Completion Report for the Jessie Lake Paleolimnology Project

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Abstract

Jessie Lake is a high-priority lake in terms of the Itasca County Water Plan, recognized as an important resource for multiple-use recreation and for its walleye (*Stizostedium vitreum* (Mitchill)) fishery in particular. The Jessie Lake Watershed Association has been particularly active in promoting and participating in research to understand and improve the resource. The major concern in the watershed is increasing nutrient loading, according to recent lakewater phosphorous studies. Internal loading is also implicated in keeping the algal growth in the lake at high levels.

We are presently using diatoms for paleolimnological interpretations of past baselines, trends, and magnitudes of change in lakewater phosphorous. Jessie Lake has been eutrophic since before European settlement of the area, though phosphorus concentrations were higher in the middle of the 20th century than they are now.

Introduction

Jessie Lake, located in the north-central part of the Minnesota (Fig. 1), is the eighteenth largest of 950 lakes in Itasca County. It is a drainage lake (length of 8 km and maximum depth of 12 m) with several smaller lakes and streams flowing into it, and with significant groundwater interaction. There are four resorts and over 100 dwellings in the watershed, which is entirely within the Chippewa National Forest. Jessie Lake is highly regarded for its walleye sport fishery, and the lake is a recreational destination for hundreds of visitors each year. There is concern – led by the Jessie Lake Watershed Association, and in coordination with the county water plan and many state, federal, and local agencies— about maintaining fishery health and water quality. Jessie Lake is a fairly shallow, meso- to eutrophic, di- to polymictic lake, and sometimes (as in 1998) the groundwater—climate interactions and TP regeneration from sediments drives lakewater TP into eutrophic territory (Table 1).

A multi-faceted research and monitoring program has been undertaken during the past four years leading to a state Clean Water Partnership grant, and as a small part of this project, we were asked to use paleolimnological techniques to develop models of past lakewater phosphorus based on diatom algae assemblages in a dated sediment core. This technology has been effectively employed using regional data sets to interpret land use affects on lakewater nutrients in many parts of North America (Fritz *et al.* 1993; Reavie *et al.* 1995a; Reavie *et al.* 1995b; Reavie & Smol 2001; Cumming *et al.* 1995), including recently in Minnesota (Ramstack 1999; Ramstack *et al.* 2002). We are using the Minnesota 55-lake diatom calibration as a basis for inferring past lakewater total phosphorus in Jessie Lake.

The Jessie Lake Watershed Association has investigated the history of settlement and land uses in the watershed (Neil Gustafson, pers. comm.). Prior to 1800, the Jessie Lake watershed was an area of virgin timber and wetlands. The indigenous people were in the area in low density, and no signs of major indigenous settlements occur in the watershed. Beavers were the most important landscapers and water-level modifiers. During the half-century from 1800—1850 Europeans extensively harvested the area for beaver and other furs, but no major settlements occurred in the watershed. The next half-century (1850—1900) saw the decline of the fur trade and the inventorying of forests for timber harvest. Minnesota became a state of the Union and homesteading increased, but mainly on the more fertile prairie portions of the state to the south and west. The Jessie Lake watershed was surveyed in

1875 and the first homesteads were occupied in the late 1880s. The most intense logging of the white and red pine forests in the watershed probably occurred during 1900—1910, and by 1905 a hoist operation at the south end of the lake was moving logs to a railroad, prior to any improved roads in the watershed. The population of Jessie Lake and Bowstring Townships was 41 settlers in 1901, and this rose to a peak of 552 people in 1940, then declined to its lowest modern level of 349 in 1960. Several small communities formed in the watershed. Severe fires spread over the watershed slash piles during 1910—1915. Settlement expanded until 1950, and subsistence agriculture became common. Reforestation was performed in the watershed by plantings during the Civilian Conservation Corps era of the 1930s. After 1950, agriculture declined, roads improved, and more use was made of the lakes as places for seasonal, summertime recreation. From 1990—present, development pressure has noticeably increased, and population in the two townships reached a new high of 577 in 2000. The Jessie Lake Watershed Association was established in 1998, and they have worked closely with county and state agencies to study Jessie Lake with the goal of maintaining and improving water quality and fisheries.

An experimental and modeling study of phosphorus dynamics of Jessie Lake sediments hypothesizes that many factors contribute to high phosphorus flux from the sediments into the water column in the anoxic portion of the lake: low phosphorus affinity of the sediments, internal waves in the deep portion of the lake, and organic loading to the hypolimnion (Wang *et al.* 2002).

Materials and Methods

We cored the deep portion of Jessie Lake through the ice in March, 2001, with a gravity corer (Glew 1989) and extruded sediment intervals in the field (Glew 1988). We began Laboratory analysis of the sediments for dating and other characteristics, but the preliminary dating analysis made it obvious that the initial 43-cm core did not capture the entire unsupported ^{210}Pb profile. Therefore, we returned to the same position in the lake by boat during November, 2001, and collected deeper sedimentary material using a Russian peat sampler, and this sediment was sectioned in the laboratory. The two cores were matched based on abundance peaks of abnormal *Stephanodiscus niagarae*, the subject of this paper, and we determined that 10cm of material was lost from the top of the November core.

We use loss on ignition methods to partition the sedimentary dry mass into organic matter, carbonate (or clay water of hydration in low-carbonate lakes), and inorganic matter (Dean 1974).

Cores of Jessie Lake sediments were analyzed for excess ^{210}Pb activity to determine age and sediment accumulation rates for the past ca. 150 years (Engstrom 1996; Appleby 2001). ^{210}Pb was measured at 20 depth intervals in the cores through its grand-daughter product ^{210}Po, with ^{209}Po added as an internal yield tracer. The dating methods are modified from Eakins and Morrison (Eakins & Morrison 1978). Activity was measured for 1-6 x 10^5 s with ion-implanted or Si-depleted surface barrier detectors and an alpha spectroscopy system. Unsupported ^{210}Pb is calculated by subtracting supported activity from the total activity measured at each level; supported ^{210}Pb is estimated from the asymptotic activity at depth (the mean of the lowermost samples in a core). Dates and sedimentation rates are determined according to the c.r.s. (constant rate of supply) model (Appleby & Oldfield 1978) with confidence intervals calculated by first-order error analysis of counting uncertainty (Binford 1990).

