76	6.74	6.94
Indeno-1,2,3-CD-pyrene	10.73	12.51	23.31	29.93	20.21	22.61	37.53	42.56	16.22	13.71
Dibenz-a,h-anthracene	0.72	4.05	3.06	3.2	3.69	5.69	4.64	5.45	1.83	1.53
Benzo-G,H,I-perylene	16.69	14.41	24.23	26.76	19.67	22.1	45.21	49.66	22.23	15.51
Total Pesticides	12.5	21.3	3.9	3.9	8.6	12.7	19.30	23.01	3.1	3.5
α-BHC	1.74	2.59	0.47	0.35	0.63	0.89	14.06	16.77	0.49	0.85
β-BHC	2.15	2.17	0.66	BDL[3]	0.62	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]
Lindane	BDL[3]	10.2	0.13	0.05	BDL[3]	0.05	BDL[3]	BDL[3]	BDL[3]	BDL[3]
γ-BHC	0.91	1.18	0.8	0.97	0.55	1.04	2.05	2.31	0.84	0.93
Heptachlor	3.92	1.54	BDL[3]	BDL[3]	1.47	1.63	BDL[3]	BDL[3]	BDL[3]	BDL[3]
Aldrin	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	0.91	1.26
Heptachlor epoxide	1.85	1.03	BDL[3]	BDL[3]	3.51	5.31	BDL[3]	BDL[3]	BDL[3]	BDL[3]
cis-Chlordane	BDL[3]	0.26	0.07	0.04	0.5	1.39	0.28	0.33	BDL[3]	BDL[3]
trans-Chlordane	0.09	0.3	0.09	0.08	0.45	0.97	0.34	0.36	0.1	BDL[3]
DDE	1.5	1.74	1.29	1.7	0.58	0.9	1.66	1.94	0.34	BDL[3]
DDD	0.31	0.2	0.36	0.71	0.27	0.55	0.91	1.30	0.44	0.43
DDT	BDL[3]	0.1	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]
Methoxychlor	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]	BDL[3]

1. The first two slices were combined (cm 0-2), and the third and fourth slices (3-4 cm), due to insufficient sample mass for analysis.
2. Since samples were combined[1] each analysis covers a range of years. The median age is presented for each of the combined samples.

Inorganic chemical sediment chronologies

There are multiple ways to examine and interpret sediment chronologies, and the most appropriate approach is dependant on objectives of the study. In this report, total concentration profiles will be presented, followed by surface concentrations, and focusing corrected anthropogenic accumulation rates. The concentration profile for each of the elements analyzed were compared within each lake, and grouped by similar profiles to determine the major influences on that element (Yohn *et al.*, 2002). Surface concentrations of arsenic, cadmium, copper, lead and zinc were compared among lakes and to sediment quality guidelines (MacDonald et al., 2000) to determine potential toxicity. Finally, focusing corrected anthropogenic accumulation rates were calculated and compared among all lakes. These rates provide the best possible estimate of the rate of input of a metal to the lake sediments due to humans.

Total concentration profiles

Introduction

Many different sources and processes influence the patterns of metal deposition in a sediment core, making it a challenge to interpret the historical records. The multi-element approach, which includes the analysis of more elements than just those of anthropogenic concern, helps provide insight into the history of the lake and assists in the interpretation of anthropogenic inputs. The first step to understanding multi-element data is grouping the elements that are influenced by similar sources and processes. Elements that have similar profiles in the sediment were grouped for each lake using cluster analysis (Table 3) (Yohn *et al.*, 2002). Four classes of elements were examined: terrestrial, calcium carbonate, diagenetic, and anthropogenic.

The first class includes the terrestrial elements, which are those that are influenced by the amount of allochthonous (material from outside the lake) non-organic material entering the lake. Changes in the input of terrestrial materials may be caused by increased erosion by natural (e.g., forest fires) or human (e.g., land use changes) processes (Davis, 1976). Elements that may be primarily influenced by these processes include aluminum, titanium and sometimes iron, potassium, cobalt, nickel, magnesium, sodium, scandium, and the rare earth elements (Boyle *et al.*, 1999, Bruland *et al.*, 1974, Johnson and Nicholls, 1988, Kemp and Thomas, 1976, Kerfoot *et al.*, 1999, Qu *et al.*, 2001, Sanei *et al.*, 2001).

Table 4. Classification of elements into terrestrial (T), carbonate (C), diagenetic (D, D1,D2),and anthropogenic (A, A1, A2). Use of A2 indicates there was more than one group of anthropogenic elements in the lake. Use of D1, D2 notation indicates that there was more than one group of diagenetic elements in the lake. Unclassified elements did not fit clearly into a group, and elements classified twice appear to be influenced by both classes. A (–) indicates that data were not collected for this element. Lakes include Gratiot (Grat), Elk, Gull, Higgins (Hig), Littlefield (Lit), Crystal M (CrM), Cadillac (Cad), Crystal B (CrB), Mullett (Mul), Paw Paw (Paw), Whitmore (Whit), Houghton (Hou), Hubbard (Hub) Imp, Round (Rou), Torch (Tor), and Witch (Wit). OR indicates that outliers were removed.

	Grat	Elk	Elk OR	Gull	Hig	Lit	CrM	Cad	CrB	Mul	Paw	Whit	Hou	Hub	Imp	Rou	Tor	Wit	Shu	San	Ava	Bir	Mu
Mg	T	T	T	C	T	C, T				T				T			T	T	C	C	T1	--	T
Al	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T2	T	A,T2	T2	T
K	D	T	T	T	T	T	T		T	--	--	--	T				T		T1		A,T2	T1	T
Ca	T	C	C	C	C	C	C	C	C	C	C	C	C	C		C	C		C	C	A,T2	T2	C
Ti	T	T	T	T		T		T		T	T	T	T	T		T		T	T1		T1	T1	T
V	T	T	T	T			T	T	T	T	T	T	T	T		T	T		T1	T	D	T1	T
Cr	T			T			T		T	T	A	T	T	T	T	T	T	T	T2	T	D	D2, T2	A
Mn	D	D		D1	D2	D2	D1	D		D								D	D		A,T2	D1	C
Fe	A	D	T	D1		D1		D	T	D			D1		A	T	T		T2	A	T1	--	T
Cu	A	A	A	A	A	T		A	A	A	A	A2	A	T	A		A		T1	A	A,T2	A	A
Zn	A	A	A	A	A		A	A	A	A	A	A1	A		A	A	A	A	A	A	A,T2	A	A
As	A	D	A	A, D2	D1	D1	D1	D		D	D2		D1		A				T2		D	D1	T
Sr	T	--	--	--	C	C	C	C	C	C	C	C	C	C	T	C	C					--	C
Mo		D		D2	D1	D1	D2				D2	D	D2			D			D	D	D	D1	A
Cd	A	A	A		A	A	A	A	A	A	A	A1	A	A	A	A	A		A	A	A,T2	A	A
Ba	D	D	T	C	D2	D2		C	C	D		T	T					D	D	T	A,T2	D1	C
Pb	A	A	A	A	A	A	A	A	A	A	A	A1	A	A	A	A	A	A	A	A	A,T2	A	A
U	T	T	T	D2	D1	D1	D2	T				D	D2			D			D		D	D2, T2	T

The second class includes calcium and strontium, which may be influenced by deposition of calcium carbonate. Soils, glacial material, and bedrock in most of the Great Lakes contain abundant limestone ($CaCO_3$). Thus, lakes become enriched in dissolved Ca and HCO_3 that can precipitate in the lake as a consequence of evaporation or photosynthesis (photosynthesis consumes CO_2, which raises the pH of the water). This portion of the sediment tends to have low concentrations of most metals and therefore acts as a diluting phase (Auer et al., 1996). The presence of carbonates may increase the concentration of calcium and strontium, and sometimes magnesium and barium (Auer *et al.*, 1996, Sanei *et al.*, 2001).

A third class includes those elements influenced by diagenesis. Early diagenesis is the alteration of sediment after deposition, and will obscure the depositional record. In the top few centimeters of sediment, there are major geochemical changes that occur. Organic matter is decomposed, which uses the oxygen in the sediment, and changes the sediment from an oxidizing to a reducing environment. This will change the mobility of many metals, and metals may mobilize from the sediment into the porewater (remobilization). For example, those metals that are associated with organic matter in the sediment can be released to the porewater as decomposition progresses. Those metals associated with iron and manganese oxyhydroxides would be released to the porewater when these oxyhydroxides dissolve because of the reducing conditions. Once in the porewater, metals may move from areas of high concentration to lower concentrations through diffusive flux and/or be readsorbed to other sediments phases (Brown *et al.*, 2000, Cooper and Morse, 1998, Douglas and Adeney, 2000, Harrington *et al.*, 1998, McKee *et al.*, 1989, Urban *et al.*, 1990). In particular, arsenic is strongly adsorbed to iron oxyhydroxides, and profiles in the sediment may not reflect the historical record of arsenic deposition. For arsenic, which is influenced by both diagenesis and anthropogenic inputs, it is essential to be able to differentiate patterns caused by diagenesis from those caused by changes in anthropogenic inputs (Harrington et al., 1998). Another complication is that elements respond to changing redox conditions in different manners. While iron oxyhydroxides mobilize in reducing conditions, uranium and molybdenum remobilize in oxidizing environments (Brown et al., 2000). Therefore, it may be possible to have more than one group of diagenetic elements.

The final class is the anthropogenic elements. These elements have accumulated in lake sediments due to human actions, and may enter lakes from atmospheric deposition, or from inputs within the watershed. Humans may influence any element, but the geochemical cycles of arsenic, cadmium, copper, chromium, mercury, lead, and zinc have been modified by humans on the global scale (Bruland *et al.*, 1974, Evans and Dillon, 1982, Iskander and Keeney, 1974, Spiethoff and Hemond, 1996). Since the sources of each metal may be different (e.g., copper from copper smelting emissions, or lead from leaded gasoline), anthropogenic elements may follow similar trends or the trends may vary among elements, depending on the dominant sources and processes. Therefore, while elements in the terrestrial class should have very similar profiles, profiles of anthropogenic elements may vary. The profiles of the anthropogenically-influenced elements listed above were examined closely and compared to profiles of terrestrial elements to determine for each lake if deposition of that element was influenced by human activities. Although terrestrial elements are also influenced by human activities, we will consider the anthropogenic elements as those elements with sources due to humans in addition to increased erosion.

Avalon Lake

Terrestrial elements in Avalon Lake include magnesium, aluminum, potassium, titanium, iron, and copper (Table 3). The concentrations of these elements remain relatively constant over time (Fig. 6), suggesting there were no large increases in terrestrial inputs (e.g., erosion due to logging) to Avalon Lake. Additionally the terrestrial element profile closely resemble those of the traditionally anthropogenic elements including lead and zinc, suggesting that terrestrial processes influence the concentration of the anthropogenic elements.

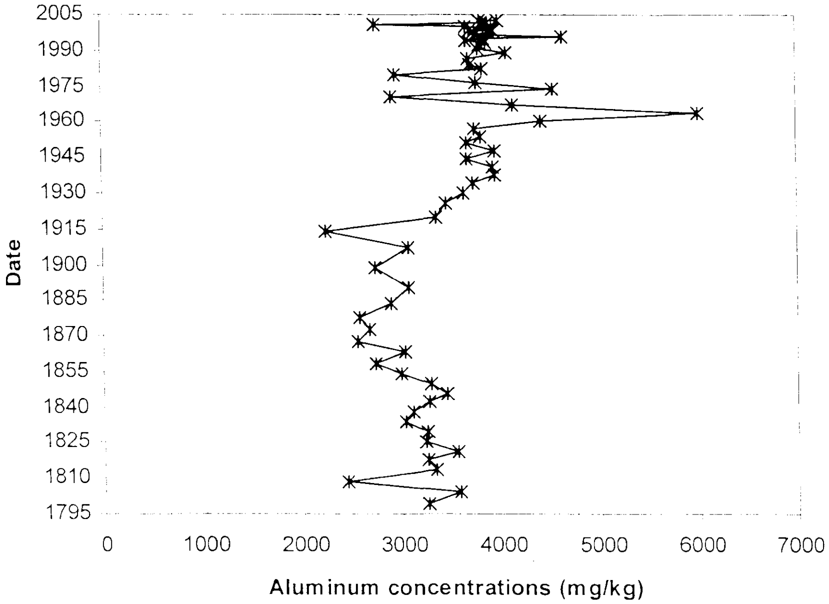


Fig. 6. Sediment concentration of aluminum (mg/kg) in Avalon Lake.

Arsenic, vanadium, chromium, molybdenum and uranium have similar profiles suggesting they are influenced by similar processes. Arsenic when influenced by diagenetic processes has a similar concentration profile to that of iron. In Avalon Lake arsenic does not behave as if it is being altered by diagenetic processes and does not appear to behave similarly to iron (Fig. 7). In addition, it does not appear that arsenic is influenced by anthropogenic activity. The processes influencing arsenic, vanadium, chromium, molybdenum and uranium in Avalon Lake is unclear.

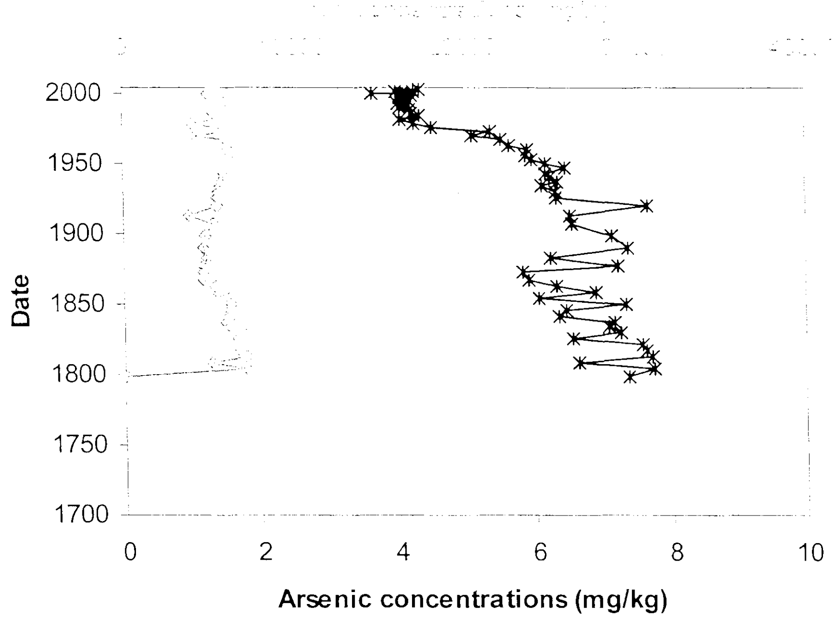


Fig. 7. Sediment concentrations of iron and arsenic in Avalon Lake.

Concentration profiles of cadmium, zinc, and lead show an increase in concentration from the mid to late 1800s (Fig. 8). Copper concentrations in Avalon Lake are higher than any other study lake. The concentration of copper in these sediments is greater than those in Lake Cadillac which was treated with copper sulfate to control swimmers itch. The profile for copper in Avalon Lake does not suggest significant anthropogenic influence.

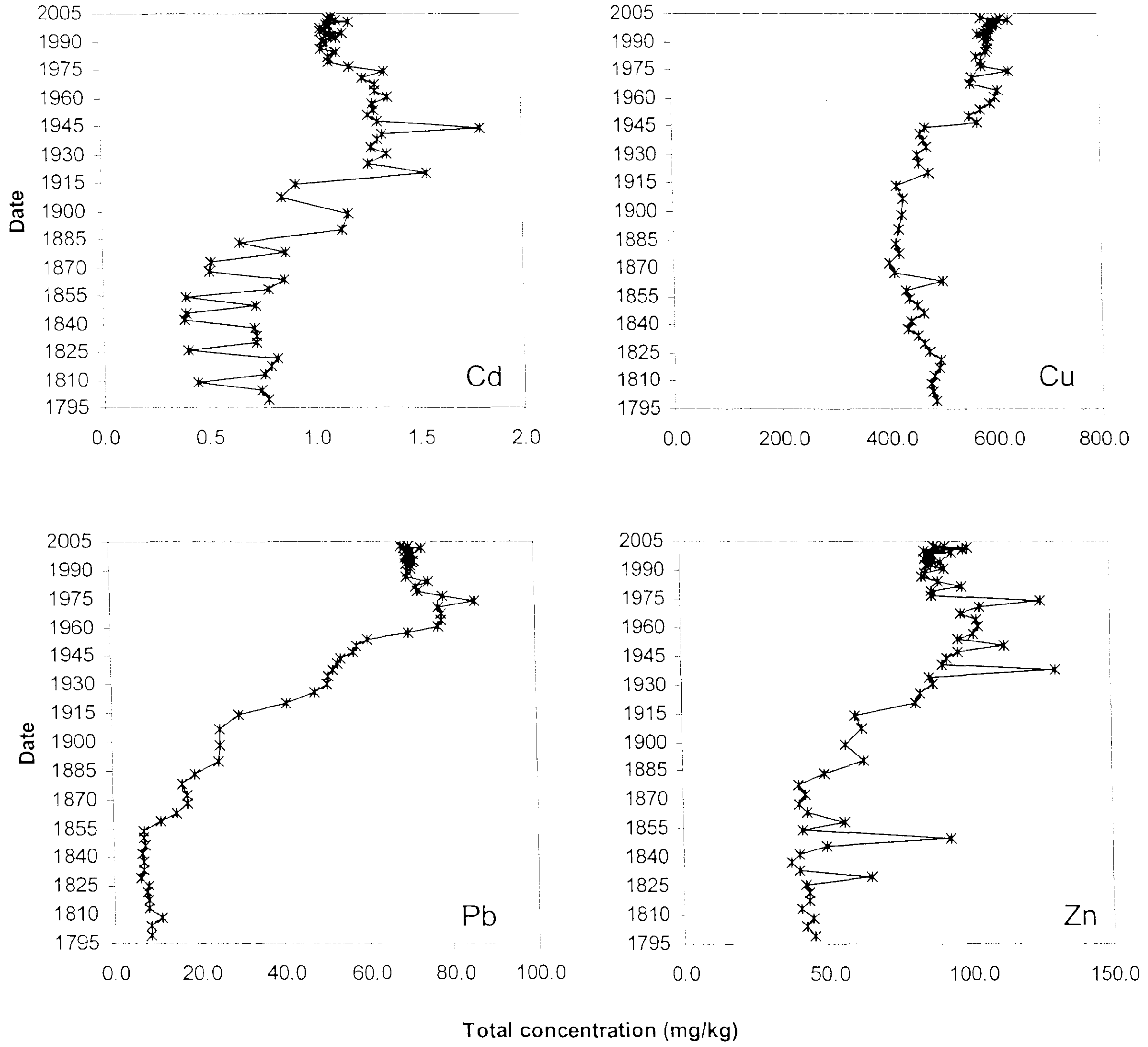


Fig. 8. Concentration profiles (mg/kg) of cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) in Avalon Lake.

Birch Lake

Elements influenced by terrestrial inputs include aluminum (Fig. 9), potassium, calcium, titanium, vanadium, chromium, and uranium (Table 3). These elements are characterized by relatively constant concentrations over time. The presence of calcium (Fig. 10) in the terrestrial group indicates that calcium deposition during autochthonous process may not be a primary pathway for calcium to the bottom sediment or that lake productivity has not changed over time.

The concentrations of lead, copper, zinc and cadmium all increase from background levels in the late 1800s to early 1900s (Fig. 11). Lead and zinc peak in the late 1970s to early 1980s. Cadmium peaks in the 1950s and copper peaks in the 1980s. All elements decrease to the surface suggesting anthropogenic influence.

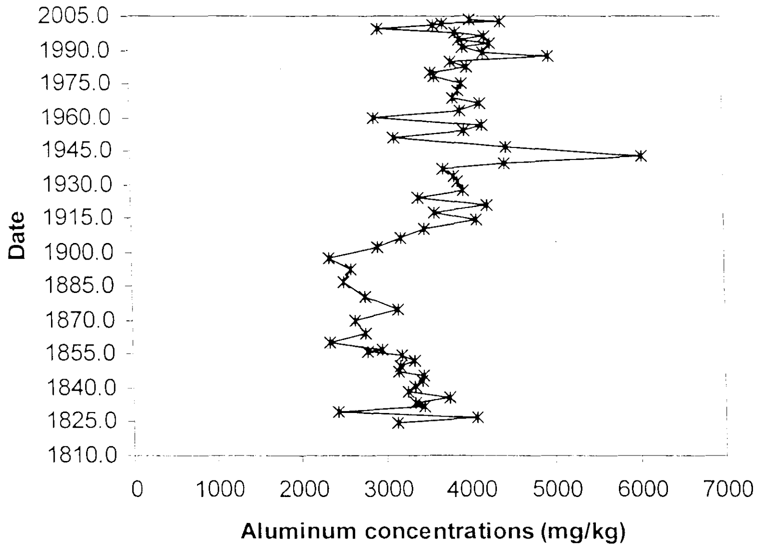


Fig. 9. Sediment aluminum concentration profile for Birch Lake.

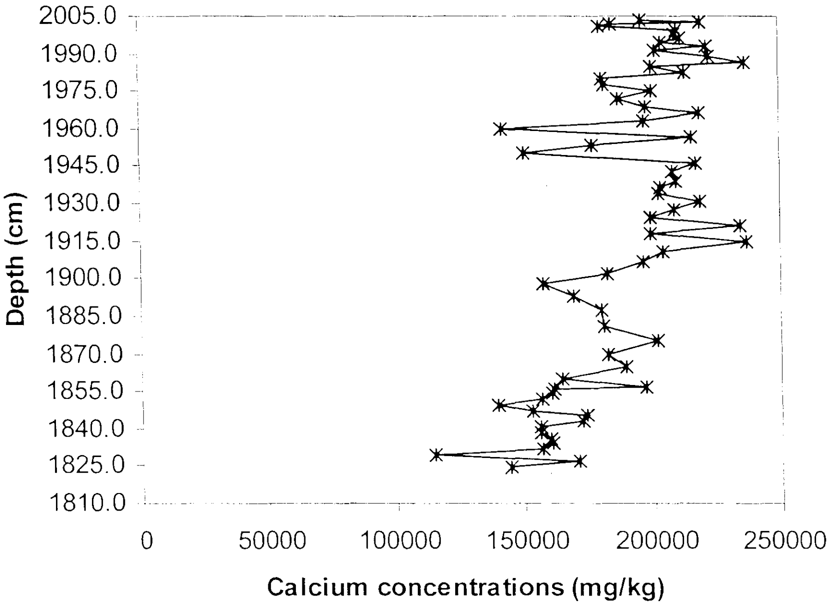


Fig 10. Sediment calcium concentration profile for Birch Lake.

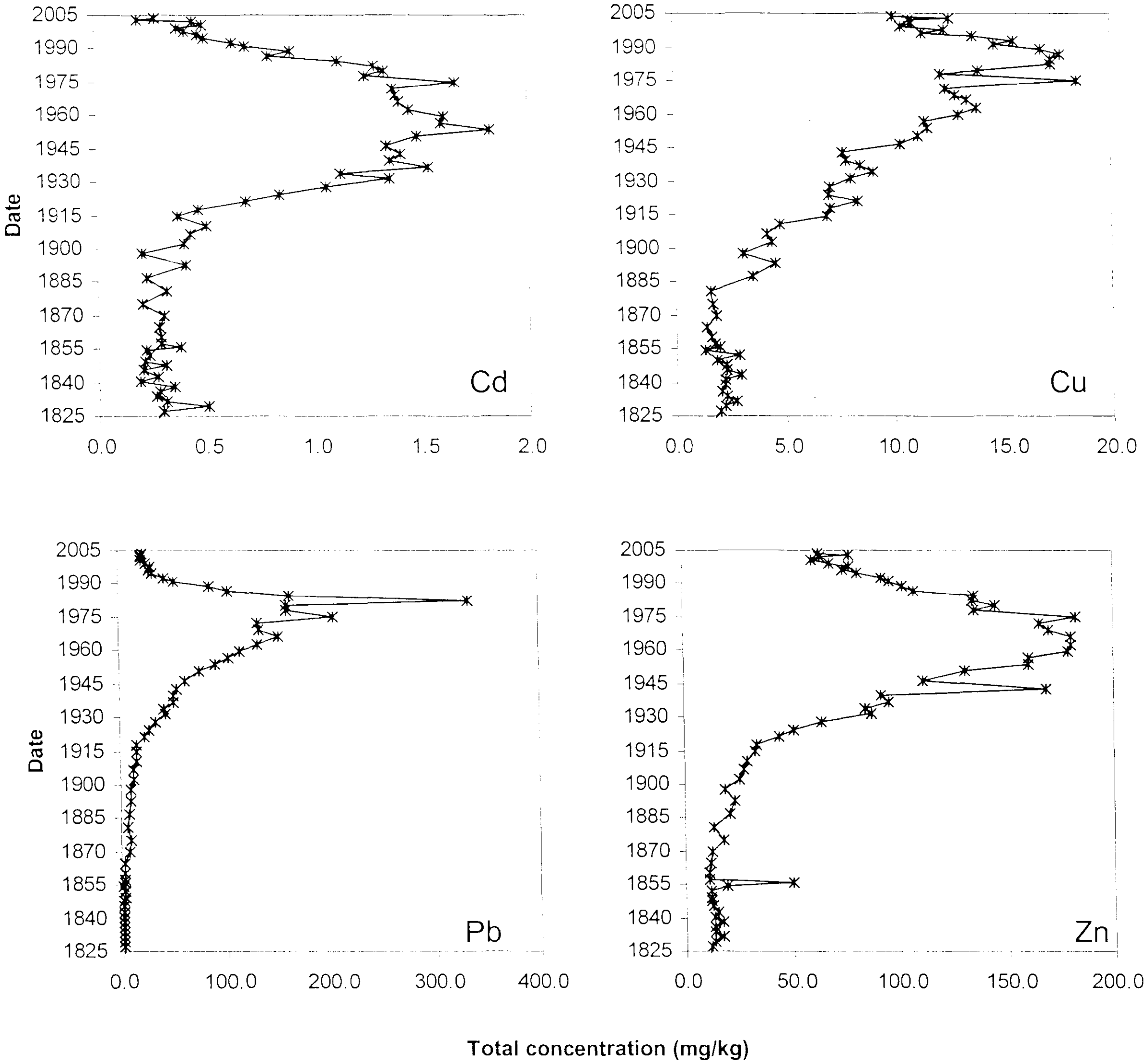


Fig. 11. Concentration profiles (mg/kg) of cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) in Birch Lake.

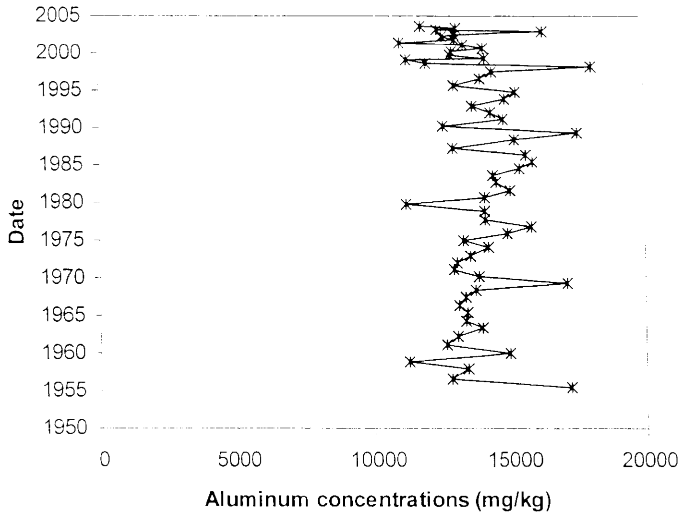


Fig. 12. Sediment aluminum concentration profile for Muskegon Lake.

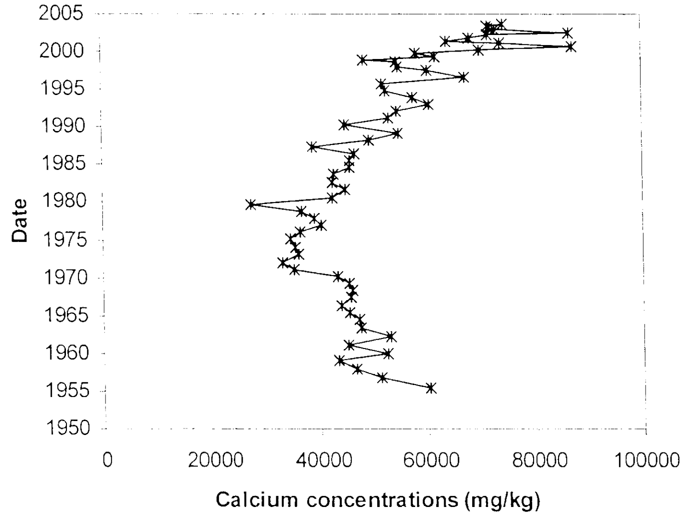


Fig. 13. Sediment calcium concentration profile for Muskegon Lake.

Muskegon Lake

Elements influenced by terrestrial processes in Muskegon Lake include magnesium, aluminum, potassium, titanium, vanadium, iron, arsenic, and uranium (Table 3). The terrestrial elements undergo little overall change in concentration over time (Fig. 11). Sediments in Muskegon Lake reflect the last fifty years of deposition and likely influenced by anthropogenic activity.

Calcium, strontium, manganese, and barium are influenced by calcium carbonate deposition in Muskegon Lake (Fig. 13, Table 3). These elements tend to increase starting around 1970 (Fig. 13). This increase may suggest an increase in productivity in the lake.

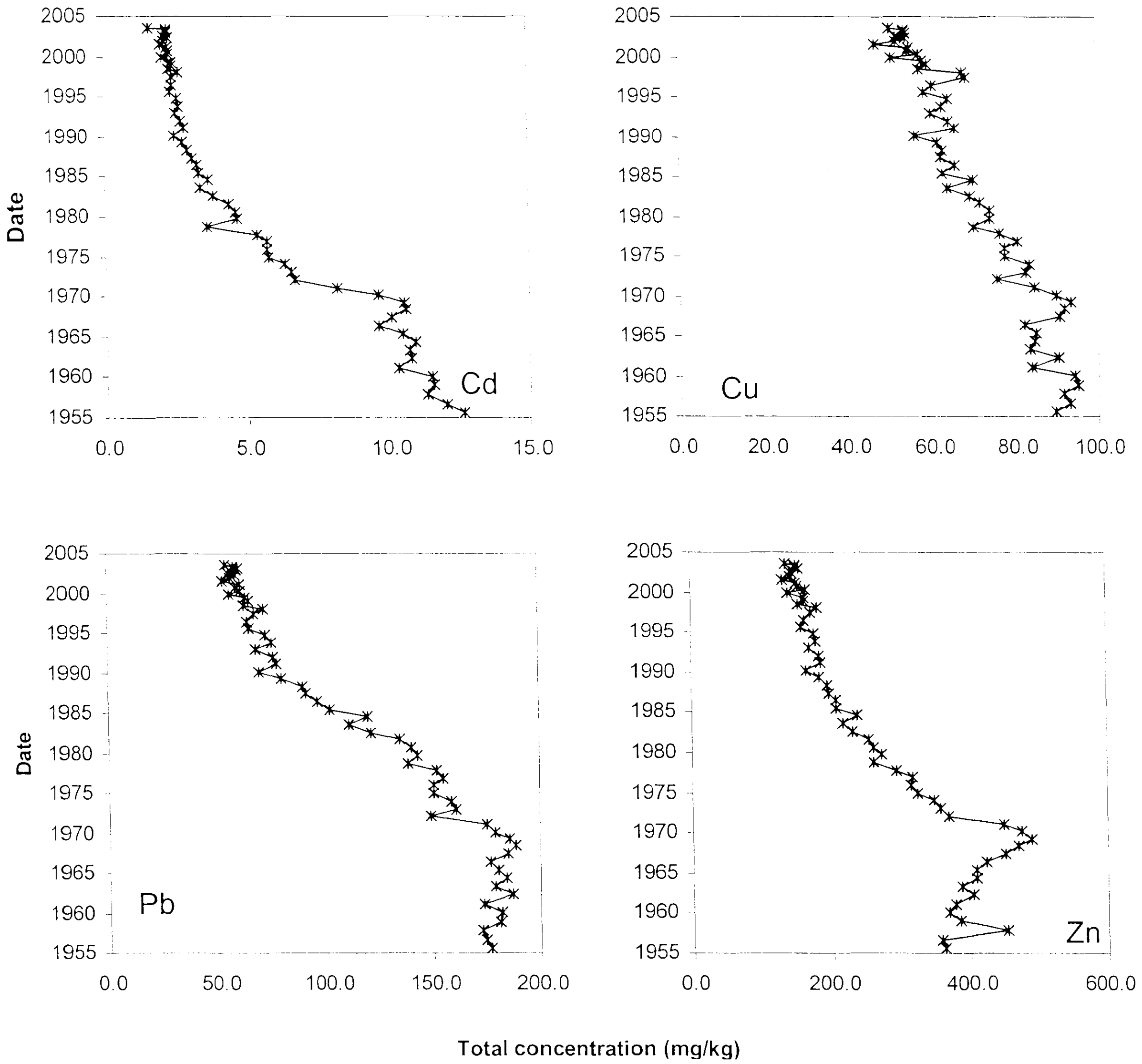


Fig. 14. Concentration profiles (mg/kg) of cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) in Muskegon Lake.

Due to high sedimentation rates in Muskegon Lake background values were not obtained. Lead, zinc, cadmium, and copper are all decreasing in concentration to the present (Fig. 14). All anthropogenic elements concurrently declining to the present and the location of the lake in an industrial area suggest anthropogenic influence. Peak concentrations of zinc and cadmium are higher than any other lake previously studied.

Sand Lake

Terrestrial elements in Sand Lake include aluminum, vanadium, chromium, and barium (Table 3). The terrestrial elements (Fig. 15 are characterized by variable sediment concentration suggesting time periods in which terrestrial processes highly influenced sediment geochemistry followed by stabilization.

Elements influenced by calcium carbonate deposition include magnesium and calcium (Table 3). These elements increase slightly until the mid 1900s then increase dramatically to the present (Fig. 16). This suggests an increase in productivity in the lake since the mid 1900s.

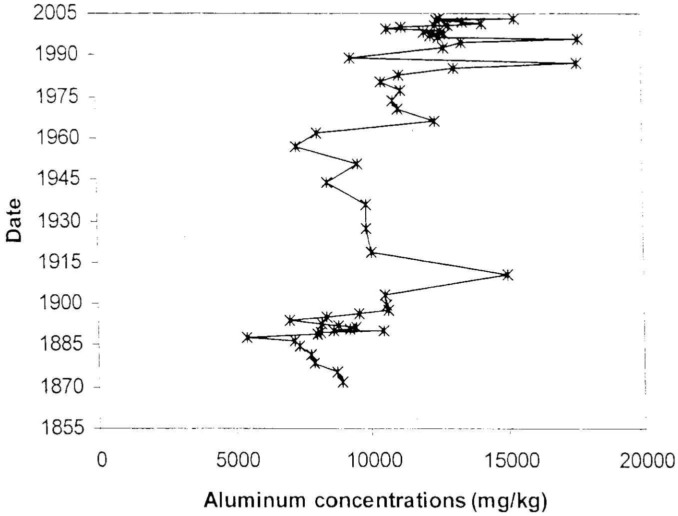


Fig. 15. Sediment aluminum concentration profile for Sand Lake.

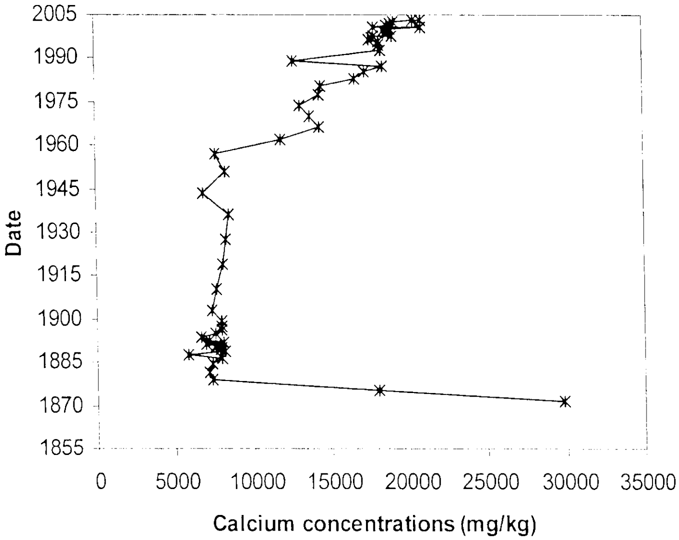


Fig. 16. Sediment calcium concentration profile for Sand Lake.

Cadmium, copper, zinc, and lead concentrations increase from background or near background values with the majority of change occurring in the later half of the 1900s (Fig. 17) and all sediment concentrations peak in the 1990s. These elements are similar to aluminum in that the concentration profiles are highly variable. This indicates the importance of terrestrial processes and the terrestrial pathway of zinc, cadmium, lead and copper input. The impact of terrestrial processes is not just a recent phenomenon in Sand Lake. Between 1885 and 1900 terrestrial impacts are observed in the aluminum, zinc, cadmium, copper and lead profiles. Zinc, cadmium, and copper do not reach background values. Most of the study lakes have peak lead concentrations near the mid 1970s; however, in Sand Lake peak lead concentration occurs as a broad peak between the late 1980s and late 1990s. It is unclear if this is due to additional sources of lead to Sand Lake, or difficulty with dating the sediment (Yohn *et al.*, 2003a).

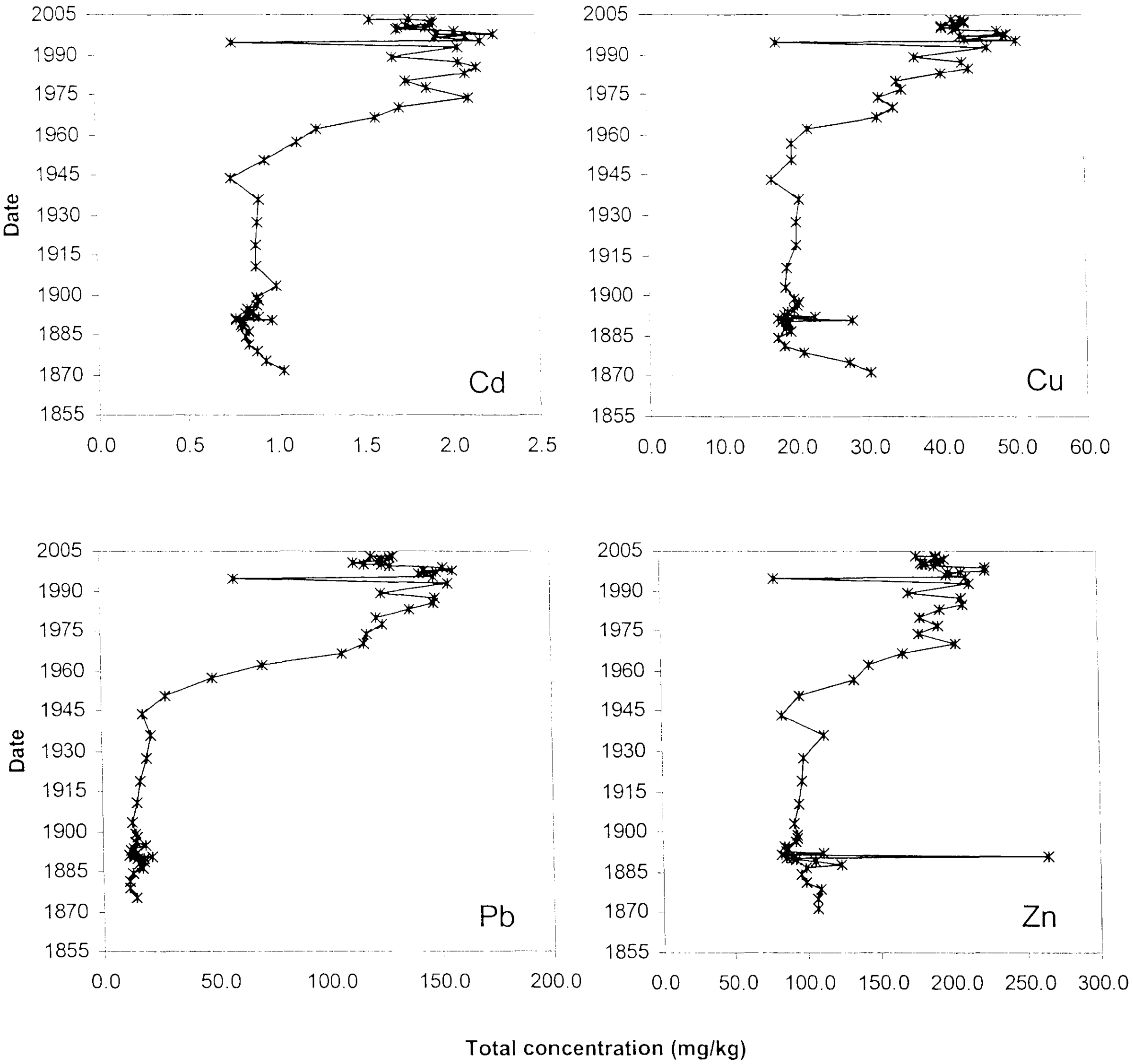


Fig. 17. Concentration profiles (mg/kg) of cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) in Sand Lake.

