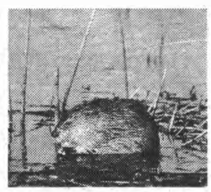
Canada Alberta Northwest Territories

Northern River Basins Study





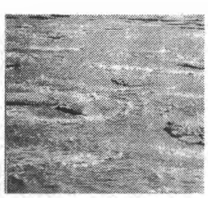




NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 99

DEPOSITIONAL HISTORY OF SEDIMENT IN GREAT SLAVE LAKE:

SPATIAL AND TEMPORAL PATTERNS IN GEOCHRONOLOGY, BULK PARAMETERS, PAHs AND CHLORINATED CONTAMINANTS






Prepared for the
Northern River Basins Study
under Projects 2333-C1, 2333-D1 and 2333-D2

by

Marlene S. Evans
National Hydrology Research Institute
Environment Canada

Richard Bourbonniere
National Water Research Institute
Environment Canada

and

Derek Muir, Lyle Lockhart, Paul Wilkinson
and Brian Billeck
Department of Fisheries and Oceans, Freshwater Institute

NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 99

DEPOSITIONAL HISTORY OF SEDIMENT IN GREAT SLAVE LAKE:

SPATIAL AND TEMPORAL PATTERNS IN GEOCHRONOLOGY, BULK PARAMETERS, PAHs AND CHLORINATED CONTAMINANTS

Published by the
Northern River Basins Study
Edmonton, Alberta
February, 1996

CANADIAN CATALOGUING IN PUBLICATION DATA

Evans, Marlene S.

Depositional history of sediment in Great Slave Lake : spatial and temporal patterns in geochronology, bulk parameters, pahs and chlorinated contaminants

(Northern River Basins Study project report, ISSN 1192-3571 ; no. 99)
Includes bibliographical references.
ISBN 0-662-24644-6
Cat. no. R71-49/3-99E

1. Lake sediments -- Northwest Territories -- Great Slave Lake -- Composition.
2. Sedimentation and deposition - Northwest Territories -- Great Slave Lake.
I. Evans, Marlene S.
II. Northern River Basins Study (Canada)
III. Series.

TD387.G73E95 1996   551 3'54'097193   C96-980217-X

PREFACE:

The Northern River Basins Study was initiated through the "Canada-Alberta-Northwest Territories Agreement Respecting the Peace-Athabasca-Slave River Basin Study, Phase II - Technical Studies" which was signed September 27, 1991. The purpose of the Study is to understand and characterize the cumulative effects of development on the water and aquatic environment of the Study Area by coordinating with existing programs and undertaking appropriate new technical studies.

This publication reports the method and findings of particular work conducted as part of the Northern River Basins Study. As such, the work was governed by a specific terms of reference and is expected to contribute information about the Study Area within the context of the overall study as described by the Study Final Report. This report has been reviewed by the Study Science Advisory Committee in regards to scientific content and has been approved by the Study Board of Directors for public release.

It is explicit in the objectives of the Study to report the results of technical work regularly to the public. This objective is served by distributing project reports to an extensive network of libraries, agencies, organizations and interested individuals and by granting universal permission to reproduce the material.

NORTHERN RIVER BASINS STUDY
PROJECT REPORT RELEASE FORM

This publication may be cited as:

Evans, Marlene S., et al. 1996. ***Northern River Basins Study Project Report No. 99, Depositional History of Sediment in Great Slave Lake: Spatial and Temporal Patterns in Geochronology, Bulk Parameters, PAHs and Chlorinated Contaminants.*** **Northern River Basins Study, Edmonton, Alberta.**

Whereas the above publication is the result of a project conducted under the Northern River Basins Study and the terms of reference for that project are deemed to be fulfilled,
IT IS THEREFORE REQUESTED BY THE STUDY OFFICE THAT;
this publication be subjected to proper and responsible review and be considered for release to the public.

(Dr. Fred J. Wrona, Science Director) — 22 Apr 96 (Date)

Whereas it is an explicit term of reference of the Science Advisory Committee "to review, for scientific content, material for publication by the Board",
IT IS HERE ADVISED BY THE SCIENCE ADVISORY COMMITTEE THAT;
this publication has been reviewed for scientific content and that the scientific practices represented in the report are acceptable given the specific purposes of the project and subject to the field conditions encountered.
SUPPLEMENTAL COMMENTARY HAS BEEN ADDED TO THIS PUBLICATION: [ ] Yes [ ] No

(Dr. P. A. Larkin, Ph.D., Chair) — April 22/96 (Date)

Whereas the Study Board is satisfied that this publication has been reviewed for scientific content and for immediate health implications,
IT IS HERE APPROVED BY THE BOARD OF DIRECTORS THAT;
this publication be released to the public, and that this publication be designated for: **[ ] STANDARD AVAILABILITY [ ] EXPANDED AVAILABILITY**

(Lucille Partington, Co-chair) — April 23/96 (Date)

(Robert McLeod, Co-chair) — 30/04/96 (Date)

DEPOSITIONAL HISTORY OF SEDIMENT IN GREAT SLAVE LAKE: SPATIAL AND TEMPORAL PATTERNS IN GEOCHRONOLOGY, BULK PARAMETERS, PAHs AND CHLORINATED CONTAMINANTS

STUDY PERSPECTIVE

Depositional sediments can be useful to chronicle natural changes and contamination events in a drainage basin. Sediment cores from Great Slave Lake offer the opportunity to (1) understand recent trends in sources of industrial and atmospheric contamination, (2) compare modern contaminant deposition with the magnitude of past events, and (3) compare the relative magnitude of natural versus man-made changes in the basin, and (4) compare these trends with those found in a companion study of Lake Athabasca and reference lakes in that basin. Almost all of the studies under the Northern River Basins Study contaminants program have been conducted on mainstem rivers and tributaries which receive some level of contaminant input from industrial, municipal and agricultural sources. Trends revealed by these studies will provide a basis from which to judge the degree of impact on Great Slave Lake, the downstream end of a large watershed altered by human activities.

Related Study Questions

4a) What are the contents and nature of the contaminants entering the system and what is their distribution and toxicity in the aquatic ecosystem with particular reference to water, sediments and biota?

4b) Are toxins such as dioxins, furans, mercury, etc. increasing or decreasing and what is their rate of change?

13b) What are the cumulative effects of man-made discharges on the water and aquatic environment?

14) What long term monitoring programs and predictive models are required to provide an ongoing assessment of the state of the aquatic ecosystems?

The primary objective of this study was to collect and analyze surficial sediments and high quality, well-described sediment cores for use in defining the depositional history of sediment-bound contaminants in the west basin of Great Slave Lake. The analysis would include those contaminants which have known atmospheric or upstream point sources. Dating of the cores was accomplished by using the lead (^{210}Pb) and cesium (^{137}Cs) methods, and procedures used by two different laboratories were compared. These geochronological results were used to determine sedimentation rates and time scales, and the suitability of the cores for subsequent contaminant analyses.

Ten surficial sediment samples were collected near the mouth of the Slave River, and five deep cores were collected and analyzed from the west basin of the lake. Analyses of surficial sediment samples near the Slave River mouth found low levels of organochlorine compounds, and the dominant dioxin and furans were the lower chlorinated forms (di- and tri-), suggestive of a pulp mill source. The Slave River was identified as a source of PAHs and the dominant forms were those associated with erosion of oil sands deposits found upstream. Analyses for PAHs in sediment cores showed a strong trend of increasing concentrations after the 1960s, particularly for compounds associated with man-made sources. PCBs in Great Slave Lake sediments appear to be increasing over time, especially the higher chlorinated congeners, similar to trends found in other subarctic and Arctic lakes. Other organochlorines, such as DDT and dieldrin, showed similar trends of increasing concentration over time, but levels of these compounds were low. For the two cores examined for dioxins and furans, concentrations of dioxins were substantially higher during the 1950s through 1970s than in more recent times. Dioxins were more abundant than total furans, and were dominated by higher chlorinated congeners (hepta- and octa-). Tri- and tetrachloroveratrole occurred in low concentrations in the 1950s, with increasing levels thereafter.

A preliminary interpretation of deposition rates and contaminant levels in sediments reveals that Great Slave Lake is essentially a pristine system. Nonetheless, it does show signs of contamination from man-made sources, particularly for organochlorine compounds. It is probable that a significant fraction of these contaminants entered the lake via the Slave River, but the primary source (point source inputs or atmospheric deposition) is less certain. This study provides the basis for further analyses of the sediment cores from Great Slave Lake, and for making a comparison with the depositional history of Lake Athabasca and other area lakes.

REPORT SUMMARY

This report presents the results of August 1993 and March 1994 sediment studies in the West Basin of Great Slave Lake. In August 1993, a series of 10 surficial sediment samples were collected in the vicinity of the Slave River mouth. PCB was the predominant organochlorine (OC) compound detected followed by chlorobenzene, total DDT, HCH, and dieldrin. Concentrations were low and comparable to values reported for other subarctic and arctic lakes. There was no apparent pattern in the distribution of these compounds relative to the Slave River outflow. PAHs were very abundant and were dominated by benzo(g,h,i)perylene, benzo(e)pyrene, and phenathrene: concentrations were slightly higher offshore the river mouth than elsewhere. PCDD and PCDF concentrations were exceedingly low. PCDDs were dominated by DiCDD and OCDD while PCDFs were dominated by DiCDF and TriCDF. The presence of the lower chlorinated forms may be suggestive of a pulp and paper mill influence. Similarly the presence of pentachloroanisole, trichloroveratrole, and tetrachloroveratrole may be suggestive of a pulp and paper mill influence.

Two cores were collected in August 1993 on the shelf region immediately west of the Slave River. Station depths were less than 30 m. Both cores were in areas of high erosion and could not be assigned meaningful dates.

In March 1994, a series of sediment cores was collected at five sites (Sites 12, 13, 16, 19, and 23) in the West Basin, to the west of the August 1993 surficial sediment and coring studies. A single core from each site was dated at the Freshwater Institute and two additional cores (one each from Sites 13 and 19) were dated at the National Water Research Institute. Cores from four of the sites were in depositional areas while the core collected offshore of the Slave River mouth (Site 23) was in an erosional area. However, sufficient sediment deposition had occurred at this site for the core to be dated. The two cores examined from Site 13, in the central region of the West Basin, gave similar dating estimates. However, the two cores examined from Site 19, further to the east, gave somewhat different estimates from each other. These two cores were collected in a less physically-stable region of the lake with some evidence of postdepositional erosion of older material on top of newer sediments. The core from Site 23 was in the least stable region of the five sites examined.

Sedimentation rate estimates were similar to those for Lake Athabasca and Lakes Ontario and Erie. They were higher than estimates for subarctic and arctic lakes and for Lake Superior. Based on estimates of the suspended sediment loading to Great Slave Lake, we conclude that our cores were not collected in the high-sedimentation regions of Great Slave Lake. The greatest sedimentation may occur offshore of the Slave River mouth. Analysis of cores collected in March 1995 should allow us to confirm this hypothesis.

Two cores (Cores 12B and 19B) were analyzed for organochlorine compounds. Concentrations of OCs in Core 12B, collected offshore of Hay River, were relatively high and require verification. Thus, these data are not presented in this report. For Core 19B, there was some evidence of increasing PCB, chlorobenzene, and HCH concentrations over the 1949 - 1994 period investigated. Dieldrin showed a weaker time trend. Based on the analysis of sediment trap material collected in

August 1994, we conclude that the Slave River is a significant source of organochlorine compounds to Great Slave Lake.

Cores from Sites 12 and 19 were analyzed for PAHs. Although the same number of slices were examined for both cores, slices from Core 12B did not extend as far back in time: thus, the PAH record has not been determined for Core 12B prior to the mid 1960s. Both cores were dominated by naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene suggesting a petrogenic source. Concentrations were higher at Site 19, closer to the Slave River, than Site 12. There was strong evidence that concentrations of these compounds increased since the 1960s suggesting an additional anthropogenic source of these PAHs: temporal patterns of increase differed for Core 12B and Core 19B. Fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, and chrysene all occurred in higher concentrations in Core 12B than Core 19B. Concentrations varied little over time for Core 19B but showed some evidence of higher concentrations in Core 12B for two periods - the late 1970s and the late 1980s. This is suggestive of a localized input, possibly from Hay River. Higher molecular weight PAHs occurred in similar concentrations in Cores 12B and 19B. There was a suggestion of slightly higher concentrations of these compounds in Core 12B during the late 1970s than earlier and later times.

PCCDs and PCDFs concentrations were determined in Cores 19D and 23A. Concentrations of PCDDs were substantially higher during the 1950s through the 1970s than in more recent times. Temporal patterns of increase differed for Core 19D and Core 23A. PCDDs were dominated by HpCDDs and OCDDs with only low concentrations of the lower chlorinated forms being detected. Total PCDFs were less abundant than PCDDs: this is in notable contrast to the surficial samples where PCDDs and PCDFs occurred in similar concentrations to one another. PCDFs (primarily TriCDF and TCDF) showed some evidence of increasing concentrations since the 1950s for Core 23A while this trend was less apparent for Core 19D. These increases in PCDD and PCDF concentrations may be related to increased atmospheric sources and/or paper and pulp mill activities. There was some evidence of a pulp and paper mill signature in Core 19B with pentachloroanisole increasing in concentration from 1949 to the early 1980s and then declining somewhat thereafter: trichloroveratrole and tetrachloroveratrole occurred in low concentrations in the 1950s and in increasing concentrations thereafter.

Total organic carbon (TOC) and total organic nitrogen (TON) concentrations were determined in Cores 13C and 19D. Concentrations of both compounds have increased since the early 1900s with the greatest increase occurring since the 1950s. Moreover, the increase was more pronounced in Core 13C than Core 19D. This suggests that the West Basin of Great Slave Lake has undergone a slight increase in productivity, possibly due to land clearing and increased anthropogenic development in the Peace and Athabasca River watersheds. Localized activities, occurring at the towns of Hay River and Yellowknife, may also have been important.

While Great Slave Lake is essentially a pristine system, it does show signs of recent anthropogenic contamination. A significant fraction of OCs, PAHs, PCCDs, and PCDFs probably entered the West Basin of Great Slave Lake with Slave River inflow. However, the primary source of these compounds is less certain, e.g., localized inputs from industries along the Peace and Athabasca Rivers and/or atmospheric deposition (wet and dry) over the broader watershed with the eventual transport of these compounds into the Peace, Athabasca, and Slave rivers and then into Great Slave Lake.

Preliminary data suggests that OCs, PCDDs, and PCDFs occur in similar concentrations in the West Basin and the East Arm (Lutsel K'e) of Great Slave Lake suggesting that long-range atmospheric sources are the primary source of these compounds. In contrast, PAH concentrations appear to be higher in the West Basin than the East Arm suggesting that there are significant point sources of these compounds along the Peace, Athabasca, and Slave Rivers in addition to diffuse, long-range, atmospheric sources.

ACKNOWLEDGMENTS

Field and analytical costs for surficial sediment and core studies conducted in August 1993 were supported by the Arctic Environmental Strategy Program (AES, Ottawa) and the AES Action on Water Program (Yellowknife). Field costs for the March 1994 core sampling were supported by the Northern River Basins Study (NRBS) while analytical costs were supported by NRBS and AES, Yellowknife. The National Hydrology Research Institute (NHRI) also provided financial support for some aspects of this research. The August 1993 sampling was conducted with the Fisheries and Oceans (Hay River) enforcement vessel, the Tucho Mariner. Special appreciation is extended to Dale Archibald and Dan DeChief for their support in this sampling. The March 1994 sampling was conducted with Aero Arctic Helicopter Services, Yellowknife. The services of Seiji Susuki in piloting the helicopter and assisting in the sampling is very much appreciated. Pat Bobinski (Fisheries and Oceans) provided the scientific party with laboratory facilities for processing the core samples in Hay River.

Eric Marles (NHRI) participated in the August 1993 sampling and provided useful advice during this and other field studies on Great Slave Lake. Julie Knox (NHRI) and Earl Walker (NWRI) were valuable team members during the March 1994 sampling. Their cheerful spirits during the long and cold days added a touch of warmth to the sampling. Ashleen Downes and Carol Casey prepared the figures and tables and compiled the final report. Their careful work, close attention to detail, and editorial comments are very much appreciated. Finally, the authors wish to acknowledge the helpful comments of the reviewers and contributors to an earlier draft of this report. Reviewers and contributors included: Dr. Milne Dick, Dr. Peter Larkin, and Dr. David Schindler with the Science Advisory Committee of NRBS; Richard Chabaylo, Component Coordinator, NRBS; Dr. Alena Mudroch, Dr. Brian Brownlee, and George Garbai (NWRI); and Dr. Brian Eadie (Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan).

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF APPENDIX TABLES

Page

LIST OF FIGURES

Page

1.0 INTRODUCTION

Great Slave Lake is one of most important aquatic ecosystems in northern Canada. This importance stems from several considerations. First, as its name implies, Great Slave Lake is one of Canada's great lakes (Herdendorf, 1982). In terms of surface area, it is Canada's fourth largest lake (27,000 km^2) following lakes Superior (82,100 km^2), Huron (59,500 km^2), and Great Bear (31,326 km^2). In terms of volume, it is Canada's fourth largest lake (2,088 km^3). In terms of maximum depth, Great Slave Lake is Canada's deepest lake (614 m).

Great Slave Lake, located in a northern continental-climatic region has long, cold winters and short, warm summers. Annual precipitation rates (20.8 - 29.5 cm/year) are low and river inflow, draining an extensive watershed to the south, is the major source of water input to the lake (Rawson, 1950). The Slave River is the major river entering Great Slave Lake (Figure 1) contributing some 87% of the total annual inflow of 135 km^3. The Slave River, in turn, receives most of its water from the confluence of the Peace and Athabasca Rivers. The total drainage basin for the Slave, Peace, and Athabasca rivers is immense, extending some 680 km to the south and over 983,000 km^2. Great Slave Lake forms the headwaters of the Mackenzie River.

More than 50% of the Northwest Territories population live along the Great Slave Lake shoreline (Figure 2). Yellowknife, the Territorial capital, has a population of ca. 14,000 while Hay River, an important shipping and commercial fishing center, has a population of ca. 3,000. Smaller communities include Fort Resolution at the Slave River delta, Lutsel K'e (Snowdrift) in Christie Bay, Fort Smith downstream of the Slave River delta, and Fort Providence located on the headwaters of the Mackenzie River.

Early settlement along the Great Slave Lake shoreline and its major tributaries was based on various aspects of the water itself: abundant fish populations; seasonally-abundant populations of waterfowl; and land-based travel along river shorelines. Later, water became more important as a vehicle for shipping and allowed for the development of the early forestry and mining industries. The Con-Rycon Vol gold mine came into operation in 1938, the Negus Mine in 1939, and Giant Yellowknife Mines in 1948 (Boyle, 1961). Pine Point, a base metal mine located on the southern shore of Great Slave Lake, began operation in 1964 but closed in 1988. A commercial fishery began operating on Great Slave Lake in 1945 (Rawson, 1947b) and continues to this date. During the 1970s the discovery of new deposits of oil and gas, offshore of the Mackenzie River and inland, accelerated the development of Hay River. Hay River serves as the major shipping port connecting inland Canada with the Mackenzie River and the Arctic Ocean. While shipping and mining have declined in recent years, economic development around the Great Slave Lake shoreline continues. Ecotourism has become increasingly important. Moreover, the recent discovery of diamond deposits to the north of Great Slave Lake will contribute to the expansion of local population centers.

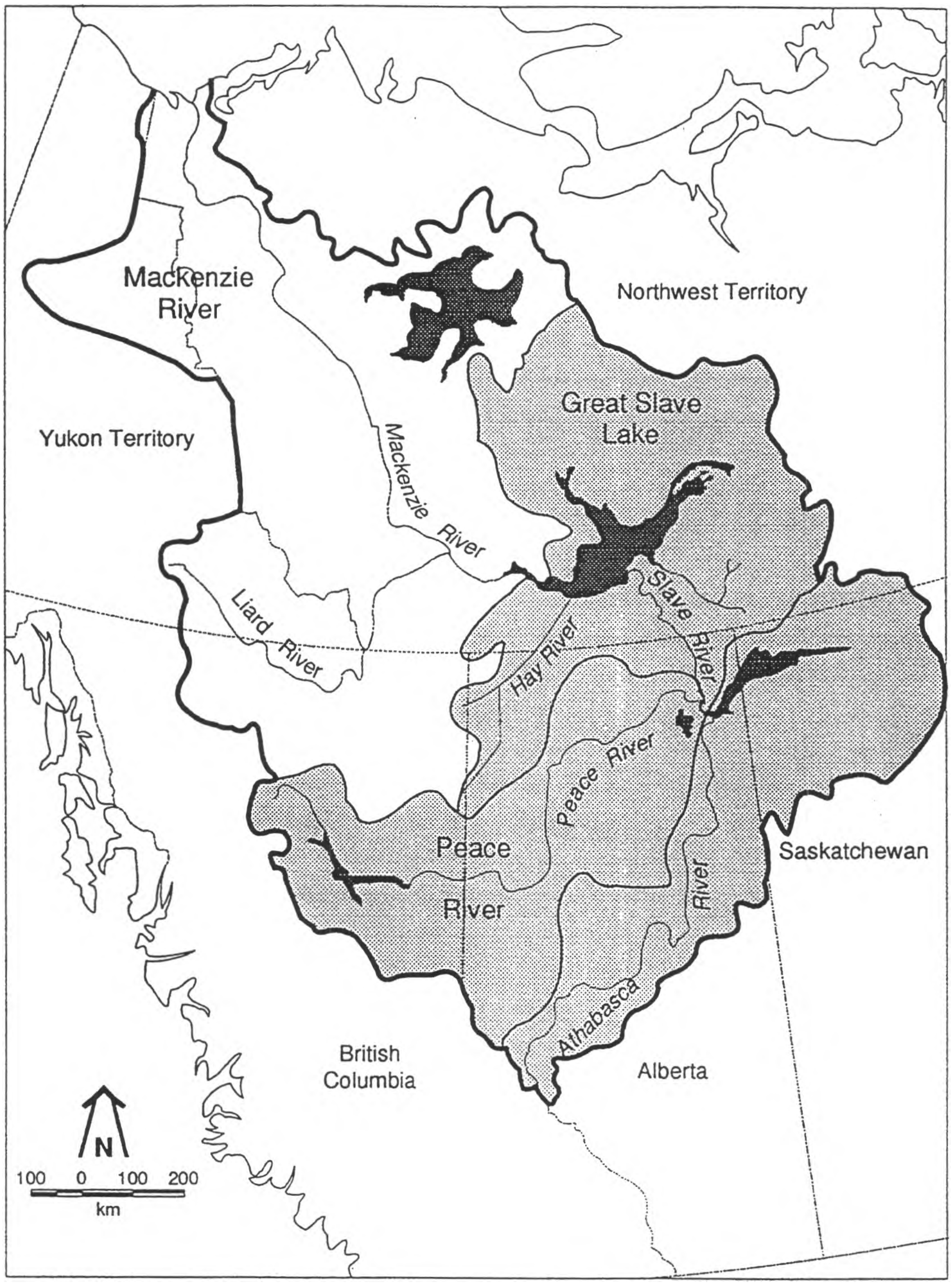


Figure 1. The Mackenzie River Basin watershed showing Great Slave Lake and its three major drainage basins: Lake Athabasca, Peace River, and Great Slave Lake proper. Modified from Mudroch et al. (1992).

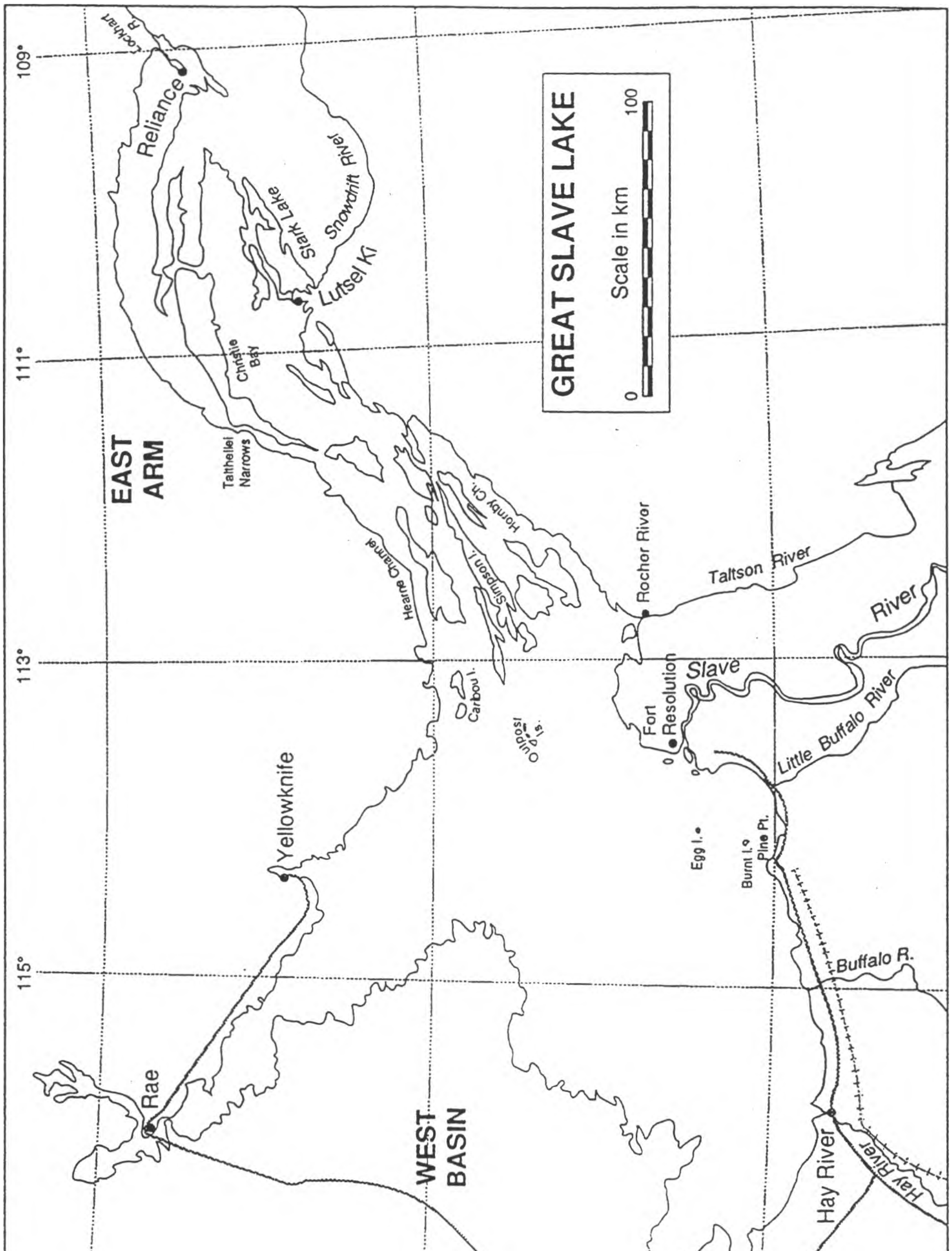


Figure 2. Map of Great Slave Lake showing major geographic features, towns, communities, highways, and the railway line.

In contrast to the Laurentian Great Lakes, Great Slave Lake has remained largely unchanged since Rawson's pioneering research during the late 1940s and early 1950s (Rawson 1947b, 1950, 1951, 1953). Nutrient levels are low (Fee et. al., 1985; Evans and Headley, 1993; Evans, 1996). Fish community structure has changed slightly (G. Lowe, personal communication, Fisheries and Oceans, Hay River) although not to the extent observed in the Great Lakes (Christie, 1974). Much of the change appears to be associated with the commercial fisheries. This fisheries has been highly regulated since its inception during the mid-1940s. Total catches increased from 0.7 million kg in 1945 to 4.3 million kg in 1949, and then declined to 2.3 million kg in later years (Keleher, 1972): whitefish catches declined from the 1.7 million kg annually in the 1960s to 1.1 million kg in 1973 (Healey, 1975). The 1992/1993 harvest was 1.4 million kg with whitefish (Coregonus clupeaformis) accounting for 81.7% of the catch (Department of Fisheries and Oceans, 1995).

Great Slave Lake is a relatively pristine ecosystem with low concentrations of inorganic and organic contaminants in all but the most industrialized areas, i.e., Yellowknife and Hay River (Stein and Miller, 1972; Moore et. al., 1978, 1979; Mudroch et al., 1989a). Contaminant concentrations remain low for two basic reasons. First, Great Slave Lake is located in a relatively inhospitable region of Canada. Thus, the human population around its shoreline is small in number and, as a consequence, anthropogenic impacts on the lake are minimal. Second, development in Great Slave Lake's extended watershed has been limited. For many decades, population levels along the Peace, Athabasca, and Slave rivers have been small and have been based on subsistence economies (hunting, fishing, agriculture). As a consequence, anthropogenic effects on the watershed generally have been small.

In recent decades, there has been increased technological development in the Peace and Athabasca drainage basins. These activities have, in large measure, been based on natural resource utilization. Pulp and paper mills have been constructed with the northward migration of the forestry industry. Refineries have been constructed to process oil from newly-discovered oil deposits and tar sands which, with changing world prices, had new market potential. There is concern that contaminants associated with these industrial activities, especially polychlorinated dibenzo-p-PCDDs (PCCDs) and polychlorinated dibenzofurans (PCCFs) produced by pulp mills and polycyclic aromatic hydrocarbons (PAHs) produced by oil refineries, may be transported downstream via the Peace, Athabasca and Slave rivers to Great Slave Lake. Moreover, because the Slave River dominates the water inflow to Great Slave Lake and the residence time of water in the West Basin is short (ca. 8 years; Rawson, 1950), Great Slave Lake has the potential to be rapidly affected by events occurring in its watershed.

It is unlikely that contaminant concentrations in Slave River waters entering Great Slave Lake will be high given the hundreds of kilometers they must travel downstream from their industrial production sources to the lake. As these contaminants flow downstream to Great Slave Lake, they become diluted and degraded: moreover, some fraction will be lost to the sediments and to the atmosphere. However, although contaminant concentrations are likely to be low, large amounts may enter Great Slave Lake. Many of these contaminants are biomagnified by aquatic organisms and have carcinogenic and/or mutagenic properties. Since many people living around the Great Slave Lake shoreline rely on fish from the lake as a significant part of their traditional diet, there is concern that industrialized activities in the southern regions of the Great Slave Lake watershed have the potential to affect the health of the local population. Communities also may be affected economically since the growing ecotourism industry is based on the pristine state of Great Slave Lake and its biota.

Organic contaminants may have more subtle negative effects on Great Slave Lake biota than similar biota living in more southern lakes, e.g., the Great Lakes. Great Slave Lake, with its low nutrient levels and prolonged winters, is a harsh environment for the biota. Growth rates are low and animals long-lived relative to similar species living in the south: their lipid levels can also be higher. Thus, biota living in Great Slave Lake have the potential to obtain a greater lifetime accumulation of organic contaminants than similar biota living in the Great Lakes with the same contaminant exposure.

Given these concerns regarding the increased development in the lower reaches of the Great Slave Lake watershed, it is of critical importance to obtain baseline data on organic contaminant concentrations in Great Slave Lake. These benchmark data will be used for future comparisons as development continues in the Great Slave Lake watershed. It also is of critical importance to determine the influence of the Slave River on contaminant loading to Great Slave Lake. While the river is the major direct source of water, sediments, and presumably contaminants to the lake, the atmosphere may also be an important source of contaminants. Finally, it is important to assess whether or not the Slave River exerts a minimizing effect on contaminant biomagnification to Great Slave Lake. Specifically, the Slave River transports tremendous amounts of sediments into Great Slave Lake: these suspended sediments scavenge organic contaminants from the water column resulting in the rapid loss of these compounds from the water column as the particulates settle to the lake floor. Thus, organic contaminant concentrations may be lower in particulates (including biota) in the water column in regions near the Slave River mouth, where suspended sediment concentrations are high, than in regions such as the East Arm, where suspended sediment concentrations are low. Ongoing research investigating organic contaminants in Great Slave Lake food webs suggests that biota living in the East Arm have higher concentrations of contaminants than similar biota living in the vicinity of the Slave River mouth (Evans, 1994, 1995).

2.0 STUDY COMPONENTS

This report is based on sediment studies conducted between August 1993 and March 1994. The components of the study are as follows.

In August 1993, a study was implemented to obtain baseline information on organic contaminant concentrations in surficial sediments near the Slave River mouth and to obtain information on the potential role of the river as a source of organic contaminants to the lake. During this study, a series of surficial sediments were collected in the vicinity of the Slave River outflow, West Basin (Figure 3). In addition, two core samples were collected in an attempt to locate a site near the Slave River mouth which was suitable for investigations of long-term trends in contaminant inputs to Great Slave Lake sediments. This research was supported by the Arctic Environment Strategy (AES) program with funding being obtained from Yellowknife (Water Resources Program) and Ottawa.

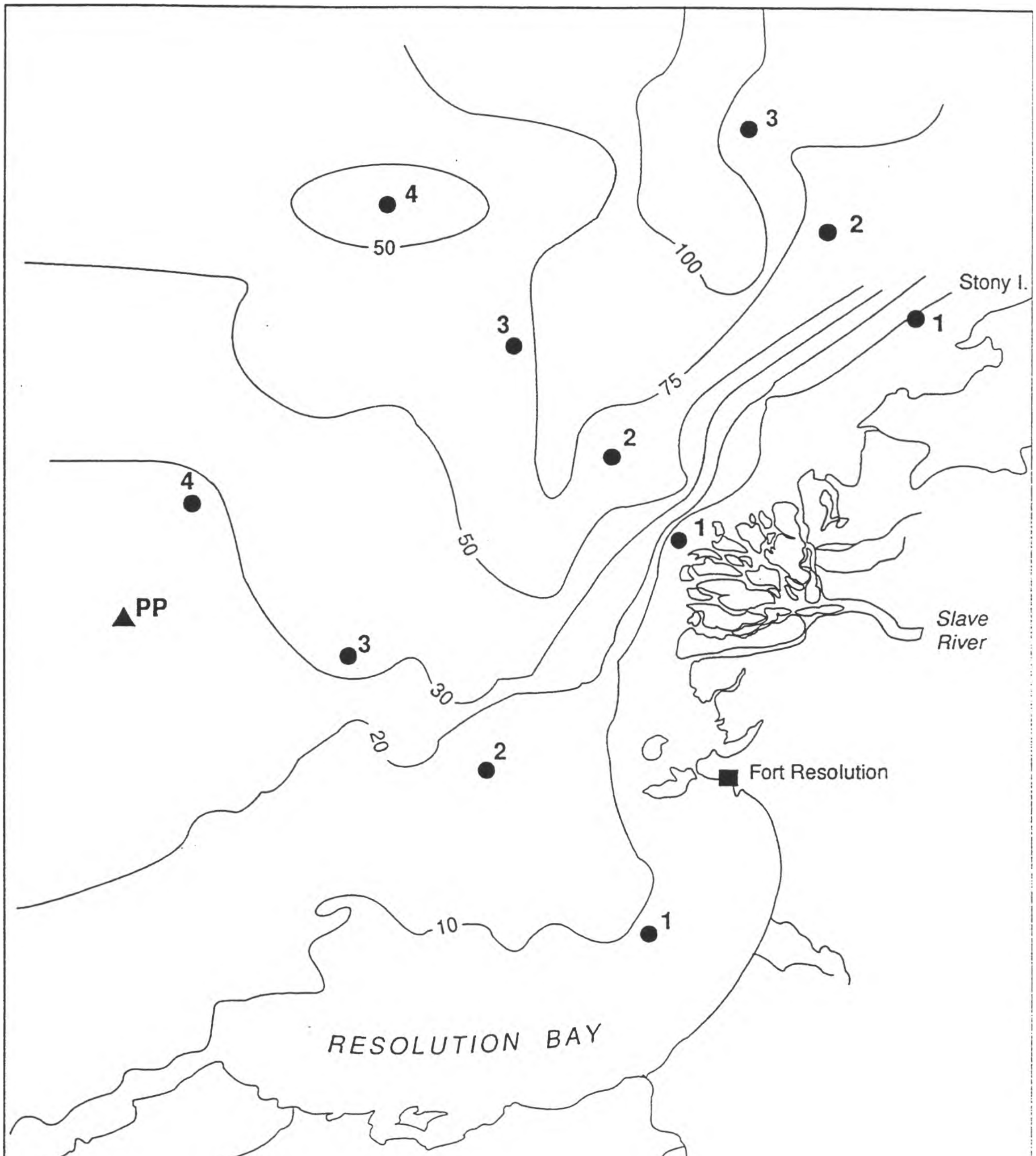


Figure 3. Map showing the location of sites sampled in the Slave River delta region during the August 1993 research cruise.

In March 1994, a second study was designed which focused on core collections in various regions of the West Basin (Figure 4). Collection costs (Appendix A) were supported by the Northern River Basins Study (NRBS). Later NRBS funding (Appendix A) was used to date a subset of cores. The goals of the March 1994 study were two-fold. The study began by assessing spatial patterns in sedimentation rates in the West Basin relative to the Slave River outflow. Once suitable cores were identified, studies were conducted to investigate contaminant concentrations (organochlorine compounds (OCs), PAHs, PCDDs and PCDFs) in sediments with time. Organic contaminant analysis costs were supported by AES (Yellowknife and Ottawa).

Research has continued on contaminant loading to Great Slave Lake via the Slave River. In August 1994, two surficial sediment samples were collected near Lutsel K'e and a third in Resolution Bay. These collections were made as part of a study of organic contaminant biomagnification in Great Slave Lake food webs (Evans, 1994, 1995). The Lutsel K'e samples provide for a comparison of organic contaminant concentrations in a region of Great Slave Lake far removed from the Slave River. Funding for this research was supported by AES (Yellowknife and Ottawa).

In March 1995, a series of additional cores was collected in the West Basin, closer to the Slave River mouth than the March 1994 cores. These cores were collected in what is believed to be a region of high sedimentation although, because of their proximity to the Slave River outflow, significant slumping and postdepositional movement of sediments may also have occurred. These cores are being dated. A small subset of these samples will be analyzed OCs, PAHs, PCCDs, and PCCFs. Funding for this research is being supported by AES (Yellowknife and Ottawa).

In August 1995, a series of 17 surficial sediment samples was collected in the East Arm to provide for a better assessment of organic contaminant concentrations relative to distance from the Slave River. These samples are being analyzed for OCs, PAHs, PCCDs, and PCCFs. The results of these studies will appear in a later NHRI report. Funding for this research is being supported by AES (Yellowknife and Ottawa).

3.0 METHODS

3.1 FIELD SAMPLING - Surficial Sediments

In August 1993, a surficial-sediment sampling grid was designed consisting of three transects: a transect offshore of Resolution Bay; a transect offshore of the Slave River mouth; and a transect offshore of Stony Point (Figure 3). All sampling was conducted from the Fisheries and Oceans enforcement vessel, the Tucho Mariner. The location of all sampling sites were determined with the ship's Global Position Finder. The transect offshore of Resolution Bay was in a relatively shallow region where depths deepened gradually offshore. The Delta transect was in a region of deeper and more irregular bottom topography. Delta 4 was in the center of a deep-water rise. The Stony transect also was in a region of irregular bottom topography and deep waters. The water column was sampled at all sites for various limnological parameters: results will be reported elsewhere (Evans, unpublished data).

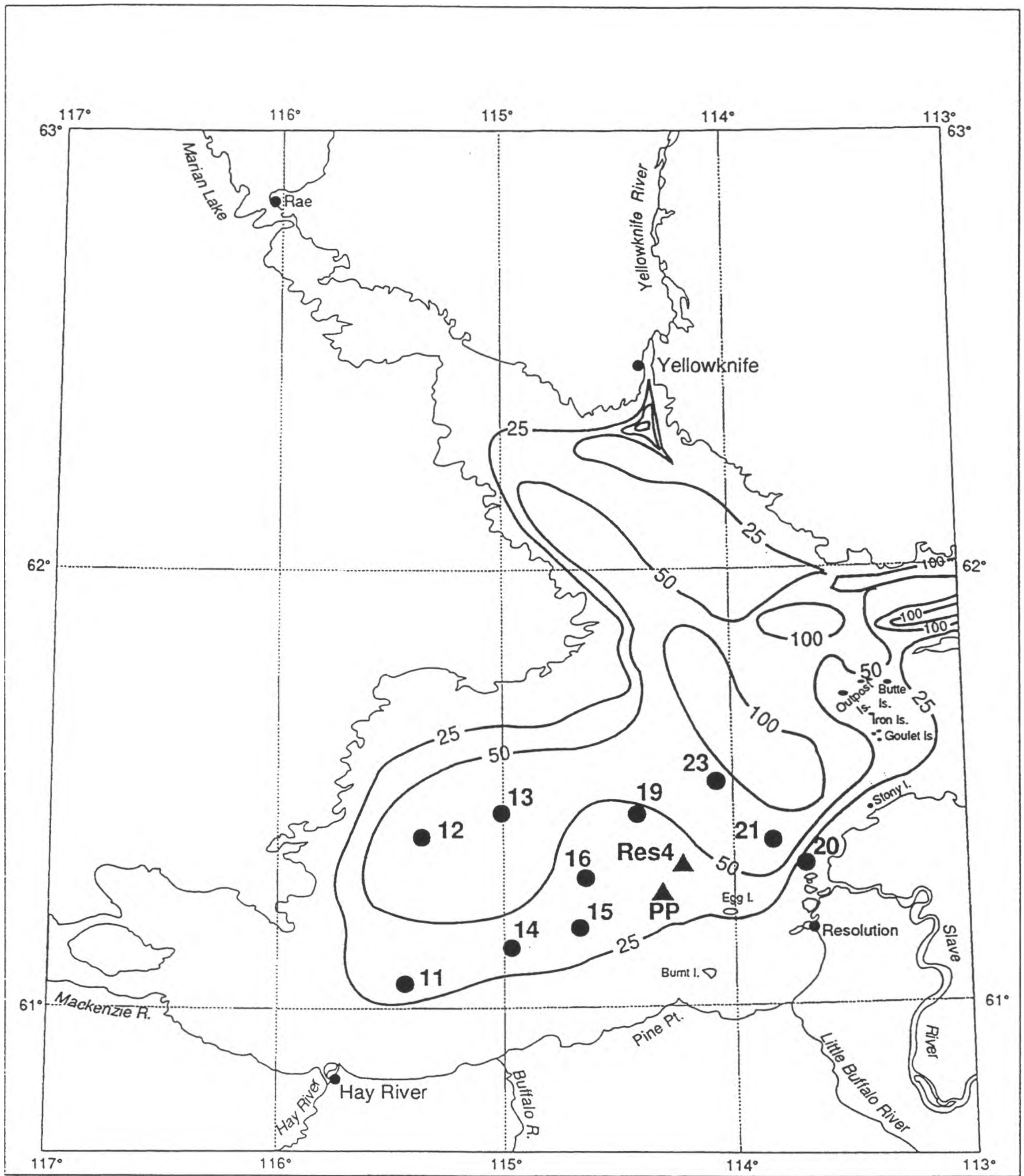


Figure 4. Map showing the location of sites sampled in the West Basin during March 1994. Also shown are the locations of Pine Point and Resolution 4 where cores were collected in August 1993.

Two sites were selected for core sampling - the outer most station (Resolution 4) of the Resolution Bay transect and a second station (Pine Point) to the west of Resolution 4. The core sites were relatively close to the Slave River mouth (where deposition rates were expected to be high) and in an area where the bottom topography was relatively flat (where slumping rates were expected to be low). We did not attempt to collect core samples offshore of the Slave River mouth. Mudroch et al. (1992) had collected two cores offshore of the river mouth. Both cores were in regions of strong sediment mixing and, for the more offshore core, slumping. Those cores were not amenable to meaningful dating.

Surficial sediment samples were collected with a stainless-steel PONAR. The PONAR was precleaned prior to the cruise with soap and water followed by a hexane and methanol rinse. During the cruise, it was maintained in a stainless steel tub and kept covered with plastic sheeting. At each station, the first two PONAR grabs were used for benthos samples with the final collection used for organic contaminant analysis. Upon retrieval of the PONAR, the sample was gently placed in the tub and the upper 2 - 3 cm of sediment removed with a clean, metal spatula and placed in a solvent-rinsed mason jar and in zip-lock bags. Sediment samples from Resolution 1 and Stony 1 consisted of hard-packed sands with little material retained by the PONAR. Insufficient material was collected in the grab for contaminant analysis. Given the fact that these sites clearly were in high erosion areas, no further effort was made to collect sufficient material for contaminant analysis.

A single core sample was collected at Resolution 4 and Pine Point using a Wildco-Ballcheck Multiple (4) corer. Each plexiglass core tube had a 5.1-cm internal diameter. Cores were sectioned at 1-cm intervals down to 30 cm and were placed in labeled, whirlpac bags.

In August 1994, three additional PONAR samples were collected. One was collected in Resolution Bay as part of a collection series designed to investigate organic contaminant biomagnification in West Basin food webs. Two samples were collected near Lutsel K'e in the East Arm. These sites were far removed from the influence of the Slave River. Previous research (Evans and Headley, 1993) suggested that PAH concentrations were higher in the West Basin than the East Arm.

3.2 FIELD SAMPLING - Sediment Cores

In March 1994, a sampling grid (Figure 4; Appendix C. Table 1) was designed to obtain a series of cores in various regions in the West Basin. The goal of the study was to obtain broad coverage of sedimentation rates with increasing distance from the Slave River outflow. Stations in shallow water (<30 m) were deleted from the study design when it became apparent that shallow-water sites did not provide good cores. Stations also were eliminated as extremely cold weather (<-20^{o}C) limited what could be accomplished during a day and during the study period.

A 6-passenger Bell 206L-1 helicopter was used to transport the scientific party and equipment to and from the sampling sites. Core samples were collected with a 10-cm internal diameter gravity corer which was gently lowered to the lake floor and allowed to settle in the sediments. Replicate cores (up to 5) were collected at each site by drilling a series of holes along a circular design which was ca. 10 m in diameter.

Cores were gently placed in the helicopter and then flown back to Hay River for sectioning. Some cores were sectioned at 0 - 1 cm, then 0.5-cm intervals down to 10-cm, followed by 1-cm intervals down to 20-cm and finally 2-cm intervals down to the bottom of the core. Other cores were sectioned at 0 - 1 cm, then 0.5-cm intervals down to 5-cm, followed by 1-cm intervals down to 8-cm and finally 2-cm intervals down to the bottom of the core. Visual observations of the core sections were recorded and later transcribed (Appendix C). Cores to be used for dating were placed in clean preweighed jars (VWR Scientific Traceclean) or in whirlpac bags. Cores to be used for contaminant studies were placed in clean but not preweighed jars. Samples were kept frozen until their shipment to Saskatoon (NHRI) or Burlington (NWRI) after which they were kept frozen at -20^oC (NWRI) or at -40^oC (NHRI).

Of the cores sent to Saskatoon, five cores (12B, 13B, 16A, 19B, and 23A) were selected for dating studies and were sent to the Freshwater Institute (FWI) for analysis. These five cores provide for a broad assessment of sedimentation patterns in the deeper regions of the West Basin from Pine Point to Hay River. Two of these dated cores (12B, 19B) were then analyzed for OCs and PAHs at FWI. The dated core from Site 23 was analyzed for PCCDs and PCCFs by EnviroTest Laboratories (Edmonton) and through FWI. Core 19D (see below) also was analyzed for PCDDs and PCDFs.

Two cores from Site 13 and two from Site 19 were sent to NWRI. Cores 13C and 19D were dated. Results of the dating analyses and other analyses (specific gravity, porosity) are reported by Turner (1994a,b). These cores also were analyzed for total organic carbon (TOC), total inorganic carbon (TIC), and total organic nitrogen (TON): results are presented in this report. Cores 13C and 19D were then sent to FWI. According to the terms of reference, the original intent of sending the two cores to FWI was to conduct an interlaboratory comparison of dating estimates (Appendix A). However, Cores 13B and 13C had similar sedimentation rates as did Cores 19B and 19D: therefore, greater scientific importance was placed on dating additional cores and conducting organic contaminant analyses on the dated cores. Thus, Core 19D was used for PCDD and PCDF analyses. Time constraints precluded dating a third core from Site 19 at FWI and completing the PCDD and PCDF analyses in the same fiscal year. Cores 13E and 19C, which reside at NWRI, were analyzed for biogeochemical markers including PAHs: results are reported in Bourbonniere et al. (1996). In the following paragraphs, methods are provided for analyses conducted or supervised by FWI and for the TOC and TON analyses conducted at NWRI.

3.3 LABORATORY METHODS - Sediment Porosity and Related Measurements

Core samples for dating studies were first weighed and the wet weight of the sample estimated by subtracting the jar (whirlpac) weight from the samples plus jar (whirlpac) weight. The frozen sample was then freeze-dried in a Virtis Model No. 10-146MR-BA freeze-drier. The sample was reweighed and the dry weight and the percent water content of the sample calculated.

Porosity is an estimate of the volume of sediment sample which is occupied by water. Variation in porosity with depth provide an approximate indication of variations in the packing of sedimentary particles and/or particle size. Porosity is not related to the permeability of sediments to water. High porosity clays are less permeable to water movement than low porosity sands (Keller, 1979).

A mean specific gravity of 2.65 (Turner, 1994a, b) was used to convert sample dry weight into sediment volume. Total sample volume was the sum of the sediment weight and the water weight. Porosity is calculated by dividing the water volume of the sample by the total sample volume.

For each of the core slices, actual sample slice thickness was estimated and compared with the nominal slice thickness. Sample slice thickness was estimated by dividing the total sample volume (in cm^3) by the surface area (internal) of the corer. In some instances, where a core was difficult to slice, estimated slice depths were less than nominal slice depth. The areal cumulative dry weight of sediment was calculated for each slice by summing the dry weight of that slice with the cumulative dry weight of the overlying slices and dividing the sum by the surface area of the corer. Similarly, the areal cumulative excess ^{210}Pb was calculated for each slice by summing the excess ^{210}Pb of that slice with the cumulative excess ^{210}Pb of the overlying slices and dividing the sum by the surface area of the corer.

Only Cores 13C and 19D were analyzed for carbon and nitrogen because of funding considerations. Analyses were performed at the National Laboratory for Environmental Testing (NLET) at NWRI. Analyses were performed using a CHN analyzer at 950°C. An aliquot of the freeze-dried sediment sample was combusted in the presence of CoO catalyst and the resulting combustion gases (NO_x, which is reduced to N_2, and CO_2) were measured chromatographically. The first analysis provides the concentration of "total carbon" and "total nitrogen". Another aliquot was treated with hydrochloric acid to remove inorganic carbon, dried, and combusted as described above. The second analysis provides the concentrations of total organic carbon and total organic nitrogen. Total inorganic carbon (TIC) was determined from the difference of total and organic carbon. The atomic C/N ratio of the organic matter in the sediments was calculated by dividing TOC by TON.

3.4 LABORATORY METHODS - Dating

Sediments were dated using two methods: ^{137}cesium (Cs) and ^{210}lead (Pb). The former method is based on the fact that large amounts of ^{137}Cs were released into the atmosphere with the atmospheric nuclear device testing which occurred during the 1950s and 1960s. The most intense testing occurred during the early 1960s peaking in 1963 and declining thereafter. Assuming that ^{137}Cs has a one-year residence time in the water column (Robbins, 1982), a ^{137}Cs peak in the sediment can tentatively be assigned a median date of 1964. A mean sedimentation rate ($g/cm^2/y$) can then be estimated by dividing the cumulative dry weight of sediments from the surface slice down to the ^{137}Cs maximum by 30 years (1994 - minus 1964). However, the mean sedimentation rate is more accurately estimated by the ^{210}Pb method.

The theory behind the ^{210}Pb method is well-described by Robbins (1978) and Robbins et al. (1978). Simply stated, it is based on the fact that the radioactive gas radon (^{222}Rn) is released from the earth's crust into the atmosphere. ^{222}Rn has a short half-life (3.8 days) and decays into ^{210}Pb which has a half-life of some 22.3 years. ^{210}Pb then returns to the earth through various scavenging processes, e.g., rain, snow, dry fallout. Unlike ^{137}Cs, the flux of ^{210}Pb to the lake surface is assumed to be constant from year to year although flux rates vary with latitude. ^{210}Pb is transported to the lake sediments through adsorption onto particles and the subsequent sinking of those particles to the lake floor. Assuming that sedimentation rates are constant and, once deposited, not disturbed, ^{210}Pb concentrations decrease with depth in the sediments as ^{210}Pb decays. However, some ^{210}Pb (called supported) is produced in situ from the radioactive decay of ^{226}Ra which has a half-life of 1,622 years. The atmospherically-derived ^{210}Pb (excess or unsupported ^{210}Pb) is estimated by subtracting total ^{210}Pb activity for the ^{226}Ra activity.

Sedimentation rates are estimated by plotting excess ^{210}Pb (log scale) against the cumulative dry weight of sediment. Three models can be used. All models assume a constant flux rate of ^{210}Pb to the lake surface. The simplest model is a linear model (Robbins et al., 1978) and makes no other assumptions about sedimentation rates or factors affecting the sedimentation profile. The second model, the constant flux model (Oldfield and Appleby, 1984), assumes that sedimentation rates vary with time and adjusts date estimates for variations in these rates. The third model, the Rapid Steady State Mixing Model (Robbins, 1982), adjusts for the rapid mixing of sediments which can occur in the upper few centimeters of sediments. This mixing is generally associated with bioturbation by the benthos, with oligochaetes and, to a lesser extent, amphipods being particularly effective in mixing sediments.

Radiochemical analyses of the sediments were carried out using a number of analytical techniques. ^{137}Cs and ^{226}Ra were determined using non-destructive techniques. First, for each core slice, a 5 - 10 g of sediment sample was sealed in 60 x 15 mm plastic petri dish and aged for 30 days (to allow ^{226}Ra and its daughters to come to equilibrium). The isotopes were then counted on a gamma spectrometer equipped with a Ge(Li) semi-conductor detector. In some cases, counting was done on a hyperpure germanium crystal and ^{210}Pb was determined along with ^{37}Cs and ^{226}Ra (Joshi, 1987). ^{137}Cs was determined on all slices while ^{226}Ra was determined on selected slices using the radon de-emanation technique (Mathieu, 1977; Wilkinson, 1985). ^{137}Cs analyses were used to provide the first indication as to whether or not the core was collected in a non-disturbed depositional site. Two criteria were used - the detection of ^{137}Cs in the surface slices and the presence of a ^{137}Cs peak at greater depth. The absence of ^{137}Cs in the surface slices indicated that the surface sediments were relatively old sediments (i.e., they originated prior to the early 1960s) and that the core had been collected from an erosional area of the lake.