We obtained the 55-lake MN diatom calibration data set from Ramstack (Ramstack 1999; Ramstack *et al.* 2002), and censored it for our own analyses as follows: all indeterminate categories (such as

Navicula spp.) were deleted, and only taxa that occurred in at least two lakes at > 1% were used in the total phosphorus calibration in this paper. Sixty diatom taxa were used. We are currently working to expand this Minnesota data set with the addition of 50 more lakes from northern Minnesota, with the idea that expanding the numbers in the “northern lakes and forests” ecoregion will lead to more robust nutrient prediction models for northern Minnesota, where we expect anthropogenic nutrient changes to be subtle. Ramstack (1999) showed that the calibration of lakewater total phosphorus was strong and explained a significant amount of variance in the diatom species data.

Diatoms were prepared from the sediment intervals and analyzed using standard paleolimnological methods (Battarbee *et al.* 2001; Kingston 1986). Sediment was cleaned of organic matter using 35% hydrogen peroxide, and cleaned diatoms were prepared on permanent slides using the high-refractive index mountant Pleurax. For the nutrient calibration, portions of randomly selected transects were counted on research grade microscopes with objective N.A. of 1.4 and differential interference contrast optics. Taxonomy used diverse literature sources and was harmonized among analysts; images of taxa were captured and cataloged on computers using a 750-line video camera and 640x480 capture card.

Results

The initial loss on ignition vs. depth data (Fig. 2) show the increase of inorganic sediment abundance near 70 cm, which probably coincides with soil erosion caused by the cutting of virgin pine in the watershed.

The ^{210}Pb activity profile is monotonic and declines from 16 pCi/g to a near constant background of 1.66 pCi/g below 81 cm (Fig. 3). The exponential decline of activity indicates fairly uniform sedimentation rates. Dates calculated according to a constant rate of supply model have an uncertainty of less than 6 years at the top of the core and over 40 years in the lowest dated interval (Fig. 4). The large uncertainty of dates over 120 years before the coring date is a typical feature of the model. Sediment accumulation rates are relatively uniform throughout the core (Fig. 5), with a slight upward trend since 1900. Sedimentation rates are approximately 20% higher than pre-European levels with downward trends in the 1930s, and again in the 1970s. High-points of sediment accumulation occur in the 1920s, the 1950s, and 2000; Modern low-points of sediment accumulation occur in the 1930s and near 1980.

The inventory of unsupported ^{210}Pb in the core is equivalent to about double the mean atmospheric flux for the region. This is an indication that our coring site in the deepest part of the lake is a site of sediment focusing with about twice the expected sedimentation rate of the majority of the lake basin.

Loss on ignition data vs. age (Fig. 6) show that the dating model estimated age of the early soil erosion seen in Fig. 2 as over 125 years before 2001, but we know that the confidence on this older date is comparatively low (Fig. 4), and we know from the history of the watershed that this 70-cm interval must be about 90 to 100 years before 2001.

The common diatoms are typical of those in a shallow mesotrophic lake, and selected taxa are shown on a summary diagram (Fig. 7) – most taxa were in the lake prior to European settlement and land clearance, but the relative abundances have changed through time. *Asterionella formosa* is a typical spring plankton bloom organism. The high abundances of the heavy *Aulacoseira* species are typical for a lake with this shallow morphometry and large wind fetch. The five members of the araphid family Fragilariaceae are either benthic littoral organisms or plankton. Based on the Minnesota calibration data set (Ramstack *et al.* 2002) most of the centric species at the right of the diagram and *Aulacoseira granulata* have high TP optima; the highest TP optimum in the data set is for *Cyclostephanos tholiformis*. During the past 50 years, increases of the centric diatoms to the right, in the family Thalassiosiraceae, indicate increased nutrient loading to the lake, and even earlier increases in the planktonic Fragilaria crotonensis show a progressive nutrient loading for over 50 years. These nutrient increases are subtle because they are added to a background of meso- to eutrophic indicator organisms.

The regression of diatom-inferred log (total phosphorus, μg/L) had an R^2 of 0.59, a root mean square error of prediction based on bootstrapping of 0.255, with N of 55. Jessie Lake diatoms usually predict lakewater TP concentrations higher than has been seen in most years, but similar to what was seen in 1998 (Table 1). The Minnesota data set does not predict well at high TP values, due partly to the small number of high TP lakes in the calibration. There is a preliminary plan to add 20 high TP lakes to the data set to improve prediction at high concentrations, this by the state agencies that want to use this diatom tool to help set nutrient criteria for the various ecoregions in the state (S. J. Heiskary, pers. comm.).

Discussion

Multiple stressors bear upon the evidence in the sediment record of Jessie Lake: logging, regrowth, herbicides used in the forest, farming, building and maintenance of lakeshore dwellings and roads, manure, fertilizer use, beaver activity, atmospheric deposition, global warming.

The loss on ignition profile (Figs 2, 6) clearly marks the major logging event in the watershed. Post-European sediment accumulation increased above pre-cultural background by about 20% (Fig. 5), but the ups and downs during the past century probably reflect everything from subsistence farming to cabin building to climate-driven water level variations. High sediment accumulation rates may reflect periods of land clearance and when the slash fires were prevalent, a post World War II peak of increased road building, and a modern peak with higher human population density and increasing recreational use and home building. Low sediment accumulation periods may correspond with regrowth of vegetation and low lake stands in the 1930s and lower land disturbance in the 1980s. If one compares the sediment accumulation (Fig. 5) to the DI-TP in the dated core (Fig. 7), the highest reconstructed lakewater TP occurs during 1960 to 1975, at a time when sedimentation rate was not increasing. We do not fully understand what may be driving the trend at highest DI-TP, because subsistence agriculture should have been in decline and less of a source than before.

The insensitivity of diatom calibrations at high TP concentrations has been noticed before (Reavie, Hall, and Smol 1995a), and we hope to improve this in the Minnesota data set as we increase the number of lakes and the number of high TP lakes. Nevertheless, we expect the DI-TP trend to be valid, as it is based on a regionally appropriate data set.

Acknowledgements

We would like to thank Art Norton, Bruce Wilson, Karl Koller, Justin Watkins, Brenda Stauffer, Noel Griese, Euan Reavie, Allison Brigham, Joel Lusby, Mark Edlund, Daniel Engstrom, Jill Coleman, Kelly Thommes, Margy Bell, Neil Gustafson of the Jessie Lake Watershed Association, and Kyle Hoagland for assistance in completing this paper.