Shupac Lake

Terrestrial elements in Shupac Lake include aluminum, potassium, titanium, vanadium, chromium, iron, copper, and arsenic (Table 3). These elements are characterized by episodic increases in concentration occurring throughout the sediment core. The near surface sediments of Shupac Lake contained (top 7 cm, corresponding to 1982-2003) alternating layers (less than 0.5 cm) of black and brown sediment with layers of white sediment at three and four cm depth and a layer of red sediment at one cm depth. These layers are a visual indication of present day episodic events that may lead to changes in the geochemical record recorded in the sediment. Further, a more general trend of concentration increase occurs, starting in the early 1900s peaking in the early 1970s and decreasing to the present (Fig. 18).

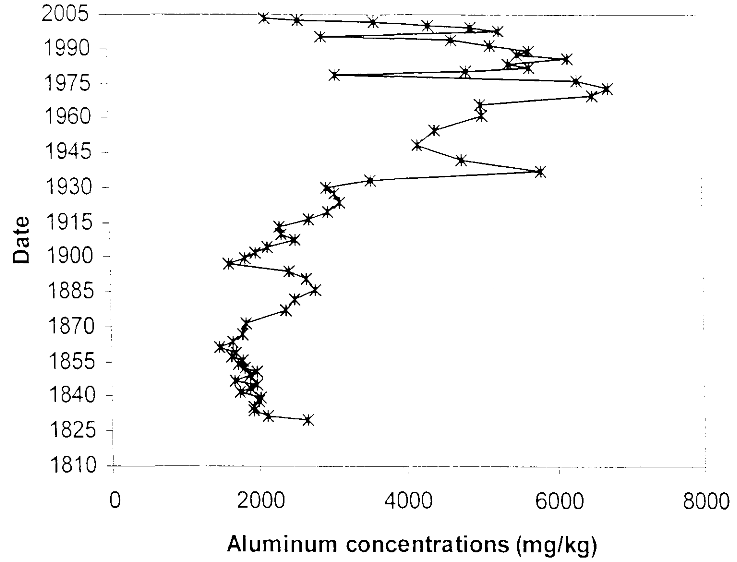


Fig. 18. Sediment aluminum concentration profile for Shupac Lake.

Elements influenced by calcium carbonate include calcium and magnesium (Table 3). Calcium carbonate influence in Shupac Lake is characterized by higher sediment concentrations in deeper sediment decreasing gradually until the mid 1970s then decreasing rapidly to the present (Fig. 19).

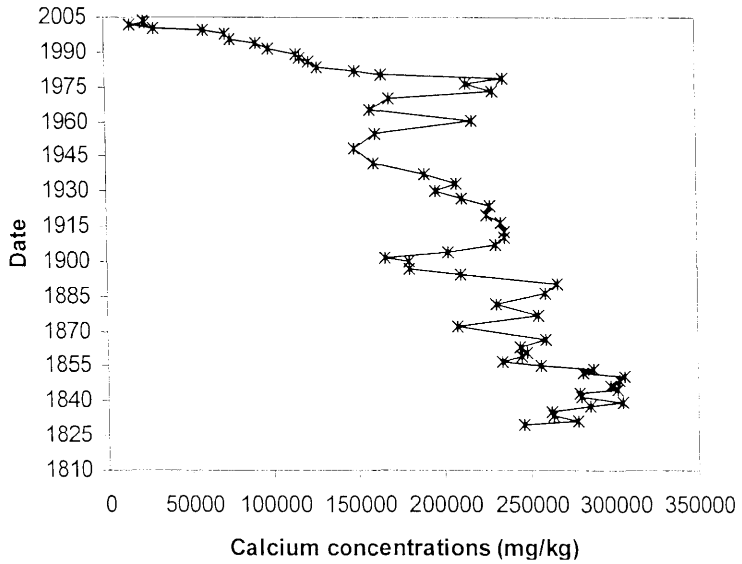


Fig. 19. Sediment calcium concentration profile for Shupac Lake.

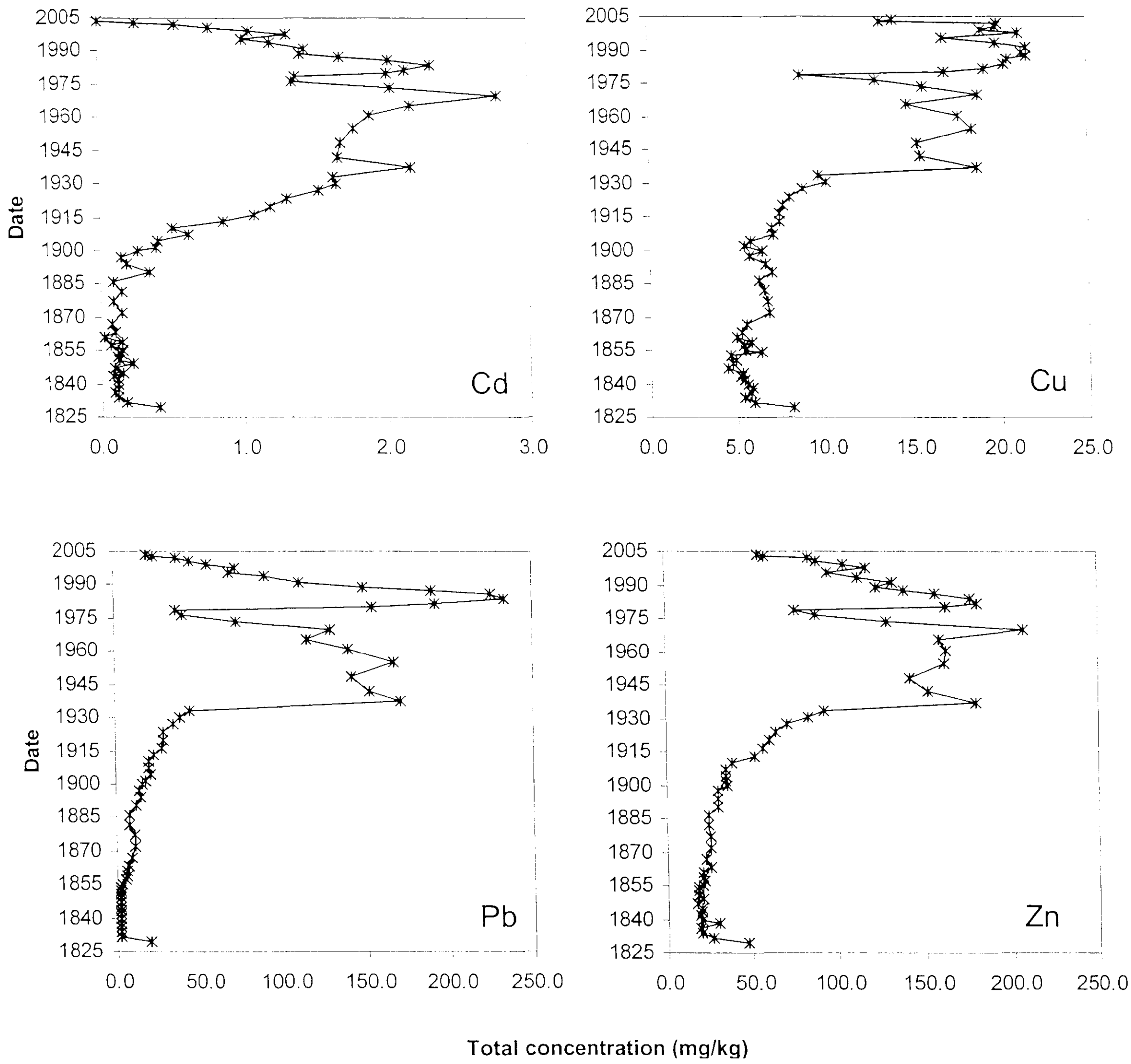


Fig. 20. Concentration profiles (mg/kg) of cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) in Shupac Lake.

Anthropogenic elements in Shupac Lake include lead, zinc, and cadmium (Table 3). All elements rise above background values in the mid to late 1800s and peak in the early to late 1970s and then decrease to the surface (Fig. 20). Copper, although classified as a terrestrial element may also be described as an anthropogenic element. It is unclear whether copper sediment concentrations in the bottom sections of the core have achieved background levels. All of the anthropogenic elements display a bimodal peak of metal concentration. The first peak occurs between the 1930s and 1960s. The second peak occurs in the early 1980s and early 1990s.

During the mid 1970s the concentration of calcium sharply increases (Fig. 10). During this same period the concentrations of the anthropogenic elements sharply decrease. This however is a result of the increase in calcium concentration. The sharp decrease in anthropogenic elements in the mid 1970s appears to be the effects of dilution by calcium carbonate elements.

Surface concentrations

While high concentrations of some contaminants may exist in sediments deposited in the 1960s and 70s, the concentrations in the surface sediments are of more concern to the health of aquatic organisms. We have averaged the top three samples, 1.5 cm, to represent the surface samples. Three samples were averaged to reduce the possible effects of one anomalous sample. These concentrations were compared among lakes, and compared to sediment quality guidelines (Table 5) (MacDonald et al., 2000). MacDonald et al. (2000) define a threshold effect concentration (TEC) and a probable effect concentration (PEC). The TEC is the concentration below which harmful effects on sediment dwelling organisms are unlikely to be observed, while the PEC is the concentration above which harmful effects are likely to be observed. Surface concentrations of arsenic, cadmium, copper, lead and zinc are presented. These are considered the critical inorganic contaminants (excluding mercury) in the Great Lakes (Agency, 1995) . Only 2003-2004 study lakes are discussed here, but data from all study lakes are presented for comparison. Discussion of previous lakes can be found in the 2001-2002 year end report (Yohn *et al.*, 2002). The concentrations reported are total concentrations, and represent both the human influenced and natural component.

Table 5. Surface (1.5 cm) concentrations (mg/kg) of five elements for eighteen lakes in Michigan, threshold effect concentrations (TEC) and probable effect concentrations (PEC) (MacDonald et al., 2000). Italics indicates values greater than TEC, bold indicates concentrations greater than PEC. The 2002-2003 study lakes are listed last, previous study lakes are listed for reference. Highest concentrations observed among all study lakes are highlighted.

	As	Cd	Cu	Pb	Zn
Cass	*30.8*	0.3	*15.4*	*53.7*	85.4
Elk	*23.9*	0.3	8.8	29.9	38.4
Gratiot	6.6	0.8	*61.0*	*39.5*	82.4
Gull	7.6	0.1	11.6	32.4	52.4
Higgins	*10.5*	*1.2*	21.1	*109.1*	*122.1*
Crystal M	7.3	0.9	21.9	*78.9*	106.5
Littlefield	*11.5*	0.5	12.2	30.1	49.0
Cadillac	*16.8*	*2.2*	***404.2***	***185.4***	*265.7*
Crystal B	4.4	1.1	18.0	*56.1*	106.7
Mullett	4.9	0.4	12.7	26.6	57.9
Paw Paw	*19.2*	0.6	43.8	*49.7*	*151.8*
Whitmore	*16.1*	*1.5*	49.7	***143.9***	*229.0*
Houghton	*23.9*	*1.2*	***175.1***	*67.9*	*159.6*
Hubbard*	4.4	0.6	9.1	19.3	49.8
Imp	*10.7*	*1.8*	*61.3*	*102.0*	*137.4*
Round	4.7	1.0	15.1	*68.4*	98.0
Torch	3.9	0.6	13.1	*43.3*	57.9
Witch	***51.9***	0.7	22.7	23.4	106.3
Avalon	4.2	*1.1*	***606.7***	*70.9*	93.5
Birch	8.0	0.3	11.2	22.5	68.2
Muskegon	*15.7*	*2.0*	*52.7*	*58.0*	*146.9*
Sand	*16.9*	*1.7*	*43.0*	*126.4*	*185.4*
Shupac	9.5	0.3	15.8	26.6	65.4
TEC	9.8	1.0	31.6	35.8	121
PEC	33	5.0	111	128	459

Surface arsenic sediment concentrations in Sand Lake are the highest of the 2003 lakes, however only Witch Lake exceeds the PEC (Fig. 21). Muskegon and Sand Lakes have sediment surface concentrations of arsenic above the TEC.

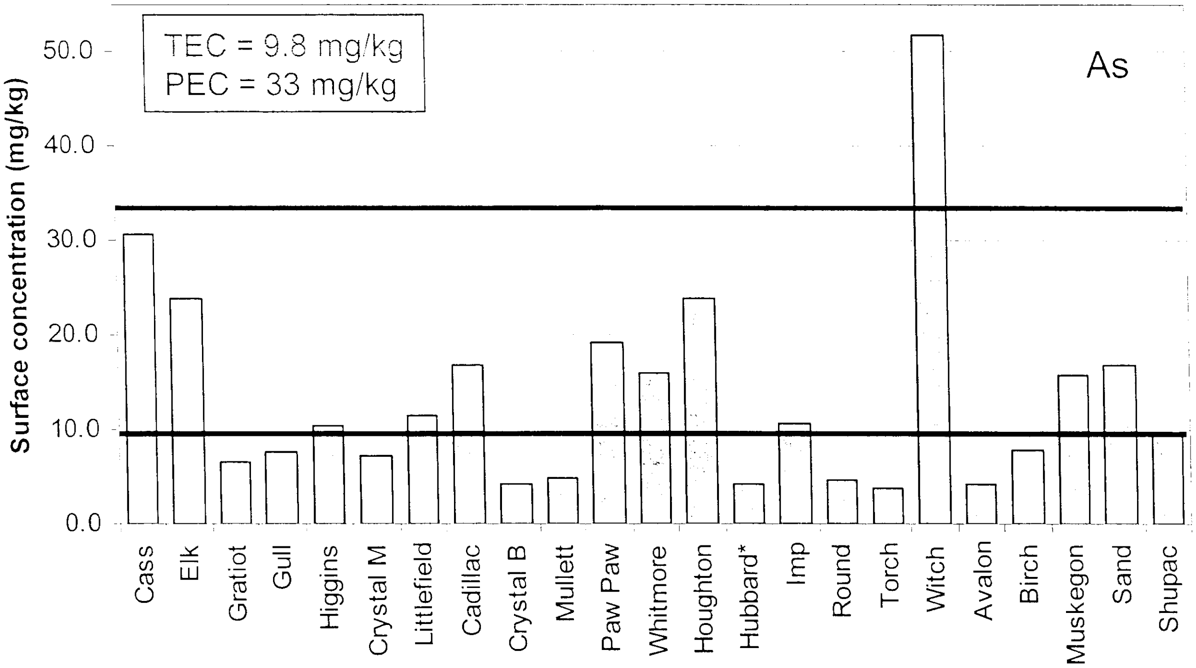


Fig. 21. Surface (1.5 cm) concentrations (mg/kg dry wt) for arsenic (As), in twenty-three Michigan lakes. The lower line indicates the TEC, the upper line indicates the PEC. *Data suggest that the surface sediments of Hubbard Lake have been eroded, therefore the top 1.5 cm will represent a different time period than other lakes.

Surface concentrations of cadmium in Avalon, Muskegon, and Sand lakes exceed the TEC (Fig. 22). None of the study lakes had concentrations near the PEC. Copper sediment concentrations in Avalon Lake were much higher than the PEC, and higher than those observed in any other study lake (Fig. 22). Cadillac and Houghton lakes were treated with copper sulfate to control swimmer's itch. Copper in Avalon Lake does not appear to be of anthropogenic origin. Both Muskegon and Sand lakes have sediment concentrations of copper greater that the TEC. Muskegon, Sand, and Avalon lakes have surface sediment concentrations of lead higher than the TEC (Fig. 22). Only Sand Lake neared the PEC for lead. Muskegon and Sand lakes have sediment surface concentrations of zinc greater then the TEC, but no lake have values greater than the PEC (Fig. 23).

Among 2003 lakes, Muskegon and Sand have the highest surface sediment concentration for most elements (excluding copper) and exceed the TEC for all elements.

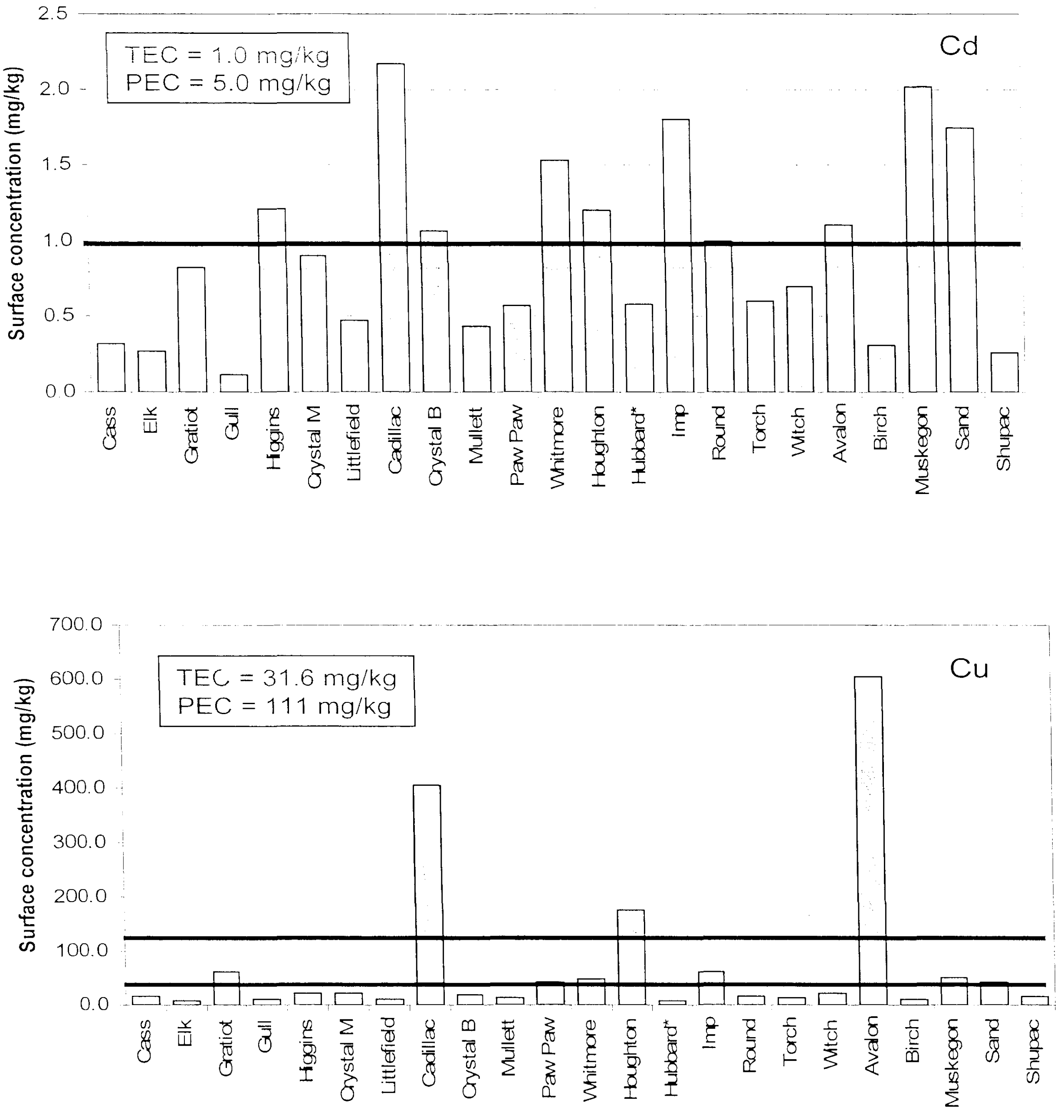


Fig. 22. Surface (1.5 cm) concentrations (mg/kg dry wt) for cadmium (Cd) and copper (Cu) in twenty-three Michigan lakes. The lower line indicates the TEC, the upper line indicates the PEC. The PEC is not shown for cadmium. *Data suggest that the surface sediments of Hubbard Lake have been eroded, therefore the top 1.5 cm will represent a different time period than other lakes.

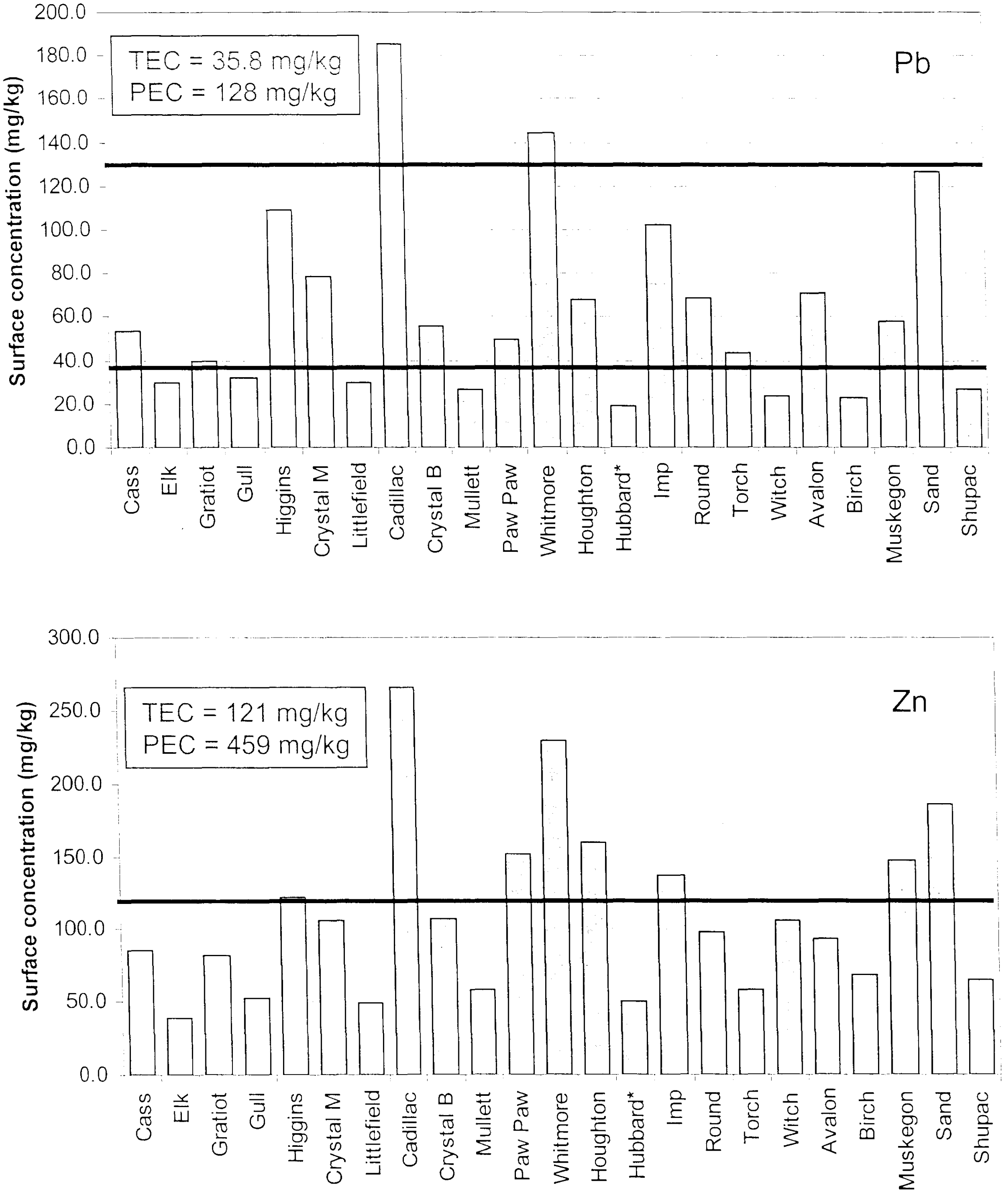


Fig. 23. Surface (1.5 cm) concentrations (mg/kg dry wt) for lead (Pb) and zinc (Zn) in twenty-three Michigan lakes. The lower line indicates the TEC, the upper line indicates the PEC. The PEC is not shown for zinc. *Data suggest that the surface sediments of Hubbard Lake have been eroded, therefore the top 1.5 cm will represent a different time period than other lakes.

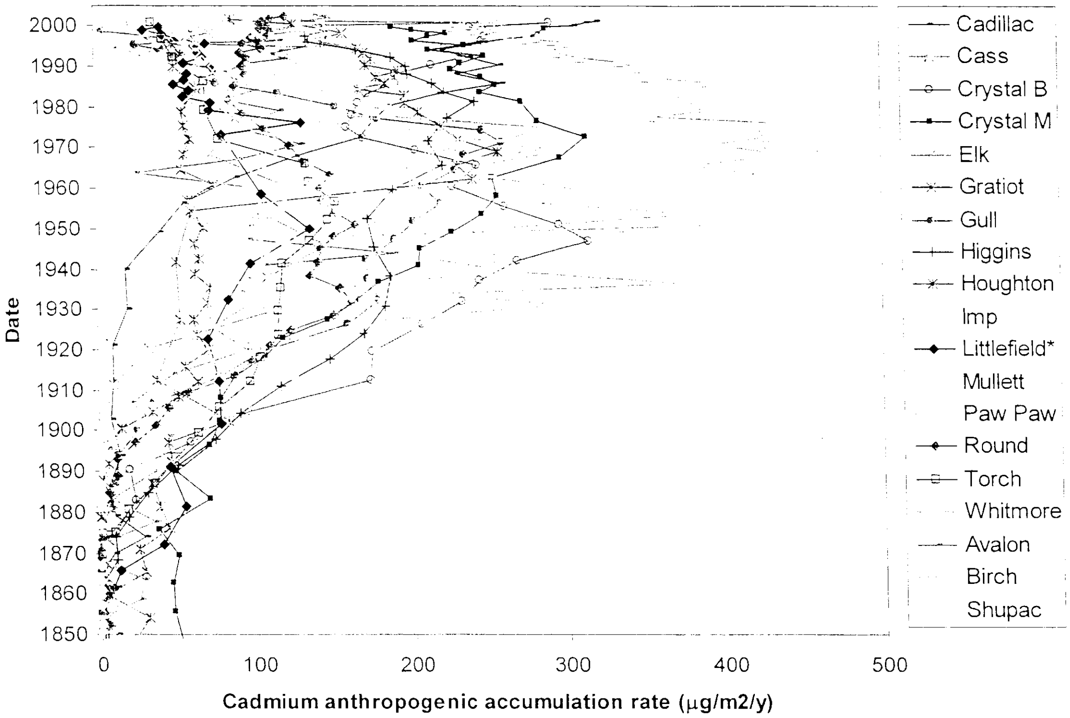
Focusing corrected anthropogenic accumulation rates

Concentrations of metals in the sediment have important implications on bottom-dwelling organisms; however, they do not provide insight into how much of the element is present due to human actions. For example, Gratiot Lake has high copper concentrations even in deep sediments because the lake is located in an area that is naturally rich in copper. Therefore, in addition to the interpretation of the total concentration profiles, focusing corrected anthropogenic accumulation rates were calculated and compared among lakes. These calculations take into account the natural inputs of elements of interest as well as the process of sediment focusing, and provide the best estimate of the actual rate of input of that element to the lake due to human actions. The calculations are described further in the 2001-2002 year end report (Yohn *et al.*, 2002).

In general, anthropogenic accumulation rates in the 2003-2004 study lakes do not vary appreciably compared to lakes from previous studies (Fig. 24 & 25). Of note are the anthropogenic accumulation of lead in Birch and Avalon lakes and the anthropogenic accumulation of zinc in Birch Lake (Fig. 26). Lead accumulation in Avalon Lake increases to the surface, suggesting that a new source of lead has emerged after the enactment of environmental legislation. Lead and zinc accumulation rates in Birch Lake are elevated with respect to the majority of study lakes (Fig 26).

Shupac Lake is characterized by three distinct events throughout the sediments geochemical history. Peaks occur at 1937, 1970, and 1985 for all (except copper) anthropogenic elements (Figs. 26 & 27). Unlike Torch Lake from the 2001-2002 sampling season these time periods are not characterized by high sedimentation rates but rather abrupt changes in anthropogenic inputs to the lake. For many lakes, the dominant source of lead in the 1930-1980s was atmospheric deposition of lead due to the burning of leaded gasoline (Graney *et al.*, 1995, Yohn *et al.*, 2002), with the largest input to the environment occurring in 1972 (United States. Bureau of Mines.). The 1970 peak probably corresponds to the peak use of leaded gasoline within the watershed of Shupac Lake. The similarity of anthropogenic accumulation profiles of lead to those of zinc and cadmium in Shupac Lake suggest that they are influenced by a common source or a common pathway (i.e. automobile use in the watershed, atmospheric deposition).

Overall, the highest anthropogenic accumulation rates of lead, cadmium, zinc or copper generally occur in the 1970s, with rates decreasing to the present. However, some lakes, such as Avalon, Crystal B, Cadillac, Imp and Round lakes presently show an increase in anthropogenic accumulation rates of various anthropogenic elements. This suggests that Avalon, Crystal B, Cadillac, Imp and Round lakes might be high priority lakes for continued monitoring.



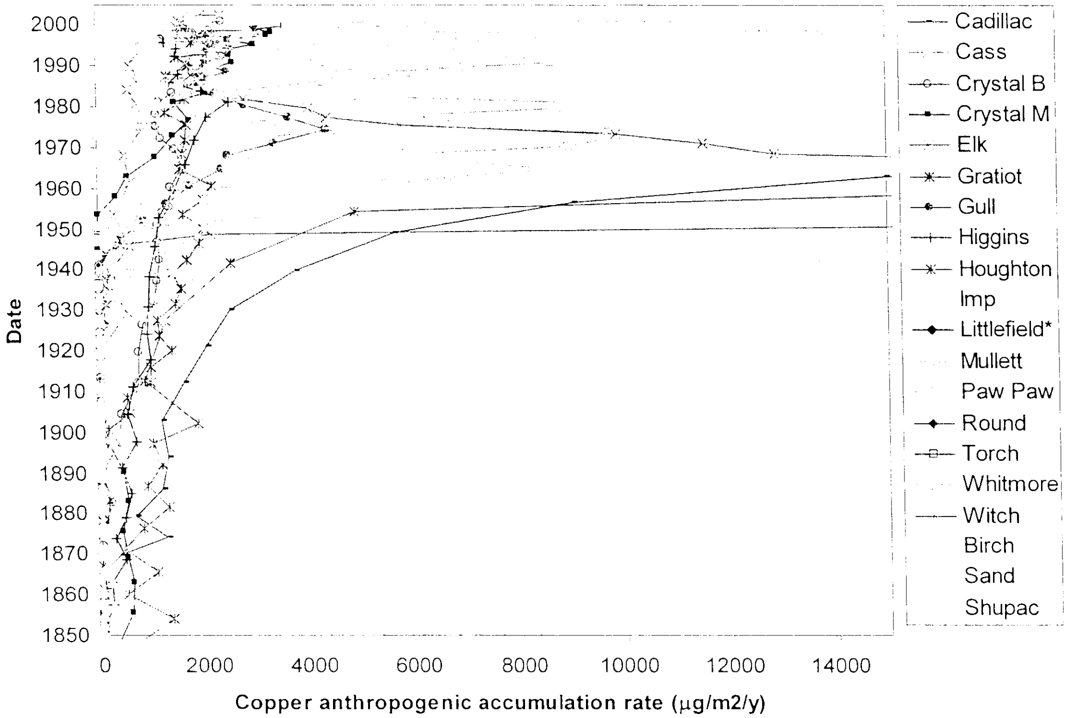


Fig. 24. Cadmium and copper focusing corrected anthropogenic accumulation rates (μg/m^2/y) for study lakes in Michigan. Copper accumulation rates for Cadillac, Houghton and Witch Lakes are greater than the scale used.

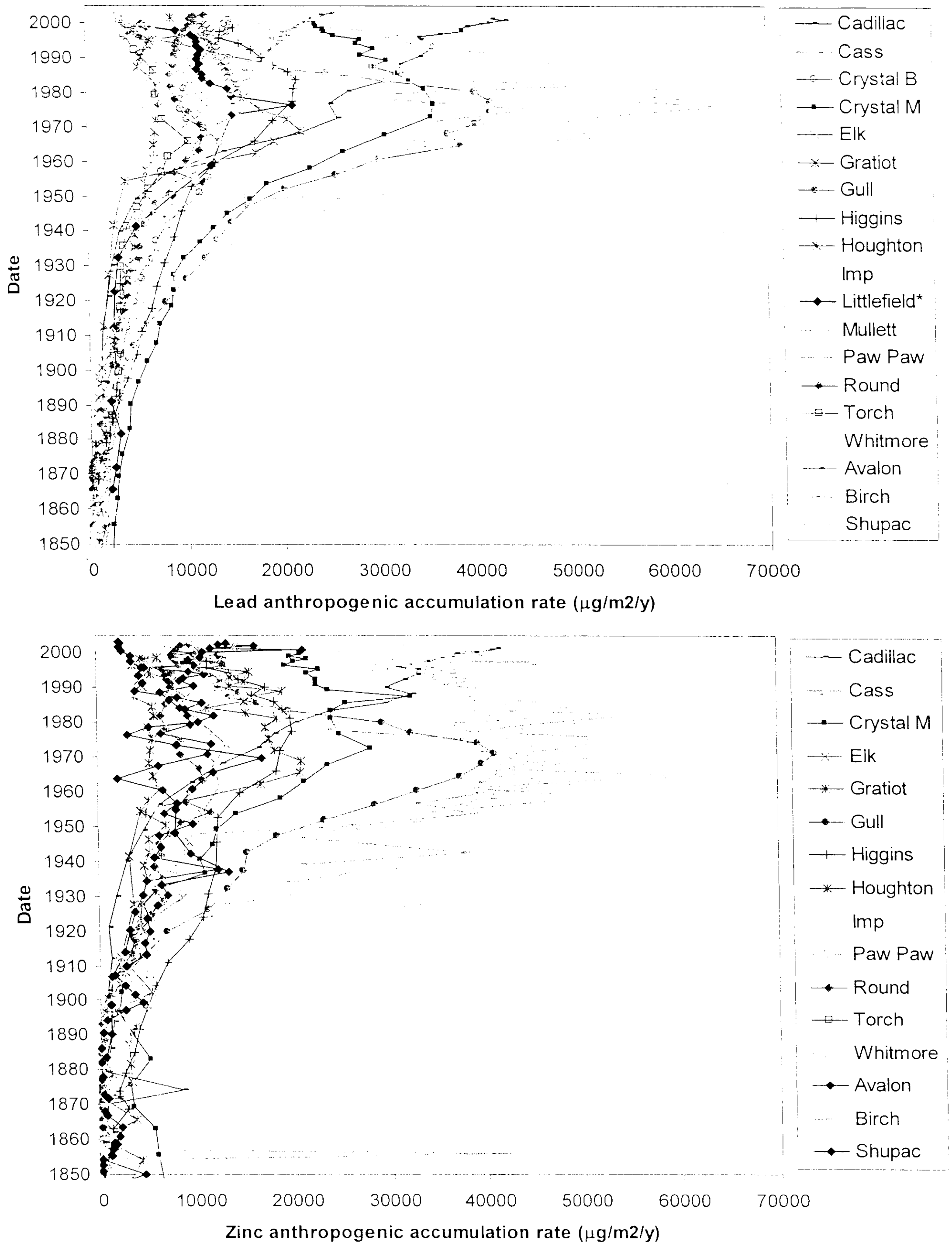
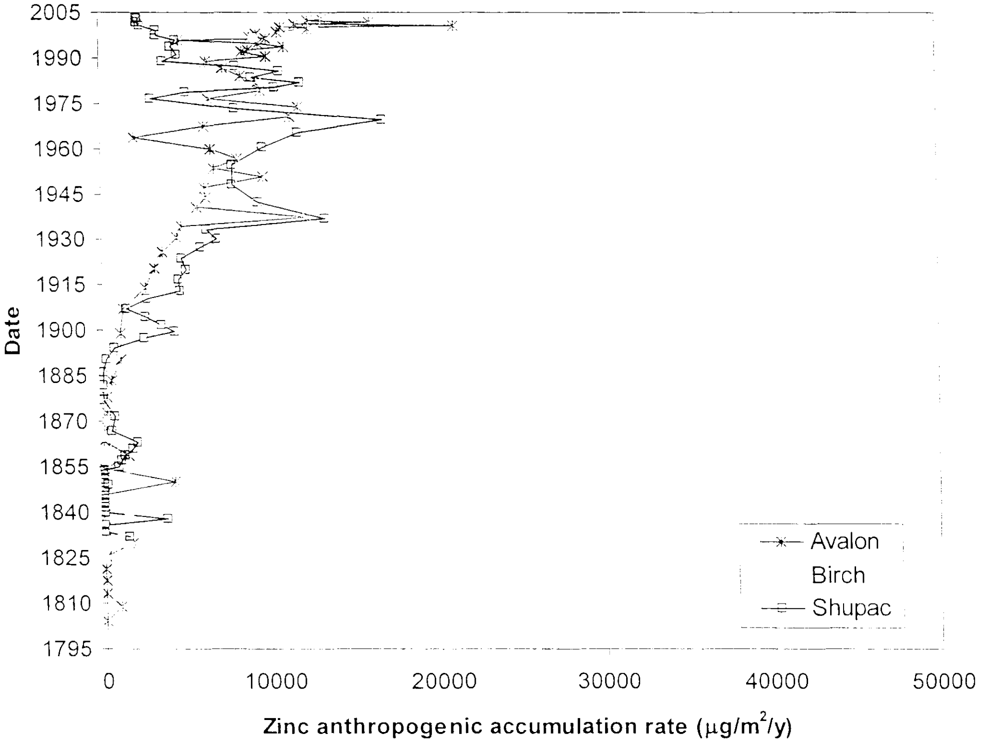


Fig. 25. Lead and zinc focusing corrected anthropogenic accumulation rates (µg/m^2/y) for study lakes in Michigan.