Most ^{210}Pb analyses were performed using destructive techniques. One to three gram subsamples were leached in 6N HCL and in the presence of a ^{209}polonium (^{209}Po) tracer. The extract was then autoplated onto a silver plate following the methods outlined in Flynn (1968). The disc was then counted on an alpha spectrometer to determine the activity of ^{210}Po (^{210} Po and ^{210}Pb are presumed to be in equilibrium).

The sediment slice mean ages were determined using the three ^{210}Pb models: the linear fit model, the constant flux model, and the Rapid Steady State Mixing (RSSM) model. Data were plotted as excess ^{210}Pb (log scale) against the cumulative dry weight to provide for a visual display of the sedimentary excess ^{210}Pb record. The linear regression model was then plotted on the graph and the data examined more closely. Data points which deviated from the model provided strong evidence of postdepositional sediment movement. Values to the left of the regression line (i.e., older sediments than predicted) suggest the erosion of older sediments from one region of the lake into the region where the core was collected. Values to the right of the regression line (i.e., younger sediments than predicted) suggest the loss of sediments from the study site, i.e., a gap in the sedimentary record. In Lakes Ontario and Erie, Robbins et al. (1978) related such erosional events to storm activity which were of sufficient intensity to mobilize deep-water sediments.

Sediment focusing was estimated by assuming a mean areal input of ^{210}Pb of 55 Bq/m^2/year to the sediment. This was divided into the areal excess ^{210}Pb flux (Bq/m^2/year) to the sediments.

3.5 LABORATORY METHODS - Organochlorines and Polyaromatic Hydrocarbons

Sediment samples were analyzed for 130 individual OC compounds (90 PCB congeners, toxaphene, and more than 40 pesticides and related compounds) and for PAHs. Subsamples (5 - 10 g) of freeze-dried sediments were Soxhlet-extracted with dichloromethane (DCM) for 16 hours. Sulfur was removed using activated copper (Cu) filings. The DCM extract was split 1:1 for determination of OCs and PAHs. Internal standards of PCB30, aldrin and octochloronaphthalene (OCN) and standards of deuterated PAHs were added at the extraction step.

OCs were isolated on a Florisil column to separate PCBs, p,p'-DDE and trans-nonachlor (hexane elute) from most chlorinated bornanes (toxaphene), chlordanes, and DDT-related compounds. Florisil eluates were then analyzed by capillary gas chromatography with electron capture detection (GC-ECD) using a 60 m x 0.25 mm i.d., DB-5 column with H_2 carrier gas. Individual PCB congeners, HCH, chlorobenzenes, DDT- and chlordane-related compounds were quantified using external standards. Toxaphene was quantified using a single response factor based on 27 peaks in the technical toxaphene standard. Confirmation of PCBs was carried out by GC-mass spectrometry using a HP5971 MSD. Chlorinated bornanes were confirmed by electron-capture negative ion mass spectrometry on a Kratos Concept high resolution mass spectrometer (EBE geometry) controlled using a Mach 3X data system.

To recover PAHs, the extract was chromatographed on a silica column (topped with 1 cm alumina) and eluted with hexane (to recover alkanes) followed by hexane:DCM (1:1) for two to six ring PAHs. PAHs were quantified by gas chromatography on a Hewlett-Packard Model 5890 equipped with a mass selective detector (model HP5970) using a 30 m x 0.25 m (0.25 µm film thickness) DB5MS capillary column. For PAHs, 2 µl of extract were injected splitless and the split vent was opened after 30 sec. Initial oven temperature was 110^{o}C and was programmed at 10^{o}C/min to 120 ^{o}C, then 20 ^{o}C/min. to 250 ^{o}C and then at 5 ^{o}C/min to 285 ^{o}C. Helium was the carrier gas and the HP5890 gas chromatograph was equipped with Electronic Pressure programming. A four-point calibration table, which included six deuterated internal standards, was used for quantification and relative retention times of unknowns, as well as a system check with surrogates.

3.6 LABORATORY METHODS- PCDDs and PCDFs

Sediment samples were analyzed for PCDDs and PCDFs by EnviroTest Laboratories in Edmonton. Sediment samples were extracted as outlined in U. S. EPA method 1613 (USEPA, 1990). In brief, a 5 - 20 g subsample was homogenized and thoroughly mixed with 80 g of anhydrous sodium sulfate. The resulting sample was then packed into a large Soxhlet apparatus containing a plug of glass wool.

Next, ^{13}C-labeled PCDD surrogates dissolved in acetone were added to the sample and the sample was extracted with 300 mL dichloromethane for 16 hours. The extraction solvent was then transferred to a 200 mL TurboVap nitrogen evaporator tube and concentrated. The concentrated extract was solvent-exchanged twice with 5 mL hexane, transferred to a 25 mL glass centrifuge tube, and brought up to 15 mL in hexane.

Initially the 15 mL hexane extract was partitioned against concentrated sulfuric acid and partitioning repeated until the hexane became clear. The spent acid was discarded. The acid-partitioned hexane was then subjected to three chromatographic column cleanups as previously described. Next, the extract was concentrated to complete dryness and redissolved in 20 µL on nonane containing ^{13}C-1,2,3,4-T_4CDD and ^{13}C-1,2,3,7,8,9-H_6CDD as the instrument internal standard.

Analysis of sample extracts was performed using a Kratos Concept high-resolution mass spectrophotometer interfaced with a Hewlett Packard Series 11 gas chromatograph and a Sun data system. The chromatograph column employed was a 50 m x 0.2 mm I.D. HP Ultra 2 with a 0.11 µm film thickness. The carrier gas was helium at a linear velocity of 34 cm/sec and at a temperature of 280^{o}C. The resolution of the mass spectrophotometer was maintained at 10,000. The oven temperature was 140^{o}C for 1.0 min., then 15 C^{o}/min. to 175^{o}C, then 2 C^{o}/min. to 220 ^{o}C, and then 8 C^{o}/min. to 280^{o}C, 285^{o}C, and 290^{o}C, respectively. One microliter of each of the cleaned extracts was injected into the gas chromatograph using splitless injection and the injector purge valve was activated 0.75 minutes after injection.

3.7 LABORATORY METHODS - Quality Assurance

Quality control procedures included the analysis of certified reference materials for PAHs and OCs in sediments. Recovery of internal standards was checked in each sample and samples with low recoveries (generally <70%) were reextracted. Blank and duplicate samples were run approximately every 10 samples to check contamination of reagents and glassware and reproducibility. During 1995, the laboratories also participated in several interlaboratory comparisons on PCB congeners and on PAHs.

4.0 RESULTS

4.1 SURFICIAL SEDIMENTS

Sediments offshore of Resolution Bay, the Slave River mouth, and Stony Point consisted of fine, hard packed sands which were not readily retained by the PONAR. Sediments elsewhere consisted on a brown, silty clays (Table 1). Subsamples were shipped to FWI, without freeze-drying, for analysis. All surficial sediments were analyzed for OCs, PAHs, PCDDs, and PCDFs.

Table 1. Depth and sediment types for the 12 sites investigated in the Slave River delta, August 1993. A * denotes sites where surficial sediments were not retained for organic contaminant analysis.

Site	Depth	Sediment type
Resolution Bay 1*	7 m	fine, hardpacked sand
Resolution Bay 2	16 m	brown, silty clay
Resolution Bay 3	35 m	brown, silty clay
Resolution Bay 4	28 m	brown, silty clay
Pine Point	24 m	brown, silty clay
Delta 1	8 m	fine, hardpacked fine sand, some silty clay
Delta 2	64 m	brown, silty clay, some organic debris
Delta 3	67 m	brown, silty clay
Delta 4	32 m	brown, silty clay
Stony Point 1*	8 m	fine, hardpacked fine sand, some silty clay
Stony Point 2	64 m	brown, silty clay
Stony Point 3	88 m	brown, silty clay

4.1.1 Organochlorines

PCBs were the predominant organochlorine found in surficial sediments in the Slave River delta region (Figure 5; Appendix B. Table 2) for the August 1993 sampling. Concentrations ranged from 4.8 - 15.2 ng/g and averaged 9.8 ng/g ±4.3 ng/g. Chlorobenzenes (CBZ) were the next most abundant class of compounds (0.2 - 1.3 ng/g, mean = 0.7 ng/g ± 0.3 ng/g) followed by total DDT (0.5 ± 0.3 ng/g), HCH (0.4 ± 0.1 ng/g), chlordane (0.3 ± 0.2 ng/g) and dieldrin (0.08 ± 0.03 ng/g).

Toxaphene (0.7 ± 1.2 ng/g) was detected at only four stations. These samples will be re-examined at a later date using mass-spectroscopy techniques which provide for superior resolution of toxaphene in lake sediments. Total PCBs showed a weak tendency to occur in highest concentrations in the deeper, more offshore waters. There was no obvious pattern in the distribution of the other OCs with respect to distance from the Slave River mouth or with water column depth. However, because the sediments in this region are physically dynamic, i.e., subject to resuspension in shallow waters and down-slope slumping in deeper regions of the lake, the failure to detect spatial patterns in OC distribution relative to the Slave River mouth was not unexpected.

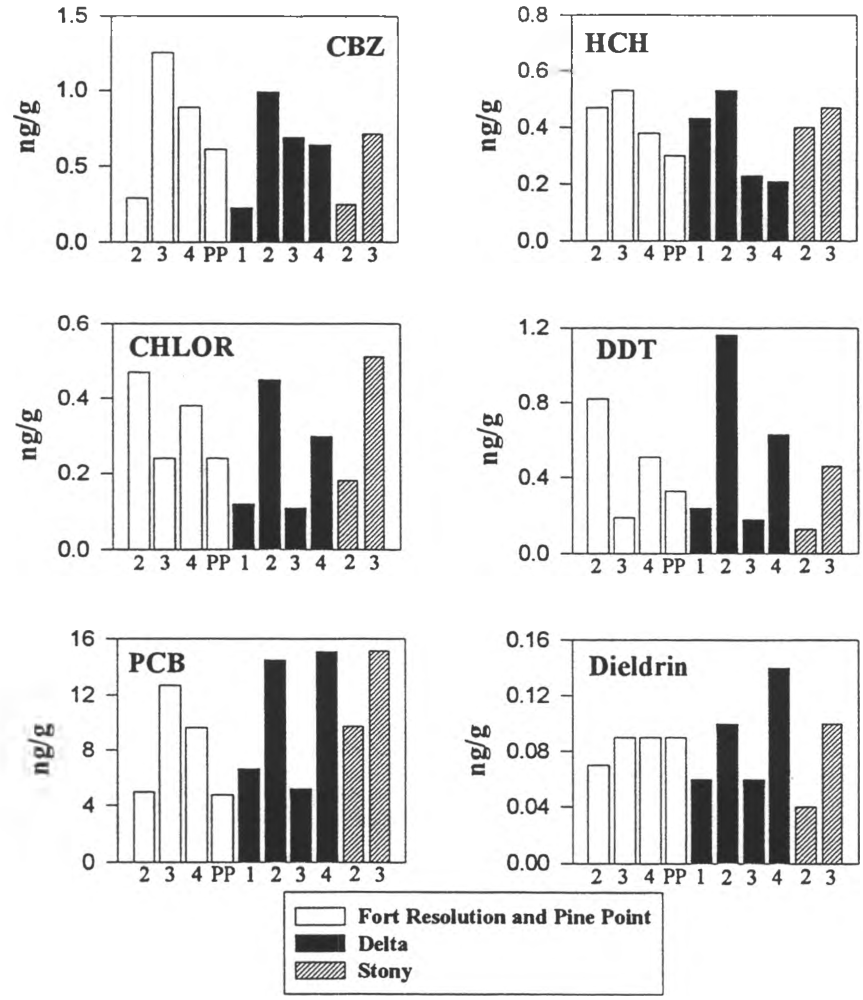


Figure 5. Concentrations (ng/g dry weight) of the predominant organochlorine compounds detected in surficial sediments in the Slave River delta region, August 1993 collections.

PCBs were dominated by mono and dichlorobiphenyls (4.3 ± 3.3 ng/g) which accounted for an average of 40.0% ± 22.7% of total PCBs (Figure 6, Table 2) . Trichloro- (1.6 ± 0.7 ng/g; 18.2% ± 8.7% of total PCBs), penta- (1.2 ± 0.4 ng/g; 14.3% ± 9.3% of total PCBs) and hexachlorobiphenyls (1.7 ± 1.5 ng/; 16.6% ± 10.3% of total PCBs) also were major components of total PCBs. The dominance of total PCBs by the volatile, lower chlorinated congeners suggests that the atmosphere was the primary source of these PCBs (Mudroch et al., 1992). Atmospheric PCBs may have entered Great Slave Lake directly (wet and or dry deposition) or may have been deposited elsewhere in the watershed and entered the lake with the Slave and other river inflow.

There was no obvious pattern in congener concentration with respect to distance from the Slave River mouth or water column depth. Eleven congeners accounted for 5% or more of total PCBs at one or more sites (Table 2). These were congeners 1, 3, 08/05, 17, 18, 31, 83, 91, 110, 149, and 153. The most common were: congener 3 at 5 sites; congeners 08/05 at 7 sites; and congener 153 at 6 sites. Most congeners occurred at very low concentrations and frequently were below detection limits.

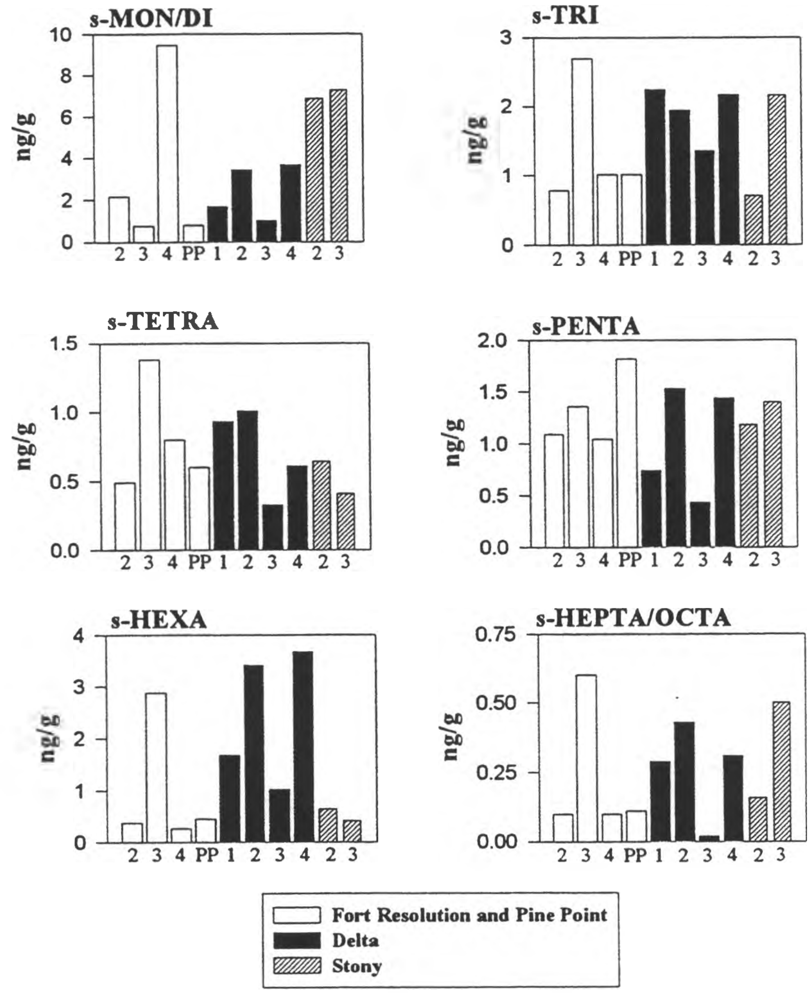


Figure 6. Concentrations of PCBs (ng/g dry weight) by chlorine number in surficial sediments in the Slave River delta region, August 1993 collections.

Table 2. PCB Congeners in Surficial Sediments. Concentration of PCB congeners (ng/g dry weight) in surficial sediments, offshore of the Slave River Mouth, August 1993. Bold denotes a congener accounted for more than 5% of total PCBs in that sample.

CONGENERS		FR-2	FR-3	FR-4	PP	D-1	D-2	D-3	D-4	S-2	S-3
MON/DI	1	<0.01	<0.01	**8.83**	<0.01	<0.01	<0.01	<0.01	<0.01	**6.61**	<0.01
	3	**1.77**	<0.01	<0.01	<0.01	<0.01	**4.44**	**1.77**	**5.19**	<0.01	**5.77**
	04/10	<0.01	<0.01	0.13	<0.01	<0.01	0.69	<0.01	0.55	0.04	0.68
	6	0.07	0.14	0.13	<0.01	0.14	0.14	<0.01	<0.01	0.08	<0.01
	7	<0.01	0.06	0.05	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01
	08/05	0.30	**0.55**	0.30	**0.78**	**0.59**	**0.86**	**0.28**	**1.15**	0.14	**0.84**
	SUM	2.14	0.75	9.44	0.78	0.78	6.13	2.05	6.89	6.87	7.29
TRI	16/32	0.06	0.23	0.13	0.08	0.22	0.23	0.11	0.26	0.07	0.20
	17	0.20	0.33	0.28	**0.55**	**0.34**	0.23	0.17	0.26	0.16	0.25
	18	0.16	**0.55**	0.25	0.11	**0.51**	0.44	**0.26**	0.65	0.22	0.72
	19	<0.01	0.13	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	22	0.07	0.12	0.10	0.04	0.09	0.08	0.06	0.08	0.06	0.06
	24/27	0.02	0.05	<0.01	<0.01	0.04	0.06	0.03	<0.01	0.04	<0.01
	25	0.05	0.09	0.04	<0.01	0.03	<0.01	0.07	<0.01	<0.01	<0.01
	26	<0.01	0.08	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	<0.01
	28	0.07	0.27	0.04	0.08	0.24	0.13	0.12	0.14	0.04	0.15
	31	0.09	**0.58**	0.07	0.07	**0.48**	0.66	**0.43**	0.64	0.07	0.65
	33	0.06	0.26	0.10	0.08	0.23	0.11	0.11	0.14	0.05	0.13
	SUM	0.78	2.69	1.01	1.01	2.24	1.94	1.36	2.17	0.71	2.16
TETRA	40	<0.01	0.10	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01
	41/71	0.02	<0.01	0.15	0.03	<0.01	0.17	<0.01	<0.01	0.17	<0.01
	42	0.03	0.08	0.04	0.03	0.04	<0.01	<0.01	<0.01	<0.01	<0.01
	44	0.04	0.15	0.07	<0.01	0.12	0.08	0.06	0.09	0.03	0.08
	45	<0.01	0.08	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	46	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	<0.01	0.09	<0.01
	47	<0.01	0.06	<0.01	<0.01	0.08	0.09	0.06	<0.01	0.02	<0.01
	48	0.03	<0.01	0.06	0.05	<0.01	0.08	<0.01	<0.01	0.03	<0.01
	49	0.06	0.20	0.04	0.07	0.09	0.12	<0.01	0.09	<0.01	<0.01
	52	0.04	0.27	0.09	<0.01	0.21	0.14	0.12	0.12	0.05	0.10
	56/60	0.06	0.07	<0.01	0.03	0.04	0.10	<0.01	0.17	0.01	0.11
	64	0.08	0.11	0.22	0.12	0.11	0.12	<0.01	<0.01	0.10	<0.01
	70/76	0.07	0.18	0.06	0.06	0.12	0.11	0.05	0.07	0.06	0.06
	74	0.06	0.08	0.07	0.10	0.07	<0.01	0.04	0.07	0.08	0.06
	SUM	0.49	1.38	0.80	0.60	0.93	1.01	0.33	0.61	0.64	0.41

Table 2, continued.

CONGENERS		FR-2	FR-3	FR-4	PP	D-1	D-2	D-3	D-4	S-2	S-3
PENTA	82	<0.01	0.05	<0.01	<0.01	<0.01	0.13	<0.01	0.11	<0.01	0.29
	84/89	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	0.15	<0.01	<0.01
	83	0.40	0.09	0.58	**0.85**	0.03	<0.01	<0.01	<0.01	**0.84**	<0.01
	85	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.14	<0.01	<0.01
	87	<0.01	0.07	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01
	91	**0.26**	0.07	0.13	**0.52**	<0.01	<0.01	<0.01	<0.01	0.06	<0.01
	95	0.09	0.38	0.11	0.09	0.28	0.11	0.12	0.12	0.05	0.09
	97	0.02	0.05	<0.01	0.04	0.03	0.06	<0.01	0.08	<0.01	0.07
	99	0.04	0.07	0.04	<0.01	0.04	0.10	<0.01	0.20	0.03	0.19
	101	0.04	0.26	0.05	<0.01	0.18	0.08	0.09	0.07	0.03	<0.01
	110	0.20	0.26	0.08	**0.29**	0.11	0.90	0.19	0.54	0.09	0.73
	114	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01
	118	0.04	0.06	0.05	0.03	0.03	0.06	0.03	0.03	0.08	0.03
	SUM	1.09	1.36	1.04	1.82	0.74	1.53	0.43	1.44	1.18	1.40
HEXA	128	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09
	130/176	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	131	<0.01	<0.01	<0.01	0.05	<0.01	0.08	<0.01	0.14	0.02	0.15
	132	<0.01	0.18	<0.01	<0.01	0.10	<0.01	<0.01	<0.01	<0.01	<0.01
	136	<0.01	0.11	<0.01	<0.01	0.08	<0.01	<0.01	<0.01	<0.01	<0.01
	138	0.05	0.24	0.03	0.04	0.12	0.09	0.05	0.08	0.02	0.07
	141	<0.01	0.18	<0.01	<0.01	0.10	0.13	0.05	0.11	<0.01	0.10
	144/135	<0.01	0.21	<0.01	<0.01	0.11	0.14	0.04	0.07	<0.01	<0.01
	146	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	0.44	<0.01	<0.01
	149	0.07	**0.56**	<0.01	0.13	**0.35**	0.29	0.12	0.18	<0.01	0.14
	151	<0.01	0.28	<0.01	<0.01	0.16	<0.01	0.07	<0.01	<0.01	<0.01
	153	0.24	**0.99**	0.24	0.23	**0.66**	**2.69**	**0.70**	**2.65**	**0.15**	**2.85**
	158	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	SUM	0.38	2.88	0.27	0.45	1.68	3.42	1.03	3.67	0.19	3.40

Table 2, continued.

CONGENERS		FR-	FR-3	FR-4	PP	D-1	D-2	D-3	D-4	S-2	S-3
HEPTA	137	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	<0.01
	156	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	0.04
	170	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
	174	0.03	0.08	<0.01	0.02	0.04	<0.01	<0.01	<0.01	0.01	0.07
	177	0.02	0.05	0.03	0.03	0.02	<0.01	0.02	0.06	0.04	0.05
	178/129	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	179	0.03	0.14	0.04	0.04	0.08	0.07	<0.01	0.09	0.04	<0.01
	180	0.02	0.07	<0.01	0.02	0.03	0.05	<0.01	<0.01	<0.01	<0.01
	183	<0.01	0.08	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01
	187	<0.01	0.15	<0.01	<0.01	0.08	<0.01	<0.01	<0.01	<0.01	<0.01
	191	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	0.10
	193	<0.01	<0.01	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	0.16
	SUM	0.10	0.60	0.07	0.11	0.29	0.36	0.02	0.19	0.10	0.42
OCTA	199	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	<0.01	0.06	<0.01	0.08
	201/157	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	0.06	0.06	<0.01
	SUM	0.00	0.00	0.03	0.00	0.00	0.07	0.00	0.12	0.06	0.08
TOTAL PCBs		4.98	9.66	12.66	4.77	6.66	14.46	5.22	15.09	9.75	15.16

Total DDT occurred as: o, p - DDE; p, p-DDE; o, p-DDD; p, p-DDD; o, p-DDT; and p, p-DDT (Figure7, Appendix B. Table 3). Concentrations were highly variable and patterns in concentration relative to the Slave River outflow were not readily apparent. DDE accounted for an average of 31.9% of total DDT, DDD an average of 22.8% of total DDT, and DDT an average of 29.0% of total DDT.

Total hexachlorohexane consisted of: α-HCH accounting for an average of 38.5% of total HCH, β-HCH accounting for an average of 25.6% of HCH, and γ-HCH accounting for an average of 35.9% of total HCH (Figure 8). Concentrations were highly variable from site to site.

Pentachloroanisole (PCA), trichloroveratrole (3cl-ver), and tetrachloroveratrole (4cl-ver) were detected in the surficial sediments (Figure 9): all three compounds are believed to be indicative of a pulp and paper mill source (Neilson et al., 1984). Trichloroveratrole was the most abundant of the three compounds: concentrations tended to be highest offshore of the Slave River. Highest pentachloroanisole concentrations also occurred offshore of the Slave River mouth although concentrations were low at two stations - Delta 2 and Delta 4. Low concentrations of tetrachloroveratrole were detected with concentrations highest offshore of Fort Resolution and at Delta 1 and Delta 3, offshore of the Slave River mouth.

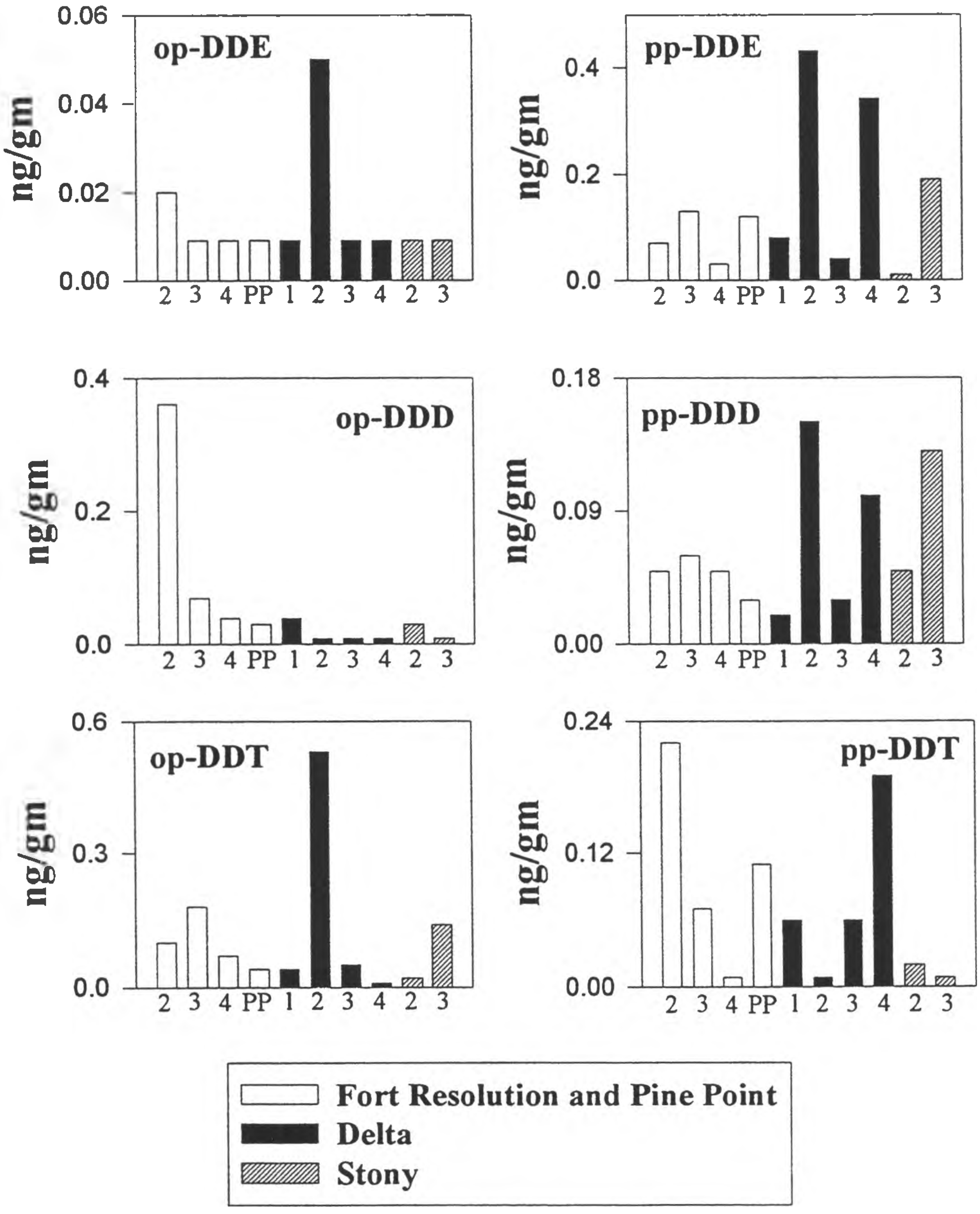


Figure 7. Concentrations of the various forms of DDT (ng/g dry weight) detected in surficial sediments in the Slave River delta region, August 1993 collections.

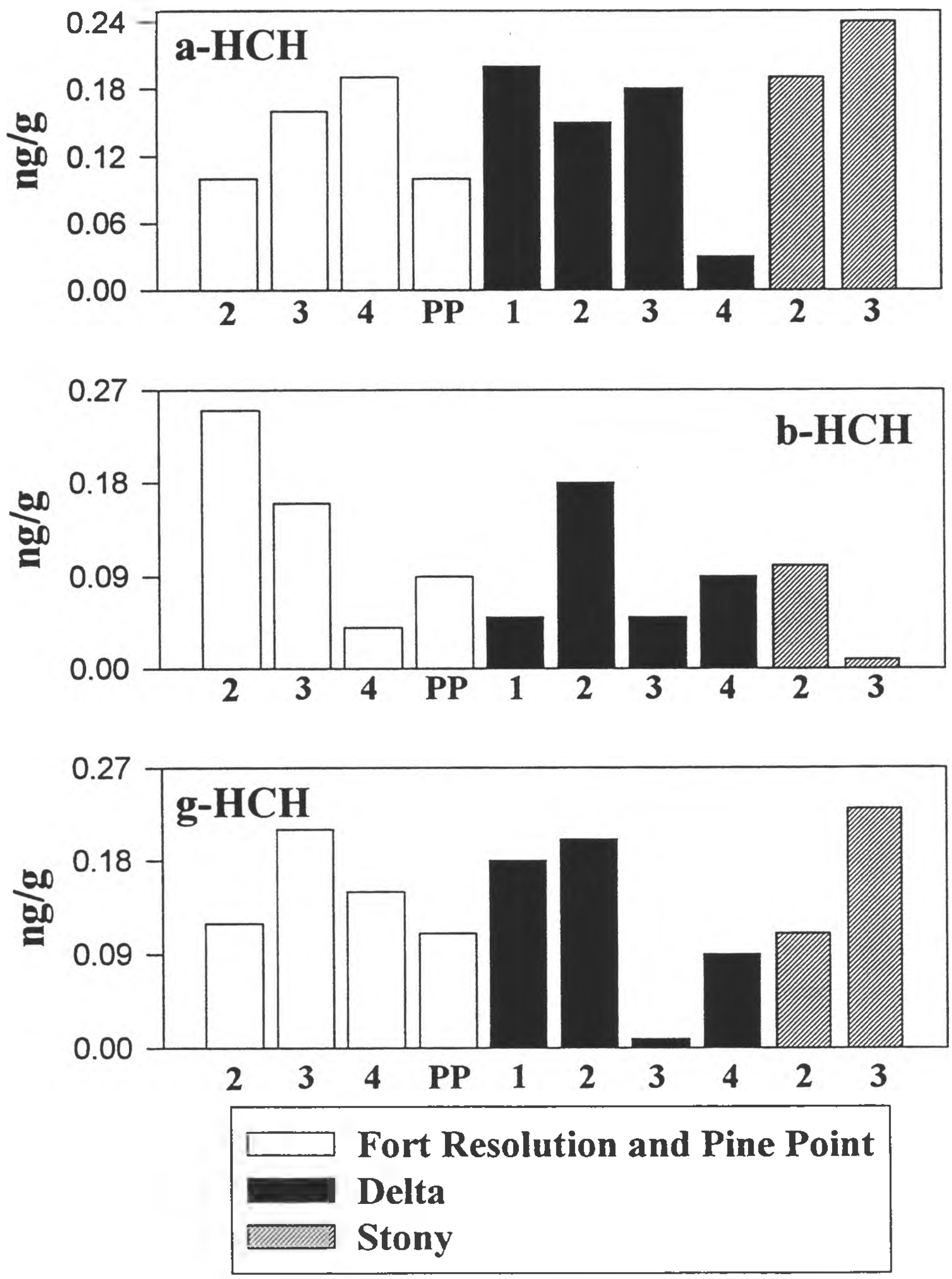


Figure 8. Concentrations of the various forms of hexachlorohexane (ng/g dry weight) detected in surficial sediments in the Slave River delta region, August 1993 collections.

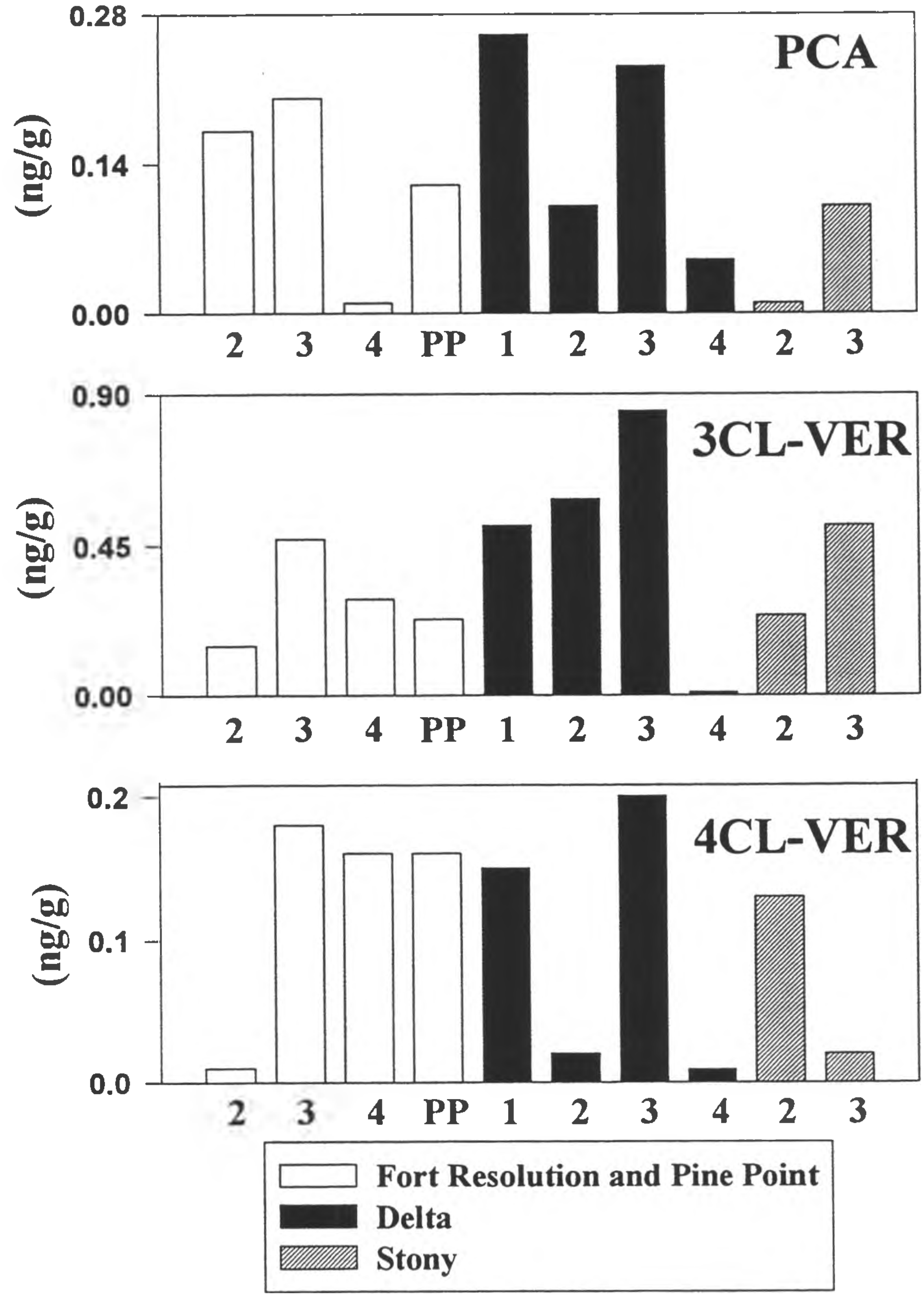


Figure 9. Concentrations of pentachloranisole, trichloroveratrole, and tetrachloroveratrole (ng/g dry weight) detected in surficial sediments in the Slave River delta region, August 1993 collections.

4.1.2 PAHs

PAHs were subdivided into two categories (Table 3). Category 1 included PAHs which are produced by combustion and/or have sources in the oil/gas industry (Tan and Heit, 1981; Bjorseth and Ramdahl, 1985; Kristofer, 1985; Ramdahl, 1985). Category 2 are PAHs which are believed to be produced in situ and from other sources, e.g., plant material. Perylene apparently is produced in reducing environments in lake sediments and from natural terrestrial and possibly aquatic plant precursors (Tan and Heit, 1981). Similarly, retene is produced in reducing environments and from the biogenic conversion of terpenoid compounds in higher plants (Tan and Heit, 1981): however, Ramdahl (1985) notes that retene can be produced from the combustion of coniferous wood.

Table 3. PAH Nomenclature Abbreviations

Category 1	Abbreviation	Category 2	Abbreviation
Acenaphthene	AN	Dibenzofuran	DF
Acenaphthylene	AC	Dibenzothiophene	DT
Anthracene	A	Retene	R
Benzo(a)anthracene	B(a)A	Perylene	PER
Benzo(a)pyrene	B(a)PY	Triphenylene	TP
Benzo(b)fluoranthene	B(b)FL		
Benzo(e)pyrene	B(e)PY		
Benzo(g,h,i)perylene	B(g,h,i)PER		
Benzo(k)fluoranthene	B(k)FL		
Chrysene	C		
Dibenzo(a,h)anthracene	D(a,h)A		
Fluoranthene	FL		
Fluorene	F		
Indeno(1,2,3-c,d)pyrene	I(1,2,3-c,d)PY		
1-Methylnaphthalene	1-MeN		
2-Methylnaphthalene	2-MeN		
Napthalene	N		
Phenanthrene	P		
Pyrene	PY		

Dibenzothiophene is associated with crude oils (Wang et al., 1994), shale oils (Willey et al., 1981) and coal (White and Lee, 1980), while dibenzofuran has been associated with coal (White and Lee, 1980; Burkhard and Sheedy, 1995). Triphenylene also has been associated with coal (Burkhard and Sheedy, 1995).

Total PAH (Category 1) concentrations ranged from 466.0 - 726.6 ng/g for the ten stations sampled in August 1993 (Table 10, Appendix B. Table 4). Highest concentrations were observed at Delta 1, Delta 2 and Delta 3 which were offshore of the Slave River mouth. Mean concentrations of PAHs at these three stations (639.3 ± 77.7 ng/g) were some 24.4% higher than mean concentrations at the other seven stations (514.0 ± 25.4 ng/g).

The most abundant Category 1 PAHs were the higher molecular weight compounds: benzo(g,h,i)perylene accounting for an average of 16.4 ± 3.4% of total PAHs; benzo(e)pyrene accounting for an average of 16.1 ± 0.8% of total PAHs; phenanthrene accounting for an average of 12.4 ± 1.2% of total PAHs; and benzo(b)fluorathene accounting for an average of 10.0 ± 0.7% of total PAHs (Table 4). With the exception of phenanthrene, these dominant PAHs were the high molecular weight PAHs: as such, they probably originated from combustion activities (Yunker and Macdonald, 1995). These heavier compounds have lower water-solubilities than the lighter-weight PAHs: thus they may adsorb more rapidly onto particulates and settle more quickly from the water column than the lighter-weight PAHs. Highest concentrations were observed at Delta 1. Compounds of secondary abundance (5 - 10 % of total PAHs) were naphthalene (7.1 ± 0.8%), indeno(1,2,3-cd-)pyrene (6.2 ± 1.1%) and chrysene (5.7 ± 0.5%). Naphthalene is a low molecular weight PAH which probably originated from a petroleum or petrogenic source although napthalenes also have combustion sources (Ramdahl, 1985; Yunker and Macdonald, 1995). Highest concentrations also were observed at Delta 1.

Four compounds comprised the Category 2 PAHs (Figure 11, Appendix B. Table 4). Perylene (244.6 ± 72.3 ng/g) and retene (69.8 ± 15.3 ng/g) tended to occur in greatest concentrations in shallow waters, particularly Delta 1. Dibenzofuran (10.6 ± 2.0 ng/g) and dibenzothiophene (11.0 ± 1.7 ng/g) concentrations were low with highest concentrations also at Delta 1. As previously noted, dibenzofuran and diobenzothiophene have been detected in coal (White and Lee, 1980). Thus, dibenzofuran and diobenzothiophene may enter Great Slave Lake from coal combustion sources. Dibenzothiophene also is associated with oils and tar sands: it may enter Great Slave Lake from natural and industrial sources along the Peace and Athabasca Rivers.

Table 4. Percent composition of Category 1 PAHs in surficial sediments, August 1993 collections.

Category 1 compound	FR-2	FR-3	FR-4	PP	D-1	D-2	D-3	D-4	S-2	S-3
Naphthalene	6.8	6.8	5.6	6.2	8.0	8.3	7.1	6.7	7.9	7.5
2-Methylnapthalene	2.3	2.2	1.8	1.8	2.3	3.0	2.6	2.3	2.7	2.5
1-Methylnaphthalene	1.5	1.4	1.1	1.2	1.5	2.0	1.7	1.4	1.7	1.6
Acenaphthylene	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.3	0.4	0.5
Acenaphthene	0.6	0.6	0.6	0.5	0.7	0.7	0.6	0.5	0.7	0.7
Fluorene	3.0	2.8	3.5	2.0	2.5	1.7	1.4	1.3	3.2	3.1
Phenanthrene	11.0	13.3	11.2	11.4	11.9	12.7	13.7	11.6	12.8	14.6
Anthracene	0.3	0.4	0.3	0.2	0.4	0.4	0.4	0.4	0.3	0.4
Fluoranthene	2.2	2.6	2.1	2.3	3.1	3.0	3.0	2.4	2.7	3.0
Pyrene	4.0	4.3	3.6	4.0	5.1	5.1	5.0	3.8	4.7	4.8
Benzo(a)anthracene	2.3	2.6	2.1	1.8	2.8	2.8	2.5	2.2	2.3	2.6
Chrysene	5.1	6.4	5.6	5.4	5.2	6.2	6.0	5.9	5.1	6.6
Benzo(b)fluoranthene	9.1	10.8	9.6	9.3	9.9	10.9	10.0	10.2	9.3	10.6
Benzo(k)fluoranthene	1.7	1.8	1.7	1.9	1.7	1.8	1.7	1.6	1.7	1.7
Benzo(e)pyrene	14.9	17.2	15.6	16.4	15.9	17.2	16.0	16.5	15.2	16.5
Benzo(a)pyrene	3.6	4.1	3.2	3.1	3.8	4.7	3.5	2.3	4.0	4.2
Indeno(1,2,3-cd)pyrene	7.5	5.4	7.3	7.0	5.9	4.7	6.0	7.5	6.2	4.7
Dibenzo(a,h)anthracene	3.8	3.2	4.6	4.3	3.0	2.6	3.7	5.1	3.4	2.8
Benzo(g,h,i)perylene	20.3	13.8	20.1	21.0	16.1	12.0	14.8	18.1	15.9	11.7

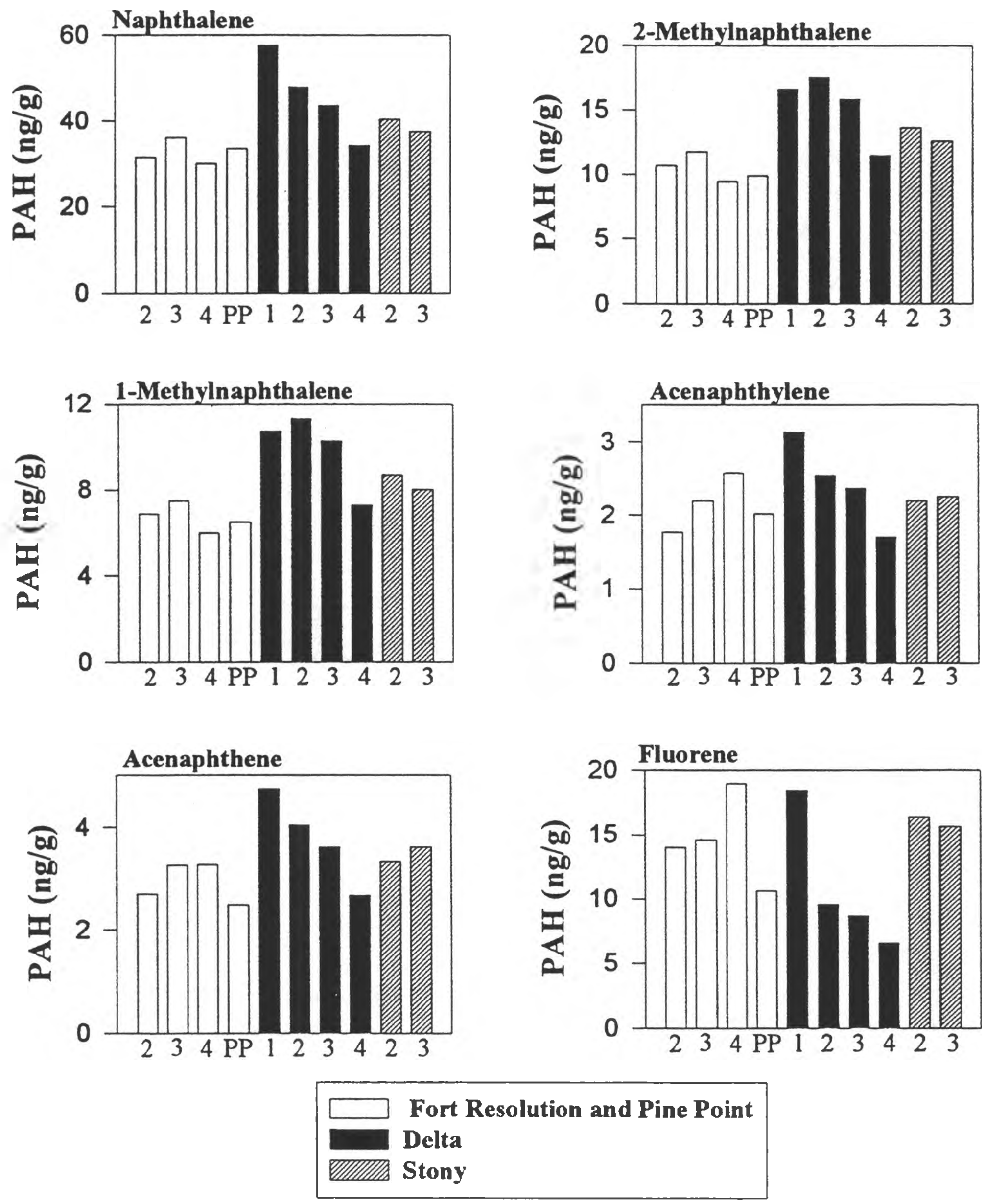


Figure 10. Concentrations of Category 1 PAHs (ng/g dry weight) in surficial sediments in the Slave River delta region, August 1993 collections.

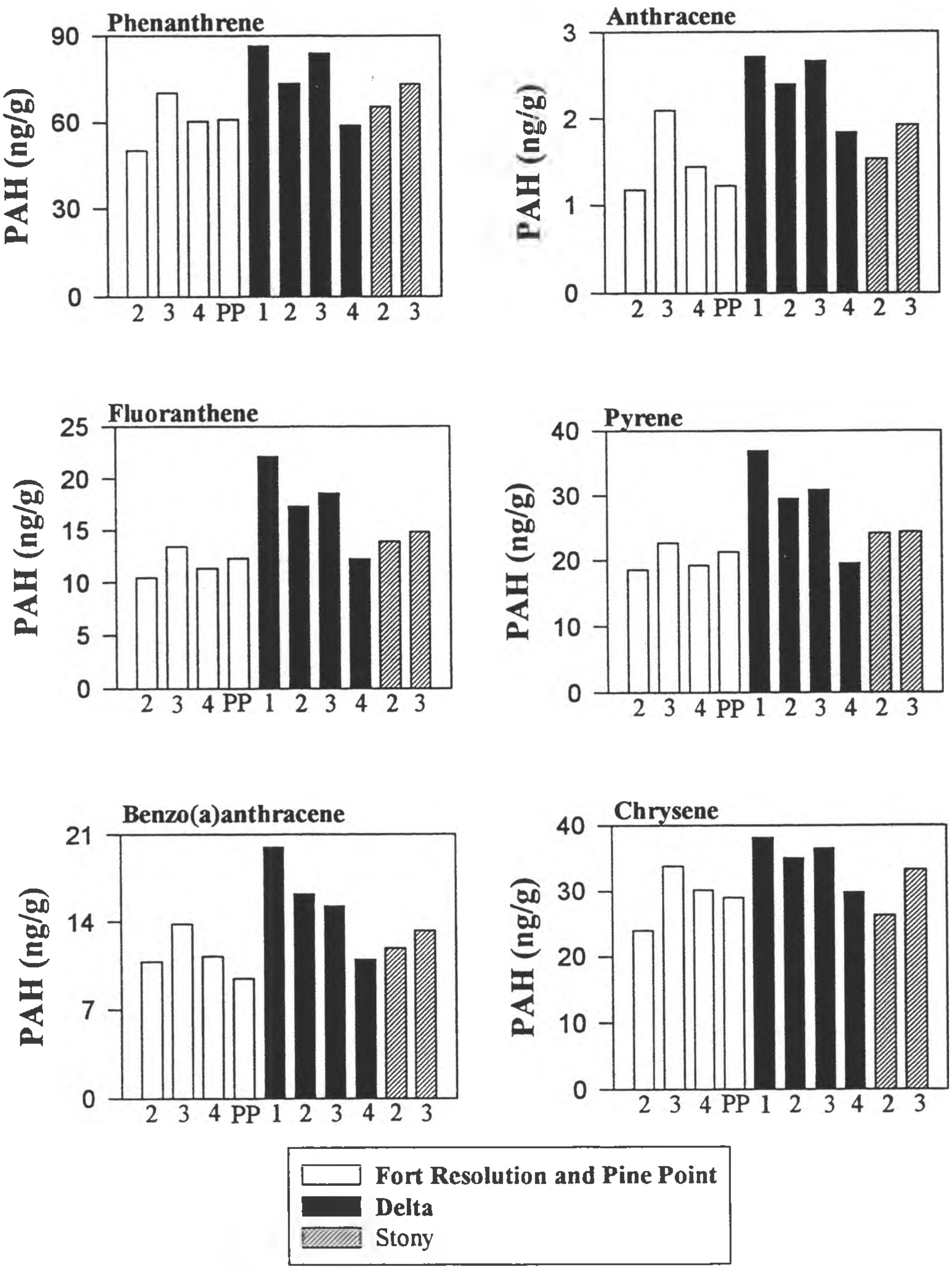


Figure 10, continued.

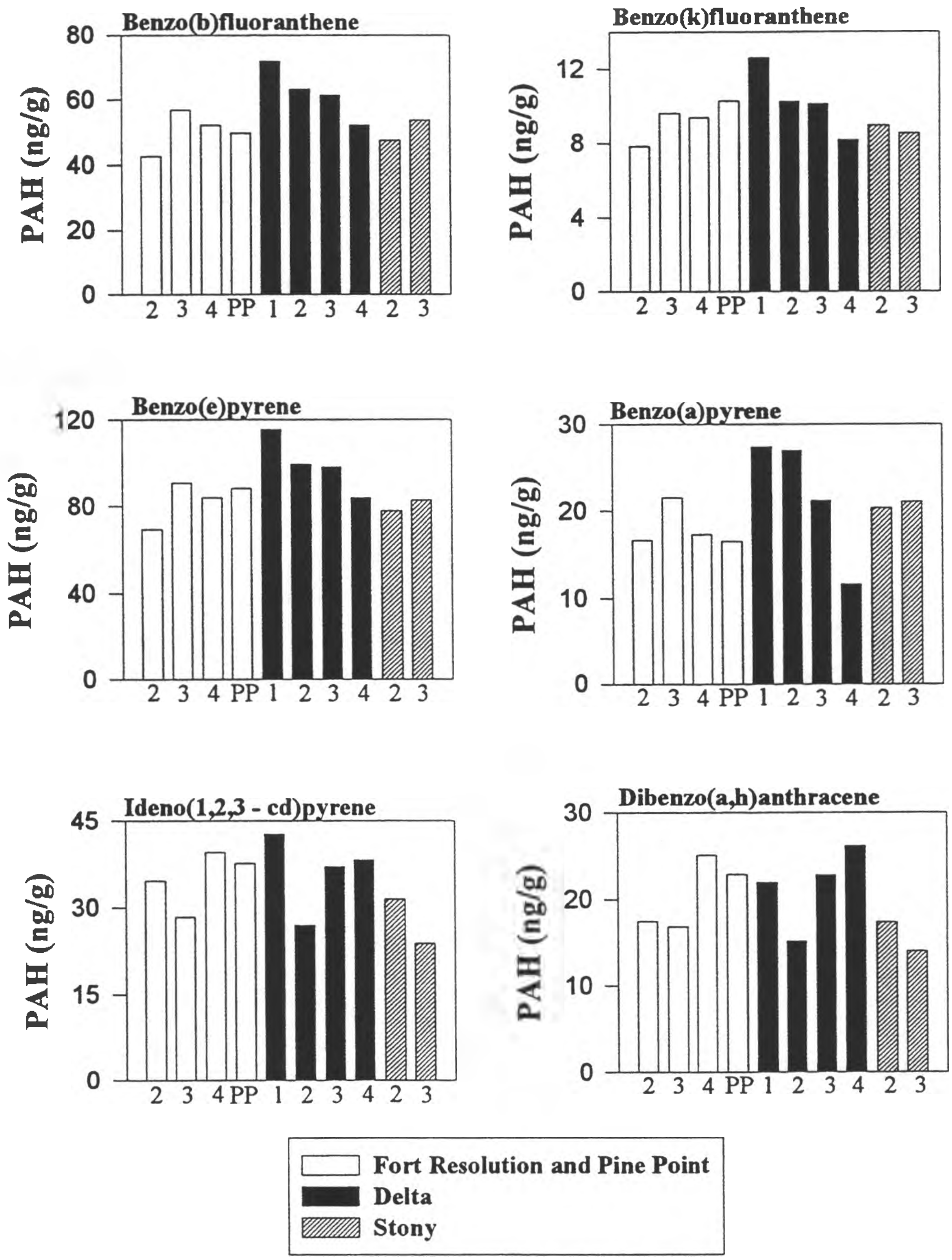


Figure 10, continued.