Table 1. Average water quality measures relevant to trophic status for Jessie Lake, MN, for 4 recent years.

YEAR	# TP READS	TP (ug/l)	# CHL-A READS	CHL-A (ug/l)	# SECCHI READS	SECCHI (m)
1998	7	58.5	7	16.2	7	1.6
1999	13	31.0	13	8.3	13	2.5
2000	29	32.0	25	9.8	29	3.0
2001	17	32.7	15	12.1	21	2.5
STDEV		**13.3**		**3.4**		**0.6**
MEAN		**38.6**		**11.6**		**2.4**

Figure Captions

Figure 1. Location map showing Jessie Lake's position in the state and region.

Figure 2. Jessie Lake loss on ignition data versus depth in the lake sediment, showing the relative abundance of organic matter, inorganic matter, and clay water of hydration.

Figure 3. The ^{210}Pb activity versus depth for the Jessie Lake core site.

Figure 4. The ^{210}Pb dates versus depth for the Jessie Lake core site, with 95% confidence intervals plotted for each date.

Figure 5. Sediment accumulation rate versus ^{210}Pb date for the Jessie Lake core site.

Figure 6. Jessie Lake loss on ignition data versus age, showing the relative abundance of organic matter, inorganic matter, and clay water of hydration.

Figure 7. Jessie Lake summary core diagram with the relative abundances (%) of selected common diatoms and the diatom inferred lakewater total phosphorus (DI-TP, µg/L) versus age.

Fig. 1.


Canada
Jessie Lake
Lake Superior
Minnesota
Wisconsin
Lake Michigan
Michigan

Fig. 2.

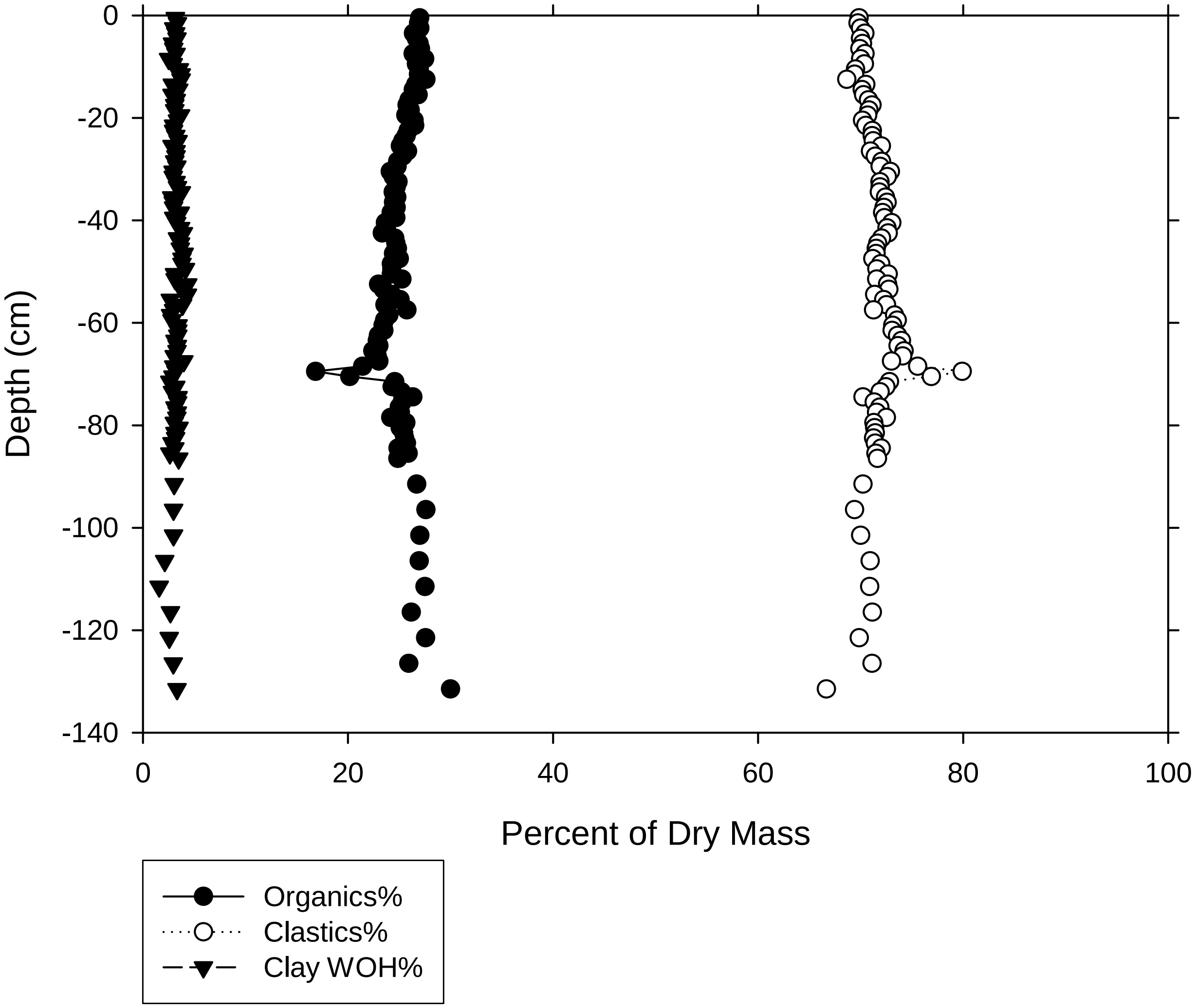
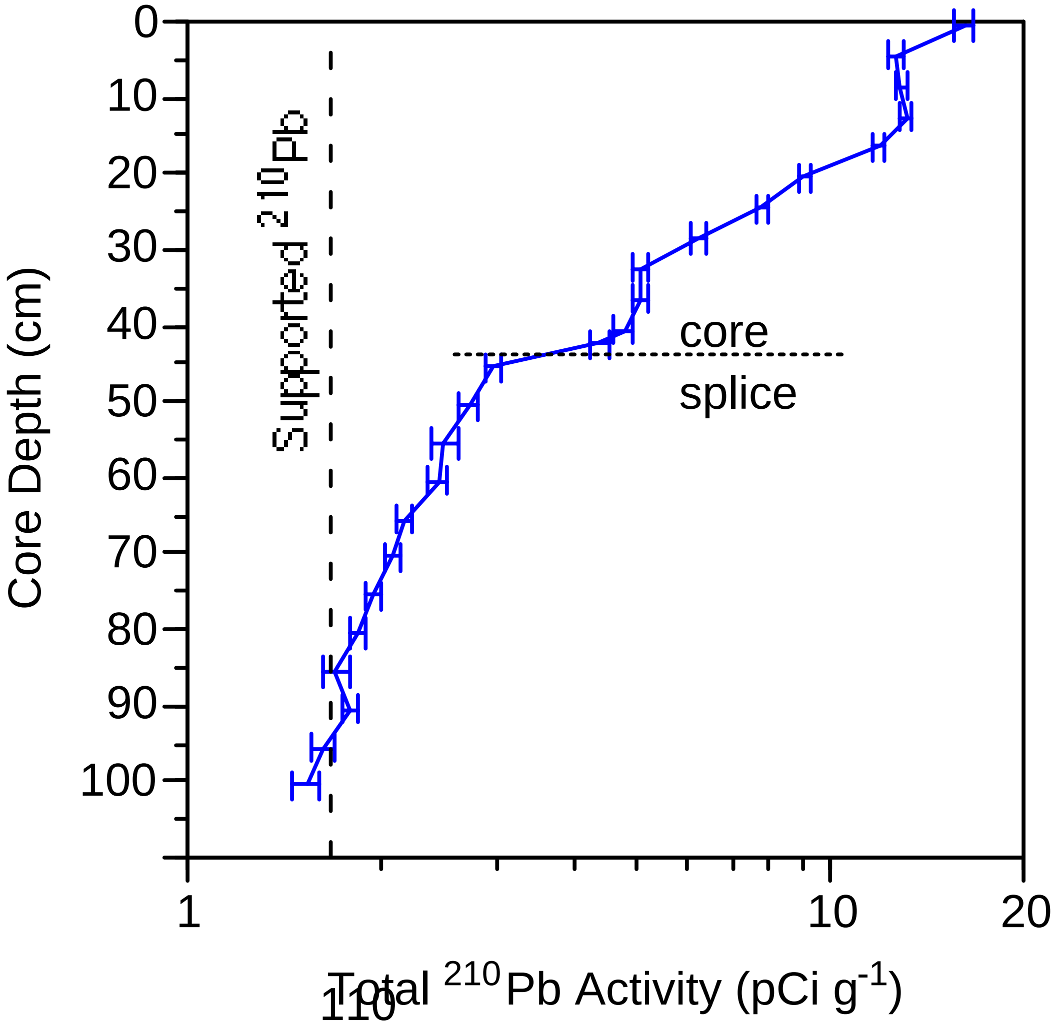