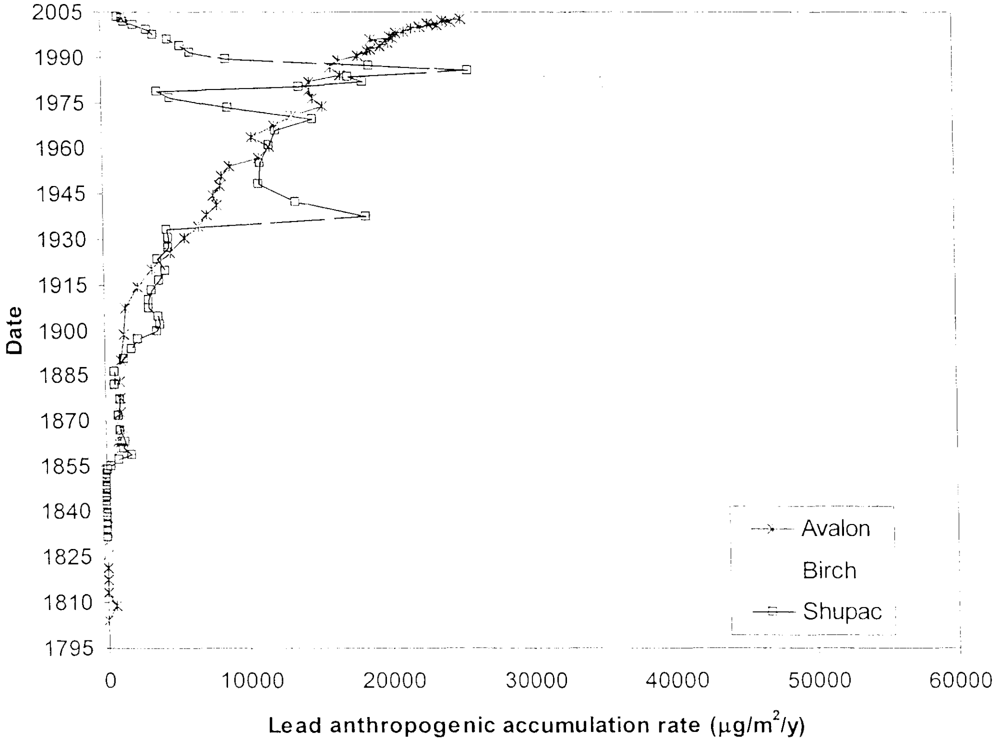
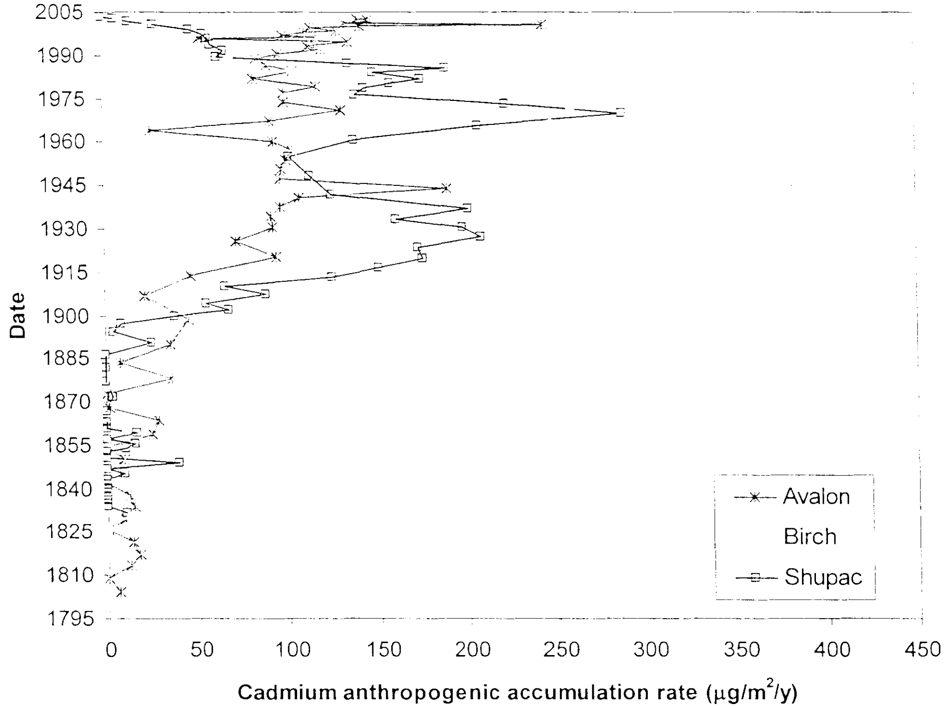


Fig. 26. Lead and zinc focusing corrected anthropogenic accumulation rates (µg/m²/y) for 2003-2004 study lakes in Michigan.



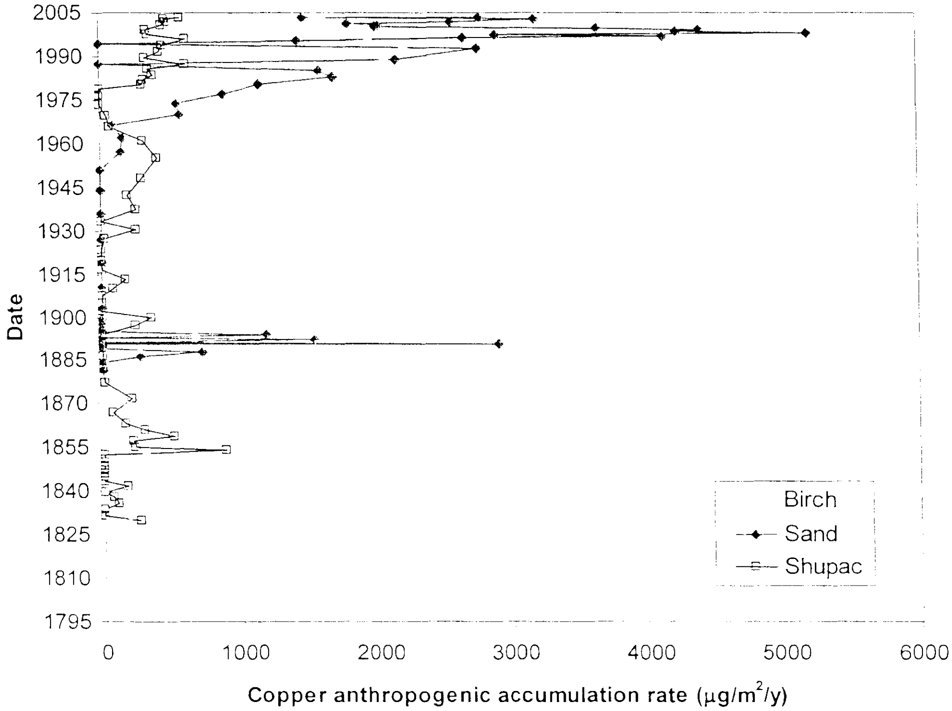


Fig. 27. Copper and cadmium focusing corrected anthropogenic accumulation rates (µg/m²/y) for 2003-2004 study lakes in Michigan.

Recommendations of a lake monitoring strategy

Designing a monitoring strategy should include the determination of two different things: (1) which lakes to monitor, and (2) how often to sample those lakes.

An overall monitoring strategy should include:

1. Lakes of concern: lakes with increasing levels of contaminants to the surface, or concentrations of contaminants higher than most other Michigan lakes
2. Background lakes: lakes with low concentrations of contaminants with few point sources in the watershed. These lakes would provide background data on atmospheric deposition and provide a comparison for the lakes of concern. Ideally, these lakes would be spatially dispersed throughout Michigan.

Several factors should be considered when determining which lakes to monitor. One important consideration is the quality of the core. The sediment core from Littlefield Lake shows evidence of disturbance. This is not surprising given the historical uses of the lake, but the disturbance prevents accurate ^{210}Pb dating of the sediment. If this lake is to be resampled, ^{210}Pb dates could not be used to determine when such sampling should occur. It would be possible to match element profiles to differentiate the depth of new deposition, however, unless there are particular contaminant concerns, resampling Littlefield Lake is not recommended. Due to sand layers encountered during core retrieval, dating of the sediments collected from Hubbard Lake was problematic. It is not recommended to resample Hubbard Lake.

It is not appropriate to make final recommendations on which lakes to monitor until all the sampling is completed; however, some of the lakes may be classified as lakes of concern or background lakes. Classifying a lake as "of concern" is not an evaluation of the toxicity of the sediments, but rather a comparison to other Michigan lakes in this study.

The lakes that have been most affected by anthropogenic activities are classified as lakes of concern. Cass Lake has clearly been influenced by human activities, and has relatively high concentrations of anthropogenic elements near the surface. Concentrations of anthropogenic elements in Muskegon, Sand, Whitmore, Paw Paw and Cadillac lakes are also higher than most lakes. Additionally, Avalon, Cadillac, Crystal B, Round and Imp lakes have anthropogenic accumulation rates that increase to the present. Crystal B, Imp and Round lakes are particularly interesting, because they do not have high rates of metal inputs, and the cause of the increasing anthropogenic inputs is not clear.

Elk Lake has consistently low concentrations of contaminants. Gratiot, Mullett, Imp and Round lakes also have low anthropogenic accumulation rates. These lakes appear to be the "cleanest" of the lakes sampled. Imp Lake would be particularly useful to sample, as it has little development in the watershed, generally low accumulation rates, but rates are increasing in the past decade.

After the results from all lakes are available, it will be possible to determine which lakes merit future sampling. It will also be possible to identify background lakes, which will serve as monitors of contaminants entering lakes with few known point sources.

The second issue is the frequency of lake sampling. The intent of monitoring is to be able to detect change from previous sampling. Change can be in the concentration of a chemical or a change in the trend of the environmental loading of a chemical. In the first case only the very surface sediment would be sampled. But given the complexities of lake dynamics (e.g., bioturbation), the surface sample may not be informative. What is more important is to determine the change in the trend of the chemical inputs. However, a single surface sample will not reveal a trend. One might consider a minimum of four samples within a core that reflect new sediment input from the previous sampling as necessary to define a trend.

Our current sampling protocol involves taking 0.5 cm samples from the top sediments. Therefore, the accumulation of 2.0 cm of new sediment would be needed to obtain the four samples. The time to deposit 2.0 cm of sediment can be determined from the sedimentation rate (Table 8).

Table 6. Minimum number of years needed to deposit approximately 2 cm of new sediment for seventeen inland lakes in Michigan. * Littlefield estimated

Avalon	Birch	Cadillac	Cass	Crystal B	Crystal M
6 y	5 y	2 y	1 y	4 y	3 y
Elk	Gratiot	Gull	Higgins	Houghton	Imp
10 y	2 y	4 y	6 y	4 y	6 y
Littlefield*	Mullett	Muskegon	Paw Paw	Round	Sand
5 y	3 y	2 y	1 y	3 y	3 y
Shupac	Torch	Whitmore	Witch		
7 y	13 y	1 y	2 y		

In addition to the issues described above, other factors to consider when determining a monitoring plan could include the usage of the lake for recreation (e.g., Houghton Lake), and spatial distribution of the monitoring lakes.

A possible suite of lakes to sample could include: Gratiot, Imp, and Round lakes in the Upper Peninsula. Gratiot Lake would represent a "clean" lake, while Imp and Round lakes represent relatively undeveloped lakes, but also have increasing human inputs entering the lake. In the Lower Peninsula, PawPaw, Whitmore and/or Cass, and Cadillac lakes could be monitored as lakes of concern, while Elk Lake could be sampled as a more pristine lake. Crystal B Lake could be useful to monitor, as anthropogenic inputs are also increasing in this lake. Crystal M Lake could be sampled to represent the middle portion of the state.

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Inland Lakes Sediment Trends: Sediment Analysis Results for Five Michigan Lakes
2003-2004

Appendix A

Background Concentrations
Focusing Factors and Sedimentation Rates
Surface Concentrations
Anthropogenic Inventories
Core Descriptions
^{210}Pb Data
Sediment Chemical Concentrations
Organic Contaminant Concentrations
Porewater Concentrations

MICHIGAN STATE UNIVERSITY

Aqueous & Environmental Geochemical Laboratory
Geological Sciences
Michigan State University

Background Concentrations

Concentrations in mg/kg dry wt

Lake	Cd	Cu	Pb	Zn
Avalon	0.63	NA	7.86	48.03
Birch	0.33	NA	1.88	NA
Cadillac	1.0	19.9	8.0	108.9
Cass	NA	NA	NA	NA
Crystal B	NA	NA	NA	NA
Crystal M	0.2	8.1	3.6	NA
Elk	BDL	3.0	0.3	4.4
Gratiot	0.6	46.0	3.0	53.0
Gull	BDL	1.3	0.2	4.6
Higgins	0.3	15.0	8.2	48.0
Houghton	0.6	14.6	7.4	99.9
Imp	0.8	NA	6.1	NA
Littlefield	0.2	NA	0.1	NA
Mullett	0.2	8.6	3.2	27.9
Muskegon	NA	NA	NA	NA
Paw Paw	NA	NA	NA	NA
Round	0.4	NA	4.4	NA
Sand	NA	18.8	NA	NA
Shupac	0.1	5.4	2.3	20.3
Torch	0.1	NA	1.6	NA
Whitmore	NA	23.2	NA	NA
Witch	NA	13.5	NA	NA

NA indicates that background levels could not be determined

BDL indicates that values were below detection limits

Focusing Factors and Sedimentation Rates

		Sedimentation Rates (g/m^2/y)				^{210}Pb Flux^5
Lake	FF	CF:CS^1	SCF:CS^2	RSSM^3	CRS^4	Bq/m^2/yr
Avalon	1.53	406		326	**340**	278
Birch	1.67	384		367	**445**	302
Cadillac	1.71	ND		91	**117**	307
Cass	6.04	**3480**			ND	1160
Crystal B	2.86	572		588	**624**	166
Crystal M	1.66	529			**465**	297
Elk	2.05	415	**337**		364	367
Gratiot	2.49	**255**			287	446
Gull	1.78	499	**404**		498	318
Higgins	2.02	**232**			257	362
Houghton	1.15	143	**165**	111	208	208
Imp	1.48	75		78	**119**	268
Mullett	3.56	920	**801**	1084	926	639
Muskegon	2.83*	**1711**		1407	ND	600
Paw Paw	2.7*	**828**		754	ND	484
Round	2.31	312		350	**317**	418
Sand	1.73	ND			**441**	323
Shupac	1.95	213		188	**261**	353
Torch	2.36	932	**944**	542	1470	427
Whitmore	2.8*	463	**556**	517	ND	522
Witch	1.66	**318**		289	**269**	301

1. Constant flux: constant sedimentation model
2. Average sedimentation rate for the segmented CF:CS model
3. Sedimentation rate for the rapid steady state mixing model
4. Average sedimentation rate for constant rate of supply model
5. Calculated

*Focusing factors for Paw Paw, Muskegon, and Whitmore Lakes were estimated

Bold indicates the model that was used to date each lake.

ND indicates that it was not possible to date the lake using that method.

Surface Concentrations

Average of the top 1.5 cm (3 samples) of sediment. Concentrations in mg/kg dry weight.

	As	Cd	Cu	Pb	Zn
Cass	30.8	0.3	15.4	53.7	85.4
Elk	23.9	0.3	8.8	29.9	38.4
Gratiot	6.6	0.8	61.0	39.5	82.4
Gull	7.6	0.1	11.6	32.4	52.4
Higgins	10.5	1.2	21.1	109.1	122.1
Crystal M	7.3	0.9	21.9	78.9	106.5
Littlefield	11.5	0.5	12.2	30.1	49.0
Cadillac	16.8	2.2	404.2	185.4	265.7
Crystal B	4.4	1.1	18.0	56.1	106.7
Mullett	4.9	0.4	12.7	26.6	57.9
Paw Paw	19.2	0.6	43.8	49.7	151.8
Whitmore	16.1	1.5	49.7	143.9	229.0
Houghton	23.9	1.2	175.1	67.9	159.6
Hubbard*	4.4	0.6	9.1	19.3	49.8
Imp	10.7	1.8	61.3	102.0	137.4
Round	4.7	1.0	15.1	68.4	98.0
Torch	3.9	0.6	13.1	43.3	57.9
Witch	51.9	0.7	22.7	23.4	106.3
Avalon	4.2	1.1	606.7	70.9	93.5
Birch	8.0	0.3	11.2	22.5	68.2
Muskegon	15.7	2.0	52.7	58.0	146.9
Sand	16.9	1.7	43.0	126.4	185.4
Shupac	9.5	0.3	15.8	26.6	65.4

*Data suggest that the surface sediments of Hubbard Lake have been eroded, therefore the top 1.5 cm will represent a different time period than other lakes.

Anthropogenic Inventories and Burdens

Inventories and focusing corrected anthropogenic inventories were calculated with a constant background concentration (Const BG and Const BG FC), and watershed correction technique (Wshed, Wshed FC). Some inventories from earlier years are slightly different than reported previously. Data were recalculated to correct errors and improve the consistency of the calculation. The watershed focusing corrected inventories (Wshed FC) are the best estimation of true anthropogenic inputs, and are graphed below.

Cadmium ($\mu g/cm^2$)

	Const BG	Const BG FC	Wshed	Wshed FC
Birch	3.2	1.9	2.9	1.7
Gull	2.7	1.5	2.7	1.5
Whitmore**	7.2	2.6	7.0	2.5
Crystal M	3.2	1.9	3.3	2.0
Littlefield*	3.0	1.5	2.4	1.2
Cadillac	1.6	1.0	1.7	1.0
Houghton	1.5	1.3	1.6	1.4
Higgins	3.4	1.7	3.5	1.8
Shupac	3.2	1.6	2.8	1.4
Elk	1.8	0.9	1.8	0.9
Torch	3.1	1.3	2.8	1.2
Avalon			1.6	1.1
Mullett	4.0	1.1	3.4	1.0
Round	2.8	1.2	2.8	1.2
Imp	1.2	0.8	1.1	0.7
Gratiot	1.3	0.5	1.5	0.6

Lead

	Const BG	Const BG FC	Wshed	Wshed FC
Birch	305	183	305	182
Paw Paw**	597	221	613	227
Gull	378	210	375	208
Whitmore*	760	272	763	272
Crystal M	286	168	288	169
Littlefield*	216	108	215	108
Cadillac	238	139	239	140
Houghton	105	91	106	92
Higgins	219	108	225	112
Shupac	194	100	188	96
Crystal B			279	98
Elk	153	75	152	74
Torch	152	64	145	61
Avalon			164	107
Mullett	297	83	288	81
Round	179	78	179	78
Imp	76	51	75	51
Gratiot	128	51	128	51

Copper

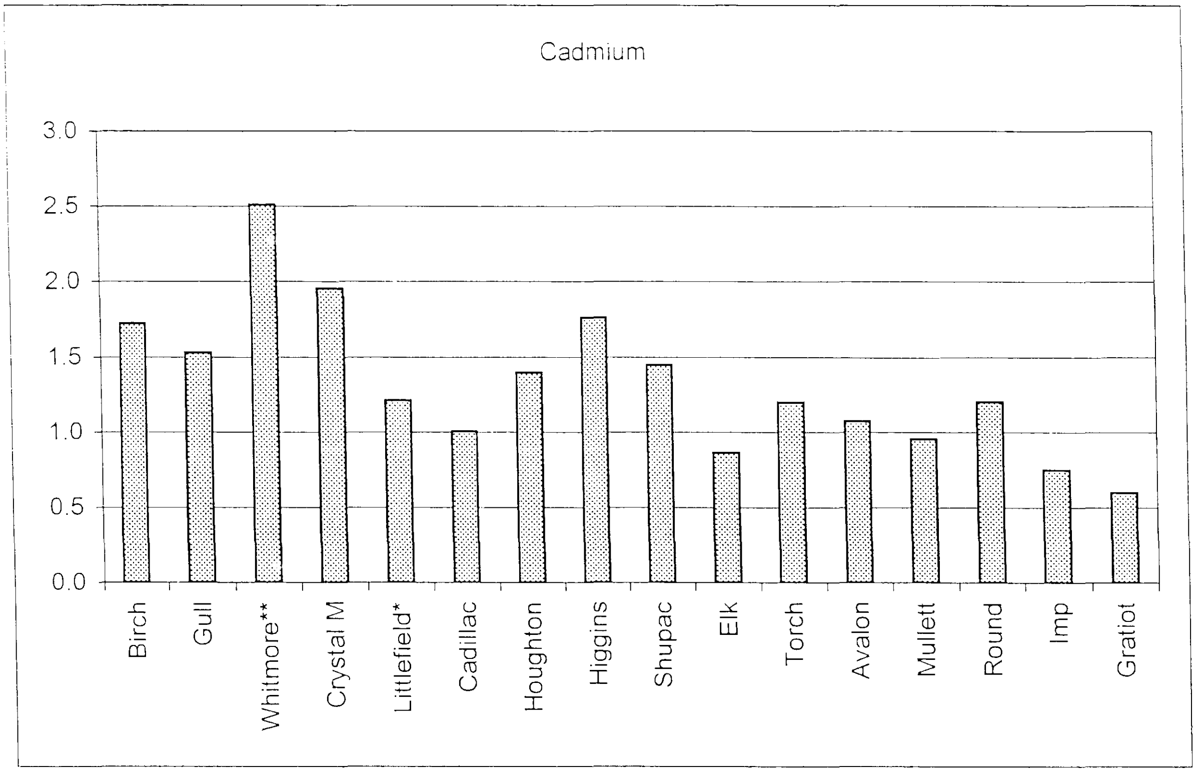
	Const BG	Const BG FC	Wshed	Wshed FC
Gull	49	27	25	14
Sand	429	241	281	158
Whitmore**	68	24	46	17
Crystal M	13	8	11	6
Cadillac	419	245	421	246
Houghton	197	171	199	173
Higgins	17	8	29	14
Shupac	19.0	9.7	5.5	2.8
Crystal B			40	14
Elk	27	13	14	7
Avalon			110	72
Mullett	52	15	30	8.5
Witch	214	129	133	80
Gratiot	57	23	38	15

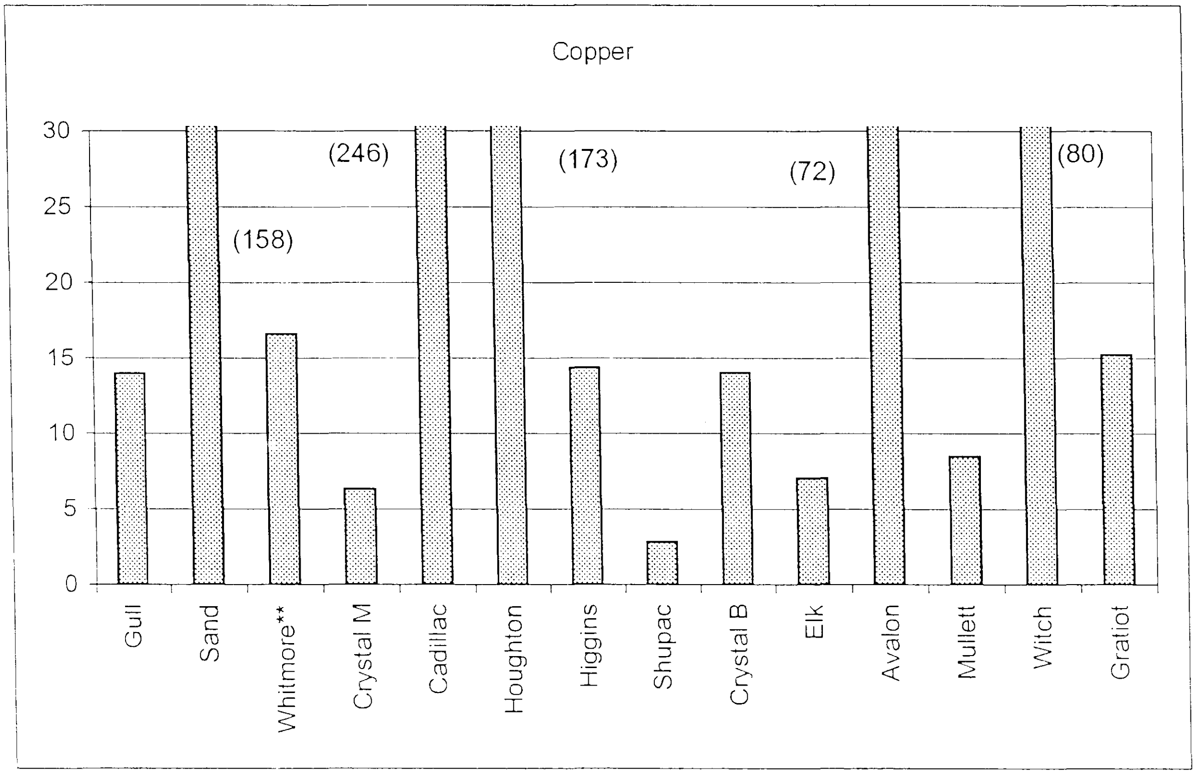
Zinc

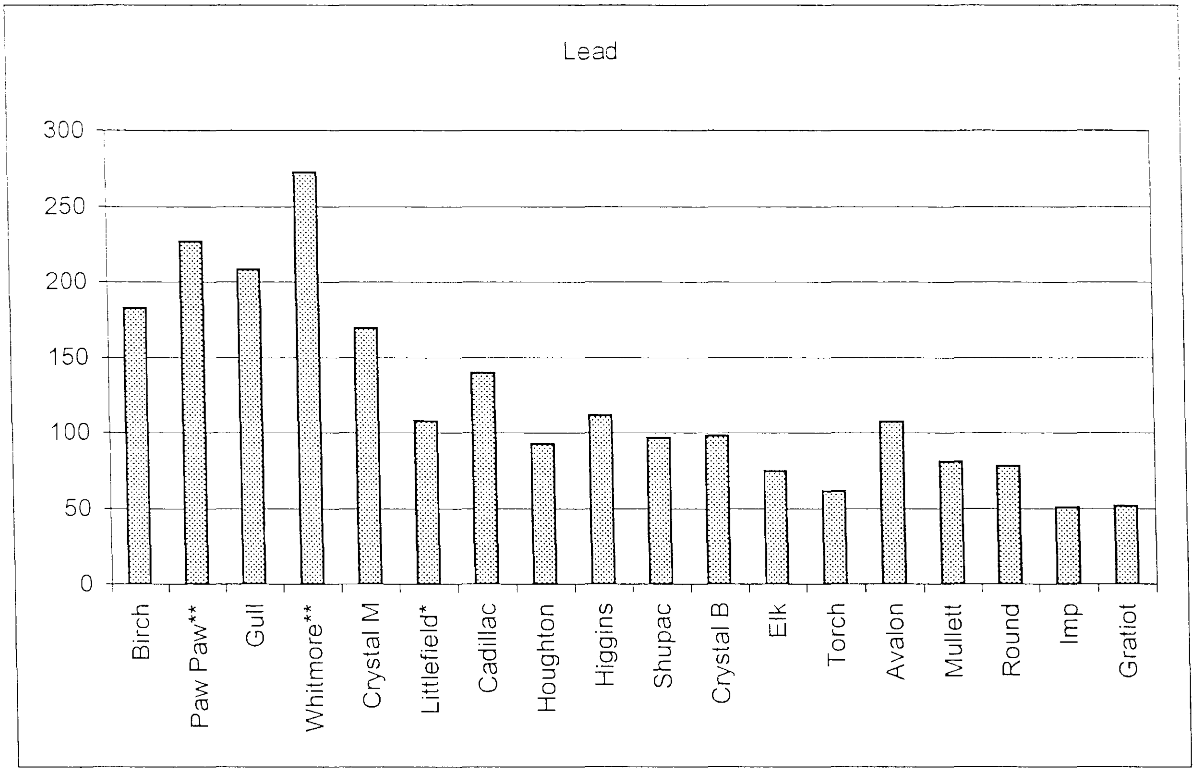
	Const BG	Const BG FC	Wshed	Wshed FC
Birch			372	223
Gull	435	241	348	193
Whitmore*	757	270	740	264
Crystal M			189	111
Cadillac	199	116	207	121
Houghton	116	100	133	116
Higgins	227	113	266	132
Shupac	207	106	152	78
Elk	237	115	210	103
Avalon			111	72
Round			159	69
Gratiot	105	42	121	48

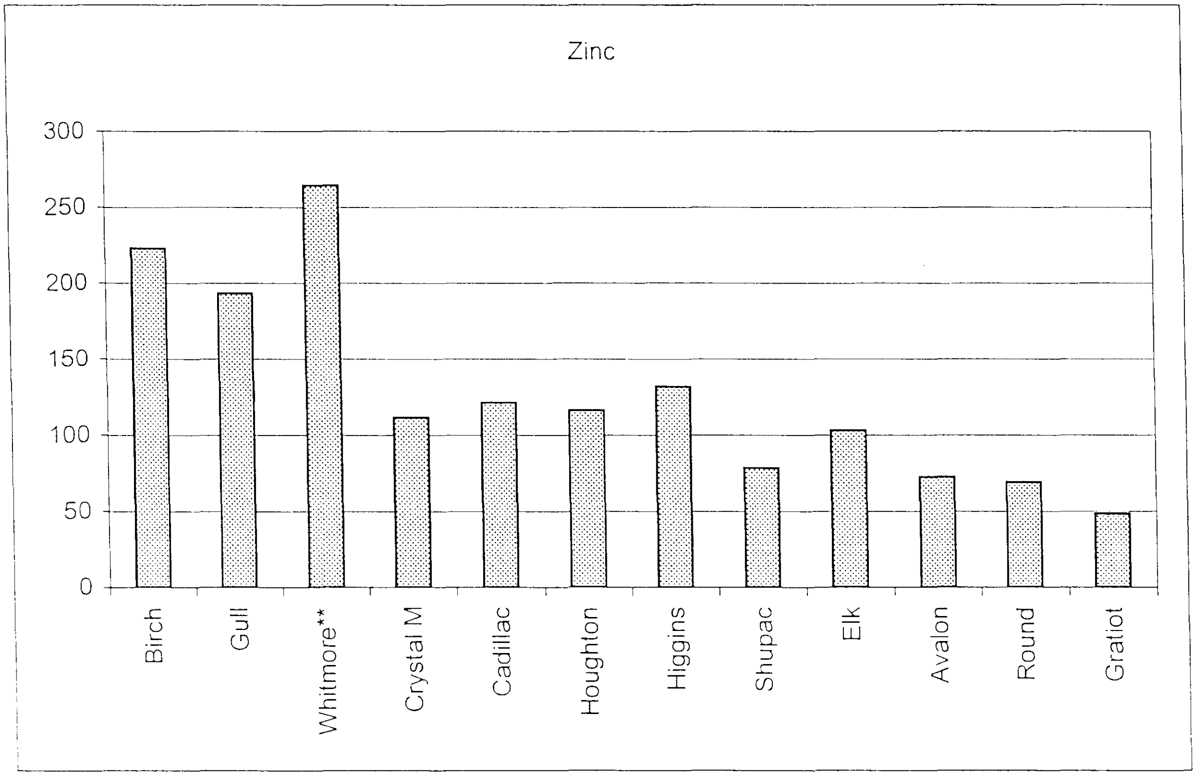
* Focusing corrected values calculated assuming a FF of 2 (average of FF from years 1 and 2)

** Background concentrations were estimated from Higgins Lake


Cadmium
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Birch
Gull
Whitmore**
Crystal M
Littlefield*
Cadillac
Houghton
Higgins
Shupac
Elk
Torch
Avalon
Mullett
Round
Imp
Gratiot


Copper
30
25
20
15
10
5
0
(158)
(246)
(173)
(72)
(80)
Gull
Sand
Whitmore**
Crystal M
Cadillac
Houghton
Higgins
Shupac
Crystal B
Elk
Avalon
Mullett
Witch
Gratiot





Anthropogenic Inventories and Burdens

Watershed characteristics

Lake	Watershed area	Lake area	Watershed:lake area ratio	k factor	k factor slope corrected	SO4 deposition	Population density 1970-1980
Units →	km^2	km^2				kg/ha/y	people/km^2
Code →	wshed_area	lake_area	shed_lake_ratio	kfact	kfact_s	SO4	popdens_75
Avalon	3.1	1.51	2.0	0.13	0.05	13.3	14.2
Birch	2.7	1.19	2.2	0.17	0.09	19.1	29.2
Cadillac	42.8	4.7	9.2	0.15	0.14	16.7	102.6
Cass	41.9	5.2	8.1	0.22	0.11	16.2	736.6
Crystal B	66.2	39.3	1.7	0.16	0.18	15.7	23.5
Crystal M	9.2	2.9	3.2	0.25	0.15	16.4	21.9
Elk	98.1	31.3	3.1	0.19	0.27	14.7	20.9
Gratiot	21.1	5.8	3.6	0.16	0.12	8.5	1.1
Gull	53.4	8.2	6.5	0.26	0.12	18.5	37.9
Higgins	67.2	38.9	1.7	0.12	0.08	14.9	14.2
Houghton	380.3	81.2	4.7	0.13	0.06	15.1	12.9
Imp	1.7	0.3	5.0	0.31	0.20	8.8	1.4
Littlefield	16.4	0.7	22.1	0.21	0.09	15.8	8.0
Mullett	1285.8	70.3	18.3	0.16	0.14	12.6	6.6
Muskegon	885.5	16.8	52.7	0.21	0.10	16.8	95.8
Paw Paw	25.9	3.7	6.9	0.28	0.08	19.4	82.5
Round	2.7	1.8	1.5	0.18	0.12	16.7	5.5
Sand	10.6	1.8	5.9	0.20	0.20	14	35.1
Shupac	15.5	0.4	38.8	0.12	0.04	12.2	1.7
Torch	115.7	76.0	1.5	0.19	0.29	14.1	16.1
Whitmore	9.1	2.7	3.3	0.23	0.14	16.6	64.3
Witch	11.1	0.9	13.0	0.29	0.16	9.3	4.8

Lake	Population density 1990-2000	% urban landcover 1970-1980	% agricultural landcover 1970-1980	% nonforested landcover 1970-1980	% forested landcover 1970-1980	% wetlands landcover 1970-1980
Units →	people/km^2	%	%	%	%	%
Code →	popdens_95	urban_p75	ag_p75	nonfor_p75	forest_p75	Wetlands_p75
Avalon	12.3	2.9	69.4	1.2	25.4	0.1
Birch	29.2	2.1	32.2	19.4	41.1	2.7
Cadillac	120.3	19.74	40.67	10.16	24.37	4.11
Cass	832.2	60.49	2.43	13.93	8.57	12.20
Crystal B	29.8	12.39	12.91	21.24	51.88	1.21
Crystal M	29.5	11.07	58.25	4.97	16.90	8.18
Elk	36.0	6.32	27.96	19.84	41.01	3.92
Gratiot	1.6	0.83	0.00	0.00	98.10	0.62
Gull	45.8	9.71	59.00	7.91	14.13	5.79
Higgins	35.3	14.98	0.50	3.46	77.37	3.43
Houghton	23.5	7.11	1.62	5.28	74.52	9.84
Imp	1.7	7.31	0.00	0.00	86.75	4.94
Littlefield	11.6	1.81	9.32	13.80	69.73	4.21
Mullett	9.8	2.99	7.36	15.18	70.83	2.86
Muskegon	88.4	8.1	50.3	9.3	2.9	0.2
Paw Paw	101.7	17.34	30.11	13.18	35.01	2.06
Round	45.7	4.78	13.78	11.43	68.45	0.97
Sand	1.5	20.1	11.4	14.9	49.0	2.4
Shupac	4.8	0.90	0.46	13.86	83.63	1.10
Torch	22.1	7.32	23.50	21.93	44.81	1.91
Whitmore	144.8	22.08	23.45	20.50	23.69	8.68
Witch	3.1	1.81	2.94	6.69	80.64	6.47

Watershed characteristics (con't)

Lake	% urban landcover 1990-2000	% agricultural landcover 1990-2000	% upland/ openland landcover 1990-2000	% forested landcover 1990-2000	% wetlands landcover 1990-2000	Cadmium FC anthro accum rates 1970-1980
Units →	%	%	%	%	%	$\mu g/m^2/y$
Code →	urban_p95	ag_p95	upland_p95	forest_p95	Wetlands_p95	Cd_1975
Avalon	8.8	0.0	15.3	70.5	1.1	111.9
Birch	9.2	29.5	9.1	44.8	1.8	226.8
Cadillac	12.0	33.5	18.7	30.9	2.0	172
Cass	31.0	0.5	19.1	38.1	10.2	345
Crystal B	6.0	10.8	22.3	58.9	0.9	165
Crystal M	11.1	49.4	2.8	21.1	13.5	219
Elk	4.7	24.7	17.7	49.6	1.8	105
Gratiot	0.9	0.0	6.2	89.0	3.5	55
Gull	5.3	57.7	6.3	22.2	5.8	217
Higgins	7.0	0.1	15.3	72.9	3.7	190
Houghton	4.1	0.8	15.3	62.2	15.7	219
Imp	1.7	0.0	0.5	94.9	0.7	67
Littlefield	2.6	5.1	13.1	73.6	4.2	191
Mullett	2.8	7.5	17.6	68.0	3.1	99
Muskegon	7.0	17.5	17.2	48.1	6.8	
Paw Paw	12.4	33.6	14.1	31.9	6.6	197
Round	8.4	6.5	12.0	65.1	7.2	108
Sand	1.6	0.5	23.7	72.6	1.1	
Shupac	5.3	8.3	9.3	67.2	9.1	1362
Torch	4.1	18.1	19.3	55.3	1.6	130
Whitmore	12.3	17.0	16.0	41.8	11.7	405
Witch	4.0	0.0	4.9	86.7	2.1	

Lake	Copper FC anthro accum rates 1970-1980	Lead FC anthro accum rates 1970-1980	Zinc FC anthro accum rates 1970-1980	Copper FC anthro accum rates 1990-2000	Cadmium FC anthro accum rates 1970-1980	Lead FC anthro accum rates 1970-1980	Zinc FC anthro accum rates 1970-1980
Units →	$\mu g/m^2/y$	$\mu g/m^2/y$	$\mu g/m^2/y$	$\mu g/m^2/y$	$\mu g/m^2/y$	$\mu g/m^2/y$	$\mu g/m^2/y$
Code →	Cu_1975	Pb_1975	Zn_1975	Cu_1995	Cd_1995	Pb_1995	Zn_1995
Avalon	16227.8	14628.4	9838.0	16031.3	123.0	20444.6	10531.5
Birch	2600.4	35966.8	31703.2	1819.6	20.0	5664.1	11044.0
Cadillac	41546	25447	17481	82245	264	37193	34077
Cass	9876	75462	74481	9299	182	40067	54103
Crystal B	1165	9921		2058	238	13837	
Crystal M	1043	26113	17908	2637	208	24814	18275
Elk	1044	14604	15531	922	63	7685	7824
Gratiot	1471	6299	4913	1678	44	4484	4102
Gull	3810	42479	36941	2537	43	10969	12875
Higgins	1702	17068	16653	1296	141	13049	11547
Houghton	41448	18172	17788	34166	161	12787	13025
Imp		7098			58	5862	
Littlefield		31246		598	98	14692	
Mullett	1136	13686		1038	63	7670	
Muskegon							
Paw Paw	8198	40381	42589	8491	123	18881	34324
Round		10402	8041	2972			
Sand	307			7053	848	69803	61582
Shupac	845	70427	58735		103	9961	7945
Torch		9196			79	8535	
Whitmore	3647	56650	46397	4023	278	31858	34897
Witch	7115			1868			

MICHIGAN STATE
UNIVERSITY

Avalon Lake Sediment Fact Sheet

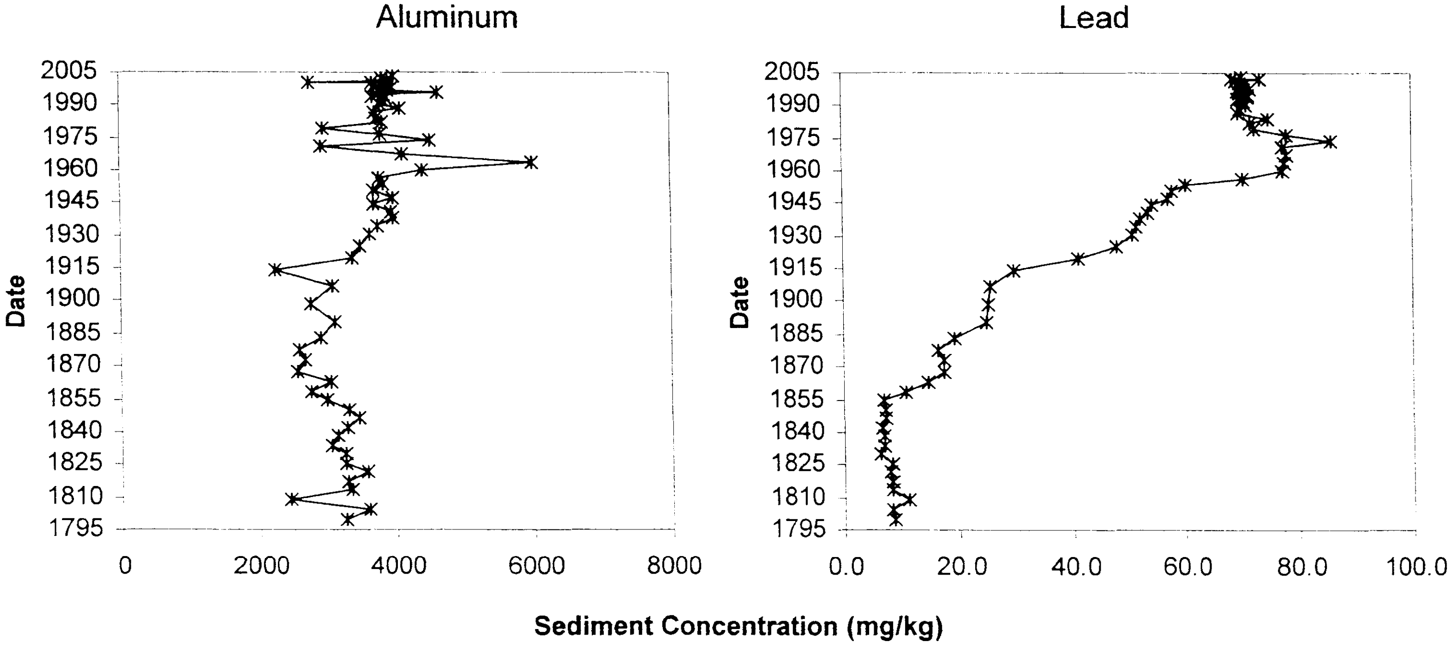
Date sampled: 12 June 2003	Sampling site water depth: 70 ft
Location: Montmorency County	Depth of core: 56 cm
Sampling site: 45°06.172'N 83°57.378'W	Sedimentation rate: 340 g/m^2/y
	Age of oldest section: 1799
Lake surface area: 372 acres	Focusing factor: 1.53

Copper concentrations in Avalon Lake are the highest among all study lakes, although there is not strong evidence of anthropogenic activity. Cadmium, lead, and zinc do demonstrate evidence of anthropogenic influence and current trends are level, indicating that a current source exists for the lake. Total PAHs are increasing in Avalon Lake; PCBs and DDTs are similar to other Michigan inland lakes.