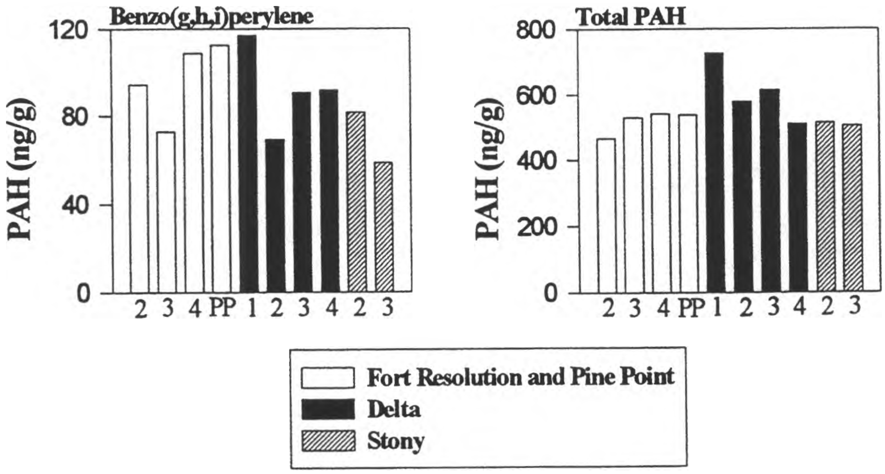


Figure 10, continued.

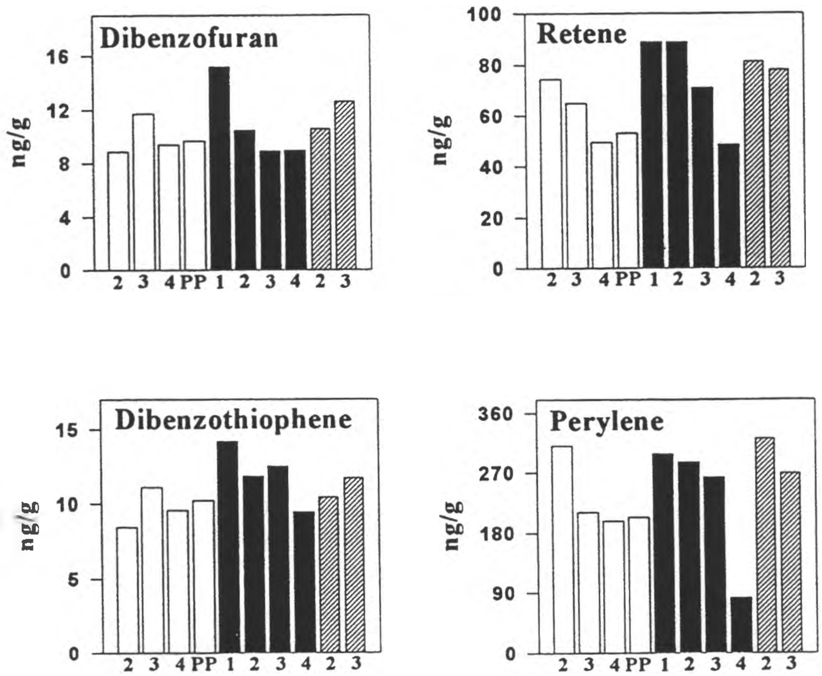


Figure 11. Concentrations of dibenzofuran, retene, dibenzothiophene, and perylene (ng/g dry weight) **in surficial sediments in the Slave River delta region, August 1993 collections.**

4.1.3 PCDDs and PCDFs

PCDDs and PCDFs were analyzed on the basis of isomers and of homologues. Although results were similar, there were minor differences between the two analyses.

Only dichlorinated (2,7/2,8- and 2,3-DiCDD) and octachlorinated (OCDD) PCDDs were detected in surficial sediments (Table 5, Figure 12). DiCDD was detected at 7 sites and in very low concentrations (1.4 - 2.1 pg/g, mean = 1.9 pg/g). OCDD was detected only at Delta 1, Delta 2 and Resolution 2, again in very low concentrations (2.1 - 3.9 pg/g, mean = 2.9 pg/g). Total PCDD concentrations of the basis of isomer analysis ranged from 1.4 - 6.2 pg/g and averaged 3.0 ± 1.7 pg/g. The highest PCDD concentrations were at Delta 2 and Resolution 2.

PCDD concentrations also were low based on homologue analysis, although the concentrations and spatial patterns differed somewhat from that based on isomer analysis. DiCDD was detected at only one site (Delta 1, 0.5 pg/g) and in only one of the two replicates examined. TriCDD was detected at eight, TCDD at five, PeDCC at seven, HxCDD at four sites, and HpCDD at one site. Total PCDD concentrations, on the basis of homologue analyses, ranged from 1.3 - 7.4 pg/g and averaged 3.0 ± 1.9 pg/g. Highest concentrations were at Stony 3 and Resolution 3.

Only dichlorinated (2,8-DiCDF), tri-(2,3,8-TriCDF) and tetrachlorinated (2,3,7,8-TCDF) PCDFs were detected (Table 6, Figure 12). Isomer concentrations ranged from 0.2 - 5.5 pg/g. On the basis of isomer analysis, total PCDF concentrations ranged from 0.4 - 5.5 pg/g and averaged 2.4 ± 2.0 pg/g. Highest concentrations were at Pine Point and Delta 4. PCDFs were detected in only one of the two replicates examined from Delta 1.

PCDFs generally were not detected on the basis of homologue analysis. This is in contrast to PCDD analyses where concentrations tended to be higher based on homologue than isomer analysis. TriCDF was detected only at Delta-3 and at 0.9 pg/g.

Overall, PCDD and PCDF concentrations were exceedingly low and close to detection limits. There was almost as much variation in PCDD and PCDF estimates in the two subsamples examined from Delta 1 as from the total remaining 9 sites. PCDDs and PCDFs tended to occur in approximately similar mean concentrations (isomer analysis) to one another. PCDDs tended to occur in slightly higher concentrations offshore of the Slave River while PCDF concentrations tended to be highest offshore of Resolution Bay. The Stony Point transect was a site of relatively low PCDD and PCDF concentrations. The lower chlorinated PCDDs and, to a lesser extent, PCDFs prevailed possibly suggesting a pulp and paper mill effluent signature. The higher chlorinated PCDDs (OCDD), on the other hand, are more suggestive of an atmospheric combustion signature - the atmospheric source could, however, be industrial.

Table 5. PCDD concentration (pg/g) in surficial sediments. Samples taken offshore of Slave River Mouth, August 1993. Bold denotes those values which accounted for more than 5% of total.

COMPOUND	FR-2	FR-3	FR-4	PP	D-1A	D-1B	D-2	D-3	D-4	S-2	S-3
2,7/2,8-DiCDD	**1.2**	**0.9**	**(1.3)**	<3.2	<1.3	**(1.0)**	**1.4**	**2.1**	<2.1	<1.5	**1.4**
2,3-DiCDD	**0.6**	**0.5**	**0.5**	<2.4	<1.3	**0.6**	**0.9**	<0.8	<1.6	<1.1	**0.6**
2,3,7-TriCDD	<0.4	<0.1	<0.4	<1.2	<0.5	<0.2	<0.4	<0.8	<0.9	<0.6	<0.3
2,3,7,8-TCDD	<0.2	<0.1	<0.3	<0.7	<0.2	<0.1	<0.1	<0.2	<0.4	<0.4	<0.2
1,2,3,7,8-PeCDD	<0.2	<0.1	<0.2	<0.8	<0.2	<0.1	<0.3	<0.3	<0.4	<0.6	<0.2
1,2,3,4,7,8-HxCDD	<0.3	<0.2	<0.7	<0.9	<0.3	<0.3	<0.4	<0.4	<0.6	<0.9	<0.4
1,2,3,6,7,8-HxCDD	<0.3	<0.2	<0.7	<1.0	<0.3	<0.3	<0.4	<0.4	<0.7	<1.1	<0.4
1,2,3,7,8,9-HxCDD	<0.3	<0.2	<0.7	<0.9	<0.3	<0.3	<0.4	<0.4	<0.6	<1.0	<0.4
1,2,3,4,6,7,8-HpCDD	<0.9	<1.1	<1.3	<1.2	<0.6	<0.7	<1.1	<1.0	<0.9	<0.9	<0.9
OCDD	**2.7**	<2.3	<3.1	<7.8	**(2.1)**	**2.9**	**3.9**	<4.4	<8.5	<3.8	<4.6
Total PCDD	4.5	1.4	1.8	ND	2.1	4.5	6.2	2.1	ND	ND	2.0
Homologue DiCDD	<0.4	<0.3	<0.3	<2.4	<1.3	**0.5**	<0.4	<0.8	<1.6	<1.1	<0.4
Homologue TriCDD	**1.9**	**2.0**	<0.4	<1.2	**0.6**	**0.7**	**1.4**	**3.4**	<0.9	**1.3**	**3.5**
Homologue TCDD	**1.4**	**1.1**	<0.3	<0.7	<0.2	**0.2**	**0.7**	<0.2	<0.4	<0.4	**0.9**
Homologue PeCDD	**0.4**	**1.1**	**1.4**	<0.8	**1.1**	**1.4**	**1.4**	<0.3	<0.4	<0.6	**2.5**
Homologue HxCDD	**1.1**	**1.2**	<0.7	<0.9	<0.3	<0.3	<0.4	<0.4	**2.3**	<1.0	**0.5**
Homologue HpCDD	<0.9	<1.1	**2.4**	<1.2	<0.6	<0.7	<1.1	<1.0	<0.9	<0.9	<0.9
Total Homologue PCDD	4.8	5.4	3.8	ND	1.7	2.8	3.5	3.4	2.3	1.3	7.4

Table 6. PCDF concentration (pg/g) in surficial sediments. Samples taken offshore of Slave River Mouth, August 1993. Bold denotes those values which accounted for more than 5% of total.

COMPOUND	FR-2	FR-3	FR-4	PP	D-1A	D-1B	D-2	D-3	D-4	S-2	S-3
2,8-DiCDF	<0.4	**2.3**	**2.4**	**3.5**	<0.7	**(1.0)**	<0.3	<0.7	**(5.5)**	<0.8	<0.3
2,3,8-TriCDF	**(0.9)**	**1.1**	**1.9**	**1.4**	<0.5	**(0.3)**	**0.4**	**(1.0)**	<0.5	**0.6**	**0.9**
2,3,7,8-TCDF	<0.2	**0.3**	<0.3	<0.5	<0.2	<0.1	<0.2	<0.2	<0.3	<0.2	**0.2**
1,2,3,7,8-PeCDF	<.0.2	<0.1	<0.2	<0.6	<0.1	<0.1	<0.1	<0.2	<0.3	<0.3	<0.2
2,3,4,7,8-PeCDF	<0.2	<0.1	<0.2	<0.5	<0.1	<0.1	<0.1	<0.2	<0.3	<0.3	<0.2
1,2,3,4,7,8-HxCDF	<0.3	<0.1	<0.4	<0.5	<0.2	<0.3	<0.4	<0.4	<0.3	<0.4	<0.3
1,2,3,6,7,8-HxCDF	<0.3	<0.1	<0.3	<0.4	<0.2	<0.3	<0.4	<0.4	<0.3	<0.4	<0.3
2,3,4,6,7,8-HxCDF	<0.4	<0.2	<0.4	<0.5	<0.2	<0.4	<0.5	<0.5	<0.4	<0.5	<0.4
1,2,3,7,8,9-HxCDF	<0.5	<0.2	<0.6	<0.7	<0.3	<0.4	<0.7	<0.7	<0.5	<0.7	<0.5
1,2,3,4,6,7,8-HpCDF	<0.6	<0.5	<0.9	<0.5	<0.2	<0.5	<0.4	<0.7	<0.5	<0.9	<0.7
1,2,3,4,7,8,9-HpCDF	<1.2	<1.0	<1.7	<1.4	<0.4	<0.7	<0.7	<1.3	<1.3	<2.0	<1.5
OCDF	<1.4	<1.9	<3.3	<5.0	<1.6	<2.1	<2.5	<3.3	<4.7	<4.3	<2.5
TOTAL PCDF	(0.9)	3.7	4.3	4.9	ND	(1.3)	0.4	(1.0)	(5.5)	0.6	1.1
Homologue DiCDF	<0.4	<0.3	<0.4	<2.1	<0.7	<0.3	<0.3	<0.7	<1.4	<0.8	<0.3
Homologue TriCDF	<0.3	<0.2	<0.3	<0.7	<0.5	<0.2	<0.2	**0.9**	<0.5	<0.4	<0.3
Homologue TCDF	<0.2	<0.1	<0.3	<0.5	<0.2	<0.1	<0.2	<0.2	<0.3	<0.2	<0.1
Homologue PeCDF	<0.2	<0.1	<0.2	<0.6	<0.1	<0.1	<0.1	<0.2	<0.3	<0.3	<0.2
Homologue HxCDF	<0.4	<0.2	<0.4	<0.5	<0.2	<0.3	<0.5	<0.5	<0.4	<0.5	<0.4
Homologue HpCDF	<0.9	<0.7	<1.3	<0.9	<0.3	<0.6	<0.5	<1.0	<0.9	<1.4	<1.1
Total Homologue PCDF	ND	ND	ND	ND	ND	ND	ND	0.9	ND	ND	ND

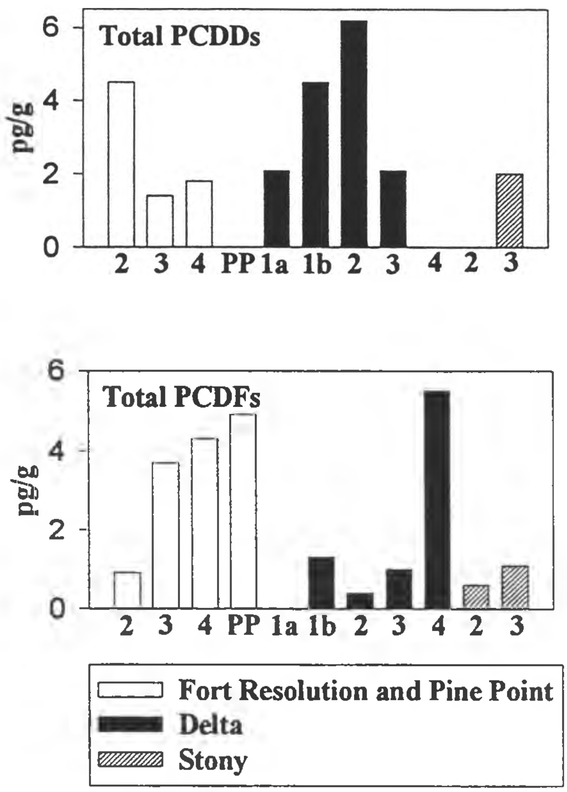


Figure 12. Concentrations of total PCDDs and PCDFs (pg/g dry weight) in surficial sediments in the Slave River delta region, August 1993 collections. Two subsamples were analyzed from Delta 1.

4.2 SUMMER 1993 CORES - Pine Point and Fort Resolution 4

Two core samples were collected in August 1993. One core was at Resolution 4 in 28 m of water and the second at Pine Point in 24 m of water. Two distinct sediment layers were observed in both cores - an upper layer of brown silty-clays and lower layer of light-brown clay sediments. The lower layer began at ca. 13 cm for the Resolution 4 core and ca. 17 cm for the Pine Point core.

The percent water content of the Resolution 4 core (Figure 13) decreased from 71.9% at 0 - 1 cm to 48.2% at 24 - 25 cm. The decrease did not occur at a uniform rate with core depth. Percent water was relatively low at 8 - 9 cm (37.8%) and 10 - 11 cm (40.8%) and then increased with greater depth. Percent water was relatively uniform below 12 cm. The percent water content of the Pine Point core generally was lower than the Resolution 4 core for the top 13 cm of sediment but greater than the Resolution 4 core below 13 cm. Porosity for the Fort Resolution and Pine Point cores (Figure 13) followed a similar pattern as percent water content. The pronounced variations in water content and porosity in the upper 13 - 17 cm of sediment suggest that the cores were collected in a physically-dynamic sedimentary environment, particularly for the Fort Resolution core.

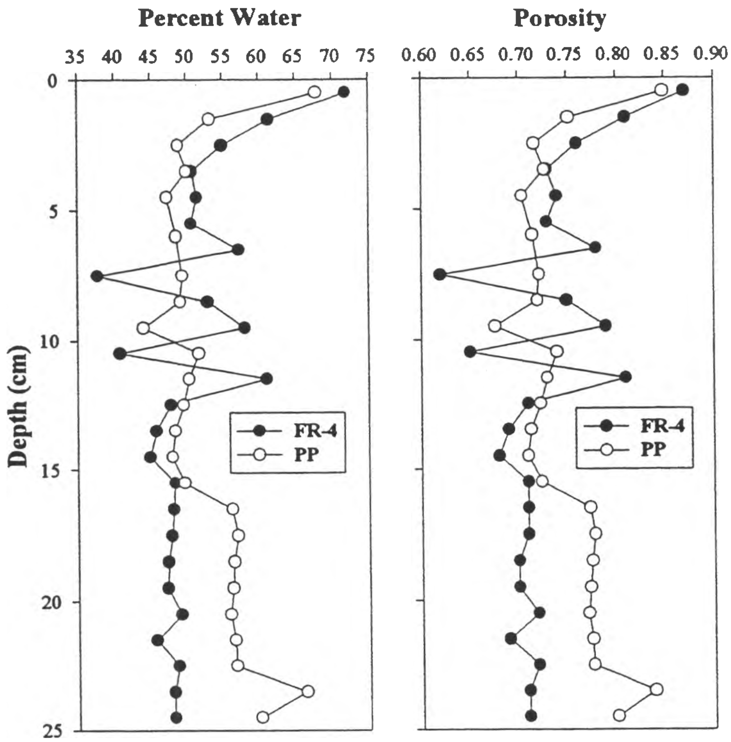


Figure 13. Percent water and porosity versus depth for Pine Point and Fort Resolution 4 cores, August 1993 collections.

Excess ^{210}Pb was detected only in the upper two cm of the Resolution 4 core and in the upper slice of the Pine Point core. Thus, it was not possible to date the cores and then estimate a sedimentation rate. Both cores clearly were collected in nondepositional areas despite their proximity to the Slave River mouth. This knowledge and the previous research conducted by Mudroch et al., (1992) were taken into consideration in designing the sampling grid for the March 1994 core collections.

4.3 MARCH 1994 CORES

4.3.1 General Sampling Results

Ten sites were examined over the nine days of study (Table 1, Appendix C): very low air temperatures precluded additional sampling. The following is a brief summary of the sediment studies and collections from these sites.

Site 11 was located in 29.5 m of water. Four attempts were made to collect cores at this site. The corer failed to retain the sediments on three attempts and only 10 cm of brown sediment were retained on the fourth cast. This site appeared to have the same characteristics of the Pine Point and Resolution 4 sites sampled in summer 1993, i.e., a relatively thin layer of silty clays overlaying harder glacial clays.

Table 7. Depth and sediment types for the 10 sites investigated in the West Basin, March 21 - 29, 1994. A * denotes sites where cores were not collected and/or retained for dating.

Site	Depth	Surface sediment type
11*	30 m	brown, silty clays over harder sediments.
12	69 m	brown, silty clay
13	62 m	brown, silty clay
14*	23 m	brown silty sediment over dense clay
15*	32 m	sediments not sampled
16	37 m	brown, silty clay
19	46 m	brown, silty clay
20*	7 m	hard-packed sands
21*	70 m	sediments not sampled due to time limitations
23	36 m	brown, silty clay

Site 12 was located in 69 m of water. Two cores were collected at this site. Surface sediments of both cores were brown silty-clays.

Site 13 was to the east of Site 12 and located in 62 m of water. Three very good and two good cores were collected at this site.

Site 14 was inshore of Site 13 in 23 m of water. Two attempts were made to collect cores. On the first attempt, the corer failed to retain the sediments. On the second attempt, dense clays were collected. This site, like Site 11, was assumed to be in an area of high erosion and thus not suitable for dating studies. The single core was not retained. Only the water column was sampled at this site and at Site 15.

Site 16 was in 37 m of water. More than six attempts were made to collect cores. On several tries, the corer failed to retain the sediment. However, two good and two very good cores were collected at this site.

Site 19 was offshore of Site 16 and in 46 m of water. More than seven attempts were made to collect cores at this site. Four very good and one good core were successfully collected. Site 19 was north and west of the Pine Point and Resolution 4 cores.

Site 20 consisted of hard packed sands ("felt" by sounding the bottom with a weighted line): no attempt was made to collect a core at this site. Only the water column was sampled at this site and Site 21.

Site 23 was located in 36 m of water and to the east of the Pine Point and Resolution 4 sites. Six attempts were made to collect cores. Three cores were collected, only one of which was undisturbed.

In summary, cores were successfully collected only at Sites 12, 13, 16, 19, and 23. Water depth ranged from 36 to 69 m at these sites. Attempts made to collect cores in shallower water (22 - 30 m) were unsuccessful. There was some evidence that these shallow water sites were erosional areas with only a moderately-thick layer of silty clays overlying glacial clays. Similarly, the two cores collected in shallow-water (24 - 28 m) offshore of the Slave River mouth in summer 1993 were in erosional areas.

More cores were collected than could be analyzed with the funding provided by NRBS. With the exception of four cores (two from Site 13 and two from site 19), all cores were shipped to NHRI. Of the cores at NHRI, only Cores 12B, 13B, 16A, 19B and 23A were selected for further analysis. The study began by preparing each core for dating determinations. Samples were freeze-dried and then dated according to the previously described methods.

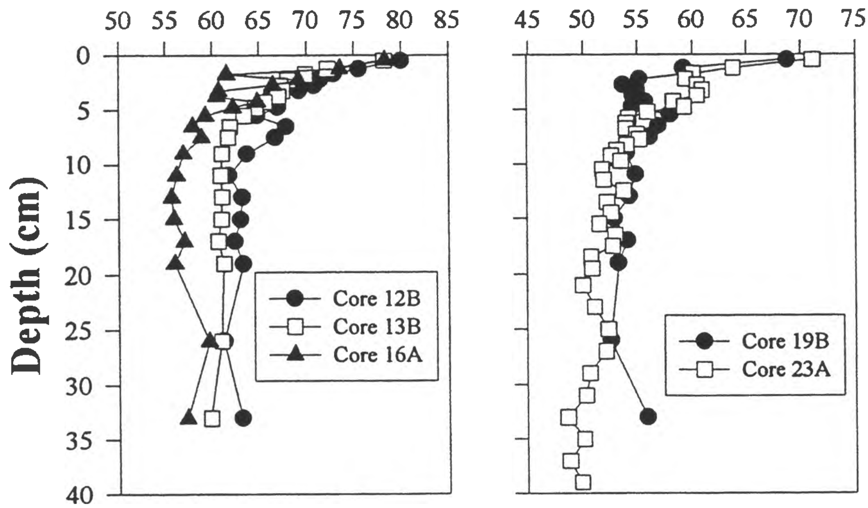
4.3.2 General Sediment Characteristics

The percent water content of the five cores decreased rapidly in the top 5 cm of sediment and then was relatively uniform with greater depth (Figure 14). In general, percent water content increased from Sites 19 and 23 (close to the Slave River mouth) to sites 12 and 13 (furthest from the Slave River mouth). Site 19, on the shelf region to the west of the Slave River mouth, had the lowest water content in the upper 5 cm of sediment of all five cores analyzed at NHRI. Differences in water content with increasing distances away from the river mouth may be indicative of small differences in sediment type, sediment packing and/or the organic content of the sediments. Specific gravity of sediments in the upper 5 cm of the cores was only slightly higher at Site 19 (Core 19D, mean = 2.63) than Site 13 (Core 13C, mean = 2.62) (Turner, 1994a, b). However, the organic content of the upper 5 cm of sediment at Site 13 (16.5 mg/g TOC) was higher than at Site 19 (15.8 mg/g TOC) (Appendix E. Table 7). The higher organic content at Site 13 may be related to its greater distance from the Slave River and its suspended sediments, i.e., organic matter at Site 19 may have been diluted to a greater extent by sedimenting silt and clay particles than organic matter at Site 13. Alternately, Site 13 may be in a region of greater organic productivity than Site 19.

Porosity of the five cores (Figure 14) tended to decrease with depth down to ca. 5 cm and then change relatively little with increasing depth. The porosity pattern of Core 19B differed from the other four cores but was similar to that of the Pine Point core. Porosity followed the same pattern as the percent water content of sediments.

The cores which were dated from Site 13 (Cores 13B and 13C) and Site 19 (Cores 19B and 19D) allowed for an investigation of the variation in the physical properties of the sediments and in sedimentation rates over a very small distance (less than 10 m) of the lake floor. The physical properties of the sediments were very similar for the two cores collected at Site 13, especially in the upper 10 cm of sediment. Thus, the accumulated dry weight of sediment for both cores was similar for the upper 10 cm of sediment, i.e., 4.6 g/m^2 for Core 13B and 4.9 g/m^2 for Core 13C. The physical properties of the sediments were less similar at greater depths where percent water content and porosity were lower for Core 13C than 13B (Figure 15).

Percent Water



Porosity

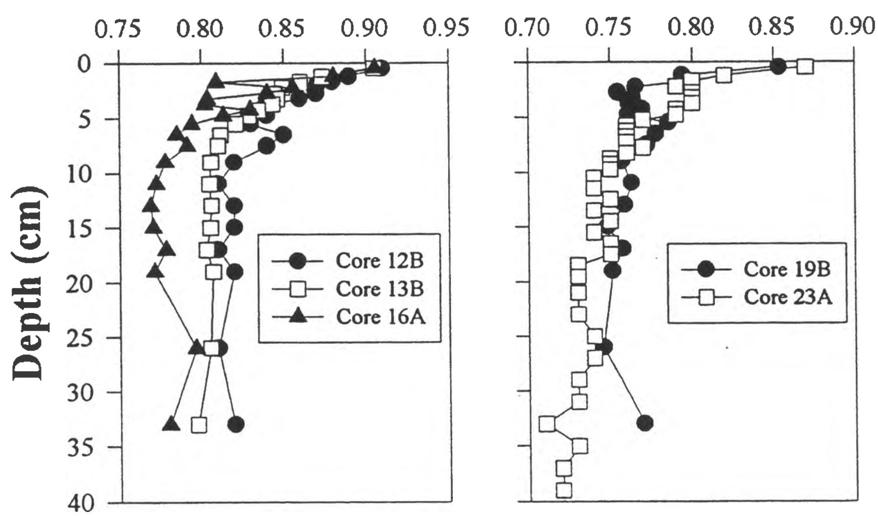


Figure 14. Percent water and porosity for Cores 12B, 13B, 16A, 19B and 23A, March 1994 collection.

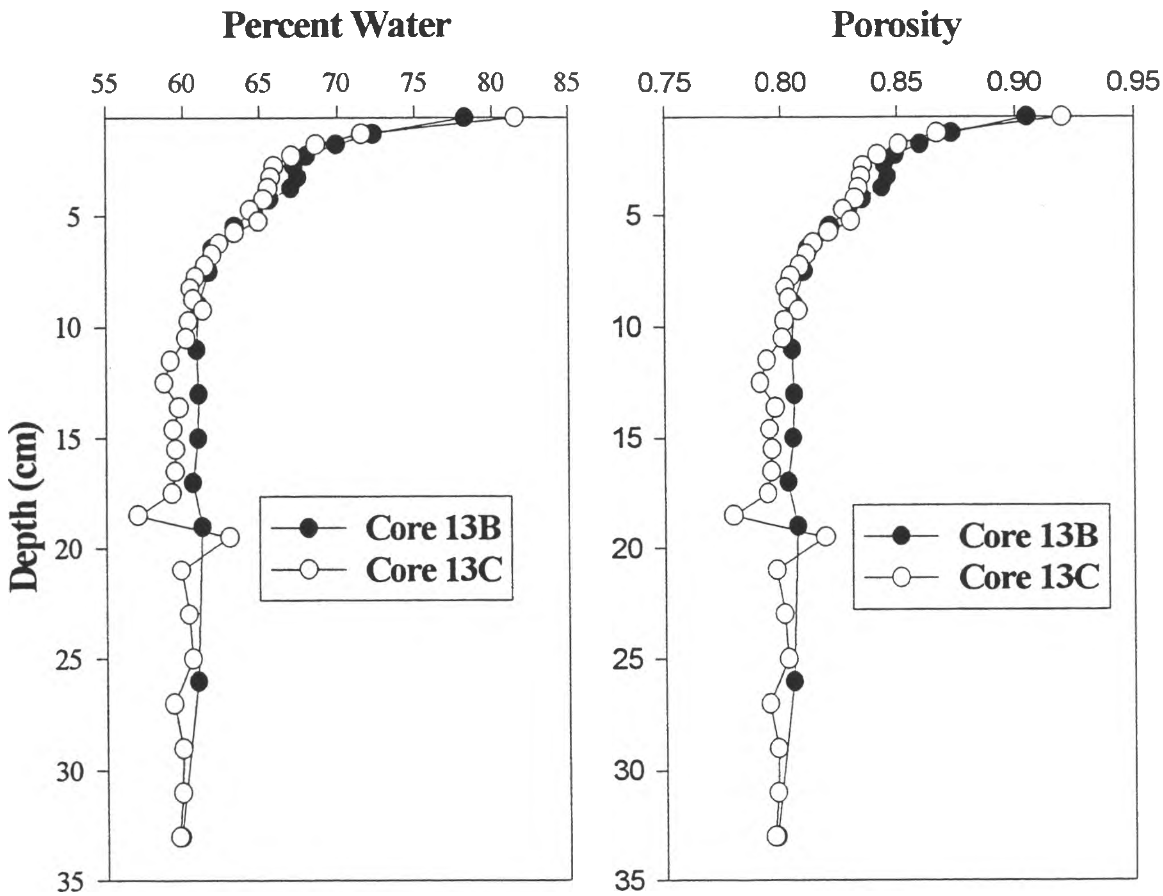


Figure 15. Percent water and porosity versus depth for Cores 13B and 13C, March 1994 collections.

The two cores collected from Site 19 differed markedly from one another (Figure 16). Percent water content and porosity were substantially lower for Core 19B than Core 19D in the upper 12 cm of sediment. These differences were less pronounced with greater depth. Thus, the accumulated dry weight of sediment differed for the two cores, i.e., accumulated dry weight for the upper 10 cm of sediments was 5.9 g/m^2 for Core 19B and 4.3 g/m^2 for Core 19D. It is remarkable that two cores collected so close to one another (<10 m apart) would differ so much in their physical properties. Nevertheless, the scientific party did note a considerable variability in core composition over short distances. Similarly, Evans and Headley (1993) noted substantial variations in sediment quality over relatively short distances.

Organic contaminant analyses were performed on the first 10 sediment slices of Cores 12B, 19B, 19D, and 23A, i.e., to a nominal depth of 5.0 - 6.0 cm. The nominal depth of the successive core slices was compared to the actual depths estimated from the volume of the samples and the surface area of the corer (Figure 17). Nominal and actual slice depths were in very good agreement for Cores 13B, 16A, 19B and 23A. However, the slices for Core 12B were relatively thin with the consequence that actual depth interval of the 5 - 6 cm slice was 3.1 - 3.8 cm.

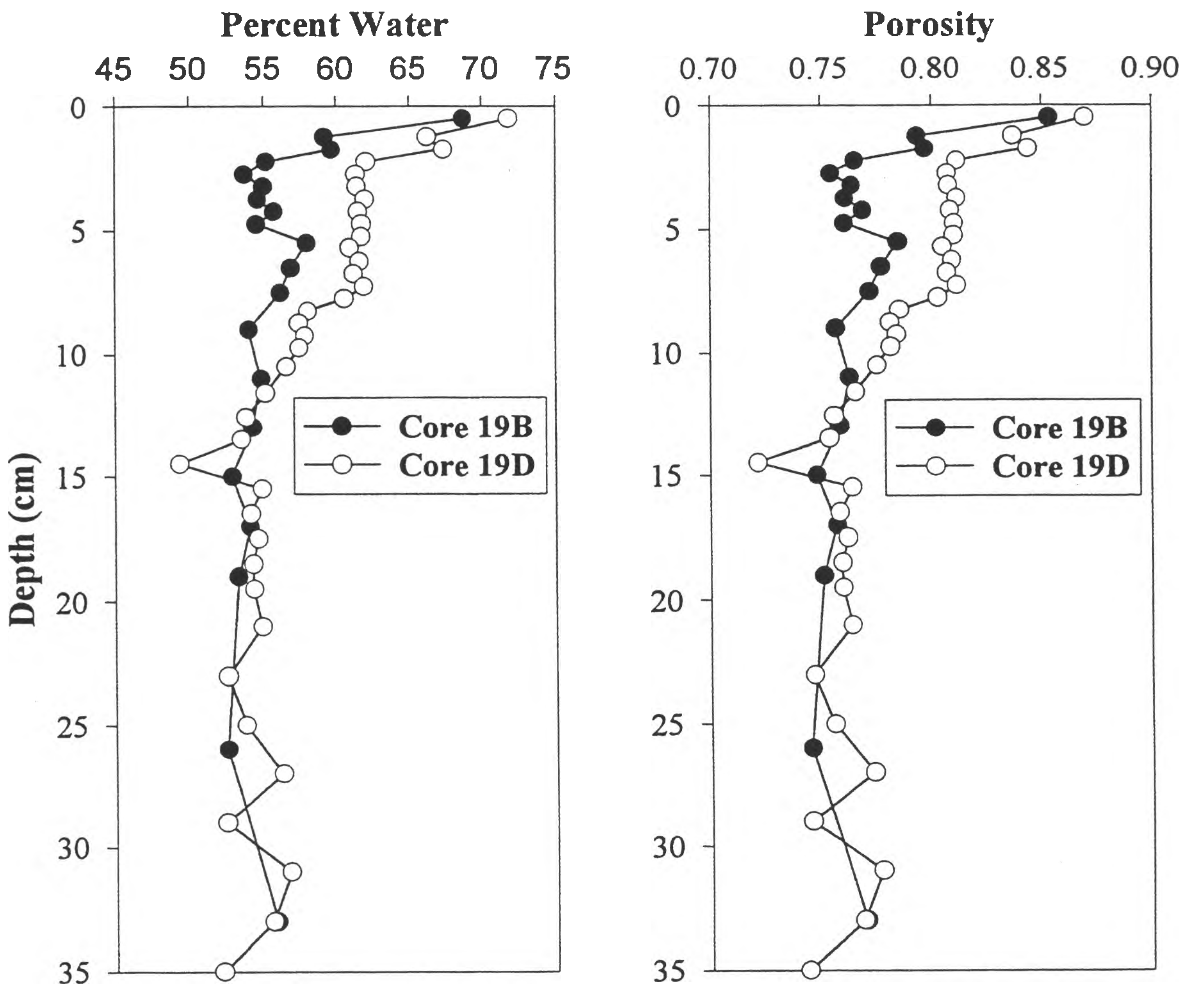


Figure 16. Porosity and percent water versus depth for Cores 19B and 19D, March 1994 collection.

4.3.3 Dating

Excess ^{210}Pb was detected in measurable quantities and to significant depths in cores collected from all five March 1994 sampling sites. This is in contrast to the two cores collected in August 1993 where excess ^{210}Pb was detected only upper 1 to 2 cm of the core. The excess ^{210}Pb profiles differed between the five sites, reflecting differences in sedimentation patterns. Cores 12B and 13B, located furthest from the Slave River mouth, had the most uniform decrease in excess ^{210}Pb with depth. In contrast, the excess ^{210}Pb profile was the least uniform for Core 23A, indicating a more complex sedimentation environment. This is in keeping with the site being closer to the Slave River mouth. There was a well-defined ^{137}Cs maximum for each core. The maximum for all cores occurred during the 1960s according the ^{210}Pb dating: thus, the ^{137}Cs data verified the ^{210}Pb estimates.

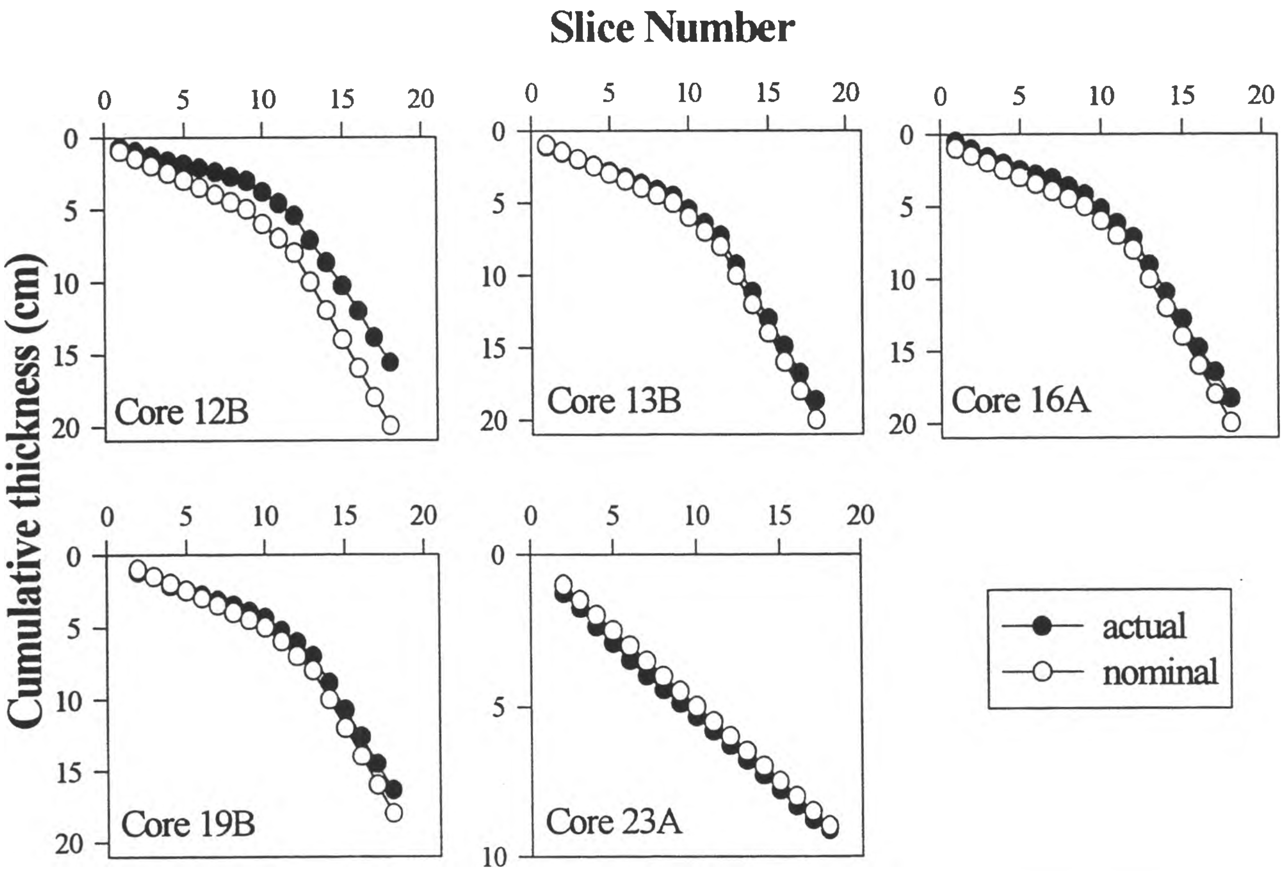


Figure 17. Slice number versus cumulative thickness. Comparison of nominal and actual section thickness for Cores 12B, 13B, 16A, 19B and 23A, March 1994 collection.

4.3.3.1 Core 12B.

The excess ^{210}Pb-depth profile for Core 12B was well described by the linear sedimentation rate model (Figure 18) with an r^2 of 0.99. Deviations from the theoretical regression line were small indicating relatively little postdepositional sediment movement or erosion of older sediments on top of younger sediments. The mean sedimentation rates for Core 12B, as estimated by the linear sedimentation model, was 554 g/m^2/y. The constant flux model, which adjusts for variations in sedimentation rate, provided a similar rate of 504 g/m^2/y. The rapid steady state mixing model (RSSM), which adjusts for sediment mixing in the surface layer, provided a mean sedimentation rate estimate of 519 g/m^2/y. The RSSM model estimated the mixing depth as 0.83 cm indicating relatively little mixing of the sediments. All three models provided similar estimated dates, particularly for the first 30 years of the sedimentary record (Figure 18). The ^{210}Pb flux rate was 119.1 Bq/m^2/y giving a focusing factor of 2.2 (assuming a mean areal input of ^{210}Pb of 55 Bq/m^2/y). ^{137}Cs increased with depth in Core 12B (Figure 17), reaching a maximum value at 5.0 - 6.0 cm (1.73 g/cm^2 accumulated dry weight) of sediment, and then decreased markedly with further depth in the core. Assuming that the ^{137}Cs maximum was deposited in 1964, this date agreed well with the dates calculated by the three ^{210}Pb models. The linear rate model estimated the median date of this slice as 1967 versus 1966 for the constant flux model and 1967 for the RSSM model.

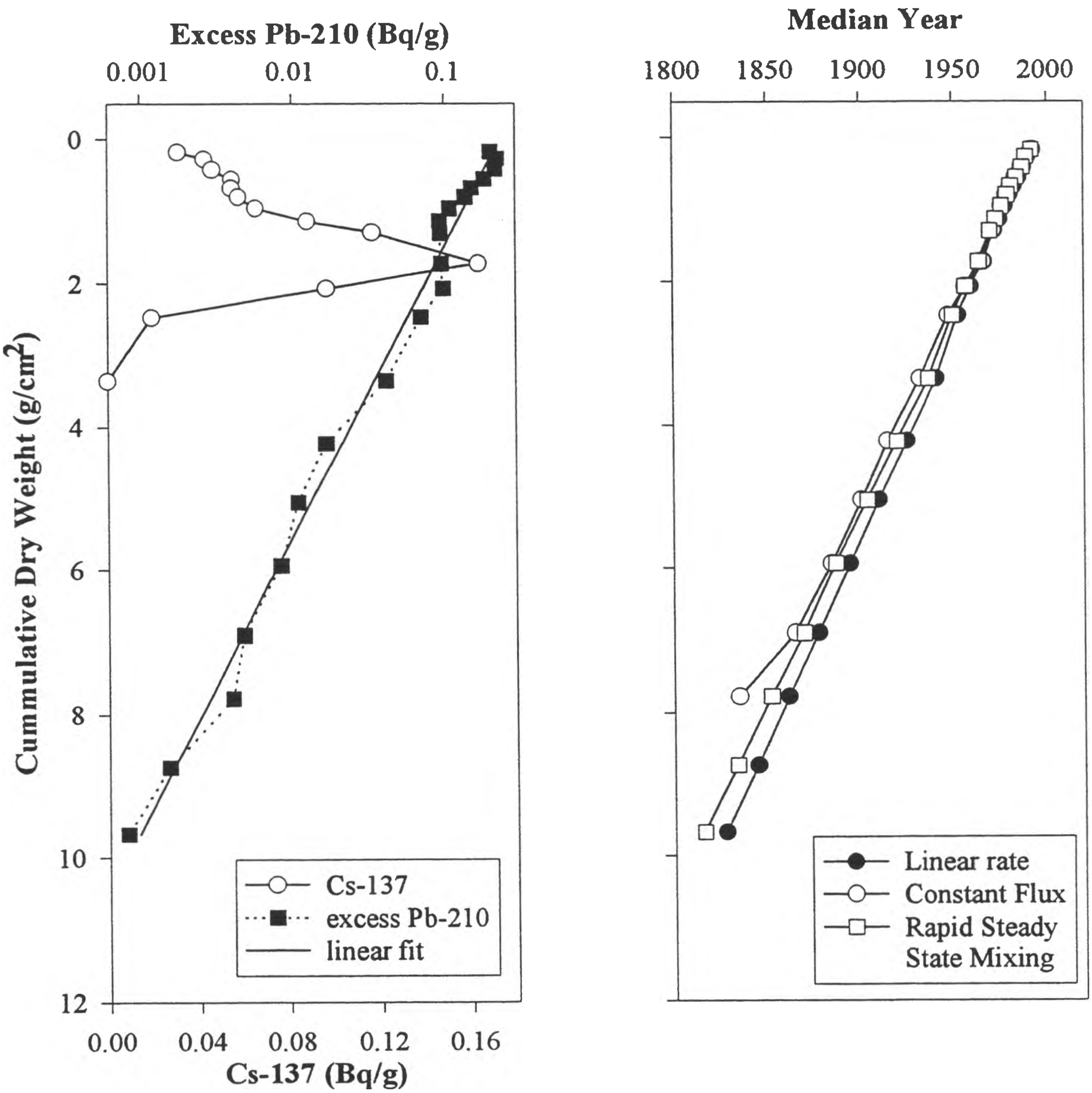


Figure 18. Excess ^{210}Pb, ^{137}Cs and estimated median date versus cumulative dry weight for Core 12B. Median dates for each core slice are estimated using three ^{210}Pb models.

4.3.3.2 Cores 13B (NHRI) and 13C (NWRI).

The excess ^{210}Pb-depth profile for Core 13B was well described by the linear sedimentation rate model (Figure 19) with an r^2 of 0.99. Deviations from the theoretical regression line were small indicating relatively little postdepositional sediment movement and erosion of older material onto the site. Deviations from the theoretical line were slightly smaller than for Core 12B, possibly suggesting a more stable environment. The mean sedimentation rate for Core 13B, as estimated by the linear sedimentation model was 359 g/m^2/y. The constant flux model provided a similar rate of 332 g/m^2/y while the RSSM model provided an estimate of 373 g/m^2/y. There was no evidence of mixing due to biological activity in the upper centimeters of sediment: estimated mixed depth was zero. All three models provided similar estimated dates, particularly for the first 30 years of the sedimentary record (Figure 19). The ^{210}Pb flux rate was 76.4 Bq/m^2/y giving a focusing factor of 1.4.

^{137}Cs increased with depth in the Core 13B, reaching a maximum value at 2.5 - 3.0 cm (1.11 g/cm^2 accumulated dry weight) of sediment, and then decreasing markedly with further depth in the core (Figure 19). The three ^{210}Pb models estimated a median date of 1966 for this slice. Thus, the ^{137}Cs maximum occurred in slightly younger sediments than predicted based on the known record of ^{137}Cs deposition into lakes and the ^{210}Pb models.

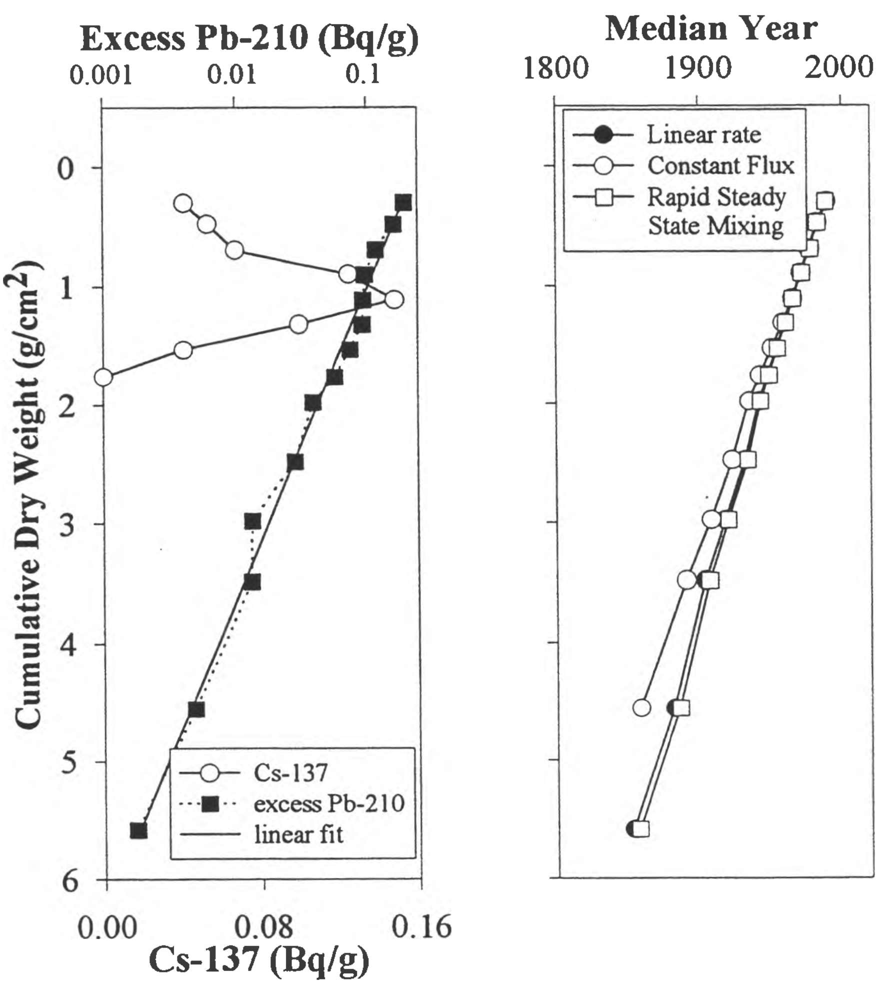


Figure 19. Excess ^{210}Pb, ^{137}Cs and estimated median date versus cumulative dry weight for Core 13B. Median dates for each core slice are estimated using three ^{210}Pb models.

Estimated core dates (linear model) were compared for Core 13B (dated at FWI) and Core 13C (dated at NWRI) (Figure 20). Core 13C had somewhat younger sediments for the same cumulated dry weight in the sediments. For the nominal 5.0 - 6.0 cm slice for Core 13B (accumulated sediment = 2.48 g/cm^2), the estimated median date according to the linear model was 1932. For Core 13C, the linear model gave an estimated median date of ca. 1942. Mean sedimentation rate for Core 13C was 430 g/m^2/y versus 359 g/m^2/y for Core 13B. Excess ^{210}Pb profiles (Figure 20) were similar for both cores for the upper 3 g/cm^2 of accumulated sediment (upper 7 cm nominal depth for Core 13B, ca. 1918; upper 8 cm nominal depth for Core 13C, ca. 1927) and then diverged thereafter.

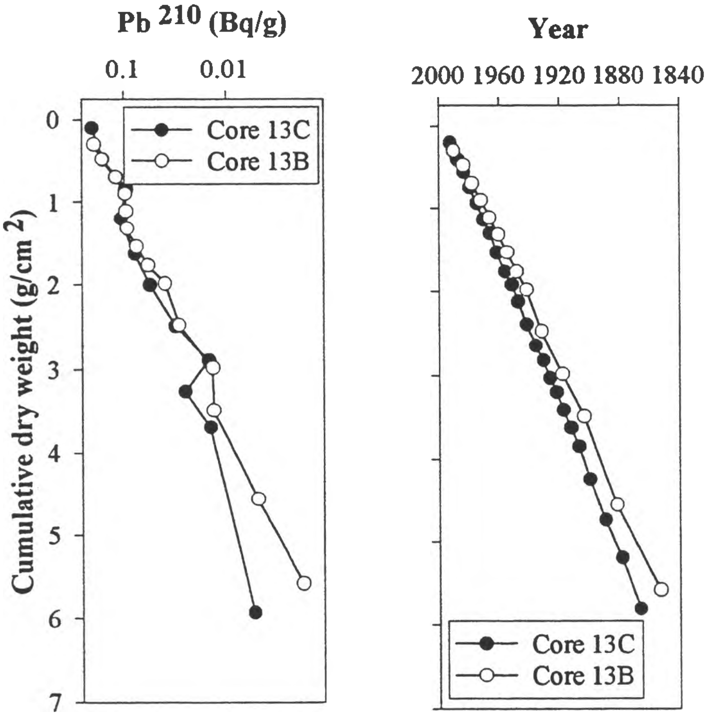


Figure 20. Excess ^{210}Pb and core date as a function of accumulated sediment for Cores 13B and 13C, March 1994 collection.

4.3.3.3 Core 16A.

The excess ^{210}Pb-depth profile for Core 16A was well described by the linear sedimentation rate model with an r^2 of 0.96 (Figure 21). Deviations from the theoretical regression line were small indicating relatively little postdepositional sediment movement and erosion of older sediments on top of younger sediments. Mean sedimentation rates for Core 16A were 343 g/m^2/y as estimated by the linear sedimentation model, and 339g/m^2/y as estimated by the steady state model. The RSSM model provided a higher estimated sedimentation rate of 442 g/m^2/y. Estimated mixed depth, according to the RSSM model was 0.55 cm. All three models provided somewhat similar estimated dates for the first 30 years of the sedimentary record although the similarities in estimates were less than at Sites 12 and 13. Differences between the dating estimates increased with depth in the core. The ^{210}Pb flux was 55.2 $Bq/m^2/y$ giving a focusing factor of 1.0.

^{137}Cs increased with depth in the Core 16A, reaching a maximum value at 2.5 - 3.0 cm (1.15 g/cm^2 accumulated dry weight) of sediment (Figure 21), and then decreased markedly with further depth in the core. This slice corresponded to a median date of 1964 according to the linear rate model, 1965 according to the steady state model, and 1970 according to the RSSM model.

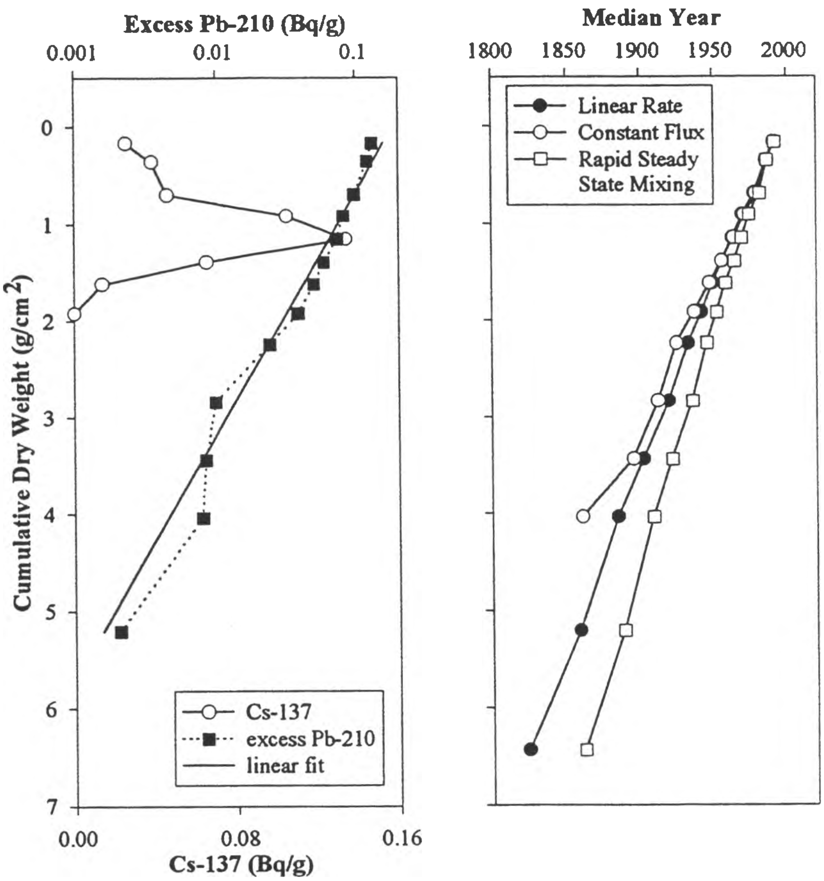


Figure 21. Excess ^{210}Pb, ^{137}Cs and estimated median date versus cumulative dry weight for Core 16A. Median dates for each core slice are estimated using three ^{210}Pb models.