0
-20
-40
-60
-80
-100
-120
-140
Depth (cm)
0
20
40
60
80
100
Percent of Dry Mass
Organics%
Clastics%
Clay WOH%

Fig. 3



0
10
20
30
40
50
60
70
80
90
100
110
Core Depth (cm)
Supported 210Pb
core
splice
1
10
20
Total 210Pb Activity (pCi g-1)

Fig. 4.

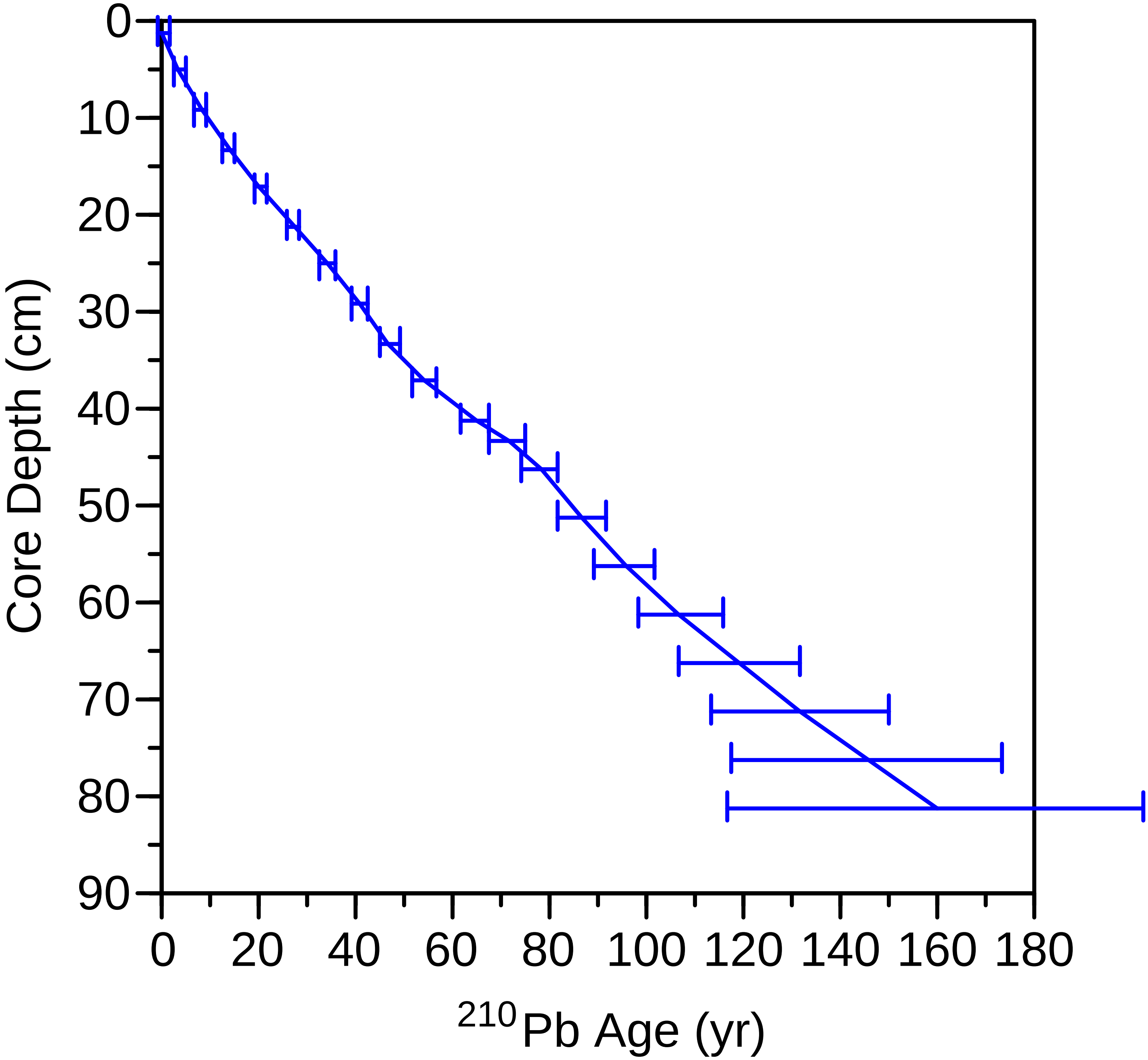
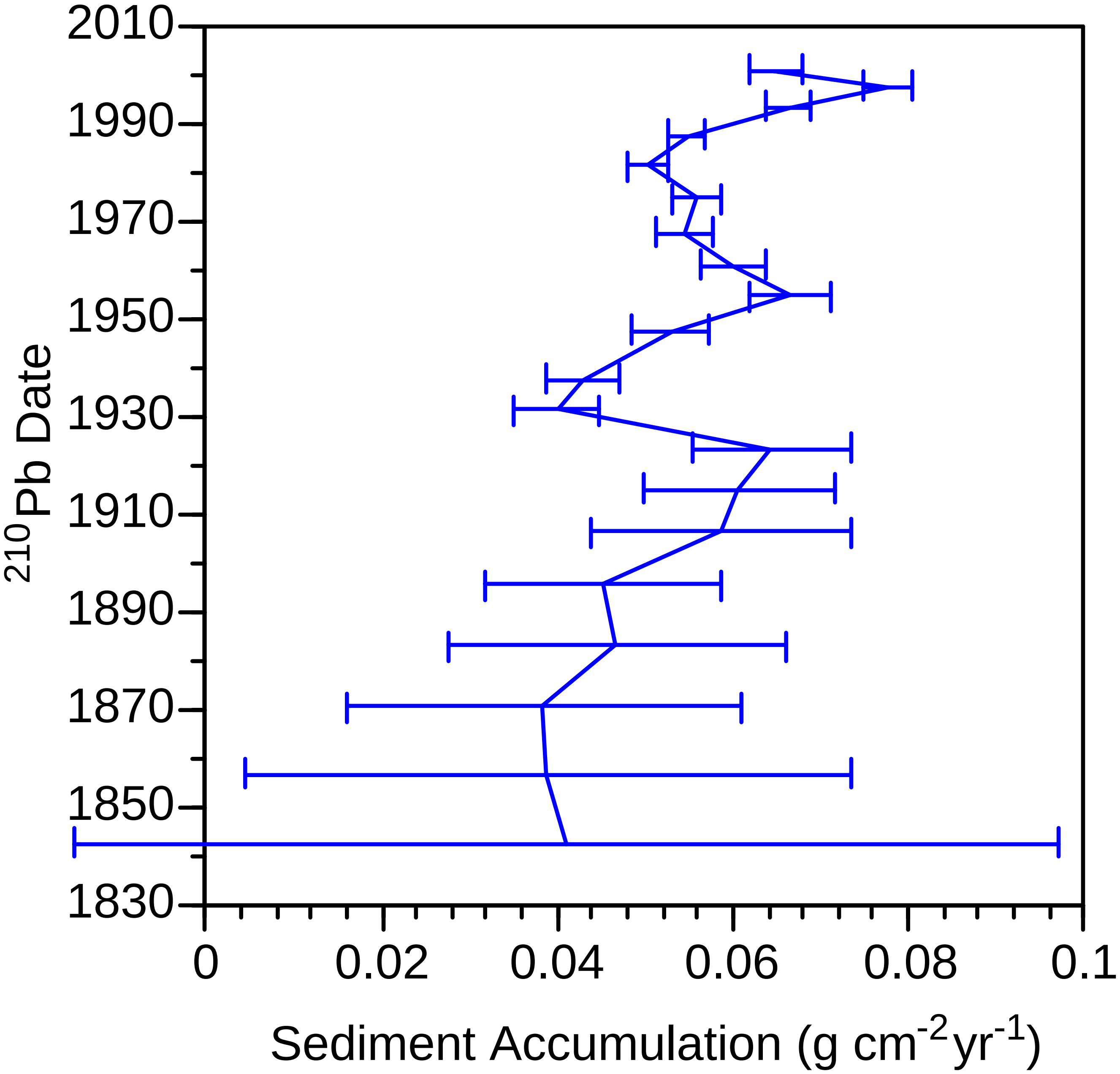

Core Depth (cm)
0
10
20
30
40
50
60
70
80
90
0
20
40
60
80
100
120
140
160
180
^{210}Pb Age (yr)

Fig. 5.



^{210}Pb Date
2010
1990
1970
1950
1930
1910
1890
1870
1850
1830
0
0.02
0.04
0.06
0.08
0.1
Sediment Accumulation (g cm^{-2}yr^{-1})

Fig. 6.