	Surface conc.	Background conc.	Trends
Cadmium (mg/kg)	1.1	0.63	level
Copper (mg/kg)	606.7	NA	increasing
Lead (mg/kg)	70.9	7.86	level
Zinc (mg/kg)	93.5	48.03	level
Total PCBs (ug/kg)	1.71		decreasing
Total PAHs (ug/kg)	153.7		Increasing
Total Pesticides (ug/kg)	3.1		decreasing

Trends for organic contaminants are taken from only two data points and should be interpreted with care.

Example profiles



Aluminum

Lead

A Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters: Sediments

Avalon Lake

Sampling Date: **12 June 2003**

Location: **45°06.172'N 83°57.378'W**

Core description: ~ Overall length:56.2 cm. Core is very "fluffy" and looks watery. Two distinct layers, one light tan and one medium tan with color grading at 36 cm from the top of the core. Medium tan layer has many air pockets present. Fewer air pockets in the lighter layer.

#	Thickness (cm)	Total thickness (cm)	Description
1	0.5	0.5	light tan, black specks, very liquidy
2	0.5	1.0	light tan, black specks, very liquidy
3	0.5	1.5	light tan, some black and dark brown specks
4	0.5	2.0	light tan, some black and dark brown specks
5	0.5	2.5	light tan, some black and dark brown specks
6	0.5	3.0	light tan, some black and dark brown specks
7	0.5	3.5	light tan, some black and dark brown specks
8	0.5	4.0	light tan, some black and dark brown specks
9	0.5	4.5	light tan, some black and dark brown specks
10	0.5	5.0	light tan, some black and dark brown specks
11	0.5	5.5	light tan, some black and dark brown specks
12	0.5	6.0	light tan, some black and dark brown specks
13	0.5	6.5	light tan, some black and dark brown specks
14	0.5	7.0	light tan, some black and dark brown specks
15	0.5	7.5	light tan, some black and dark brown specks
16	0.5	8.0	light tan, some black and dark brown specks
17	1.0	9.0	light tan, some black and dark brown specks
18	1.0	10.0	light tan, some black and dark brown specks
19	1.0	11.0	light tan, some black and dark brown specks
20	1.0	12.0	light tan, some black and dark brown specks, H_2S smell
21	1.0	13.0	tan, black specks
22	1.0	14.0	tan, black specks
23	1.0	15.0	tan, black specks
24	1.0	16.0	tan, black specks H_2S smell
25	1.0	17.0	tan, black specks
26	1.0	18.0	tan, black specks, still goopy
27	1.0	19.0	tan, black specks
28	1.0	20.0	tan, black specks
29	1.0	21.0	tan, black specks
30	1.0	22.0	tan, black specks
31	1.0	23.0	tan, black specks
32	1.0	24.0	tan, black specks
33	1.0	25.0	tan, black specks, H_2S smell
34	1.0	26.0	medium brown, grayish
35	1.0	27.0	medium brown, grayish
36	1.0	28.0	medium brown, grayish
37	1.0	29.0	medium brown, grayish
38	1.0	30.0	gray

#	Thickness (cm)	Total thickness (cm)	Description
39	1.0	31.0	gray
40	1.0	32.0	gray
41	1.0	33.0	gray
42	1.0	34.0	gray
43	1.0	35.0	gray
44	1.0	36.0	gray
45	1.0	37.0	gray
46	1.0	38.0	gray
47	1.0	39.0	gray and brown, some organic matter
48	1.0	40.0	gray and brown, chunky
49	1.0	41.0	gray and brown, chunky
50	1.0	42.0	gray and brown, chunky
51	1.0	43.0	gray and brown, chunky
52	1.0	44.0	much thicker, medium brown and chunky
53	1.0	45.0	thick, medium brown, chunky
54	1.0	46.0	thick, medium brown, chunky
55	1.0	47.0	thick, medium brown, chunky
56	1.0	48.0	thick, medium brown, chunky
57	1.0	49.0	thick, medium brown, chunky
58	1.0	50.0	thick, medium brown, chunky
59	1.0	51.0	thick, medium brown, chunky
60	1.0	52.0	thick, medium brown, chunky
61	1.0	53.0	thick, medium brown, chunky
62	1.0	54.0	thick, medium brown, chunky
63	1.0	55.0	thick, medium brown, chunky
64	1.0	56.0	thick, medium brown, chunky
65	1.0	57.0	thick, medium brown, chunky

^{210}Pb Analysis: Avalon Lake

Data provided by Paul Wilkinson. Freshwater Institute. Manitoba. Canada

SAMPLE	DRY WT.(g)	ACCUMULATED DRY WT (gm./sq.cm.)	POROSITY	% WATER	ACTIVITY Bq/g ± 1SD			excess Pb-210 Bq/g	ACTIVITY Bq/g ± 1SD		
					Pb-210	±	ERROR		CS-137	±	ERROR
1	1.2300	0.0174	0.99	96.0	4.72E-01	+/-	2.92E-02	4.32E-01	7.84E-02	+/-	8.31E-03
2	2.0700	0.0466	0.97	92.1	4.76E-01	+/-	2.93E-02	4.36E-01			
3	2.6000	0.0832	0.96	90.4	4.94E-01	+/-	3.10E-02	4.54E-01	9.20E-02	+/-	4.97E-03
4	2.3500	0.1164	0.97	92.8	4.85E-01	+/-	2.99E-02	4.45E-01			
5	2.5800	0.1528	0.97	92.2	4.89E-01	+/-	3.01E-02	4.49E-01	9.69E-02	+/-	4.82E-03
6	2.5200	0.1883	0.97	92.3	4.88E-01	+/-	3.01E-02	4.48E-01			
7	3.2200	0.2338	0.97	91.5	4.92E-01	+/-	3.03E-02	4.52E-01	9.25E-02	+/-	2.51E-03
8	2.4800	0.2688	0.97	92.3	4.90E-01	+/-	3.02E-02	4.50E-01			
9	2.9400	0.3102	0.97	92.0	5.01E-01	+/-	3.08E-02	4.61E-01	8.87E-02	+/-	4.69E-03
10	2.6400	0.3475	0.97	91.6	4.91E-01	+/-	3.02E-02	4.51E-01			
11	2.7700	0.3866	0.97	91.4	4.72E-01	+/-	2.92E-02	4.32E-01	8.44E-02	+/-	4.41E-03
12	2.6400	0.4238	0.97	91.3	4.84E-01	+/-	3.01E-02	4.44E-01			
13	3.7000	0.4760	0.97	91.5	4.68E-01	+/-	2.90E-02	4.28E-01	9.32E-02	+/-	3.20E-03
14	3.2300	0.5216	0.97	90.6	4.70E-01	+/-	2.88E-02	4.30E-01			
15	2.9000	0.5625	0.97	90.9	4.58E-01	+/-	2.82E-02	4.18E-01	9.19E-02	+/-	2.63E-03
16	2.7500	0.6013	0.96	90.3	4.61E-01	+/-	2.83E-02	4.21E-01			
17	6.2000	0.6888	0.96	88.7	4.61E-01	+/-	2.85E-02	4.21E-01	8.98E-02	+/-	4.25E-03
18	6.0700	0.7744	0.96	89.1	4.56E-01	+/-	2.83E-02	4.16E-01			
19	6.4800	0.8658	0.96	89.6	4.45E-01	+/-	2.76E-02	4.05E-01	9.07E-02	+/-	4.43E-03
20	6.1500	0.9526	0.96	90.2	4.35E-01	+/-	2.73E-02	3.95E-01			
21	6.6600	1.0466	0.96	89.4	4.39E-01	+/-	2.72E-02	3.99E-01	8.52E-02	+/-	3.89E-03
22	6.2700	1.1350	0.96	89.0	4.24E-01	+/-	2.63E-02	3.84E-01			
23	6.3200	1.2242	0.96	89.0	4.08E-01	+/-	2.54E-02	3.68E-01	9.76E-02	+/-	4.08E-03
24	6.5000	1.3159	0.96	89.5	3.91E-01	+/-	2.43E-02	3.51E-01			
25	6.8900	1.4131	0.96	88.9	3.87E-01	+/-	2.41E-02	3.47E-01	9.21E-02	+/-	2.46E-03
26	6.8700	1.5100	0.96	89.3	3.71E-01	+/-	2.31E-02	3.31E-01			
27	6.3500	1.5996	0.96	89.4	3.58E-01	+/-	2.19E-02	3.18E-01	9.38E-02	+/-	3.99E-03
28	7.1000	1.6998	0.96	89.8	3.08E-01	+/-	1.90E-02	2.68E-01	9.64E-02	+/-	3.79E-03
29*	6.5100	1.7916	0.96	90.4	2.76E-01	+/-	1.70E-02	2.36E-01	1.02E-01	+/-	3.97E-03
30	5.1100	1.8637	0.97	91.8	2.61E-01	+/-	1.62E-02	2.21E-01	8.94E-02	+/-	3.52E-03
31	6.5600	1.9563	0.96	90.1	2.46E-01	+/-	1.56E-02	2.06E-01	8.82E-02	+/-	3.82E-03
32	6.0700	2.0419	0.96	90.4	2.23E-01	+/-	1.44E-02	1.83E-01			
33	6.1800	2.1291	0.97	90.7	2.07E-01	+/-	1.35E-02	1.67E-01	6.18E-02	+/-	1.84E-03
34	6.2000	2.2166	0.97	90.8	1.81E-01	+/-	1.16E-02	1.41E-01			
35	5.9700	2.3008	0.97	90.7	1.76E-01	+/-	1.13E-02	1.36E-01	3.42E-02	+/-	2.61E-03
36	6.7500	2.3960	0.97	90.5	1.71E-01	+/-	1.09E-02	1.31E-01			
37	6.2600	2.4843	0.96	90.3	1.75E-01	+/-	1.12E-02	1.35E-01	3.35E-02	+/-	2.65E-03
38	6.7700	2.5799	0.96	90.2	1.75E-01	+/-	1.14E-02	1.35E-01			
39	6.6800	2.6741	0.96	90.0	1.70E-01	+/-	1.12E-02	1.30E-01	2.94E-02	+/-	2.60E-03
40	6.6600	2.7681	0.96	90.1	1.57E-01	+/-	1.11E-02	1.17E-01			
41	6.6100	2.8613	0.96	90.2	1.55E-01	+/-	9.95E-03	1.15E-01	2.52E-02	+/-	2.47E-03
42	6.7900	2.9571	0.97	90.6	1.40E-01	+/-	9.20E-03	1.00E-01			
43	5.7600	3.0384	0.97	91.1	1.23E-01	+/-	8.01E-03	8.29E-02	1.84E-02	+/-	2.12E-03
44	5.2100	3.1119	0.97	91.8	9.03E-02	+/-	6.01E-03	5.03E-02			
45	5.5800	3.1906	0.97	92.1	7.84E-02	+/-	5.71E-03	3.84E-02	7.90E-03	+/-	1.03E-03
46	4.9600	3.2606	0.97	92.4	7.48E-02	+/-	4.98E-03	3.48E-02			
47	4.7400	3.3275	0.97	92.6	6.77E-02	+/-	4.43E-03	2.77E-02	1.05E-02	+/-	2.54E-03
48	4.9000	3.3966	0.97	92.5	6.33E-02	+/-	4.33E-03	2.33E-02			
49	5.1700	3.4695	0.97	92.4	6.10E-02	+/-	4.11E-03	2.10E-02	7.60E-03	+/-	2.04E-03
50	4.7200	3.5361	0.97	92.6	5.52E-02	+/-	3.74E-03	1.52E-02			
51	4.6200	3.6013	0.98	93.3	4.01E-02	+/-	2.72E-03		7.54E-03	+/-	1.44E-03
52	4.4600	3.6642	0.98	93.3	4.39E-02	+/-	2.97E-03				
53	4.3100	3.7250	0.98	93.4	4.45E-02	+/-	3.11E-03		0.00E+00	+/-	0.00E+00
54	4.3700	3.7867	0.98	93.5	3.74E-02	+/-	2.60E-03				
55	4.2700	3.8469	0.98	93.3	4.00E-02	+/-	2.87E-03		1.31E-02	+/-	2.01E-03
56	4.7200	3.9135	0.98	93.3	3.31E-02	+/-	2.42E-03				
57	4.2800	3.9739	0.98	93.4	3.72E-02	+/-	2.71E-03		9.71E-03	+/-	1.06E-03
58	4.4600	4.0368	0.98	93.4	3.52E-02	+/-	2.55E-03				
59	4.4700	4.0999	0.98	93.3	4.53E-02	+/-	2.98E-03		9.91E-03	+/-	2.21E-03
60	4.6500	4.1655	0.98	93.2	4.38E-02	+/-	2.92E-03				
61	4.8000	4.2332	0.97	93.0	4.09E-02	+/-	2.79E-03		8.35E-03	+/-	1.88E-03
62	5.2000	4.3066	0.97	92.8	4.25E-02	+/-	2.90E-03				
63	5.1600	4.3794	0.97	92.6	4.73E-02	+/-	3.32E-03		1.10E-02	+/-	1.95E-03
64	5.4800	4.4567	0.97	92.3	6.43E-02	+/-	4.32E-03				
65	5.7800	4.5382	0.97	92.0	5.52E-02	+/-	3.81E-03		1.39E-02	+/-	1.35E-03

^{210}Pb Analysis: Avalon Lake (con't)

SAMPLE	CRS			CF:CS		RSSM	
	years/ slice	Median Yr of deposition	SedRate $g/m^2/yr$	years/ slice	Median Yr of deposition	years/ slice	Median Yr of deposition
1	0.3	2003	637	0.4	2003	0	2004
2	0.5	2003	624	0.7	2003	0	2004
3	0.6	2002	590	0.9	2002	1	2003
4	0.6	2002	590	0.8	2001	1	2002
5	0.6	2001	574	0.9	2000	1	2001
6	0.6	2001	565	0.9	1999	1	2000
7	0.8	2000	547	1.1	1998	1	1999
8	0.7	1999	537	0.9	1997	1	1998
9	0.8	1998	512	1.0	1996	1	1997
10	0.7	1998	511	0.9	1995	1	1996
11	0.8	1997	521	1.0	1994	1	1995
12	0.8	1996	496	0.9	1994	1	1994
13	1.0	1995	500	1.3	1992	1	1993
14	0.9	1994	482	1.1	1991	1	1992
15	0.8	1993	483	1.0	1990	1	1991
16	0.8	1993	467	1.0	1989	1	1990
17	2.0	1991	447	2.2	1988	2	1989
18	2.0	1989	426	2.1	1985	2	1987
19	2.2	1987	409	2.3	1983	3	1984
20	2.2	1985	391	2.1	1981	2	1982
21	2.6	1982	359	2.3	1979	3	1979
22	2.6	1980	344	2.2	1977	3	1976
23	2.7	1977	331	2.2	1974	3	1973
24	2.9	1974	318	2.3	1972	3	1970
25	3.3	1971	292	2.4	1970	3	1967
26	3.5	1968	275	2.4	1968	3	1964
27	3.5	1964	257	2.2	1965	3	1961
28	3.7	1961	273	2.5	1963	3	1958
29	3.3	1957	277	2.3	1961	3	1955
30	2.7	1954	270	1.8	1958	3	1952
31	3.5	1951	263	2.3	1956	4	1949
32	3.2	1948	267	2.1	1954	3	1945
33	3.3	1945	265	2.1	1952	4	1942
34	3.1	1941	283	2.2	1950	4	1938
35	3.1	1938	268	2.1	1948	4	1934
36	3.8	1935	249	2.3	1946	4	1930
37	4.1	1931	213	2.2	1943	4	1926
38	5.2	1926	184	2.4	1941	4	1922
39	5.9	1921	161	2.3	1939	4	1918
40	6.3	1915	148	2.3	1936	4	1914
41	7.7	1907	121	2.3	1934	5	1909
42	8.9	1899	108	2.4	1932	5	1904
43	8.2	1891	100	2.0	1930	5	1899
44	5.5	1884	133	1.8	1928	5	1894
45	5.4	1878	146	1.9	1926	5	1889
46	5.1	1873	137	1.7	1924	5	1884
47	4.5	1868	148	1.6	1922	5	1879
48	4.5	1864	153	1.7	1921	5	1874
49	5.0	1859	147	1.8	1919	5	1869
50	3.8	1855	177	1.6	1917	5	1864

Metal Concentrations in the Sediment: Avalon Lake

All concentrations in mg/kg dry weight

Sample	Depth (cm)	Age (CRS)	Mg	Al	K	Ca	Ti	V	Cr	Mn
Avalon 1	0.50	2003	6190	3990	899.9	193659	6.53	8.47	8.75	195.7
Avalon 2	1.00	2002	6006	3817	829.4	189488	5.23	7.88	8.35	185.6
Avalon 3	1.50	2002	5838	3836	885.2	189381	6.14	8.35	8.94	195.4
Avalon 4	2.00	2001	6015	3910	816.6	194574	4.96	8.00	8.60	188.6
Avalon 5	2.50	2001	6033	2765	572.8	195390	0.00	6.18	7.42	188.8
Avalon 6	3.00	2000	6042	3684	742.5	198655	2.65	7.57	8.33	188.9
Avalon 7	3.50	1999	6002	3944	792.3	197934	5.91	8.13	8.68	190.5
Avalon 8	4.00	1999	5941	3717	743.6	193431	4.14	7.67	8.59	189.0
Avalon 9	4.50	1998	6169	3957	743.8	205116	4.73	7.92	8.57	192.0
Avalon 10	5.00	1997	6060	3927	733.6	199044	5.64	7.94	8.44	188.7
Avalon 11	5.50	1996	6093	3788	674.0	200856	3.51	7.58	8.58	183.0
Avalon 12	6.00	1996	6794	4633	744.5	220832	6.77	8.28	8.63	181.8
Avalon 13	6.50	1995	6108	3862	671.6	202305	2.94	7.83	8.39	184.1
Avalon 14	7.00	1994	6006	3680	651.3	195696	2.85	7.54	8.07	179.1
Avalon 15	7.50	1993	5834	3875	675.9	195253	4.22	8.15	8.53	180.6
Avalon 16	8.00	1992	5717	3822	683.3	191355	4.69	7.97	8.40	182.1
Avalon 17	9.00	1991	5853	3796	672.2	193040	4.36	7.94	8.64	178.4
Avalon 18	10.00	1989	6068	4076	707.2	195292	5.39	8.22	8.55	177.4
Avalon 19	11.00	1987	5790	3697	636.2	190651	3.81	7.72	8.18	174.7
Avalon 20	12.00	1984	5886	3727	640.9	196032	3.58	7.89	8.41	175.5
Avalon 21	13.00	1982	5925	3834	643.8	192531	5.17	8.00	8.39	176.2
Avalon 22	14.00	1979	4448	2955	652.0	144892	5.33	8.34	9.19	174.6
Avalon 23	15.00	1977	5935	3790	564.1	195424	2.17	8.31	8.84	173.6
Avalon 24	16.00	1974	6201	4535	594.0	202812	3.80	10.24	9.28	184.6
Avalon 25	17.00	1971	4358	2920	546.0	140370	4.09	8.85	8.36	166.8
Avalon 26	18.00	1967	6251	4130	576.6	201728	6.00	9.16	9.07	178.1
Avalon 27	19.00	1964	6375	6009	570.9	206464	4.83	9.45	9.12	179.6
Avalon 28	20.00	1960	6391	4410	684.6	208269	10.72	9.89	9.54	182.7
Avalon 29	21.00	1957	6239	3757	501.9	205585	0.00	8.99	9.01	177.1
Avalon 30	22.00	1954	6275	3816	524.6	201251	2.00	8.94	8.85	170.6
Avalon 31	23.00	1951	6199	3677	491.6	207526	0.87	8.79	9.07	174.1
Avalon 32	24.00	1947	6261	3965	549.9	208951	3.13	9.16	9.25	172.9
Avalon 33	25.00	1944	6133	3673	503.1	215070	6.57	8.74	9.24	168.8
Avalon 34	26.00	1941	6372	3945	538.9	218702	9.44	9.06	9.10	170.3
Avalon 35	27.00	1938	6222	3957	554.3	218738	9.96	9.31	9.20	170.4
Avalon 36	28.00	1934	6154	3735	509.5	215666	8.44	8.72	8.92	163.5
Avalon 37	29.00	1930	6032	3633	502.7	213285	7.53	8.92	8.84	165.8
Avalon 38	30.00	1926	6064	3464	479.8	213185	6.55	8.55	8.67	164.4
Avalon 39	31.00	1920	6127	3369	462.0	209823	6.16	9.05	9.16	159.5
Avalon 40	32.00	1914	4529	2232	424.1	150081	6.33	8.67	9.14	146.2
Avalon 41	33.00	1907	6255	3075	461.5	200780	6.75	8.60	9.28	148.6
Avalon 42	34.00	1899	5933	2750	391.2	196821	5.45	8.39	9.12	139.1
Avalon 43	35.00	1890	6148	3090	470.5	201130	8.31	8.80	9.77	143.1
Avalon 44	36.00	1883	6080	2908	447.2	186205	7.24	9.28	9.79	136.7
Avalon 45	37.00	1878	5986	2577	391.6	178581	4.27	9.22	9.68	135.9
Avalon 46	38.00	1873	6088	2673	396.4	182634	4.09	8.96	9.43	134.7
Avalon 47	39.00	1868	6118	2553	358.4	180033	2.81	8.99	9.58	131.0
Avalon 48	40.00	1863	7190	3038	361.8	202719	3.38	9.24	9.62	130.4
Avalon 49	41.00	1859	6395	2743	377.6	158234	2.63	10.56	10.80	121.3
Avalon 50	42.00	1854	6518	2996	425.6	150197	3.57	11.39	11.48	115.7
Avalon 51	43.00	1850	6684	3290	474.6	154562	5.32	11.53	11.78	118.2
Avalon 52	44.00	1846	6683	3450	518.4	151301	7.47	11.63	11.89	117.4
Avalon 53	45.00	1842	6748	3273	456.5	157957	4.63	11.11	11.28	114.6
Avalon 54	46.00	1838	6760	3116	436.6	157021	5.05	10.95	11.52	114.5
Avalon 55	47.00	1834	6797	3039	408.2	152072	3.44	11.12	11.78	114.6
Avalon 56	48.00	1830	7021	3254	418.6	151603	3.21	11.80	11.98	109.0
Avalon 57	49.00	1826	6920	3246	422.7	154883	2.89	11.84	12.22	112.4
Avalon 58	50.00	1822	6871	3564	626.7	151628	11.54	12.13	13.22	114.5
Avalon 59	51.00	1817	7179	3262	430.8	156246	3.05	11.46	12.32	113.1
Avalon 60	52.00	1813	7053	3334	475.3	151549	4.82	12.41	13.27	114.8
Avalon 61	53.00	1809	5169	2431	489.9	114793	4.13	11.92	12.53	124.8
Avalon 62	54.00	1804	7082	3586	523.7	150434	6.87	12.43	13.05	115.7
Avalon 63	55.00	1799	7070	3257	423.0	150339	2.78	11.66	12.76	109.7

Metal Concentrations in the Sediment: Avalon Lake

All concentrations in mg/kg dry weight

Sample	Fe	Ni	Cu	Zn	As	Mo	Cd	Ba	Pb	U
Avalon 1	5417	10.42	614.5	92.22	4.36	0.78	1.10	52.20	70.55	0.47
Avalon 2	5345	9.34	576.1	88.35	4.00	0.62	1.09	41.35	68.52	0.43
Avalon 3	5258	9.66	629.7	99.83	4.26	0.59	1.12	41.38	73.54	0.44
Avalon 4	5455	9.17	608.6	89.46	4.09	0.60	1.10	38.51	69.34	0.41
Avalon 5	5059	8.59	593.3	98.20	3.64	0.50	1.18	36.43	70.08	0.41
Avalon 6	5389	9.42	597.7	85.04	4.12	0.53	1.09	36.98	69.90	0.41
Avalon 7	5375	9.51	607.3	94.47	4.25	0.55	1.08	37.64	70.89	0.43
Avalon 8	5283	9.13	599.6	86.44	4.10	0.58	1.08	36.67	70.08	0.42
Avalon 9	5613	9.58	597.5	87.84	4.16	0.57	1.09	37.31	71.74	0.44
Avalon 10	5514	9.15	595.5	86.28	4.06	0.57	1.05	36.48	70.55	0.40
Avalon 11	5505	9.12	591.9	86.45	4.13	0.55	1.07	34.81	69.79	0.41
Avalon 12	6249	9.01	589.6	84.79	4.12	0.53	1.05	35.58	70.00	0.40
Avalon 13	5737	10.24	584.8	87.34	4.21	0.58	1.15	34.47	71.51	0.42
Avalon 14	5388	9.27	570.6	90.65	4.05	0.53	1.08	34.11	71.43	0.41
Avalon 15	5554	8.98	593.3	86.80	4.03	0.55	1.10	34.75	69.86	0.41
Avalon 16	5461	8.87	583.9	85.59	4.14	0.59	1.13	34.45	70.84	0.43
Avalon 17	5505	9.53	590.1	91.63	4.05	0.57	1.06	33.97	71.04	0.43
Avalon 18	5528	9.27	589.5	84.61	4.22	0.55	1.08	34.12	70.02	0.41
Avalon 19	5386	9.02	589.4	83.56	4.25	0.54	1.05	32.99	69.69	0.40
Avalon 20	5473	12.95	585.2	89.39	4.35	0.55	1.12	33.66	74.90	0.41
Avalon 21	5391	9.21	569.1	97.81	4.07	0.58	1.09	33.47	71.94	0.43
Avalon 22	4084	9.49	576.2	87.23	4.26	0.65	1.09	33.74	72.57	0.44
Avalon 23	5627	9.44	577.0	87.33	4.52	0.68	1.18	33.09	78.31	0.46
Avalon 24	6122	9.43	629.0	125.17	5.39	0.74	1.35	39.87	85.96	0.52
Avalon 25	4287	8.62	560.1	103.68	5.12	0.65	1.25	32.71	77.31	0.49
Avalon 26	6082	9.39	556.0	96.96	5.51	0.73	1.30	35.34	78.04	0.58
Avalon 27	6269	9.37	608.9	102.83	5.64	0.77	1.30	37.13	77.82	0.59
Avalon 28	6241	9.35	601.3	103.62	5.89	0.86	1.37	38.00	77.39	0.63
Avalon 29	6162	9.21	593.1	101.71	5.88	0.90	1.29	37.02	70.29	0.66
Avalon 30	5930	8.53	573.6	96.17	5.96	0.89	1.30	34.04	60.36	0.70
Avalon 31	6028	8.85	552.6	112.14	6.17	0.93	1.27	41.63	57.88	0.77
Avalon 32	6078	8.98	567.8	95.80	6.47	1.00	1.32	37.24	57.18	0.75
Avalon 33	6015	8.44	469.8	92.08	6.16	1.00	1.80	35.10	54.08	0.78
Avalon 34	5995	8.85	460.5	90.56	6.21	1.07	1.34	34.90	53.50	0.79
Avalon 35	5862	8.34	465.1	130.26	6.34	1.05	1.31	47.55	52.06	0.80
Avalon 36	5692	13.05	471.9	86.14	6.12	0.98	1.28	34.25	51.30	0.77
Avalon 37	5608	8.22	453.1	87.16	6.31	1.05	1.36	34.62	50.67	0.77
Avalon 38	5441	8.14	457.7	82.59	6.31	1.08	1.27	33.69	47.92	0.84
Avalon 39	5460	8.63	474.2	80.73	7.66	1.77	1.55	34.55	41.10	1.15
Avalon 40	3838	7.32	413.7	60.31	6.52	1.60	0.92	31.02	29.90	1.29
Avalon 41	5219	7.13	427.9	62.30	6.56	1.69	0.86	32.17	25.55	1.38
Avalon 42	4812	7.75	423.8	56.85	7.14	1.96	1.17	30.17	25.39	1.36
Avalon 43	4723	7.60	417.3	62.71	7.38	2.00	1.14	36.88	24.86	1.30
Avalon 44	4886	7.47	411.4	49.56	6.24	1.92	0.65	29.58	19.45	1.63
Avalon 45	4704	7.59	416.7	40.70	7.21	2.54	0.87	28.33	16.60	1.90
Avalon 46	4685	6.85	399.8	42.62	5.83	1.88	0.51	28.00	17.59	1.66
Avalon 47	4715	6.60	407.8	40.71	5.91	2.14	0.50	27.97	17.69	1.76
Avalon 48	5424	7.31	498.1	43.09	6.30	2.65	0.86	27.63	14.94	1.87
Avalon 49	5482	7.53	430.5	56.19	6.89	3.15	0.78	30.27	11.09	2.37
Avalon 50	6200	7.70	435.8	41.76	6.05	3.07	0.39	26.99	6.95	2.50
Avalon 51	6261	8.07	451.7	92.59	7.33	3.37	0.72	30.10	7.25	2.40
Avalon 52	6245	7.98	463.6	50.00	6.46	2.88	0.39	28.72	7.43	2.47
Avalon 53	6207	7.49	438.1	40.30	6.34	2.87	0.39	27.34	6.81	2.31
Avalon 54	5990	8.79	434.3	37.88	7.16	3.19	0.71	27.55	7.09	2.23
Avalon 55	6227	8.31	449.9	40.20	7.06	3.16	0.72	27.40	7.06	2.43
Avalon 56	6934	8.16	461.7	65.17	7.25	3.59	0.72	26.81	6.17	2.65
Avalon 57	6657	7.90	471.1	42.77	6.55	3.17	0.40	27.70	8.34	2.51
Avalon 58	6630	8.57	492.8	43.65	7.56	3.52	0.82	31.00	7.93	2.54
Avalon 59	6813	8.33	489.7	43.61	7.64	3.33	0.79	27.58	8.28	2.42
Avalon 60	7154	8.82	481.6	40.82	7.73	3.33	0.76	28.29	8.29	2.53
Avalon 61	5203	8.40	476.6	45.08	6.64	2.98	0.45	28.70	11.23	0.75
Avalon 62	7081	8.69	477.0	42.98	7.73	3.28	0.75	28.91	8.56	0.79
Avalon 63	6915	8.61	484.7	45.60	7.36	3.46	0.78	27.79	8.71	2.17

Concentrations of Organic Contaminants: Avalon Lake

All concentrations in ng/g dry wt

cm depth[1]	1.0	2.0
Age[2]	2002	2001
Total polychlorinated biphenyls (PCBs)	1.71	1.95
Total polyaromatic hydrocarbons (PAHs)	153.69	143.80
Acenaphthalene	1.01	1.01
Acenaphthene	0.41	0.55
Fluorene	3.70	3.88
Phenanthrene	15.66	14.77
Anthracene	1.80	1.67
Fluoranthene	22.99	23.08
Pyrene	18.21	18.24
Benzo-A-anthracene	5.67	5.89
Chrysene	8.33	7.99
Benzo-B-fluoranthene	28.89	29.03
Benzo-K-fluoranthene	6.74	6.94
Indeno-1,2,3-CD-pyrene	16.22	13.71
Dibenz-a,h-anthracene	1.83	1.53
Benzo-G,H,I-perylene	22.23	15.51
Total Pesticides	3.1	3.5
α-BHC	0.49	0.85
β-BHC	BDL[3]	BDL[3]
Lindane	BDL[3]	BDL[3]
γ-BHC	0.84	0.93
Heptachlor	BDL[3]	BDL[3]
Aldrin	0.91	1.26
Heptachlor epoxide	BDL[3]	BDL[3]
cis-Chlordane	BDL[3]	BDL[3]
trans-Chlordane	0.1	BDL[3]
DDE	0.34	BDL[3]
DDD	0.44	0.43
DDT	BDL[3]	BDL[3]
Methoxychlor	BDL[3]	BDL[3]

1. The first two slices were combined (cm 0-1), and the third and fourth slices (1-2 cm), due to insufficent sample mass for analysis.
2. Since samples were combined[1] each analysis covers a range of years. The median age is presented for each of the combined samples.
3. BDL indicates contaminant below detection limit.

Metal Concentrations in the Porewater: Avalon Lake

Concentrations in ng/mL

Sample	Depth (cm)	P	V	Cr	Co	Ni	Cu	Zn	As	Mo	Al	Ti
Avalon Topwater	0	32.46	0.41	0.03	0	0	0.14	87.32	0.46	0.16	3.26	15.72
Avalon 1	0.5	104.73	1.09	0.18	0.02	1.83	0.52	666.02	2.34	0.83	22.72	52.69
Avalon 2	1.5	117.52	0.83	0.27	0.42	2.54	0.9	419.63	1.75	0.31	36.97	69.43
Avalon 3	2.5	95.13	0.69	0.19	0.73	6.6	0.36	162.85	1.12	0.1	15.87	85.25
Avalon 4	3.5	91.16	0.4	0.15	0.87	3.88	2.35	74.38	1.14	0.01	10.04	97.26
Avalon 5	4.5	168.12	0.64	0.58	1.13	1.65	0.43	109.63	1.04	0.02	11.7	102.9
Avalon 6	5.5	399.62	0.79	0.59	1.18	1.63	0.49	117.72	1.4	0.14	13.7	104.96
Avalon 7	6.5	683.38	0.66	0.78	0.93	3.7	1.59	109.88	1.13	0.11	16.34	110.51
Avalon 8	7.5	1144.12	0.66	0.48	1.55	3.31	0.73	103.42	1.63	0.15	13.31	125.25
Avalon 9	8.5	1508.99	0.96	0.37	1.55	1.49	0.25	96.78	1.28	0.06	11.54	126.23
Avalon 10	9.5	1742.02	0.68	0.28	1.67	1.59	0.72	94.59	1.34	0.05	11.26	131.68
Avalon 11	11.5	2278.74	0.67	0.71	1.87	2.35	0.51	83.67	1.78	0.17	11.3	137.92
Avalon 12	13.5	2395.19	0.74	0.53	1.89	3.71	0.83	287.21	2.22	0.23	48.98	138.77
Avalon 13	15.5	2894.85	0.72	0.28	2.05	2.4	0.55	80.73	1.6	0.08	8.38	143.87
Avalon 14	17.5	2879.61	0.98	0.41	2.13	1.56	0.43	161.41	2.07	0.13	10.53	140.91
Avalon 15	19.5	3228.75	0.81	0.51	2.15	3.62	0.87	78.93	2.05	0.27	12.94	141.96
Avalon 16	21.5	3365.33	0.67	1.53	2.14	2.23	0.42	84.43	1.86	0.17	11.15	144.27
Avalon 17	23.5	3293.26	0.67	0.45	1.98	2.93	1.1	112.43	2.07	0.17	11.36	137.99
Avalon 18	25.5	3428.12	0.71	0.39	1.81	1.89	1.35	73.27	1.88	0.16	9.39	135.65
Avalon 19	27.5	3353.5	0.91	0.83	1.65	0.7	0.44	137.22	1.47	0.12	10.3	129.28
Avalon 20	29.5	3798.95	0.73	1.04	2.1	1.34	1.03	84.66	2.16	0.21	16.03	141.48
Avalon 21	31.5	3809.2	0.63	0.43	1.94	11.01	0.97	87.82	1.99	0.23	20.56	140.11
Avalon 22	33.5	3856.17	0.72	1.35	1.96	1.51	0.57	300.80	2.06	0.36	13.88	141.41
Avalon 23	35.5	3874.94	0.55	1.02	1.85	0.79	0.49	136.47	1.81	0.43	13.41	138.72
Avalon 24	37.5	3756.56	0.52	1.41	1.77	1.77	1.18	89.21	1.79	0.43	20.19	135.12
Avalon 25	39.5	3775.82	0.67	0.54	1.85	3.5	0.74	149.98	1.88	0.52	14.42	134.38
Avalon 26	41.5	3311.89	0.79	0.97	1.48	1.81	0.8	195.82	1.56	0.39	14.33	118.07
Avalon 27	43.5	3711.46	1.01	0.52	2.12	6.47	0.72	220.48	2.08	0.44	15.28	132.01
Avalon 28	45.5	3134.47	0.81	0.91	1.41	16.19	2.12	251.46	1.5	0.33	22.86	111.55

Sample	Depth (cm)	Cd	Ba	Pb	U	K	Mn	Mg	Ca	Fe	Sn	B
Avalon Topwater	0	0	17.5	0.07	0.12	600.09	27.37	11390	40131	3.1	0.02	10.8
Avalon 1	0.5	0.05	31.33	0.57	0.17	748.42	148.05	12188	59252	18.3	0.08	29.06
Avalon 2	1.5	0.12	40.57	0.51	0.09	1077.96	214.78	12372	68672	18.6	0.08	25.87
Avalon 3	2.5	0	32.15	0.16	0.05	1185.96	229.13	12894	78939	14.8	0.05	24.9
Avalon 4	3.5	0	54.14	0.8	0.05	1293.29	228.99	13132	86725	16.3	0.02	28.04
Avalon 5	4.5	0	36.6	0.08	0.04	1434.06	241.13	13913	92951	13.4	0.01	26.77
Avalon 6	5.5	0.06	34.09	0.2	0.08	1465.48	239.97	14161	94759	13.0	0.08	28.25
Avalon 7	6.5	0.02	32.11	0.47	0.03	1645.15	248.28	14750	100051	17.7	0.04	27.18
Avalon 8	7.5	0.08	34.31	0.25	0.07	1773.34	256.05	15500	105595	15.7	0.08	30.11
Avalon 9	8.5	0.01	35.32	0.21	0.03	1863.27	257.07	15871	108109	9.6	0.02	28.51
Avalon 10	9.5	0	35.86	0.2	0.02	1929.13	256.24	15863	108958	12.0	0.02	30.61
Avalon 11	11.5	0.09	35.91	0.43	0.07	1955.9	251.6	16093	111477	13.3	0.1	33.62
Avalon 12	13.5	0.12	35.86	0.42	0.08	1897.22	244.44	16237	113145	23.3	0.12	37.69
Avalon 13	15.5	0	35.81	0.25	0.03	2058.93	247.33	16509	115294	13.1	0.03	36.09
Avalon 14	17.5	0	37.67	0.17	0.03	2009.71	239.5	16578	115454	11.0	0.04	37.45
Avalon 15	19.5	0.11	40.54	0.45	0.07	2026.58	239.87	16853	119765	97.0	0.1	42.32
Avalon 16	21.5	0.02	38.12	0.33	0.03	2039.94	238.81	17039	121119	16.0	0.03	43.36
Avalon 17	23.5	0.01	35.9	0.48	0.03	1938.34	223.59	16242	116341	14.1	0.07	40.79
Avalon 18	25.5	0.03	36.91	1.02	0.04	1943.65	222.75	16518	117911	16.3	0.04	41.52
Avalon 19	27.5	0.02	51.22	0.36	0.03	1839.81	205.6	15582	111679	10.3	0.05	39.49
Avalon 20	29.5	0.05	45.12	0.63	0.06	1981.96	217.11	17727	125360	22.7	0.05	43.92
Avalon 21	31.5	0.85	42.85	1.44	0.06	2032.63	215.47	17261	124446	20.5	0.13	45.36
Avalon 22	33.5	0.09	43.92	0.42	0.08	2062.44	212.82	17501	124168	12.4	0.06	51.44
Avalon 23	35.5	0.04	42.64	0.52	0.07	1969.67	199.35	17654	126531	26.8	0.05	50.65
Avalon 24	37.5	0.11	41.54	0.79	0.08	1899.07	193.71	17502	123829	23.9	0.07	48.48
valon 25	39.5	0.06	43.39	0.55	0.11	2011.44	191.42	17610	124933	19.0	0.06	53.67
Avalon 26	41.5	0.03	39.52	1.77	0.08	1711.6	167.43	15309	109023	12.5	0.14	44.72
Avalon 27	43.5	0.83	42.72	0.55	0.08	1943.23	178.95	17486	123829	19.0	0.08	53.99
Avalon 28	45.5	0.32	47.63	0.58	0.06	1629.86	149.54	14429	101790	11.2	8.73	44.56

Highlighted values are below the low standard.