4.3.3.4 Cores 19B (NHRI) and 19D (NWRI).

The excess ^{210}Pb-depth profile for Core 19B was well described by the linear sedimentation rate model with an r^2 of 0.99 (Figure 22). Deviations from the theoretical regression line were larger than for the other cores indicating greater postdepositional sediment movement. The mean sedimentation rate for Core 19B, as estimated by the linear sedimentation model was 692 $g/m^2/y$ and 729 $g/m^2/y$ as estimated by the constant flux model. As at Site 16, the RSSM model provided a higher estimated sedimentation rate of 915 g/m^2/y. Estimated mixed depth, according to the RSSM model was 0.27 cm. Thus mixing due to biological activity was less than at Sites 12 and 16 but greater than at Site 13. All three models provided somewhat similar estimated dates for the first 30 years of the sedimentary record. Differences between the dating estimates increased with depth in the core. The ^{210}Pb flux was 89.1 Bq/m^2/y giving a focusing factor of 1.6.

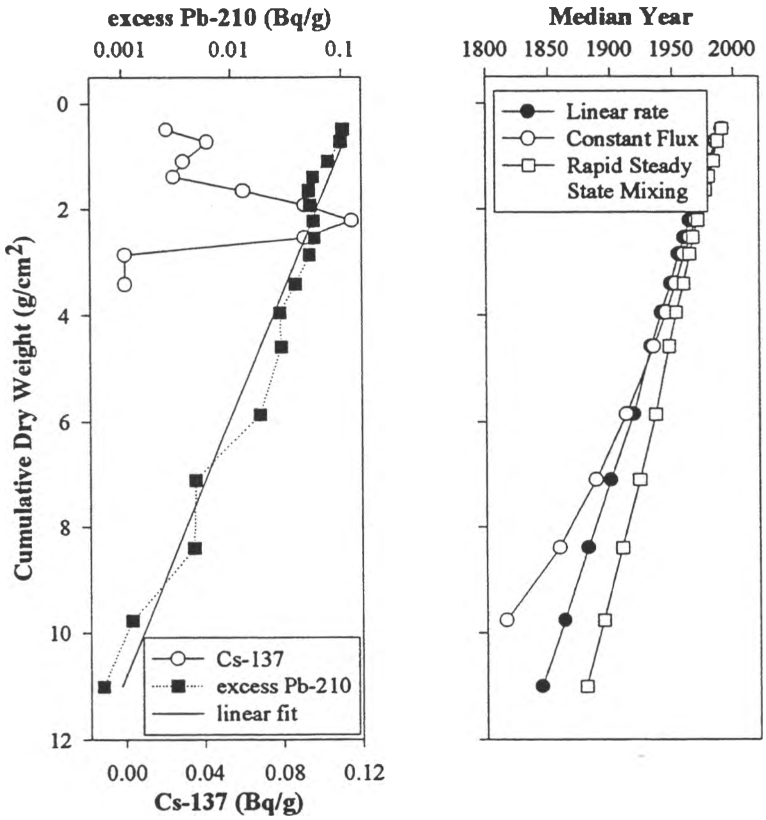


Figure 22. Excess ^{210}Pb, ^{137}Cs and estimated median date versus cumulative dry weight for Core 19B. Median dates are estimated using three ^{210}Pb models.

The ^{137}Cs profile for Core 19B (Figure 22) differed from that of Cores 12B, 13B and 16A in that there were two maxima: a small maximum at 1.0 - 1.5 cm and a larger maximum value at 3.5-4.0 cm of sediment. ^{137}Cs concentrations then decreased markedly with further depth in the core. Considering the 3.5 - 4.0 cm slice, the median date was 1964 according to the linear rate model, 1969 according to the steady state model, and 1971 according to the RSSM model. Thus, there was a very large discrepancy between the estimated dates based on the three ^{210}Pb models and the ^{137}Cs model. Deviations from the linear model for ^{210}Pb were large, particularly, between the two ^{137}Cs maxima. Deviations were to the left of the regression line suggesting that older sediments laid down in the early 1960s in one region of Great Slave Lake were subsequently eroded and sedimented on top of younger sediments at Site 19. However, the linear regression model could be used to back-calculate the probable dates for sediments based on their ^{210}Pb values.

Estimated sedimentation rates and core dates (linear model) were compared for Core 19B (FWI) and Core 19D (NWRI). Mean sedimentation rate was 692 g/m^2/y for Core 19B and 450 g/m^2/y for Core 19D. Excess ^{210}Pb profiles (Figure 23) for the two cores differed slightly in the upper 3 g/cm^2 accumulated sediment (upper 5 cm nominal depth for Core 19B, ca. 1955; upper 7.5 cm nominal depth for Core 19D, ca. 1931). Excess ^{210}Pb concentrations tended to be slightly greater in Core 19B than Core 19D. Both cores showed evidence of significant deposition of older sediments on top of younger sediment Excess ^{210}Pb values diverged markedly at greater depths with values lower (i.e., older sediments) in Core 19D than Core 19B for the same weight of accumulated sediment. Overall, Core 19B had considerably older sediments for the same accumulated dry weight of sediment than Core 19D. As indicated earlier, Cores 19B and 19D differed in percent water content and porosity as a function of depth.

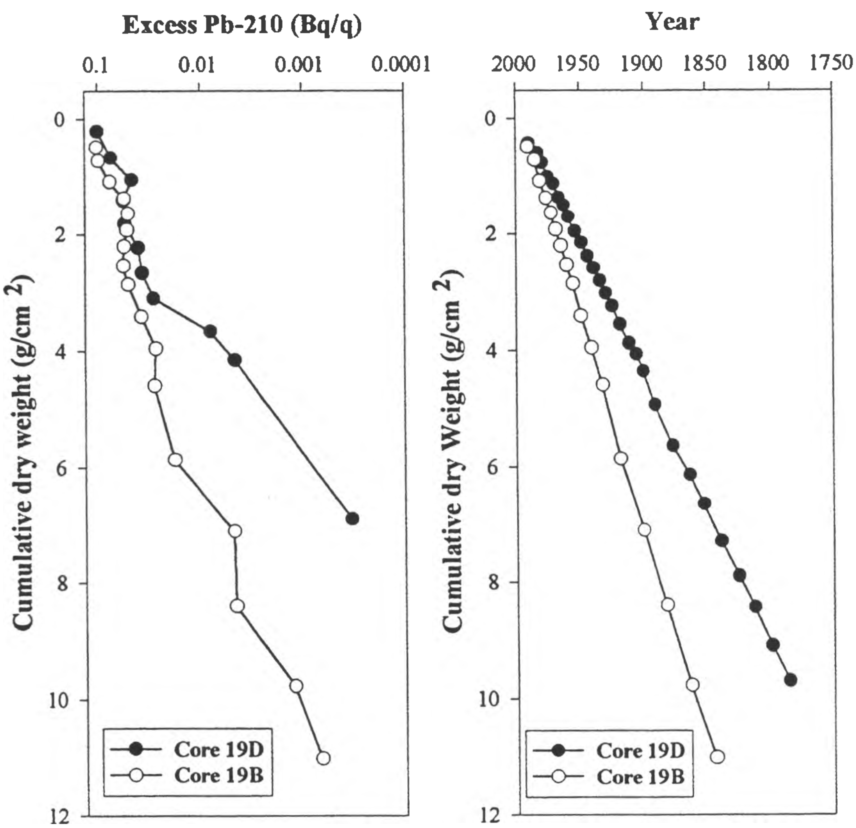


Figure 23. Excess ^{210}Pb and estimated core date as a function of accumulated sediment for Cores 19B and 19D.

4.3.3.5 Core 23A.

Site 23 was closest to the Slave River mouth and in a physically dynamic area. The decrease in ^{210}Pb with depth was irregular but could be described by a linear model: the correlation coefficient was lower ($r^2 = 0.85$) than for the other four sites, indicating greater postdepositional sediment mobility (Figure 24). Sedimentation rate was estimated only with the linear regression model: the rate was 542 $g/m^2/y$. Although closer to the river mouth than Site 19, the sedimentation rate was lower suggesting much loss of sediment from this region of the lake. This was further indicated by the ^{210}Pb flux rate which was only 28.9 $Bq/m^2/y$. This gave a focusing factor of 0.5 further indicating significant loss of sediment from the area. The ^{137}Cs maximum occurred at 2 - 3 cm. This value agreed well with the estimated median date of 1964 for the 2.5 - 3.0 cm slice (Figure 24) based on the ^{210}Pb analysis. However, because excess ^{210}Pb values in the vicinity of the ^{137}Cs maximum were to the left of the regression model, this suggests that sediments containing the ^{137}Cs peak were older than the underlying sediments, i.e., they had been deposited in some other region of Great Slave Lake and postdepositionally eroded and deposited at Site 23.

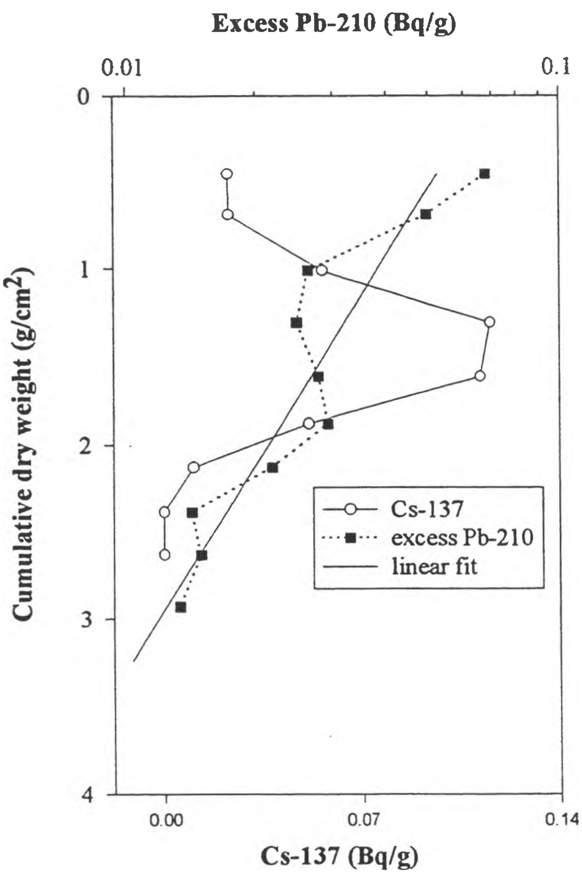


Figure 24. Excess ^{210}Pb and ^{137}Cs as a function of cumulative dry weight for Core 23A.

4.4 MARCH 1994 CORES: TOC and TON

TOC and TON concentrations were measured only in Cores 13C and 19D. TOC concentrations were low in both cores prior to the early 1900s with slightly higher concentrations in Core 13C. (Figure 25; Appendix E. Table 7). Higher TOC concentrations in Core 13C than Core 19D may be related to the greater distance of Site 13 from the Slave River outflow with its heavy burden of suspended sediments. Thus, organic matter may have been diluted to a greater extent by suspended silts and clays at Site 19 than at Site 13: sedimentation rates were higher at the former than latter site. Alternately, productivity was greater at Site 13 than Site 19.

TOC concentrations increased steadily at both sites with the greatest increase occurring after the 1950s (Figure 25). A similar trend was noted for TON: however, Site 19 did not show as strong an increase as Site 13 in TON concentration after the 1950s. These time trends could be related to three factors. First, the increase in TOC and TON in more recent times may be related to anthropogenic activities in the Great Slave Lake watershed, e.g., deforestation which resulted in increased erosion and nutrient inputs into the lake. There is some precedence for this hypothesis. Land clearing in the

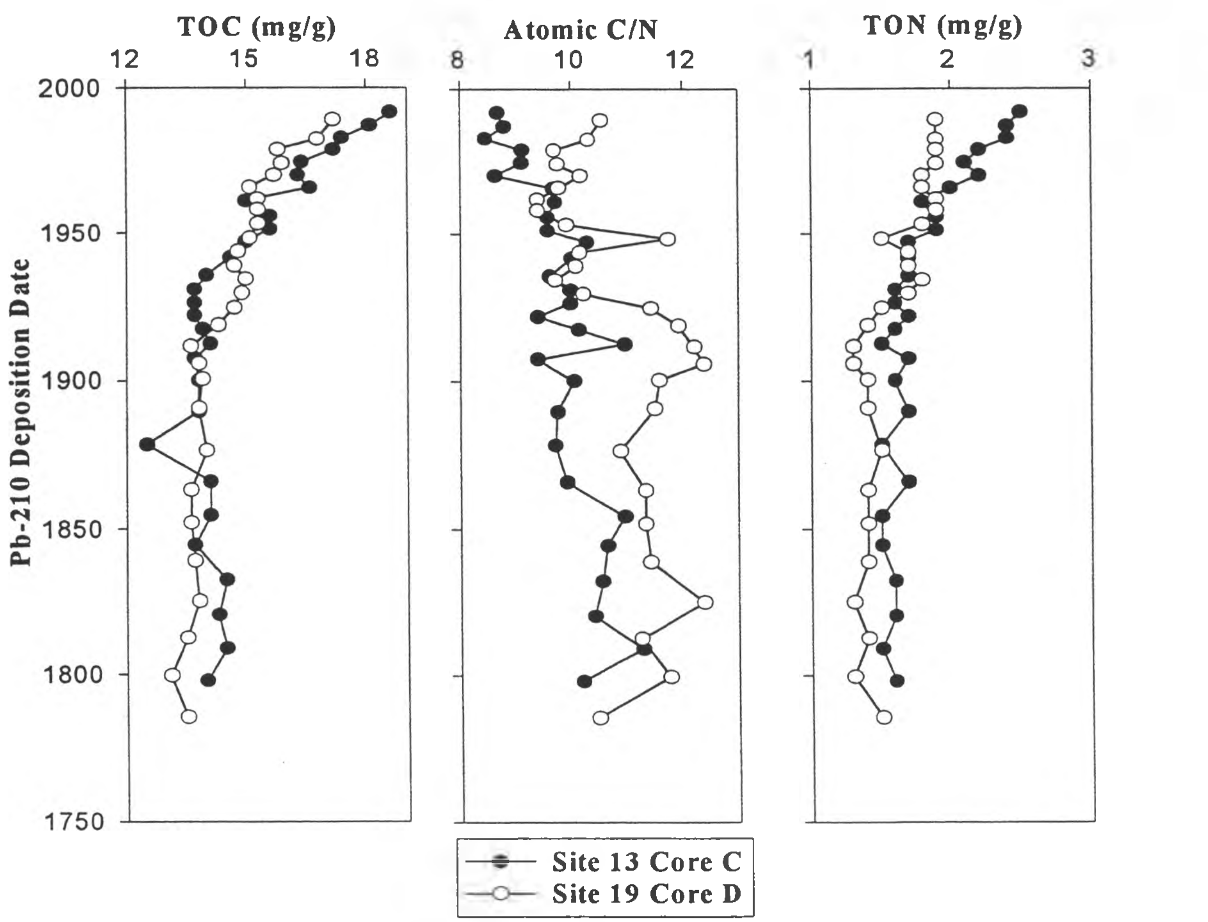


Figure 25. Organic carbon and nitrogen concentrations for Cores 13C and 19D, March 1994 collection.

Lake Ontario watershed apparently began to effect an increase in nutrient (phosphorus, nitrogen, silica) inputs and the productivity of Lake Ontario as early as the mid-1600s (Schelske et al.,1985), although the population level at that time was less than 1 million people (Beeton, 1969). These impacts increased markedly in the early 1800s when forest clearance and land clearing intensified: population levels had increased to nearly 1 million people by that time. Similarly, the increase in TOC and TON concentrations in sediments at Sites 13 and 19 may be related to land clearing and increased population and technology growth in the Peace and Athabasca watersheds during this century. In more recent times, some of the increase in TOC and TON may be associated with increased nutrient inputs from Hay River and Yellowknife. Stoermer et al. (1990) related changes in the algal assemblages in McLeod Bay to increased nutrient inputs, presumably from the atmosphere.

A second factor potentially affecting the decrease in TOC and TON concentration in sediments with time is the degradation of TOC and TON in the sediments. However, TOC and TON did not show the same pattern of decreasing concentrations with depth in the sediments of Lake Athabasca (Bourbonniere et al., 1995). This suggests that the trends observed in Great Slave Lake were related to anthropogenic factors, which were more readily detected in Great Slave Lake than Lake Athabasca sediments, than to the diagenesis of TOC and TON in older sediments.

Finally, the increase in TOC and TON inputs to Great Slave Lake sediments may have been due to an increase in primary production resulting from global warming over the past century. An increase in water temperatures and the ice-free period may have allowed for greater primary production. However, this hypothesis may not be valid because Cores 13C and 19D did not follow the same time trends, especially during the 1930s and 1940s. Alternately, the hypothesis may require refinement, e.g., considerations of the effect of variations in Slave River inflow on productivity and/or sedimentation.

The C/N ratio tended to be higher for Core 19D than 13C. (Figure 25; Appendix E. Table 7). Moreover, the ratio tended to be higher prior to the 1900s than in more recent times. Over the last 20 years, the ratio has been about ca. 8.5 - 9.5 for Core 13C and ca. 9.8 - 10.6 for Core 19D. Prior to the 1900s, the ratios were ca. 10 - 11 for Core 13C and 9.9 - 11.5 for Core 19D. C/N ratios provide an approximate indication of the carbon and nitrogen source to the sediments. Terrestrial plants have C/N ratios of >20 while plankton have ratios of 6 - 9 (Bourbonniere et al., 1996). Periphyton and aquatic macrophytes have ratios intermediate to those of plankton and terrestrial plants but are probably only minor contributors to the organic carbon pool for Great Slave Lake. Where both terrestrial and lacustrine organic carbon sources are present, the ratio will be intermediate between these two extremes. Variations in the C/N ratio for Great Slave Lake sediments suggest that while both terrestrial plants and plankton were important contributors to the organic carbon pool prior to the 1900s, plankton have become increasingly important in more recent years. This was most pronounced at Site 13. Again, this is suggestive of an increase in primary production, possibly associated with increased nutrient inputs to the watershed and the lake itself. A greater input of terrestrial carbon closer to the Slave River mouth is suggested by the higher C/N ratio at Core 19D than at Core 13C.

4.5 MARCH 1994 CORES: Contaminant Studies

OC and PAH analyses were initiated before Core 23A had been dated. However, Cores 12B, 13B, 16A, and 19B had been successfully dated at FWI. The depositional record was good with relatively little erosion of older material and/or postdepositional disturbance of material at all four sites. Of the four cores, two were selected for OC and PAH analyses - Core 12A which was the furthest removed from the Slave River mouth and had the second highest sedimentation rate, and Core 19B which was the closest to the river mouth (of the four dated cores) and had the highest sediment deposition rates.

Two different cores were selected for PCDD and PCDF analyses. Because of the large amount of material required for PCDD and PCDF analyses, these analyses could not be performed on the same cores used for OC and PAH studies. Core 19D was selected because it had been dated (NWRI) and was collected closer to the Slave River mouth than Core 13C. Although Core 23A had not been dated, it was selected for PCDD and PCDF analyses because of its very close proximity to the Slave River mouth. Even if this core had been in an erosional area (as the Pine Point and Fort Resolution Cores) information would have been obtained on PCDD and PCDF concentrations with core depth.

Funding was limited for these analyses so only the upper 6 cm (nominal depth) of each core was analyzed for organic contaminants. The notable exception was Core 19B where the 14 - 16 cm slice was examined for OCs and PAHs. Contaminant concentrations were plotted as a function of median age for the various slices of that core. The linear regression model was used for assigning slice ages.

4.5.1 Organochlorine analyses

Cores 12B and 19B were analyzed for OCs. However, PCB values were relatively high for Core 12B and the data are being verified. Therefore, only the results of Core 19B are presented in this report. The upper 6 cm of Core 19B spanned 1949 to the present: the 14 -16 cm slice had a median date of 1863. Measurable quantities of OCs were detected in the 14 - 16 cm slice. These values were used to blank correct the results of analyses for the upper 6 cm of Core 19B.

Concentrations of OCs were low in the late 1940s but showed evidence of increasing concentrations in later years. While these increases were not large, they do indicate that Great Slave Lake is receiving organic contaminants from the more developed regions of Canada and, presumably, other regions of the northern hemisphere.

PCB was the predominant organochlorine in Core 19B (Figure 27; Appendix E. Table 1). Total PCB concentrations ranged from 0.7 - 9.0 ng/g and averaged 6.3 ± 3.0 ng/g: average concentrations were lower than that observed in the 10 surficial sediment samples (mean = 9.8 n/g) offshore of the Slave River mouth. Highest PCB concentration in Core 19B were observed at 4.5 - 5.0 cm (median date 1955). Total PCBs showed a weak concentration increase with time after the early 1960s.

PCBs were dominated by tri-, tetra-, penta- and hexachlorobiphenyls which accounted for an average of 25.4%, 18.2%, 24.0%, 12.7% respectively of total PCBs (Figure 26; Appendix E. Table 2): in contrast, mono- and dichlorobiohenyls dominated (mean = 40.2%) total PCBs in the surficial

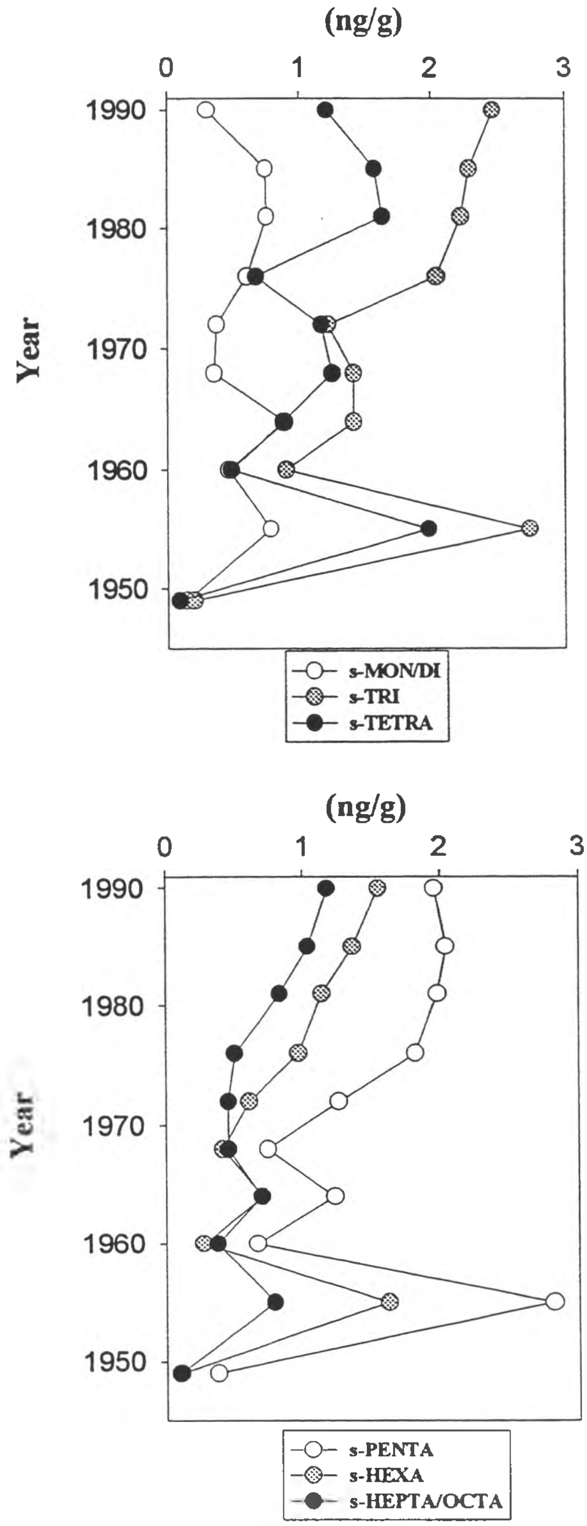


Figure 26. Concentratations of PCBs by chlorine number in Core 19B.

sediments collected offshore of the Slave River mouth. In Core 19B, the higher chlorinated PCBs, penta, hexa-and hepta/octachlorobiphenyls, showed a pattern of steadily increasing concentrations from 1960 up to the early 1990s. The lower chlorinated PCBs, mono/dichlorobiphenyls, showed the weakest trend for increasing concentrations with time. The lower chlorinated PCBs are more volatile (Baker and Eisenreich,1990; Jeremiason et al., 1994) and may be more readily biodegraded than the more highly chlorinated forms: thus they may provide for a poorer assessment of long-term changes in total PCB inputs to Great Slave Lake than the more highly chlorinated PCBs.

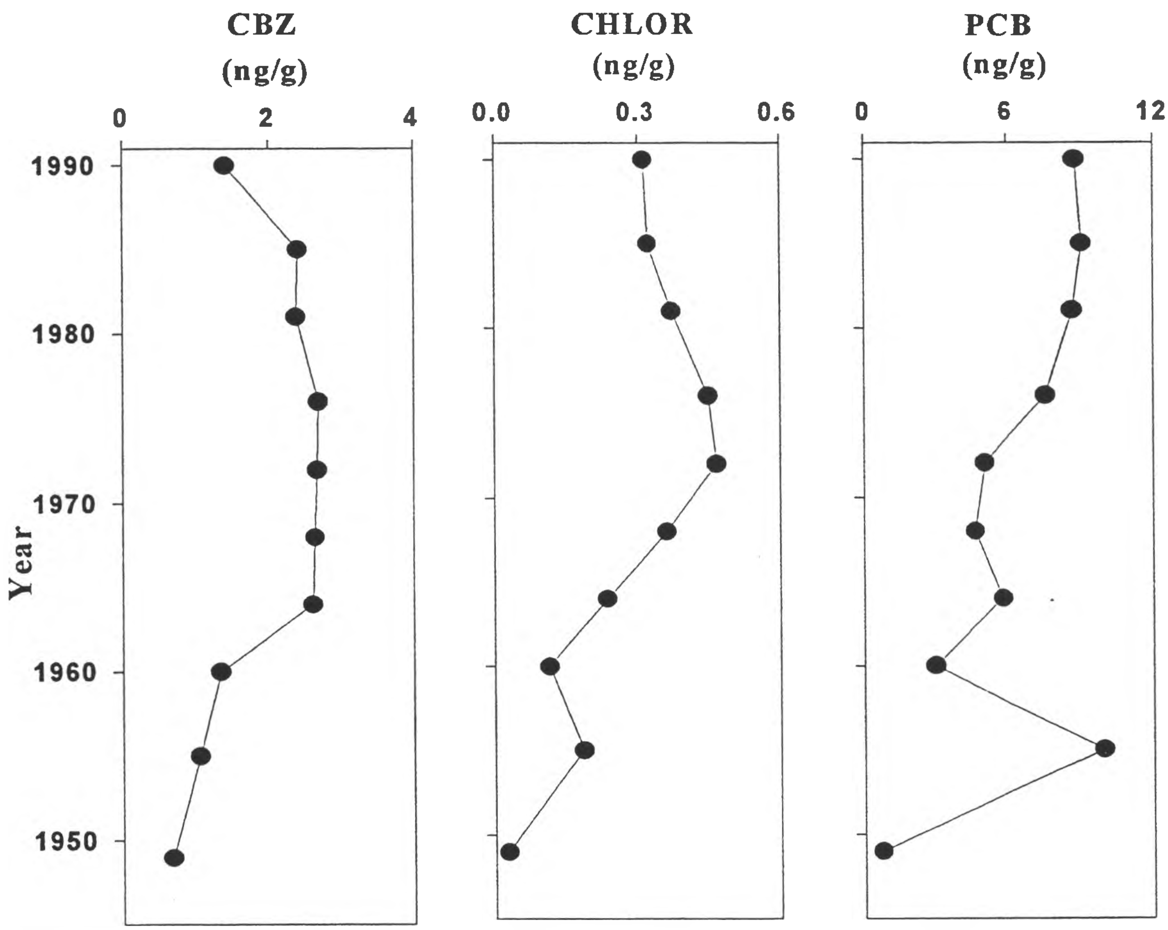


Figure 27. Concentrations of total PCB, chlorobenzenes, and chlordane in Core 19B.

CBZ was the next most abundant compound (mean 2.0 ± 0.7 ng/g) (Figure 27): mean concentrations were substantially greater than in the surficial sediments offshore of the Slave River mouth (mean = 0.7 ng/g). Concentrations in Core 19B increased slightly from 1949 to 1960 and then more sharply in the mid-1960s. Concentrations were stable until the mid 1980s and then decreased in the early 1990s. Chlordane (mean concentration 0.4 ± 0.1 ng/g) concentrations increased in the early 1960s to 1970s and declined slightly in more recent time. Concentrations were similar to those observed in surficial sediments offshore of the Slave River.

HCH (mean concentration 0.3 ± 0.1 ng/g) increased in concentration from 1949 to 1972 and then decreased in slightly thereafter (Figure 28). DDT (mean 0.8 ± 0.3 ng/g) concentrations were highly variable. Highest concentrations were observed in the median years 1960-1964, 1971 and 1981: no time trends were apparent from these data. Dieldrin (mean 0.2 ± 0.1 ng/g) showed a weak trend of increasing concentration up to the early 1970s and a trend of decreasing concentration thereafter. The mid-1970s were however, a period with relatively low DDT and dieldrin concentrations. HCH and DDT concentrations were similar to those observed in surficial sediment samples offshore of the Slave River although dieldrin concentrations tended to be higher.

The presence of pentachloroanisole, trichloroveratrole, and tetrachloroveratrole in lake sediments is believed to be indicative of a pulp and paper mill source (Neilson et al., 1984). These compounds were not detected in Core 19B in the late 1940s but increased thereafter although concentrations were low (Figure 29). Pentachloroanisole was detected in the mid 1950s, increased in concentration up to the mid 1970s and decreased thereafter. In contrast, trichloroveratrole was not detected until the early 1960s and has occurred in steadily increasing concentrations since. Tetrachloroveratrole was first detected in the mid-1960s and in fluctuating but increasing concentrations thereafter. Differences in the time trends of these compounds suggest that changes in pulp and paper mill operation have

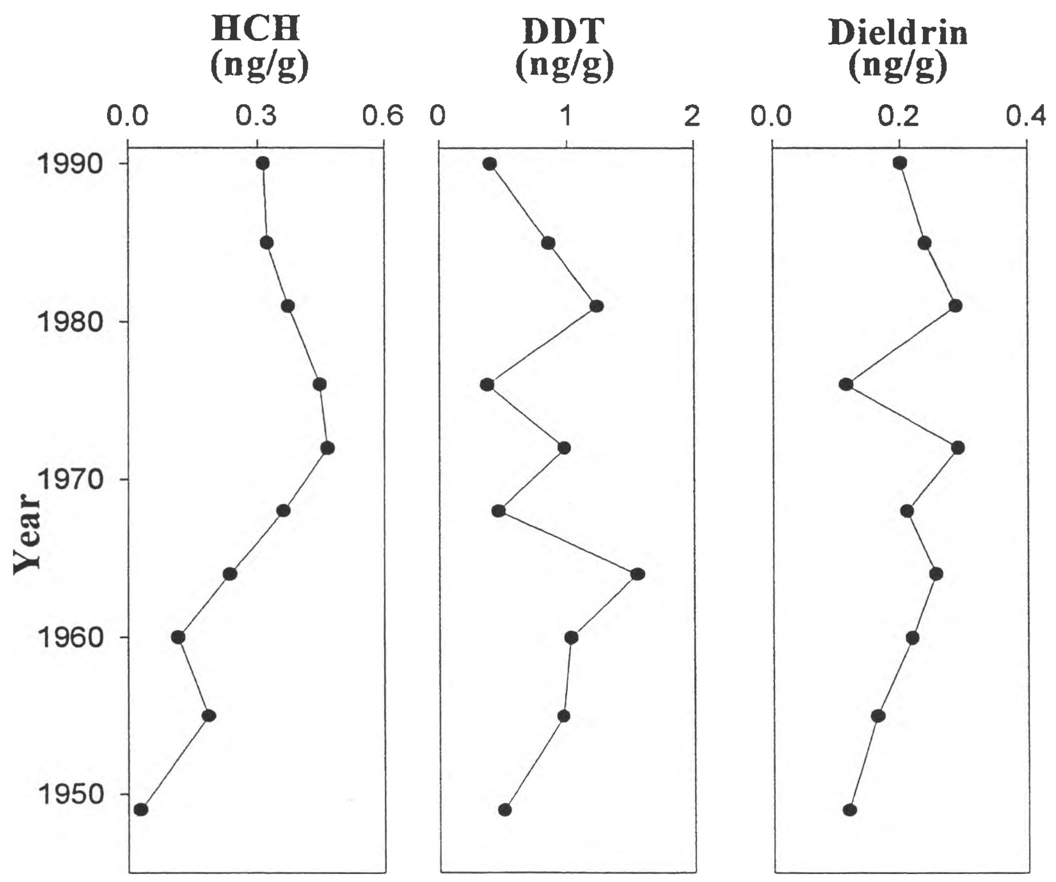


Figure 28. Concentrations of HCH, total DDTs, and dieldrin in Core 19B.

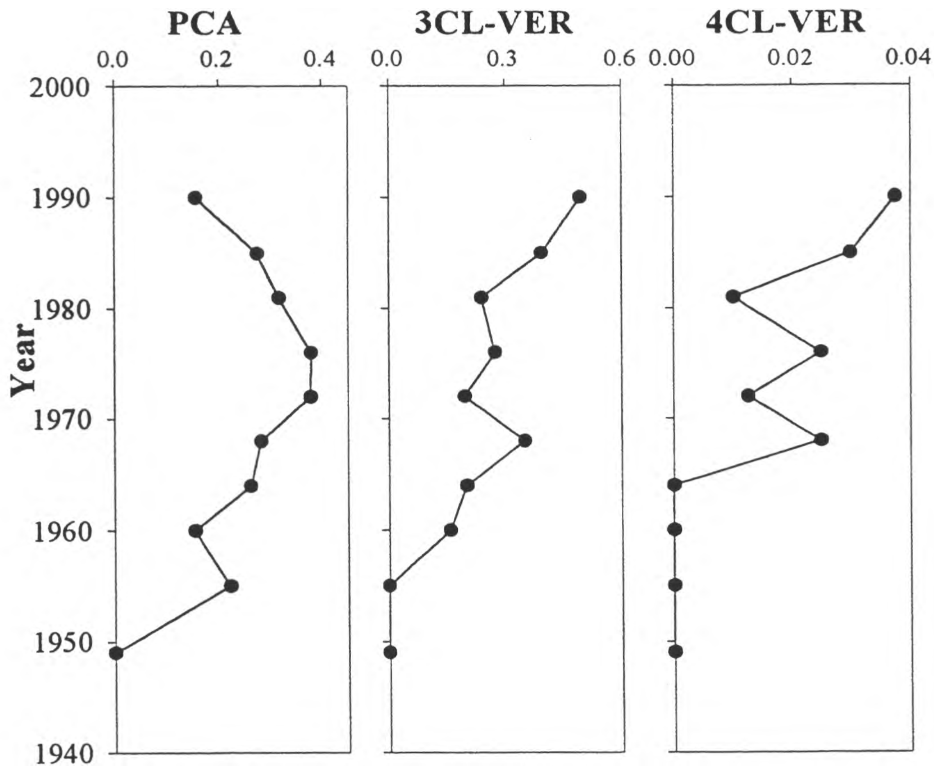


Figure 29. Concentrations of pentachloroanisole, trichloroveratrole and tetrachloroveratrole versus year for Core 19B. Results reported in ng/g dry weight.

affected both the quantity and the relative proportions of pentachloroanisole, trichloroveratrole, and tetrachloroveratrole produced during these activities.

4.5.2 PAH analyses

PAH concentrations were measured in the upper 6 cm (nominal depth) of Cores 12B and 19B. The median date for the 5 - 6 cm slice was 1967 for Core 12B and 1949 for Core 19B (Figure 30). Core 19B spanned a broader period of time than Core 12B. Differences in the time period covered by the same slice series for the two stations are due to three factors. First, actual core slices were thinner for Core 12B than Core 19B. This meant that the actual sediment depth for the Core 12B slices was 3.8 cm (rather than 6 cm) versus 5.2 cm for Core 19B. Second, Core 12B had a slightly lower mass sedimentation rate than Core 19B (554 $g/m^2/y$ versus 692 $g/m^2/y$). Finally, Core 12B had a higher water content than Core 19B.

Naphthalene, 2-methylnaphthalene, and 1-methylnaphthalene were the major components of total PAHs (Category 1) in both cores (Figure 30). Moreover, concentrations were consistently higher in Core 19B than Core 12B. Concentrations in Core 12B were low in the late 1960s, reached a peak in the late 1970s and then declined slightly through the mid 1980s and then increased slightly.

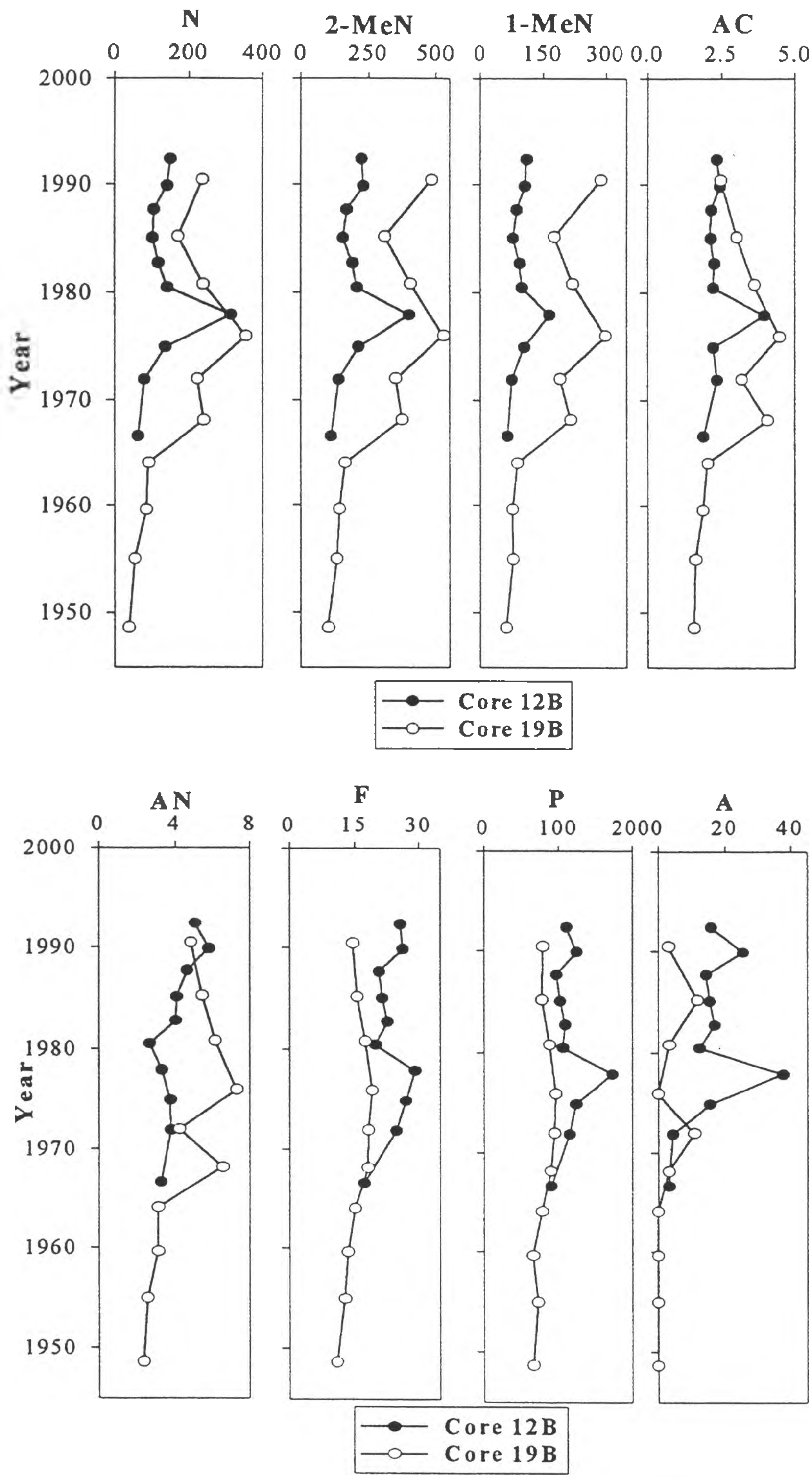


Figure 30. Concentrations of Category 1 PAHs (ng/g) versus year for Cores 12B and 19B.

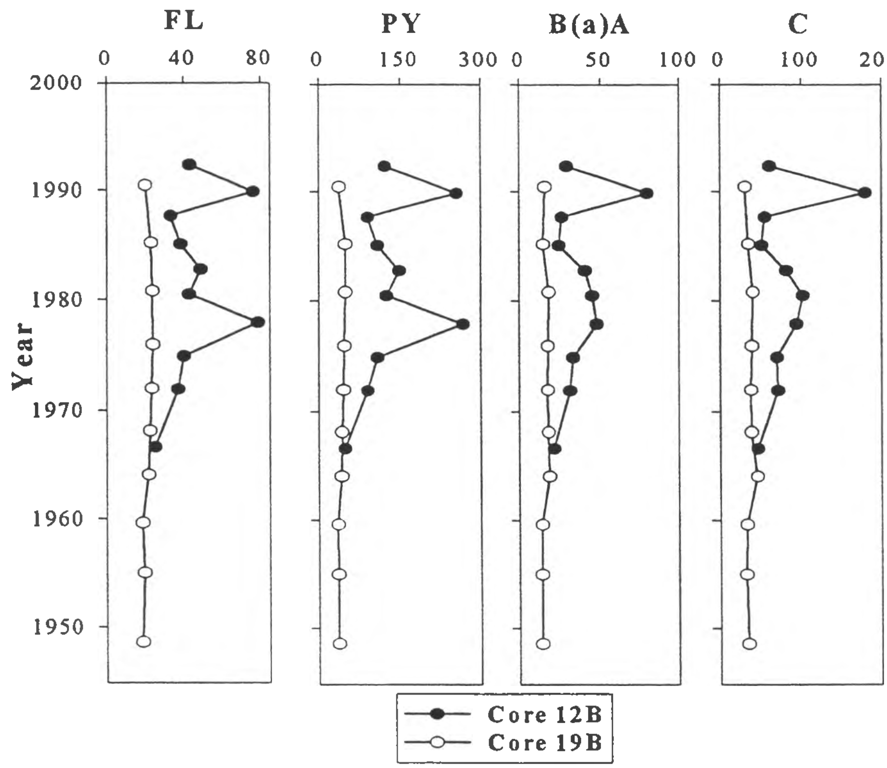
Concentrations in Core 19B (Appendix E. Table 5) were low from the late 1940s to the mid-1960s but higher thereafter. Peak concentrations of these compounds were observed in the mid-1970s. As in Core 12B, napthalene concentrations increased in the 1990s. These trends for increasing concentration of napthalenes with time are somewhat similar to those observed for CBZ, pentachloroanisole, trichloroveratrole, and tetrachloroveratrole. They are suggestive of increased industrial activity within the Slave, Peace, and Athabasca River watersheds. Total naphthalene (naphthalene, 2-methylnaphthalene, and 1-methylnaphthalene) concentrations were substantially higher in the upper 6 cm of the two cores than in the surficial sediments offshore of the Slave River mouth. Mean concentration for Core 12B was 440.6 ± 174.6 ng/g, 555.3 ± 300.3 ng/g for Core 19 B, versus 58.6 ± 15.1 ng/g for the surficial sediments offshore of the Slave River Mouth. The 14 - 16 cm slice of Core 19B had a total naphthalene concentration of 252.5 ng/g.

Acenaphthylene and acenaphthlene were minor constituents of total PAHs (Figure 30). Concentrations tended to be higher in Core 19B than Core 12B. Concentrations were higher in Core 19B after the mid-1960s than from 1947 to the mid-1960s. Concentrations of these compounds in both cores were similar to those observed in the surficial sediments offshore of the Slave River mouth. Acenaphthylene and acenaphthlene concentrations were lower in the 14 - 16 cm slice (1.9 ng/g and 2.8 ng/g respectively) of Core 19B than in the most recent slices.

Fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene and chrysene occurred in higher concentrations in Core 12B than Core 19B (Figure 30). There was relatively little temporal variation in the concentrations of these PAHs in Core 19B. Moreover, concentrations of these PAHs were similar in the upper 6 cm of the Core 19B as at 14 -16 cm. In contrast, there were substantial temporal variations in the concentrations of these PAHs in Core 12B. Concentrations generally increased from the late 1960s to reach a peak in 1978 and then declined somewhat thereafter. The reasons for these variations is uncertain. Since Core 12B was collected offshore of Hay River, it is possible that some of the time trends were associated with increasing and then decreasing inputs of contaminants from a localized source. For example, increased shipping and other industrial activities at Hay River associated with the oil exploration industry may have resulted in a localized increase of PAHs from combustion sources. It would be be highly desirable to analyze Core 12B to greater depths to obtain more information on the concentrations of these PAHs prior to the late 1960s.

Benzo(b)flurorene, benzo(k)fluorene, benzo(e)pyrene, and benzo(a)pyrene occurred in slightly higher concentrations in Core 12B than 19B (Figure 30). There was relatively little temporal variability in the concentration of these PAHs: the notable exception was low benzo(a)pyrene concentrations between the late 1950s and late 1960s in Core 19B. Concentrations at 14 - 16 cm were similar to those observed in the upper 6 cm of Core 19B. For Core 12B, maximum concentrations of these four PAHs tended to occur in 1983.

Indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perlyene and benzo(a)pyrene occurred in similar concentrations in Cores 12B and 19B (Figure 30). For Core 12B, concentrations were lowest prior to the early 1960s, peaked in the 1970s, and declined thereafter. For Core 19B, highest concentrations tended to occur from the early 1970s to the early 1980s. Concentrations at 14 - 16 cm were similar to those observed in the upper 6 cm of Core 19B.



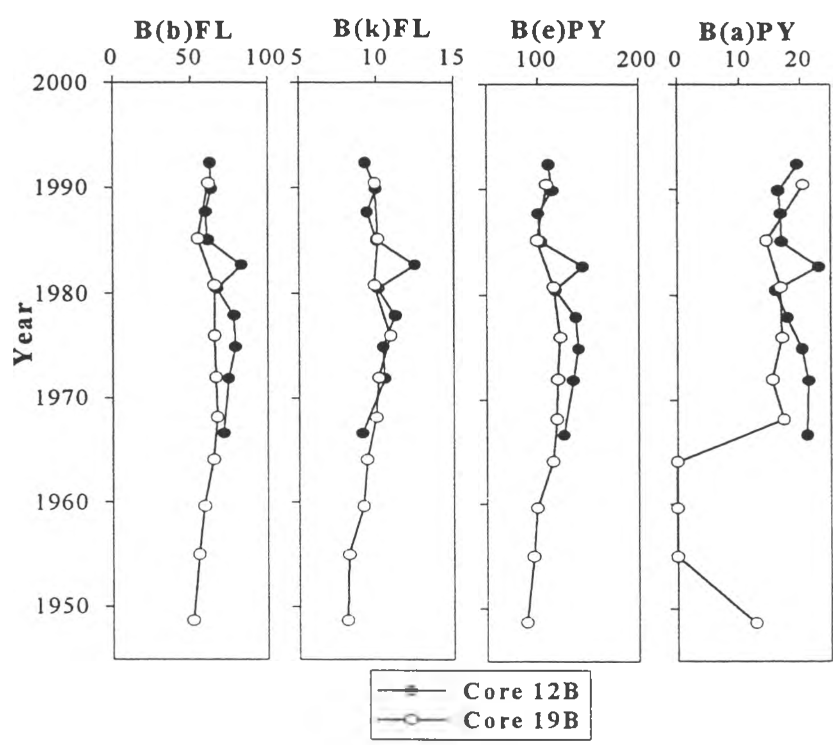


Figure 30, continued.

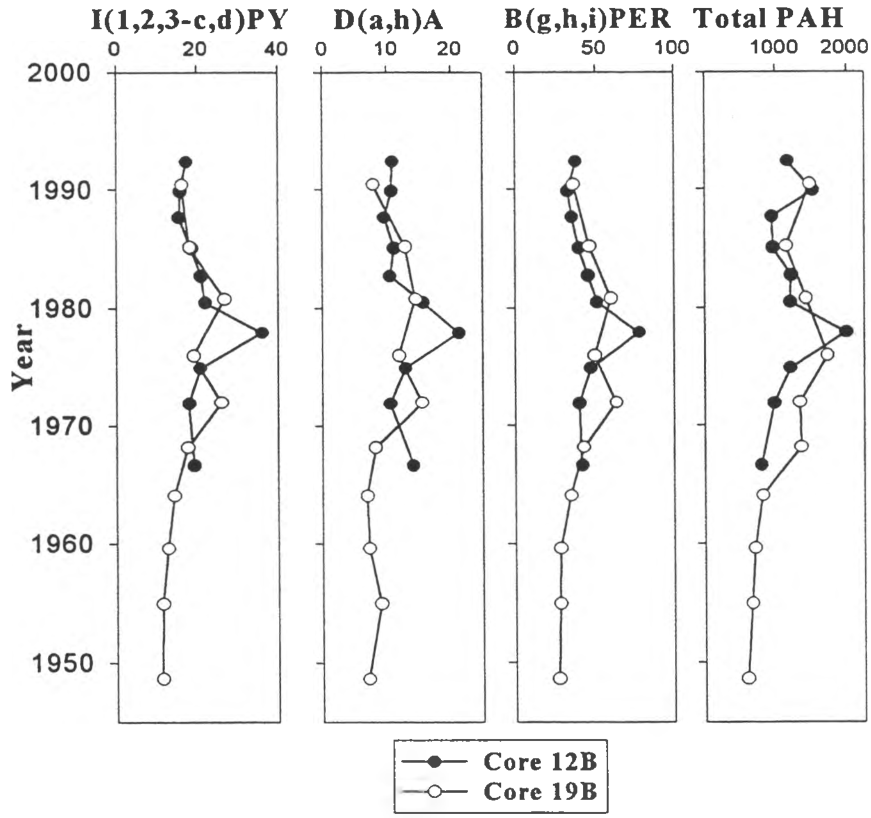


Figure 30, continued.

Total Category 1 PAHs in Core 12B ranged in concentration from 804.3 - 1,998.3 ng/g and averaged 1,206.0 ± 342.4 ng/g (Appendix E. Table 3). Highest PAH concentrations occurred in 1978 and the second highest in 1990. The lowest PAH concentration occurred in 1967. Total PAHs concentrations were similar in Core 19B ranging from 599.8 - 1,733.7 ng/g and averaging 1,128.3 ± 399.9 ng/g for the top 6 cm of sediment (Appendix E. Table 3). The highest PAH concentration occurred in 1976 and the second highest in 1992. Lowest PAH concentration was observed in the late 1940s. Total PAH concentration for the 14 -16 cm slice was 737.0 ng/g.

Category 2 PAHs, dibenzofuran, retene, dibenzothiophene, and triphenylene occurred in uniform concentrations with time in Core 19B (Figure 31; Appendix E. Table 6). Concentrations were higher in Core 12B with peak concentrations occurring in the late 1970s and late 1980s (Appendix E. Table 4). Perylene occurred in constant concentrations with time in Core 12B and the most recent 20 years of Core 19B. Perylene concentrations in Core 19B were very low prior to the 1970s and frequently were below detection limits. Perylene concentration in the 14 - 16 cm slice was 20.3 ng/g.

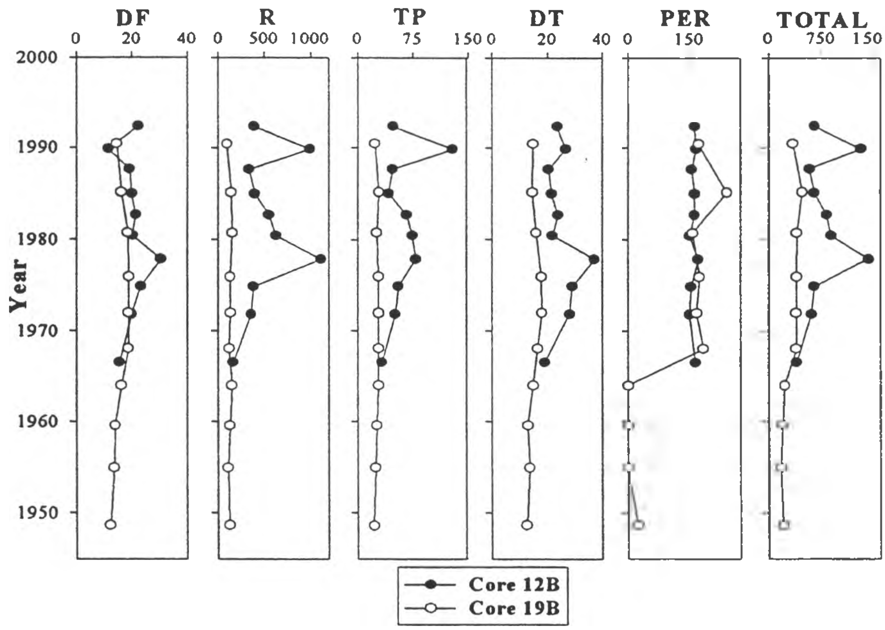


Figure 31. Category 2 PAHs (ng/g)

4.5.3 PCDDs and PCDFs

Cores 19D and Core 23A were analyzed for PCDDs and PCDFs: samples were analyzed down to a nominal depth of 5 - 6 cm and 5.0 - 5.5 cm respectively (Tables 8 and 9; Figure 32). Total PCDD concentrations in Core 19D ranged from 16.4 - 86.3 pg/g and averaged 36.7 ± 21.4 pg/g. The lowest concentrations were observed during the late 1940s and the highest in the mid to late 1950s. Concentrations decreased thereafter with concentrations in the late 1980s and early 1990s approaching values observed in the late 1940s (Figure 33). Average PCDD concentrations were lower in Core 23A (21.5 ± 10.6 pg/g) than Core 19D, and the Core 23A maximum occurred slightly later than in Core 19D. PCDDs in both cores were dominated by OCDDs which occurred in a mean concentration of 29.9 pg/g in Core 19D (81.5% of total PCDDs) and 15.2 pg/g in Core 23A (70.7% of total PCDDs). 1,2,3,4,5,6,8-HpCDD was the next most abundant compound in both cores.