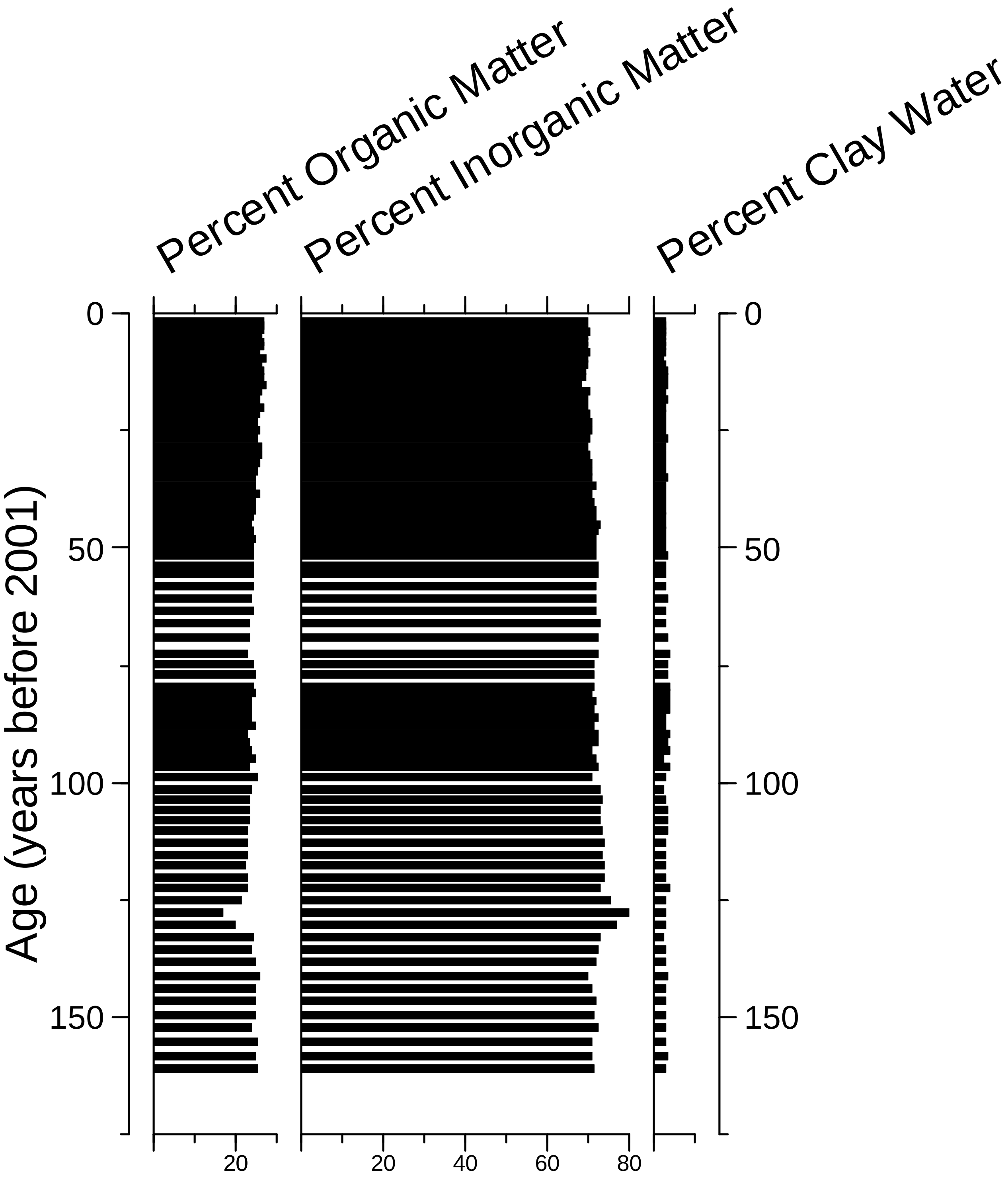
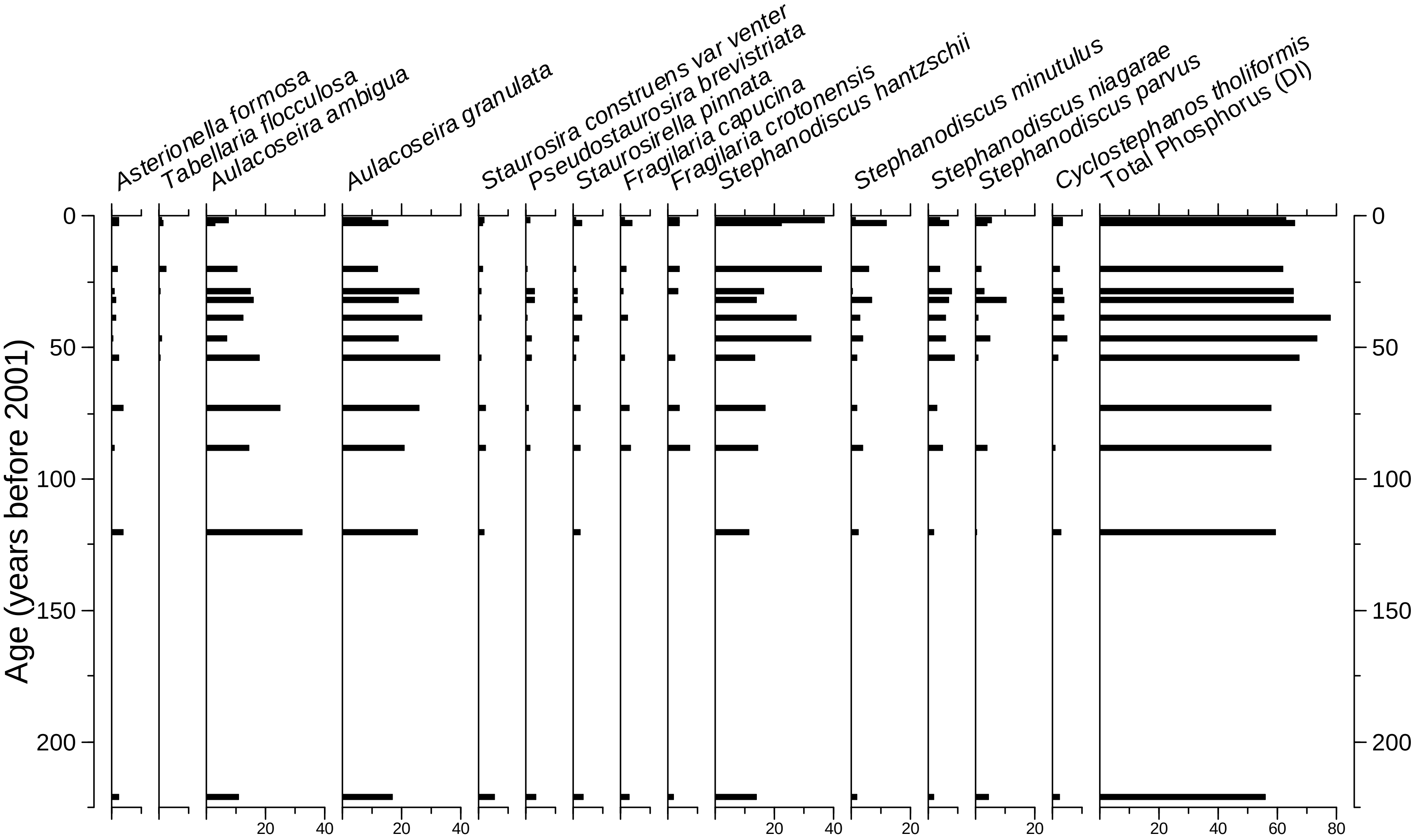

Percent Organic Matter
Percent Inorganic Matter
Percent Clay Water
Age (years before 2001)
0
50
100
150
20
20
40
60
80
0
50
100
150

Fig. 7.