MICHIGAN STATE
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Birch Lake Sediment Fact Sheet

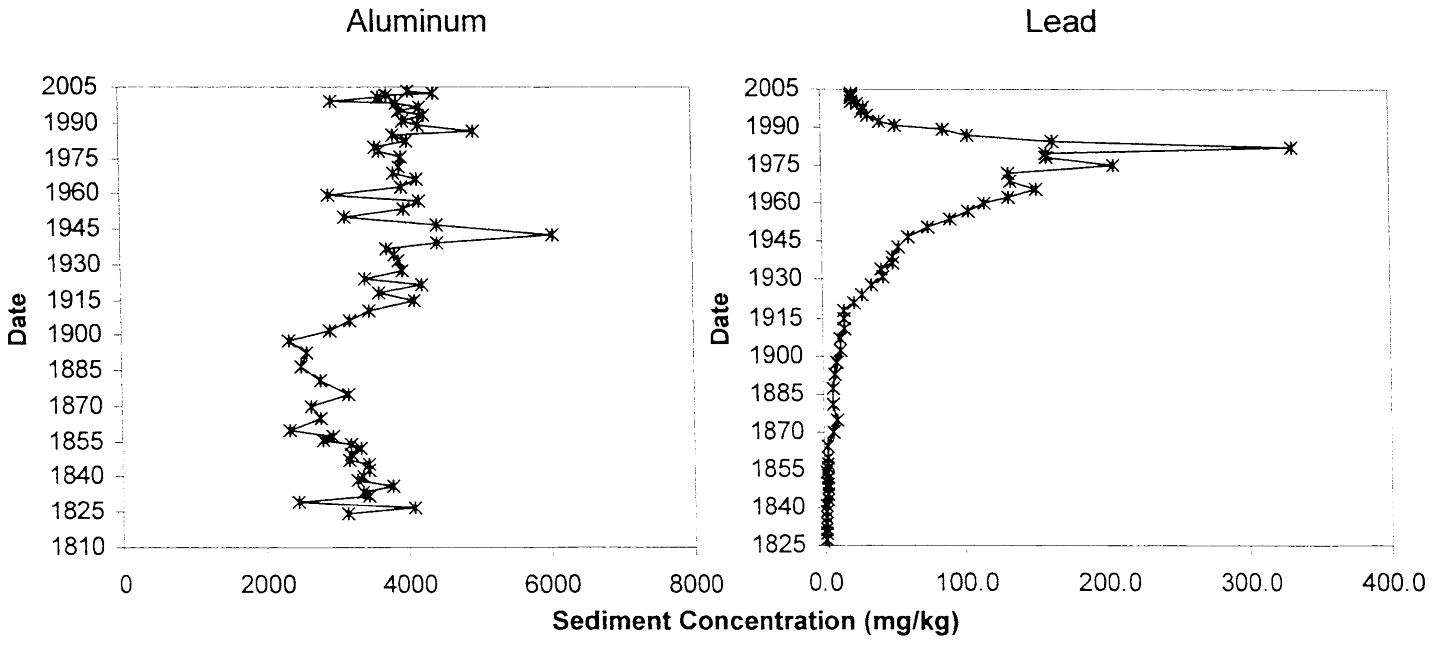
Date sampled: 24 July 2003	Sampling site water depth: 97.1 ft
Location: Cass County	Depth of core: 56 cm
Sampling site: 41°52.849'N 85°51.429'W	Sedimentation rate: 445 g/m^2/y
	Age of oldest section: 1824
Lake surface area: 295 acres	Focusing factor: 1.67

Cadmium, copper, lead, and zinc appear to be controlled by anthropogenic activity up until the 1950s-1980s. Peak concentrations of lead are highest in Birch Lake among the 2003 study lakes. All anthropogenic elements are decreasing to the surface indicating that Birch Lake may be recovering from historic sources. Concentrations of organic contaminants are typical of Michigan's inland lakes.

	Surface conc.	Background conc.	Trends
Cadmium (mg/kg)	0.3	0.33	decreasing
Copper (mg/kg)	11.2	NA	decreasing
Lead (mg/kg)	22.5	1.88	decreasing
Zinc (mg/kg)	68.2	NA	decreasing
Total PCBs (ug/kg)	0.89		decreasing
Total PAHs (ug/kg)	225		decreasing
Total Pesticides (ug/kg)	8.6		decreasing

Trends for organic contaminants are taken from only two data points and should be interpreted with care.

Example profiles



A Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters: Sediments

Birch Lake

Sampling Date: 24 July 2003

Location: 41°52.849'N 85°51.429'W Water depth: 97.1'

Core description: 55.8 cm total length, varved layers of alternating white/gray and dark layers with white/gray at sed/wayter interface. Layers at top widest (1-2mm), beneath, average 0.5mm. Stratigraphy extends for 11 cm from sed/water interface. Rest of core black with numerous air bubbles.

#	Thickness (cm)	Total thickness (cm)	Description
1	0.5	0.5	watery with white, black brown grains and fluff
2	0.5	1.0	watery with white, black brown grains and fluff, small shells
3	0.5	1.5	watery with white, black brown grains and fluff, small shells
4	0.5	2.0	more viscous white, black, gray, brown grains, white shells
5	0.5	2.5	black, gray grains, white shell looking things
6	0.5	3.0	black, gray grains, white shell looking things
7	0.5	3.5	black, gray grains, white shell looking things
8	0.5	4.0	black, gray grains, white shell looking things
9	0.5	4.5	black, gray grains, white shell looking things
10	0.5	5.0	black, gray grains, white shell looking things
11	0.5	5.5	black, gray grains, white shell looking things, but more gray
12	0.5	6.0	black, gray grains, white shell looking things, but more gray
13	0.5	6.5	black, gray grains, white shell looking things, but more gray
14	0.5	7.0	black, gray grains, white shell looking things, but even more gray
15	0.5	7.5	gray sediment with black grains
16	0.5	8.0	gray sediment with black grains
17	1.0	9.0	gray sediment with black grains
18	1.0	10.0	gray and light gray with little black grains
19	1.0	11.0	gray and light gray with little black grains
20	1.0	12.0	dark gray with less light gray and black grains
21	1.0	13.0	more dark gray and black grains
22	1.0	14.0	more dark gray and black grains
23	1.0	15.0	more dark gray and black grains
24	1.0	16.0	darker gray than above, more black
25	1.0	17.0	darker gray than above, more black
26	1.0	18.0	darker gray than above, more black
27	1.0	19.0	dark gray with black veins
28	1.0	20.0	dark gray with black veins
29	1.0	21.0	dark gray with black veins
30	1.0	22.0	dark gray with black veins
31	1.0	23.0	dark gray with black veins
32	1.0	24.0	dark gray with black veins
33	1.0	25.0	dark gray with black veins
34	1.0	26.0	black with gray grains
35	1.0	27.0	black with gray grains
36	1.0	28.0	black with gray grains
37	1.0	29.0	dark gray with black
38	1.0	30.0	dark gray, veins of brown, black

#	Thickness (cm)	Total thickness (cm)	Description
39	1.0	31.0	dark gray, veins of brown, black
40	1.0	32.0	black and gray mix, leaf
41	1.0	33.0	black and gray mix, filament organic matter
42	1.0	34.0	black and gray mix, filament organic matter
43	1.0	35.0	dark gray, some black and light gray
44	1.0	36.0	dark gray, some black and light gray
45	1.0	37.0	dark gray, some black and light gray
46	1.0	38.0	dark gray, some black and light gray
47	1.0	39.0	dark gray, some black and light gray
48	1.0	40.0	dark gray, some black and light gray
49	1.0	41.0	black, some gray
50	1.0	42.0	black
51	1.0	43.0	black, leaf
52	1.0	44.0	black
53	1.0	45.0	black, leaf
54	1.0	46.0	black, leaf
55	1.0	47.0	black, leaf
56	1.0	48.0	black
57	1.0	49.0	black
58	1.0	50.0	black
59	1.0	51.0	black
60	1.0	52.0	black
61	1.0	53.0	black
62	1.0	54.0	black
63	1.0	55.0	black

^{210}Pb Analysis: Birch Lake

Data provided by Paul Wilkinson, Freshwater Institute, Manitoba, Canada

SAMPLE	DRY WT.(g)	ACCUMULATED DRY WT (gm./sq.cm.)	POROSITY	% WATER	ACTIVITY Bq/g ± 1SD Pb-210	±	ERROR	excess Pb-210 Bq/g	ACTIVITY Bq/g ± 1SD CS-137	±	ERROR
1	0.77	0.011	0.99	97.8	8.41E-01	+/-	5.26E-02	8.24E-01	0.00E+00	+/-	0.00E+00
2	1.40	0.031	0.99	95.8	1.06E+00	+/-	6.62E-02	1.04E+00			
3	2.36	0.064	0.98	93.6	1.12E+00	+/-	6.89E-02	1.10E+00	1.68E-02	+/-	3.65E-03
4	2.98	0.106	0.97	92.4	7.76E-01	+/-	4.82E-02	7.59E-01			
5	3.90	0.161	0.96	89.6	6.95E-01	+/-	4.29E-02	6.78E-01	1.56E-02	+/-	2.64E-03
6	2.59	0.198	0.97	92.7	1.09E+00	+/-	6.72E-02	1.08E+00			
7	3.47	0.246	0.97	91.6	8.71E-01	+/-	5.34E-02	8.54E-01	2.73E-02	+/-	2.57E-03
8	3.22	0.292	0.97	91.2	7.75E-01	+/-	4.80E-02	7.58E-01			
9	4.22	0.351	0.96	90.2	7.48E-01	+/-	4.64E-02	7.31E-01	2.77E-02	+/-	3.63E-03
10	3.35	0.399	0.97	91.4	7.82E-01	+/-	4.92E-02	7.65E-01			
11	3.77	0.452	0.97	91.1	7.82E-01	+/-	4.83E-02	7.65E-01	4.43E-02	+/-	5.08E-03
12	3.82	0.506	0.96	89.4	7.17E-01	+/-	4.44E-02	7.00E-01			
13	3.66	0.557	0.96	90.4	7.07E-01	+/-	4.34E-02	6.90E-01	6.64E-02	+/-	4.23E-03
14	5.72	0.638	0.95	87.5	6.04E-01	+/-	3.69E-02	5.87E-01			
15	4.22	0.698	0.96	88.8	4.64E-01	+/-	2.85E-02	4.47E-01	8.45E-02	+/-	4.12E-03
16	4.01	0.754	0.96	89.3	4.17E-01	+/-	2.58E-02	4.00E-01			
17	10.22	0.898	0.95	86.1	3.46E-01	+/-	2.16E-02	3.29E-01	1.08E-01	+/-	2.27E-03
18	11.02	1.054	0.95	85.9	2.64E-01	+/-	1.65E-02	2.47E-01	1.86E-01	+/-	5.13E-03
19*	8.52	1.174	0.96	88.4	2.26E-01	+/-	1.41E-02	2.09E-01	2.10E-01	+/-	5.98E-03
20	9.00	1.301	0.95	87.6	2.36E-01	+/-	1.49E-02	2.19E-01	1.32E-01	+/-	3.38E-03
21	9.87	1.440	0.95	86.8	2.25E-01	+/-	1.42E-02	2.08E-01	8.50E-02	+/-	4.05E-03
22	6.89	1.538	0.96	89.6	2.12E-01	+/-	1.33E-02	1.95E-01	3.09E-02	+/-	4.30E-03
23	9.99	1.678	0.95	87.7	1.97E-01	+/-	1.24E-02	1.80E-01	1.08E-02	+/-	4.03E-03
24	8.25	1.795	0.96	88.1	1.58E-01	+/-	1.01E-02	1.41E-01			
25	10.69	1.946	0.95	85.6	1.71E-01	+/-	1.06E-02	1.54E-01	8.08E-03	+/-	2.35E-03
26	10.48	2.094	0.94	85.5	1.48E-01	+/-	9.18E-03	1.31E-01			
27	12.28	2.267	0.94	84.2	1.18E-01	+/-	7.43E-03	1.01E-01	5.34E-03	+/-	2.17E-03
28	9.95	2.407	0.95	86.0	9.94E-02	+/-	6.31E-03	8.24E-02			
29	9.73	2.544	0.95	86.3	8.61E-02	+/-	6.17E-03	6.91E-02	2.91E-03	+/-	1.22E-03
30	9.33	2.676	0.95	87.3	8.79E-02	+/-	6.09E-03	7.09E-02			
31	11.13	2.833	0.94	84.2	7.84E-02	+/-	5.62E-03	6.14E-02	0.00E+00	+/-	0.00E+00
32	13.34	3.021	0.93	82.1	7.76E-02	+/-	5.86E-03	6.06E-02			
33	11.99	3.190	0.94	83.8	6.31E-02	+/-	4.44E-03	4.61E-02			
34	11.71	3.356	0.94	83.5	6.02E-02	+/-	4.44E-03	4.32E-02			
35	12.98	3.539	0.93	82.4	5.56E-02	+/-	3.97E-03	3.86E-02			
36	15.23	3.754	0.92	79.1	4.68E-02	+/-	3.53E-03	2.98E-02			
37	17.04	3.994	0.91	78.7	4.79E-02	+/-	3.81E-03	3.09E-02			
38	16.31	4.224	0.91	77.9	4.12E-02	+/-	3.28E-03	2.42E-02			
39	15.90	4.449	0.91	78.8	4.27E-02	+/-	3.19E-03	2.57E-02			
40	16.20	4.677	0.91	78.7	3.98E-02	+/-	3.37E-03	2.28E-02			
41	14.21	4.878	0.92	80.8	4.08E-02	+/-	3.03E-03	2.38E-02			
42	12.10	5.048	0.94	83.3	4.83E-02	+/-	3.53E-03	3.13E-02			
43	12.25	5.221	0.93	82.6	4.10E-02	+/-	3.02E-03	2.40E-02			
44	14.23	5.422	0.92	80.1	3.09E-02	+/-	2.81E-03	1.39E-02			
45	12.91	5.604	0.93	81.4	3.08E-02	+/-	2.29E-03	1.38E-02			
46	12.23	5.777	0.93	83.1	2.84E-02	+/-	2.38E-03	1.14E-02			
47	13.46	5.966	0.93	82.0	2.46E-02	+/-	1.97E-03	7.65E-03			
48	13.65	6.159	0.93	81.3	1.96E-02	+/-	1.61E-03	2.56E-03			
49	12.76	6.339	0.93	82.0	1.86E-02	+/-	1.55E-03	1.62E-03			
50	13.29	6.527	0.93	81.3	1.76E-02	+/-	1.37E-03				
51	14.57	6.732	0.92	80.6	1.77E-02	+/-	1.44E-03				
52	13.23	6.919	0.93	82.3	1.87E-02	+/-	1.57E-03				
53	12.49	7.095	0.93	82.2	1.83E-02	+/-	1.47E-03				
54	13.77	7.289	0.93	81.4	1.81E-02	+/-	1.54E-03				
55	13.77	7.483	0.92	80.6	1.59E-02	+/-	1.46E-03				
56	12.74	7.663	0.93	82.9	1.83E-02	+/-	1.82E-03				
57	13.85	7.859	0.92	81.0	1.59E-02	+/-	1.18E-03				
58	14.93	8.069	0.92	79.9	1.58E-02	+/-	1.24E-03				
59	13.29	8.257	0.93	81.2	1.70E-02	+/-	1.34E-03				
60	14.10	8.456	0.92	80.6	1.70E-02	+/-	1.50E-03				
61	11.85	8.623	0.94	84.2	1.88E-02	+/-	1.63E-03				
62	15.47	8.841	0.91	78.3	1.69E-02	+/-	1.48E-03				
63	16.71	9.077	0.91	77.7	1.62E-02	+/-	1.50E-03				
64	16.28	9.307	0.91	78.0	1.48E-02	+/-	1.65E-03				

^{210}Pb Analysis: Birch Lake (con't)

	CRS			CF:CS		RSSM	
SAMPLE	years/ slice	Median Yr of deposition	SedRate $g/m^2/yr$	years/ slice	Median Yr of deposition	years/ slice	Median Yr of deposition
1	0.3	2003	364	0.3	2003	0	2004
2	0.7	2003	284	0.5	2003	0	2004
3	1.3	2002	260	0.9	2002	0	2004
4	1.2	2001	363	1.1	2001	1	2003
5	1.4	1999	390	1.4	2000	1	2002
6	1.6	1998	235	1.0	1999	1	2001
7	1.7	1996	281	1.3	1998	1	2000
8	1.5	1995	301	1.2	1997	1	1999
9	2.0	1993	296	1.5	1995	1	1998
10	1.8	1991	266	1.2	1994	1	1997
11	2.1	1989	251	1.4	1993	1	1996
12	2.1	1987	257	1.4	1991	1	1995
13	2.1	1985	244	1.3	1990	1	1994
14	3.1	1982	264	2.1	1988	2	1993
15	1.9	1980	321	1.5	1986	1	1991
16	1.7	1978	341	1.5	1985	1	1990
17	3.8	1975	380	3.8	1982	3	1988
18	3.4	1972	452	4.0	1978	4	1985
19	2.5	1969	488	3.1	1975	3	1981
20	3.0	1966	429	3.3	1971	3	1978
21	3.4	1963	407	3.6	1968	3	1975
22	2.4	1960	397	2.5	1965	2	1973
23	3.6	1957	392	3.7	1962	3	1970
24	2.6	1954	453	3.0	1958	3	1967
25	4.0	1951	374	3.9	1955	4	1964
26	3.8	1947	390	3.8	1951	4	1960
27	3.9	1943	448	4.5	1947	4	1956
28	2.8	1939	496	3.7	1943	4	1952
29	2.5	1937	544	3.6	1939	3	1948
30	2.7	1934	489	3.4	1936	3	1945
31	3.0	1931	517	4.1	1932	4	1942
32	4.0	1928	469	4.9	1927	5	1937
33	3.1	1924	553	4.4	1923	4	1933
34	3.1	1921	536	4.3	1918	4	1929
35	3.4	1918	542	4.8	1914	5	1924
36	3.4	1915	633	5.6	1909	6	1919
37	4.5	1911	540	6.3	1903	6	1913
38	3.8	1907	605	6.0	1897	6	1907
39	4.5	1902	501	5.8	1891	6	1901
40	4.7	1898	490	5.9	1885	6	1895
41	5.0	1893	405	5.2	1879	6	1889
42	6.6	1887	257	4.4	1874	5	1883
43	6.3	1881	274	4.5	1870	5	1878
44	5.1	1875	397	5.2	1865	6	1873
45	5.4	1870	338	4.7	1860	5	1867
46	4.9	1865	349	4.5	1856	5	1862
47	4.2	1860	452	4.9	1851	6	1857
48	1.6	1857	1231	5.0	1846	6	1851
49	1.0	1856	1871	4.7	1841	6	1845
50	1.8	1873	296	1.8	1880	1	1893
51	1.0	1872	298	1.6	1878	1	1891
52	0.7	1871	300	1.5	1877	1	1890
53	1.0	1870	301	1.5	1875	1	1889
54	2.0	1869	300	1.6	1873	1	1887
55	4.1	1866	295	1.6	1872	1	1886
56	6.5	1860	285	1.6	1870	1	1885
57	3.8	1855	282	1.6	1869	1	1883
58	1.1	1853	283	1.8	1867	1	1882
59	0.4	1852	286	1.8	1865	1	1880
60	0.4	1852	289	1.9	1863	1	1878
61	0.9	1851	292	2.1	1861	2	1877

Metal Concentrations in the Sediment: Birch Lake

All concentrations in mg/kg dry weight

Sample	Depth (cm)	Age (CRS)	Mg	Al	K	Ca	Ti	V	Cr	Mn
Birch 1	0.50	2003	6284	4051	787.0	196574	54.06	8.47	5.61	680.8
Birch 2	1.00	2003	6961	4424	430.3	219624.6	42.00	7.10	4.95	545.7
Birch 3	1.50	2002	5693	3740	328.1	184685.3	36.96	7.36	4.73	785.8
irch 4	2.00	2001	5577	3625	273.1	180410	37.24	6.84	4.62	825.8
irch 5	2.50	1999	6486	2973	302.7	210043.8	38.94	7.96	5.58	717.1
Birch 6	3.00	1998	6369	3884	316.7	209428.4	39.44	8.57	5.79	839.4
Birch 7	3.50	1996	6419	4218	328.7	211702.8	64.00	8.20	5.65	904.9
Birch 8	4.00	1995	6280	3930	266.2	204484.6	34.24	7.52	6.42	768.0
Birch 9	4.50	1993	6682	4286	392.1	222171.8	45.56	9.39	7.31	723.1
Birch 10	5.00	1991	6134	3975	297.0	201486.7	38.36	8.94	6.36	713.9
Birch 11	5.50	1989	6751	4197	324.3	222546.9	43.11	9.63	6.48	817.0
Birch 12	6.00	1987	7295	4975	351.5	237119.1	45.55	11.24	6.98	625.4
Birch 13	6.50	1985	6048	3824	394.9	200313.8	43.25	12.36	7.76	709.5
Birch 14	7.00	1982	6561	4019	401.4	213753.4	50.92	12.66	7.83	778.5
Birch 15	7.50	1980	5395	3583	340.0	180544.8	40.04	11.32	7.61	719.4
Birch 16	8.00	1978	5439	3636	346.6	182030	50.37	10.70	6.63	748.7
Birch 17	9.00	1975	6075	3941	462.9	200386.5	69.07	14.74	9.11	758.6
Birch 18	10.00	1972	5818	3909	352.2	187265.9	42.09	11.23	7.51	713.7
Birch 19	11.00	1969	6016	3842	324.1	198111.3	34.70	11.78	7.46	640.9
Birch 20	12.00	1966	6571	4161	438.2	218866.8	46.26	12.66	8.15	663.0
Birch 21	13.00	1963	6079	3933	539.8	197507	40.87	11.81	8.61	664.5
Birch 22	14.00	1960	4370	2903	572.3	142355.1	71.01	13.33	9.14	665.5
Birch 23	15.00	1957	6553	4185	399.6	215789.6	50.86	11.26	7.29	623.8
Birch 24	16.00	1954	5423	3966	472.4	177364.3	80.51	13.06	7.30	682.8
Birch 25	17.00	1950	4682	3137	551.8	150800.6	45.84	14.12	7.98	715.0
Birch 26	18.00	1946	6741	4454	640.6	217525.5	45.28	13.65	12.53	684.0
Birch 27	19.00	1943	6414	6046	296.1	207732.8	38.42	8.50	4.86	649.7
Birch 28	20.00	1939	6432	4438	348.1	209593.2	38.07	8.96	5.36	616.3
Birch 29	21.00	1937	6171	3716	517.3	203354.9	83.12	11.48	5.81	631.5
Birch 30	22.00	1934	6315	3841	493.4	202543.7	43.88	12.87	7.34	648.4
Birch 31	23.00	1931	6542	3880	335.6	219006	34.96	10.70	5.43	748.4
irch 32	24.00	1928	6248	3957	322.4	208515.2	38.19	9.81	5.25	639.3
irch 33	25.00	1924	5689	3407	286.8	199492	37.22	9.68	5.09	676.4
Birch 34	26.00	1921	6835	4232	292.5	234608.1	33.41	9.66	4.85	698.4
Birch 35	27.00	1918	5684	3615	323.6	199829.5	37.72	9.59	5.76	725.7
Birch 36	28.00	1914	6752	4098	368.2	236626.8	39.46	10.26	5.70	697.2
Birch 37	29.00	1911	5786	3485	330.6	204571.2	27.76	9.86	11.26	753.1
Birch 38	30.00	1906	5596	3197	265.5	196724.7	22.96	8.70	4.86	761.0
Birch 39	31.00	1902	5327	2930	282.9	182437.6	25.16	8.93	4.93	758.5
Birch 40	32.00	1898	4751	2341	216.6	157462.5	19.32	6.74	3.71	775.6
Birch 41	33.00	1893	5282	2597	287.2	169547.4	39.91	9.46	6.11	1045.9
Birch 42	34.00	1887	5424	2514	272.6	179918.1	34.24	7.48	4.16	889.8
Birch 43	35.00	1881	5542	2785	142.6	181279	16.07	4.00	2.10	787.3
Birch 44	36.00	1875	6594	3154	140.5	201945.6	10.72	4.04	1.90	827.7
Birch 45	37.00	1870	6129	2638	105.8	182832.5	6.00	3.83	1.62	805.9
Birch 46	38.00	1865	6320	2775	108.4	189613.6	1.89	3.38	1.53	670.8
Birch 47	39.00	1860	5601	2337	119.3	164828.4	6.20	3.51	1.50	653.3
Birch 48	40.00	1857	6999	2957	103.7	197330.1	3.21	3.89	1.55	711.3
Birch 49	41.00	1856	6516	2794	138.4	161219.9	4.91	4.51	1.89	830.8
Birch 50	42.00	1854	6960	3199	108.5	160385.6	2.58	3.81	1.55	739.9
Birch 51	43.00	1852	6797	3346	114.3	157164.8	3.18	4.53	27.75	787.5
Birch 52	44.00	1850	6175	3188	156.6	139794.9	7.26	4.47	2.93	642.9
Birch 53	45.00	1847	6524	3165	169.1	152724.8	9.44	5.20	2.05	707.6
Birch 54	46.00	1845	7502	3458	137.3	174254.9	6.32	4.53	1.85	664.6
Birch 55	47.00	1843	7699	3442	164.4	172241.5	14.88	5.83	2.23	756.8
Birch 56	48.00	1841	7239	3354	135.6	156301.7	5.33	4.88	1.98	636.5
Birch 57	49.00	1839	6976	3272	122.6	156134.9	4.69	4.67	1.98	702.7
Birch 58	50.00	1836	7258	3765	124.9	160161.5	4.91	5.22	2.03	777.6
Birch 59	51.00	1834	7385	3356	113.5	160730.2	3.62	5.23	1.96	815.4
irch 60	52.00	1832	7302	3452	135.2	156905	7.88	5.63	1.91	918.3
rch 61	53.00	1829	5169	2431	166.9	114792.5	10.97	5.32	2.06	920.2
Birch 62	54.00	1827	8047	4074	168.8	170918.7	9.11	5.19	1.85	802.1
Birch 63	55.00	1824	6793	3129	188.4	144432.2	12.9666	4.911591	1.905697	711.5

Metal Concentrations in the Sediment: Brich Lake (con't)

All concentrations in mg/kg dry weight

Sample	Fe	Ni	Cu	Zn	As	Mo	Cd	Ba	Pb	U	P	Rb
Birch 1	5498	5.05	10.04	63.12	7.68	1.66	0.28	78.90	22.92	0.56	1534	3.03
Birch 2	6195	3.77	12.66	77.41	7.39	1.83	0.20	61.00	22.40	0.65	906.5	2.53
Birch 3	5128	4.55	10.83	64.11	8.90	2.11	0.45	71.82	22.25	0.85	708.2	2.42
Birch 4	5058	4.77	10.94	59.98	9.54	1.65	0.50	73.18	22.36	0.71	611.8	2.26
Birch 5	5438	4.50	10.46	68.67	9.44	1.83	0.38	68.04	26.33	0.75	544.4	2.69
Birch 6	5681	5.70	12.47	77.48	10.74	2.04	0.41	70.89	31.15	0.89	608.3	2.91
Birch 7	5749	4.70	11.41	74.26	9.83	1.78	0.48	72.00	29.28	0.74	549.8	2.89
Birch 8	5585	4.86	13.69	80.90	8.55	1.63	0.51	70.11	33.12	0.73	539.8	2.59
Birch 9	6080	6.00	15.58	92.41	9.21	1.68	0.63	72.67	42.71	0.77	546.0	4.16
Birch 10	5582	4.76	14.66	95.91	10.31	1.96	0.70	63.19	53.23	0.86	505.4	3.11
Birch 11	6100	6.09	16.85	102.44	11.81	2.25	0.91	73.11	86.63	0.93	505.3	3.52
Birch 12	6710	5.88	17.72	107.87	11.78	2.10	0.80	69.37	103.8	0.82	445.6	4.06
Birch 13	5680	7.24	17.26	135.69	13.80	2.42	1.12	78.78	162.8	0.91	466.0	4.61
Birch 14	5885	7.34	17.30	134.68	14.18	2.45	1.29	86.95	333.1	0.84	432.3	4.70
Birch 15	5136	7.44	13.92	144.76	12.92	1.86	1.34	83.92	159.5	0.73	375.5	4.09
Birch 16	5195	6.57	12.20	134.99	11.85	1.95	1.25	84.91	159.5	0.68	352.7	3.90
Birch 17	5715	8.84	18.41	182.94	15.52	3.02	1.67	97.38	205.1	0.89	390.4	5.41
Birch 18	5301	7.16	12.45	165.32	12.33	2.00	1.37	92.02	132.4	0.67	380.5	4.29
Birch 19	5597	6.41	12.89	169.80	13.15	1.87	1.39	84.17	133.5	0.63	363.0	3.98
Birch 20	6111	7.65	13.43	180.48	13.67	1.96	1.41	87.65	152.1	0.68	400.4	5.12
Birch 21	5530	8.03	13.86	180.58	13.86	1.67	1.45	88.27	132.0	0.72	395.8	6.02
Birch 22	4012	7.72	13.05	178.62	15.74	1.81	1.61	87.30	115.4	0.68	395.9	6.56
Birch 23	6214	6.52	11.49	159.98	14.17	1.82	1.60	86.98	103.9	0.64	373.9	4.90
Birch 24	5354	6.98	11.62	160.00	19.13	1.73	1.83	90.84	91.31	0.72	376.2	5.32
Birch 25	4606	7.86	11.21	130.51	17.47	1.59	1.49	99.21	75.90	0.79	394.4	7.05
Birch 26	6559	8.84	10.36	111.51	15.82	1.59	1.35	101.79	62.39	0.86	384.1	7.59
Birch 27	6308	5.35	7.68	168.59	15.92	1.45	1.41	87.79	54.65	0.59	330.2	3.89
Birch 28	6280	5.76	7.84	91.40	16.33	1.14	1.36	91.91	50.91	0.55	315.7	4.66
Birch 29	6095	5.81	8.50	95.34	22.32	1.41	1.54	91.32	51.19	0.67	344.2	5.66
Birch 30	5968	7.39	9.08	84.50	17.77	0.94	1.13	100.11	41.91	0.71	356.7	7.04
Birch 31	6362	5.81	8.09	86.96	15.04	0.81	1.36	94.57	43.51	0.51	453.6	4.77
Birch 32	6066	5.88	7.08	63.77	19.19	1.33	1.06	92.00	34.60	0.69	374.4	4.58
Birch 33	5579	6.02	7.00	51.21	17.59	1.37	0.85	97.85	27.59	0.66	375.9	4.29
Birch 34	6431	5.76	8.36	44.44	16.93	1.47	0.69	93.39	22.59	0.65	507.6	4.59
Birch 35	5355	6.27	7.13	34.09	13.16	1.08	0.47	99.84	16.01	0.51	599.3	4.93
Birch 36	6245	6.18	6.98	32.94	9.94	0.86	0.37	97.65	15.94	0.50	463.7	5.38
Birch 37	5379	7.67	4.82	29.67	11.73	1.52	0.51	102.94	15.89	0.62	489.6	4.98
Birch 38	5021	5.84	4.20	27.80	12.13	1.49	0.43	96.18	12.45	0.58	561.4	4.27
Birch 39	4748	5.99	4.43	25.37	13.28	1.77	0.40	94.86	12.19	0.60	672.5	4.36
Birch 40	4026	4.24	3.09	18.63	13.81	1.80	0.20	89.39	9.22	0.51	751.4	3.28
Birch 41	4407	5.93	4.61	23.09	20.44	2.69	0.41	87.17	9.07	0.72	1397	3.72
Birch 42	4398	4.31	3.53	20.73	16.43	2.52	0.23	82.65	7.73	0.63	964.3	3.40
Birch 43	4256	4.41	1.66	13.41	15.42	2.74	0.32	75.40	6.83	0.52	951.6	1.60
Birch 44	5299	2.47	1.69	17.96	19.65	3.59	0.21	77.38	10.02	0.49	687.2	1.30
Birch 45	4816	2.25	1.88	13.07	21.49	4.46	0.30	71.82	7.58	0.58	885.8	1.02
Birch 46	4865	1.93	1.44	12.06	17.35	3.72	0.28	67.75	3.12	0.55	434.8	1.02
Birch 47	4317	2.30	1.65	11.48	20.27	4.34	0.29	72.09	2.53	0.60	517.4	1.07
Birch 48	5280	2.25	1.80	11.64	24.46	4.58	0.29	71.23	2.39	0.63	480.5	0.92
Birch 49	5586	2.94	1.97	50.21	21.76	3.86	0.38	77.02	2.54	0.61	478.8	1.24
Birch 50	6621	2.32	1.33	19.85	20.33	3.76	0.22	76.54	2.10	0.50	424.7	0.94
Birch 51	6366	14.11	2.91	12.08	24.53	4.36	0.23	72.93	2.44	0.57	476.4	1.05
Birch 52	5771	2.57	1.86	12.34	16.71	3.19	0.21	67.74	2.40	0.55	374.8	1.37
Birch 53	6001	2.84	2.28	12.15	19.07	4.02	0.31	74.08	2.24	0.70	395.3	1.47
Birch 54	6647	3.03	2.28	13.13	21.81	3.96	0.20	77.36	2.13	0.63	416.0	1.30
Birch 55	7053	3.26	2.95	15.35	25.73	4.51	0.27	76.67	2.17	0.78	473.9	1.54
Birch 56	7149	2.71	2.25	13.74	20.52	3.60	0.19	73.57	2.02	0.64	390.0	1.30
Birch 57	6711	3.21	2.20	17.35	19.74	3.47	0.34	77.80	1.90	0.65	409.5	1.21
Birch 58	7003	2.99	2.10	13.51	21.84	3.83	0.28	81.62	1.90	0.67	433.7	1.23
Birch 59	7008	2.96	2.27	13.77	23.60	4.11	0.26	80.60	1.74	0.79	462.7	1.10
Birch 60	7407	3.04	2.74	17.13	30.52	4.26	0.31	75.63	1.87	0.79	537.5	1.25
rch 61	5203	4.55	2.25	13.58	24.03	3.85	0.51	81.50	1.94	0.57	428.1	1.50
Birch 62	8045	3.53	2.02	12.28	23.21	3.87	0.30	80.45	1.64	0.49	416.4	1.45
Birch 63	6643	3.300589	1.787819	11.15914	23.81139	3.752456	0.275049	74.81336	2.180747	0.51	447.3	1.55

Concentrations of Organic Contaminants: Birch Lake

All concentrations in ng/g dry wt

cm depth[1]	1.0	2.0
Age[2]	2002	2000
Total polychlorinated biphenyls (PCBs)	0.89	1.58
Total polyaromatic hydrocarbons (PAHs)	225.03	254.57
Acenaphthalene	1.48	1.7
Acenaphthene	0.86	1.13
Fluorene	1.97	2.55
Phenanthrene	19.44	19.95
Anthracene	2.68	3.27
Fluoranthene	37.37	40.99
Pyrene	31.02	34.01
Benzo-A-anthracene	12.75	14.23
Chrysene	24.75	30.58
Benzo-B-fluoranthene	38.33	42.33
Benzo-K-fluoranthene	10.81	13.43
Indeno-1,2,3-CD-pyrene	20.21	22.61
Dibenz-a,h-anthracene	3.69	5.69
Benzo-G,H,I-perylene	19.67	22.1
Total Pesticides	8.6	12.7
α-BHC	0.63	0.89
β-BHC	0.62	BDL
Lindane	BDL	0.05
γ-BHC	0.55	1.04
Heptachlor	1.47	1.63
Aldrin	BDL	BDL
Heptachlor epoxide	3.51	5.31
cis-Chlordane	0.5	1.39
trans-Chlordane	0.45	0.97
DDE	0.58	0.9
DDD	0.27	0.55
DDT	BDL	BDL
Methoxychlor	BDL	BDL

1. The first two slices were combined (cm 0-1), and the third and fourth slices (1-2 cm), due to insufficent sample mass for analysis.
2. Since samples were combined[1] each analysis covers a range of years. The median age is presented for each of the combined samples.
3. BDL indicates contaminant below detection limit.

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Muskegon Lake Sediment Fact Sheet

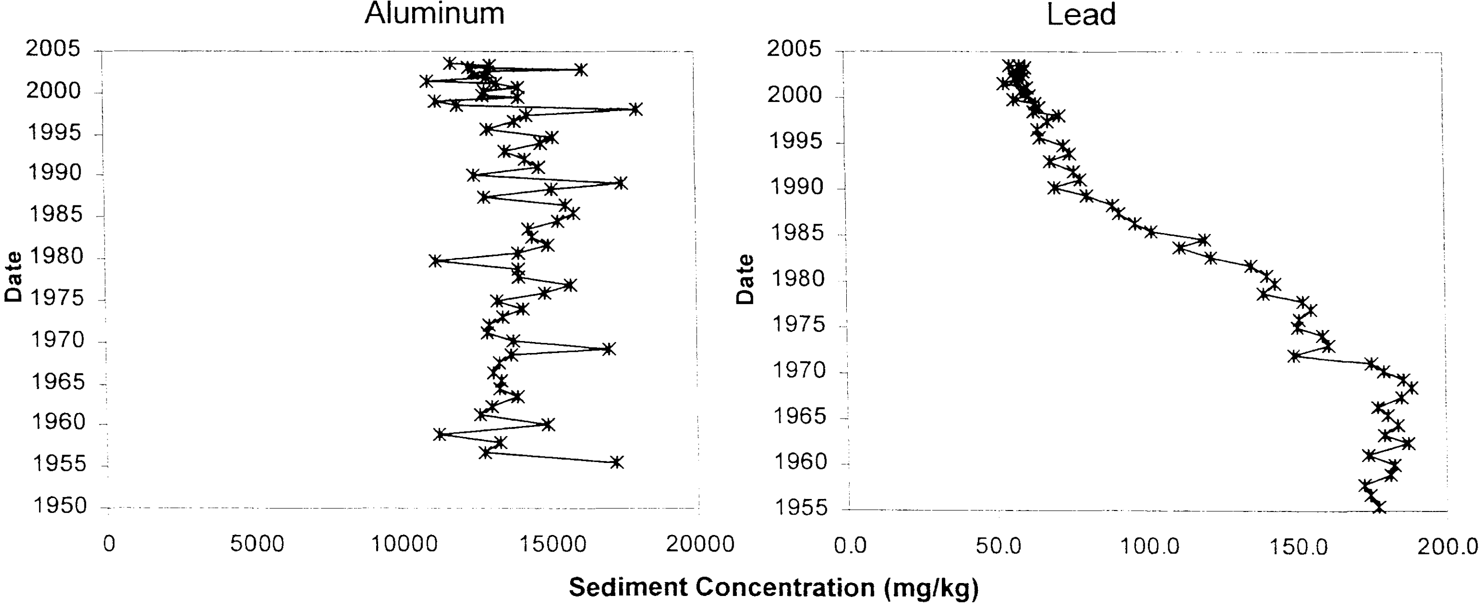
Date sampled: 23 July 2003	Sampling site water depth: 47.6 ft
Location: Muskegon County	Depth of core: 55 cm
Sampling site: 43°14.042'N 86°17.006'W	Sedimentation rate: 1711 g/m^2/y Age of oldest section: 1956
Lake surface area: 4150 acres	Focusing factor: 2.83

Due to high sedimentation rates concentrations in the Muskegon Lake core do not reach background values. Copper, lead, zinc and lead all decrease towards present times. Peak cadmium concentrations are the highest observed among all study lakes. Muskegon Lake organic contaminant concentrations are similar to other Michigan inland lakes.