As previously mentioned, Di- and Tri-CDDs were not detected during the first PCDD/PCDF analysis. Sufficient material remained in the 0 - 1 cm slice and the 5.5 - 6.0 cm slice of Core 19D for reanalysis. A total of 5.2 pg/g DiCDD (2,7-, 2,8, and 2,3-DiCDD) and 0.9 pg/g 2,3,6-TriCDD were detected in the 0 - 1 cm slice: slightly lower concentrations (3.4 pg/g Di-CDD and 0.7 pg/g Tri-CDD) were detected in the 5.5 - 6.0 cm slice (Table 9). For Core 23A, sufficient material remained from the 1.5 - 5.0 cm slices for reanalysis. Concentrations of DiCDD were low with a peak occurring in the early 1970s (Figure 33). Tri-CDD exhibited little variation in concentration with time. No time trend could be determined because of numerous missing data points.

Table 8. PCDD and PCDF concentrations (pg/g) in Core 19D. Great Slave Lake, March 1994.

	Depth										
COMPOUND	0 -1	1 - 1.5	1.5 - 2	2 - 2.5	2.5 - 3	3 - 3.5	3.5 - 4	4 - 4.5	4.5 - 5.0	5 - 5.5	5.5 - 6
2,7/2,8-DiCDD	**3.9**	ND	ND	ND	ND	ND	ND	ND	ND	ND	**2.2**
2,3-DiCDD	**1.3**	ND	ND	ND	ND	ND	ND	ND	ND	ND	**1.2**
2,3,7-TriCDD	**0.9**	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.7**
2,3,7,8-TCDD	<0.1	<0.2	<0.3	**(0.2)**	<0.2	<0.4	<0.2	<0.1	<0.5	<1.1	<0.1
1,2,3,7,8-PeCDD	<0.2	<0.3	<0.3	<0.4	<0.2	<0.4	<0.5	<0.2	<0.5	<0.7	<0.1
1,2,3,4,7,8-HxCDD	<0.2	<0.2	**(0.2)**	<0.2	<0.1	<0.1	<0.3	<0.3	<0.4	<0.9	<0.2
1,2,3,6,7,8-HxCDD	**0.3**	<0.2	**0.6**	**(0.3)**	**0.8**	**(0.6)**	**(0.8)**	<0.3	<0.5	**1.1**	<0.2
1,2,3,7,8,9-HxCDD	**0.3**	<0.2	**0.3**	<0.2	**(0.3)**	**(0.6)**	**(0.5)**	**(0.6)**	<0.5	<0.9	<0.2
1,2,3,4,6,7,8-HpCDD	**2.1**	**2.4**	**2.7**	**3.4**	**(3.8)**	**4.4**	**5.8**	**4.7**	**7.3**	**3.8**	**1.4**
OCDD	**14.0**	**14.0**	**18.0**	**20.0**	**20.0**	**32.0**	**46.0**	**40.0**	**79.0**	**35.0**	**11.0**
TOTAL PCDD	**22.8**	**16.4**	**(21.8)**	**(23.9)**	**(24.9)**	**(37.6)**	**(53.1)**	**(45.3)**	**86.3**	**39.9**	**16.5**
2,8-DiCDF	**6.2**	ND	ND	ND	ND	ND	ND	ND	ND	ND	**3.1**
2,3,8-TriCDF	**5.3**	ND	ND	ND	ND	ND	ND	ND	ND	ND	**1.2**
2,3,7,8-TCDF	**0.9**	**0.8**	**(0.7)**	**0.5**	**0.3**	**(0.5)**	**0.4**	**0.3**	**(0.5)**	**(0.6)**	**0.6**
1,2,3,7,8-PeCDF	<0.1	<0.2	**(0.2)**	<0.1	<0.1	<0.1	<0.2	<0.1	<0.3	<0.4	**0.4**
2,3,4,7,8-PeCDF	<0.1	<0.2	**(0.1)**	<0.2	<0.1	<0.2	<0.3	<0.2	<0.3	<0.5	<0.1
1,2,3,4,7,8-HxCDF	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.2	<0.3	<0.2	<0.4	<0.2
1,2,3,6,7,8-HxCDF	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.2	<0.3	<0.2	<0.4	<0.2
2,3,4,6,7,8-HxCDF	**0.2**	<0.2	<0.2	<0.2	**0.5**	**0.3**	**(0.5)**	<0.3	<0.2	<0.5	**0.2**
1,2,3,7,8,9-HxCDF	<0.1	<0.2	<0.3	<0.2	<0.1	<0.2	<0.2	<0.4	<0.2	<0.5	<0.2
1,2,3,4,6,7,8-HpCDF	**0.4**	**0.4**	**0.7**	**(0.4)**	**0.4**	**(0.5)**	**0.7**	**(0.8)**	<1.0	**0.7**	**0.5**
1,2,3,4,7,8,9-HpCDF	<0.2	<0.3	<0.4	<0.2	<0.3	<0.5	<0.4	<0.2	<1.4	<0.7	<0.7
OCDF	**(0.6)**	**(1.2)**	**1.0**	**0.7**	**1.0**	**(0.8)**	**(1.0)**	<0.5	**(1.1)**	<1.1	<0.4
TOTAL PCDF	**(13.6)**	**(2.4)**	**(2.7)**	**(1.6)**	**2.2**	**(2.1)**	**(2.6)**	**(1.1)**	**(1.6)**	**1.3**	**6.0**

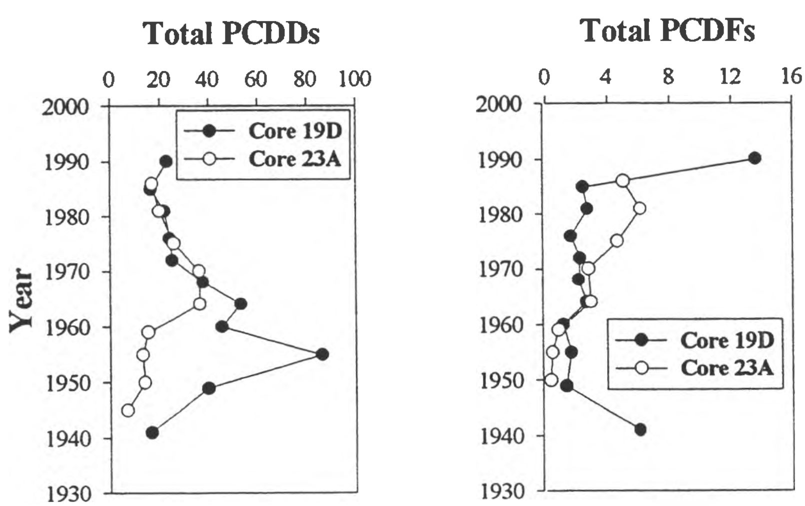


Figure 32. Total PCDD and total PCDF in Cores 19D and 23A. Results reported in pg/g dry weight.

TCDD and PeCDD were not detected in Core 19D nor Core 23A. HxCDD occurred in very low concentrations in both cores. These compounds also not detected in the surficial sediments offshore of the Slave River mouth. HpCDD was detected in all core slices. OCDD was the most abundant compound detected. Thus, two groups of PCDDs were detected in Great Slave Lake sediments - lower chlorinated forms (dominated by DiCDDs), which may have had their source in pulp and paper mill effluents, and higher chlorinated forms (dominated by HpCDD and OCDD), which probably had their source in combustion activities. However, the time trends in HpCDD and OCDD for Core 19D did not follow that for any of the PAHs in Core 19B. Hexa-, Hepta- and Octa-PCBs were the only compounds which showed a similar peak in concentration during the late 1950s and 1960s as HpCDD and OCDD.

Table 9. PCDD and PCDF concentrations (pg/g) in Core 23A. Great Slave Lake, March 1994 collections.

	DEPTH										
COMPOUND	0 - 1 A	0 - 1 B	1 - 1.5	1.5 - 2	2 - 2.5 A	2 - 2.5 B	2.5 - 3	3 - 3.5	3.5 - 4	4 - 4.5	5 - 5.5
2,7/2,8-DiCDD	ND	ND	ND	3.2	1.4	5.5	1.4	1.4	2.2	2.5	ND
2,3-DiCDD	ND	ND	ND	0.9	1.2	1.2	1.3	1.4	1.6	1.5	ND
2,3,7-TriCDD	ND	ND	0.8	<0.6	0.6	0.6	0.6	0.6	0.6	0.8	ND
2,3,7,8-TCDD	<0.2	<0.2	<0.3	<0.1	<0.2	<0.2	<0.2	<0.1	<0.2	<0.1	<0.2
1,2,3,7,8-PeCDD	<0.4	<0.3	<0.5	<0.3	<0.3	<0.4	<0.3	<0.3	<0.4	<0.3	<0.3
1,2,3,4,7,8-HxCDD	<0.2	<0.2	<0.1	<0.2	<0.2	<0.3	<0.2	<0.2	<0.2	<0.1	<0.1
1,2,3,6,7,8-HxCDD	(0.4)	0.3	(0.4)	(0.4)	<0.2	<0.4	<0.2	(0.2)	<0.3	(0.2)	<0.2
1,2,3,7,8,9-HxCDD	(0.3)	<0.2	<0.2	0.3	<0.2	<0.4	<0.2	(0.3)	<0.2	<0.1	<0.1
1,2,3,4,6,7,8-HpCDD	1.8	2.8	2.6	2.8	3.5	4.1	3.1	1.3	0.8	0.8	0.8
OCDD	(11.0)	17.0	16.0	18.0	28.0	26.0	30.0	10.0	7.8	8.0	(5.9)
TOTAL PCDD	(13.5)	(20.1)	(19.8)	(25.6)	34.7	37.4	36.4	(15.2)	13.0	(13.8)	(6.7)
2,8-DiCDF	<0.2	<0.2	<0.2	<0.4	2.1	<0.5	1.8	<0.1	<0.1	<0.1	<0.2
2,3,8-TriCDF	<0.2	4.8	3.1	(1.1)	0.8	1.1	0.8	0.4	0.4	0.3	<0.2
2,3,7,8-TCDF	0.6	0.8	0.6	0.3	<0.2	<0.5	<0.3	<0.1	<0.2	<0.2	<0.1
1,2,3,7,8-PeCDF	<0.1	<0.1	<0.1	<0.2	<0.1	<0.3	<0.2	<0.1	<0.1	<0.1	<0.2
2,3,4,7,8-PeCDF	<0.1	0.7	0.6	0.5	<0.2	<0.4	<0.2	<0.1	<0.2	<0.2	<0.2
1,2,3,4,7,8-HxCDF	<0.2	<0.2	<0.2	<0.2	<0.3	<0.2	<0.2	<0.2	<0.3	<0.2	<0.2
1,2,3,6,7,8-HxCDF	<0.2	<0.2	<0.2	<0.2	<0.3	<0.2	<0.3	<0.2	<0.3	<0.2	<0.3
2,3,4,6,7,8-HxCDF	<0.2	0.4	0.4	(0.6)	<0.3	(0.5)	0.3	<0.2	<0.3	<0.2	<0.2
1,2,3,7,8,9-HxCDF	<0.2	<0.2	<0.2	<0.2	<0.3	<0.2	<0.3	<0.2	<0.3	<0.2	<0.3
1,2,3,4,6,7,8-HpCDF	(0.3)	(0.6)	(0.5)	<0.5	0.4	<0.4	<0.3	0.4	<0.3	<0.2	<0.2
1,2,3,4,7,8,9-HpCDF	<0.3	<0.5	<0.4	<0.7	<0.2	<0.6	<0.3	<0.4	<0.4	<0.2	<0.2
OCDF	0.8	1.0	0.9	1.0	(0.7)	<1.1	<0.3	<0.5	<0.4	<0.2	<0.5
Total PCDF	(1.7)	(8.3)	(6.1)	(4.6)	(4.0)	(1.6)	2.9	0.8	0.4	0.3	ND

PCDFs were much less abundant than PCDDs in Cores 19D and 23A (Figure 32). For Core 19D, total PCDF concentrations ranged from 1.1 - 13.6 pg/g and averaged 3.8 ± 3.6 pg/g (Table 8). The data are incomplete because only the 0 - 1 cm and the 5.5 - 6.0 slices were reanalyzed for the lower chlorinated PCDFs. Di- and Tri-CDDFs accounted for 84.6% of the total PCDFs in the 0-1 cm slice and 71.7% in the 5.5 cm slice (Figure 34). Total PCDF concentrations were lower in Core 23A and ranged from below detection limits in the 1940s to 8.3 pg/g in the early 1980s (Table 9, Figure 32).

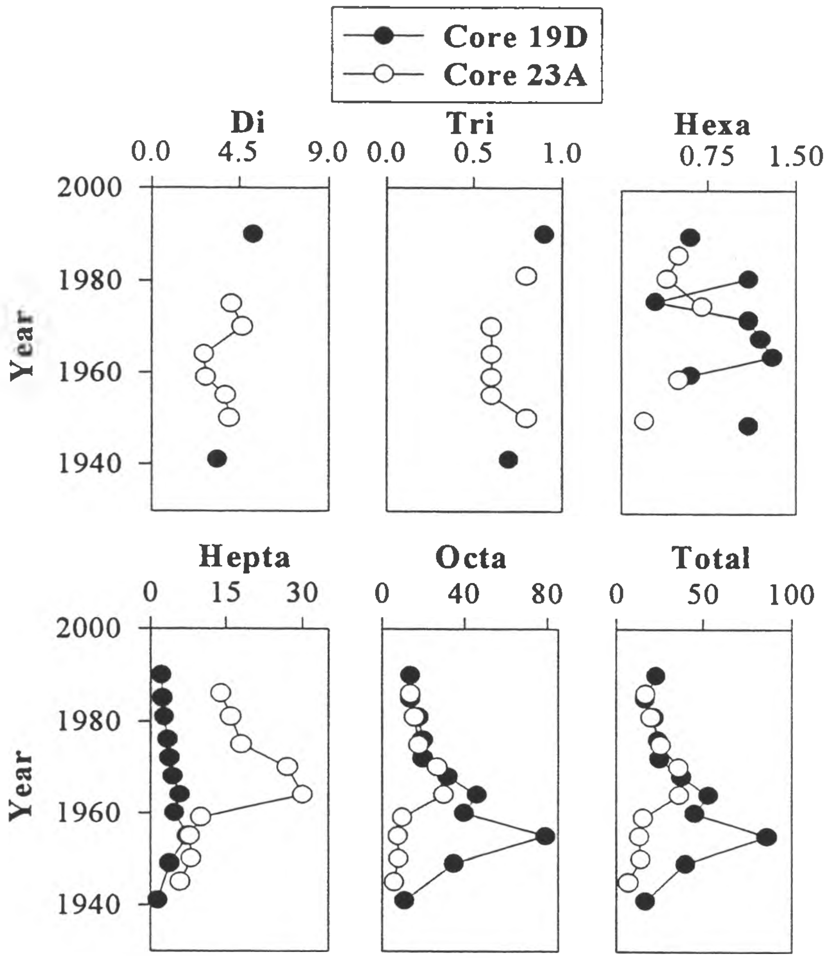


Figure 33. PCDD concentrations versus year for Cores 19D and 23A. Results reported in pg/g dry weight.

2,8 - DiCDF was detected in only one of the two replicates of the 2.0 - 2.5 cm slice analyzed and in the 2.5 - 3.0 cm slice for Core 23A (Figure 34, Table 9). 2,3,8 - TriCDF was detected in all slices and accounted for an average of 54% of total PCDFs. Tri - CDF concentration appeared to increase with time in Core 23A and possibly in Core 19D. 2,3,7,8-TCDF, 1,2,3,4,5,6,7-HpCDF, and OCDF also were significant components of total PCDFs. TCDF exhibited a trend of increasing concentration in both cores during the 1970s and 1980s. No trends were evident in both cores with the more highly chlorinated PCDFs.

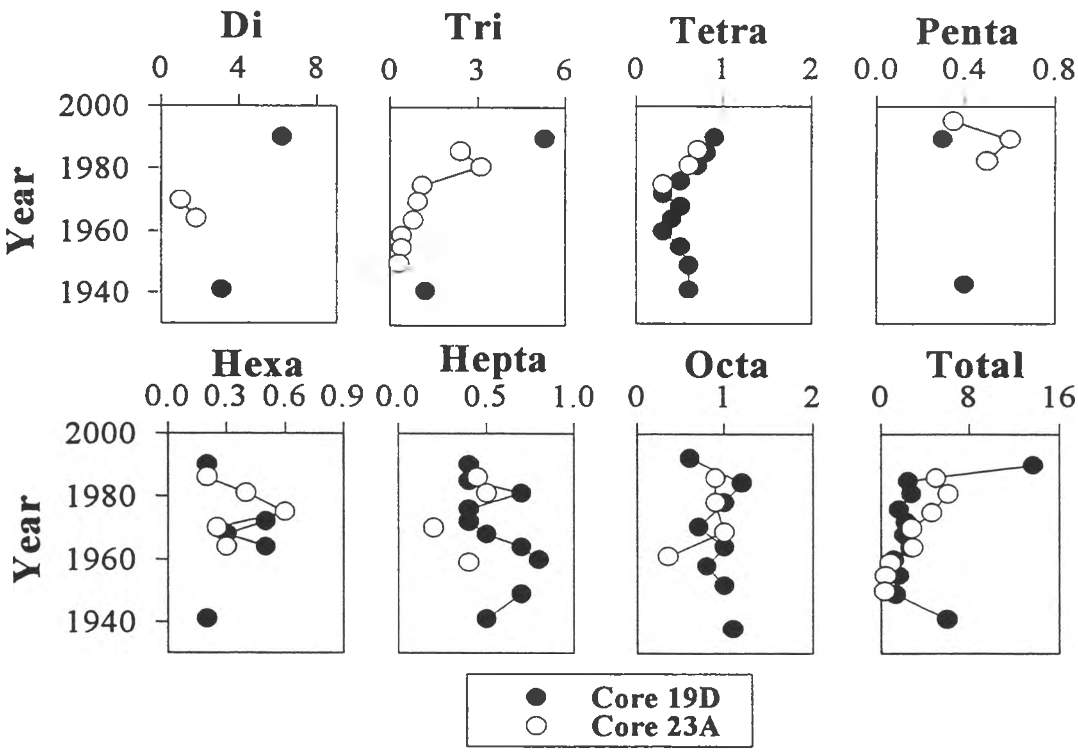


Figure 34. PCDF concentrations versus year for Cores 19D and 23A. Results reported in pg/g dry weight

5.0 DISCUSSION

This report presents the results of August 1993 and March 1994 sampling sediment sampling in Great Slave Lake. The August study focused on surficial sediments in the immediate vicinity of the Slave River mouth and on two core samples collected immediately west of the Slave River mouth. The March 1994 sampling focused on collecting cores to the west of the August 1993 collections. Ongoing studies are obtaining more information on contaminant concentrations in surficial sediments in the East Arm, i.e., at sites increasingly far removed from the direct Slave River influence. Additional core samples were collected offshore of the Slave River mouth in March 1995 and will provide more information on the depositional history of organic contaminants to Great Slave Lake. Much core material remains from the March 1994 collections which, if analyzed, could provide for more definitive interpretations of the influence of the Slave River on contaminant loading to Great Slave Lake. Nevertheless, preliminary interpretations can be made with the current data sets presented in this report. Later reports will continue these investigations and interpretations.

5.1 SEDIMENTATION RATES

The Slave River transports tremendous amounts of suspended sediments into Great Slave Lake. The Mackenzie River Basin Committee (1981) reported the mean sediment load as 2.72 kg x 10^{10}/y while Allan (1979) reported the 1972 - 1975 mean load as 2.64 kg x 10^{10}/y. Allan also noted that the peak sediment load occurs prior to spring melt and during a period when it is impossible to sample suspended sediments. Allan estimated the true sediment load as 6.72 kg x 10^{10}/y. The West Basin has a total surface area of 19,400 km^2. If sediments from the Slave River were uniformly distributed over this area, mean sedimentation rate would range from a low estimate of 1,361 $g/m^2/y$ to a high estimate of 3,464 $g/m^2/y$.

Sedimentation rates at the five coring sites (March 1994) ranged from 343 $g/m^2/y$ (Core 16A) to 692 $g/m^2/y$ (Core 19B). These rates are some 4 - 10 times lower than the estimated rates based on the area of the West Basin and the estimated suspended sediment load of the Slave River. This suggests that the majority of Slave River sediments settle elsewhere in the West Basin.

When sedimentation rates at the five coring sites are corrected for focusing, there was a trend of decreasing sedimentation from Site 19 to Site 12: 432 $g/m^2/y$ for Core 19B, 343 $g/m^2/y$ for Core 16A, 256 $g/m^2/y$ for Core 13B, and 252 $g/m^2/y$ for Core 12B. Thus, sedimentation rates decreased with distance from the Slave River mouth. The highest corrected rate, 1,082 $g/m^2/y$ was observed for Core 23A. However, this was a site of strong erosion with a focusing factor of 0.53.

Much of the sedimentation of particulates transported into Great Slave Lake by the Slave River occurs directly offshore of the Slave River mouth. The Mackenzie River Basin Committee (1981) estimated that 50% of the sediments from the Slave River are deposited in the Slave River delta region. Sediments deposited in this region and further offshore are subject to resuspension, slumping, and further offshore movement. The Pine Point and Resolution 4 cores collected in August 1993 were from sites with significant sediment erosion, as was Site 23. Mudroch et al. (1992) observed very high sedimentation rates at Site 4, a 110 m deep station 50 km offshore of the river mouth. This high "sedimentation" was due to slumping rather than the direct settling of particles from the overlying water column onto the sediments. Because of this slumping, the sediments could not be accurately dated and a sedimentation rate estimated. Nevertheless, Mudroch et al. (1989a, 1992) estimated that the 14 - 15 cm section of the core collected from this site was only 0.23 year old. If we assume that the accumulated dry weight of sediments at 15 cm depth in this core was ca. 9.1 g/cm^2 (as in Core 19B), some 91,000 g/m^2 sediment were deposited in less than 3 months at this site.

Sedimentation processes vary regionally in Great Slave Lake. In areas of high sedimentation (Mudroch et al., 1992), much of the sedimentation may be associated with deep-water turbidity currents which flow down the lake shelf and slope, eroding and transporting material in their paths. During the 1993 summer water - column studies, we frequently noted a marked increase in turbidity in the few meters above the lake sediments (Evans, unpublished data). Resuspension of sedimentary material in a nepheloid layer is a well-known phenomenon in large lakes (Baker et al., 1985, 1991). The rapid sedimentation of particulates and erosion of shelf and slope material may also be associated with the offshore migration of the spring thermal bar. During early spring, Slave River water is substantially warmer than the <4°C Great Slave Lake water. As Slave River water mixes with lake water, it cools and increases in density. Convective cells of sinking water are formed at the thermal bar (Rodgers, 1966), accelerating the downward transport of particulates. Significant sedimentation may occur during this period and much of the initial deposition of sediments in Great Slave Lake may occur before and immediately following ice breakup. Because of Coriolis forces, currents are deflected to the right in the northern hemisphere (Wetzel, 1975). Thus, much of the Slave River outflow may be deflected to the northeast, particularly before the open lake becomes free of ice. Thus, the deep channel offshore of the Slave River mouth (Figure 3) may be a consequence of erosion by turbidity currents, especially in spring. The greatest sedimentation and contaminant deposition rates probably occur immediately offshore of the Slave River mouth. Our March 1995 core studies will allow us to test this hypothesis.

The August 1993 surficial sediment samples were collected offshore of the Slave River mouth. Our work to date suggests that sediments in this region are highly mobile. Thus, the age of these sediments is unknown. The upper 2 cm of sediments may represent as little as a few months of sedimentation as in Site 4 (Mudroch et al., 1992) or may represent 15 years of accumulation as for Core 19B. Or, these sediments may be even older. The 1.0 - 2.0 cm slice for the Resolution 4 core was tentatively assigned a median date of 1930 while the 1.0 - 2.0 cm slice for the Pine Point core was even older (although not datable). Uncertainties in the age of the surficial sediments in the August (1993) survey confound the interpretation of spatial patterns in organic contaminant concentrations in these sediments.

The March 1994 cores, which were collected further away from a strong Slave River influence, were readily datable. There were five interesting aspects to these data in addition to the actual date estimates.

Although four cores (Cores 12B, 13B, 16A, and 19B) were collected in deposition areas, the physical environment varied from site to site. Sites 12 and 13, furthest away from the Slave River mouth, were the most physically stable, i.e. deviations in excess ^{210}Pb from the linear regression line were the smallest. However, as cores were collected closer and closer to the Slave River mouth, deviations from the regression line increased, indicating more postdepositional movement of sediments and the erosion of older sediments on top of younger sediments. Thus, there is some inaccuracy in the assigned dates for core slices on the basis of the ^{210}Pb linear model. Accuracy could be improved by correcting slice dates on the basis of the generated regression line and the actual excess ^{210}P values for each core slice. Core 23A, while datable, was actually in a region of significant sediment erosion.

Variability between cores was small for the two cores collected at Site 13, far removed from a strong Slave River influence. Percent water, porosity, accumulated dry weight of sediment, and excess ^{210}Pb profiles with depth were similar to one another. In contrast, Cores 19B and 19D, collected in a more disturbed area closer to the river mouth, were markedly different from one another with respect to their percent water, porosity, accumulated dry weight of sediment, and excess ^{210}Pb profiles with depth. This is remarkable considering that the cores were collected within 10 m of one another. However, the scientific party noted considerable variability in the ability of the corer to retain sediments at a particular site. The same was noted by Evans and Headley (1993) in an earlier study although in different regions of the lake.

The highest sedimentation rate was observed at Site 12, the furthest site from the Slave River outflow. This was unexpected. The high sedimentation rate was related to the strong sediment focusing which occurred at this site. Moreover, it is possible that Site 12 was receiving sediments from Hay River in addition to the Slave River. Although Hay River contributes only 3.4 km^3 of inflow per year to Great Slave Lake versus the 118 km^3 of the Slave River (Mackenzie River Basin Committee, 1981), Site 12 may be close enough to the Hay River outflow to be affected by it. Thus, organic contaminant data from Site 12 may reflect a Hay River influence in addition to an atmospheric and Slave River influence. Moreover, because Hay River is a major shipping port and fuel storage depot, it may be a significant local source of PAHs and possibly OCs, PCDDs, and PCDFs.

Estimated sedimentation rates (uncorrected for focusing) ranged from 343 - 692 $g/m^2/y$. Sedimentation rates in the West Basin were similar to those observed by Bourbonniere et al. (1995; Table 8) for Site 1 in east-central Lake Athabasca. In that study, rates ranged from 380 - 720 $g/m^2/y$ (1.0 - 2.0 mm/y). Sedimentation rates in the West Basin of Great Slave Lake also are similar to those observed by Lockhart (1994) for a series of Yukon lakes. Lake Laberge had sedimentation rates of 591 - 656 $g/m^2/y$ while Kusawa Lake had a rate of 227 $g/m^2/y$. These lakes, like Great Slave Lake, are dominated by river inflow. Sedimentation rates in Great Slave Lake were not appreciably different from rates measured by Robbins et al. (1978) for two sites in mesotrophic Lake Ontario (570 - 780 $g/m^2/y$; 2.8 - 3.4 mm/y) and two sites in eutrophic Lake Erie (830 - 960 $g/m^2/y$; 2.0 - 4.6 mm/y). Robbins et al. (1978) measured a very high rate of sedimentation rate of 4,400 $g/m^2/y$ (14 mm/y) at one site in Lake Erie. Similar high-sedimentation sites occur in Great Slave Lake as previously noted by Mudroch et al. (1992). Like the West Basin of Great Slave Lake, the surface geology of the Lake Erie and Lake Ontario watersheds is characterized by recent Paleozoic deposits which are readily eroded into Lakes Erie and Ontario through a variety of processes. Sedimentation rates in Great Slave Lake were substantially higher than in Lake Superior. Baker et al. (1991) reported rates of 26 - 48 $g/m^2/y$ in the open waters of the Lake Superior and 190 $g/m^2/y$ for a core collected in nearshore waters. Lake Superior is oligotrophic and, like the East Arm of Great Slave Lake, is located in a Precambrian shield drainage basin. Lake Belot, a medium-sized lake located near Great Bear Lake, had an estimated sedimentation rate of 57 - 70 $g/m^2/y$ (Lockhart, 1994).

The fifth interesting aspect of the Great Slave Lake cores was the fact that the mixed depth was shallow, i.e., < 1 cm. The thin mixed-layer was probably related to two factors. First, the sediments in the West Basin have a relatively low porosity. Robbins (1982) determined that mixing depths were < 1 cm for sediments which had porosities of <0.9. Second, macrobenthos, which are the primary factor responsible for sediment mixing, occur in very low densities in Great Slave Lake. Total benthos densities average $1,630/m^2$: oligochaetes, which are especially effective in mixing sediments, occur in average densities of less than $200/m^2$ (Rawson, 1953). In contrast, sediments which are well-mixed have higher densities of these organisms: $6,000/m^2$ in a Lake Huron study and $38,000/m^2$ in a Lake Erie study (Robbins, 1982). The low density of macrobenthos in Great Slave Lake is probably related to the low productivity of the lake and the low flux rate of organic matter to the sediments. Thus, because Great Slave Lake sediments are not subject to strong reworking by the biota, contaminants buried in the sediments will not be readily recycled back into the water column as in lakes with well-mixed sediments.

5.2 ORGANOCHLORINE COMPOUNDS

PCB was the predominant OC found in surficial sediments offshore of the Slave River mouth (August 1993), but there were no obvious patterns in PCB concentration relative to the Slave River mouth. Concentrations ranged from 4.8 - 15.2 ng/g and averaged 9.8 ng/g. PCB concentrations in a single surficial sample analyzed from Lutsel K'e (East Arm) was 5.4 ng/g. Continuing analyses of sediment samples collected after March 1994 will allow us to determine whether or not PCB concentrations are higher in West Basin or the East Arm. Nevertheless, the limited data suggest that total PCBs occur in similar concentrations in the West Basin and the East Arm.

PCB concentrations in sediment cores and surficial sediments were comparable although slightly higher than concentrations observed by Mudroch et al. (1992) in an earlier investigation in the West Basin. In that study, PCB concentrations in the upper 6 cm of sediment analyzed from three sites ranged from 1.5 - 6.4 ng/g. Differences in concentration may be due to differences in sampling location and/or inter-laboratory analytical procedures. Concentration differences may also be due to the fact that we included analyses for mono - and di-chlorophenyls in our study and Mudroch et al. (1992) did not. PCB concentrations also were similar to those observed by Muir et al. (manuscript in prep) for a series of 12 lakes located in a region of central Canada extending from 49^{o}N - 82^{o}N.

PCB concentrations in Great Slave Lake sediments are similar to those reported for Lake Superior. Frank (1980a) reported that PCB concentrations were low, ranging from <2.5 - 57 ng/g and averaging 3.3 ng/g. In a later study, Baker et al. (1991) reported that Lake Superior sediments had an average PCB concentration of 8.6 ng/g while Jeremiason et al. (1994) reported surficial sediment concentrations of 7.8 - 17.6 ng/g. In contrast, PCB concentrations are much higher in Lake Michigan than in Great Slave Lake. Concentrations in Lake Michigan sediments have been reported as ranging from 1 - 132.6 ng/g and averaging 38.2 ng/g (Simmons, 1984). Evans et al. (1991) reported a mean concentration of 90 ng/g at an offshore station in southeastern Lake Michigan. PCB concentrations tend to be even higher in Lake Ontario. Mudroch et al. (1989b) reported a PCB concentration of 587 ng/g for a 0 - 1 cm core slice collected in the Eastern Basin while Frank et al. (1980b) reported that PCB concentrations in the Bay of Quinte ranged from <2 - 260 ng/g. Eisenreich et al. (1989) reported concentrations of ca. 75 - 200 ng/g in the surficial slices of cores collected in the open waters of Lake Ontario. High concentrations of PCBs in Lake Michigan and Ontario sediments are strongly related to localized inputs (see below).

PCBs enter Great Slave Lake through atmospheric deposition and through riverine inputs. The PCB accumulation rate for Core 19B can be estimated from the product of the sediment flux rate (692 $g/m^2/y$) and the mean PCB concentration (6.3 ng/g) in the upper 6 cm of sediment. According to these calculations, the mean PCB sediment accumulation rate for Core 19B was 4,360 $ng/m^2/y$ for the 1949 - 1994 period. This adjusted rate for sediment focusing is 2,722 $ng/m^2/y$. This value can be compared to rates estimated from the Muir et al. (unpublished manuscript) model which predicts PCB sediment accumulation rates based on latitude. With a latitude of 61.5°N, Site 19 has a predicted PCB sediment accumulation rate of 636.8 ng/m^2/y. The adjusted actual rate for Great Slave Lake was some 4.3 times greater than model predictions.

The total areal inventory of PCB in the upper 6 cm of sediments at Core 19B is estimated by the product of the accumulated dry weight of sediments and the mean PCB concentration. This value, 215.3 ng/m^2, is substantially higher than the estimated 19.1 - 99.2 µg/m^2 inventory estimated by Muir <u>et al</u>. (unpublished manuscript) for Canadian lakes located in central Canada and between 50 - 81°N. Differences between the PCB inventory for Great Slave Lake and the lakes investigated by Muir <u>et al</u>. (unpublished manuscript) are related to differences in PCB sediment accumulation rates between the lakes rather than to PCB concentrations, per se, in the sediments. Nevertheless, if this inventory for Core 19B is representative of the West Basin of Great Slave Lake, some 4,177 kg of PCB may reside in the upper 6 cm of sediments of the basin. In comparison, Lake Superior sediments contained an estimated 4,900 kg of PCB in 1986 (Jeremiason <u>et al</u>., 1994). Great Slave Lake, like the Great Lakes, has the potential to be a major, continental sink for PCBs.

The source of the PCBs entering Great Slave Lake with the Slave River is uncertain. Most of the PCBs must originate from dry and wet fallout including that originating from the southern regions of the Great Slave Lake watershed. If we assume that the southern extent of the watershed is 55°N, the Muir <u>et al</u>., (unpublished manuscript) model predicts that lakes in this region would have a PCB sediment accumulation rate of 912 ng/m^2/yr. Even though this rate is 1.4 times higher than the rate estimated for Site 19 at 61.5°N, it is still lower than the measured sediment accumulation rate at that site. Possibly PCBs are more efficiently transported to and retained in lakes fed by high turbidity rivers like Great Slave Lake than lakes fed by only direct precipitation and/or low turbidity rivers. This may occur because PCBs, once adsorbed onto particulates, may be less readily lost to the atmosphere through volatilization, than PCBs dissolved in the water phase. Moreover, particulate-bound PCBs may be more rapidly transported to the sediments. Finally, because Great Slave Lake has a very large watershed relative to its surface area, (983,000 km^2 to 27,000 km^2), it may receive a greater influx of PCBs on an areal basis than smaller lakes with a smaller watershed to lake surface area ratio.

The PCB input rate to Great Slave Lake via the Slave River can be estimated by sediment trap studies. In August 1994, a series of sediment traps were set offshore of the Slave River mouth and left in place for 10 days. PCB concentrations were measured in sediment flux immediately offshore of the Slave River mouth. PCB concentrations averaged 4.3 ng/g (Evans <u>et al</u>., in prep). For the purposes of this exercise, this value is assumed to be a representative estimate of PCB concentrations in Slave River suspended sediments. Using this "representative" value and the lower (1,361 g/m^2/y) and upper (3,464 g/m^2/y) estimates of the Slave River suspended sediment loading to Great Slave Lake, the river may be contributing some 5,852 - 14,895 ng/m^2/y of PCBs. This range of values is substantially higher than the PCB accumulation rate observed for Core 19B. This suggests that significant deposition of PCBs is occurring in other regions of the lake, e.g., in the delta region (Mackenzie River Basin Committee, 1981) and offshore of the Slave River mouth (Mudroch <u>et al</u>., 1992). In addition, a major fraction of the sedimented PCBs may be lost to volatilization (Manchester-Neesvig and Andren, 1989). Jeremiason <u>et al</u>. (1994) estimated that while 3,000 kg of

PCB settled to the lake floor in Lake Superior, only 110 kg accumulated in the sediments. Moreover, it was the heavier PCBs which more readily accumulated in the sediments (Baker et al., 1985, 1991).

PCB sediment accumulation rates (2,722 $ng/m^2/y$) for Core 19B in Great Slave Lake can be compared to those for other Great Lakes. Jeremiason et al.'s (1994) estimate that 110 kg of PCB were buried in the sediments of Lake Superior in 1986 corresponds to an areal sediment accumulation rate of 1,338 $ng/m^2/yr$. In contrast, PCB sediment accumulation rates in Lake Ontario during the early 1980s were ca. 129,000 - 175,000 $ng/m^2/y$ (Eisenreich et al., 1989). These higher accumulation rates in Lake Ontario than Superior were due to higher sedimentation rates and PCB input rates.

PCB budgets have been developed for only a small number of lakes. Eisenreich and Strachan (1992; Table 4a) estimated that Lake Superior receives some 157 kg/y of PCB via the atmosphere, corresponding to an areal atmospheric deposition rate of 1,910 $ng/m^2/y$. Rivers contribute an additional 1,703 $ng/m^2/y$ of PCB to the lake (Eisenreich et al., 1989). Most of the PCBs (10,100 kg) resided in the water column with a net volatilization loss of 1,900 kg (23,115 $ng/m^2/y$) in 1986. PCB concentrations in Lake Superior have declined over 1978 - 1992 due to volatilization losses. Localized sources of PCBs can result in one Great Lake having a relative low PCB budget, e.g., Lake Superior, while other lakes may have higher PCB budgets, e.g., Lake Michigan and Ontario. As PCB inputs have declined, so have the PCB budgets for these lakes. Eisenreich and Strachan (1992; Table 4a) estimated that Lake Michigan receives 114 kg of PCB per year from the atmosphere, corresponding to an areal deposition rate of 1,971 $ng/m^2/y$.

PCB flux rates to Lake Michigan were higher during the mid 1970s when PCBs were more widely used. Murphy and Rzeszutko (1977) estimated that during the mid 1970s, Lake Michigan received 5,000 kg/y of PCB from precipitation, 1,650 kg/y from streams and waste effluents, and 2,500 kg/y from other sources for a total of 9,150 kg/y. These mass flux rates correspond to areal PCB flux rates of 86,430 $ng/m^2/y$ from atmospheric sources, 28,522 $ng/m^2/y$ from streams and effluents, and 43,215 $ng/m^2/y$ from other sources for a total of 158,168 $ng/m^2/y$. Localized industrial sources were the primary factor accounting for high PCB concentrations in Lake Michigan sediments. For example, PCB concentrations as high as 60,000 ng/g were reported for Waukegan Harbor by Murphy and Rzeszutko (1977). These researchers estimated that Lake Michigan may have received 25,000 kg of PCB over a 20-year period from major industrial sources such as Waukegan Harbor. Areal PCB flux rates were substantially higher in the more industrialized southern end (115,000 $ng/m^2/y$) of Lake Michigan than the less developed northern end (18,000 $g/m^2/y$) of the lake (Murphy et al., 1981).

In Lake Ontario, PCB accumulation rates in core samples peaked during the 1960s and have been declining ever since (Eisenreich et al., 1989). This decline is related to a decrease in PCB sales in the United States. It may also be related, in part, to strong sediment mixing by the benthos which allows for the more efficient recycling of sedimentary PCBs into the overlying water column. Once PCBs re-enter the water column, they can be lost from the lake through volatilization. These volatilized PCBs, on entering the atmosphere, are transported to other regions, including the arctic and subarctic regions of Canada.

In contrast to the Great Lakes where PCB levels appear to be declining in lake sediments, PCB levels in Great Slave Lake (Core 19B) have increased with time, especially the higher-chlorinated congeners. Additional cores need to be analyzed from Great Slave Lake to determine whether or not this time trend is real. However, similar time trends have been noted in sediment cores collected in other regions of central and northern Canada (Muir et al., unpublished manuscript). These trends suggest that PCB inputs into subarctic and arctic lakes are continuing to increase although input rates to temperate lakes have decreased. This phenomenon is related to the long lag time between the period of maximum PCB production and the subsequent increase in concentration of these compounds in the subarctic and arctic atmosphere. Mackay (1994) has noted a net poleward transport of OCs such as "-HCH to the atmosphere and ocean. Because PCBs continue to be lost from terrestrial and aquatic sinks through volatilization, this increase in PCB concentrations in subarctic and arctic lakes may be expected to continue.

CBZ, chlordane, HCH, DDT, and dieldrin all showed similar trends of increasing concentration with time in Core 19B. Concentrations of these compounds were low and comparable to those observed by Mudroch et al. (1992). Further interpretation of these data will be presented in later reports as additional cores and surficial sediments are analyzed.

5.3 PAH COMPOUNDS

In contrast to the organochlorine compounds which have anthropogenic origins, PAHs are produced naturally. However, anthropogenic activities can also result in the increased production of these compounds.

There are many sources of PAHs to the environment. Bjorseth and Ramdahl (1985) noted that pyrolosis (incomplete combustion) and carbonization are the two major mechanisms contributing to PAH formation. There are several combustion sources of PAHs: residential heating; industry (asphalt and coke production, petroleum catalytic cracking); mobile sources (automobiles, airplanes, ships); power and heat generating plants (coal and oil fired, industrial and commercial boilers); and incineration and open fires (municipal and industrial incinerators, refuse burning, forest fires). The formation of oil and coal by carbonization, i.e., the decaying of biological material at low temperatures (< $200^{o}C$) and high pressures over millions of years also produces PAHs. A wide variety of PAHs are present in these carbon products (Wang et al., 1994, White and Lee, 1980, Wiley et al., 1981). PAHs can be released into the environment through water in addition to atmospheric pathways (Burkhard and Sheedy, 1995).

The types of PAHs produced by combustion depend primarily upon the combustion temperature (Bjorseth and Ramdahl, 1985). Larger amounts of alkyl-substituted PAHs (mainly methyl derivatives) are produced at temperatures less than $700^{o}C$ than at higher temperatures: relatively more of the heavier PAHs are produced as temperature increases. The amount of PAHs produced also is dependent upon the combustion temperature. Because of these and other factors, there is a tremendous variability in the composition and concentration of PAHs produced by anthropogenic activities. Moreover, there is significant regional variation in the production rate of PAHs and the relative contribution of various sources. Sweden, for example, has an estimated PAH emission of 250 metric tons per year with residential heating accounting for 52%, industrial production 21%, and power generation 6% of the total sources. In the United States, PAH emission rates have been estimated at 6,000 metric tons per year with automobiles accounting for 36%, industrial production 28%, and residential combustion 12% of the sources.

Various approaches have been utilized to infer sources of PAHs to the environment. One approach is based on surveys where sediments are sampled along an environmental gradient (Hostettler et al., 1989). Bates et al. (1987) collected a series of surficial sediment samples in Puget Sound and observed that retene concentrations decreased with increasing distance from the Puyallup River. The retene source was related to several coal outcrops along the river water course. Kauss and Hamdy (1991) related spatial gradients in PAHs concentrations in surficial sediments in the St. Marys River to anthropogenic activities. The predominance of higher molecular weight PAHs (phenanthrene, fluoranthene, pyrene) was related to the high - temperature combustion of fossil fuels. Relatively high concentrations of low molecular-weight PAHs (naphthalenes, acenaphthene, acenaphthylene, and fluorene) were suggestive of spills of fossil fuels (coal, petroleum). The presence of dibenzothiophene was also related to coal but could have been associated with crude oils (Wang and Fingas, 1995). Yunker and Macdonald (1995) compared PAH concentrations in suspended sediment samples from the Mackenzie River and surficial sediments from the Beaufort Sea Shelf. They inferred that the low molecular-weight PAHs had petrogenic sources while the higher molecular-weight PAHs were produced by past combustion activities: these PAHs had subsequently been preserved in peat and were later eroded into the Mackenzie River. Thus, the primary transport route of these PAHs to the Beaufort Sea was river born rather than atmospheric.

Sediment traps have been used to investigate PAH input rates and sedimentation pathways (Bates et al., 1987: Baker et al., 1991). In addition, PAH concentrations in the atmosphere have been used to infer flux rates and pathways to and from the receiving water body (Baker and Eisenreich, 1990; Eisenreich and Strachan, 1992). Volatilization losses of PAHs are not well understood because of uncertainties in PAH Henry's Law constants (Baker and Eisenrich, 1990). Paleolimnology studies have been used to investigate changes in PAH inputs to lakes and to infer the anthropogenic contribution to such changes (Wakeham et al., 1980a, b; Furlong et al., 1987).

Great Slave Lake receives PAHs from three basic sources: 1) localized sources such as Yellowknife and Hay River, 2) long-range transport from the Peace-Athabasca-Slave River and the Hay-River watersheds, and 3) long-range atmospheric transport from Asia, southern Canada and the US. The relative contribution of these various sources is unknown.

PAH concentrations in surficial sediments offshore of the Slave River mouth averaged 553.6 ± 73.8 ng/g with slightly higher concentrations at the three stations immediately offshore of the Delta transect. The predominant PAHs were benzo(g,h,i)perylene, benzo(b)fluoranthene, and phenanthrene which together accounted for 38.5% of total PAHs. PAH concentrations were substantially lower in two surficial sediment samples (88.2 ± 78.2 ng/g) collected offshore of Lutsel K'e in August 1994 (Evans, unpublished data). Moreover, there were significant compositional differences in PAHs between the two study regions. In the Lutsel K'e sample, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene were the predominant PAHs accounting for 67.6% of the total. The predominance of low molecular weight PAHs in the Lutsel K'e samples is suggestive of a petrogenic and possibly a localized source, e.g., the community itself and/or a nearby fishing lodge. Continuing analysis of the series of surficial sediment samples collected in the East Arm in August 1995 will elucidate gradients in PAH concentrations between the Slave River outflow and Lutsel K'e and allow us to better infer sources. Nevertheless, preliminary data (this report, Evans and Headley, 1993) suggest that PAH concentrations are lower in the East Arm than the West Basin.

The Slave River clearly is a source of PAHs to Great Slave Lake. Sediment traps left offshore of the Slave River mouth contained relatively high concentrations of PAHs (832.7 ± 125.9 ng/g) of which 52.2% were naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene. Relatively high concentrations of these PAHs is suggestive of petrogenic sources (Yunker and Macdonald, 1995). Bourbonniere et al. (1995) noted that the methylated naphthalenes, phenathrene, and pyrene are the major constituents of waste water discharge from the Suncor, Inc. oil sands plant in Fort McMurray. These compounds also enter rivers through the natural leaching of PAHs from oil sands (Barton and Wallace, 1979).

The lower molecular weight PAHs (naphthalene to pyrene) tended to occur in greater concentrations in suspended sediments than surficial sediments while the heavier PAHs were ca. 1.2 - 3.0 times less concentrated in suspended than surficial sediments. Differences in the relative concentrations of PAHs between suspended and surficial sediment samples may be related to a number of factors - how rapidly these PAHs degrade into other chemical species, how rapidly PAHs become associated with particulates and settle from the water column, and how rapidly PAHs disassociate from the sediments and are volatilized into the atmosphere. Baker et al. (1991) noted that water samples collected from Lake Superior tended to be enriched with the lower molecular weight PAHs while surficial sediments were enriched in the heavier PAHs.

PAH concentrations in surficial sediments were low when compared to concentrations in lakes located in more industrialized regions. Kauss and Hamdy (1991) reported that naphthalene concentrations ranged from 30 - 5,900 ng/gm, fluoroanthene from 120 - 135,000 ng/g, and benzo(a)pyrene concentrations from 110 - 48,000 ng/g in a series of collections made in the St. Marys River: these authors cite similar studies conducted in other contaminated Great Lakes rivers and harbors. Eadie (1984) reported mean fluoranthene concentrations of 754 ng/g in Lake Michigan, 487 ng/g in Lake Huron, 569 ng/g in Lake Erie and 615 ng/g in Lake Ontario. Lowest PAH concentrations (88 ng/g) were observed in Lake Superior. PAH concentrations in Great Slave Lake surficial sediments were similar to those observed in surficial sediments of Lake Superior (Baker et al., 1991).

Although PAH concentrations in Great Slave Lake surficial sediments were low, there is some evidence that the inputs of PAHs to Great Slave Lake has changed in recent decades. Two sediment cores were analyzed for PAHs and provide preliminary information on the past depositional history of PAHs to the West Basin of Great Slave Lake. Continuing work (Bourbonniere et al., 1996; Evans, unpublished data) will further elucidate this issue. Nevertheless, increased concentrations of PAHs in lake sediments which coincide with increased industrial activity are typically associated with anthropogenic activities (Furlong et al., 1987). The presence of PAHs in sediments prior to periods of increased anthropogenic activity are attributed to natural sources as described in Wakeham et al. (1980a, b), Tan and Hite (1981), Bjorseth and Ramdahl (1985) and Yunker and Macdonald (1995).

Naphthalene, 1-methylnaphthalene, 2-methylnaphthalene were the predominate PAHs in Cores 12B and 19B: concentrations were higher in Core 19B, collected closer to the Slave River. For both cores, there was a strong trend of increasing concentrations in the cores after the 1960s. Concentrations of these compounds from the single 14 - 16 cm slice analyzed for Core 19B were similar to those for the 5.0 - 6.0 cm slice. The increased concentrations of these PAHs may be associated with increased inputs from natural petrogenic sources (e.g., seepage from tar and oil sands) and/or industrial activities.

Higher molecular-weight PAHs (fluorene, pyrene, and anthracene) also showed some evidence of higher concentrations during the 1970s and later years. This trend was more pronounced for Core 12B than Core 19B. These compounds may have been produced by low-temperature combustion activities. Moreover, localized sources may have important contributors to these trends.

Fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, and chrysene occurred in almost uniform concentrations with time for Core 19B. Concentrations of these compounds were substantially higher in Core 12B than Core 19B. Moreover, concentrations were lower in Core 12B from the mid-1960s to the mid-1970s than in more recent time. This suggests that Core 12B is reflecting a time trend which is associated with localized inputs, possibly from Hay River. In Lake Athabasca, Bourbonniere et al. (1995) noted that fluoranthene, pyrene, benzo(a)pyrene, and chrysene exhibited no apparent time trend of increasing concentration with time.

Heavier PAHs such as indeno(1,2,3-cd)pyrene and benzo(g,h,i)pyrene showed only a weak trend of slightly higher concentrations after 1970 than in earlier times. Concentrations of these compounds were similar in Core 12B and Core 19B. Similarly, Bourbonniere et al. (1995) noted no obvious time trend in the concentration of benzo(g,h,i) in cores collected from Lake Athabasca.

Overall, while limited, these data suggest that there has been an increase in naphthalene, 1-methylnaphthalene, 2-methylnaphthalene deposition rates in the West Basin of Great Slave Lake (Cores 12B and 19B) which may be associated with anthropogenic activities. These activities may be related to the petroleum industry in the Peace/Athabasca drainage basins. Alternately, the lower concentrations of these compounds deeper in the core could be related to their in situ degradation. This appears less likely because a similar trend of decreasing concentrations of these compounds was not observed in Lake Athabasca cores. There also appears to have been a localized increase in fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, and chrysene deposition at Site 12. Site 12 is located relatively close to Hay River, a important shipping port and transportation center. Thus it may be experiencing some localized inputs from various sources. Additional research is required to test this hypothesis of an increase in localized anthropogenic sources of PAHs.

5.4 PCDDS, PCDFS, PENTACHLORANISOLE, TRICHLOROVERATROLE AND TETRACHLOROVERATROLE

One of the primary NRBS concerns is that pulp and paper mill operation along the Peace and Athabasca Rivers may contribute to increased PCDD and PCDF loadings to the watershed. However, PCDDs and PCDFs are produced by many activities in addition to pulp and paper mill operation (Bumb et al., 1980; Safe and Hutzinger, 1980). Fletcher and McKay (1993) indicate that there are two main sources of these compounds to the environment - chemical production processes and combustion processes. Chemical processes include: the manufacture of various chlorinated organic compounds such as PCBs, herbicides, and pentachlorophenol; the production of paper products from chlorine-bleached wood pulp; and metal smelting. PCDDs and PCDFs also are produced during the combustion of organic matter in the presence of chlorine, e.g., from municipal, chemical, and hospital incineration plants, motor vehicle exhausts, and domestic fires. Other sources include combustion of sewage sludge, scrap metal recycling, and leakage from waste disposal sites (Rappe et al., 1987; Safe, 1990; Fiedler and Hutzinger, 1990). Thus, like PAHs, PCDDs and PCDFs can have many sources.

A wide variety of organic compounds are produced during pulp and paper mill operation (Voss, 1983; Kringstad and Lindstrom, 1984; Suntio et al., 1988) which, while not having the same health concerns as PCDDs and PCDFs (Safe 1990; Fiedler and Hutzinger, 1990), can serve as tracers of pulp and paper mill operation. Of these, pentachloranisole, trichloroveratrole and tetrachloroveratrole may be particularly useful because they are among the most quantitatively significant chlorinated aromatics produced from bleached hardwood pulp (Neilson et al., 1984). Moreover, these compounds can be detected during OC analyses for PCBs, DDT, and other chlorinated compounds.

PCDDs and PCDFs occurred in low concentrations in surficial sediments offshore of the Slave River mouth. PCDDs ranged in concentration from below detection limits to 6.2 pg/g and were dominated by DiCDDs and OCDDs. PCDFs ranged in concentration from below detection limits to 5.5 pg/g and were dominated by Di- and TriCDFs. Two surficial sediment samples collected from Lutsel K'e had similar PCDD (6.6 - 10.0 pg/g) and PCDF (3.9 - 4.3 pg/g) concentrations as observed offshore of the Slave River: PCDDs were dominated by DiCDD, TriCDD, HpCDDs and OCDDs while PCDFs were dominated by DCDF and TriCDF (Evans et al., unpublished data). Overall, there was no evidence that PCDDs and PCDFs occurred in higher concentrations in surficial sediments near the Slave River mouth than at sites far removed from this river. Moreover, concentrations of most PCDDs and PCDFs (tetra- to hexa-) in Great Slave Lake surficial sediments were not appreciably different from concentrations in surficial sediments collected downstream (Athabasca River) of the Weldwood of Canada Ltd. Pulp and Paper Mill (Pastershank and Muir, 1995). However, HpCDD and OCDD concentrations were higher in the Athabasca River sediments than in surficial sediments offshore of the Slave River mouth. These HpCDDs and OCDDs probably entered the river from the atmosphere (rather than the mill) because similar concentrations were observed upstream and downstream of the mill. Moreover, these higher concentrations of HpCDDs and OCDDs in Athabasca River sediments may have been related to the fact that the Athabasca River samples were collected in depositional sediments while the Great Slave Lake surficial sediment samples were collected in erosional areas. This hypothesis is also supported by the fact that similarly high OCDD concentrations were detected in Cores 19D and 23A which were collected in a depositional area.