Asterionella formosa
Tabellaria flocculosa
Aulacoseira ambigua
Aulacoseira granulata
Staurosira construens var venter
Pseudostaurosira brevistriata
Staurosirella pinnata
Fragilaria capucina
Fragilaria crotonensis
Stephanodiscus hantzschii
Stephanodiscus minutulus
Stephanodiscus niagarae
Stephanodiscus parvus
Cyclostephanos tholiformis
Total Phosphorus (DI)
Age (years before 2001)
0
50
100
150
200
20
40
20
40
20
40
20
20
20
40
60
80

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ATTACHMENT A

From our January, 2001, contract for services for $8,000:

Jessie Lake Project Paleolimnology Work Plan

(Consultant: Dr. John Kingston, Center for Water and Environment, Natural Resources Research Institute, 1900 B. Camp St., Ely, MN 55731; 218-365-2246.)

1. Sediment coring and processing from Jessie Lake, winter or spring, 2001; calm day from a boat or through the ice, using a Glew gravity corer, Renberg freeze sampler, Russian peat borer, or similar sampling device.

2. Loss-on-ignition methods used to determine water content, carbon content, carbonate content and clastic mineral content.

3. Radioisotope dating, mainly ^{210}Pb (subcontract for $1,600 to $1,800); this step determines whether the core is suitable, and determines the intervals to be analyzed, based on project priorities. Approximately 20 to 25 intervals will be analyzed.

4. Diatom processing and analysis; quantitative slides to get diatom abundance (alternatively, will use relative abundance of diatoms only and biogenic silica concentration and accumulation as the surrogate for diatom production). Interpretations based on known characteristics of species (as in Harvey's Lake VT study); analysis limited to approximately 10 to 15 intervals.

5. Creation of a diatom calibration set based on literature values only, including data from MN, WI, MI, ONT. This databasing exercise will allow limited quantitative inference of past total phosphorous concentrations during various stages of development in the Jessie Lake watershed.

6. Quality Control: Standard Operating Procedures, taxonomy checked by experts, deposition of diatom subsamples and slides at the California Academy of Sciences.

7. Synthesis: Concentration and accumulation rates of:

    - Sediment characteristics including carbonate (surrogate for production in alkaline lakes).

    - Diatoms (categories such as plankton and benthos, key common indicator species).

8. Final report: Full description and interpretation of items 1-7 above, including data summaries, graphs, figures and tables, with appropriate text. Separate reports and peer-reviewed literature may be produced by the consultant upon mutual signed agreement with ICSWCD.

CHECKLIST FOR WORKPLAN

John C. Kingston
September 4, 2002

1. Accomplished; coring had to be done in March and November 2001, to capture the dating profile
2. Accomplished
3. Accomplished
4. Accomplished all but biogenic Si; equipment and method are being tested at NRRI; will be done late.
5. Accomplished with Ramstack MN data set.
6. Samples yet to be deposited at CAS.
7. Summary diagram shows selected common indicator taxa and a total phosphorus reconstruction that is mainly good for trends.
8. Most of the interpretation is in the manuscript submitted to the Proceedings of the 17th International Diatom Symposium held last month in Ottawa, Ontario. I have attached a copy. This core will be reinterpreted by next spring as a test case for the expanded MN diatom calibration set that is being funded through Itasca County Soil and Water Conservation District.

ALL DATA FILES WILL BE MADE AVAILABLE TO ITASCA COUNTY SWCD AND COOPERATORS.

DATING AND SEDIMENT ACCUMULATION SUMMARY BY Dr. D.R. Engstrom

Email from John Kingston, August 12, 2002:

Here is Dan's dating and sediment accumulation spreadsheet with two columns added: percent organic and organic accumulation rate.
Also, I have attached a working spreadsheet of mine with water content and loss-on-igniton data that interpolates the dates (years before 2001) between the dated levels. I used linear interpolation between each dated pair of intervals, which is easiest and suitable. Water content shows that Jessie's sediments in the deep hole are very watery. The percents of organic, inorganic, and clay water of hydration are all percents of the dry mass; the inorganic is arrived at by difference after organic (dry - ignited at 550 degrees C) and clay-water or carbonate (ignited at 550 degrees C - ignited at 1000 degrees C) are determined.
I have made some enhanced windows metafiles of the core data, but haven't figured out how to easily look at them yet. I will keep working on that, and I can fax draft copies if you need them to write from.

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-----Original Message-----
From: John Kingston [mailto:j.kingston@thor.vr.cc.mn.us]
Sent: Friday, August 09, 2002 3:07 PM
To: Noel Griese; Art Norton; Karl Koller; Miki Hondzo; Bruce Wilson
Cc: John C. Kingston; Morgan Peterson
Subject: FW: Jessie Final

Here are the final dating results from Daniel Engstrom, with a spreadsheet and graphs attached. There is one little glitch on the top graph where the Y-axis value of 110 is in the wrong place if you open it on a Wintel box. Dan and I had a little discussion on the phone too, and there are a few other points to add to what he has already said below. Keep in mind that Dan is my subcontractor on this, and he has probably put enough effort into this already that you should not each be calling him up with questions -- direct any to me, please. I am adding Dan's dates into my Loss-on-ignition spreadsheet and interpolating dates for intervals that don't have them, and I will soon send the results from that to each of you too. Organic matter was approximately 24 to 27 percent throughout most of the core.

Keep in mind Dan's comments about sediment focusing, that the core in the deep hole over-represents lakewide accumulation by a factor of 2. The sedimentation rate does increase after logging of pine, going up approximately 20% above the lower, pre-European-effect levels. Sedimentation stays higher, but shows several excursions in both directions after logging, but keep in mind that these can reflect both focusing in the deep hole and whole-lake processes. Therefore, the sharp decline in sedimentation rate in the 1930s could be partly a result of lower sediment focusing due to lower lakewater level, for example. The background sedimentation rate of approximately 0.04 gcm-2yr-1 for the deep hole means that the overall lake sediment accumulation rate might be about 0.02, and this is slightly higher than Dan's average for 20 NE MN lakes (0.125, plus or minus 0.0077). The slightly above average sedimentation rate for Jessie Lake meshes with our diatom data showing that the lake was always eutrophic and producing lots of algal particles. These sedimentation rates are much lower than for nutrient and Calcium-rich lakes to the south. Jessie is like many other NE MN lakes in having very watery sediments (85 to 95 percent). The focusing in the deep hole is what threw me off in thinking that we only needed ca. 45 cm long core for dating, when we needed about twice that. Dan mentioned that focusing seems greatest in lakes like this, with a small deep hole but large shallow area to contribute sediments to that sink in the stratified hole. Smaller lakes and flat bottomed lakes will have less focusing.