	Surface conc.	Background conc.	Trends
Cadmium (mg/kg)	2.00	NA	decreasing
Copper (mg/kg)	52.7	NA	decreasing
Lead (mg/kg)	58.0	NA	decreasing
Zinc (mg/kg)	146.9	NA	decreasing
Total PCBs (ug/kg)	4.7		level
Total PAHs (ug/kg)	429.9		decreasing
Total Pesticides (ug/kg)	19..3		decreasing

Trends for organic contaminants are taken from only two data points and should be interpreted with care.

Example profiles



A Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters: Sediments

Muskegon Lake

Sampling Date: 23 July 2003

Location: 43° 14.042'N 86°17.006'W Water depth: 47.6'

Core description: 54.8 cm total. Very little to no definition of transition zones. Blackish sediment, macro invertebrates in topwater

#	Thickness (cm)	Total thickness (cm)	Description
1	1.0	1.0	blackish with brown sediment, swampy smell, watery
2	0.5	1.5	blackish with brown sediment, swampy smell, watery
3	0.5	2.0	blackish with brown sediment, watery
4	0.5	2.5	blackish with brown sediment, watery
5	0.5	3.0	blackish with brown sediment, watery
6	0.5	3.5	blackish with brown sediment, watery
7	0.5	4.0	more brown than above, 20% black
8	0.5	4.5	more brown than above, 20% black
9	0.5	5.0	brown and dark brown
10	0.5	5.5	brown and dark brown
11	0.5	6.0	brown and dark brown
12	0.5	6.5	brown and dark brown
13	0.5	7.0	brown and dark brown
14	0.5	7.5	brown and dark brown
15	0.5	8.0	dark brown and dark gray
16	1.0	9.0	dark gray, filamentous organic
17	1.0	10.0	dark gray, filamentous organic
18	1.0	11.0	dark gray and black, leaf
19	1.0	12.0	dark gray and black, 3 small shells
20	1.0	13.0	dark gray and black, specks of white, filament organic
21	1.0	14.0	black, vein of brown, white specks
22	1.0	15.0	dk. brown, veins of black/brown, clam shell, white specks, filamentous org.
23	1.0	16.0	dk. brown, veins of black/brown, clam shell, white specks, filamentous org.
24	1.0	17.0	dark brown, veins of brown/black, white specks, clam shells
25	1.0	18.0	black, veins of brown, clam shell bits
26	1.0	19.0	black, veins of brown, clam shell bits
27	1.0	20.0	black, veins of brown, clam shell bits
28	1.0	21.0	black, veins of brown, clam shell bits, filament organics
29	1.0	22.0	dark grayish black, veins of brown
30	1.0	23.0	dark grayish black, veins of brown
31	1.0	24.0	dark gray, veins of brown, white specks
32	1.0	25.0	dark gray, veins of brown. white specks
33	1.0	26.0	black with vein of brown
34	1.0	27.0	black with vein of brown
35	1.0	28.0	black with vein of brown
36	1.0	29.0	black with vein of brown
37	1.0	30.0	black with vein of brown
38	1.0	31.0	black with vein of brown

#	Thickness (cm)	Total thickness (cm)	Description
39	1.0	32.0	black with vein of brown
40	1.0	33.0	black with vein of brown
41	1.0	34.0	black with vein of brown
42	1.0	35.0	black with vein of brown
43	1.0	36.0	black with vein of brown
44	1.0	37.0	black with vein of brown
45	1.0	38.0	black with vein of brown
46	1.0	39.0	black with vein of brown
47	1.0	40.0	black with vein of brown
48	1.0	41.0	black with vein of brown
49	1.0	42.0	dark gray with veins of brown
50	1.0	43.0	dark gray with veins of brown, large leaf
51	1.0	44.0	dark gray with veins of brown, large leaf
52	1.0	45.0	dark gray with veins of brown
53	1.0	46.0	dark gray with veins of brown
54	1.0	47.0	dark gray with veins of brown
55	1.0	48.0	dark gray with veins of brown
56	1.0	49.0	dark gray, 8 cm stick extracted
57	1.0	50.0	dark gray, filamentous organic matter
58	1.0	51.0	dark gray, filamentous organic matter
59	1.0	52.0	dark gray, filamentous organic matter, white specks
60	1.0	53.0	black, white specks
61	1.0	54.0	no sample, 0.5 cm left

^{210}Pb Analysis: Muskegon Lake

Data provided by Paul Wilkinson, Freshwater Institute, Manitoba, Canada

SAMPLE	DRY WT.(g)	ACCUMULATED DRY WT (gm./sq.cm.)	POROSITY	% WATER	ACTIVITY Bq/g ± 1SD			excess Pb-210 Bq/g	ACTIVITY Bq/g ± 1SD		
					Pb-210	±	ERROR		CS-137	±	ERROR
1	0.8500	0.0120	0.99	97.2	3.16E-01	+/-	2.10E-02	3.01E-01	0.00E+00	+/-	0.00E+00
2	2.8500	0.0522	0.97	91.4	3.12E-01	+/-	2.05E-02	2.97E-01			
3	3.3000	0.0988	0.96	90.5	3.25E-01	+/-	2.07E-02	3.10E-01	1.75E-02	+/-	3.99E-03
4	3.3400	0.1459	0.96	88.3	3.31E-01	+/-	2.11E-02	3.16E-01			
5	3.8400	0.2001	0.95	87.3	3.37E-01	+/-	2.14E-02	3.22E-01	1.35E-02	+/-	3.45E-03
6	4.1400	0.2585	0.96	88.1	3.28E-01	+/-	2.11E-02	3.13E-01			
7	5.2200	0.3321	0.95	87.9	3.31E-01	+/-	2.11E-02	3.16E-01	0.00E+00	+/-	0.00E+00
8	4.5700	0.3966	0.95	87.6	3.36E-01	+/-	2.18E-02	3.21E-01			
9	4.8900	0.4656	0.95	87.3	3.33E-01	+/-	2.11E-02	3.18E-01	1.28E-02	+/-	1.81E-03
10	5.1400	0.5381	0.95	87.2	3.38E-01	+/-	2.16E-02	3.23E-01			
11	4.9700	0.6082	0.95	86.6	3.32E-01	+/-	2.07E-02	3.17E-01	1.25E-02	+/-	3.75E-03
12	5.3200	0.6833	0.95	86.4	3.15E-01	+/-	1.96E-02	3.00E-01			
13	5.0500	0.7545	0.95	86.4	3.37E-01	+/-	2.10E-02	3.22E-01	0.00E+00	+/-	0.00E+00
14	4.7700	0.8218	0.95	86.2	3.39E-01	+/-	2.12E-02	3.24E-01			
15	5.9300	0.9055	0.95	86.1	3.37E-01	+/-	2.15E-02	3.22E-01	1.06E-02	+/-	3.03E-03
16	5.2200	0.9791	0.95	86.0	3.26E-01	+/-	2.12E-02	3.11E-01			
17	11.0700	1.1353	0.94	84.8	3.32E-01	+/-	2.12E-02	3.17E-01	8.87E-03	+/-	2.19E-03
18	10.8300	1.2881	0.94	85.4	3.36E-01	+/-	2.16E-02	3.21E-01			
19	10.7900	1.4403	0.94	85.5	3.44E-01	+/-	2.19E-02	3.29E-01	1.39E-02	+/-	2.04E-03
20	10.6300	1.5903	0.94	85.4	3.34E-01	+/-	2.12E-02	3.19E-01			
21	10.7000	1.7413	0.95	85.7	3.31E-01	+/-	2.09E-02	3.16E-01	1.61E-02	+/-	2.82E-03
22	11.5200	1.9038	0.94	85.3	3.26E-01	+/-	2.08E-02	3.11E-01			
23	11.4700	2.0656	0.94	85.4	3.24E-01	+/-	2.10E-02	3.09E-01	1.91E-02	+/-	3.18E-03
24	10.4300	2.2128	0.95	85.7	3.27E-01	+/-	2.15E-02	3.12E-01			
25	11.4800	2.3747	0.95	85.8	3.09E-01	+/-	1.98E-02	2.94E-01	1.82E-02	+/-	3.57E-03
26	11.1100	2.5315	0.95	85.9	2.75E-01	+/-	1.81E-02	2.60E-01			
27	11.8600	2.6988	0.94	85.3	2.53E-01	+/-	1.61E-02	2.38E-01	2.54E-02	+/-	3.92E-03
28	11.5700	2.8620	0.94	85.0	2.42E-01	+/-	1.54E-02	2.27E-01			
29	11.3600	3.0223	0.94	85.4	2.44E-01	+/-	1.57E-02	2.29E-01	2.59E-02	+/-	2.75E-03
30	10.8100	3.1748	0.95	85.9	2.36E-01	+/-	1.53E-02	2.21E-01			
31	11.1900	3.3327	0.94	85.5	2.35E-01	+/-	1.49E-02	2.20E-01	3.21E-02	+/-	4.26E-03
32	11.9400	3.5011	0.94	84.0	2.32E-01	+/-	1.47E-02	2.17E-01			
33	12.1600	3.6727	0.94	84.5	2.31E-01	+/-	1.47E-02	2.16E-01	2.62E-02	+/-	3.01E-03
34	12.0800	3.8431	0.94	84.8	2.32E-01	+/-	1.47E-02	2.17E-01			
35	11.5800	4.0065	0.94	85.1	2.25E-01	+/-	1.45E-02	2.10E-01	2.35E-02	+/-	3.68E-03
36	11.5900	4.1700	0.94	84.9	2.18E-01	+/-	1.41E-02	2.03E-01			
37	11.5600	4.3331	0.94	85.0	1.99E-01	+/-	1.29E-02	1.84E-01	3.42E-02	+/-	4.55E-03
38	11.1800	4.4908	0.94	85.3	1.88E-01	+/-	1.22E-02	1.73E-01			
39	11.6300	4.6549	0.94	84.2	1.69E-01	+/-	1.07E-02	1.54E-01	3.29E-02	+/-	3.02E-03
40	11.1000	4.8115	0.94	85.3	1.57E-01	+/-	1.00E-02	1.42E-01			
41	11.3900	4.9722	0.94	84.8	1.57E-01	+/-	1.02E-02	1.42E-01	3.52E-02	+/-	4.20E-03
42	11.8700	5.1397	0.94	84.2	1.54E-01	+/-	9.99E-03	1.39E-01			
43	12.6400	5.3180	0.94	83.3	1.49E-01	+/-	9.48E-03	1.34E-01	3.31E-02	+/-	4.14E-03
44	11.7100	5.4832	0.94	83.9	1.37E-01	+/-	8.86E-03	1.22E-01			
45	11.2600	5.6421	0.94	84.8	1.38E-01	+/-	8.78E-03	1.23E-01	4.76E-02	+/-	5.33E-03
46	10.6700	5.7926	0.94	85.1	1.33E-01	+/-	8.48E-03	1.18E-01			
47	10.9300	5.9468	0.94	85.5	1.27E-01	+/-	8.20E-03	1.12E-01	4.02E-02	+/-	5.44E-03
48	11.0600	6.1028	0.94	84.7	1.22E-01	+/-	7.87E-03	1.07E-01			
49	12.6900	6.2819	0.93	83.1	1.18E-01	+/-	7.63E-03	1.03E-01	4.38E-02	+/-	2.43E-03
50	11.9700	6.4508	0.94	83.6	1.14E-01	+/-	7.45E-03	9.92E-02			
51	12.4700	6.6267	0.94	83.4	1.14E-01	+/-	7.35E-03	9.85E-02	4.79E-02	+/-	5.53E-03
52	12.2600	6.7997	0.94	83.5	1.10E-01	+/-	7.18E-03	9.52E-02			
53	12.4800	6.9757	0.93	82.9	1.03E-01	+/-	6.61E-03	8.79E-02	5.19E-02	+/-	5.45E-03
54	13.4700	7.1658	0.93	81.6	1.06E-01	+/-	6.92E-03	9.15E-02			
55	13.4300	7.3552	0.93	81.5	1.09E-01	+/-	6.84E-03	9.36E-02	5.99E-02	+/-	5.24E-03
56	13.6700	7.5481	0.93	81.8	1.08E-01	+/-	6.94E-03	9.32E-02			
57	12.7600	7.7281	0.93	82.2	1.05E-01	+/-	6.70E-03	9.03E-02	8.46E-02	+/-	2.35E-03
58	14.1600	7.9279	0.92	80.7	1.05E-01	+/-	6.67E-03	8.97E-02	1.13E-01	+/-	5.21E-03
59	14.2600	8.1291	0.92	80.9	1.10E-01	+/-	7.12E-03	9.51E-02	1.14E-01	+/-	5.17E-03
60	14.1300	8.3284	0.92	80.8	1.06E-01	+/-	6.96E-03	9.11E-02	1.11E-01	+/-	5.05E-03

^{210}Pb Analysis: Muskegon Lake (con't)

SAMPLE	CF:CS	
	years/ slice	Median Yr of deposition
1	0.1	2004
2	0.2	2003
3	0.3	2003
4	0.3	2003
5	0.3	2003
6	0.3	2002
7	0.4	2002
8	0.4	2001
9	0.4	2001
10	0.4	2001
11	0.4	2000
12	0.4	2000
13	0.4	1999
14	0.4	1999
15	0.5	1999
16	0.4	1998
17	0.9	1997
18	0.9	1997
19	0.9	1996
20	0.9	1995
21	0.9	1994
22	0.9	1993
23	0.9	1992
24	0.9	1991
25	0.9	1990
26	0.9	1989
27	1.0	1988
28	1.0	1987
29	0.9	1986
30	0.9	1985
31	0.9	1985
32	1.0	1984
33	1.0	1983
34	1.0	1982
35	1.0	1981
36	1.0	1980
37	1.0	1979
38	0.9	1978
39	1.0	1977
40	0.9	1976
41	0.9	1975
42	1.0	1974
43	1.0	1973
44	1.0	1972
45a	0.9	1971
45b	0.9	1970
46	0.9	1969
47	0.9	1968
48	1.0	1967
49	1.0	1966
50	1.0	1965
51	1.0	1964
52	1.0	1963
53	1.1	1962
54	1.1	1961
55	1.1	1960
56	1.1	1959
57	1.2	1958
58	1.2	1957
59	1.2	1956

Metal Concentrations in the Sediment: Muskegon Lake

All concentrations in mg/kg dry weight

Sample	Depth (cm)	Age	Mg	Al	K	Ca	Ti	V	Cr	Mn
Muskegon 1	0.5	2004	12495	11812	1821	74385	96.37	26.48	50.13	1951
Muskegon 2	1	2003	14296	13123	1698	71261	82.06	26.13	51.67	2140
Muskegon 3	1.5	2003	13558	12400	1711	71440	82.66	26.50	52.68	2222
Muskegon 4	2	2003	13554	16261	2764	72888	188.3	32.65	57.92	2189
Muskegon 5	2.5	2003	13300	13066	1864	86396	95.44	27.44	51.69	2198
Muskegon 6	3	2002	13875	12578	1669	71183	75.68	27.06	51.98	2157
Muskegon 7	3.5	2002	13551	13030	1834	67920	90.63	27.50	51.00	2081
Muskegon 8	4	2001	11581	11029	1705	63668	80.85	25.38	46.42	2183
Muskegon 9	4.5	2001	14036	13381	1869	73699	90.06	28.22	55.15	2146
Muskegon 10	5	2001	13869	14090	2078	87053	112.5	28.80	54.62	2088
Muskegon 11	5.5	2000	13787	12945	1798	69677	82.95	27.29	54.08	1904
Muskegon 12	6	2000	12832	12898	1835	58155	89.28	26.40	51.16	2111
Muskegon 13	6.5	1999	14496	14106	1947	61675	94.62	29.32	57.70	2013
Muskegon 14	7	1999	11079	11255	2159	48604	120.1	30.86	60.18	2107
Muskegon 15	7.5	1999	13433	12001	1529	54598	64.01	25.39	55.35	1920
Muskegon 16	8	1998	15665	18057	2926	54739	183.4	36.80	71.78	1908
Muskegon 17	9	1997	15859	14370	1727	60265	74.11	30.02	59.66	2179
Muskegon 18	10	1997	15005	13936	1782	67154	82.78	29.58	56.78	1904
Muskegon 19	11	1996	13757	13003	1705	51882	72.70	28.76	56.59	2128
Muskegon 20	12	1995	15045	15263	2113	52322	97.84	32.90	66.04	2071
Muskegon 21	13	1994	15422	14834	1913	57382	80.64	32.31	65.83	1950
Muskegon 22	14	1993	14196	13649	1823	60408	76.97	31.24	59.63	1920
Muskegon 23	15	1992	15010	14279	1834	54616	69.39	32.36	64.10	1922
Muskegon 24	16	1991	15551	14765	1917	53007	72.84	33.87	69.13	2103
Muskegon 25	17	1990	13814	12559	1582	44840	52.30	28.77	59.90	1831
Muskegon 26	18	1989	15430	17519	2446	54838	138.8	36.82	73.59	1474
Muskegon 27	19	1988	15976	15167	1906	49288	72.73	33.98	79.17	1438
Muskegon 28	20	1987	13298	12914	1958	39014	79.68	33.92	80.02	1384
Muskegon 29	21	1986	15611	15632	2066	46686	89.81	36.56	86.13	1339
Muskegon 30	22	1985	15195	15874	2227	45928	109.4	35.61	90.41	1255
Muskegon 31	23	1985	15653	15397	1974	45823	86.80	36.80	102.97	1375
Muskegon 32	24	1984	14058	14388	1817	42831	103.7	32.58	96.59	1117
Muskegon 33	25	1983	14019	14503	1945	42555	90.29	35.12	109.87	1170
Muskegon 34	26	1982	14888	15043	1798	44989	72.50	33.69	126.12	1102
Muskegon 35	27	1981	13713	14041	1856	42436	85.06	35.19	132.47	1092
Muskegon 36	28	1980	9966	11200	1980	27443	96.35	35.71	138.28	1047
Muskegon 37	29	1979	13250	14056	1665	36871	82.33	32.35	137.18	895.6
Muskegon 38	30	1978	13679	14059	1539	39321	76.94	32.50	164.48	860.1
Muskegon 39	31	1977	14665	15761	1746	40280	93.92	34.85	179.87	897.4
Muskegon 40	32	1976	13710	14868	1633	36523	88.45	33.87	186.45	892.9
Muskegon 41	33	1975	12419	13297	1534	34646	83.65	31.83	188.17	803.3
Muskegon 42	34	1974	12987	14172	1581	35693	84.67	33.44	205.76	771.7
Muskegon 43	35	1973	13042	13510	1421	36178	70.08	31.58	209.27	763.3
Muskegon 44	36	1972	11699	13044	1413	33359	78.93	28.75	220.99	670.5
Muskegon 45	37	1971	11566	12923	1534	35214	90.02	30.59	291.85	735.3
Muskegon 46	38	1970	12335	13848	1450	43318	91.71	28.49	379.00	932.3
Muskegon 47	39	1969	13016	17065	1954	45458	144.0	32.25	429.98	955.2
Muskegon 48	40	1968	12378	13725	1428	46084	90.24	27.72	437.94	1099
Muskegon 49	41	1967	12059	13377	1390	45897	92.41	27.40	435.05	1174
Muskegon 50	42	1966	11528	13122	1406	44008	93.25	27.15	421.13	993.7
Muskegon 51	43	1965	11830	13432	1456	45624	96.02	27.51	443.84	1004
Muskegon 52	44	1964	12237	13363	1423	47161	88.14	27.37	459.77	1048

Metal Concentrations in the Sediment: Muskegon Lake (con't)

All concentrations in mg/kg dry weight

Sample	Fe	Ni	Cu	Zn	As	Sr	Mo	Cd	Ba	Pb	U
Muskegon 1	36731	19.43	50.22	138.5	14.50	82.60	0.61	1.61	230.8	55.00	0.59
Muskegon 2	41826	21.27	53.83	151.4	15.83	83.13	1.13	2.21	225.1	58.44	0.73
Muskegon 3	39248	21.50	53.95	150.9	16.89	83.94	1.12	2.23	221.1	60.71	0.71
Muskegon 4	40032	22.44	54.27	157.0	15.77	82.52	1.32	2.21	217.8	59.94	0.85
Muskegon 5	38547	20.95	51.86	144.0	13.79	73.79	1.08	2.08	201.3	56.78	0.78
Muskegon 6	39862	21.88	54.36	147.7	13.88	81.34	1.25	2.30	204.7	59.83	0.81
Muskegon 7	38516	21.38	51.81	144.4	13.41	78.05	1.26	2.11	202.1	57.09	0.79
Muskegon 8	32645	19.41	46.93	132.5	12.16	73.45	1.14	1.99	197.4	53.45	0.72
Muskegon 9	39357	22.03	55.15	151.7	14.00	79.32	1.31	2.22	212.9	61.45	0.85
Muskegon 10	39068	21.97	54.50	152.9	14.34	80.04	1.39	2.29	213.5	59.12	0.86
Muskegon 11	38706	21.83	57.29	166.6	13.86	79.65	1.37	2.29	208.0	61.79	0.86
Muskegon 12	35746	20.56	50.75	140.9	12.03	77.10	1.24	2.05	184.2	56.58	0.79
Muskegon 13	40916	23.16	58.05	162.5	13.57	75.65	1.36	2.38	202.1	64.09	0.90
Muskegon 14	31715	23.33	59.37	162.5	13.89	75.91	1.41	2.41	206.8	65.36	0.96
Muskegon 15	38221	21.13	57.36	152.9	12.24	77.16	1.21	2.30	193.9	63.20	0.83
Muskegon 16	44453	25.72	67.89	181.3	14.17	77.12	1.67	2.63	214.2	71.78	1.09
Muskegon 17	45633	23.82	68.71	171.8	13.67	78.43	1.43	2.38	198.2	67.87	1.03
Muskegon 18	41946	23.02	60.29	164.5	13.92	82.46	1.71	2.41	187.3	64.83	1.05
Muskegon 19	39184	22.26	58.69	159.6	12.59	80.99	1.46	2.32	173.6	65.46	1.00
Muskegon 20	43305	24.24	64.50	177.9	14.26	81.09	1.82	2.58	184.3	73.14	1.15
Muskegon 21	42440	24.43	62.72	180.0	14.31	81.29	1.89	2.62	179.8	75.53	1.17
Muskegon 22	41796	24.91	60.21	170.7	14.63	81.44	2.28	2.47	162.4	68.69	1.16
Muskegon 23	44333	31.26	64.16	183.5	15.53	83.22	2.67	2.65	158.0	76.85	1.32
Muskegon 24	45738	46.27	65.73	186.3	15.96	82.46	2.65	2.77	165.1	78.43	1.33
Muskegon 25	41486	58.25	56.25	165.7	14.48	82.85	2.74	2.42	136.5	70.10	1.19
Muskegon 26	44305	45.43	61.67	184.0	16.86	82.27	3.33	2.71	149.3	80.53	1.35
Muskegon 27	43272	34.43	62.61	196.9	15.83	79.45	2.63	2.90	144.0	89.64	1.21
Muskegon 28	35774	28.95	62.21	197.9	15.77	79.51	2.72	3.09	139.6	91.50	1.14
Muskegon 29	42993	30.88	65.91	208.5	16.73	76.79	2.75	3.23	144.4	96.39	1.18
Muskegon 30	41400	35.03	62.63	207.4	16.34	78.14	2.94	3.31	137.0	102.24	1.18
Muskegon 31	45400	29.52	70.29	238.5	17.54	76.74	3.33	3.62	142.9	120.14	1.28
Muskegon 32	42161	27.40	63.77	218.0	15.97	78.09	3.37	3.35	126.6	111.43	1.17
Muskegon 33	41985	27.16	69.47	230.4	18.02	79.36	4.17	3.79	131.9	122.23	1.26
Muskegon 34	43182	29.15	71.70	253.3	18.54	80.31	4.27	4.35	130.8	135.33	1.23
Muskegon 35	40231	29.79	74.02	262.4	19.63	79.02	4.90	4.61	135.4	140.56	1.27
Muskegon 36	25160	29.75	73.90	273.9	19.71	77.93	4.83	4.66	134.9	143.63	1.35
Muskegon 37	32033	27.04	70.30	260.6	15.31	79.12	3.68	3.56	125.0	139.05	1.05
Muskegon 38	33628	31.46	76.43	294.5	19.27	78.27	5.07	5.33	132.8	152.64	1.30
Muskegon 39	34783	34.03	80.51	317.8	20.86	78.88	5.59	5.65	138.8	155.30	1.29
Muskegon 40	32514	33.41	77.55	314.2	20.61	77.21	5.40	5.65	135.7	151.05	1.22
Muskegon 41	30871	34.10	77.56	324.6	21.22	80.12	5.94	5.74	136.4	150.84	1.22
Muskegon 42	34587	35.91	83.23	347.5	23.12	82.49	6.82	6.28	145.1	159.40	1.31
Muskegon 43	34338	36.33	82.54	357.6	22.54	82.48	6.49	6.51	144.3	161.24	1.28
Muskegon 44	29468	37.86	75.52	369.7	19.30	82.31	6.57	6.63	140.2	149.49	1.09
Muskegon 45	28707	46.11	84.54	447.8	19.63	79.79	7.38	8.15	163.9	175.64	1.14
Muskegon 46	29666	42.73	90.00	474.6	18.13	80.21	8.02	9.67	171.7	179.43	1.04
Muskegon 47	30952	41.34	93.22	487.8	17.48	82.99	9.42	10.58	185.6	186.07	1.14
Muskegon 48	28569	38.74	91.78	469.5	16.14	82.36	9.58	10.60	183.0	188.62	1.02
Muskegon 49	28937	41.25	90.73	450.1	15.51	83.20	10.28	10.09	183.7	185.23	0.99
Muskegon 50	27186	35.77	82.02	422.2	14.37	84.15	10.11	9.64	180.0	177.18	0.98
Muskegon 51	27147	38.34	85.01	408.9	14.88	84.01	10.59	10.50	191.8	180.96	0.94
Muskegon 52	27471	38.37	84.63	408.5	14.43	86.01	10.98	10.96	204.7	184.24	0.92

Concentrations of Organic Contaminants: Muskegon Lake

All concentrations in ng/g dry wt

cm depth[1]	1.0	2.0
Age[2]	2003	2003
Total polychlorinated biphenyls (PCBs)	4.70	4.68
Total polyaromatic hydrocarbons (PAHs)	429.87	459.48
Acenaphthalene	2.64	2.85
Acenaphthene	4.56	4.62
Fluorene	5.07	5.42
Phenanthrene	36.79	38.97
Anthracene	7.24	7.64
Fluoranthene	60.77	64.88
Pyrene	60.56	65.09
Benzo-A-anthracene	27.57	25.76
Chrysene	52.03	54.51
Benzo-B-fluoranthene	56.30	60.31
Benzo-K-fluoranthene	28.96	31.76
Indeno-1,2,3-CD-pyrene	37.53	42.56
Dibenz-a,h-anthracene	4.64	5.45
Benzo-G,H,I-perylene	45.21	49.66
Total Pesticides	19.30	23.01
α-BHC	14.06	16.77
β-BHC	BDL[3]	BDL[3]
Lindane	BDL3	BDL3
γ-BHC	2.05	2.31
Heptachlor	BDL3	BDL3
Aldrin	BDL3	BDL3
Heptachlor epoxide	BDL3	BDL3
cis-Chlordane	0.28	0.33
trans-Chlordane	0.34	0.36
DDE	1.66	1.94
DDD	0.91	1.30
DDT	BDL3	BDL3
Methoxychlor	BDL3	BDL3

1. The first two slices were combined (cm 0-1), and the third and fourth slices (1-2 cm), due to insufficent sample mass for analysis.
2. Since samples were combined[1] each analysis covers a range of years. The median age is presented for each of the combined samples.
3. BDL indicates contaminant below detection limit.

Metal Concentrations in the Porewater: Muskegon Lake

Concentrations in ng/mL

Sample	Depth (cm)	P	V	Cr	Co	Ni	Cu	Zn	As	Rb	Mo	Al
Topwater	0	215.24	0.71	0.28	0.62	4.13	0.84	111.5	6.72	1.29	1.17	13.62
Muskegon 1	0.5	552.15	2.31	1.09	1.42	4.24	0.68	239.9	46.84	2.46	1.4	8.42
Muskegon 2	1.5	238.64	3.42	1.07	1.89	6.57	1.6	530.1	68.4	3.02	1.29	41.15
Muskegon 3	2.5	264.18	3.63	1.01	1.87	9.39	0.87	486.3	64.83	3.13	1	17.85
Muskegon 4	3.5	1010.81	4.26	1.45	1.68	3.2	1.39	217.8	61.5	3	0.83	10.38
Muskegon 5	4.5	1227.37	4.69	1.12	1.68	5.42	4.2	442.3	53.11	2.88	0.65	23.66
Muskegon 6	5.5	1771.23	3.76	2.54	1.36	3.39	0.82	315.4	45.55	2.62	0.48	17.13
Muskegon 7	6.5	2168.6	2.78	0.79	1.41	3.02	0.68	106.2	38.24	2.45	0.46	7.1
Muskegon 8	7.5	2887.84	2.95	0.85	1.43	2.15	0.63	152.7	32.34	2.48	0.4	11.03
Muskegon 9	8.5	2983.55	3.12	1.14	1.36	5.64	0.81	277.2	23.45	2.41	0.4	16.19
Muskegon 10	9.5	2360	2.47	0.81	1.21	3.13	0.59	134.8	23.07	2.31	0.43	8.85
Muskegon 11	11.5	2392.32	3.05	1.3	1.17	3.45	0.75	452.1	15.87	2.29	0.38	16.93
Muskegon 12	13.5	2316.9	2.22	0.84	1.03	3.34	0.62	311.9	13.43	2.17	0.43	9.58
Muskegon 13	15.5	1568.77	1.78	1.46	0.76	4.97	0.78	369.2	10.21	2	0.61	56.1
Muskegon 14	17.5	1670.71	1.67	1.09	1.03	5.31	0.55	377.5	9.47	2	0.52	42.85
Muskegon 15	19.5	1863.98	1.77	1.11	0.86	2.99	0.63	681.0	8.01	2.2	3.31	64.4
Muskegon 16	21.5	1375.48	2.2	0.74	0.82	1.74	0.8	564.3	7.42	2.04	0.65	16.31
Muskegon 17	23.5	1780.49	1.85	1.49	1.18	11.04	1.21	345.3	6.49	2.25	0.53	46.01
Muskegon 18	25.5	1992.76	1.66	1.7	1.04	4.27	0.81	133.7	5.05	2.18	0.46	138.86
Muskegon 19	27.5	1893.84	1.66	1.49	1.17	2.28	0.5	98.1	3.84	2.44	0.49	10.41
Muskegon 20	29.5	1519.85	1.79	1.37	1.11	1.89	0.48	278.1	3.51	2.46	0.59	8.41
Muskegon 21	31.5	1382.54	1.84	2.06	1.4	2.59	0.57	288.6	3.73	2.67	0.56	12.71
Muskegon 22	33.5	1097.29	1.48	2.02	1.26	1.97	0.43	102.2	3.52	2.72	0.5	8.2
Muskegon 23	35.5	1224.58	1.85	3.66	1.76	2.09	0.48	299.9	3.43	3.1	0.39	5.84
Muskegon 24	37.5	1563.56	2.57	4.56	1.82	3.3	0.64	478.6	3.27	3.02	0.48	8.96
Muskegon 25	39.5	508.53	1.46	7.81	2.63	3.71	0.5	202.5	3	3.66	0.43	6.01
Muskegon 26	41.5	201.46	1.89	8.21	2.7	4.31	0.55	579	2.98	3.71	0.41	21.18
Muskegon 27	43.5	333.63	1.64	10.29	3.21	12.68	0.85	472.1	3.17	3.93	0.38	59.25
Muskegon 28	45.5	29.56	1.69	10.28	3.2	4.82	0.52	510	3.42	4.15	0.6	80.76

Sample	Depth (cm)	Cd	Ba	Pb	U	K	Mn	Mg	Ca	Fe	B	Sn
Topwater	0	0.06	58.51	0.9	0.23	1718	2297.5	13813	42635	556.5	31.65	0.08
Muskegon 1	0.5	0.05	43.79	0.27	0.12	2536	7244.6	16036	50898	419	34.63	0.02
Muskegon 2	1.5	0.17	38.98	0.9	0.04	3024	8388.4	18122	58682	361.4	36.04	0.04
Muskegon 3	2.5	0.1	23.02	1.74	0.05	3075	8289.8	17664	59217	499.1	43.04	0.03
Muskegon 4	3.5	0.07	19.88	0.71	0.04	2951	6211.8	17439	59217	780.8	51.74	0.04
Muskegon 5	4.5	0.08	30.24	0.83	0.05	2881	5129.3	17075	58720	920	57.75	0.05
Muskegon 6	5.5	0.08	18.96	8.85	0.05	2743	4350.2	16495	56946	815.6	59.21	0.05
Muskegon 7	6.5	0.04	14.57	0.28	0.05	2592	3592.7	16368	56081	522.8	57.54	0.03
Muskegon 8	7.5	0.05	16.44	0.12	0.05	2603	3605.4	16459	55946	802.5	60.54	0.04
Muskegon 9	8.5	0.06	39.99	0.24	0.08	2515	3091	15763	53569	1302.1	57.25	0.04
Muskegon 10	9.5	0.04	32.77	0.3	0.07	2441	3068	15722	52756	587.3	57.41	0.04
Muskegon 11	11.5	0.06	63.73	0.33	0.08	2475	2638.1	15239	51263	1057.7	55.4	0.05
Muskegon 12	13.5	0.04	52.41	0.49	0.07	2433	2071.2	14696	48983	841.9	52.37	0.04
Muskegon 13	15.5	0.05	58.52	0.55	0.08	2271	1596.2	13824	45703	536.7	48.6	0.03
Muskegon 14	17.5	0.04	57.56	0.2	0.06	2291	1584.7	14014	46530	563.2	48.65	0.03
Muskegon 15	19.5	0.08	56.75	0.4	0.06	4039	1543.7	14078	46938	688.8	52.27	0.07
Muskegon 16	21.5	0.03	51.56	0.46	0.07	2314	1416.7	14214	46816	313.6	49.22	0.04
Muskegon 17	23.5	0.09	68.67	1.47	0.11	2402	1491.6	14583	49243	529.2	52.24	0.05
Muskegon 18	25.5	0.04	48.23	0.83	0.03	2437	1409.2	15044	50074	626.6	52.3	0.04
Muskegon 19	27.5	0.04	47.75	0.3	0.06	2605	1471.4	15807	54321	549.7	53.84	0.05
Muskegon 20	29.5	0.04	40.43	0.11	0.06	2650	1430.2	16292	55170	332	53.89	0.03
Muskegon 21	31.5	0.04	47.57	1.4	0.08	2760	1479.8	17021	58502	792	55.08	0.04
Muskegon 22	33.5	0.04	41.15	0.28	0.05	2879	1428.5	17424	60092	656.8	56.27	0.04
Muskegon 23	35.5	0.05	46.25	0.49	0.1	2956	1539.9	18501	65223	1458.3	60.2	0.06
Muskegon 24	37.5	0.11	55.57	0.67	0.04	2958	1542.4	18465	67745	3608.3	57.3	0.08
Muskegon 25	39.5	0.08	46.11	0.07	0.05	3074	1811.2	19562	75911	4018.9	68.96	0.08
Muskegon 26	41.5	0.08	56.83	0.14	0.04	3129	1865.1	19763	77654	3633.5	71.02	0.08
Muskegon 27	43.5	0.1	50.71	0.23	0.05	3166	2082	20548	84117	5744.7	74.87	0.11
Muskegon 28	45.5	0.11	74.39	0.13	0.05	3281	2358.4	21522	88767	5622.4	78.36	0.10

DEQ

MICHIGAN STATE
UNIVERSITY

Sand Lake Sediment Fact Sheet

Date sampled: 30 July 2003
Location: Lenawee County
Sampling site: 42°02.878'N
84°08.347'W
Lake surface area: 440 acres

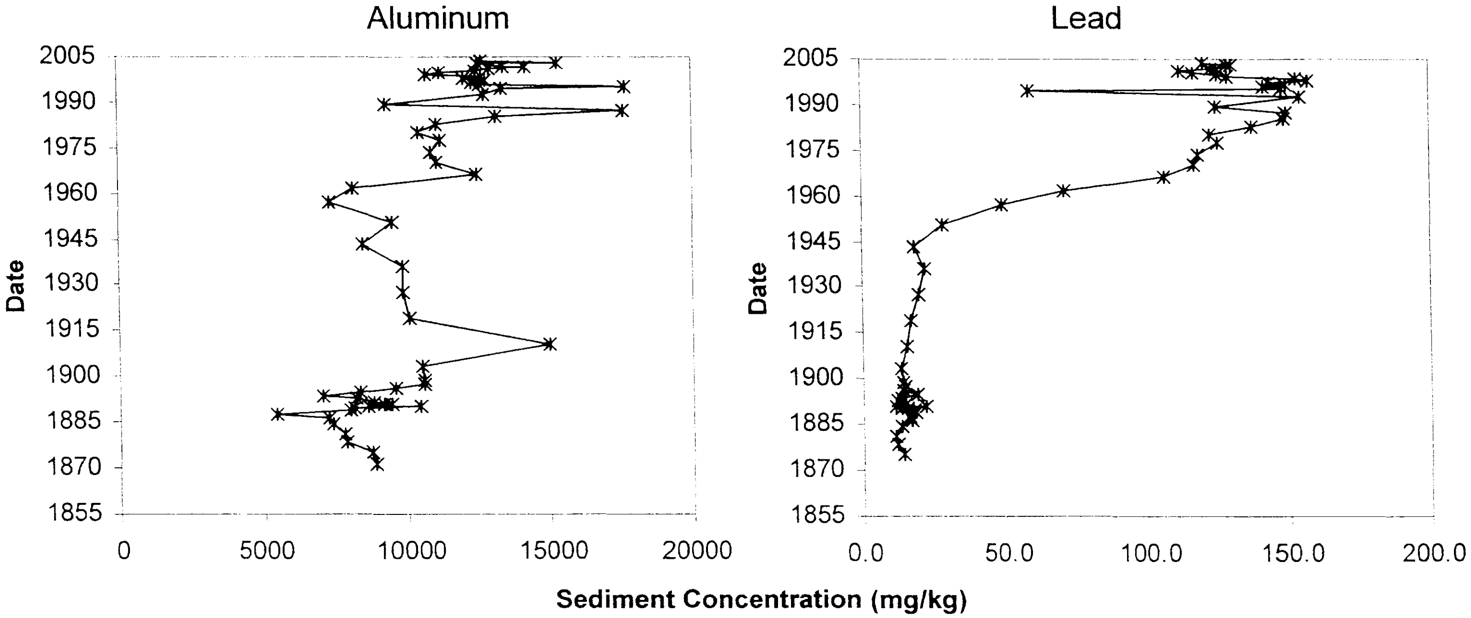
Sampling site water depth: 56.8 ft
Depth of core: 53 cm
Sedimentation rate: 441 $g/m^2/y$
Age of oldest section: 1864
Focusing factor: 1.73

Anthropogenic elements: cadmium, copper, lead, and zinc are highly variable and correlate to aluminum, especially in recent years, suggesting terrestrial influence.