The influence of the Slave River on PCDD and PCDF loading to Great Slave Lake is uncertain. Too few samples have been analyzed to infer whether or not the river is a enriched source of PCDDs and PCDFs to the lake. The analysis of the sediment trap samples collected in August 1994 and the surficial sediment samples collected in the East Arm in August 1995 will help elucidate this issue. However, because the river is a major source of PCBs, other OCs, and PAHs to Great Slave Lake, it is reasonable to assume that it also is a major source of PCDDs and PCDFs to the West Basin.

Pentachloroanisole, trichloroveratrole, and tetrachloroveratrole were detected in the surficial sediments offshore of the Slave River. Thus, it is reasonable to hypothesize that some of that some PCDDs and PCDFs are entering Great Slave Lake with the effluent discharge from pulp and paper mill activities in the Peace and Athabasca Rivers. Similar PCA concentrations (0.17 - 0.27 ng/g) were observed in sediment traps set offshore of the river mouth and in surficial sediments: however, trichloroveratrole and tetrachloroveratrole were not detected in sediment traps. Only PCA (0.10 ng/g) was detected in the single surficial sediment sample analyzed from Lutsel K'e. The presence of PCA in this sample may suggest that there are other sources of this compound in addition to pulp and paper mill operation. Continuing work (the analysis of surfical sediments collected in the East Arm in August 1995) will help elucidate spatial patterns in PCA, trichloroveratrole and tetrachloroveratrole concentrations relative to increasing distances from the Slave River mouth.

There was evidence that input rates of PCDDs to Great Slave Lake have changed over the past few decades. Core 19D showed a strong trend for higher concentrations of PCDD during the 1950s and 1960s than earlier or later times. This trend was less evident for Core 23A, possibly because it was collected in an area where some sediment erosion occurred. OCDD accounted for most of the PCDDs followed by the HPCDDs. DiCDDs were the third most abundant category of PCDDs. Because only two slices were analyzed for DiCDDs from Core 19D, it was not possible to infer time trends in these lower chlorinated PCDDs. Bourbonniere et al. (1995) noted greater concentrations of the more highly chlorinated PCDDs in the late 1970s and 1980s than in earlier decades in a core collected from Lake Athabasca. He noted similarly high concentrations of HpCDDs and OCDDs in a core collected in Weekes Lake, a reference lake to the Lake Athabasca study (Bourbonniere, 1996).

There are various interpretations to these data. First, combustion sources producing PCDDs may have increased during the 1950s and 1960s and then declined with better emission controls. This hypothesis is supported by Bourbonniere's (1996) observation of relatively high PCDD concentrations in the Weekes Lake core with concentrations decreasing from the 1970s to the present. Thus, most of the PCDD trends in Cores 19D and 23A may be associated with changes in atmospheric pathways. However, PCDD data did not follow the same time trend as the PAH data.

The general absence of a time trend for the lower-chlorinated PCDDs in Cores 19D and 23A could suggest that effluents from pulp mill activities were not a major PCDD contributor, i.e., like the Weekes Lake core, time trends are associated mainly with atmospheric sources. Alternately, these lower chlorinated PCDDs may degrade rapidly in the environment (Parsons, 1992) and thus not be present in relatively large quantities in Cores 19B and 23A. Or, like PCBs, the lower-chlorinated compounds may be more volatile than the higher-chlorinated compounds. While not occurring in relatively high concentration in these cores, they did account for approximately 50% of the PCDDs in surficial sediments collected in the immediate vicinity of the Slave River. Again, analysis of surficial sediments collected in the East Arm in August 1995 should help to elucidate PCDD (and PCDF) pathways with increasing distance from the Slave River plume.

In contrast to surficial sediments collected near the Slave River in August 1993, PCDFs occurred in substantially lower concentrations than PCDDs in core samples. As in Great Slave Lake cores, Bourbonniere et al. (1995) noted that PCDDs were substantially more abundant than PCDFs in Lake Athabasca sediments. TriCDFs and OCDFs predominated in Core 23A which was more completely reanalyzed for the lower-chlorinated compounds. DiCDFs and TriCDFs dominated in the two slices from Core 19D which were also reanalyzed for the lower chlorinated PCDFs. TCDFs and HpCDDs were of secondary abundance in both cores. Core 23A displayed a weak trend of increasing PCDF concentrations (primarily TriCDF and TCDF) from the late 1950s to the 1980s. No such trend was evident for Core 19D with the possible exception of TCDD.

Pentachloroanisole, trichloroveratrole, and tetrachloroveratrole all showed evidence of changes in deposition rates in Core 19B with time. Pentachloroanisole concentrations increased through the 1960s and have declined since; trichloroveratrole concentrations began increasing during the late 1960s while tetrachloroveratrole concentrations began increasing during the mid 1960s. Concentrations of the latter two compounds continued to increase through the late 1980s. This may be suggestive of a general increase in the quantity and a change in the quality of pulp and paper mill effluents entering Great Slave Lake. However, these changes have not occurred in sequence with changes in PCDD and PCDF deposition rates.

In summary, there is some evidence of increased PCDD and, to a lesser extent, PCDF deposition in the West Basin of Great Slave Lake since the 1950s (PCDDs) or 1960s (PCDFs). Earlier deposition of these compounds may have been associated with localized, natural combustion sources or long-range transport from more industrialized regions. Increased concentrations may be associated with a variety of sources including increased industrial activity in the Peace and Athabasca watersheds, including pulp and paper mills. Interpretation of the data are confounded by uncertainties in the persistence of the lower chlorinated PCDDs and PCDFs sources. Interpretation of these data also are confounded by the fact that there are a variety of sources of PCDDs and PCDFs to the environment.

5.5 ORGANIC CARBON AND NITROGEN

Organic carbon analyses of Cores 13C and 19D show strong evidence that the West Basin of Great Slave Lake has undergone a subtle increase in productivity since the turn of the century. This increase has accelerated since the 1950s and was more pronounced for Site 13 than Site 19. This suggests that both local (Site 13) and long-range factors have affected an increase in productivity in the West Basin. Possible causal factors include increased land-clearing and technological development in the Peace and Athabasca River watersheds and urban and industrial activities at the towns of Hay River and possibly Yellowknife.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Our study has shown that while Great Slave Lake is essentially a pristine system, it does show signs of anthropogenic contamination. Organochlorine contaminants, which are anthropogenic in origin, occur in similar concentrations in Great Slave Lake sediments as in Lake Superior, more than 2,000 km to the south. PAH concentrations in sediments also are similar in the two lakes. Concentrations of both classes of contaminants are higher in the more recent sediments than during the late 1940s (Core 19B) or the late 1960s (Core 12B). However, the source of these contaminants is unknown. It is probable that a significant fraction of these contaminants entered Great Slave Lake with Slave River inflow but the primary source of these compounds is less certain, e.g., localized inputs from along the Peace and Athabasca Rivers or atmospheric deposition (wet and dry) in the watershed which eventually was transported into these rivers and then to Great Slave Lake.

While only two cores were analyzed for OCs and PAHs, there is a suggestion that some contaminant concentrations were higher in Core 12B, collected near Hay River, than Core 19B, collected nearer to the Slave River. Thus, Hay River (and possibly Yellowknife) may represent localized sources of OCs and PAHs.

There is some evidence that the West Basin of Great Slave Lake has become more productive since the beginning of the century. Both localized (Hay River and possibly Yellowknife) and long-range factors are implicated in this increase in productivity.

This study is based on the analysis of a small subset of cores collected in March 1994. In order for a more complete understanding of the depositional history of organic contaminants in the West Basin of Great Slave Lake, the following are recommended:

It is highly desirable that additional cores from the March 1994 sampling be analyzed for OCs, PAHs, PCDDs, PCDFs. Only one core from Site 13 has been analyzed for PAHs (Bourbonniere et al., 1996): no cores have been analyzed from Site 16. Additional analyses of core material from these sites should allow for a better separation of time trends in contaminant deposition rates due to direct inputs from the Slave River versus localized inputs.

For the cores analyzed in this study, additional core slices, covering earlier times (prior to the mid 1960s for Core 12B, the mid-1950s for Core 23A, the late 1950s for Core 19B, and the early 1940s for Core 19D) should be analyzed for OCs, PAHs, PCDDs, PCDFs. This would allow for a better assessment of background deposition rates of these compounds in Great Slave Lake prior to increased development in the Peace and Athabasca River watersheds and local development.

It is highly desirable that a core from Site 16 be analyzed for TOC and TON to provide additional information on long-term trends in the productivity of Great Slave Lake. Ideally, the analyses would be broadened to include biogenic silica and an investigation of diatom remains. Such analyses provide useful information on changes in nutrient loading and the productivity of lake ecosystems (Schelkse et al., 1985; Stoermer et al., 1990).

Finally, with the increased interest in metals as an environmental contaminant, cores from two sites investigated in March 1994 should be examined for long-term trends in metals. Site 16, located near the mine at Pine Point, and Site 13 are sites which merit analysis. There is insufficient material remaining from collections at Sites 12 and 23 for such analyses.

Continuing research on the cores collected in March 1994 will require additional core dating. This additional effort will provide new information on small-scale variations in sedimentation and contaminants, i.e. as in the comparisons of Cores 13B and C and 19B and D.

As previously noted, research continues on core samples collected offshore of the Slave River in March 1995 and surficial sediments collected in the East Arm in August 1995. The samples were not fully analyzed with 1995/1996 funding. Additional analysis of these collections would provide further insight to sedimentation and contaminant transport offshore of the Slave River mouth and into the East Arm.

REFERENCES

Allan, R. J. 1979. Heavy metals in bottom sediments of Great Slave Lake (Canada): a reconnaissance. Environ. Geol. 3:49-58.

Baker, J. E., S. J. Eisenreich, T. C. Johnson, and B. M. Halfman. 1985. Chlorinated hydrocarbon cycling in the benthic nepheloid layer of Lake Superior. Environ. Sci. Technol. 19:854-861.

Baker, J. E., and S. J. Eisenreich. 1990. Concentrations and fluxes of polycyclic aromatic hydrocarbons and polychlorinated biphenyls across the air-water interface of Lake Ontario. Environ. Sci. Technol. 24:343-352.

Baker, J. E., S. J. Eisenreich, and B. J. Eadie. 1991. Sediment trap fluxes and benthic recycling of organic carbon, polycyclic aromatic hydrocarbons, and polychlorobiphenyl congeners in Lake Superior. Environ. Sci. Technol. 25:500-508.

Barton, D.R., and R.R. Wallace. 1979. Effects of eroding oil sand and periodic flooding on benthic macroinvertebrate communities in a brown-water stream in Northeastern Alberta, Canada. Can. J. Zool. 57: 533-541.

Bates, T. S., P. P. Murphy, H. C. Curl, Jr., and R. A. Feely. 1987. Hydrocarbon distributions and transport in an urban estuary. Environ. Sci. Technol. 21:193-198.

Beeton, A.M. 1969. Changes in the environment and biota of the Great Lakes. Pages 150-187 in: Eutrophication: causes, consequences, correctives. Natl. Acad. Sci. Publ. 1700.

Bjorseth, A., and T. Ramdahl. 1985. Emission Sources and Recent Progress. Pages 1-20 in A. Bjorseth and T. Ramdahl, eds. Handbook of Polycyclic Aromatic Hydrocarbon Vol. 2. Marcel Dekker, Inc., New York. 416 pp.

Bourbonniere, R. A. 1996. Depositional history of sediments from Lake Athabasca, Legend Lake and Weekes Lake: chlorinated contaminants. National Hydrology Research Institute Contribution 96-152.

Bourbonniere, R. A., S. Telford, and J. B. Kemper. 1995. Depositional history of sediments in Lake Athabasca: geochronology, bulk parameters, contaminants and biogeochemical markers. National Water Research Institute Contribution 95-76. 131 pp.

Bourbonniere, R. A., M. S. Evans, L. A. Ziolkowski, and J. Lee. 1966. Depositional history of sediments from Great Slave Lake: hydrocarbons and biogeochemical markers. Northern River Basins Study Report.

Boyle, R. W. 1961. The geology, geochemistry and origin of gold deposits of the Yellowknife district. Geol. Surv. Canada Memoir 310, 193 p.

Bumb, R. R., W. B. Crummett, S. S. Cuite, J. R. Gledhill, R. H. Hummel, R. O. Kagel, L. L. Lamparski, E. V. Luoma, D. L. Miller, T. J. Nestrick, L. A. Shadoff, R. H. Stehl, and J. S. Wood. 1980. Trace chemistries of fire: a source of chlorinated dioxins. Science 210 : 385-390.

Burkhard, L. P., and B. R. Sheedy. 1995. Evaluation of screening procedures for bioconcentratable organic chemicals in effluents and sediments. Envir. Toxicol. Chem. 14: 697 - 711.

Christie, J.C. 1974. Changes in fish species composition of the Great Lakes. J. Fish. Res. Board Can. 31: 827-854.

Department of Fisheries and Oceans. 1995. Annual Summary of Fish and Marine Mammal Harvest Data for the Northwest Territories. Vol. 6, 1993-1994:

Eadie, B. J. 1984. Distribution of Polycyclic Aromatic Hydrocarbons in the Great Lakes. Pages 195 - 211 in J. O. Nriagu and M. S. Simmons, eds. Toxic Contaminants in the Great Lakes. John Wiley & Sons, New York. 527 pp.

Eisenreich, S. J., P. D. Capel, J. A. Robbins, and R. Bourbonniere. 1989. Accumulation and diagenesis of chlorinated hydrocarbons in lacustrine sediments. Environ. Sci. Technol. 23:116-1126.

Eisenreich, S. J., and W. M. J. Strachan. 1992. Estimating atmospheric deposition of toxic substances to the Great Lakes - An Update. Proceedings from a January 31 - February 2, 1992 Workshop. Canada Centre for Inland Waters. 59 pp.

Evans, M. S. 1994. Biomagnification of persistent organic contaminants in Great Slave Lake. Pages 295 -300 in J. L. Murray and R. G. Shearer, eds. Synopsis of Research Conducted under the 1993/94 Northern Contaminants Program. Environmental Studies No. 72. Indian and Northern Affairs, Ottawa. 459 pp.

Evans, M. S. 1995. Biomagnification of persistent organic contaminants in Great Slave Lake. Pages 295 - 297 in J.L. Murray and R. G. Shearer, eds. Synopsis of Research Conducted under the 1994/95 Northern Contaminants Program. Environmental Studies. Indian and Northern Affairs, Ottawa. Indian and Northern Affairs, Ottawa. 459 pp.

Evans, M.S. 1996. Limnological investigations in the West Basin of Great Slave Lake: March 1994 studies. National Hydrology Research Institute Contribution 96002.

Evans, M. S., G. E. Noguchi, and C. P. Rice. 1991. The biomagnification of polychlorinated biphenyls, toxaphene, and DDT compounds in a Lake Michigan offshore food web. Arch. Environ. Contam. Toxicol. 20:87-93.

Evans, M. S., and J. Headley. 1993. A March 1992 investigation of Great Slave Lake: organic contaminant concentrations in lake sediments and water column characteristics. National Hydrology Research Institute Contribution CS-93020. 46 pp.

Fee, E. J., M. P. Stainton, and H. J. Kling. 1985. Primary production and related limnological data for some lakes in the Yellowknife, NWT area. Can. Tech. Rept. Fish. Aquat. Sci. 1409. 55 pp.

Fiedler, H. and O. Hutzinger. 1990. Dioxins: sources of environmental load and human exposure. Toxicol. Environ. Chem. 29: 157-234.

Fletcher, C. L. and W. A. McKay. 1993. Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) in the aquatic environment - a literature review. Chemosphere 26(6): 1041-1069.

Flynn, W. W. 1968. The determination of low levels of polonium-210 in environmental samples. Anal. Chem. Acta 43:221-227.

Frank, R. R., R. L. Thomas, M. V. H. Holdrinet, and V. Damiani. 1980a. PCB residues in bottom sediments collected from the Bay of Quinte, Lake Ontario 1972-1973. J. Great Lakes Res. 6:371-376.

Frank, R., R. L. Thomas, H. E. Braun, J. Rasper, and R. Dawson. 1980b. Organochlorine insecticides and PCB in the surficial sediments of Lake Superior (1973). J. Great Lakes Res. 6:113-120.

Furlong, E. T., L. R. Cessar, and R. A. Hites. 1987. Accumulation of polycyclic aromatic hydrocarbons in acid sensitive lakes. Geochimica et Cosmochimica Acta 51:2965-2975.

Healey, M. C. 1975. Dynamics of exploited whitefish populations and their management with special reference to the Northwest Territories. J. Fish. Res. Board Can. 32:427-448.

Herdendorf, C. E. 1982. Large lakes of the world. J. Great Lakes Res. 8:379-412.

Hostettler, F. D., J. B. Rapp, K. A. Kvenvolden, and S. N. Luoma. 1989. Organic markers as source discriminants and sediment transport indicators in south San Francisco Bay, California. Geochimica et Cosmochimica Acta 53:1563-1576.

Jeremiason, J. D., K. C. Hornbuckle, and S. J. Eisenreich. 1994. PCBs in Lake Superior, 1978 - 1992: decreases in water concentrations reflect loss by volatilization. Envir. Sci. Technol. 28:903-914.

Joshi, S. R. 1987. Nondestructive determination of lead-210 and radium-226 in sediments by direct photon analysis. J. Radioanalytical and Nuclear Chemistry, Articles 116:169-182.

Kauss, P. B., and Y. S. Hamdy. 1991. Polycyclic aromatic hydrocarbons in surficial sediments and caged mussels in the St. Marys River, 1985. Hydrobiologia 219:37-62.

Keleher, J. J. 1972. Great Slave Lake: effects of exploitation on the salmonid community. J. Fish. Res. Board Can. 29:741-753.

Keller, E. A. 1979. Environmental Geology. 2nd Edition. Charles E. Merrill Publishing Company, Columbia. 671 pp.

Kringstad, K. P. , and K. Lindstrom. 1984. Spent liquors from pulp bleaching. Environ. Sci. Technol. 18: 236A-248A.

Kristofer, W. 1985. PAH emission from coal-lined plants. Pages 21-59 in A. Bjorseth and T. Ramdahl, eds. Handbook of Polycyclic Aromatic Hydrocarbons. Vol. 2. Marcel Dekker, Inc., New York. 416 pp.

Lockhart, W. L. 1994. Depositional trends - lake and marine sediments. Pages 138-151 in J. L. Murray and R. G. Shearer, eds. Synopsis of Research Conducted under the 1993/94 Northern Contaminants Program. Indian and Northern Affairs, Canada, Environmental studies no. 72

Mackay, D. 1994. Development of models describing the distribution of organic chemicals into cold ecosystems. Pages 53-57 in J. L. Murray and R. G. Shearer, eds. Synopsis of Research Conducted under the 1993/93 Northern Contaminants. Indian and Northern Affairs, Ottawa. Indian and Northern Affairs, Ottawa. 459 pp.

Mackenzie River Basin Committee. 1981. Mackenzie River Basin study report. A report under the 1978-81 Federal-Provincial Study Agreement respecting the water and related resources of the Mackenzie River Basin. Ottawa. Ministry of Supply and Services Canada. 231 pp.

Manchester-Neesvig, J. B., and A. W. Andren. 1989. Seasonal variation in the atmospheric concentration of polychlorinated biphenyl congeners. Environ. Sci. Technol. 1989:1138-1148.

Mathieu, G. G. 1977. Rn-222-Ra-226 technique analysis. Ann. Tech. Rep. C00-2185-0. Lamont-Doherty Geol. Observ., Palisades, NY.

Moore, J. W., 1978. Some factors influencing the density of invertebrates near a sewage outfall. Hydrobiol. 61:81-93.

Moore, J. W. 1979. Diversity and indicator species as measures of water pollution in a subarctic lake. Hydrobiol. 66:73-80.

Moore, J. W., S. J. Wheeler, and D. J. Sutherland. 1978. The effects of metal mines on aquatic ecosystems in the Northwest Territories. II. Great Yellowknife Mines Limited. Can. Dep. Environ., Environ. Prot. Serv. Rept. EPA-5-NW-78-9. 58 pp.

Moore, J.W., D. J. Sutherland and V. A. Beaubien. 1979. Comparative effects of sediment and water characteristics on benthic invertebrates in four lakes. Bull. Environ. Contam. Toxicol. 23: 840-847.

Mudroch, A., S. R. Joshi, D. Sutherland, P. Mudroch, and K. M. Dickson. 1989a. Geochemistry of sediments of Back Bay and Yellowknife Bay of Great Slave Lake. Environ. Geol. Water Sci. 14:35-42.

Mudroch, A., R. J. Allan, and S. R. Joshi. 1989b. Preliminary investigation of toxic chemicals in the sediments of Great Slave Lake, Northwest Territories, Canada. National Water Research Institute Contribution 89-21.

Mudroch, A., R. J. Allan, and S. R. Joshi. 1992. Geochemistry and organic contaminants in the sediments of Great Slave Lake, Northwest Territories, Canada. Arctic 45:10-19.

Murphy, T. J., and C. P. Rzeszutko. 1977. Precipitation inputs of PCBs to Lake Michigan. J. Great Lakes Res. 3:305-313,

Murphy, T.J., A. Schinsky, G. Paolucci , and C.P. Rzeszutko. 1981. Atmospheric inputs of pollutants to natural waters. S.J. Einsenreich ed.., Ann Arbor Science Publishers.

Neilson, A. H., A. -S. Allard, S. Reiland, M. Remberger, A. Tarnholm, T. Viktor, and L. Landner. 1984. Tri- and tetra-chloroveratrole, metabolites produced by bacterial O-methylation of tri- and tetra-chloroguaiacol : an assessment of their bioconcentration potential and their effects on fish reproduction. Can. J. Fish. Aquat. Sci. 41(10): 1502-1512.

Oldfield, F. and P. G. Appleby. 1984. Empirical testing of Pb-210 dating models for lake sediments. Pages 93-124 in E. V. Howath, J. W. G. Lund eds. Lake Sediments and Environmental History. University of Minnesota Press, Minneapolis.

Parsons, J.R. 1992. Influence of suspended sediment on the biodegradation of chlorinated dibenzo-p-dixoins. Chemosphere 25(12): 1973-1980.

Pastershank, G. M., and D. C. G. Muir. 1995. Contaminants in environmental samples: PCDDs and PCDFs downstream of bleached kraft mills Peace and Athabasca Rivers, 1992. Northern River Basins Study Report 44.

Ramdahl, T. 1985. PAH emission from combustion of biomass. Pages 61-85 in A. Bjorseth and T. Ramdahl, eds. Handbook of Polycyclic Aromatic Hydrocarbons. Vol. 2. Marcel Dekker, Inc., New York. 416 pp.

Rappe, C., R. Andersson, P. Bergqvist, C. Brohede, M. H. L. Kjeller, G. Lindstrom, S. Marklund, N. Nygren, S. E. Swanson, M. Tysklind, and K. Wiberg. 1987. Overview on environmental fate of chlorinated dioxins and dibenzofurans: sources, levels and isomeric pattern in various matrices. Chemosphere 16(8/9): 1603-1618.

Rawson, D. S. 1947a. Great Slave Lake. Bull. Fish. Res. Board Can. 72:45-68.

Rawson, D. S. 1947b. Estimating the fish production of Great Slave Lake. Trans. Amer. Fish. Soc. 77:81-92.

Rawson, D. S. 1950. The physical limnology of Great Slave Lake. J. Fish. Res. Board Can. 8:3-66.

Rawson, D. S. 1951. Studies of the fish of Great Slave Lake. J. Fish. Res. Board Can. 8:207-240.

Rawson, D. S. 1953. The bottom fauna of Great Slave Lake. J. Fish. Res. Board Can. 10:486-520.

Rawson, D. S. 1956. The net plankton of Great Slave Lake. J. Fish. Res. Board Can. 13:43-127.

Robbins, J. A. 1978. Geochemical and Geophysical Applications of Radioactive Lead. Pages 285 - 393 in: Nriagu, J. O., ed. The Biogeochemistry of Lead in the Environment. Elsevier/North-Holland Biomedical Press, New York.

Robbins, J. A. 1982. Stratigraphic and dynamic effects of sediment reworking by Great Lakes zoobenthos. Hydrobiol. 92:611-622.

Robbins, J. A., D. N. Edgington, and A. L. W. Kemp. 1978. Comparative ^{210}Pb and ^{137}Cs, and pollen chronologies of sediments from Lakes Ontario and Erie. Quat. Res. 10:256-278.

Rodgers, G. K. 1966. The thermal bar in Lake Ontario, spring 1965 and winter 1965-66. Publ. Great Lakes Res. Div., Univ. Mich., 15:369-374.

Safe, S. 1990. Polychlorinated biphenyls (PCBs), dibenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs), and related compounds: environmental and mechanistic considerations which support the development of toxic equivalent factors. Crit. Rev. Toxic. 21: 51-88.

Safe, S., and O. Hutzinger. 1990. PCDDs and PCDFs: Sources and Environmental Impact. Pages 1-20 in S. Safe and O. Hutzinger, eds. Polychlorinated dibenzo-p-dioxins and -furans (PCDDs/PCDFs): Sources and Environmental Impact, Epidemiology, Mechanisms of Action, Health Risks. Springer-Verlag, Heidelberg, FRG.

Schelkse, C. L., D. J. Conley, and W. F. Warwick. 1985. Historical relationships between phosphorus loading and biogenic silica accumulation in Bay of Quinte sediments. Can. J. Fish. Aquat. Sci. 42:1401-1409.

Simmons, M. S. 1984. PCB contamination in the Great Lakes. Pages 287-309 in J.O. Nriagu and M.S. Simmons eds. Toxic Contaminants in the Great Lakes. John Wiley & Sons, New York. 527 pp.

Stein, J. N., and M. D. Miller. 1972. An investigation into the effects of a lead-zinc mine on the aquatic environment of Great Slave Lake. Fish. Res. Bd. tech. Bull., 28 pp.

Stoermer, E. F., C. L. Schelske, and J. A. Wolin. 1990. Siliceous microfossil succession in sediments of McLeod Bay, Great Slave Lake, Northwest Territories. Can. J. Fish. Aquat. Sci. 47: 1865-1874.

Suntio, L. K., W. Y. Shia, and D. Mackay. 1988. A review of the nature and properties of chemicals present in pulp mill effluents. Chemosphere 17: 1249-1290.

Tan, Y. L., and M. Heit. 1981. Biogenic and abiogenic polynuclear aromatic hydrocarbons in sediments from two remote Adirondack lakes. Geochimica et Cosmochimica Acta. 45: 2267-2279.

Turner, L. J. 1994a. ^{210}Pb dating of lacustrine sediments from Great Slave Lake (core 057, Station 19-D), NWT. National Water Research Institute Contribution 94-129. 25 pp.

Turner, L. J. 1994b. ^{210}Pb dating of lacustrine sediments from Great Slave Lake (core 061, Station 13-C), NWT. National Water Research Institute Contribution 94-129. 25pp.

United States Environmental Protection Agency. 1990. US-EPA Method 1613. Tetra- through octa-chlorinated dioxins and furans by isotope dilution. Test Methods for Evaluating Solid Waste Physical-chemical Methods. 3rd edition. Washington, D. C.

Voss, R. H. 1983. Chlorinated neutral organics in biologically heated kraft mill effluents. Environ. Sci. Technol. 17: 530-537.

Wakeham, S. G., C. Schaffner, and W. Giger. 1980a. Polycyclic aromatic hydrocarbons in Recent lake sediments - I. Compounds having anthropogenic origins. Geochimica et Cosmochimica Acta 44:403-413.

Wakeham, S. G., C. Schaffner, and W. Giger. 1980b. Polycyclic aromatic hydrocarbons in Recent lake sediments - II. Compounds derived from biogenic precursors during early diagenesis. Geochimica et Cosmochimica Acta 44:415-429.

Wang, Z., M. Fingas, and K. Li. 1994. Fractionation of a light crude oil and identification and quantitation of aliphatic, aromatic and biomarker compounds by GC-FID and GC-MS, Part II. Journal of Chromatographic Sciences 32: 367- 382.

Wang, Z., and M. Fingas. 1995. Use of methyldibenzothiophenes as markers for differentiation and source identification of crude and weathered oils. Environ. Sci. Technol. 29:2842-2949.

Wetzel, R. G. 1975. Limnology. W. B. Saunders Company. Philadelphia.

White, C. M., and M. L. Lee. 1980. Identification and geochemical significance of some aromatic components of coal. Geochimica et Cosmochimica Acta 44:1825-1832.

Wilkinson, P. 1985. The determination of environmental levels of uranium and thorium series isotopes and Cs-137 in aquatic and terrestrial samples. Can. Spec. Publ. Fish. Aquat. Sci. 78.

Willey, C., M. Iwao, R. N. Castle, and M. L. Lee. 1981. Determination of sulfur heterocycles in coal liquids and shale oils. Anal. Chem 53: 400-407.

Yunker, M. B., and R. W. Macdonald. 1995. Composition and origins of polycyclic aromatic hydrocarbons in the Mackenzie River and on the Beaufort Sea Shelf. Arctic 48:118-129.

NORTHERN RIVER BASINS STUDY

APPENDIX A

TERMS OF REFERENCE

Project 2333-C1: Slave River Delta and Great Slave Lake Sediment Sampling

I. Introduction

Great Slave Lake is one of the most important aquatic ecosystems in northern Canada. It supports important commercial (West Basin) and sports fisheries (East Arm). Moreover, many indigenous people rely on Great Slave Lake fish as an essential component of their diet. The lake is also a major staging area for a number of waterfowl species. Some 18,000 people or more than 50% of the population of the Northwest Territories live along the shore of the lake. These people are, in various ways, highly dependent upon the quality of Great Slave Lake waters and its biota. Contaminants entering the lake therefore are and will continue to be of concern. Such contaminants include aerial-born compounds (e.g., PCBs, PCCs, organochlorine pesticides, PAHs, some metals) which are deposited (wet and dry deposition) on the watershed, washed into the Peace and Athabasca rivers, and transported downstream via the Slave River to Great Slave Lake. Other contaminants have localized anthropogenic sources, especially from the more developed regions to the south. These localized sources will be of increasing concern to Great Slave Lake (and the Arctic ecosystem) as economic development (pulp and paper mills, oil and gas developments, agriculture, urban centres) continues to intensify in Alberta, British Columbia and Saskatchewan.

The purpose of this study is to collect surficial sediments and sediment cores from the Slave River Delta and Great Slave Lake for dating and organic and heavy metal contaminant analyses to determine the extent to which the Great Slave Lake aquatic ecosystem has been impacted by air-born and water transported contaminants.

II. Requirements

The contractor is to collect a series of sediment cores and/or surficial sediment samples from at least two regions (Hay River and the Slave River Delta) of Great Slave Lake. If time, conditions and funding permit, additional samples are to be collected from the East Arm of the lake. The sampling program should be as follows:

1) The study is to begin with a series of exploratory core collections to determine the best location to collect a more detailed series of cores for contaminant studies. The first series of cores will be centred on the Hay River region with the transect extending as far west as Pointe de Roche and as far east as Sulphur Cap. Approximately six stations are to be sampled.

2) The second transect series will be centred on Resolution Bay. The actual location of the transect will be dependent upon further analysis of core samples collected in the area by Dr. Marlene Evans, National Hydrology Research Institute, Saskatoon in August 1993. However, it is anticipated that the transect will run from the Egg Island region west to Presqu'lle Cape. A second transect will be sampled running from the Middle Channel of the Slave River to approximately 25 km offshore. Of particular interest is whether the quiscent water column conditions allow for the accumulation of a light flocculent layer of organic material (and contaminants) immediately above the sediments as has been observed by Dr. Rick Bourbonniere, National Water Research Institute, Burlington in Lake Athabasca. At each of these sites, a core sample will be collected and visually inspected to determine gross sediment types. Cores which have a continuous sediment-profile of silts and clays with no obvious layerings with sand are to be retained for further study. Cores collected along the transects are to be returned to the base laboratory, sectioned, placed in plastic bags, frozen and retained for later dating and sediment grain analysis. In addition, a surficial sediment grab will is to be taken at each site, placed in a precleansed glass jar, frozen and retained for organic contaminant analysis. The water column at each sediment sampling site is to be characterized with respect to temperature, dissolved oxygen, turbidity (or suspended solids) and dissolved organic carbon. These data are to be used to characterize the physical-chemical regime of the water column (i.e., is it quiscent or is their a significant amount of resuspension in a nephloid layer?). These data are also to be used for mapping (horizontal and vertical) of the Slave River plume. Finally, if time allows, limited numbers of water column samples are to be collected to measure nutrient concentrations relative to the Slave River outflow.

3) Following the transect studies, one or two sites in each of the major regions are to be selected for detailed collection of cores for organic contaminant analysis. Multiple cores are to be collected using a 10-cm internal diameter gravity corer. All samples are either to be transported via helicopter to the base laboratory or immediately processed in the field. Cores are to be sectioned at 1-cm intervals down to 24 cms and at 2-cm intervals down to the base of the core or to a maximum depth of 1 m. Samples are to be extruded vertically using a hydraulic extrusion system, placed in pre-cleaned glass containers, and immediately frozen. During the extrusion process, general characteristics of each section are to be noted (i.e., sediment colour, apparent grain size (clay, silt, etc.) and any other noteworthy observations). Core materials are also to be retained for dating and sediment grain-size analysis.

4) If time, conditions and funding permit, a third transect series is to be collected in the East Arm, extending from Grant Point to Peterson Point. This transect is to extend the spatial coverage of cores collected for the investigation of regional

variation in sedimentation rates and surficial-sediment organic contaminant concentrations relative to the Slave River plume.

5) The latitude and longitude are to be recorded for each sediment and water column sampling location using Geographic Positioning System technology.

III. Reporting Requirements

The contractor is to submit a brief summary report documenting the sampling locations for sediment and water column collections to the component coordinator by March 31, 1994.

IV. Contract Administration

This contract is being carried out under the Contaminants Component of the Northern River Basins Study. Dr. John Carey, National Water Research Institute, Burlington is the Contaminants Component leader.

The Scientific Authority on this project is:

Dr. Marlene Evans
National Hydrology Research Institute
11 Innovation Boulevard
Saskatoon, Saskatchewan S7N 3H5
phone: (306) 975-5310 fax: (306) 975-5143

Questions of a scientific nature should be directed towards her.

The component coordinator for this project is:

Greg Wagner
Northern River Basins Study
690 Standard Life Centre
10405 Jasper Avenue
Edmonton, Alberta T5J 3N4
phone: (403) 427-1742 fax: (403) 422-3055

Questions of an administrative nature should be directed towards him.

NORTHERN RIVER BASINS STUDY

TERMS OF REFERENCE

Project 2333-D2: Great Slave Lake Sediments - Lead-210 and Cesium-137 Dating

I. Background and Objectives

Great Slave Lake is one of the most important aquatic ecosystems in northern Canada. It supports important commercial (West Basin) and sports fisheries (East Arm). Moreover, many indigenous people rely on Great Slave Lake fish as an essential component of their diet. The lake is also a major staging area for a number of waterfowl species. Some 18,000 people or more than 50% of the population of the Northwest Territories live along the shore of the lake. These people are, in various ways, highly dependent upon the quality of Great Slave Lake waters and its biota. Contaminants entering the lake therefore are and will continue to be of concern. Such contaminants include aerial-born compounds (e.g., PCBs, PCCs, organochlorine pesticides, PAHs, some metals) which are deposited (wet and dry deposition) on the watershed, washed into the Peace and Athabasca rivers, and transported downstream via the Slave River to Great Slave Lake. Other contaminants have localized anthropogenic sources, especially from the more developed regions to the south. These localized sources will be of increasing concern to Great Slave Lake (and the Arctic ecosystem) as economic development (pulp and paper mills, oil and gas developments, agriculture, urban centres) continues to intensify in Alberta, British Columbia and Saskatchewan.

In March 1994, sediment cores were collected from two regions (offshore of Buffalo River and of Pine Point) in the West Basin of Great Slave Lake (NRBS Project 2333-C1) (Evans and Bourbonniere 1994). A total of ten stations were sampled. Short, exploratory cores were obtained at five of the stations and long, detailed cores obtained at three of the five stations. These cores were collected for dating, and organic and heavy metal contaminant analyses to determine the extent to which the Great Slave Lake aquatic ecosystem has been impacted by air-born and water transported contaminants. Water chemistry samples were obtained at eight stations.

The purpose of this study is to date two of the cores by Pb-210 (site 12 and 16 or 23) and four by the Cs-137 method (sites 12, 13, 19 and 16 or 23). In addition one core each from site 13 and 19 which will have been dated by the Pb-210 method (under NRBS Project 2333-D1) will be dated again by the Pb-210 method by a different laboratory, using a somewhat different procedure. This second Pb-210 dating will constitute an interlaboratory comparison so that past Dating on Lake Athabasca

(2332) and Reference Sites (2113) cores can be compared to thsoe from Great Slave Lake. Core dating will allow for a determination of whether or not the cores were collected in regions of continuous sediment deposition and of sufficient duration and sediment stability to warrant organic contaminant analyses. Funding for any contaminant analyses that might be done on the core sections will come from outside sources (i.e., Arctic Environmental Strategy, DIAND). Secondly, biogeochemical marker determination will also be carried out on the site 13 and 19 cores.

II. Requirements

1) Date four of the sediment cores (cores 12, 13, 19 and 16 or 23) collected in March 1994 using Lead-210 and Cesium-137 methods.

2) Based on the results of 1 above, determine whether the cores are suitable for contaminant analyses.

III. Reporting Requirements

1) Submit a Progress Report on the results of the biogeochemical analysis including recommendations for future contaminant analysis to the Project Liaison Officer by November 15, 1994.

2) Prepare a comprehensive report documenting the results of Lead-210 and Cesium-137 dating on the four cores collected in March 1994.

3) Ten copies of the draft report, along with an electronic copy, are to be submitted to the Project Liaison Officer by March 31st, 1995.

   Three weeks after the receipt of review comments on the draft report, the contractor is to submit ten cerlox bound copies and two unbound, camera-ready originals of the final report to the Project Liaison Officer. An electronic copy of the report, in Word Perfect 5.1 or Word Perfect for Windows Version 6.0 format, is to be submitted to the Project Liaison Officer along with the final report. The style and format of the final report is to conform with that outlined in the NRBS Style Manual. A copy of the Style Manual entitled "A Guide for the Preparation of Reports" will be supplied to the contractor by the NRBS.

4) The final report is to include the following: an acknowledgement section that indicates any local involvement in the project, Project Summary, Table of Contents, List of Tables, List of Figures and an Appendix with the Terms of Reference for this project.

Text for the report should be set up in the following format:

a) Times Roman 12 point (Pro) or New Times Roman (WPWIN60) font.
b) margins; are 1" at top and bottom, 7/8" on left and right.
c) Headings; in the report body are labelled with hierarchical decimal Arabic numbers.
d) Text; is presented with full justification; that is, the text aligns on both left and right margins.
e) Page numbers; are Arabic numerals for the body of the report, centred at the bottom of each page and bold.

- If photographs are to be included in the report text they should be high contrast black and white.
- All tables and figures in the report should be clearly reproducible by a black and white photocopier.
- Along with copies of the final report, the Contractor is to supply an electronic version of the report in Word Perfect 5.1 or Word Perfect for Windows Version 6.0 format.
- Electronic copies of tables, figures and data appendices in the report are also to be submitted to the Project Liaison Officer along with the final report. These should be submitted in a spreadsheet (Quattro Pro preferred, but also Excel or Lotus) or database (dBase IV) format. Where appropriate, data in tables, figures and appendices should be geo-referenced.

IV. Deliverables

All sampling locations presented in report and electronic format should be geo-referenced. This is to include decimal latitudes and longitudes (to six decimal places) and UTM coordinates. The first field for decimal latitudes / longitudes should be latitudes (10 spaces wide). The second field should be longitude (11 spaces wide).

V. Project Administration

The Scientific Authority for this project is:

Dr. Marlene Evans
National Hydrology Research Institute
Environment Canada
11 Innovation Blvd.
Saskatoon, Saskatchewan
S7N 3H5
phone: (306) 975-5310
fax: (306) 975-5143

Questions of a scientific nature should be directed to him.

The NRBS Study Office Project Liaison Officer for this project is:

Ken Crutchfield
Associate Science Director
Office of the Science Director
Northern River Basins Study
690 Standard Life Centre
10405 Jasper Avenue
Edmonton, Alberta
T5J 3N4
phone: (403) 427-1742
fax: (403) 422-3055

Administrative questions related to this project should be directed to him.

VI. Literature Cited

Evans, M. S. and R. A. Bourbonniere. 1994. History of Persistent Organic Contaminants Deposition in the Western Basin, Great Slave Lake. Interim Report prepared for the Northern River Basins Study. 8 pp.

Environment Canada Environnement Canada

CANADA'S GREEN PLAN
LE PLAN VERT DU CANADA

Ecosystem Evaluation Division
National Hydrology Research Institute
11 Innovation Boulevard
Saskatoon, Saskatchewan S7N 3H5

Dr. Fred Wrona, Science Director
Northern River Basins Study
#690 Standard Life Centre
10405 Jasper Avenue
Edmonton, Alberta T5J 3N4

February 23, 1995

Dear Dr. Wrona:

As I recently discussed with you, I wish to modify the terms of reference and extend the reporting dates for my Project 233-D2: Great Slave Lake sediments - lead-210 and cesium-137 dating. Specifically, the project calls for the dating of four cores (12, 13, 19 and either 16 or 23) using lead-210 and cesium-137 methods. Two of the four cores, 13 and 19 are to be dated after being dated in a different laboratory: the purpose of this is provide for a interlaboratory comparison of dating methods. I propose to modify the original contract as explained below.

At present, I have had cores 12B, 13B, 16A, and 19B dated at the Freshwater Institute. Core 19B still requires cesium dating. In addition, I have been provided with three estimates of sedimentation rate for all four sites. All four cores are excellent and suitable for further contaminant analyses studies. Rich Bourbonniere, under separate contract, has had cores 13C and 19D dated and shipped them to me. His cores also were excellent. I am having slices from cores 19B and 19D analyzed for organic contaminants along with a small number of slices from Core 23 which has yet to be dated. Analyses include PCBs, other organochlorine contaminants, PAHs, dioxins and furans. Core 23 is being analyzed because of its proximity to the Slave River and because it is of high priority interest to the Department of Indian Affairs and Northern Development, Yellowknife. They are funding the dioxin and furan analyses.

Under the original contract, we were to have Cores 13C and 19B redated as part of an interlaboratory comparison. Since cores 13B and 13C have similar dating estimates and cores 19B and 19D, I believe that it is more prudent to apply the funds remaining to the analysis of other cores. By doing so, we would improve our estimates of the spatial variation in sedimentation rate estimates in Great Slave Lake and have more cores from a given site which could be used for contaminant analyses. Of particular interest is Core 23 which is the closest core to the Slave River.

In March of this year, I will collect an additional series of cores in Great Slave Lake, focusing on the East Arm. I anticipate collecting two or three cores in the East Arm and, depending on funds remaining, another core in the West Basin. One of the East Arm cores could serve as a reference core which NRBS requires as part of its Peace/Athabasca River studies.

Accordingly, I am requesting that the terms of reference for my project be modified to include the addition of one or two more cores for dating, i.e., Core 23 from my March 1994 and a new core from the East Arm sampling. I further recommend that Cores 13C and 19D not be redated, unless additional examination of the raw data deems this a useful exercise. Remaining funds, after the dating, will be applied to contaminant analyses. As part of this modification, I am requesting that the due date for the final report be extended to late summer. Finally, I would note that we have been able to date the cores for less funding than anticipated and so will be providing NRBS with much more data than outlined in the original proposal submission.

Yours sincerely,

Marlene S. Evans
Research Scientist

c.c. Dr. Rick Bourbonniere, NWRI
Dr. John Carey, Contaminants Component Leader, NRBS

APPENDIX B: CO-ORDINATES, OC AND PAH DATA FOR SURFICIAL SEDIMENTS

Table 1. Geographic coordinates for the 12 sites investigated in the Slave River delta, August 1993.

Site	Latitude	Longitude
Resolution Bay 1*	61° 04.99'N	113° 44.97'W
Resolution Bay 2	61° 10.29'N	113° 56.10'W
Resolution Bay 3	61° 13.99'N	114° 04.94'W
Resolution Bay 4	61° 19.31'N	114° 16.47'W
Pine Point	61° 14.56'N	114° 21.54'W
Delta 1	61° 19.90'N	113° 42.47'W
Delta 2	61° 21.30'N	113° 47.96'W
Delta 3	61° 24.97'N	113° 54.52'W
Delta 4	61° 29.83'N	114° 03.97'W
Stony Point 1*	61° 26.40'N	113° 29.50'W
Stony Point 2	61° 29.09'N	113° 34.08'W
Stony Point 3	61° 32.05'N	113° 39.07'W

* no sediments retained from these sites.

Table 2 . Concentration of organochlorine compounds (ng/g dry weight) in surficial sediments of the Slave River mouth, August 1993.

LOCATION	CBZ	HCH	CHLOR	DDT	PCB	Toxaphene	Dieldrin
Ft. Resolution 2	0.29	0.47	0.47	0.82	4.98	3.61	0.07
Ft. Resolution 3	0.89	0.38	0.38	0.51	9.66	0.00	0.09
Ft. Resolution 4	1.25	0.53	0.24	0.19	12.66	1.16	0.09
Pine Point	0.61	0.30	0.24	0.33	4.77	1.28	0.09
Delta 1	0.23	0.43	0.12	0.24	6.66	0.00	0.06
Delta 2	0.99	0.53	0.45	1.16	14.46	0.60	0.10
Delta 3	0.69	0.23	0.11	0.18	5.22	0.00	0.06
Delta 4	0.64	0.21	0.30	0.63	15.09	0.00	0.14
Stoney 2	0.25	0.40	0.18	0.13	9.75	0.00	0.04
Stoney 3	0.71	0.47	0.51	0.46	15.16	0.00	0.10

Table 3. DDT compounds (ng/g dry weight) in surficial sediments , offshore of the Slave River mouth, August 1993.

	FR-2	FR-3	FR-4	PP	D-1	D-2	D-3	D-4	S-1	S-2
op-DDE	0.02	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01
pp-DDE	0.07	0.13	0.03	0.12	0.08	0.43	0.04	0.34	0.01	0.19
op-DDD	0.36	0.07	0.04	0.03	0.04	<0.01	<0.01	<0.01	0.03	<0.01
pp-DDD	0.05	0.06	0.05	0.03	0.02	0.15	0.03	0.1	0.05	0.13
op-DDT	0.1	0.18	0.07	0.04	0.04	0.53	0.05	<0.01	0.02	0.14
pp-DDT	0.22	0.07	<0.01	0.11	0.06	<0.01	0.06	0.19	0.02	<0.01
SUM	0.82	0.51	0.19	0.33	0.24	1.16	0.18	0.63	0.13	0.46

Table 4 . PAHs in surficial sediments (ng/g dry weight), offshore of the Slave River mouth, August 1993.

COMPOUND	FR-2	FR-3	FR-4	PP	D-1	D-2	D-3	D-4	S-2	S-3
Naphthalene	31.45	36.09	30.15	33.47	57.65	47.84	43.53	34.25	40.43	37.55
2-Methylnapthalene	10.69	11.75	9.46	9.89	16.62	17.48	15.83	11.48	13.62	12.62
1-Methylnaphthalene	6.87	7.49	5.97	6.50	10.76	11.33	10.28	7.29	8.72	8.03
Acenaphthylene	1.77	2.20	2.58	2.02	3.13	2.55	2.37	1.70	2.20	2.25
Acenaphthene	2.69	3.26	3.27	2.48	4.74	4.05	3.62	2.67	3.33	3.61
Fluorene	14.00	14.60	18.96	10.64	18.42	9.55	8.69	6.58	16.38	15.67
Phenanthrene	50.25	70.05	60.30	60.92	86.38	73.51	83.81	58.99	65.41	73.33
Anthracene	1.17	2.09	1.44	1.22	2.72	2.40	2.67	1.84	1.53	1.93
Fluoranthene	10.46	13.46	11.36	12.27	22.18	17.31	18.56	12.19	13.90	14.85
Pyrene	18.61	22.68	19.30	21.33	36.89	29.49	30.90	19.51	24.20	24.38
Benzo(a)anthracene	10.82	13.81	11.27	9.44	20.02	16.25	15.30	11.02	11.90	13.30
Chrysene	23.97	33.82	30.22	28.95	38.11	34.99	36.43	29.83	26.30	33.27
Benzo(b)fluoranthene	42.50	56.85	52.13	49.73	71.77	63.15	61.38	52.19	47.48	53.59
Benzo(k)fluoranthene	7.84	9.61	9.40	10.25	12.59	10.24	10.12	8.18	8.95	8.53
Benzo(e)pyrene	69.40	90.63	84.08	88.15	115.51	99.32	98.07	84.01	77.91	82.87
Benzo(a)pyrene	16.67	21.54	17.36	16.56	27.37	26.99	21.18	11.61	20.33	21.09
Indeno(1,2,3-cd)pyrene	34.71	28.33	39.54	37.64	42.67	26.99	37.14	38.24	31.59	23.85
Dibenzo(a,h)anthracene	17.48	16.82	25.09	22.93	21.98	15.14	22.83	26.16	17.43	14.06
Benzo(g,h,i)perylene	94.61	72.92	108.73	112.56	117.10	69.13	90.77	92.01	81.47	58.70
Total PAH	465.96	528.00	540.61	536.95	726.61	577.71	613.48	509.75	513.08	503.48
Dibenzofuran	8.85	11.71	9.38	9.67	15.19	10.48	8.92	8.93	10.55	12.58
Retene	74.29	64.95	49.49	53.34	88.92	88.96	70.87	48.49	81.13	77.82
Dibenzothiophene	8.45	11.11	9.61	10.23	14.21	11.85	12.51	9.48	10.43	11.70
Perylene	310.54	211.38	197.87	203.62	298.89	285.62	263.62	83.18	322.26	268.96

APPENDIX C: CO-ORDINATES AND CORE DESCRIPTIONS FOR MARCH 1994 CORES

Table 1. Geographic coordinates for the 10 sites investigated in the West Basin, March 21 - 29, 1994.

Site	Date	Latitude	Longitude
11*	March 21	61° 02' 11"N	115° 30' 02"W
12	March 22	61° 22' 43.9"N	115° 21' 24.4"W
13	March 23	61° 24' 24.1"N	115° 00' 01.0"W
14*	March 23	61° 07' 00"N	114° 59' 33"W
15*	March 25	61° 09'34.4"N	114° 40' 49.2"W
16	March 25	61° 17' 02.6"N	114° 40' 31.2"W
19	March 25	61° 25' 12.0"N	114° 24' 10.0"W
19	March 27	61° 24' 55.8"N	114° 24' 49.6"W
20*	March 29	61° 18' 24.2"N	113° 44' 53.8"W
21*	March 29	61° 21' 37.7"N	113° 48' 33.6"W
23	March 29	61° 30' 04.2"N	114° 04' 01.8"W

* no sediments retained from these sites.

Table 2. Core Sample Descriptions, March 1994.

CORE DESCRIPTION	**Lake:** Great Slave Lake
Date: 9403xx22 march	**Site:** 12
Lat (d-m-s):	**Lon (d-m-s):**
Core ID: A	**Initial Length:** T--> BB: 37 cm
Extruded & Described by (date):	**Final Length:** T--> BB:27cm
Richard Bourbonniere	**Cmp/Exp (%):**
Transcribed by (date):Mich (1/11/96)	

Notes: Very disturbed it had brown sediment floating in the water for mare than a day and a half now, some of it setled out, but not all of it settled out. We are going to extrude it corsley for contaminents10 cm in 2 cm intervals then throw the rest away. This core looks like it might have had at least the outside frozen in the process of handing auround in the helecopter yesterday.

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	2	Brown	Fluid. At the 2cm cutstill a brown fine clay material.
2	4	Darker, Dark Brown streaks mixed in with grey	Quite a bit stiffer and darker in colour. It is already quite a but dry looking, and there is a few really thick areas.
4	6	Brown, grey	Quite a mixed bag, The upper part, say between 4 and 5 cm was like the previous jar at 2 to 4. Then there was a thin, mabye a 2 to 3 mm thick band of very hard brown clay. Underneath that was an area of very fine grey clay, but it was not as consoladated as above. At the cut at 6 cm though it looks like very grey-brown mud like we have always seen
6	8	Grey-brown	Looks more normal. Fine, nothing unusal, less consoladated than the one above.
8	10	Grey	Clay, consoladated, but not very stiff. Not much different than what we have seen.