--John

-----Original Message-----
From: D.R. Engstrom [mailto:dre@UMN.EDU]
Sent: Friday, August 09, 2002 11:47 AM
To: John Kingston
Subject: Jessie Final

Hi John,

Here's the final 210Pb results for your Jessie Lake core. Despite the various setbacks (the first core being too short, etc.), the dating has turned out very nicely. If you're convinced of the match on the core splice, then I think you've got a very robust chronology. We ended up analyzing a larger number of samples than is typical, largely because we expected slower sed rates than we actually found. Here are the main points of the interpretation (graphs and spreadsheet attached)

1. The 210Pb activity profile declines from surface values around 16 pCi/g to a near constant background (supported 210Pb) of 1.66 pCi/g below 81 cm. The down-core decrease is monotonic and over large sections close to exponential. The sections of exponential decline indicate fairly uniform sedimentation rates.

2. The break between sediments containing unsupported 210Pb (81 cm and above) from older sediments with only supported (background) 210Pb is fairly clear; supported values are well defined by the four intervals below 81 cm with similar low activities.

3. Dates calculated according to the constant rate of supply (c.r.s.) model have an uncertainty (based on counting precision -- a minimum error) of less than ± 6 years for the last century; these errors rise substantially for the oldest two dated intervals, exceeding 40 years at 1841 (81 cm). The large uncertainty of the older dates is typical for 210Pb, which is generally reliable only for the last 120-150 years.

4. Sediment accumulation rates are relatively uniform throughout the core. The error terms for rates prior to 1890 are quite large, so the small peak that appears 1900-1930 may not be significant. There is a return to slightly lower sed rates during the 1930s and then a couple more fluctuations thereafter.

5. The inventory of unsupported 210Pb in the core (30.5 pCi/cm2) is equivalent to a 210Pb flux of 0.98 pCi/cm2/yr. This value is about double the mean atmospheric flux of 210Pb for the region (ca. 0.5 pCi/cm2/yr), indicating that the core-site over-represents sedimentation rates to the lake as a whole. An estimate of whole-lake fluxes could be made by dividing core-specific sed rates by a focusing factor of two.

6. The chronology suggests that your peak in inorganic matter (69-70 cm) dates to around 1870 -- pretty close to the time of logging and settlement in northern Minnesota. You may know more about this from local land-use history for Itasca county.

Overall the results are excellent -- a very nicely dated core!

Give me a call if you have any questions about these results. An invoice for the dating will be sent separately by the Museum's accounting department.

Best regards,

Dan

--
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Top of Interval (cm)	Base of Interval (cm)	Cum. Dry Mass (g/cm2)	Unsup. Activity (pCi/g)	Error of Unsup. Act. (±s.d.)	Cum. Act. below Int. (pCi/cm2)	Age: Base of Int. (yr)	Error of Age (±s.d.)	Date A.D.	Sediment Accum. (g/cm2 yr)	Error of Sed. Accum. (±s.d.)	Organic %	Organic Accum. (g/cm2 yr)
0	1	0.0409	14.5109	0.5757	29.8832	0.63	1.08	2000.6	0.0648	0.00298	0.270	0.01750
4	5	0.2845	10.9650	0.3085	26.9282	3.98	1.09	1997.2	0.0776	0.00284	0.267	0.02072
8	9	0.6034	11.2032	0.2944	23.3863	8.50	1.17	1992.7	0.0663	0.00249	0.275	0.01823
12	13	0.9384	11.4084	0.2873	19.5909	14.19	1.30	1987.0	0.0548	0.00222	0.276	0.01512
16	17	1.2735	10.2027	0.2747	16.0247	20.64	1.47	1980.6	0.0502	0.00232	0.260	0.01305
20	21	1.6362	7.4274	0.2140	12.9838	27.40	1.46	1973.8	0.0559	0.00264	0.264	0.01476
24	25	2.0154	6.1470	0.2178	10.4777	34.29	1.63	1966.9	0.0545	0.00303	0.253	0.01379
28	29	2.3946	4.5434	0.1794	8.5399	40.85	1.72	1960.4	0.0600	0.00364	0.248	0.01488
32	33	2.8018	3.3672	0.1578	7.0010	47.24	1.85	1954.0	0.0664	0.00456	0.249	0.01653
36	37	3.2258	3.3811	0.1769	5.5696	54.58	2.23	1946.6	0.0529	0.00430	0.244	0.01291
40	41	3.7068	3.0818	0.1550	4.0354	64.93	2.94	1936.3	0.0428	0.00416	0.237	0.01014
42	43	3.9818	2.6916	0.1689	3.2695	71.69	3.57	1929.5	0.0400	0.00476	0.234	0.00936
45	46	4.3342	1.3149	0.1133	2.6526	78.40	3.89	1922.8	0.0644	0.00921	0.245	0.01578
50	51	4.8642	1.0723	0.1139	2.0339	86.93	4.92	1914.3	0.0607	0.01092	0.253	0.01536
55	56	5.3942	0.8421	0.1471	1.5398	95.87	6.31	1905.4	0.0586	0.01492	0.236	0.01383
60	61	5.9581	0.7795	0.1056	1.0864	107.07	8.80	1894.2	0.0452	0.01324	0.235	0.01062
65	66	6.5107	0.5144	0.0916	0.7447	119.20	12.45	1882.0	0.0467	0.01922	0.228	0.01065
70	71	7.0407	0.4237	0.0844	0.5011	131.92	18.32	1869.3	0.0385	0.02228	0.246	0.00947
75	76	7.5707	0.2718	0.0891	0.3255	145.77	27.80	1855.5	0.0389	0.03452	0.250	0.00973
80	81	8.1346	0.1656	0.0824	0.2088	160.03	42.82	1841.2	0.0411	0.05604	0.254	0.01044

Supported Pb-210: 1.6605 ± 0.068 pCi/g
Number of Supported Samples: 4

Cum. Unsup. Pb-210: 30.4767 pCi/cm2
Unsup. Pb-210 Flux: 0.9778 pCi/cm2 yr

Jesse Lake
Itasca Co., MN