	Surface conc.	Background conc.	Trends
Cadmium (mg/kg)	1.7	NA	decreasing
Copper (mg/kg)	43.0	18.8	unclear
Lead (mg/kg)	126.4	NA	unclear
Zinc (mg/kg)	185.4	NA	unclear
Total PCBs (ug/kg)	2.7		decreasing
Total PAHs (ug/kg)	252.0		decreasing
Total Pesticides (ug/kg)	3.9		level

Trends for organic contaminants are taken from only two data points and should be interpreted with care.

Example profiles



A Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters: Sediments

Sand lake

Sampling Date: 30 July 2003

Location: 42°02.878'N 84°08.347'W Water depth: 56.8'

Core description: 53 cm in length. Very dark in color. Very loose and fluffy. Bottom of core has a ~4cm lighter graysih section that is uneven and wavy around the core. Otherwise, little or no layering.

#	Thickness (cm)	Total thickness (cm)	Description
1	0.5	0.5	black, very liquid
2	0.5	1.0	black, very liquid
3	0.5	1.5	black, very liquid
4	0.5	2.0	dark brown and some black
5	0.5	2.5	dark brown and some black
6	0.5	3.0	dark brown and some black
7	0.5	3.5	dark brown and some black
8	0.5	4.0	dark brown and some black
9	0.5	4.5	dark brown and some black
10	0.5	5.0	dark brown and some black
11	0.5	5.5	dark brown and some black
12	0.5	6.0	dark brown and some black
13	0.5	6.5	dark brown and some black
14	0.5	7.0	dark brown and some black
15	0.5	7.5	dark brown and some black
16	0.5	8.0	dark brown and some black
17	1.0	9.0	dark brown and some black
18	1.0	10.0	dark brown and some black
19	1.0	11.0	dark brown and some black
20	1.0	12.0	dark brown and some black
21	1.0	13.0	dark brown and some black
22	1.0	14.0	dark brown and some black, still liquidy, organic matter
23	1.0	15.0	dark brown and some black
24	1.0	16.0	dark brown and some black
25	1.0	17.0	dark brown and some black, red worm, organic matter
26	1.0	18.0	dark brown with some black, organic matter
27	1.0	19.0	dark brown, organic matter, chunky
28	1.0	20.0	dark brown, organic matter
29	1.0	21.0	dark brown, organic matter
30	1.0	22.0	dark brown, organic matter
31	1.0	23.0	dark brown, organic matter, red worm
32	1.0	24.0	dark brown, organic matter
33	1.0	25.0	dark brown, organic matter, chunky
34	1.0	26.0	dark brown, thicker, many organic matter chunks
35	1.0	27.0	thick, chunky, organic matter
36	1.0	28.0	thick, chunky, organic matter
37	1.0	29.0	thick, chunky, organic matter
38	1.0	30.0	thick, chunky, organic matter

#	Thickness (cm)	Total thickness (cm)	Description
39	1.0	31.0	thick, chunky, organic matter
40	1.0	32.0	thick, chunky, organic matter
41	1.0	33.0	thick, chunky, organic matter
42	1.0	34.0	thick, chunky, organic matter
43	1.0	35.0	dark brown, thick, chunks of organic matter
44	1.0	36.0	dark brown, thick, chunks of organic matter
45	1.0	37.0	dark brown, thick, chunks of organic matter
46	1.0	38.0	dark brown, thick, light colored chunks
47	1.0	39.0	dark brown, thick, light colored chunks
48	1.0	40.0	dark brown, thick, light colored chunks
49	1.0	41.0	dark brown, thick, light colored chunks, liquid around sides
50	1.0	42.0	dark brown, thick, light colored chunks, liquid around sides
51	1.0	43.0	dark brown, thick, light colored chunks, liquid around sides
52	1.0	44.0	dark brown, thick, light colored chunks, liquid around sides
53	1.0	45.0	dark brown, thick, light colored chunks, liquid around sides
54	1.0	46.0	dark brown, thick, water around outside, organic matter
55	1.0	47.0	dark brown, thick, water around outside, organic matter
56	1.0	48.0	dark brown, thick, water around outside, organic matter, leaf
57	1.0	49.0	dark brown, thick, water around outside, organic matter
58	1.0	50.0	dark brown and gray, water around outside
59	1.0	51.0	dark brown and gray, water around outside
60	1.0	52.0	gray, organic matter, very thick
60	1.0	53.0	gray, organic matter, very thick
60	1.0	54.0	gray, organic matter, very thick

^{210}Pb Analysis: Sand Lake

Data provided by Paul Wilkinson, Freshwater Institute, Manitoba, Canada

SAMPLE	DRY WT.(g)	ACCUMULATED DRY WT (gm./sq.cm.)	POROSITY	% WATER	ACTIVITY			excess Pb-210 Bq/g	ACTIVITY		
					Bq/g ± 1SD				Bq/g ± 1SD		
					Pb-210	±	ERROR		CS-137	±	ERROR
1	0.4800	0.0068	0.99	97.7	9.31E-01	+/-	5.93E-02	9.05E-01	1.04E-01	+/-	2.96E-02
2	0.8100	0.0182	0.99	97.0	8.61E-01	+/-	5.41E-02	8.35E-01			
3	1.1600	0.0346	0.98	95.5	7.89E-01	+/-	4.97E-02	7.63E-01	1.19E-01	+/-	1.29E-02
4	1.3800	0.0540	0.98	95.2	7.35E-01	+/-	4.59E-02	7.09E-01			
5	1.4900	0.0751	0.97	90.9	7.40E-01	+/-	4.66E-02	7.14E-01	1.17E-01	+/-	5.58E-03
6	1.6300	0.0981	0.98	93.6	7.09E-01	+/-	4.50E-02	6.83E-01			
7	1.4200	0.1181	0.98	93.6	7.41E-01	+/-	4.60E-02	7.15E-01	1.05E-01	+/-	1.08E-02
8	1.5900	0.1405	0.96	88.5	7.52E-01	+/-	4.74E-02	7.26E-01			
9	1.6100	0.1632	0.98	93.2	7.38E-01	+/-	4.56E-02	7.12E-01	1.22E-01	+/-	9.45E-03
10	1.5000	0.1844	0.96	89.5	7.65E-01	+/-	4.72E-02	7.39E-01			
11	1.7900	0.2097	0.98	94.3	8.45E-01	+/-	5.22E-02	8.19E-01	1.22E-01	+/-	8.25E-03
12	1.8200	0.2353	0.98	94.4	6.93E-01	+/-	4.28E-02	6.67E-01			
13	1.5700	0.2575	0.97	91.8	6.04E-01	+/-	3.76E-02	5.78E-01	1.13E-01	+/-	7.99E-03
14	1.9200	0.2846	0.98	94.2	6.57E-01	+/-	4.06E-02	6.31E-01			
15	1.9700	0.3124	0.97	93.0	6.17E-01	+/-	3.81E-02	5.91E-01	1.16E-01	+/-	5.03E-03
16	1.9800	0.3403	0.96	89.2	6.31E-01	+/-	3.92E-02	6.05E-01			
17	4.0400	0.3973	0.97	90.9	6.88E-01	+/-	4.25E-02	6.62E-01	1.26E-01	+/-	4.27E-03
18	4.3100	0.4581	0.96	89.2	6.89E-01	+/-	4.26E-02	6.63E-01			
19	4.1600	0.5168	0.97	92.1	6.83E-01	+/-	4.26E-02	6.57E-01	1.26E-01	+/-	4.50E-03
20	4.3800	0.5786	0.97	92.9	6.64E-01	+/-	4.11E-02	6.38E-01	1.14E-01	+/-	2.92E-03
21	4.4100	0.6408	0.97	92.3	6.42E-01	+/-	3.99E-02	6.16E-01	1.27E-01	+/-	4.66E-03
22	4.2800	0.7012	0.97	92.5	6.41E-01	+/-	4.00E-02	6.15E-01			
23	4.6500	0.7668	0.97	92.1	6.76E-01	+/-	4.25E-02	6.50E-01	1.16E-01	+/-	3.94E-03
24	4.6600	0.8325	0.97	92.8	7.02E-01	+/-	4.34E-02	6.76E-01			
25	4.9600	0.9025	0.97	92.0	6.60E-01	+/-	4.04E-02	6.34E-01	1.21E-01	+/-	2.38E-03
26	5.4500	0.9794	0.97	92.5	6.20E-01	+/-	3.85E-02	5.94E-01			
27	5.6100	1.0585	0.97	91.9	5.39E-01	+/-	3.34E-02	5.13E-01	1.01E-01	+/-	2.02E-03
28	5.8600	1.1412	0.97	91.9	5.33E-01	+/-	3.27E-02	5.07E-01			
29	5.5600	1.2197	0.97	91.9	5.34E-01	+/-	3.34E-02	5.08E-01	1.15E-01	+/-	3.45E-03
30	5.5500	1.2980	0.97	92.3	5.67E-01	+/-	3.55E-02	5.41E-01			
31	5.6100	1.3771	0.97	92.3	5.68E-01	+/-	3.71E-02	5.42E-01	1.24E-01	+/-	3.81E-03
32	5.7600	1.4584	0.97	91.7	4.80E-01	+/-	3.01E-02	4.54E-01			
33	7.3400	1.5619	0.97	90.7	3.32E-01	+/-	2.20E-02	3.06E-01	9.94E-02	+/-	1.95E-03
34	7.3200	1.6652	0.96	90.1	2.88E-01	+/-	1.83E-02	2.62E-01			
35	8.3700	1.7833	0.96	88.3	1.84E-01	+/-	1.17E-02	1.58E-01	7.26E-02	+/-	2.81E-03
36	8.1700	1.8986	0.96	89.3	1.57E-01	+/-	1.03E-02	1.31E-01			
37	5.9600	1.9826	0.97	91.9	1.33E-01	+/-	8.65E-03	1.07E-01	4.62E-02	+/-	2.88E-03
38	4.9100	2.0519	0.98	93.4	5.66E-02	+/-	3.87E-03	3.06E-02			
39	5.2800	2.1264	0.97	92.9	4.83E-02	+/-	3.50E-03	2.23E-02	1.15E-02	+/-	2.49E-03
40	5.4800	2.2037	0.97	92.8	4.73E-02	+/-	3.41E-03	2.13E-02			
41	5.1600	2.2765	0.97	93.0	4.32E-02	+/-	3.05E-03	1.72E-02	4.82E-03	+/-	2.74E-03
42	4.9100	2.3458	0.98	93.3	4.39E-02	+/-	3.13E-03	1.79E-02			
43	4.6500	2.4114	0.98	93.4	3.90E-02	+/-	2.82E-03	1.30E-02	2.56E-03	+/-	1.31E-03
44	4.5100	2.4750	0.98	93.8	3.69E-02	+/-	2.78E-03	1.09E-02			
45	4.3700	2.5367	0.98	94.0	3.55E-02	+/-	2.75E-03	9.52E-03	5.59E-03	+/-	2.26E-03
46	4.1800	2.5957	0.98	94.0	3.32E-02	+/-	2.59E-03	7.18E-03			
47	4.7200	2.6622	0.98	93.5	3.04E-02	+/-	2.29E-03	4.37E-03	0.00E+00	+/-	0.00E+00
48	4.5400	2.7263	0.98	93.8	3.12E-02	+/-	2.48E-03	5.25E-03			
49	3.9700	2.7823	0.98	94.1	3.63E-02	+/-	2.53E-03	1.03E-02			
50	4.1100	2.8403	0.98	94.0	3.95E-02	+/-	2.83E-03	1.35E-02			
51	4.2600	2.9004	0.98	94.0	4.38E-02	+/-	3.25E-03	1.78E-02			
52	3.9700	2.9564	0.98	94.1	4.97E-02	+/-	3.43E-03	2.37E-02			
53	3.9700	3.0124	0.98	94.1	6.28E-02	+/-	4.48E-03	3.68E-02			
54	4.6800	3.0784	0.98	93.7	5.86E-02	+/-	4.33E-03	3.26E-02			
55	4.5600	3.1428	0.98	93.5	5.37E-02	+/-	3.97E-03	2.77E-02			
56	4.5700	3.2073	0.98	93.9	6.10E-02	+/-	4.45E-03	3.50E-02			
57	4.7400	3.2741	0.98	93.5	5.63E-02	+/-	3.90E-03	3.03E-02			
58	5.5600	3.3526	0.97	92.5	4.89E-02	+/-	3.36E-03	2.29E-02			
59	8.2400	3.4688	0.96	88.5	3.47E-02	+/-	2.62E-03	8.72E-03			
60	10.8000	3.6212	0.95	85.7	3.30E-02	+/-	2.40E-03	6.95E-03			
61	11.1300	3.7782	0.94	85.3	3.31E-02	+/-	2.79E-03	7.06E-03			
62	12.4800	3.9543	0.94	85.3	3.43E-02	+/-	2.65E-03	8.34E-03			

^{210}Pb Analysis: Sand Lake (con't)

SAMPLE	CRS		
	years/ slice	Median Yr of deposition	SedRate $g/m^2/yr$
1	0.2	2004	354
2	0.3	2003	381
3	0.4	2003	412
4	0.4	2002	438
5	0.5	2002	429
6	0.5	2002	441
7	0.5	2001	415
8	0.6	2000	402
9	0.6	2000	403
10	0.6	1999	381
11	0.7	1999	337
12	0.6	1998	405
13	0.5	1997	460
14	0.7	1997	414
15	0.6	1996	433
16	0.7	1996	414
17	1.6	1994	365
18	1.8	1993	346
19	1.8	1991	331
20	1.9	1989	322
21	2.0	1987	314
22	2.0	1985	295
23	2.5	1983	260
24	2.9	1980	230
25	3.1	1977	223
26	3.6	1974	215
27	3.6	1970	222
28	4.1	1966	200
29	4.5	1962	174
30	5.6	1957	140
31	6.9	1951	115
32	7.4	1944	110
33	8.1	1936	128
34	9.0	1927	115
35	8.1	1919	147
36	8.5	1911	136
37	6.4	1903	132
38	1.7	1899	408
39	1.4	1898	533
40	1.4	1896	535
41	1.1	1895	634
42	1.2	1894	590
43	0.8	1893	783
44	0.7	1892	915
45	0.6	1891	1026
46	0.4	1891	1339
47	0.3	1891	2173
48	0.4	1890	1792
49	0.6	1890	903
50	0.9	1889	669
51	1.2	1888	493
52	1.6	1887	354
53	2.6	1884	214
54	3.0	1882	221
55	2.7	1879	238
56	3.8	1876	170
57	3.8	1872	174
58	3.8	1868	205
59	2.4	1865	489
60	2.7	1862	567
61	3.1	1859	510
62	4.6	1856	384

Metal Concentrations in the Sediment: Sand Lake

All concentrations in mg/kg dry weight Extrapolated dates shown in red

Sample	Depth (cm)	Age (CRS)	Mg	Al	K	Ca	Ti	V	Cr	Mn
Sand 1	0.50	2003	10207	12655	2478	20936	104.2	36.81	21.45	395.6
Sand 2	1.00	2003	11039	15360	2803	20450	123.9	40.23	24.53	377.2
Sand 3	1.50	2002	10516	12554	1993	19158	73.08	33.12	21.52	354.8
Sand 5	2.50	2001	10328	13462	2334	18952	100.2	39.37	22.71	336.7
Sand 6	3.00	2001	10568	14209	2378	18730	98.17	37.80	23.48	310.1
Sand 7	3.50	2000	10121	12955	2154	17965	86.35	33.08	21.88	279.2
Sand 8	4.00	2000	11419	12498	1677	20928	59.98	29.30	20.13	269.6
Sand 9	4.50	1999	10622	11242	1678	18935	55.24	28.99	20.16	259.0
Sand 10	5.00	1999	10257	10710	1419	18493	44.49	26.00	18.35	239.8
Sand 11	5.50	1998	10654	12690	1854	18825	64.34	31.85	21.76	258.5
Sand 12	6.00	1997	10211	12069	1732	19012	61.44	30.95	21.26	256.3
Sand 13	6.50	1997	10044	12837	1629	17949	64.26	30.10	20.02	225.6
Sand 14	7.00	1996	9959	12329	1917	17785	62.01	30.15	20.37	235.3
Sand 15	7.50	1996	9969	12607	1488	17578	70.02	31.99	20.76	232.2
Sand 16	8.00	1995	10655	17707	1837	18193	159.4	43.47	26.29	245.9
Sand 17	9.00	1994	10355	13411	3805	18255	29.96	13.32	8.70	95.4
Sand 18	10.00	1992	10237	12764	1953	18303	65.66	31.18	21.43	240.4
Sand 20	12.00	1989	7320	9350	1697	12745	47.47	24.72	17.16	189.0
Sand 21	13.00	1987	10876	17622	1702	18401	121.34	37.40	24.14	227.0
Sand 22	14.00	1985	9995	13146	2073	17294	67.67	31.01	21.28	227.8
Sand 23	15.00	1982	9417	11100	3226	16666	42.33	26.22	22.57	218.3
Sand 24	16.00	1980	8319	10459	797	14489	41.05	24.12	16.71	200.0
Sand 25	17.00	1977	8433	11210	1834	14440	43.94	25.16	17.37	207.3
Sand 26	18.00	1973	7756	10899	1206	13132	48.11	25.02	17.04	203.8
Sand 27	19.00	1970	7993	11072	2534	13730	46.41	25.25	17.82	204.0
Sand 28	20.00	1966	8837	12442	1572	14428	59.76	27.95	18.51	203.4
Sand 29	21.00	1962	7318	8126	1284	11912	40.33	19.18	13.35	164.7
Sand 30	22.00	1957	4339	7327	1076	7687	60.61	22.01	13.87	155.7
Sand 31	23.00	1950	4396	9574	1197	8233	56.13	25.79	15.60	171.7
Sand 32	24.00	1943	3585	8484	1583	6788	46.28	22.83	13.96	146.6
Sand 33	25.00	1935	4390	9871	1309	8504	49.38	26.26	16.38	179.5
Sand 34	26.00	1927	4331	9904	1667	8253	43.28	25.84	16.72	183.9
Sand 35	27.00	1918	4350	10084	1524	8097	46.35	25.73	16.60	175.7
Sand 36	28.00	1910	4612	15006	1898	7616	152.1	39.10	22.34	179.3
Sand 37	29.00	1903	4071	10510	1146	7363	65.14	28.21	17.15	167.6
Sand 38	30.00	1899	4206	10615	1150	7927	61.29	27.73	16.94	165.3
Sand 39	31.00	1897	4200	10626	1391	7936	67.24	27.99	18.29	162.6
Sand 40	32.00	1896	3888	9588	1198	7983	44.93	25.26	15.76	154.3
Sand 41	33.00	1894	3579	8392	1321	7533	38.61	22.61	14.31	143.0
Sand 42	34.00	1893	3144	7031	1465	6593	35.10	22.27	13.82	150.0
Sand 43	35.00	1892	3342	8242	1193	7145	41.58	23.32	14.62	140.6
Sand 44	36.00	1891	3661	8826	2870	8055	38.88	24.12	15.11	152.1
Sand 45	37.00	1891	3370	9487	1652	6978	151.71	24.19	14.63	127.1
Sand 46	38.00	1890	3584	9226	1663	7638	47.18	23.69	15.22	138.0
Sand 47	39.00	1890	3438	8638	1562	7529	45.76	22.73	14.80	134.8
Sand 48	40.00	1890	3816	10470	1261	7933	67.80	26.23	16.51	141.6
Sand 49	41.00	1889	3583	8145	1160	7863	39.11	21.24	13.99	134.2
Sand 50	42.00	1888	3739	8031	904.4	8138	32.81	20.78	13.78	133.0
Sand 51	43.00	1887	2546	5420	1130	5770	28.38	20.10	13.17	134.2
Sand 52	44.00	1886	3530	7215	1073	7971	30.89	20.97	13.33	134.4
Sand 53	45.00	1884	3312	7407	1546	7366	32.71	21.58	13.09	126.2
Sand 54	46.00	1881	3398	7803	1176	7133	34.27	22.96	13.99	125.6
Sand 55	47.00	1878	3819	7908	1189	7308	30.06	24.25	14.44	130.8
Sand 56	48.00	1875	11624	8753	1510	18064	23.51	21.94	16.06	163.5
Sand 57	49.00	1871	18819	8933	1052	29785	27.63	23.15	17.33	196.8
Sand 58	50.00	1867	18704	8234	1034	29606	30.17	23.68	16.73	191.8
Sand 59	51.00	1864	13123	5826	921.4	20637	29.25	23.82	16.80	193.4

Metal Concentrations in the Sediment: Sand Lake (con't)

All concentrations in mg/kg dry weight

Sample	Fe	Ni	Cu	Zn	As	Mo	Cd	Ba	Pb	U
Sand 1	31414	29.12	41.91	176.2	17.71	3.73	1.55	123.9	120.4	1.80
Sand 2	28668	28.45	43.34	190.1	16.47	3.69	1.79	122.9	130.3	2.00
Sand 3	26899	28.46	43.67	190.1	16.64	4.15	1.91	110.2	128.5	2.06
Sand 5	31980	30.35	43.72	195.2	19.71	4.72	1.92	109.5	125.5	2.23
Sand 6	26455	29.61	42.39	193.4	15.97	3.29	1.91	109.2	123.4	2.02
Sand 7	20740	29.24	40.71	180.5	12.84	2.47	1.76	102.7	112.3	1.94
Sand 8	22379	30.61	40.63	181.2	12.29	2.40	1.88	99.61	117.1	1.83
Sand 9	21104	27.85	42.59	183.1	11.92	2.45	1.72	97.63	125.0	1.82
Sand 10	22928	26.26	42.24	189.3	12.16	3.08	1.71	90.68	128.6	1.79
Sand 11	27177	30.15	48.22	223.6	15.20	4.49	2.04	103.7	152.5	2.24
Sand 12	27592	31.11	49.62	223.0	15.71	4.89	2.26	103.7	156.8	2.37
Sand 13	27786	29.07	43.19	197.5	14.11	4.71	1.94	95.93	143.7	2.24
Sand 14	28679	28.84	49.10	207.1	14.90	5.36	2.10	99.52	149.3	2.39
Sand 15	27908	27.26	43.76	196.9	14.79	5.27	1.93	100.4	141.5	2.37
Sand 16	29323	29.68	50.95	209.8	15.76	6.06	2.19	117.2	148.1	2.49
Sand 17	26875	12.00	18.11	78.44	5.30	1.65	0.77	40.57	58.8	0.81
Sand 18	26536	31.85	46.95	212.4	14.99	4.32	2.06	104.0	154.4	2.27
Sand 20	21014	30.28	36.81	171.7	12.34	4.08	1.68	84.26	124.7	1.99
Sand 21	32386	33.97	43.30	206.4	15.08	5.64	2.06	107.3	149.0	2.54
Sand 22	28795	42.29	44.23	208.2	15.00	5.26	2.16	100.4	148.5	2.40
Sand 23	25638	102.63	40.42	192.4	12.61	3.92	2.09	93.25	137.5	1.95
Sand 24	26986	97.15	34.36	178.6	13.20	4.43	1.75	86.47	122.2	2.15
Sand 25	31790	181.18	35.01	191.6	14.51	4.97	1.87	86.48	125.2	2.25
Sand 26	29302	59.61	32.10	177.5	13.53	4.39	2.11	83.33	118.1	2.10
Sand 27	27283	74.46	34.09	202.5	12.88	4.19	1.72	88.53	116.7	2.14
Sand 28	25977	46.80	31.83	166.9	13.63	4.07	1.58	88.47	106.2	2.30
Sand 29	20117	85.19	22.29	143.2	9.93	3.29	1.25	63.36	71.00	1.71
Sand 30	18265	20.10	19.94	133.5	11.97	3.33	1.13	58.51	48.95	1.88
Sand 31	21063	29.44	20.10	95.81	12.98	3.65	0.95	71.71	28.41	2.16
Sand 32	15998	22.17	17.21	82.81	10.84	3.05	0.75	63.74	18.23	2.52
Sand 33	18153	35.51	20.97	112.6	12.35	3.77	0.91	80.70	21.58	2.12
Sand 34	18237	24.69	20.43	97.38	11.64	3.95	0.90	79.49	19.59	2.24
Sand 35	18020	35.71	20.39	96.22	11.08	3.78	0.89	76.78	16.78	1.95
Sand 36	18575	25.48	19.17	93.97	11.42	4.17	0.90	88.23	15.22	2.66
Sand 37	17128	24.72	18.94	90.96	10.42	4.28	1.00	75.68	13.24	1.91
Sand 38	16945	36.36	20.00	93.30	10.00	3.92	0.89	76.54	14.17	1.59
Sand 39	16301	34.83	20.77	92.99	9.98	4.06	0.90	77.24	14.76	1.97
Sand 40	15782	22.15	20.52	92.04	9.80	3.87	0.89	74.11	14.15	1.61
Sand 41	14448	23.67	19.90	84.24	9.18	3.55	0.84	69.18	18.71	2.00
Sand 42	14798	21.57	19.19	86.73	9.11	3.78	0.87	68.26	13.65	2.21
Sand 43	14777	22.42	18.65	85.83	9.94	3.62	0.83	67.71	12.29	1.67
Sand 44	16006	26.16	22.85	111.6	10.52	4.25	0.90	75.77	14.61	2.10
Sand 45	13770	20.44	17.83	82.63	9.12	3.90	0.77	73.90	11.36	2.04
Sand 46	14536	43.71	28.00	264.5	10.52	3.71	0.97	73.58	21.57	2.07
Sand 47	13696	22.80	18.24	85.55	9.78	3.46	0.77	71.85	13.53	1.96
Sand 48	15183	22.52	19.16	89.81	10.50	3.19	0.82	76.98	15.17	1.90
Sand 49	13868	20.81	19.19	92.57	9.46	3.31	0.81	71.37	17.80	1.74
Sand 50	14237	20.54	19.04	105.1	9.58	3.35	0.80	72.33	18.31	1.43
Sand 51	10409	20.46	18.78	122.8	9.48	3.40	0.81	69.32	15.86	1.61
Sand 52	14026	20.87	19.65	98.78	9.88	3.62	0.85	69.30	17.21	1.61
Sand 53	13842	20.34	17.76	95.41	10.48	3.45	0.83	67.43	13.15	1.35
Sand 54	14237	21.11	18.63	98.77	10.99	3.55	0.85	67.22	11.33	1.49
Sand 55	14357	23.28	21.33	108.7	10.93	4.38	0.89	68.67	11.66	1.41
Sand 56	19121	32.88	27.51	106.8	14.20	7.41	0.94	65.20	14.39	1.49
Sand 57	19799	35.79	30.50	106.9	15.71	8.90	1.04	67.63	15.88	1.35
Sand 58	18267	33.98	29.48	102.4	17.01	9.05	1.10	65.69	15.28	1.54
Sand 59	12677	34.11	29.67	101.1	14.85	10.10	1.00	67.86	118.6	1.45

Concentrations of Organic Contaminants: Sand Lake

All concentrations in ng/g dry wt

cm depth[1]	1.0	2.0
Age[2]	2003	2001
Total polychlorinated biphenyls (PCBs)	2.7	3.5
Total polyaromatic hydrocarbons (PAHs)	252.0	262.0
Acenaphthalene	1.75	1.77
Acenaphthene	2.05	1.65
Fluorene	5.12	5.69
Phenanthrene	24.84	24.61
Anthracene	3.88	3.83
Fluoranthene	40.01	36.18
Pyrene	32.8	31.22
Benzo-A-anthracene	14.18	9.37
Chrysene	25.53	27.97
Benzo-B-fluoranthene	31.03	41.81
Benzo-K-fluoranthene	20.2	18.04
Indeno-1,2,3-CD-pyrene	23.31	29.93
Dibenz-a,h-anthracene	3.06	3.2
Benzo-G,H,I-perylene	24.23	26.76
Total Pesticides	3.9	3.9
α-BHC	0.47	0.35
β-BHC	0.66	BDL3
Lindane	0.13	0.05
γ-BHC	0.8	0.97
Heptachlor	BDL3	BDL3
Aldrin	BDL[3]	BDL[3]
Heptachlor epoxide	BDL3	BDL3
cis-Chlordane	0.07	0.04
trans-Chlordane	0.09	0.08
DDE	1.29	1.7
DDD	0.36	0.71
DDT	BDL[3]	BDL3
Methoxychlor	BDL[3]	BDL[3]

1. The first two slices were combined (cm 0-1), and the third and fourth slices (1-2 cm), due to insufficent sample mass for analysis.
2. Since samples were combined[1] each analysis covers a range of years. The median age is presented for each of the combined samples.
3. BDL indicates contaminant below detection limit.

Metal Concentrations in the Porewater: Sand Lake

Concentrations in ng/mL

Sample	Depth (cm)	P	V	Cr	Co	Ni	Cu	Zn	As	Rb	Mo
Sand Topwater	0	87.25	0.45	0.21	0.1	0.76	0.24	419.1	2.38	1.31	0.8
Sand 1	0.5	76.50	2.23	1.58	0.14	9.29	1.14	466.3	4.68	2.08	2.47
Sand 2	1.5	126.9	2.28	3.12	0.14	10.68	2.28	253.7	4.23	2.22	1.72
Sand 3	2.5	389.2	1.4	1.19	0.29	1.99	0.87	232.5	3.54	2.43	0.88
Sand 4	3.5	260.4	3.3	0.63	0.18	2.19	0.67	314.6	3.21	2.47	1.01
Sand 5	4.5	320.8	2.61	0.48	0.52	2.9	0.49	631.2	4	3.01	2.05
Sand 6	5.5	448.8	2.74	0.54	0.37	2.01	0.4	562.1	3.7	2.95	1.23
Sand 7	6.5	251.9	2.85	0.68	0.34	4.25	0.44	671.7	4.36	3.25	2.35
Sand 8	7.5	291.6	2.45	0.69	0.38	4.35	1.18	606.2	3.77	3.17	2.01
Sand 9	8.5	435.5	2.46	0.81	0.42	2.71	1.7	523.8	3.83	3.18	1.32
Sand 10	9.5	281.7	3.19	0.43	0.3	3.66	0.58	710.5	4.58	3.01	1.95
Sand 11	11.5	298.3	2.69	0.77	0.15	0.99	0.39	432.6	4.54	2.8	2.07
Sand 12	13.5	327.5	2.19	1.25	0.25	3.63	2.09	729.0	5.39	3	2.05
Sand 13	15.5	302.1	3.74	0.59	0.06	1.05	0.57	507.2	4.57	2.6	1.74
Sand 14	17.5	285.9	1.63	0.17	0.03	0.96	0.47	288.2	4.86	2.59	1.88
Sand 15	19.5	256.7	2.33	0.58	0.11	9.58	0.89	594.9	4.91	2.46	1.81
Sand 16	21.5	243.0	2.23	1.22	0.21	1.8	1.35	476.2	7.64	2.69	2.93
Sand 17	23.5	175.8	2.54	0.39	0.12	14.09	1.73	314.2	8.63	2.47	2.81
Sand 18	25.5	109.7	4.69	1.17	0	1.55	1.44	614.8	4.65	1.95	2.19
Sand 19	27.5	127.7	2.2	0.35	0.08	5.37	1.09	473.4	4.48	2.32	2.11
Sand 20	29.5	96.95	3.86	1.31	0	2.2	1.24	548.2	3.79	1.81	1.84
Sand 21	31.5	54.86	1.66	0 3	0.02	24.33	1.81	305.5	4.72	2.2	2.41
Sand 22	33.5	150.4	3.87	0.89	0.33	2.6	0.99	874.3	5.15	2.45	2.39
Sand 23	35.5	111.8	2.56	1.21	0.12	2.77	1.4	752.4	3.35	2.19	1.71
Sand 24	37.5	86.27	2.84	0.45	0	0.64	0.53	585.3	3.63	1.94	1.6
Sand 25	39.5	71.60	2.52	0.48	0.24	5.93	0.69	806.1	2.88	1.76	1.35
Sand 26	41.5	88.60	3.59	1.11	0.23	3.3	1.15	1312	4.39	2.34	2.15
Sand 27	43.5	102.8	1.49	0.25	0.06	1.02	0.62	490.5	3.14	1.84	1.04
Sand 28	45.5	98.54	4.71	2.9	0.2	6.95	4.33	1447	4.34	2.05	1.79

Sample	Depth (cm)	Cd	Ba	Pb	U	K	Mn	Mg	Ca	Fe
Sand Topwater	0	0.08	53.95	0.65	0.11	1599	568.4	11248	34439	535.5
Sand 1	0.5	0.14	86.53	1.22	0.17	1949	613.2	10961	34526	132.3
Sand 2	1.5	0.23	85.65	1.67	0.09	1890	674.3	10881	35288	140.9
Sand 3	2.5	0.05	71.8	1	0.07	2107	625	11852	38003	641.2
Sand 4	3.5	0.17	90.38	1.65	0.08	2257	494.3	10864	34663	152.6
Sand 5	4.5	0.19	83.12	0.42	0.14	2295	438.9	12910	40338	155.6
Sand 6	5.5	0.13	108.74	0.88	0.13	2294	409.3	12867	39793	449.5
Sand 7	6.5	0.14	90.39	5.94	0.21	2354	420.6	13391	40761	206.4
Sand 8	7.5	0.17	93.69	3.47	0.15	2393	366.2	13437	40285	203.3
Sand 9	8.5	0.05	92.09	1.34	0.12	2479	338.7	13517	40216	294.4
Sand 10	9.5	0.18	78.38	0.73	0.14	2442	358.9	12590	37759	204
Sand 11	11.5	0.06	88.27	3.24	0.15	2356	265.3	12185	35549	108
Sand 12	13.5	0.12	83.4	2.36	0.14	2436	264.5	13756	39473	78.5
Sand 13	15.5	0.06	87.72	1.24	0.16	2392	224.8	12105	34273	89.7
Sand 14	17.5	0.02	67.74	0.67	0.11	2271	232.1	12959	36192	169.1
Sand 15	19.5	0.11	67.64	1.2	0.11	2122	206.6	11954	33532	91.6
Sand 16	21.5	0.13	77.48	2.29	0.15	2289	246.4	13002	36679	254.9
Sand 17	23.5	0.97	75.05	10.8	0.11	2234	231.2	12332	35360	167.8
Sand 18	25.5	0.27	160.97	3.2	0.08	2242	207.8	9609	27786	164.2
Sand 19	27.5	0.05	79.19	1.76	0.1	2117	228.1	11865	34594	274.2
Sand 20	29.5	0.06	64.66	2.04	0.06	2134	203.2	9265	27261	339.2
Sand 21	31.5	0.04	83.18	1.1	0.1	1997	230.1	11218	32930	381.9
Sand 22	33.5	0.1	143.32	1.32	0.07	2163	260	11823	35664	872.8
Sand 23	35.5	0.05	91.68	0.99	0.11	2135	244.3	11746	35487	721.1
Sand 24	37.5	0.16	81.58	0.69	0.09	2124	236.8	10676	32723	742.5
Sand 25	39.5	0.24	78.02	0.8	0.06	2066	238.9	10911	34658	1252.5
Sand 26	41.5	0.44	115.35	2.29	0.09	1978	231.9	10748	33490	1164.6
Sand 27	43.5	0.02	78.57	0.25	0.06	2172	247.7	11530	36133	954.4
Sand 28	45.5	0.12	112.51	1.97	0.06	1839	208.5	9771	30271	720.5

Highlighted values are below low standard.

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Shupac Lake Sediment Fact Sheet

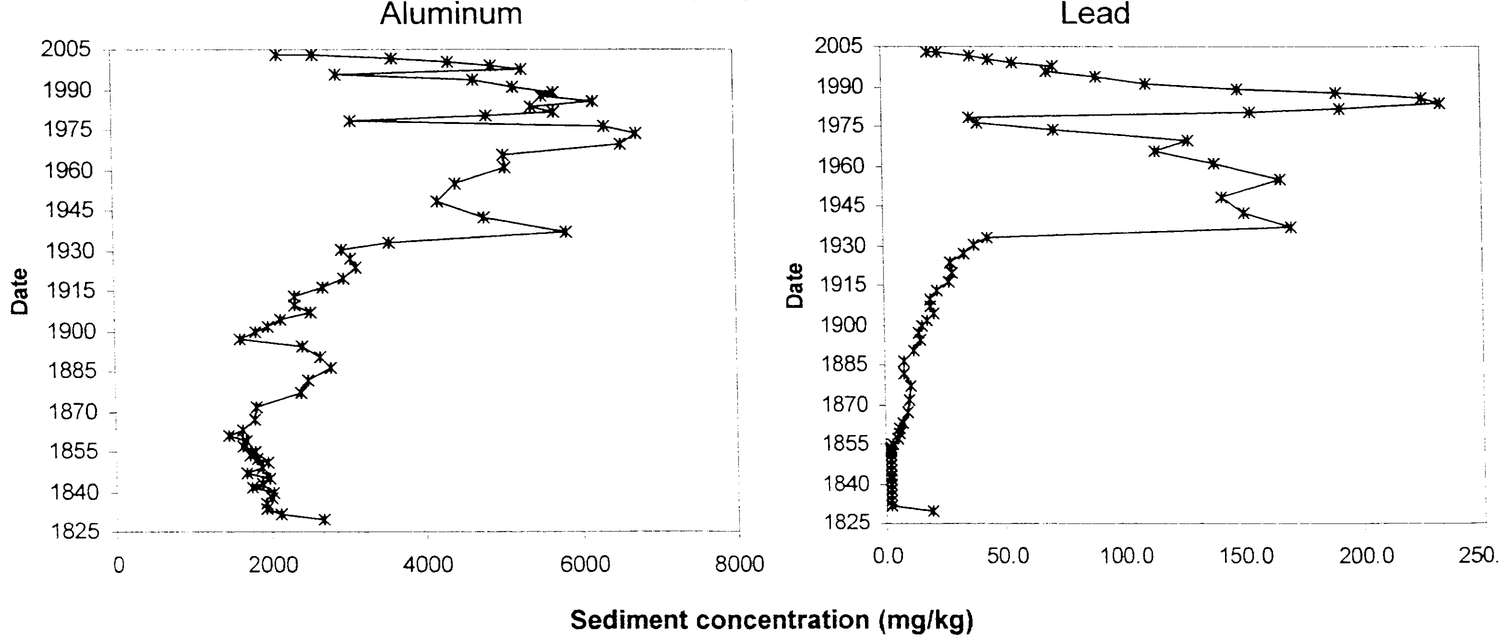
Date sampled: 11 June 2003	Sampling site water depth: 99.8 ft
Location: Crawford County	Depth of core: 56 cm
Sampling site: 44°44.249'N 84°28.579'W	Sedimentation rate: 261 g/m^2/y
	Age of oldest section: 1829
Lake surface area: 107 acres	Focusing factor: 1.95

Shupac Lake has two distinct anthropogenic events recorded in the anthropogenic accumulation rate trends of lead, cadmium, zinc and copper. The first event occurs in the late 1960s and the second in the mid 1980s. These two events are recorded in the sediment record of aluminum suggesting that these events are highly influenced by watershed inputs. Organic contaminant concentrations in Shupac Lake are similar to other Michigan inland lakes.

	Surface conc.	Background conc.	Trends
Cadmium (mg/kg)	0.3	0.1	decreasing
Copper (mg/kg)	15.8	5.4	decreasing
Lead (mg/kg)	26.6	2.3	decreasing
Zinc (mg/kg)	65.4	20.3	decreasing
Total PCBs (ug/kg)	0.4		decreasing
Total PAHs (ug/kg)	126.6		decreasing
Total Pesticides (ug/kg)	12.5		decreasing

Trends for organic contaminants are taken from only two data points and should be interpreted with care.

Example profiles



A Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters: Sediments

Shupac Lake

Sampling Date: 11th June, 2003

Location: 44°44.249'N 84°28.579'W **Water depth:** 99.8 feet

Core description: ~ Overall length: 55 cm. Top 5 cm alternating brown/black layers with distinct white layers at 3 and 4 cm. Core between 5 and 7 cm has many more brown layers with thin layers of alternating black layers. Red layer at 1cm from the sediment-water interface. After 7 cm, darker brown core grades into light brown layer, and then darkens again at about 52 cm.