CORE DESCRIPTION	Lake: Great Slave Lake
Date: March 22, 1994	**Site:** 12
Lat (d-m-s): (61-22-43.9 N)	**Lon (d-m-s):** (115-21-24.4 W)
Core ID: B	**Initial Length:** T--> BB : 65 cm
Extruded & Described by (date):	**Final Length:** T --> BB: 34 cm
R. Bourbonniere (March 23, 1994 - 1013)	**Cmp/Exp (%):**
Transcribed by (date): Complete	Tape 94-1 - Mich (960110)

Notes: We had trouble getting the core to fit into the extruder we took out the gasket and just used black tape and it seems to be working. There are three or four pontos floating around in this core. The core looks like it didn't freeze, although it was frozen on top. It sat in a cold room overnight which is greater than zero, but probably less than four. There is a brownish layer on the surface of the core and it grades down through a lighter grey to a darker grey there is some searing on the side so you can't really tell the layers. this core is being extruded into ziplock bags for geochronolgy, it is one of the so called poking cores. It has a companion (core A) which is much shorter and much more disturbed. You will hear about that one later. Just a note, the core is ready to begin extruding as the sediment column tube moved up to get rid of the overlying water, the total length is still 65 cm. So there is no compression just in the travelling

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	Light brown, Olive brown.	Very fluid, I got most of it into the bag, but not all. Very fine, no holes. Looking at the surface after extruding the first cm it is still a light brown, an olive brown, something like that.
1	1.5	Same as above	The only main difference is that it is a bit less liquid
1.5	2	The colour after slicing is the same sort of olive brown	Quite a bit thicker
2	2.5	Same as above	Again was thick
2.5	3	Same as above	Same as above
3	3.5	darker after the cut and you can see black streaks,	Noticeably thicker, it didn't even come out of the slicing ring. The bottom is at 3.5 cm. So it looks like this is what we call the bottom of the oxidised layer.
3.5	4	50% black and 50% brown	Was noticeably more consolidated. There is still brown oxidised in it, it is probably the cross section.
4	4.5	a darker sort of grey-brown colour	Again thick. Black streaks don't show after we cut it off .
4.5	5	Still grey-brown	Still thick
5	6	Brownish-grey.	Thick On the slice we could see a little bit of light brown material touching the tube so there is a little bit of smearing from the top
6	7	After slicing a little bit of black streaks occur	
7	8	Noticeably greyer	Definitely thicker, this is very fine silty clay, all the way down.
8	10	Greyish-green	This, the first 2 cm interval was quite a bit thicker. Very fine

			material, it had a noticeable sulphate odour, the first time we have noticed this in this core
12	14	Greyish-green	Pretty much the same as the one above, didn't notice the sulcate smell in this section
14	16	Same as above	
16	18	same as above	
18	20	Same as above	Last 2 cm section
20	25	Grey, Face has Black streaks	I am going to throw away. We are only saving now a couple of lower sections for supported lead and background cesium. Thick
25	27	Face has no black streaks, and the face is a consistent grey colour	Quite a bit stiff
27	32	Face significantly darker. Black streaks all over. Grey	
32	34	same as above	That is going to be the end, that was background material, I will give you the measurements of what is left

CORE DESCRIPTION	**Lake:** Great Slave Lake		
Date: 940323	**Site:** 13		
Lat (d-m-s):	**Lon (d-m-s):**		
Core ID: A	**Initial Length:** T--> BB:		
Extruded & Described by (date):23rd of march. Richard	**Final Length:** T--> BB:		
	Cmp/Exp (%):		
Transcribed by (date): Complete			

Notes: This was a short core tube that was very full. There is only about 2 cm of disturbed water. Again we plan to section this one corsley, the top ten is in 2 cm intervals for contaminents. Bear in mind that the very surface might be missing in this core, so 0-2 might not really be 0-2

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	2	Brown	Fluid for some of it, and beginning to be consoladated. I am sure we lost alot of the origanal material due to disturbance and due to the fact that is was close to the top of the core. But not all of it.
2	4	Grey-brown	consoladated clay
4	6	Grey-Brown	Fine mud. Pretty consoladated just like the one above
6	8	Same as above	

CORE DESCRIPTION	Lake: Great Slave Lake
Date: March 23, 1994	Site: 13 ("A" Visit)
Lat (d-m-s): (61-24-24.1 N)	Lon (d-m-s): (115-00-01.1 W)
Core ID: B	Initial Length: T--> BB: 49.5 cm
Extruded & Described by (date):	Final Length: T-->BB: 16 cm
Richard Bourbonniere (940323, eve)	Cmp/Exp (%):
Transcribed by (date): Complete	Tape: 94-1A Mich (96-01-10)

Notes: It was stored in a helicopter for several hours and then it was stored at room temperature for extruding for another two to three hours. It is going to be extruded for general dating, as opposed to detail dating, this is one of the poking sites The top of the core has a dome, sort of a central location which means there has been some friction on the core as it was going down, the surface is very fluid, it is the normal brown oxidised colour, there are a few pontos

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	Brown	Lots of water, very fluid, brown oxidised material. At the face it is the same sort of brown, oxidised material
1	1.5	Brown	Still a brown fluid but already showing a bit more consolidation relative to the top cm. At the half cm slice same view on top
1.5	2	Same as above	
2	2.5	Still brown	Noticeably thicker
2.5	3	Same as above	Same as above but slightly thicker. At the 3 cm cut we start seeing black streaks and the brown is getting darker
3	3.5	Same as above	
3.5	4	At the cut a bit greyer, it still has a brown colour to it	Still stiff
4	4.5	Brownish-grey. No black streaks	Fine consolidated material. No noticeable odour
4.5	5	Same as above. A brownish grey	A very fine and smooth clay
5	6	Same as above, maybe a little greyer, not so much brown	
6	7	Same as the pervious	
7	8	Same as above, this is very slowly getting grey. No black streaks to speak of	No odour, still very fine
8	10	Grey brown mud	Very stiff
10	12	Same as above	

12	14	Maybe greyer	Thicker...Definitely getting dryer
14	16	Same as above	
16	18	Same as above	
18	20	Same as above	
20	25	Grey	I threw away a 5 cm section of thick grey clay
25	27	Grey	I'm taking a 2 cm section to do background and supported cesium. Thick
27	32		At the end I have a 5 cm section to throw away
32	34		I saved this. At the end of extruding we threw away the remainder. 16 cm to the top of the remaining core to the bottom of the bung That's it, Bye

CORE DESCRIPTION	Lake: Great Slave Lake
Date: 940328	**Site:** 13
Lat (d-m-s): 61-24-13.9	**Lon (d-m-s):** 114-59-49.4
Core ID: C	**Initial Length:** T-->BB: 84.5 cm
Extruded & Described by (date):	**Final Length:** T-->BB: 8 cm
Marlene 940328	**Cmp/Exp (%):** 4.6% expansion
Transcribed by (date):COMPLETE	tape 2B kathy jan. 20 96

Notes: Today is the 28th of March. This is a core that Marlene is going to extrude. It is core C from site 13. It is being extruded for geochronology. Total length from the top of the core to the bottom of the bung was 84.5 cm at the start. I am getting the top cm off. It 's got a very nice top it actually has got a bit of a dome in the middle almost the entire diameter is covered with mud. I would not call the a skewed core the doming is just what happens with cores. Bit of friction onthe top. And it is a brown fluid material probably silty. What else? That is it.

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	"olive Brown"	Watery, domed
1	1.5	olive brown	Section pretty watery. Looking at the upper surface of the next section it is an olive brown colour, smooth and fills most of the core wall.
1.5	2	olive brown	It was also fairly watery consistency. Looking at the upper surface of the next section it is an olive brown colour, smooth, fills most of the core wall.
2	2.5	olive brown	It was somewhat gelatinous. Looking at the upper surface of the next section it is an olive brown colour, smooth, and fills most of the core wall.
2.5	3	olive brown w/ grey streaks	It was some what gelatinous. The upper surface of the next section it is olive brown with quite a few grey streaks in it, very fine and it fills most of the core wall tube.
3	3.5	olive brown w/ faint grey streaks	Section is gelatinous in consistency. Looking at the upper surface of the next section it is an olive brown colour with very faint grey streaks, fills most of the core wall.
3.5	4	olive brown, no streaks	A bit of material fell out, about somewhere between 7 and 10 percent. So the section is not complete. The upper surface of the next section is an olive brown colour, no real streaks in it, fills most of the core wall.
4	4.5	olive brown	Section gelatinous even consistency. The upper section of the next core section is an olive brown colour, no discolourations and fills the core wall.
4.5	5	olive brown	Section is even consistency. Upper section of the next core is an olive brown colour. I think there is a little bit of grey in it now, fills most of the core wall
5	5.5	olive brown w/ some grey	Nothing unusual about the consistency. Upper section of the next core is olive brown colour with some grey in it, smooth.

			fills most of the core wall.
5.5	6	olive brown w/ some grey	Section is even consistency. Upper section of the next core section upper surface is an olive brown colour with some grey in it, fills the core wall.
6	6.5	olive brown w/ some grey	Section has nothing unusual about it. Upper surface of the next section is an olive brown colour with some grey, smooth no discolourations, fills the core wall tube.
6.5	7	olive brown w/ some grey	Nothing unusual about the consistency. Upper surface of the next section olive brown with some grey in it, no discolourations, fills the core wall.
7	7.5	olive brown w/ some grey	Nothing unusual about it. Upper surface of the next section is an olive brown colour with grey in it, smooth, no discolourations, fills the core wall tube.
7.5	8	olive brown w/ faint grey	Nothing unusual about the consistency. Upper surface of the next section is an olive brown colour with a faint amount of grey in it, really fills the core wall tube at this point.
8	8.5	olive brown w/ little bit of grey	Nothing unusual about it. Upper surface of the next section is an olive brown colour with a little bit of grey in it, fills the core wall tube, smooth. Nothing else to say about it.
8.5	9	olive brown w/ some grey	Nothing unusual about it. Looking at the upper surface of the next section olive brown with some grey in it, fills the core wall tube.
9	9.5	olive brown w/ grey	Even colour throughout. Upper surface of the next section olive brown with grey in it no discolourations, fills the core wall tube.
9.5	10	olive brown w/ pale grey	Even colour throughout. Upper surface of the next section olive brown colour with some pale grey in it, no discolourations, fills the core wall tube.
10	11	olive brown w/ grey	Section same colour throughout. Upper surface of the next section is an olive brown colour with grey in it, no other discolourations, fills the core wall tube.
11	12	olive brown w/ grey	Section even colour throughout. Upper surface of the next section olive brown with grey in it, very faint pale light brown streaks, even consistency, fills the core wall tube.
12	13	olive brown w/ quite a bit of grey	Section same colour throughout. Upper surface of the next section is an olive brown colour with quite a bit of grey in it, no other colours or streaks, fills the core wall.
13	14.2	grey, olive brown has gradually deminished	over shot the mark on this section 13 to 14.2 cm same colour throughout. Upper surface of the next section is grey the olive brown has gradually diminished, no discolourations, fills core wall.
14.2	15	grey w/ lt brown streaks	Section same in colour throughout. Upper surface of the next section is a grey colour, very faint light brown streaks, fills most of the core wall.

15	16	grey	Section same colour throughout when it was cut up. Upper surface of the next section is grey, fills the core wall tube, no other colours.
16	17	grey w/ faint lt brown streaks	Section same colour throughout the section. Upper surface of the next section is grey , very faint light brown streaks, fills the core wall.
17	18	grey	Section is same colour throughout. Upper surface of the next section is grey, no other colours, fills core wall.
18	19	grey	Same colour throughout. Upper surface of the next section is a grey colour no other discolourations, fills core wall.
19	20	grey	Same consistency throughout in colour. Upper surface of the next section is grey, no other colours, fills core wall.
20	22	grey	Same colour and consistency throughout, getting quite stiff. The upper surface of the next section is grey, no other colours in it, fills core wall tube.
22	24	grey	Same colour throughout. Upper surface of the next section is grey, no other streaks, fills core wall tube.
24	26	grey	Same colour and consistency throughout. Upper surface of the next section is grey, no other colours to it, fills core wall tube. This particular section is actually extruded a bit above the core wall I left the pump on accidently.
26	28	grey	Consistent colour throughout. Upper surface of the next section is grey no other colours or streaks, fills core wall.
28	30	grey	Same colour throughout. Upper surface of the next section is grey colour no other colours or streaks, fills core wall.
30	32	grey	Same colour throughout.Upper surface of the next section is grey no other colours, fills core wall.
32	34	grey	Section same colour throughout. Upper surface of the next section is grey, no other colours to it, fills core wall.
34	36	grey w/ pale lt brown streaks	Section same colour throughout. Upper surface of the next section is grey with some very pale light brown streaks, fills core wall.
36	38	grey	Section same colour throughout. Upper surface of the next section is grey with nothing else to it, fills core wall.
38	40	grey	Section same colour throughout. Upper surface of the next section is grey, no other colours, fills core wall.
40	42	grey w/ dk grey streaks	Section is same colour throughout. Upper surface of the next section is grey with faint tracings of a dark grey or light black, fills core wall
42	44.2	grey	Overshot the mark a bit. It was grey, I did not really notice any other colours in the middle pieces of the section. The upper surface of the next section is grey, no other colours, fills core

			wall.
44.2	46	grey	Section was grey colour throughout. Upper surface of the next section was grey, no other colours to it, fills core wall.
46	48	grey w/ lt blk streaks	Section grey but there are some long black streaks in some of the sections, cuts. Upper surface of the next section was grey and there was faint tracings of light black or dark grey, core fills core wall.
48	50	grey	Even grey colour throughout. Upper surface of the next section is grey, no other colours to it, fills most the core wall.
50	52	grey w/ numerous blk streaks	Section grey in colour throughout. Upper surface of the next section is grey but there are numerous black and dark grey streaks, fills most of the core wall.
52	54	grey	Section was grey, no other different colour types obvious throughout it. I dropped a section on the table and I cut it off cut off the part that touched and I estimated that I lost 5% of the weight. In case I forgot the upper surface of the 54 to 56 cm section grey no other colours to it, fills the core wall.
54	56	grey w/ faint blk streaks	Section was grey no other colours in it when I sliced it. Upper surface of the next section is grey with very faint tracings of black and dark grey.
56	58	grey w/ numerous blk streaks	Section was grey but once I sectioned it there was several areas where there was dark grey material grading onto black. The upper surface of the next section continues along this type with grey but numerous streaks of a dark grey and black, fills the core wall.
58	60	grey w/ faint dk grey tracings	Section grey with some areas inside where there were streaks of dark grey. Upper surface of the next core section is grey, very pale and faint tracings of dark grey fills core wall.
60	62.2	grey w/ lot of blk streaks	I over shot the mark a bit. It was grey towards the bottom part of the section there was very distinctive band of dark black material. Upper surface of the next section is grey with a lot of streakings of black or dark grey.
62.2	64	grey w/ faint blk streaks	Section was grey, there wasn't a great deal of black streaking in it. Upper surface of the next section grey with faint black streakings.
64	66	grey w/ faint black	Section was grey with a little bit of black tracings in it. Upper section of the next core section is grey and there is just very faint black tracings.
66	68	grey w/ many pronounced black streaks	Grey and as I sectioned it there was a couple layers where there was little bands of dark black material. Upper surface of the next section is grey with very pronounced black streaks and there are many of them.
68	70	grey w/ faint grey streaks	Section grey the upper part of the noise ... 68 to 70 cm section was grey although the upper part had lot of streakings of dark black. The upper surface of the next section is grey and

			relatively free of any kind of streakings, although if you look hard there is some faint dark grey ones.
70	72	grey w/ numerous dk grey streaks	Section was grey and as I sectioned it I could see a few layers of dark black material. Upper surface of the next section is grey with numerous streaks of dark grey, fills the core wall.
72	74	grey w/ pale dk grey tracings	Section grey with layers with dark black in it, dark grey. Upper surface of the next core is grey with very pale tracings of dark grey. With the 72 to 74 cm section there really weren't that many tracings of dark grey.
74	76	grey w/ faint dk grey streaks	Grey some areas in it where there was some dark black material. Upper surface of the next core section was grey with some faint streaking of dark grey.
76	78	grey w/ many dk grey streaks	Grey with some areas with darker greyer black material in it. Upper surface of the next core is grey with many numerous streaks of dark grey, fills most of the core wall.
78	80	grey w/ black streaks	78 to 80 cm grey with a lot of dark black streaking material in it. The upper surface of the next section which probably won't contain 2 cm is grey with black streaks.
			As I thought I was not able to get another section . There is 8 cm of sediment left between the upper surface of the sediment and the bottom of the bung.

CORE DESCRIPTION	Lake: Great Slave Lake
Date: 940328	Site: 13
Lat (d-m-s): 61 - 24 - 13.9	Lon (d-m-s): 114 - 59 - 49.4
Core ID: D	Initial Length: T-->BB:77.5 cm
Extruded & Described by (date):	Final Length: T-->BB: 8.3 cm
Marlene	Cmp/Exp (%): 6.9% expansion
Transcribed by (date): Complete	KB Jan.,25,96 tape94 2 B

Notes: We are getting to core section 13D which was collected march 28 today is march 29. It was stored in the cooler until we could get to it. The distance from the bottom of the bung to the top of the sediment was 77.5 cm. The upper surface of the sediment was uneven ????? light in texture, an olive brown, numerous amphipods swimming around and there were little holes in it could have been amphipod burrows. or ????

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	olive brown	The top surface of the next core section is an olive brown colour, smooth, fills the core wall.
1	1.5	olive brown	Section watery in texture. The upper surface of the next section is an olive brown colour, smooth no other discolourations, watery around the edges.
1.5	2	olive brown	Watery. Upper surface of the next section olive brown colour, smooth, and watery around the edges.
2	2.5	olive brown	2 to 2.5 cm section was also somewhat watery in texture. The upper surface of the next section is olive brown,smooth, fills the core wall.
2.5	3	olive brown w/ fine grey streaks	Section was less watery than the upper ones. The upper surface of the next section is olive brown with very fine grey streaks on the surface. The core fills most of the core wall.
3	3.5	olive brown w/ numerous grey streaks	Section was even in consistency. The upper surface of the next section olive brown with again numerous faint streaks of light brown or dark grey not light brown, dark grey.
3.5	4	olive w/ fewer faint grey streaks	Section was even in consistency. The upper surface of the next section is olive brown with lesser faint tracings of the dark grey, fills the core wall.
4	4.5	olive brown w/ dk brown tracings	Section is a little more dense in consistency than the upper sections. The upper surface of the next section is an olive brown colour, with faint dark brown tracings in it.
4.5	5	olive brown, no streaks	Section even in consistency, The upper surface of the next section is an olive brown with no tracings of any other colour.
5	5.5	olive brown w/ some grey	Section was even in consistency. The upper surface of the next section is an olive brown with some grey in it, no other colours to it, fills most of the core wall.
5.5	6	olive brown	Section was even in consistency. The upper surface of the next

			section is an olive brown colour, nothing else to note about it, except that it fills the core wall completely.
6	6.5	olive brown w/ grey	Section even in consistency. The upper surface of the next section is an olive brown with grey in it, no other colours, fills the core wall.
6.5	7	olive brown, w/ maybe some grey	Section even in consistency. The upper surface of the next section is an olive brown colour, maybe some grey in it, nothing else to note about except that it fills the core wall.
7	7.5	olive brown some grey	Section that I sliced I didn't slice cleanly, I think I got about half a centimetre, but it is a little hard to tell,certainly it is level at the top now of the core tube. The upper surface of the next section is olive brown, some grey in it, fills the core wall.
7.5	8	olive brown w/ some grey	Section was even in consistency but there was there appears to be a small amount of sand in it, when I rubbed the sediment against the glass wall I heard a scratchy sound. The upper surface of the next section is an olive brown colour with some grey, some very pale streaks.
8	8.5	olive brown w/ quite a bit of grey	Section was even in consistency, although there was still some sand in it, small amounts. The upper surface of the next section is an olive brown with quite a bit of grey in it, smooth in texture.
8.5	9	olive brown w/ quite a bit of grey	Even in consistency. The upper surface of the next section is olive brown with quite a bit of grey in it, there might be some little sand grains on the top surface, fills the core wall.
9	9.5	olive brown w/ pale light brown streaks	Section even in consistency, there didn't appear to be any sand particles in the section. The upper surface of the next section is an olive brown with some light brown streaks but they are real pale, not that noticeable.
9.5	10	olive brown w/ some grey, faint dk brown streaks	Section was even in consistency, the upper surface of the next section is olive brown with some grey some very faint pale streaks of brown, darker brown.
10	11	olive brown w/ quite a bit of grey	Section was even in consistency. The upper surface of the next section is olive brown with quite a bit of grey in it, fairly smooth, no other colours, well faint brown streaks.
11	12	olive brown w/ quite a bit of grey	Section even in consistency. The upper surface of the next section, olive brown with quite a bit of grey in it, a few faint tracings of a light brown.
12	13	olive brown, more grey, faint lt brown streaks	Even in consistency and colour throughout. Upper surface of the next section is more grey than an olive brown and there are faint light brown streakings across the top
13	14	grey w/ olive brown	Section even in consistency and colour throughout. Upper surface of the next section is grey with olive brown in it, fills the core wall.
14	15	grey w/ olive brown, faint dk	Section even in colour and consistency. Upper surface of the next section is grey with olive brown in it, a number faint

		brown streaks	tracings of dark brown.
15	16	grey w/ some olive brown	Section even in colour and consistency throughout. The upper surface of the next section is grey with some olive brown in it, some faint tracing of light brown, not very long.
16	17	grey	Section smooth in colour and consistency throughout. Upper surface of the next section is an olive brown colour, I'm sorry a grey colour.
17	18	grey	Section even in colour and consistency throughout. Upper surface of the next section is grey even colour and texture, fills core wall.
18	19	grey w/ faint brown streak(s)	Section even in colour and consistency throughout. Upper surface of the next section is grey very faint brown streak.
19	20	grey w/ faint blackish streaks	Even in colour and consistency throughout. Upper surface of the next section is grey with faint blackish streaks but really not very many.
20	22	grey	Section even in consistency and colour throughout. Upper surface of the next section is grey, fills core wall.
22	24	grey w/ faint pale grey streaks	Section even in colour and consistency throughout. Upper surface of the next section is grey with faint pale grey streaks.
24	26	grey w/ faint grey streaks	Section even in colour and consistency throughout. Upper surface of the next section is grey with faint tracings of dark grey.
26	28	grey	Even in colour and consistency throughout. Upper surface of the next section is grey also even in colour.
28	30	grey	Section even in colour and consistency throughout. I dropped a chunk on the table I cut off the touched surface and I estimate that it was less than 2% of the total weight of the sample. Upper surface of the next section is grey seams a little dry for some reason, and no other colours.
30	32	grey	Even in colour and consistency throughout. Upper surface of the next section grey nothing else to note about it, fills core wall.
32	34	grey	Section was the same as the previous one. Upper surface of the next section is grey, smooth, nothing else to note about it.
34	36	grey	Same in colour and texture throughout. Upper surface of the next section is grey, no other colours.
36	38	grey	Even in colour and consistency throughout. Upper surface of the next section is grey.
38	40	grey w/ a few faint dk grey streaks	Even in colour and consistency throughout. Upper surface of the next section is grey although there is a couple of faint tracings of a darker grey.
40	42	grey	section even in colour and consistency. Upper surface of the

			next section is grey, no other colours.
42	44	grey w/ some dk grey	Section even in colour and consistency throughout. Upper surface of the next section is grey with some very faint dark grey tracings.
44	46	grey w/ some dk grey	Section even in colour and consistency throughout. Upper surface of the next section is grey with some darker grey in it... streaks
46	48	grey	Section even in colour and consistency throughout. Upper surface of the next section is grey. ...Seems to me that Japanese people like to travel a lot, maybe more so than other.
48	50	grey	Even in colour and consistency throughout. Upper surface of the next section is grey.
50 52	52 54	grey	Even in colour and consistency throughout. Upper surface of the next section is grey.
54	56	grey w/ some faint dk brown streaks	Section even in colour and consistency throughout. Upper surface of the next section is grey with some faint darker brown streaks.
56	58	grey	Even in colour and consistency throughout. Upper surface of the next section is grey.
58	60	grey w/ black streaks	Even in colour and consistency throughout. The upper surface of the next section is the beginning of a layer where its grey,with some... one edge there is a lot of dark black streaks which obviously began with some little spherical objects like sand grains sizes.
60	62	grey w/ black streaks	Grey with numerous areas in it which contain darker black material. Upper surface of the next section is grey with black streaks.
62	64	grey w/ some blk streaks	Section is grey with black streaks at various portions inside the section. Upper surface of the next section is grey with still some remnants of the black streak
64	66	grey w/ faint darker grey streaks	Section grey with only small section with dark black in it. Upper surface of the next section is grey with faint tracings of a darker grey.
66	68	grey w/ extensive blk streaking	Grey for the most part although at the bottom there was some dark black areas. Upper surface of the next section grey with extensive areas of black streaking and little bits of material that look like large sand grains that are black.
68	70	grey w/ blk streaks	Grey with black areas in it. Upper surface of the next section is grey with black streaks
70	72	grey w/ extensive blk streaks in this section---@ section grey w/ faint dk grey streaks.	Section grey with lots of black streaks Throughout upper surface of the next section which is getting near the top of the bung is grey only a small bit of black streaking, very faint. .... I don't think I had this tape recorder on the 70 to 72 cm section is grey with numerous areas of black streaking. Upper

			surface of the next section is grey with just faint traces of darker grey.
72	74	grey	Section grey even colour and consistency throughout. I am not able to get any more core sections so that concludes the core. I will just measure the length of the remaining material. There is approximately 8.3 cm material remaining between the top of the sediment surface to the bottom of the bottom core bung. This concludes the tape for core 13 D .

CORE DESCRIPTION	Lake: Great Slave Lake
Date: 28 Mar 94	**Site:** 13
Lat (d-m-s): 61 - 24 - 13.9	**Lon (d-m-s):** 114 - 59 - 49.4
Core ID: E	**Initial Length:** T-->BB: 86 cm
Extruded & Described by (date):	**Final Length:** TR-->BB: 8 cm (est)
Rick 94 03 29	**Cmp/Exp (%):** Compressed by 8% (est)
Transcribed by (date):	KB tape 3 B Jan 27, 1996

Notes: (Rick) Oh, it is the 29th of March we are extruding a core collected on the 28th of March, site 13 core E. It was collected and stored 4 degrees C overnight. The length of the core from the top to the bottom of the bung at the beginning was 86 cm. Being sectioned by our fine sectioning intervals for biogeochemical use. The top of the core is domed it has pulled away from the side a bit. It has lots of little holes there were amphipods floating around in it, and it is only very slightly skewed.

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	brown	Brown oxidized fluid. At 1.5 cm it is brown silty clay so is the 0 to 1 was also silty clay
1	1.5	brown	Very similar to the one above but a little bit more consolidated there was still some water in it there is actually water on the edge of the core pulled away about 1 and a half the circumference of the core, pulled away from the edges tube.
1.5	2	same	Same as above
2	2.5	Darker brown	Getting a bit darker and a bit more consolidated, still water on the edges. The 2.5 cm slice definitely darker, dark brown is becoming the main colour, rather than the lighter brown than it use to be.
2.5	3	Brown w/ Dark streaks	Same as above. The face at the 3 cm cross section is again brown with dark streaks, over all darker cast.
3	3.5	Dk Brown no streaks	At the 3.5 cm face it is still a dark brown colour but doesn't show much streaking very smooth and even dark brown.

3.5	4	Same	Same as above. Face at 4 same as above.
4	4.6	Dk Brown	Actually a 4 to 4.6 I'll make the next one 4.6 to 5. Colour the same as above, but it seems to be getting noticeably more consolidated at this point. At the 4.6 cm face is even darker brown colour.
(4.6) 5	(5) 5.5	Greyer	Section(s) same as above. At 5.5 cm cut face looks noticeably greyer.
5.5	6	Same	Same
6	6.5	Brown w/ quite a bit of grey	The 6.5 cm face smooth evenly coloured brown with quite a bit of grey in it.
6.5	7	Same	Same as above. Same at 7 cm cut face
7	7.5	Same	Same as above. 7.5 cm cut face still brown with quite a bit of grey in it.
7.5	8	Grading to grey	Same as above. At the 8 cm the cut face is still smooth this core is very slowly grading from brown to grey. Seams to be a bunch of water flowed across the surface at this cut face, probably definitely from the edge core
8	8.5	Same	Same as above
8.5	9	Greyer	Same as above. The cut face at 9 is again greyer, greyer than above.
(9) 9.5	(9.5) 10	Faint blk streaks	Same as above. 10 cm cut face shows very faint black streaking, maybe they are brown streaks hard to say.
10	11	Grey	Noticeably more consolidated, noticeably more grey, probably what I saw at 10 cm then wasn't black streaks as much as the grey finally coming through underneath the brown.
11	12	Grey	Smooth and consolidated grey clay.
12	13	Same	Same as above.
13	14	Same	Same.

(14) 15	(15) 16	Grey	Section at 16 cm quite a smooth grey colour. still a little but of smearing from the surface water on the edges.
16	17	Same	Same as above.
17	18	Grey	In case I have not already said this the colour in the 17 to 18 cm section is definitely grey, brown is really not present any more. And that has been the case in the last few centimetres. Also particularly the case at the 18th cm cross section
18	19	Same	Same
19	20	Same	Same as above.
20	22	Same	Same.
(22)	(24)		((did not mention that it was the 22 to 24 cm section on the tape))there is still evidence of a small amount of smearing from the surface water, and a little bit of brown mud on the edges, maybe one fifth of the circumference of the tube shows wetness
24	26	Grey	Boringly smooth, fine grey clay.
28	30	Same	Same
30 32	32 34	Grey	Cut face at 34, same, smooth even grey colour.
34	36	Grey	Smooth consolidated fine grey clay.
36	38	Same	Same
38 40	40 42	Same	Same
42 44	44 46	Black streaks at face	Same and at the 46 cm cross section is the first evidence of black streaking quite a bit of it, about 60% of the core has black streaks in it.
46	48	Blk bands	Black banding is only in the top cm of this section, the cut face at 48 shows no banding.

(48) 50	(50) 52	Black banding	The bottom part of this section showed black banding. At the 52 cm cut there is some black banding as well, and the consolidation is increasing cause there are cracks developing middle of the core.
52	54	Some black banding	There was black banding only in the top of this section 54 cm there is no black banding, very small amount showing.
54	56	Some banding	Same as above very little banding showing.. no banding showing at the 56 cm cut
56	58	Same	Same we are taking a 20 to 30 min break here to do some other business. Covering the remaining core with the stainless steel slicer.
58	60	Extensive black streaks	There is extensive black streaks in the bottom 5 millimeters of this section and a lot as well at the face at 60 cm.
60	62	Same	Black banding in the top 5 mm of this section
(62)	(64)	no banding	((62 to 64 cm not mentioned on tape dialogue included with the above section))no black banding at the 62 cm face non at all throughout the 64 cm section and also none at 64 cm. We have grey fine clay cracking in the middle because it is getting dryer.
64	66	Blk Bands	Black banding at the bottom section and quite a bit at 66 cm slice.
66	68	Same	Black banding throughout this 2 cm section and also showing up at the 68 cm cut.
68	70	Extensive bands	Extensive black banding, extensive black banding at the top of the section very little at the 70 cm cut.
70	72	Blk Bands	Some black banding in the section at 72 there is 5 or 6 wide black bands with space in between them.

			70 to 72 section will be the last one. We had some problem with water coming up the middle of the mud it appears that the bung started leaking on the edge. Not sure why it seemed to work very well all the way. It is possible that water came up through the bolt but that's not been noticed before. Unfortunately I just threw the whole core away without taking the top or the bottom, the final measurements. So we don't know wether it's compressed or expanded. We finished site 13 core E, I believe, at 72 cm. We had problems at the end with water coming through so we terminated prematurely. There were about 8 cm left to go to the end . The End

CORE DESCRIPTION	**Lake:** Great Slave Lake
Date: 28 March 1994	**Site:** 13
Lat (d-m-s): 61 - 24 - 13.9	**Lon (d-m-s):** 114 - 59 - 49.4
Core ID: F	**Initial Length:** T-->BB: 89.5 cm
Extruded & Described by (date):	**Final Length:** TR-->BB: 16.5 cm
Rick (940329)	**Cmp/Exp (%):** Expansion (11%)
Transcribed by (date): Complete	KB Jan. 27, 1996 tape 94-4-A

Notes: (Rick) OK, It's March 29th. We are extruding a core from site 13 it is called core F. It's sampled yesterday and kept in a cold room at 4 degrees C for more than 24 hours. It is a very long core. The surface was disturbed, because there is not that much water above between it and the valve. Doesn't appear we lost much of it. Not like the surface was banged up into the valve. But it is still a bit more questionable. It was judged to be the worst of 4 good cores from site 13. Being extruded into untared jars and we can consider it to be an archive core it may be used checking on other kinds of analysis or checking contaminants core or whatever is necessary. The total length of the core from the top of the core to the bottom of the bung at the beginning is 89.5 cm. there are pontoporeia floating around in this core and it looks like it's barely moving. The core is disturbed in the sense that it has a little overlying water has a bit of a milky clay colour to the overlying water which probably means it is shaking up some clay from a little bit deeper in the core and it is taking time to settle. But the top of the core looks like normal brown oxidized mud. It has a slight dome, couple of holes in it from the pontoporeia jumping in and other than that it doesn't look bad.

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	Brown	Section was brown fluid other than that nothing unusual same as we see everywhere. At 1 cm the cut is silty brown material no wholes from pontoporeia down this far there is some water on the side of the core and there is a pontoporeia swimming in that water. Maybe 20% of the circumference of the core is split away from the edge.
1	1.5	Brown	Already little bit more consolidated obviously a lot less fluid colours are the same. At 1.5 cm colour is the same brown smooth silt
1.5	2	Same	Same as 1 to 1.5, as well the 2 cm cut was the same.

2	2.5	Brown w/ greyish cast	A bit more consolidated. I think it is getting to be a greyish cast to the sediment, still mostly brown but a bit of grey in it.
2.5	3	Darker brown	Colour is a bit darker brown a bit more consolidated. At 3 cm there is quite a noticeable layer of black or real dark brown streaking, giving the whole core a darker cast.
3	3.5	Same	Same as above including the 3.5 cut same as above.
3.5	4	Same	Same as above. At 4 cm the cut was not so grey there, I mean the whole cast is turning grey a bit not much in the way of streaks. The whole core circumference is separated away from the tube.
4	4.5	Brown w/ grey	About the same as above. 4.5 cm face is brown with grey in it.
4.5	5	Same	Same as above.
5	5.5	Same	Slice is brown with grey smooth fine clayey silt.
5.5	6	Same	Same as above. The 6 cm cross section is definitely greyer than above.
6	6.5	Same	Same as above.
6.5	7	A bit greyer	Definitely more consolidated maybe a bit greyer.
7	7.5	Same	Same as above.
7.5 8 8.5	8 8.5 9	Brown w/ grey	About the same, fine brown with a lot of grey in the clay.
9	9.5	Same	Same as above.
9.5	10	Same	Same as above.
10	11	Grey w/ brown	Section was noticeably more consolidated. smooth grey clay with quite a bit of brown in it.
11	12	Grey w/ brown streaks	Same as above. At the 12 cm slice brown I can see brown streaks in the predominately grey brown mud.
12	13	Same	Same as above

13	14	Same	Same as above. The cut at the 14 has some streaking in it kinda brown the overall colour is greyish brown .
15	16	greyer	Section is similar to the one above. definitely a greyer colour now at this point at 16 cm slice
16	17	Same	Same as the one above.
17	18	Same, w/ brown streaks	Same, at 18 cm I can see some brown streaks mixed in with the grey clay.
18	19	Same	Same as above
19	20	Same	Same as above
20	22	Grey	Section is definitely grey definitely more consolidated at 22 cm very even grey colour right throughout. Entire core tube is filled with the mud there is a slight wetting on the edges probably from smear from above.
22	24	Grey	Fine grey clay.
24	26	Same	Same as above, fine grey clay.
26	28	Same	Same.
28	30	Same	Same as above. 30 cm cut slice is fine, consistent, all the same colour across, grey, no mottling, it looks like smooth clay.
30 32	32 34	Same	Sections both the same as each other and very similar to those above, fine grey clay, consistent smooth.
34	36	Same	Same again.
36	38	Same	Same as the one above. Cut face at 38 is consistently grey smooth fine clay. Like I said same as above.
(38) 40	(40) 42	Same	Fine grey clay as we have seen before nothing unusual to report at 42.
42	44	Same w/ blk streaks?	Same as above. At 44 cm we finally have a difference. There is black streaking showing not a lot but some
44	46	Same. No streaks	Same except I don't see any black streaks.

46	48	Same	Same as above no black streaks. None showing at 48 either.
48	50	Blk banding	There is black banding in the bottom few mm of this section. Quite a few black streaks showing up at the 50 cm cut.
(50) 52	(52) 54	Some blk streaks	Section has some black streaks in it 54 there is still black streaks.
54	56	Same	There was black banding in this section but at 56 there is none.
56	58	Same	Same as above.
58	60	Same	There were blacks streaks in the center of the section
60	62	Extensive blk streaks	Extensive black streaking in the center of this section and some visible at 62 cm.
62	64	Same	Extensive black streaking throughout the entire section, only a small amount visible at 64 cm.
64	66	Blk streaks	Only a small amount of black streaking in this section large extensive black streaking shown at the 66 cm face.
66 68	68 70	Extensive blk streaks	Both contained a lot of black streaks particularly the second one at the 70 cm slice the extensive black streaks on one third area of the cross section and large crack down the middle it is getting more dry so it is being cracked by the action of the slider.
70	72	Blk streaks	Same but at 72 cm there are no black streaks showing but there is a crack.
72	74	Less blk streaks	Not much black streaking in that section, but at 74 cm a lot of it is showing.
74	76	Extensive blk str	Extensive black streaking in that section at 76 cm there is about one forth of the core streaked black.
76 78	78 80	Extensive blk str	Extensive black streaking throughout the entire section. At 80 cm there is no black streaking.

80	82	Some blk str	Some black streaks in it and at 82 cm the base showed about 25% black streaking. End this core at this point 82 cm is good enough for an archive. 16.5 cm was the remaining height from the top of the remaining part of the core to the bottom of the bung after extruding which concludes site 13 core F.

CORE DESCRIPTION	**Lake:** Great Slave Lake
Date: 9403xx23rd of march.	**Site:** 14
Lat (d-m-s):	**Lon (d-m-s):**
Core ID: A	**Initial Length:** T--> BB:
Extruded & Described by (date):	**Final Length:** T--> BB:
	Cmp/Exp (%):
Transcribed by (date):	

Notes: Badly skuedued core. It is so bad that i'm not going to bother measuring the total length. Because it is within five cm to what you call the middle anyway. We will take this one corsley in 2 cm sections again like we did on site 12. This was so crappy that we didn't do anything to it. As it got to the surface when it was being extruded we felt the clay, it was very hard, just like glacial clustering clay the core was just pushed very hard into this stuff and it went sideways. Not worth sampling any of it at all.

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	2		

CORE DESCRIPTION	Lake: Great Slave Lake
Date: 9403xx25th of march	**Site:** 16
Lat (d-m-s):	**Lon (d-m-s):**
Core ID: A	**Initial Length:** T--> BB: 50.5 cm
Extruded & Described by (date):	**Final Length:** T--> BB: 16cm
Richard Bourbonniere(25th of march)	**Cmp/Exp (%):**
Transcribed by (date): Michelle(1-11-96)	
Notes: The core looks normal, it has an olive brown surface layer and it grades down to a grey-brown, again it is very fine. Exturded into ziplock bags for geocronolgy	

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	Brown	Oxydised Fluid
1	1.5	Same as above, Brown	At the face there are some cracks and some areas of, wetter areas in the middle with, it almost looks like water has come through, through some holes or something. Fine Clay
1.5	2	Brown	Fine Mud, No perticular areas of holes or water
2	2.5	Same as above	This core, like the one previous has alot of water on the edges. The core dosn't fill the entire diameter of the tube. I don't know if this was frozen and the water split out or what, Mabye it has something to do witrh the kind of sediment here
2.5	3	Same as above:Black Streaks, brown and grey	At the face you can see black streaks the colour though of the main sedement is still brown with grey the black streaks darkening considerably
3	3.5	Colour at the face is grey with a tinge of brown. Only a small amount of streaking	Same consistancy
3.5	4	Same as above. Black streaks	At the 4cm face there arevisible black streaks again.
4	4.5	Same as above	At the face: No (or very little) black streaks
4.5	5	Same as above	
5	6	Same as Above Maybe greyer at the cut)	Looks to me a little bit greyer at the 6 cm section face
6	7	Same as above	
7	8	Colour about the same, Grey with brown tinge, no black streaks	Noticably more consoladayet, compared to even the one above
8	10	Grey	Pretty thick
10	12	Same as above	

12	14	Same as above	
14	16	Same as above	Slightly over 2 cm
16	18	Grey-brown	Couple of mm shorter, in order to make up for the couple of mm higher in the pervious one, Fine Clay
19	20	Same as above	
20	25		Threw away
25	27	Thick dark black band, Few other streaks	Backround or supported lead 2:10 section. Sulfate odor
27	32	Brown	Grey, fine, wet sediment on the edges, probubly smeared down from above. The way the core pulled down from the edges,probubly let the surface mud slide down.
32	34	Grey-Brown	At the end of 34 cm the last 2 cm was saved as a background Face:grey-brown fine clay

CORE DESCRIPTION	Lake: Great Slave Lake
Date: 940326	**Site:** 16
Lat (d-m-s): 61 - 17 - 02.6	**Lon (d-m-s):** 114 - 40 - 31.2
Core ID: D	**Initial Length:** T-->BB: 74 cm
Extruded & Described by (date):	**Final Length:** T-->BB: 9 cm
	Cmp/Exp (%): 4.6% expansion
Transcribed by (date): Complete	Kathy (960115) - Tape 2 A

Notes: We are looking at site 16 core D. This core is one of two that looks reasonably good from today . The total length from the top of the core to the bottom if the bung is 74 cm. We are going to section it in the top cm then half centimetre down to 10, 1 cm down to 20, then 2 for the rest of the core. The top surface is about 60% across it is domed in the middle very light sort of fluid lots of water, a bit disturbed.

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	Olive Brown	Section mostly water, is olive brown very fluid like as usual. At the 1 cm the face is again olive brown, few lines showing in the mud and its pulled away from the edge of the core on one side only with a lot of water around the edges.
1	1.5	olive brown	Section was already a little bit thicker and gelatinous but its the same colour, smooth, olive brown. At the 1.5 cm cut same as it was at 1 cm.
1.5	2	olive brown	Same as 1 to 1.5. At 2 cm the cut is still smooth olive brown colour with quite a bit of water on the edge maybe a centimetre ?at half??. The core is pushed over to one side.
2	2.5	olive brown w/ some greying	Same as above. The face at 2.5 cm very smooth looking like its greying some but still pretty much olive brown.
2.5	3	olive brown w/ blk streaks	Getting a little bit more consolidated at 3 cm you can start seeing black streaks running across the olive brown mud.
3	3.5	olive brown, greying w/ brown streaks	Same as the one above. At the 3.5 cm face there still are look like brown streaks instead of black streaks.
3.5	4	olive brown, with brown & grey streaks	A bit more consolidated still about the same as above it's a very fine clay. The 4 cm face is the same as the one above brownish and grey streaks in the basic olive brown background
4	4.5	Same as above	Section same sort of fine clay as usual. At the 4.5 cm face it is the same basic olive brown with some brown and black streaks.
4.5	5	olive with more grey and black streaks	Section it was same fine grey olive brown clay but it is getting a tinge greyer. At the 5 cm face the core continues to be pulled away from the edge, and the black streaks are showing up and the whole consistency the whole colour is a bit more grey than it was before.
5	5.5	olive brown, greying, no streaks	Section it was the same as the one above. At the 5.5 cm face its very smooth olive brown but greying colour no streaks noticeable at this face.

5.5	6	same as above	Section noticeably more consolidated than the ones above and at the 6 cm break still an olive brown is the main colour with some grey and a few streaks.
6	6.5	same	Same as 5.5 to 6. The face at 6.5 is also the same.
6.5	7	olive brown w/ more grey	Section is fine grey clay still olive brown in there but starting to get more grey. Yes it is beautiful mud according to Pat.
7	7.5	grey & olive brown, dark streaks	Section same as the one above. The 7.5 cm face grey and olive brown mixed with some dark streaks.
7.5 8?	8 8.5?	more grey than brown	Section is noticeably more consolidated than the one above and the face at 8 cm is quite smooth, and is much more grey now than it is brown
8.5	9	same as (8-8.5?)	Section is very much the same as the one above and the face at 9 is about the same.
9	9.5	grey w/ black streaks and some brown	Section is consolidated clay reasonably grey and at the 9.5 cm face you can see some black streaks in the grey with some brown colour.
9.5	10	Same	Section it is pretty much the same as the one above and so is the 10 cm face.
10	11	Grey, brown streaks	Section mostly grey in colour quite consolidated. At the 11 cm face I can see brown streaks in the grey background.
11	12	Same	Section same as the one above. At 12 cm the face is the same with a few brownish streaks.
12	13	Same	Section same as the one above.
13	14	same	Section same as the one above sort of grey mostly with some olive brown tinge fine clay. At the 14 cm face there is just the grey colour only a few brown streaks.
14	15	Same	Section is the same as the one above. At 15 cm it is grey with some brown streaks. Through out this core the total diameter was not filled up. Right now we are at about 90% complete. There is a crack on one side. There is no water in this though there has been earlier.
15	16	Same, no streaks	Section was the same as the ones above. At 16 cm it is grey fine mud with no streaks.
16	17	Same	Section was the same as the ones above.
17	18	Same	Section was same grey fine clay. The face at 18 cm was the same as the one above
18	19	Same	Grey fine clay. And at 19 cm we can see a couple black streaks.
19	20	Same	Same as above
20	22	Same	Same grey material. At the face of 22 cm it was also the same.
22	24	Same	Section was the same as above we are at grey thick clay.

24	26	Same	Same as above.
26	28	Same	Same as above.
28	30	Same	Same as above.
30 32	32 34	Grey w/ smearing Same	Fine grey clay with some smearing of surface material on the sides. The same for the one previous 30 to 32.
34	36	Same w/ black streaks	Same as above. At the 36 cm face there were black streaks.
36	38	Same, NO blk streaks.	Same. At 38 cm the were no black streaks.
38	40	Same	Same as above. Brown material from the surface smearing on the sides.
40	42	Same	Consolidation is the same colour same. Smearing of surface material is the same. A piece dropped on the table, and I cut away the part that touched the table, and I lost about 5% of the sample.
42	44	Same	Same as above except I did not loose any.
44 46	46 48	Same Same	Same for both.
48	50	Lots of black streaks	This 2 cm section had a lot of black streaks on the inside of the 2 cm, you could not see (them) at the top 48 face or at the bottom at 50 face. So all of the black streaks are within the 2 cm section.
50	52	Same	Same as 48 to 50 including the fact that there were black streaks interior, but none at either face, although I can see one now at 52.
52	54	Black streaks	A sulphide odour was noticed there are black streaks in this section. There are wide black streaks at the 54 cm face.
54	56	Same	Same
56	58	Same	Same there is a lot of black in that section.
58	60	Same	There is a lot in this section and very large black chunks and streaks and at the 60 cm face. These look like cinders.
60	62	Same	Again a lot of black in this one. A lot of black at the 62 cm face. Some of these chunks look pretty big. Looks like pieces of burnt wood to me.
62	64	Same	Lots of black in here too There seems to be less black at the 64 cm face.
64	66	Same	Same wide big black chunks right in the middle of 66 cm face.
66	68	Same	A lot of black in this section. Not sure I can get the next at all. This finishes the core.Can't get another 2 cm section. I will measure the last bit. From the top of the remaining part of the core to the bottom of Core D.

CORE DESCRIPTION	Lake: Great Slave Lake
Date: 940326	**Site:** 16
Lat (d-m-s): 61 - 17 - 02.6	**Lon (d-m-s):** 114 - 40 - 31.2
Core ID: E	**Initial Length:** T-->BB: 95.5 cm
Extruded & Described by (date):	**Final Length:** T-->BB: 44.5 cm
Rick Bourbonniere (940328)	**Cmp/Exp (%):** 2.0% expansion
Transcribed by (date):complete	Kathy (960115) - Tape 3B

Notes: Ok core is site 16 core we are going to call it E, it's the one that was very full and disturbed. Its still got brown material on top, probably only lost a bit of the top. We are sectioning it rather coarsely just as sort of an extra for contaminants. We had to do this because we did not get that many cores at site 16, so it is valuable. We worked hard and we are going to keep it. It will be sectioned in 1 cenitmeter intervals down to 20 cm, 2 down to 50 and then we'll quit. Main function will be as an extra sample or to check on how you serve(?) on other analysis on other cores. The total length of the core from the bottom of the bung to the top of core is 95.5 cm. Top cm was brown and fluid lost a lot of the water extruding it

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	brown	Top cm was brown and fluid we lost a lot of the water while we were extruding it. The cut face at 1 cm is brown kind of watery and mottled.
1	2	brown (grey streaks)	Brown and at the 2 cm slice were starting to see some grey or brown streaks.
2	3	same as above	Same as above, brown. At the 3 cm slice there is some grey streaks, a lot of water on the side of this core, like we had before at site 16 about 2/3rds of the circumferance of the core liner, core is pulled away from the liner
3	4	same as abpve	Same as above
4	5	grey-brown	Turning to a grey brown colour smooth fine clay at the 5 cm cut no streaks
5	6	same	Same as above. And by the way today is the 28th of March, so this core was sitting for 48 hours at least or more than 48 hours in a 4 degree cooler before extruding
6	7	Same	Same, some smearing from top.
7	8	Same	Same as above
8	9	more grey	Seems to be a bit more grey, more consolidated, considerable smearing of surface mud on the sides of this core for the last several centimetres
9	10	Same as above	Same as asbove
10 11	11 12	Grey w/ brown tinge	Both were grey clay with brown tinge at the 12 cm slice same, there is still considerable smearing of surface mud dowm the core

12	13	Same as above	Same as above
13	14	Definitely greyer	Noticably more consolidated and definatley greyer
14	15	Same as above	Same as above
15	16	Same as above	Same as above
16	17	Grey	Same; it is definately grey at this level 17 cm and there is still considerable smearing of surficial mud on the side of the core. All around the core it is separated from the core tube.
17 18	18 19	Grey	The same grey mud with smearing from the upper surface
19	20	Same as above	Same as above
20	22	Same as above	Same as above grey clay still continue to have smearing of surface mud all the way down this core. Which means you will probably find contaminінates at low levels in old layers.
22	24	Same as above	Same as above
24 26	26 28	Same grey mud	26 to 28 lost a bit when it hit the table threw away, who knows, probably about about 2 or 3%. Last few sections have been monotonously the same grey thick mud thick clay and smearing is still existing from the surface but it seems to be less at the 28 cm cross section.
28 30	30 32	Same	Same and the smearing is getting less and less as we go down the core.
34 36 38	36 38 40	Grey	All the same grey fine clay with very little smearing but not zero on the edges from the surface mud. First sign of black streaking is at the 40 cm slice
40	42	Grey	at 42 cm faint black streaking
42 44	44 46	Same	Same
46	48	Same	Again the same we still have smearing from the top but it is much less than 20 cm ago
48	50	Grey	Same as above with basically boring grey clay. We only had that one layer that showed black streaking about 10 to 20 cm ago, that's also too good to throw away.
50	52	Grey w/ extensive black streaks	Section had quite a bit of black streaking for the bottom part of the seciton. At the 52 cm cut it has extensive black streaking, the most seen in any core from trip. Hopefully that is a marker when you compare all the other tapes. At the end of the core the length from the top of the remaining part of the core to the bottom of the bung is 44.5 cm that ends this core. Interesting to note the black streaking at 52 cm might give us some guidance when you compare it to the notes of the other cores as to how much of the surface we may have lost when the core pushed right to the top into the valuve. So this end site 16 core E

CORE DESCRIPTION	Lake: Great Slave lake
Date:	Site: 16
Lat (d-m-s):	Lon (d-m-s):
Core ID: F	Initial Length: T-->BB:80 cm
Extruded & Described by (date):	Final Length:
RAB and MSE	Cmp/Exp (%):
Transcribed by (date):	tape 94-3 Kathy (96-01-10)

Notes: is being extruded into preweighed jars according to our well known extrusion protocall. Top of the core is quite disturbed the entire diameter is not completely filled with mud. We have quite a bit of loose water around so the top 1 cm section would be water.