#	Thickness (cm)	Total thickness (cm)	Description
1	0.5	0.5	very liquidy; black with some pink
2	0.5	1.0	very liquidy; black with some pink
3	0.5	1.5	black and brown
4	0.5	2.0	black and brown
5	0.5	2.5	dark brown with some black and tan
6	0.5	3.0	dark brown with some black and tan
7	0.5	3.5	dark brown with some black and tan
8	0.5	4.0	dark brown with some black and tan, some white
9	0.5	4.5	dark brown with some black and tan, some white
10	0.5	5.0	dark brown, some tan, some black
11	0.5	5.5	dark brown, some tan, some black
12	0.5	6.0	dark brown, some tan, some black
13	0.5	6.5	dark brown, some tan, some black
14	0.5	7.0	medium brown, some tan and black
15	0.5	7.5	medium brown, some tan and black
16	0.5	8.0	medium brown, some tan and black
17	1.0	9.0	medium to light brown, some tan and black
18	1.0	10.0	medium to light brown, some tan and black
19	1.0	11.0	medium to light brown, some tan and black
20	1.0	12.0	medium brown
21	1.0	13.0	medium brown with large leaf
22	1.0	14.0	medium brown, some light brown, some black leaf
23	1.0	15.0	more light brown, thicker
24	1.0	16.0	medium brown, some black, light brown
25	1.0	17.0	medium brown, some black, light brown
26	1.0	18.0	medium brown, some black, light brown and white threadlike string
27	1.0	19.0	thicker, more tan, medium brown and black
28	1.0	20.0	light brown/gray, some black and dark brown
29	1.0	21.0	light brown/gray, some black and dark brown
30	1.0	22.0	light brown/gray, some black and dark brown
31	1.0	23.0	light brown/gray, few black specks
32	1.0	24.0	light brown/gray, few black specks
33	1.0	25.0	light brown/gray. few black specks
34	1.0	26.0	light brown/gray, few black specks
35	1.0	27.0	light brown/gray, few black specks
36	1.0	28.0	light brown/gray, few black specks
37	1.0	29.0	tan, some medium brown and black
38	1.0	30.0	tan, some medium brown and black

#	Thickness (cm)	Total thickness (cm)	Description
39	1.0	31.0	tan, few black specks
40	1.0	32.0	tan, some black specks
41	1.0	33.0	tan, some black specks
42	1.0	34.0	tan, some black specks
43	1.0	35.0	tan, some black specks
44	1.0	36.0	tan, some black specks
45	1.0	37.0	tan, some black specks
46	1.0	38.0	tan, some black specks
47	1.0	39.0	tan, some black specks
48	1.0	40.0	tan, some black specks
49	1.0	41.0	tan, some black specks
50	1.0	42.0	tan, some black specks
51	1.0	43.0	tan, some black specks
52	1.0	44.0	tan, some black specks
53	1.0	45.0	tan, some black specks
54	1.0	46.0	tan, some black specks
55	1.0	47.0	tan, some black specks
56	1.0	48.0	tan, some black specks
57	1.0	49.0	tan, some black specks
58	1.0	50.0	tan, some black specks
59	1.0	51.0	tan, some black specks
60	1.0	52.0	slightly darker brown
61	1.0	53.0	thicker, dark tan
62	1.0	54.0	thicker, dark tan
63	1.0	55.0	thick, tan with a few pine needles
64	1.0	56.0	thick, than, less than 1 cm touching piston

^{210}Pb Analysis: Shupac Lake

Data provided by Paul Wilkinson, Freshwater Institute, Manitoba, Canada

SAMPLE	DRY WT.(g)	ACCUMULATED DRY WT (gm./sq.cm.)	POROSITY	% WATER	ACTIVITY Bq/g ± 1SD			excess Pb-210 Bq/g	ACTIVITY Bq/g ± 1SD		
					Pb-210	±	ERROR		CS-137	±	ERROR
1	0.3200	0.0045	1.00	98.9	2.48E+00	+/-	1.55E-01	2.44E+00	0.00E+00	+/-	0.00E+00
2	0.7400	0.0150	0.99	97.6	2.28E+00	+/-	1.43E-01	2.23E+00			
3	0.8200	0.0265	0.99	97.4	3.43E+00	+/-	2.15E-01	3.38E+00	0.00E+00	+/-	0.00E+00
4	1.0600	0.0415	0.99	96.9	2.80E+00	+/-	1.76E-01	2.76E+00			
5	1.4000	0.0612	0.99	95.9	2.42E+00	+/-	1.51E-01	2.38E+00	4.75E-02	+/-	6.21E-03
6	1.3400	0.0801	0.98	95.7	2.67E+00	+/-	1.66E-01	2.63E+00			
7	1.8700	0.1065	0.98	94.6	2.03E+00	+/-	1.25E-01	1.98E+00	8.08E-02	+/-	7.99E-03
8	2.1700	0.1371	0.98	93.5	2.01E+00	+/-	1.26E-01	1.97E+00			
9	1.9800	0.1651	0.98	94.3	2.08E+00	+/-	1.32E-01	2.03E+00	8.62E-02	+/-	8.19E-03
10	1.6700	0.1886	0.98	93.9	1.90E+00	+/-	1.19E-01	1.86E+00			
11	2.5000	0.2239	0.98	93.6	1.11E+00	+/-	7.06E-02	1.07E+00	1.12E-01	+/-	7.69E-03
12	2.7200	0.2623	0.97	91.7	9.26E-01	+/-	5.90E-02	8.82E-01			
13	2.3000	0.2947	0.98	93.7	1.33E+00	+/-	8.24E-02	1.28E+00	1.69E-01	+/-	9.03E-03
14	2.2000	0.3258	0.98	93.9	9.70E-01	+/-	6.06E-02	9.26E-01			
15	2.2100	0.3569	0.98	93.5	9.79E-01	+/-	6.11E-02	9.35E-01	2.29E-01	+/-	5.85E-03
16	2.3700	0.3904	0.97	93.0	7.18E-01	+/-	4.59E-02	6.74E-01			
17	6.0300	0.4755	0.97	91.3	5.66E-01	+/-	3.57E-02	5.22E-01	2.28E-01	+/-	8.47E-03
18	6.4300	0.5662	0.97	91.2	5.50E-01	+/-	3.52E-02	5.06E-01			
19	6.7500	0.6614	0.97	90.7	5.61E-01	+/-	3.59E-02	5.17E-01	2.43E-01	+/-	7.59E-03
20	6.7900	0.7572	0.96	90.2	5.35E-01	+/-	3.44E-02	4.91E-01	3.27E-01	+/-	5.57E-03
*21	6.5000	0.8489	0.97	90.9	5.84E-01	+/-	3.63E-02	5.40E-01	3.82E-01	+/-	9.09E-03
22	6.2300	0.9368	0.97	90.8	6.23E-01	+/-	3.89E-02	5.79E-01	1.95E-01	+/-	6.37E-03
23	7.4400	1.0418	0.96	89.9	4.46E-01	+/-	2.77E-02	4.02E-01	1.25E-01	+/-	7.07E-03
24	7.2400	1.1439	0.96	89.7	3.32E-01	+/-	2.16E-02	2.88E-01			
25	6.8500	1.2405	0.97	90.5	2.46E-01	+/-	1.60E-02	2.02E-01	0.00E+00	+/-	0.00E+00
26	5.3000	1.3153	0.97	92.4	2.19E-01	+/-	1.47E-02	1.75E-01			
27	4.9700	1.3854	0.97	93.0	1.80E-01	+/-	1.18E-02	1.36E-01	0.00E+00	+/-	0.00E+00
28	7.6000	1.4927	0.96	89.0	1.51E-01	+/-	1.05E-02	1.07E-01			
29	8.4600	1.6120	0.95	87.4	1.39E-01	+/-	8.91E-03	9.49E-02			
30	8.3700	1.7301	0.96	88.0	1.20E-01	+/-	7.66E-03	7.57E-02			
31	7.9900	1.8428	0.96	88.3	1.16E-01	+/-	7.54E-03	7.17E-02			
32	8.1600	1.9580	0.96	88.2	1.05E-01	+/-	7.17E-03	6.09E-02			
33	7.8700	2.0690	0.96	88.7	9.50E-02	+/-	6.41E-03	5.10E-02			
34	7.4200	2.1737	0.96	89.0	8.96E-02	+/-	6.19E-03	4.56E-02			
35	8.7500	2.2971	0.95	87.5	8.18E-02	+/-	5.45E-03	3.78E-02			
36	7.9200	2.4089	0.96	88.1	7.27E-02	+/-	4.81E-03	2.87E-02			
37	8.4100	2.5275	0.96	88.4	7.01E-02	+/-	4.83E-03	2.61E-02			
38	7.2300	2.6295	0.96	89.3	7.76E-02	+/-	5.33E-03	3.36E-02			
39	7.7500	2.7389	0.96	88.1	8.10E-02	+/-	5.31E-03	3.70E-02			
40	8.3800	2.8571	0.95	87.6	7.95E-02	+/-	5.62E-03	3.55E-02			
41	9.3900	2.9896	0.95	86.9	7.42E-02	+/-	4.91E-03	3.02E-02			
42	8.2400	3.1058	0.95	87.0	7.35E-02	+/-	4.92E-03	2.95E-02			
43	9.2800	3.2367	0.95	86.6	7.15E-02	+/-	5.31E-03	2.75E-02			
44	8.9000	3.3623	0.95	87.0	6.96E-02	+/-	4.86E-03	2.56E-02			
45	9.4500	3.4956	0.95	86.5	6.08E-02	+/-	3.93E-03	1.68E-02			
46	9.3600	3.6277	0.94	85.2	5.26E-02	+/-	3.55E-03	8.57E-03			
47	10.4300	3.7748	0.95	85.7	5.03E-02	+/-	3.44E-03	6.32E-03			
48	9.3600	3.9069	0.95	86.1	4.83E-02	+/-	3.29E-03	4.34E-03			
49	9.1200	4.0356	0.95	85.9	5.09E-02	+/-	3.69E-03	6.90E-03			
50	9.0600	4.1634	0.95	86.5	4.74E-02	+/-	3.51E-03	3.36E-03			
51	10.2700	4.3083	0.94	85.4	4.70E-02	+/-	3.48E-03	2.96E-03			
52	9.9100	4.4481	0.94	84.3	4.42E-02	+/-	3.45E-03				
53	11.6300	4.6122	0.94	83.3	4.46E-02	+/-	3.30E-03				
54	10.9900	4.7672	0.94	83.3	4.31E-02	+/-	2.98E-03				
55	12.0200	4.9368	0.94	83.6	4.37E-02	+/-	3.04E-03				
56	11.1200	5.0937	0.94	83.6	4.55E-02	+/-	3.17E-03				
57	10.4400	5.2410	0.94	84.6	4.37E-02	+/-	3.32E-03				
58	10.4900	5.3890	0.94	84.5	4.35E-02	+/-	3.21E-03				
59	11.5600	5.5521	0.93	82.7	4.41E-02	+/-	3.05E-03				
60	12.0700	5.7223	0.93	82.9	4.32E-02	+/-	3.31E-03				
61	12.1700	5.8940	0.93	82.3	4.25E-02	+/-	2.89E-03				
62	12.3900	6.0688	0.93	83.1	4.49E-02	+/-	3.10E-03				
63	12.5700	6.2462	0.93	82.5	4.56E-02	+/-	3.09E-03				
64	11.6200	6.4101	0.92	80.6	7.19E-02	+/-	5.11E-03				

^{210}Pb Analysis: Shupac Lake (con't)

SAMPLE	CRS			CF:CS		RSSM	
	years/ slice	Median Yr of deposition	SedRate $g/m^2/yr$	years/ slice	Median Yr of deposition	years/ slice	Median Yr of deposition
1	0.3	2003	144	0.2	2003	0	2004
2	0.7	2003	154	0.5	2003	0	2004
3	1.2	2002	99	0.5	2003	0	2004
4	1.3	2001	117	0.7	2002	0	2004
5	1.5	1999	130	0.9	2001	1	2003
6	1.7	1998	112	0.9	2000	1	2002
7	1.9	1996	140	1.2	1999	1	2001
8	2.3	1994	132	1.4	1998	1	2000
9	2.3	1991	119	1.3	1996	1	1999
10	1.9	1989	122	1.1	1995	1	1998
11	1.8	1987	201	1.7	1994	1	1997
12	1.7	1986	230	1.8	1992	2	1996
13	2.2	1984	149	1.5	1990	1	1994
14	1.6	1982	194	1.5	1989	1	1993
15	1.7	1980	183	1.5	1987	1	1992
16	1.4	1979	242	1.6	1986	1	1991
17	2.9	1977	292	4.0	1983	4	1989
18	3.3	1974	274	4.3	1979	4	1985
19	4.0	1970	239	4.5	1975	5	1980
20	4.3	1966	221	4.5	1970	5	1975
21	5.3	1961	173	4.3	1966	4	1971
22	6.5	1955	134	4.1	1962	4	1967
23	6.7	1948	158	4.9	1957	5	1962
24	5.6	1942	182	4.8	1952	5	1957
25	4.4	1937	221	4.5	1948	5	1952
26	3.3	1933	226	3.5	1944	4	1948
27	2.6	1930	265	3.3	1940	3	1944
28	3.5	1927	308	5.0	1936	5	1940
29	3.9	1924	309	5.6	1931	6	1935
30	3.4	1920	345	5.5	1925	6	1929
31	3.4	1917	328	5.3	1920	6	1923
32	3.3	1913	348	5.4	1914	6	1917
33	3.0	1910	376	5.2	1909	6	1911
34	2.7	1907	386	4.9	1904	6	1905
35	2.9	1904	426	5.8	1899	6	1899
36	2.2	1902	518	5.2	1893	6	1893
37	2.2	1900	533	5.6	1888	6	1887
38	2.7	1897	384	4.8	1882	6	1881
39	3.5	1894	316	5.1	1877	6	1875
40	4.0	1890	294	5.6	1872	6	1869
41	4.4	1886	303	6.2	1866	7	1862
42	4.3	1882	271	5.5	1860	6	1856
43	5.2	1877	251	6.1	1855	7	1849
44	5.5	1872	229	5.9	1849	7	1842
45	4.5	1867	297	6.3	1843	8	1835
46	2.5	1863	523	6.2	1836	7	1827
47	2.2	1861	659	6.9	1830	8	1820
48	1.5	1859	904	6.2	1823	8	1812
49	2.4	1857	536	6.0	1817	8	1804
50	1.2	1855	1040	6.0	1811	8	1796
51	1.3	1854	1135	6.8	1805	8	1788

Metal Concentrations in the Sediment: Shupac Lake

All concentrations in mg/kg dry weight

Sample	Depth (cm)	Age (CRS)	Mg	Al	K	Ca	Ti	V	Cr
Shupac 1	0.5	2003	2487	2158	1198	23637	46.29	16.06	8.41
Shupac 2	1	2003	2036	2604	656.9	24732	44.64	15.02	9.31
Shupac 3	1.5	2002	2369	3624	663.4	15472	50.45	22.80	10.66
Shupac 4	2	2001	2382	4351	659.1	29898	55.15	24.43	11.20
Shupac 5	2.5	1999	2603	4903	665.0	59869	57.55	24.37	12.37
Shupac 6	3	1998	2947	5277	697.4	73265	63.02	26.19	13.51
Shupac 7	3.5	1996	1867	2900	570.8	76027	55.49	21.70	12.08
Shupac 8	4	1994	2860	4658	541.6	91669	46.41	22.58	12.70
Shupac 9	4.5	1991	3017	5168	599.5	98609	54.53	22.70	11.95
Shupac 10	5	1989	3261	5691	696.7	114519	66.02	23.22	12.80
Shupac 11	5.5	1987	3294	5531	624.5	116945	54.82	24.92	13.09
Shupac 12	6	1986	3490	6197	573.9	122650	51.84	26.38	12.56
Shupac 13	6.5	1984	3489	5399	582.7	127149	55.46	25.68	12.66
Shupac 14	7	1982	3701	5685	723.8	149663	74.27	23.21	13.30
Shupac 15	7.5	1980	3672	4831	605.9	165650	57.17	19.43	11.92
Shupac 16	8	1979	3836	3087	379.7	235928	37.13	12.34	7.83
Shupac 17	9	1976	4340	6322	844.2	214660	61.62	19.41	10.36
Shupac 18	10	1973	4812	6739	886.9	230261	47.45	19.68	12.63
Shupac 19	11	1970	4518	6530	663.5	168872	56.72	21.12	14.42
Shupac 20	12	1966	3607	5038	626.0	158410	50.19	18.38	11.73
Shupac 21	13	1961	4288	5050	632.6	217635	45.93	21.32	11.54
Shupac 22	14	1955	3534	4409	531.8	161015	46.95	20.29	11.15
Shupac 23	15	1948	3282	4183	545.0	149206	51.56	17.19	10.54
Shupac 24	16	1942	3581	4770	637.1	160161	60.77	18.38	11.60
Shupac 25	17	1937	4289	5832	773.2	189985	74.80	21.96	13.82
Shupac 26	18	1933	3763	3567	467.7	208479	47.48	14.10	8.66
Shupac 27	19	1930	3282	2951	360.0	195744	27.43	13.99	19.85
Shupac 28	20	1927	3510	3072	368.7	211804	30.66	11.69	7.17
Shupac 29	21	1924	3619	3128	398.2	227863	41.34	10.22	7.01
Shupac 30	22	1920	3518	2975	402.6	225758	42.62	10.02	11.91
Shupac 31	23	1916	3639	2708	332.9	233782	33.73	9.67	6.82
Shupac 32	24	1913	3562	2325	272.2	236261	23.64	9.90	6.30
Shupac 33	25	1910	3428	2336	293.4	235799	25.75	9.58	6.58
Shupac 34	26	1907	3318	2536	341.9	230739	31.50	9.94	6.55
Shupac 35	27	1904	2912	2153	268.4	203704	21.31	8.31	6.01
Shupac 36	28	1902	2410	1991	248.9	166690	16.95	8.00	6.24
Shupac 37	29	1900	2476	1838	230.3	180727	16.53	9.20	5.79
Shupac 38	30	1897	2440	1620	177.6	180792	7.35	8.67	5.63
Shupac 39	31	1894	2933	2426	314.1	210585	25.71	10.89	7.99
Shupac 40	32	1890	3560	2661	307.3	266452	26.38	11.63	7.82
Shupac 41	33	1886	3576	2790	310.6	259952	22.39	11.76	7.31
Shupac 42	34	1882	3232	2492	291.2	230929	21.04	13.60	7.52
Shupac 43	35	1877	3459	2391	328.4	255964	22.52	13.22	8.09
Shupac 44	36	1872	2846	1836	286.3	208327	18.30	13.04	7.96
Shupac 45	37	1867	3415	1802	243.1	259958	13.07	10.06	7.03
Shupac 46	38	1863	3106	1652	282.0	243914	14.36	9.78	6.75
Shupac 47	39	1861	3137	1467	184.3	248856	6.45	8.35	5.95
Shupac 48	40	1859	3234	1697	226.5	245083	15.51	9.78	7.02
Shupac 49	41	1857	3067	1635	192.0	234168	10.02	9.79	6.04
Shupac 50	42	1855	3364	1807	244.9	256960	16.12	9.72	6.07
Shupac 51	43	1854	3774	1736	232.9	287679	16.08	8.90	6.10
Shupac 52	44	1853	3680	1819	267.1	280943	19.23	8.76	5.77
Shupac 53	45	1851	3989	1977	290.1	305658	20.39	9.26	6.16
Shupac 54	46	1849	4085	1886	242.3	302847	17.36	8.34	6.09
Shupac 55	47	1847	3989	1685	202.6	297364	12.08	7.07	5.77
Shupac 56	48	1845	3934	1978	261.9	302058	19.73	8.93	6.78
Shupac 57	49	1843	3604	1897	269.1	278923	17.12	9.59	6.19
Shupac 58	50	1842	3626	1760	252.9	280344	15.81	9.43	6.17
Shupac 59	51	1840	3923	2038	265.8	304859	14.63	9.83	6.29
Shupac 60	52	1838	3585	2023	268.4	285427	13.85	11.43	6.67
Shupac 61	53	1836	3281	1941	228.4	262599	11.15	10.81	6.30
Shupac 62	54	1834	3411	1945	253.4	264282	16.25	10.70	6.37
Shupac 63	55	1832	3627	2134	275.7	278290	19.93	11.25	7.13

Metal Concentrations in the Sediment: Shupac Lake (con't)

All concentrations in mg/kg dry weight

Sample	Mn	Fe	Co	Ni	Cu	Zn	As	Mo	Cd
Shupac 1	1124.18	8323.53	0.00	3.47	14.09	54.47	6.74	15.71	0.00
Shupac 2	1009.60	8162.30	0.00	3.63	13.37	58.19	9.29	15.50	0.26
Shupac 3	1125.24	10108.55	0.00	5.41	19.89	83.68	12.59	20.96	0.53
Shupac 4	990.13	10516.39	0.04	6.59	19.78	88.27	13.52	20.15	0.77
Shupac 5	963.61	11715.91	0.24	7.03	18.99	104.52	15.63	19.05	1.05
Shupac 6	947.97	12723.53	0.89	10.24	21.10	117.36	18.50	22.70	1.32
Shupac 7	825.94	6947.24	1.01	8.55	16.88	95.31	16.00	19.35	1.01
Shupac 8	755.50	12237.73	0.59	8.30	19.86	113.20	16.37	19.29	1.20
Shupac 9	741.52	12345.12	0.67	9.00	21.54	132.11	16.14	17.42	1.44
Shupac 10	750.06	12494.64	0.76	8.89	21.26	122.85	16.99	18.04	1.40
Shupac 11	731.06	12030.49	0.98	9.19	21.61	138.74	17.91	18.15	1.69
Shupac 12	721.60	11502.45	0.98	9.02	20.49	157.32	17.93	17.40	2.02
Shupac 13	739.66	10922.15	0.91	9.68	20.27	176.65	17.95	14.43	2.32
Shupac 14	779.14	11266.12	1.67	9.87	19.18	180.79	16.76	10.00	2.14
Shupac 15	772.37	9905.31	1.33	8.80	16.93	162.90	14.36	6.83	2.01
Shupac 16	820.44	7047.26	0.91	5.21	8.71	74.92	12.26	4.89	1.37
Shupac 17	871.20	11214.77	1.67	7.36	13.02	87.76	17.13	8.73	1.35
Shupac 18	978.75	12905.31	2.27	9.11	15.71	129.07	22.29	8.94	2.04
Shupac 19	804.23	17114.81	1.18	9.61	18.76	207.17	23.24	8.91	2.79
Shupac 20	764.84	11981.52	1.28	8.25	14.84	158.51	15.09	6.61	2.17
Shupac 21	910.41	9442.39	1.79	9.24	17.70	162.84	15.70	12.20	1.89
Shupac 22	737.86	9280.62	0.87	8.45	18.43	162.06	15.15	12.19	1.77
Shupac 23	686.35	8077.96	0.91	7.63	15.39	142.15	12.35	6.74	1.69
Shupac 24	741.03	8575.69	0.97	7.83	15.55	152.49	12.39	5.99	1.66
Shupac 25	871.32	10321.29	1.48	9.75	18.68	179.90	15.14	7.27	2.17
Shupac 26	777.73	6628.66	0.54	5.01	9.73	92.37	11.88	5.34	1.63
Shupac 27	728.17	6131.42	0.34	7.83	10.17	82.78	10.79	7.18	1.66
Shupac 28	721.57	6600.60	0.64	5.26	8.80	70.44	9.78	5.60	1.53
Shupac 29	706.88	5760.59	1.06	4.76	8.03	63.70	9.05	4.59	1.30
Shupac 30	712.09	5601.56	0.86	5.08	7.68	60.61	8.79	4.10	1.19
Shupac 31	739.65	5558.43	0.94	4.55	7.49	56.24	9.29	4.35	1.08
Shupac 32	745.14	6190.48	1.01	4.53	7.49	51.37	9.56	5.71	0.86
Shupac 33	757.81	4831.46	0.83	4.21	7.02	38.73	7.90	4.81	0.50
Shupac 34	741.09	4465.35	0.87	4.16	7.09	34.48	8.02	5.29	0.61
Shupac 35	655.63	3712.36	0.30	2.95	5.84	34.56	6.56	4.24	0.40
Shupac 36	552.58	3659.78	0.00	2.06	5.46	34.45	5.76	6.26	0.39
Shupac 37	657.21	3942.51	0.00	3.11	6.49	35.41	6.93	8.44	0.26
Shupac 38	681.66	4129.89	0.00	3.27	5.78	30.11	6.26	9.25	0.15
Shupac 39	794.54	4732.57	0.00	4.09	6.68	29.75	7.45	8.40	0.19
Shupac 40	904.84	5159.01	0.51	4.76	7.06	29.64	8.71	8.35	0.34
Shupac 41	862.77	5588.39	0.00	3.94	6.26	24.41	7.14	8.47	0.09
Shupac 42	897.01	6138.26	0.45	4.45	6.59	24.56	8.09	10.21	0.15
Shupac 43	975.68	5679.82	0.50	4.67	6.80	25.66	8.07	7.19	0.09
Shupac 44	927.24	4237.39	0.11	3.87	6.89	25.54	7.65	7.83	0.15
Shupac 45	951.23	4753.39	0.28	3.69	5.55	22.27	6.89	6.12	0.08
Shupac 46	877.35	4092.73	0.28	3.54	5.25	25.21	6.61	8.40	0.10
Shupac 47	892.25	3779.74	0.00	3.37	5.00	20.64	5.99	6.78	0.02
Shupac 48	883.81	3280.48	0.63	3.92	5.87	20.66	6.69	6.65	0.15
Shupac 49	884.87	4194.47	0.00	2.98	5.38	21.19	6.87	10.77	0.06
Shupac 50	896.42	4484.83	0.81	4.19	5.51	20.88	7.49	8.71	0.15
Shupac 51	984.08	4144.38	1.24	4.46	6.42	17.45	7.16	6.13	0.13
Shupac 52	941.95	3708.07	1.10	4.23	4.65	18.01	6.22	5.14	0.12
Shupac 53	1051.55	4035.67	1.36	4.64	4.93	18.04	6.60	4.78	0.12
Shupac 54	1029.65	4047.55	1.45	4.70	4.76	20.41	6.11	3.64	0.22
Shupac 55	942.50	3244.95	1.31	4.30	4.40	17.12	5.26	2.65	0.10
Shupac 56	1043.50	2964.19	1.81	5.05	5.26	19.56	6.11	4.04	0.15
Shupac 57	954.99	3031.88	1.06	4.16	5.16	19.36	5.67	5.45	0.08
Shupac 58	980.63	3546.11	1.56	4.59	5.35	18.65	6.17	4.80	0.11
Shupac 59	1054.74	4352.59	1.25	4.87	5.54	19.76	6.29	6.03	0.11
Shupac 60	1010.63	4239.61	0.97	4.22	5.84	30.13	6.86	8.20	0.11
Shupac 61	948.96	4016.60	0.83	3.87	5.70	18.89	6.53	9.36	0.09
Shupac 62	940.53	4745.51	1.02	4.20	5.41	19.47	7.23	8.48	0.12
Shupac 63	1003.52	4590.42	1.68	5.29	5.93	25.93	7.53	6.78	0.17

Metal Concentrations in the Sediment: Shupac Lake (cor

All concentrations in mg/kg dry weight

Sample	Ba	Pb	U	Rb
Shupac 1	84.97	19.44	1.68	2.85
Shupac 2	65.77	23.39	2.68	2.92
Shupac 3	48.55	36.92	3.25	3.80
Shupac 4	37.40	44.88	3.30	4.39
Shupac 5	35.46	55.25	3.38	5.05
Shupac 6	35.56	72.41	3.61	5.40
Shupac 7	30.74	69.16	2.95	4.67
Shupac 8	30.06	89.98	3.14	4.75
Shupac 9	30.57	110.45	2.97	5.45
Shupac 10	33.05	149.59	2.85	6.12
Shupac 11	32.32	190.14	2.97	5.71
Shupac 12	32.04	225.83	2.80	5.38
Shupac 13	32.34	233.84	2.59	5.55
Shupac 14	33.61	191.58	2.01	6.37
Shupac 15	31.52	154.52	1.63	5.60
Shupac 16	28.02	36.16	1.18	3.80
Shupac 17	39.81	40.04	1.92	8.00
Shupac 18	42.63	72.27	2.17	8.41
Shupac 19	33.73	128.78	2.32	6.44
Shupac 20	31.24	114.06	1.70	5.94
Shupac 21	35.04	139.40	2.28	5.84
Shupac 22	29.88	166.66	2.08	4.87
Shupac 23	27.81	141.85	1.52	4.93
Shupac 24	29.90	151.68	1.42	5.59
Shupac 25	35.78	170.86	1.80	6.76
Shupac 26	28.19	43.34	1.34	4.39
Shupac 27	26.07	37.58	1.59	3.78
Shupac 28	25.82	33.47	1.24	3.80
Shupac 29	26.17	28.18	0.97	3.83
Shupac 30	26.41	28.34	0.86	3.75
Shupac 31	26.22	27.22	0.96	3.33
Shupac 32	25.62	22.21	1.26	2.86
Shupac 33	25.81	19.02	1.08	2.96
Shupac 34	25.49	19.11	1.19	3.29
Shupac 35	22.57	20.44	0.97	2.66
Shupac 36	19.12	17.57	1.18	2.32
Shupac 37	21.52	15.95	1.30	2.10
Shupac 38	21.03	13.96	1.25	1.74
Shupac 39	24.92	14.75	1.14	2.80
Shupac 40	27.13	12.11	1.20	2.77
Shupac 41	26.15	7.87	1.14	2.80
Shupac 42	26.80	8.01	1.23	2.75
Shupac 43	28.07	10.46	1.05	2.85
Shupac 44	26.70	10.30	1.04	2.50
Shupac 45	25.91	8.96	0.93	2.14
Shupac 46	24.51	7.21	1.03	1.96
Shupac 47	24.41	5.40	0.88	1.70
Shupac 48	24.68	6.00	0.85	1.97
Shupac 49	24.30	5.17	1.17	1.83
Shupac 50	26.12	2.87	1.01	2.15
Shupac 51	27.75	2.34	0.86	2.15
Shupac 52	26.67	2.13	0.81	2.26
Shupac 53	29.01	2.31	0.85	2.47
Shupac 54	27.81	2.33	0.76	2.23
Shupac 55	26.32	2.10	0.65	1.94
Shupac 56	28.69	2.40	0.80	2.34
Shupac 57	27.35	2.15	0.85	2.26
Shupac 58	26.70	2.13	0.78	2.16
Shupac 59	28.34	2.22	0.86	2.31
Shupac 60	28.14	2.29	1.02	2.36
Shupac 61	26.68	2.17	1.09	2.09
Shupac 62	26.62	2.11	1.02	2.23
Shupac 63	29.74	2.34	0.98	2.50

Concentrations of Organic Contaminants: Shupac Lake

All concentrations in ng/g dry wt

cm depth[1]	1.0	2.0
Age[2]	2003	2001
Total polychlorinated biphenyls (PCBs)	0.4	2.4
Total polyaromatic hydrocarbons (PAHs)	126.6	149.8
Acenaphthalene	0.54	1.52
Acenaphthene	0.98	1.27
Fluorene	2.05	4.34
Phenanthrene	8.19	12.59
Anthracene	4.69	1.94
Fluoranthene	13	18.73
Pyrene	13.64	15.49
Benzo-A-anthracene	7.65	6.38
Chrysene	12.21	16.39
Benzo-B-fluoranthene	12.83	31.88
Benzo-K-fluoranthene	22.72	8.29
Indeno-1,2,3-CD-pyrene	10.73	12.51
Dibenz-a,h-anthracene	0.72	4.05
Benzo-G,H,I-perylene	16.69	14.41
Total Pesticides	12.5	21.3
α-BHC	1.74	2.59
β-BHC	2.15	2.17
Lindane	BDL	10.2
γ-BHC	0.91	1.18
Heptachlor	3.92	1.54
Aldrin	BDL[3]	BDL
Heptachlor epoxide	1.85	1.03
cis-Chlordane	BDL	0.26
trans-Chlordane	0.09	0.3
DDE	1.5	1.74
DDD	0.31	0.2
DDT	BDL	0.1
Methoxychlor	BDL	BDL

1. The first two slices were combined (cm 0-1), and the third and fourth slices (1-2 cm), due to insufficent sample mass for analysis.
2. Since samples were combined[1] each analysis covers a range of years. The median age is presented for each of the combined samples.
3. BDL indicates contaminant below detection limit.

Metal Concentrations in the Porewater: Shupac Lake

Concentrations in ng/mL

Sample	Depth (cm)	P	V	Cr	Co	Ni	Cu	Zn	As	Mo	Al	Ti
Shupac Topwater	0	38.28	0.26	0.01	0.00	0.02	0.12	161.5	0.07	0.93	5.95	21.20
Shupac 1	0.5	226.63	1.90	0.44	0.00	3.10	1.34	321.2	10.91	11.03	11.66	55.14
Shupac 2	1.5	244.95	2.36	0.67	16.25	229.6	2.28	276.3	9.31	5.38	87.76	66.11
Shupac 4	3.5	731.16	3.47	1.13	0.21	4.89	1.00	928.9	10.20	4.95	21.57	107.4
Shupac 5	4.5	831.13	4.82	1.77	0.05	4.84	1.38	1496	14.51	7.31	102.5	107.8
Shupac 6	5.5	1176	3.91	0.96	0.26	4.19	0.87	602.5	9.05	4.85	15.25	116.3
Shupac 7	6.5	1247	3.45	1.36	0.25	3.53	1.70	870.3	14.57	6.73	20.23	116.0
Shupac 8	7.5	1367	4.96	1.55	0.20	2.05	1.28	895.9	18.33	10.41	35.02	118.9
Shupac 9	8.5	1430	2.22	0.69	0.26	2.34	1.02	185.0	10.83	5.90	19.48	116.5
Shupac 10	9.5	1684	2.09	0.39	0.43	2.31	0.77	94.31	12.76	3.82	13.45	121.1
Shupac 11	11.5	1783	2.35	0.44	0.69	5.32	0.70	245.8	12.85	4.69	15.90	121.4
Shupac 12	13.5	2142	2.17	0.57	0.70	4.24	0.80	112.9	17.32	2.69	18.15	129.2
Shupac 13	15.5	2521	1.69	1.16	1.00	2.13	0.59	73.40	7.27	1.58	15.33	137.1
Shupac 14	17.5	2751	0.98	0.42	1.19	2.99	0.67	94.35	5.37	1.37	10.64	140.7
Shupac 15	19.5	2787	1.92	0.39	1.06	2.58	1.22	202.9	7.03	1.17	7.88	138.9
Shupac 16	21.5	2989	2.07	0.49	1.25	34.15	1.16	221.7	10.65	1.15	9.61	139.7
Shupac 17	23.5	3155	1.00	0.61	1.39	2.22	0.58	53.12	7.12	0.98	8.00	140.9
Shupac 18	25.5	3523	1.45	0.75	1.46	2.42	1.39	158.3	13.42	2.21	20.03	148.7
Shupac 19	27.5	3590	1.36	0.66	1.61	4.10	0.97	114.0	11.07	1.98	6.44	146.4
Shupac 20	29.5	3670	2.40	1.70	1.65	2.75	1.12	252.2	10.74	1.87	14.86	146.8
Shupac 21	31.5	3619	2.05	0.91	1.77	3.36	0.98	235.1	7.83	1.47	22.95	142.5
Shupac 22	33.5	3763	2.44	0.61	1.53	5.01	0.89	160.1	9.21	1.24	15.39	143.2
Shupac 23	35.5	4254	0.95	0.83	2.07	2.98	0.65	57.7	5.30	0.74	8.55	152.3
Shupac 24	37.5	4533	1.85	0.64	2.22	2.88	1.22	594.6	8.04	1.63	46.06	161.1
Shupac 25	39.5	4437	1.81	0.81	2.27	7.22	0.97	123.9	10.58	1.69	12.11	152.9
Shupac 26	41.5	4507	1.61	0.68	2.14	3.39	0.87	511.5	10.01	1.28	21.01	154.5
Shupac 27	43.5	4754	1.58	0.62	2.20	4.44	0.94	129.9	12.30	1.50	18.18	158.5
Shupac 28	45.5	4573	3.04	1.45	2.37	4.03	1.15	164.7	7.50	1.09	31.30	154.3

Sample	Depth (cm)	Cd	Ba	Pb	U	K	Mn	Mg	Ca	Fe	Sn	B
Shupac Topwater	0	0.00	14.02	0.11	0.19	328.7	1126	8073	33929	40.14	0.00	3.01
Shupac 1	0.5	0.10	37.43	1.46	0.88	367.5	1302	8139	39817	418.8	0.11	12.23
Shupac 2	1.5	0.20	40.26	1.61	0.67	407.4	1288	7715	37570	294.9	0.13	9.88
Shupac 4	3.5	0.05	38.35	1.15	0.71	518.8	1336	8307	48302	177.0	0.06	11.64
Shupac 5	4.5	0.03	34.52	1.16	0.77	552.2	1288	8369	51167	94.78	0.07	12.66
Shupac 6	5.5	0.07	37.47	3.57	0.53	597.5	1283	8652	55066	59.10	0.09	13.67
Shupac 7	6.5	0.57	47.11	4.19	0.61	759.8	1287	9059	59186	109.9	0.15	18.67
Shupac 8	7.5	0.12	44.59	3.59	0.76	561.7	1296	8971	59927	66.90	0.10	15.81
Shupac 9	8.5	0.12	39.25	3.13	0.46	565.3	1294	8893	58987	62.34	0.10	15.18
Shupac 10	9.5	0.10	41.40	2.22	0.31	590.2	1319	8866	61208	32.98	0.10	16.02
Shupac 11	11.5	0.12	43.42	1.23	0.34	617.4	1318	9090	65188	28.93	0.10	17.14
Shupac 12	13.5	0.14	47.73	1.98	0.26	683.6	1278	9351	69662	31.81	0.14	17.64
Shupac 13	15.5	0.09	48.41	0.81	0.16	702.9	1283	9790	74991	23.65	0.10	16.78
Shupac 14	17.5	0.11	51.07	1.23	0.15	711.2	1289	9927	78190	22.44	0.12	16.91
Shupac 15	19.5	0.12	49.29	0.65	0.12	731.7	1270	9896	79173	19.14	0.11	19.07
Shupac 16	21.5	0.12	50.61	1.16	0.11	723.1	1279	10021	81268	16.32	0.13	19.69
Shupac 17	23.5	0.12	52.33	0.49	0.10	724.9	1278	10427	85526	23.09	0.13	19.67
Shupac 18	25.5	0.18	54.17	1.31	0.18	748.6	1285	10330	86436	64.13	0.14	21.76
Shupac 19	27.5	0.17	56.80	0.71	0.15	748.9	1291	10485	88216	29.01	0.15	21.80
Shupac 20	29.5	0.17	57.70	0.83	0.14	815.0	1280	10794	92008	37.83	0.16	25.39
Shupac 21	31.5	0.22	55.49	0.52	0.11	808.9	1264	10534	90448	69.21	0.14	26.25
Shupac 22	33.5	0.10	60.49	0.45	0.10	800.7	1258	10799	93523	36.92	0.10	25.56
Shupac 23	35.5	0.11	57.93	0.28	0.06	797.3	1286	11170	96554	61.18	0.11	25.31
Shupac 24	37.5	0.14	61.53	0.72	0.12	817.5	1293	11312	99862	199.9	0.12	27.94
Shupac 25	39.5	0.12	61.27	0.22	0.10	842.5	1279	11281	99389	64.48	0.11	28.84
Shupac 26	41.5	0.15	74.89	0.22	0.08	876.9	1293	11240	98641	62.59	0.14	28.11
Shupac 27	43.5	0.15	64.50	0.29	0.09	881.3	1298	11307	99204	61.54	0.13	30.75
hupac 28	45.5	0.18	61.01	0.41	0.07	904.3	1281	11681	103112	107.6	0.13	32.41

Highlighted values are below low standard.