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	olive brown	very fluid, not the complete diameter of the core
1	1.5	olive brown	smooth , a little water around the edges
1.5	2	olive brown	same as above but a little less watery, the sediment is starting to pull away form the edges
2	2.5	olive brown	same as above but the material is pulling away from the edges even more, and is a little stiffer in consistency
2.5	3	olive brown with black streaks	small little black streaks in it , not pulling away form the edges as the upper few sections
3	3.5	olive brown with a lot of black streaks	pulled away from the wall of the core tube and it looks stiffer in consistency, I'm talking about the upper surface
3.5	4	olive brown	Upper surface is an olive brown, there aren't so many little black streaks in it, and it's pulled away from the core tube
4	4.5	olive brown	lower section is olive brown small black streaks in it, pulled away quite a bit from the wall, section itself is getting quite stiff
4.5	5	olive brown	quite stiff,pulled away quite a bit form the wall
5	5.5	olive brown	quite stiff the upper surface of the next core section is a smooth olive brown colour with no streaks, it's pulled away from most of the wall of the core tube
5.5	6	olive brown	same as above
6	6.5	olive brown with chocolately brown streaks	very stiff, next section pretty much the same except apart from being olive brown in colour there is some sort of a chocolately brown streaks in it not grey black like in the previous ones , the section is pulled away from the core wall quite a bit a centimetre in parts.
6.5	7	olive brown	like the previous one being stiff in consistency, really are no streaks in it , it has pulled away from core wall quite a bit

7	7.5	olive brown colour with a little bit more grey	very stiff in consistency, pulled away from the core tube along most of the diameter
7.5	8	olive brown with pale grey streaks	noticeably stiffer,pulled largely away from the walls of the tube
8	8.5	olive brown w/ grey in it	quite stiff,olive brown colour with quite a bit of grey in it, I am not sure but there might be a little bit of sand in it is hard to tell,maybe when I section I can tell, pulled away from the core tube quite a bit
8.5	9	olive brown with quite a bit o grey	not really clear to me if there is any sand in it so we will just assume there isn't, very stiff,I still think there could be small minerals in there small sand I could be wrong
9	9.5	same as above	scratching noise when I sectioned the core which makes me think there is a trace amount of fine sand in it, smooth,core section is pulled away from the wall about half of it
9.5	10	olive brown with more grey in it	stiff in consistency there might have been a very tinny amount of sands in it, surface is a bit uneven maybe because there is a bit of sand in it
10	11	olive brown	basically smooth, pulls away form the core tube and is stiff in consistency
11	12	olive brown with some grey in it and some light brown streaks	quite stiff, I haven't noticed so much the possible presence of the very very small amount of sand, pulled away from the core tube
12	13	olive brown with more grey appearing	quite stiff, just a few faint light brown streaks, pulled away from the wall of the core tube along about half the diameter
13	14	olive brown with grey in it quite a few light brown streaks running through it	quite stiff, core pulled away from the core tube
14	15	olive brown with grey in it numerous light brown streaks running the length of the core	same as above
15	16	olive brown colour noticeable streaks in it	quite stiff
16	17	olive brown colour with more grey in it	doesn't appear quite as stiff as some of the earlier ones, core pulled away from the core tube as with the previous sections
17	18	olive brown with grey in it	same as above quite smooth no obvious streaks, pulling away from the core tube
18	19	olive brown with quite a bit of grey in it	similar in consistency to some of the earlier cores,smooth no streaks, pulled away from the core tube
19	20	grey colour gone past olive	really smooth , don't notice anything interesting about it, pulled away from the walls of the tube but not as much as some of the other sections

20	22	smooth grey colour	fairly gelatinous but easy to section, smooth grey colour no streaks, slightly pulled away from the core tube about half the diameter
22	24	grey	similar in consistency to some of the other cores, grey smooth no obvious streaks, pulled away slightly from the core tube but not as much as some of the olive brown core sections
24	26	grey	nothing unusual about it, smooth,no obvious streaks in it, sits in the core tube better than some of the other sections
26	28	grey	stiff, did not seam to have anything unusual about it, stays in the core tube better,smooth
28	30	grey olive brown on the edges	quite stiff,looking at the upper surface of the next section it is grey colour on the edges there is some of that olive brown colour, I am not sure where that came from , if it slid down the sides of the core from the upper depths or is a new layer entering
30	32	grey	stiff like the other ones,grey colour that small section of olive brown colour I noticed on the other section isn't really present,the core isn't that far removed from the core tube,
32	34	grey	seamed to be heavier for a section maybe the material is more dense,practically touching the entire wall of the core tube, no obvious other colours to it, it is quite smooth
34	36	grey	quite dense,upper surface of the next section is a grey colour,sooth and is touching most of the core tube wall
36	38	grey	quite stiff,upper section of the next surface is a grey colour,smooth pretty much touching all the core tube wall, and there is small amounts of an olive brown material that probably just came down from the upper surface of the core, on all the core tube walls
38	40	grey	not much to say about it,looking at the upper surface of the next section it is a grey colour smooth, almost completely touching the walls of the core tube
40	42	grey	quite dense in consistency,the next the upper surface is grey colour,it is completely touching the core tube, it is smooth no obvious other colours into it except a little bit of a smeared material from the top, see how good I am getting at this
42	44	grey	quite dense in consistency the upper surface of the next section is grey smooth no other colours to it and just a little bit of smeared material,it is completely touching the edges of the core tube
44	46	grey	quite dense,??? bulging at the seams, at the surface of the next one is grey no obvious colours to it and is completely touching the edges of the core tube
46	48	grey	dense in consistency,the next core section is the same grey, smooth , no other colours and is touching the core tube walls

48	50	grey	nothing unusual about the consistency,the upper surface of the next section is the same grey, no other colours to it,smooth touching the wall of the core tube
50	52	grey	nothing unusual about the consistency, the next core section is grey smooth , touching the walls of the core tube,
52	54	grey	although it was grey when we were chopping it up we did noticed some small amounts of black material in it, not a lot, and the consistency was the same as more recent ones, the next core section is grey colour no obvious streaks or other colourations and is filling the core tube
54	56	grey	nothing unusual about it a tiny amount of black material, the next section is grey colour, smooth, no obvious other colourations, and it pretty much fills the core tube
56	58	grey	nothing unusual about it, the next section is a grey colour, it seams to be a little bit more dense that the other there is a crack in the middle it's kinda split, nothing else unusual about it
58	60	grey	same consistency as the earlier ones, a few black streaks in it, the upper surface of the next section is a grey colour, no real obvious colourations to it, smooth fills the walls of the core tube
60	62	grey	like some of the other cores it is a grey colour with some black streaks in it,dense in consistency, the upper surface of the next section is grey pretty much fills the walls of the core tube just pulling away in a few small spots
62	64	olive with black streaks	section was dense in consistency,upper section of the next section is olive and there are numerous black streaks in it running horizontally parallel to the surface of the core, I did not notice those black streaks when I section the 62 to 64 cm section
64	66	grey and black see comments	had a lot of black streaks running through it throughout the whole section, however looking at the upper surface of the next section it is a grey colour and i don't really see any of those black streaks so those black streaks were generally 2 cm in depth or less
66	68	grey with black streaks	is grey and had a lot of black streaks in it, a small amount os sediment fell on the bench top,and I took off the surface where it was touching the bench top, I estimate it was no more than 5% of the total sample weight, the upper surface of the next section is grey and there are numerous black streaks in it, its touching most of the core tube
68	70	grey with black streaks	it was grey with some black streaks in it, dense , the upper surface of the next core section is grey and there is just very pale few very pale grey,black streaks it's dense
70	72	grey with pale black streaks	greysediment with black streaks in it, the next section is grey and there are pale tracings of black streaks, quite dense

CORE DESCRIPTION	Lake: Great Slave Lake
Date: 9403xx	Site: 19
Lat (d-m-s):	Lon (d-m-s):
Core ID: A	Initial Length: T--> BB:
Extruded & Described by (date):	Final Length: T--> BB:
	Cmp/Exp (%):
Transcribed by (date):	

Notes: This is a badly skewed core, we are sectioning it for contaminents. We took a 0-2 section which was quite a bit thicker than the normal 0-1probably alot of the surface mud is down, lost from the skewing.

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	2	See above	
2	4	Grey and brown. Brown streaks	More consolidated than the one above. At the face I can see brown streaks, not black streaks or grey streaks, brown streaks
4	6	Noticably greyer	consolidated

CORE DESCRIPTION	Lake: Great Slave Lake
Date: 9403xxmarch 25th 1994	Site: 19
Lat (d-m-s):	Lon (d-m-s):
Core ID: B	Initial Length: T--> BB:76 cm
Extruded & Described by (date):	Final Length: T--> BB:
	Cmp/Exp (%):
Transcribed by (date):	

Notes: Core is quite nice looking, reasonably flat accross the top, there is a brown layer accross the top. It dosn't look like it gets to too dark of a grey, it looks rather gelationus and suprisingly uncompacted. We had alot of trouble with the bung sliding out the bottom of this core, so we could have a high sedimentation here. This core is being extruded into ziplock bags for geocronalgy

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	Brown	Very fluid. at the slice it is very smooth
1	1.5		Already getting thicker
1.5	2	Same as above	
2	2.5	Same as above, olive brown	Fine clay
2.5	3	Same as above, at the cut, grey with black streaks mixed in with the olive	still fine
		brown clay	
3	3.5	At the face: less balck streaks, but the colour has turned alot greyer, still olive brown with a grey tinge	Alot of water on the side of this core, in face you can see that the full diameter of the core isn't there. I am not sure, it may have frozen a bit on the edges and some of the water seprated out and is now on the edges
3.5	4	Same as above, baisicly brown with olive and grey tinge	
4	4.5	Same as Above	
4.5	5	Same as above	
5	6	SameAs above. At the cut it looks a little bit more grey and a little more brown	
6	7	Same as above	
7	8	Same as Above. Grey with a little but of brown materiel	Fine, Very nice looking
8	10	Still grey with a bit of brown	A bit more consoladated
10	12	Grey with a brown tinge,	Getting a bit more consoladated

		Same as above	
12	14	Grey	Again Fine sediment
14	16	Same as above	
16	18	At the face noticably greyer	Very fine clay, quite consoladated
18	20	Same as above	

CORE DESCRIPTION	Lake: Great Slave Lake
Date: March 27,94	Site: 19
Lat (d-m-s): 61 - 24 - 55.8	Lon (d-m-s): 114 - 24 - 49.6
Core ID: C	Initial Length: T-->BB: 96.5 cm
Extruded & Described by (date):	Final Length: T-->BB: 9 cm
RAB March 28,94	Cmp/Exp (%): 4.0% expansion
Transcribed by (date):complete	KB Jan. 12,96 tape 94-3-B

Notes: The core we are doing today is the 28th of March,and we are extruding a core from... that was taken yesterday March 27, from site 19 this core ??? biogeochemical markers it's site 19 core C it's been stored in a 4 degree cooler since we got it back yesterday. Total length from the top of the core to the bottom of the bung is 96.5cm. This will be about 88 centmeter of mud. And we don't have enough jars we'll deal with that latter

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	brown	Was fluid brown silty material quite a lot of mud id the section the core may have consolidated a little bit in the cooler more mud then we normally get in the top centimetre, however, it was a full jar across the tube was completely full across so not unusual. At the face at 1cm still brown fluid silty material
1	1.5	brown	Already a bit more consolidated but wasstil brown soft oxidized mud at the 1.5cm surface it finer looking same colour
1.5	2	brown	Same as above face is still the same brown material no particular streaks or any colour showing
2	2.5	brown with a hint of grey	The material is the same as the one above slightly greyer maybe the colour when you look at the face is sort of brown in the mud it looks a little more grey at the the 2.5cm face it is very smooth brown with a hint of grey material in it no streaks
2.5	3	same as above	Same as the one above the cit at 3 looks the same as well
3	3.5	brown with a bit of grey	Same as one above the cut face at 3.5 again is the same smooth brown wtih a bit of grey. Pulling away from the side of the core for about one half circumference
3.5	4	Brown with some grey ,dark because of brown streaks	Same as the one above at the 4cm cut we are seeing black streaks brown streaks, actually quite a few brown streaks overall mud is brown with some grey but is quite dark because of the streaks the brown streaks went completlely through the half centimetre section
4	4.5	brown slight greying withbrown streaks	The brown streaks went completly throught the half centimeter section 4 to 4.5 at the 4.5 cut face there is still more brown streaks colour is greying slightly
4.5	5	brown slight greying with brown streaks	The brown streaks went all the way through the section at the 5 cm cut still about the same brown mud slight greying with brown streaks
5	5.5	same as above	same as above cut surface at 5.5 same as above

5.5	6	same as above	the 5.5 to 6cm section was probably 6mm instead of half 5mm thick and I will make the next one four and otherwise it is the same as above
6	6.5	Brown with grey , brown streaks	was actually 4mm thick it is about the same as the one above I don't think it is getting any more greyish just brown with grey, face has brown streaks in it lots of them
6.5	7		
7	7.5	moregreying brown not relally streaky	the 7 to 7.5 cm section and the previous section I probably forgot to discribe they are both the same at 7.5 cm I think a streak in here but it might be a long piece of filament of some sort let me see ..I thought at the cut face there was a piece if leaf or twig but it's not it was just a scratch in the mud . The surface at 7.5 cm is more grey not really streaky more greying brown then before
7.5	8	sameasabove	7.5 to 8 cut face at 8 same
8	8.5	greying slowly	same as the one above the sediment is greying very slowly , consolidation is increasing very slowly
8.5	9	same as above	same as above
9	9.5	same as above	same as above
9.5	10	same as above	Same cut face is grey no streaks now we go to 1cm sections
10	11	brown with a lot of greyin it	It was brown with a lot of grey in it smooth fine clay
11	12	same as above	same as above
12	13	noticably greyer	Noticably greyer at the 13 cm face and the consoidation seems to ber increasing as well the ????seems to be more consolidated at12 to 13
13	14	same as avove	same as above
14	15	same as above	same as above
15	16	same as above	same as above
16	17	same as above	same as above quite consolidated
17	18	same	same
18 19	19 20	grey	These are both very consolidated and we(bent)??? the last 5 or so cm??? into the grey section of the core if I had not said that before
20	22	grey with a tinge if brown	Same, cut face at 22 slight brown streaks still pretty much a grey clay with tinges of brown in it
22	24	same as above	Same as above I might have said this twice
24	26	grey	Again same quite as smooth consolidated grey clay the cut face at 26 very snmmoth grey, fills the core 100%
26	28	grey	very consolidated actually harder to get in the jar, the cut face is

			grey smooth fine clay
28 30	30 32	grey	These sections are the same as each other and the ones above, core is boringly grey just like the one yesterday
32	34	same	same
34	36	same	same
36	38	same	same
38	40	same	Same as those abve consolidated grey fine clay
40	42	grey	thick grey mud all of the sections except for the top of this core we had brown streaks there has been no streaking at all noticed in the grey mud
42	44	same as above	same as abpve
44	46	same	same
46	48	same	same
48	50	same	same as above
50	52	same	same as above we are now at 2 cm break it's grey difinately grey not any brown in it here and still fine grey smooth clay and it's boring me the same as yesterday's
52	54	same	same as above
54	56	same	same as above
56	58	same	same as above
58	60	grey	same at 60 cm the slice is boringly smooth grey clay
60	62	same	same
62	64	same	60 to 62 and 62 to 64 are boringly the same
64	66	same	same
66	68	same	again guess what same as above
68	70	same	same
70	72	same	same as above
72 74	74 76	same	Same and on 74 to 76 I lost a very small amount landed on the table and I cut away that part who knows probably lost 2%
76	78	grey with black streaks	Same as above except there was a small amount of black streaking at ...I'm sorry that was 76 to 78... little bit of black streaking after 76 centimeter mark
78	80	gery with dark streaks	There were no dark streaks in this but at 80 cm I can see dark streaking about 15% of the cross secitonal area
80	82	grey with black streaks	Black streaks in this section the 83 cm cut was very faint black streaking

82	84	grey	Same consolidation as above no black streaking noticed at the 84 cm slice
84	86	grey with black banding	Slice has some black banding with in the slice and at 86 cm is extensive black banding visble at the cut face
86	88	grey with black streaking	The black banding was in the upper part of that section at the 88 cm there is only faint black streaking
88	90	grey	Section will be the last section in the core at the cut face at 90 cm there is no black streaking of the length remaining from the top of the remaining part of the core to the bottom of the bung is 9cm is the amount remaining . This concludes site 19 core C a biogeochemical marker core

CORE DESCRIPTION	**Lake:** Great Slave Lake
Date: 27 March 1994	**Site:** 19
Lat (d-m-s): 61 - 24 - 55.8	**Lon (d-m-s):** 114 - 24 - 49.6
Core ID: D	**Initial Length:** ???
Extruded & Described by (date):	**Final Length:** TR-->BB: 11.5 cm
Marlene (940327)	**Cmp/Exp (%):** ???
Transcribed by (date):	tape 2 A KB 960118
Notes:	

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	Olive brown	The upper surface was uneven tending to be a little higher on one side than on the other. The sediment was an olive brown colour. We are looking at the upper surface of the next section at the cut it is an olive brown colour and it is not touching the walls of the core tube about half the diameter. No obvious other colorations.
1	1.5	Olive brown	Not much to say about it, except it was smooth cutting. The upper surface of the next section it is an olive brown colour, real smooth on top. Core is away from the core wall along about half the diameter. No worm holes here.
1.5	2	Olive brown	Easy sectioning. Looking at the upper surface the next section, it is an olive brown colour smooth, no discolourations, no worm holes or anything. Core is detached from the core wall about half the diameter.??????
2	2.5	Olive brown	It was a similar consistency to the upper ones. At the upper surface of the next section smooth olive brown colour no obvious discolourations, and the core has pulled away from the core tube about half the diameter.

2.5	3	Olive brown	It was same consistency as the upper one (one above), more or less. Looking at the surface of the next section it is an olive brown colour, no unusual discolourations and again it has pulled away from the core tube along about half the diameter.
3	3.5	Olive brown w/ numerous dk brown or dk grey streaks	It was of a similar consistency as the other ones. Looking at the upper surface of the next section it was an olive brown colour, with numerous dark brown and dark grey streaks along the surface. And the core tube is pulled away from the core wall along about half the diameter, with the part that has pulled way the extreme edge against which I sectioned the core.
3.5	4	Olive brown w/ brown or grey streaks	It was a fairly reasonable consistency. Looking at the upper surface of the next section it is an olive brown colour and it has more of these brown and grey streaks running across the length. Core is pulled away from the core tube.
4	4.5	Olive brown w/ pale light brown streaks	Nothing unusual about section it. Looking at the upper surface of the next section is an olive brown colour and there are very pale light brown streaks
4.5	5	Olive brown w/ fewer faint brown streaks	Nothing striking about the consistency. Looking at the upper surface of the next section is an olive brown colour, and there are very faint brown streaks although they are not as extensive as on the upper surface of the other sections. The core sample is pulling away from the core tube three quarters of the diameter.
5	5.5	Olive brown, same as above	Looking at the upper surface of the next section it is an olive brown colour, very pale light brown streaks not a lot of them, smooth consistency and the core has pulled away from the core tube about half the diameter.

5.5	6	Olive brown w/ some grey , no streaks	Smooth consistency. Looking at the upper surface of the next section olive brown colour with some grey in it, no obvious streaks and the core is pulled away from the core tube about three quarters of the diameter ???? (circumference?)
6	6.5	Same as above	Smooth consistency. The upper surface of the next section is an olive brown colour, with grey in it. Core is pulled away from the core tube about half the diameter. (See above)
6.5	7	Olive brown w/ grey	Smooth consistency. Looking at the upper surface of the next section, olive brown colour with some grey, no colour streaks except for one pale light brown , the core has pulled away from the core tube along about half the diameter. (See above)
7	7.5	Same	Smooth consistency. Same otherwise
7.5	8	Same	Smooth even consistency. Core is pulled away form the core tube although not as much as in the upper sections.
8	8.5	Same	Smooth consistency, getting tougher to slice than the more shallow ones. Only slightly pulled away form the core surface.
8.5	9	Same	Smooth in consistency. Core is pulled away from the core tube only about a third of the diameter.

9	9.5	Olive brown w/ quite a bit of grey	Smooth in consistency. Core sample is touching most of the core wall except for about a third of the diameter but the gaps not that large.
9.5	10	More grey than brown	Smooth consistency, the upper surface of the next section, I'd say it is more grey now than olive brown, smooth there is a few faint brown streaks on one section of the upper surface. The core is only slightly pulled away from the core wall.
10	11	Grey w/ few brown streaks	Smooth in consistency. Looking at the upper surface of the next section primarily grey there are a few faint brown streaks but they are very small. The core is only slightly pulled away from the core wall.
11	12.2	Grey w/ brown streaks	I overshot the mark a little bit. It was smooth in consistency. The upper surface of the next section is more of a grey than an olive brown colour, with a lot of light brown streaks in it and there may be a little bit of sand. I can't tell. There is some texture to it.
12.2	13	Grey w/ oilve brown	Smooth in consistency, although there was a slightly gritty sound when I cut it . The upper surface of the next section is a grey olive brown colour. Looks pretty smooth. Most of the core is touching the core wall.
13	14	Grey w/ some olive brown, no streaks	Smooth in consistency fairly difficult to section. Most of the core is touching the core wall.
14	15	Grey w/ olive brown and lt brn streaks	Smooth in consistency. Most of the core is filling the core tube.

15	16	Distinctly grey, faint brown streaks	Pretty smooth in consistency although there might have been a slight grating sound from fine sand, or maybe it is my imagination. And most of the core is filling the core tube.
16	17	Grey	Smooth consistency. Upper surface of the next section is a grey colour, no obvious streaks, smooth consistency. Most of the core is touching the core wall.
17	18	Grey	Smooth consistency. Filling most of the core wall.
18	19	Grey	Smooth in consistency. Filling most of the core wall.
19	20	Grey w/ a few lt brown streaks	Smooth in consistency. Looking at the upper surface of the next section it is a grey colour, smooth in consistency, there a few light brown streaks over a very small fraction of the core. And most of the core fills the core wall.
20	22	Same	Smooth in consistency. It is filling most of the core wall.
22	24	Grey w/ no streaks	Smooth in consistency. The upper surface of the next section is grey, smooth no colour discolourations, fills most of the core wall.
24	26	Grey w/ pale brown streaks	Smooth in consistency. The core fills most of the core wall.

26	28	Grey	Smooth, fills most of the core wall.
28	30.3	Grey	I overshot the mark a bit. The core was even in consistency, no obvious colour discolourations through the length of the core when I sectioned it or the section.. The next section is a grey colour, smooth, no discolourations, and it fills most of the core tube.
30.3	32	Grey	Smooth in consistency, fills most of the core tube.
32	34	Grey	Pretty clean slice no discolourations into little sections of it. Looking at the upper surface of the next section, it is a grey colour, smooth, no discolourations, fills most of the core tube.
34	36	Grey	Even consistency, no discolorations in the various sections that I cut up from the 2 cm section. Most of the core is filling the core wall.
36	38	Same	Same
38	40	Same	Same

40	42	Same	
42	44	Grey	
44	46	Grey w/ faint light brown streaks	
46	48	Grey, no streaks	Smooth in consistency, no other colours in it. Most of the core fills the core wall.
48	50	Grey	Even consistency in colour throughout. Smooth, seems a little drier maybe than some of the other sections that were more shallow.
50	52	Grey	Grey consistent colour through out and consistent texture.
52	54	Grey	Boringly the same as the other ones no discolorations and touching most of the core wall.
54	56	Grey	Upper surface of the next section is grey, smooth, no other colours, and fills most of the core wall.

56	58	Grey	Smooth in consistency and colour throughout.
			We have stopped coring at this point because we have filled box and there is only one more section left. This particular core D looks to me like it is (in) untared jars and it is to be used for contaminants . There is 11.5 cm of sediment and a bung. How do I express this? (Rick) 11.5 cm is the length remaining from the top of the remaining part of the core to the bottom of the bungs.

CORE DESCRIPTION:	Lake: Great Slave Lake
Date: 27 March 1994	Site: 19
Lat (d-m-s): 61 - 24 - 55.8	Lon (d-m-s): 114 - 24 - 49.6
Core ID: E	Initial Length: T-->BB: 74 cm
Extruded & Described by (date):	Final Length: TR-->BB: 8 cm
RAB March 27 95	Cmp/Exp (%): NONE (66 cm extruded)
Transcribed by (date):KB Jan 11, 96	Tape 94-3A kathy (96-01-11)

Notes: It is being sectioned into tared jars for possible use in geochronology. Top of the core is not skewed very much it's quite fluid on top the brown surface layer has a few cracks in it bubbles and mound sand can't say for sure that those are related to natural features for they might be related to core disturbance.But it as least not skewed or domed it is pretty much flat across.

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	brown	Top cm was very fluid brown oxidized layer, it has no obvious problems. The face at 1 cm is again brown smooth, fine clay no streaks, no smells, looks great fills the whole diameter of the core.
1	1.5	brown	Oxidized, extremely fluid but not as fluid as the top layer, at the 1.5 cm face again it is brown oxidized, smooth material.
1.5	2	brown	A little more thick but brown oxidized material at the face of 2 cm is same as above, pulling away from the core a very small amount on one side.
2	2.5	brown	Same, face at 2.5cm is the same it is also brown smooth oxidized, pulling away from the edge of the core on one side only very slightly.
2,5	3	brown	Same as above, 3cm face same as above
3	3.5	brown with a hint of grey	Still brown oxidized but a little bit more consolidated than above the 3.5cm face is smooth and brown but the is a hint of grey in the brown, brown with a hint of grey yes

3.5	4	brown with grey or brown streaks	Again, consolidated smooth brown with a little bit of grey clay, the face at 4 cm is the same as above brown with a very slight hint of grey, maybe some streaks in here look like grey but they could be brown streaks.
4	4.5	brown with grey and brown streaks	Begins to show some brown streaking at the 4.5 cm face there is an overall darker colour the brown because there is brown streaks in it so colour is still very fine clay. Colour is brown with some grey but a lot of brown streaks so its darker.
4.5	5	brown with a hint of grey, brown streaks	Still thick, more consolidated fine clay contains the darker brown material I talked about before at the face of 5 cm there is fewer brown streaks but the overall colour is darker than it was above there is still a hint of grey.
5	5.5	Brown and grey w/ brown streaks	Clay getting more consolidated as you go down through core. The face at 5.5 cm noticeably greyer than above and still a lot of brown streaks in it.
5.5	6	brown and grey w/ brown streaks	Becoming more consolidated, basically looks brown with grey clay, the face at 6 cm is the same as above but fewer brown streaks.
6	6.5	brown w/ grey tinge & brown streaks	Same as the one above. For a long time the total core diameter has been filled with sediment.
6.5	7	grey-brown with some brown streaks	Same as before. At 7 cm is fine grey-brown clay with some brown streaks.
7.5	8		Noticeably more consolidated than the others,
8	8.5	brown with a lot of grey in it	Same as the one above the face is also the same no brown streaks, brown with a lot of grey in it.
8.5	9	grey brown	Same, colour is now more grey than brown maybe 50\50, very smooth, very fine.
9	9.5	grey brown	Same as above
9.5	10	grey brown	Same as above. fine grey with brown clay few faint streaks noticeable at the 10 cm cut.

10	11	grey -brown	Same as above grey-brown clay very fine no black streaks at the 11 cm slice.
11	12	grey-brown	Same as above.
12	13	Grey-brown	Interval again fine grey-brown clay, fills the entire diameter of the tube, consolidated as normal.
13	14	grey brown	Section same as above.
14	15	grey-brown	At 15cm you see a few streaks showing up they are pretty faint, and it looks like a little bit of brown material from the surface, has leaked onto the side on one side.
15	16	grey slight tinge if brown	Same as above the cut at 16 is smooth grey slight tinge of brown you might say it is getting to be more pure grey smooth clay, no streaks.
16	17	grey	Again fine grey clay. The 17 cm slice looks a little drier maybe a few streaks in it nothing too great.
17	18	grey brown	Very fine clay, at the 18 cm slice same as above, little drier.
18	19	grey	Same
19	20	grey	Same
20	22	grey	Same as above
22	24	grey	Same fine grey clay, I dropped a chunk onto the stainless steal table picked up the chunk and cut off about 5% which I threw out - I'm sorry - cut off a piece which is 5% or less of the total volume of the 22 to 24 cm section.
24	26	grey	Same as above
26	28	grey	Same as above
28	30	grey	Same as above
30	32	grey	Same as above
32	34	grey	Same as above , lost a small amount of sediment on the table less then 1%.

34	36	grey	Same as above
36	38	grey	Same as above
38	40	grey	Same as above
40	42	grey	Same as above. At the 42 cm face you can see three cracks right in the middle of the core so it is getting much more consolidated and quite dry.
42 44	44 46	same as above	Same as above
46?	48?	????	NOISE ON TAPE - GAP?
48	50	same as above	Same as above
50	52	same as above	Same as above
52 54	54 56	same as above	Same as above, same the one before it was the same this one is probably the same as well
56	58	same as above	Same as above
58 60 62 64	60 62 64 66	same as above	Same as above all the remaining sections were the same down to 64-66 cm which was the last section of the core kept the amount of core remaining from top to the bottom of the bung is 8 cm remaining. This concludes site 19 core E

CORE DESCRIPTION	Lake: Great Slave Lake
Date: 29 March 1994	Site: 23
Lat (d-m-s): 61 - 36 - 04.2	Lon (d-m-s): 114 - 04 - 01.8
Core ID: A	Initial Length: T-->BB: 49 cm
Extruded & Described by (date):	Final Length: TR-->BB: 8.5 cm
Rick (940329)	Cmp/Exp (%): Compression = 1.2%
Transcribed by (date):	KB Jan. 29, 96 tape 94-4-A

Notes: (Rick) We are beginning to extrude core from site 23 it is core A it is the only core we have at this site. So it will be extruded for geochronology and possibly other uses for freeze dried sediment. The total length of the core from the bottom of the bung to the top of the core at the beginning is 49 cm. So we will get about 40 to 41cm of sections out of this core. It is a short core. The top surface looks pretty normal there are pontoporeia floating around couple of holes, burrows from the pontoporeia. Doesn't look particularly smeared. It looks like it grades from brown to brown grey to grey.. Like all other cores do except the only difference it is a lot shorter.

UpD	LwD	Colour @ Section	Texture & Other Comments @ Section
0	1	brown	Fluid brown silt. might be actually a bit more than 1 cm on average long because it had it was skewed a bit at the top little higher one side lower on the other side. So, it seamed to fill the jar quite a bit more than usual.
1	1.5	Brown	Section it is already getting a little bit more consolidated but is still a brown silty material.
1 1.5	1.5 2	Brown	Sections are about the same as each other.
2	2.5	Brown	Still brown silt. At 2.5 same thing consistent all the same colour across brown.
2.5	3	Same	Same as above.
3	3.5	Brown Silt	Same brown silt.
4	4.5	Brown	Still brown silt maybe a bit of sand grit notice can tell by when I am scraping with the spatula and it may be grating some. I will hold judgement on that.
4.5	5	Brown	Definitely sand in this section. The cross section at 5.0 is still brown and consistent looking no streaks

5	5.5	Brown	Definitely still some sand in this section but seams to be less than in the previous section. The cross section at 5.5 is still consistent looking brown.
5.5	6	Brown w/ Grey tinge	A little bit of sand still showing up in that section. And the cut face at 6 may be a little bit greyer, grey tinge showing up and it looks like brown streaks
6	6.5	Brown w/ brown streaks, grey tinge	Brown silt with some sand. At 6.5 cm extensive brown streaking showing up and the sediment is getting still brown with a tinge of grey getting a bit darker.
6.5	7	Same	Same as above.
7	7.5	Same	Same as above.
7.5	8	Brown w/ grey tinge	Noticeably finer and more consolidated definitely no sand colour is still brown with grey tinge.
8	8.5	Same	Same
8.5	9	Same	Same
9	9.5	Brown	Section is brown silt with sand mixed in.
9.5	10	Brown & Grey w/ dk brown streaking	Definitely more consolidated no sand at 10 cm lots of dark brown streaking going across the lighter brown and grey mud
10	11	Brown w/ grey tinge and brown streaks	Brown streaking throughout this section, brown with a grey tinge and a small amount of sand
11	12	Brown streaks	Definitely more consolidated brown streaks throughout. At the 12 cm cut there is a very small amount of brown streak.
12	13	A little greyer	Fine, clay like material getting a little greyer, no streaks.
13	14	Same	Same
14	15	Colure shift to grey w/ brown	Definitely more consolidated, colour has shifted from brown with grey to grey with brown. A very fine clay.
15	16	Same	Same
(16) 17	(17) 18	Same	Same

18	19	Same?	Same texture but getting thicker and much more consolidated.
(19) 20	(20) 22	?	20 - 22 cm Section was accidentally put in as two 1 cm sections, so I combined them both jars together. This section might be a bit light. Lost about 5% of the weight. A new jar was made for the 22-24 cm section which was extruded normally.
22	24	Grey	Section was very consolidated, definitely grey at this point, at 24 cm consistent grey clay.
(24) 26	(26) 28	Grey, no streaks	Definitely more consolidated, some smearing from the upper layers got mixed in with this sediment. It looks like a chunk of the layer below broke off with the slider or might have gotten pushed.
28	30	Grey, no streaks	This section and the one previous both very thick, consolidated. There is cracking at the 30 cm cut. Obviously the water content is decreasing. Definitely grey, no streaks..
30	32	Same	Same
32	34	Same	Same
34 36 38	36 38 40	Grey	All same grey very consolidated clay. Stopped sectioning at 40 cm. At the end the length from the top of the remaining part of the core to the bottom of the bung is 8.5 cm. This ends Site 23 Core A.

APPENDIX D: CORE DATING

Table 1. Core 12B, Great Slave Lake, March 1994.

Section number	Total Sediment weight (g)	Cumulative Dry weight (gm./sq.cm.)	Linear rate model no. years /section	Linear rate model Median year	Constant Flux Model no. years /section	Constant Flux Model Median year	Rapid Steady State Mixing Model no. years /section	Rapid Steady State Mixing Model Median year	Porosity	Section Thickness	excess Pb-210 (Bq/g)	alpha Pb-210 activity (Bq/g)	+/-	2 SD	linear regression line	Cs-137 activity (Bq/g)	+/-	2 SD
1	14.7400	0.184	3.3	1992	3.3	1992	3	1992	0.91	0.72	2.02E-01	2.49E-01	+/-	7.08E-03	2.12E-01	3.11E-02	+/-	1.55E-03
2	7.4300	0.277	1.7	1990	2.0	1990	1	1989	0.86	0.23	2.22E-01	2.69E-01	+/-	6.28E-03	2.02E-01	4.27E-02	+/-	1.28E-03
3	12.1800	0.429	2.7	1988	3.5	1987	2	1987	0.86	0.38	2.18E-01	2.65E-01	+/-	7.89E-03	1.85E-01	4.62E-02	+/-	1.85E-03
4	11.0100	0.566	2.5	1985	2.9	1984	2	1984	0.85	0.31	1.84E-01	2.31E-01	+/-	7.60E-03	1.71E-01	5.50E-02	+/-	1.65E-03
5	9.5800	0.686	2.2	1983	2.3	1981	2	1981	0.83	0.25	1.52E-01	1.99E-01	+/-	6.76E-03	1.60E-01	5.49E-02	+/-	1.65E-03
6	10.3000	0.814	2.3	1980	2.4	1979	2	1979	0.82	0.25	1.38E-01	1.85E-01	+/-	6.22E-03	1.48E-01	5.78E-02	+/-	1.73E-03
7	12.4700	0.970	2.8	1978	2.5	1976	3	1976	0.81	0.28	1.09E-01	1.56E-01	+/-	4.09E-03	1.36E-01	6.57E-02	+/-	1.97E-03
8	14.1300	1.146	3.2	1975	2.6	1974	3	1973	0.81	0.33	9.35E-02	1.40E-01	+/-	3.81E-03	1.23E-01	8.85E-02	+/-	1.42E-03
9	12.8500	1.307	2.9	1972	2.6	1971	3	1970	0.81	0.30	9.43E-02	1.41E-01	+/-	4.11E-03	1.12E-01	1.17E-01	+/-	2.34E-03
10	34.2200	1.734	7.7	1967	8.3	1966	8	1964	0.81	0.77	9.63E-02	1.43E-01	+/-	3.66E-03	8.81E-02	1.64E-01	+/-	1.96E-03
11	27.7700	2.080	6.3	1960	9.0	1957	6	1957	0.84	0.77	9.87E-02	1.46E-01	+/-	3.78E-03	7.23E-02	9.69E-02	+/-	1.94E-03
12	32.1900	2.482	7.2	1953	10.0	1948	8	1950	0.84	0.86	7.03E-02	1.17E-01	+/-	4.65E-03	5.76E-02	1.93E-02	+/-	1.16E-03
13	70.7800	3.365	15.9	1941	20.6	1932	17	1937	0.82	1.69	4.13E-02	8.83E-02	+/-	4.17E-03	3.48E-02	0.00E+00	+/-	0.00E+00
14	69.6600	4.234	15.7	1925	14.3	1915	17	1920	0.81	1.54	1.67E-02	6.37E-02	+/-	2.82E-03	2.13E-02			
15	66.1400	5.060	14.9	1910	13.7	1901	16	1904	0.82	1.62	1.10E-02	5.80E-02	+/-	2.72E-03	1.33E-02			
16	71.1400	5.948	16.0	1895	18.5	1885	18	1887	0.82	1.73	8.40E-03	5.54E-02	+/-	1.69E-03	8.03E-03			
17	76.9600	6.908	17.3	1878	21.0	1865	19	1870	0.82	1.84	4.77E-03	5.18E-02	+/-	1.51E-03	4.65E-03			
18	69.8200	7.779	15.7	1862	39.0	1835	18	1852	0.83	1.72	4.00E-03	5.10E-02	+/-	1.75E-03	2.83E-03			
19	77.2000	8.743	17.4	1845			20	1834	0.80	1.69	1.53E-03	4.85E-02	+/-	1.84E-03	1.64E-03			
20	74.8200	9.677	16.8	1828			20	1816	0.82	1.84	8.11E-04	4.78E-02	+/-	2.02E-03	9.64E-04			

linear sed rate=	55	g/sq.m/y	r2=.9
Constant flux rate=	50	g/sq.m/y	
RSSM rate =	51	g/sq.m/y	

Pb-210 Integral =	0.3	Bq/cm
Pb-210 Flux=	119.1	Bq/m2/y
Int Error	0.0	
Flux error	6.5	

Table 2. Core 13B, Great Slave Lake, March 1994.

Section number	Total Sediment weight (g)	Cumulative Dry weight (gm./sq.cm.)	Linear rate model no. years /section	Linear rate model Median year	Constant Flux Model no. years /section	Constant Flux Model Median Median year	Rapid Steady State Mixing Model no. years /section	Rapid Steady State Mixing Model Median year	Porosity	Section Thickness	excess Pb-210 (Bq/g)	alpha Pb-210 activity (Bq/g)	+/-	2 SD	linear regression line	Cs-137 activity (Bq/g)	+/-	2 SD
1	23.9700	0.299	8.3	1990	8.7	1990	1989	8	0.91	1.09	1.93E-01	2.40E-01	+/-	5.67E-03	1.90E-01	4.13E-02	+/-	4.13E-03
2	14.3200	0.478	5.0	1983	5.4	1983	1983	4	0.86	0.44	1.62E-01	2.09E-01	+/-	5.33E-03	1.62E-01	5.31E-02	+/-	3.19E-03
3	17.2900	0.694	6.0	1978	5.7	1977	1978	5	0.85	0.49	1.19E-01	1.66E-01	+/-	4.30E-03	1.34E-01	6.72E-02	+/-	4.70E-03
4	16.4800	0.899	5.7	1972	5.3	1972	1972	5	0.83	0.42	9.73E-02	1.44E-01	+/-	4.22E-03	1.12E-01	1.25E-01	+/-	3.75E-03
5	17.2400	1.114	6.0	1966	6.4	1966	1966	5	0.83	0.43	9.46E-02	1.42E-01	+/-	3.68E-03	9.28E-02	1.48E-01	+/-	3.86E-03
6	16.5300	1.321	5.7	1960	7.5	1959	1961	5	0.83	0.42	9.31E-02	1.40E-01	+/-	4.11E-03	7.74E-02	1.00E-01	+/-	3.00E-03
7	17.2000	1.535	6.0	1954	8.1	1951	1955	6	0.83	0.43	7.50E-02	1.22E-01	+/-	4.23E-03	6.41E-02	4.09E-02	+/-	3.28E-03
8	18.6200	1.768	6.5	1948	8.7	1943	1949	6	0.82	0.44	5.78E-02	1.05E-01	+/-	3.79E-03	5.23E-02	0.00E+00	+/-	0.00E+00
9	17.3000	1.984	6.0	1942	7.1	1935	1943	6	0.81	0.38	3.93E-02	8.63E-02	+/-	3.10E-03	4.33E-02			
10	39.4800	2.476	13.7	1932	16.8	1923	1934	13	0.82	0.94	2.86E-02	7.56E-02	+/-	3.28E-03	2.81E-02			
11	40.3400	2.980	14.0	1918	12.8	1908	1920	14	0.81	0.91	1.34E-02	6.04E-02	+/-	2.75E-03	1.81E-02			
12	40.5900	3.486	14.1	1904	21.4	1891	1907	14	0.81	0.91	1.32E-02	6.02E-02	+/-	2.59E-03	1.16E-02			
13	85.9000	4.558	29.8	1882	43.8	1858	1886	29	0.81	1.96	4.90E-03	5.19E-02	+/-	2.34E-03	4.52E-03			
14	82.5300	5.588	28.7	1853			1857	28	0.81	1.88	1.75E-03	4.87E-02	+/-	1.77E-03	1.83E-03			
15	81.9100	6.611							0.81	1.87		4.46E-02	+/-	1.95E-03	7.47E-04			
16	82.5200	7.640							0.81	1.88		4.72E-02	+/-	1.88E-03	3.03E-04			
17	84.0700	8.690							0.81	1.89		4.62E-02	+/-	1.87E-03	1.21E-04			
18	81.6300	9.708							0.81	1.88		4.64E-02	+/-	1.74E-03				
19	83.0600	10.745							0.81	1.89		4.64E-02	+/-	1.97E-03				
20									0.81			4.78E-02	+/-	1.85E-03				

linear sed rate=	35	g/sq.m/y	r2=.9
Constant flux rate=	33	g/sq m/y	
RSSM rate =	37	g/sq m/y	

Pb-210 Integral =	0.2	Bq/cm
Pb-210 Flux=	76.4	Bq/m2/y
Int Error	0.0	
Flux error	4.4	

Table 3. Core 16A Great Slave Lake, March 1994.

Section number	Total Sediment weight (g)	Cumulative Dry weight (gm /sq cm.)	Linear rate model no. years /section	Linear rate model Median year	Constant Flux Model no. years /section	Constant Flux Model Median year	Rapid Steady State Mixing Model no. years /section	Rapid Steady State Mixing Model Median year	Porosity	Section Thickness	excess Pb-210 (Bq/g)	alpha Pb-210 (Bq/g)	activity +/-	2 SD	linear regression line	Cs-137 activity (Bq/g)	+/-	2 SD
1	1.38E+01	0.173	5.0	1991	4.4	1992	3	1992	8.85E-01	5.19E-01	1.32E-01	1.74E-01	+/-	3.55E-03	1.61E-01	2.54E-02	+/-	1.27E-03
2	1.49E+01	0.358	5.4	1986	5.1	1987	4	1987	8.71E-01	4.97E-01	1.22E-01	1.64E-01	+/-	3.40E-03	1.36E-01	3.83E-02	+/-	1.92E-03
3	2.72E+01	0.698	9.9	1979	9.4	1980	7	1982	7.97E-01	5.77E-01	9.84E-02	1.40E-01	+/-	3.16E-03	9.92E-02	4.57E-02	+/-	1.83E-03
4	1.74E+01	0.914	6.3	1970	6.5	1972	4	1975	8.43E-01	4.77E-01	8.23E-02	1.24E-01	+/-	2.65E-03	8.13E-02	1.05E-01	+/-	2.09E-03
5	1.92E+01	1.154	7.0	1964	8.0	1965	5	1970	8.26E-01	4.74E-01	7.41E-02	1.16E-01	+/-	2.53E-03	6.52E-02	1.34E-01	+/-	2.68E-03
6	1.93E+01	1.394	7.0	1957	8.3	1956	5	1965	7.11E-01	2.87E-01	5.92E-02	1.01E-01	+/-	2.29E-03	5.23E-02	6.50E-02	+/-	3.25E-03
7	1.84E+01	1.624	6.7	1950	8.8	1948	5	1959	7.00E-01	2.64E-01	4.99E-02	9.19E-02	+/-	2.69E-03	4.23E-02	1.38E-02	+/-	5.52E-04
8	2.42E+01	1.925	8.8	1942	12.4	1937	7	1953	8.19E-01	5.75E-01	3.88E-02	8.08E-02	+/-	2.37E-03	3.21E-02	0.00	+/-	0.00
9	2.54E+01	2.242	9.2	1933	12.0	1925	7	1946	8.01E-01	5.47E-01	2.44E-02	6.64E-02	+/-	2.06E-03	2.40E-02			
10	4.78E+01	2.838	17.4	1920	13.7	1912	13	1936	7.92E-01	9.91E-01	1.00E-02	5.20E-02	+/-	1.85E-03	1.39E-02			
11	4.87E+01	3.446	17.7	1902	19.8	1895	14	1922	7.82E-01	9.63E-01	8.48E-03	5.05E-02	+/-	1.79E-03	7.93E-03			
12	4.77E+01	4.041	17.4	1885	49.5	1861	14	1909	7.89E-01	9.74E-01	7.97E-03	5.00E-02	+/-	1.56E-03	4.59E-03			
13	9.38E+01	5.212	34.2	1859			26	1889	7.84E-01	1.87E+00	2.06E-03	4.41E-02	+/-	1.28E-03	1.57E-03			
14	9.78E+01	6.432	35.6	1824			28	1862	7.79E-01	1.90E+00		4.11E-02	+/-	1.23E-03	5.10E-04			
15	97.8000	7.653							7.75E-01	1.87E+00					1.66E-04			
16	104.0600	8.951							7.77E-01	2.01E+00					5.04E-05			
17	84.4100	10.005							7.83E-01	1.67E+00					1.91E-05			
18	94.3600	11.182							7.77E-01	1.82E+00								
19	72.6800	12.089							8.01E-01	1.57E+00								
20	78.6900	13.071							7.84E-01	1.57E+00								

linear sed rate=	343	g/sq m/yr	r2=.96
Constant flux rate=	339	g/sq m/yr	
RSSM rate =	442	g/sq m/yr	
Pb-210 Integral =	0.18	Bq/cm2	
Pb-210 Flux=	55.22	Bq/m2/yr	
Int Error	0.01		
Flux error	2.83		

Table 4. Core 19B Great Slave Lake, March 1994.

Section number	Total Sediment weight (g)	Cumulative Dry weight (gm./sq.cm.)	Linear rate model no. years /section	Linear rate model Median year	Constant Flux Model no. years /section	Constant Flux Model Median year	Rapid Steady State Mixing Model no. years /section	Rapid Steady State Mixing Model Median year	Porosity	Section Thickness	excess Pb-210 (Bq/g)	alpha Pb-210 (Bq/g)	activity +/-	2 SD	linear regression line	Cs-137 activity (Bq/g)	+/-	2 SD
1	3.98E+01	0.496	7.18E+00	1990	6.3	1991	5	1991	8.55E-01	1.18E+00	1.02E-01	1.42E-01	+/-	4.09E-03	1.17E-01	2.12E-02	+/-	5.03E-03
2	1.86E+01	0.729	3.36E+00	1985	3.3	1986	2	1987	7.61E-01	3.36E-01	9.85E-02	1.38E-01	+/-	4.39E-03	1.05E-01	4.20E-02	+/-	5.06E-03
3	2.98E+01	1.100	5.37E+00	1981	4.6	1982	4	1984	7.85E-01	5.97E-01	7.57E-02	1.16E-01	+/-	4.34E-03	8.89E-02	2.97E-02	+/-	8.39E-03
4	2.35E+01	1.394	4.24E+00	1976	3.0	1978	3	1980	7.34E-01	3.81E-01	5.49E-02	9.49E-02	+/-	3.30E-03	7.78E-02	2.47E-02	+/-	1.16E-02
5	2.08E+01	1.654	3.76E+00	1972	2.6	1976	3	1977	7.10E-01	3.09E-01	5.01E-02	9.01E-02	+/-	3.28E-03	6.91E-02	6.02E-02	+/-	6.72E-03
6	2.21E+01	1.929	3.99E+00	1968	3.1	1973	3	1974	7.28E-01	3.50E-01	5.15E-02	9.15E-02	+/-	3.10E-03	6.09E-02	9.10E-02	+/-	8.17E-03
7	2.31E+01	2.218	4.17E+00	1964	3.9	1969	3	1971	7.26E-01	3.63E-01	5.51E-02	9.51E-02	+/-	3.09E-03	5.34E-02	1.15E-01	+/-	4.88E-03
8	2.61E+01	2.543	4.70E+00	1960	5.1	1965	4	1967	7.44E-01	4.38E-01	5.60E-02	9.60E-02	+/-	3.34E-03	4.61E-02	0.00	+/-	0.00
9	2.56E+01	2.862	4.61E+00	1955	5.3	1960	4	1964	7.31E-01	4.10E-01	5.04E-02	9.04E-02	+/-	3.50E-03	3.98E-02	0.00	+/-	0.00
10	4.45E+01	3.417	8.02E+00	1949	8.5	1953	6	1959	7.81E-01	8.72E-01	3.75E-02	7.75E-02	+/-	3.15E-03	3.09E-02			
11	4.33E+01	3.958	7.82E+00	1941	7.7	1945	6	1953	7.72E-01	8.16E-01	2.72E-02	6.72E-02	+/-	2.61E-03	2.42E-02			
12	5.13E+01	4.598	9.25E+00	1932	12.8	1934	7	1947	7.69E-01	9.57E-01	2.80E-02	6.80E-02	+/-	2.40E-03	1.81E-02			
13	1.02E+02	5.867	1.83E+01	1918	31.1	1912	14	1936	7.63E-01	1.85E+00	1.79E-02	5.79E-02	+/-	1.94E-03	1.01E-02			
14	9.97E+01	7.111	1.80E+01	1900	17.5	1888	14	1923	7.69E-01	1.86E+00	4.68E-03	4.47E-02	+/-	1.67E-03	5.75E-03			
15	1.03E+02	8.399	1.86E+01	1882	41.4	1859	15	1909	7.65E-01	1.89E+00	4.52E-03	4.45E-02	+/-	1.61E-03	3.20E-03			
16	1.10E+02	9.771	1.98E+01	1863	45.5	1815	16	1894	7.55E-01	1.93E+00	1.22E-03	4.12E-02	+/-	1.41E-03	1.71E-03			
17	99.4700	11.013	17.9	1844			16	1880	0.76	1.81	6.64E-04	4.07E-02	+/-	1.53E-03	9.73E-04			
18	110.2000	12.388							0.76	1.96		3.98E-02	+/-	1.57E-03	5.20E-04			
19	111.4000	13.778							0.75	1.93					2.76E-04			
20	99.6700	15.022							0.78	1.92								

linear sed rate=	692	g/sq m/yr	r2=.99
Constant flux rate=	729	g/sq.m/yr	
RSSM rate =	915	g/sq.m/yr	

Pb-210 Integral =	0.29	Bq/cm2
Pb-210 Flux=	89.19	Bq/m2/yr
Int Error	0.01	
Flux error	3.92	

Table 5. Core 23A Great Slave Lake, March 1994.

Section number	Total Sediment weight (g)	Cumulative Dry weight (gm./sq.cm.)	Linear rate model no. years /section	Linear rate model Median year	Constant Flux Model no. years /section	Constant Flux Model Median year	Rapid Steady State Mixing Model no. years /section	Rapid Steady State Mixing Model Median year	Porosity	Section Thickness	excess Pb-210 (Bq/g)	alpha Pb-210 activity (Bq/g)	+/-	2 SD	linear regression line	Cs-137 activity (Bq/g)	+/-	2 SD
1	36.47	0.455	8.4	1986	Model not	appropriate	Model not	appropiriate	0.88	1.28	6.78E-02	1.13E-01	+/-	4.95E-03		2.29E-02	+/-	5.01E-03
2	18.81	0.690	4.3	1981					0.84	0.49	4.95E-02	9.45E-02	+/-	4.07E-03		2.30E-02	+/-	3.06E-03
3	25.83	1.012	5.9	1975					0.81	0.60	2.63E-02	7.13E-02	+/-	3.70E-03		5.59E-02	+/-	8.39E-03
4	23.86	1.310	5.5	1970					0.81	0.54	2.48E-02	6.98E-02	+/-	3.14E-03		1.16E-01	+/-	1.16E-02
5	24.33	1.614	5.6	1964					0.82	0.57	2.78E-02	7.28E-02	+/-	3.55E-03		1.12E-01	+/-	6.72E-03
6	21.37	1.880	4.9	1959					0.82	0.51	2.92E-02	7.42E-02	+/-	3.78E-03		5.11E-02	+/-	8.17E-03
7	19.76	2.127	4.5	1955					0.82	0.46	2.17E-02	6.67E-02	+/-	3.24E-03		1.06E-02	+/-	4.88E-03
8	20.67	2.385	4.8	1950					0.80	0.45	1.42E-02	5.92E-02	+/-	2.68E-03		0.00E+00	+/-	0.00E+00
9	19.71	2.631	4.5	1945					0.81	0.44	1.49E-02	5.99E-02	+/-	2.93E-03		0.00E+00	+/-	0.00E+00
10	24.05	2.931	5.5	1940					0.79	0.48	1.34E-02	5.84E-02	+/-	3.50E-03				
11	25.37	3.248	5.8	1934					0.77	0.48		4.48E-02	+/-	2.53E-03				
12	26.18	3.574	6.0	1928					0.77	0.50		4.14E-02	+/-	2.44E-03				
13	25.93	3.898	6.0	1922					0.77	0.49		4.57E-02	+/-	2.39E-03				
14	26.22	4.225	6.0	1916					0.78	0.51								
15	26.80	4.560	6.2	1910					0.78	0.53								
16	24.82	4.869	5.7	1904					0.77	0.47								
17	17.87	5.092	4.1	1900					0.77	0.33								
18	18.49	5.323	4.3	1896					0.76	0.34								
19	33.19	5.737	7.6	1888					0.77	0.62								
20	57.37	6.453	13.2	1875					0.76	1.02								

linear sed rate=		542	g/sq.m/yr	r2=.85
Pb-210 Integral		0.09	Bq/cm2	
Pb-210 Flux=		28.90	Bq/m2/yr	
Int Error		0.01		
Flux error		3.80		

APPENDIX E: OC , PAH , CARBON AND NITROGEN DATA FOR MARCH 1994 CORES

Table 1. Concentration of organochlorine compounds (ng/g dry weight) in Core 19B, Great Slave Lake, March 1994.

Depth (cm)	CBZ	HCH	CHLOR	DDT	PCB	Dieldrin
0.0 - 1.0	1.410	0.313	0.263	0.407	8.754	0.201
1.0 - 1.5	2.412	0.322	0.096	0.857	9.028	0.240
1.5 - 2.0	2.384	0.373	0.488	1.237	8.647	0.288
2.0 - 2.5	2.697	0.449	0.484	0.379	7.582	0.116
2.5 - 3.0	2.677	0.467	0.454	0.980	5.064	0.291
3.0 - 3.5	2.645	0.362	0.437	0.465	4.642	0.211
3.5 - 4.0	2.617	0.235	0.485	1.553	5.816	0.256
4.0 - 4.5	1.346	0.115	0.282	1.031	2.978	0.219
4.5 - 5.0	1.057	0.185	0.393	0.970	9.945	0.164
5.0 - 6.0	0.687	0.028	0.115	0.508	0.731	0.119
mean	1.99	0.28	0.35	0.84	6.32	0.21
SD	0.74	0.14	0.14	0.37	2.84	0.06

Table 2. Concentration of PCB congeners (ng/g dry weight) in Core 19B, Great Slave Lake, 1994.

CONGENERS		0.0 - 1.0	1.0 - 1.5	1.5 - 2.5	2.0 - 2.5	2.5 - 3.0	3.0 - 3.5	3.5 - 4.0	4.0 - 4.5	4.5 - 5.0	5.0 - 6.0
MONO/DI	6	0.08	0.25	0.22	0.17	0.12	0.17	0.11	0.06	0.12	0.14
	8/5	0.22	0.50	0.53	0.42	0.25	0.18	0.78	0.40	0.67	0.00
	SUM	0.30	0.74	0.75	0.60	0.37	0.35	0.89	0.46	0.78	0.14
TRI	18	0.58	0.64	0.39	0.52	0.18	0.47	0.15	0.00	0.15	0.01
	17	0.13	0.14	0.21	0.19	0.20	0.11	0.16	0.15	0.21	0.02
	24/27	0.07	0.10	0.09	0.07	0.09	0.06	0.07	0.03	0.06	0.02
	16/32	0.22	0.35	0.34	0.20	0.15	0.21	0.26	0.26	0.42	0.08
	25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00
	31	0.11	0.15	0.28	0.28	0.10	0.09	0.16	0.07	0.29	0.01
	28	0.94	0.50	0.48	0.40	0.29	0.23	0.25	0.14	0.40	0.03
	33	0.24	0.21	0.35	0.30	0.17	0.15	0.22	0.08	0.34	0.02
	22	0.17	0.18	0.08	0.08	0.05	0.10	0.14	0.08	0.14	0.01
	SUM	2.46	2.28	2.22	2.04	1.22	1.41	1.41	0.90	2.00	0.20
TETRA	52	0.31	0.31	0.39	0.44	0.28	0.12	0.19	0.07	0.53	0.00
	49	0.19	0.26	0.35	0.21	0.12	0.06	0.12	0.09	0.24	0.00
	47	0.02	0.03	0.03	0.03	0.01	0.01	0.02	0.00	0.00	0.00
	44	0.10	0.20	0.24	0.24	0.17	0.08	0.13	0.12	0.32	0.01
	42	0.07	0.06	0.07	0.07	0.03	0.65	0.20	0.00	0.00	0.05
	41/71	0.02	0.03	0.03	0.03	0.19	0.01	0.02	0.00	0.03	0.00
	64	0.09	0.08	0.11	0.11	0.05	0.04	0.07	0.06	0.13	0.01
	74	0.13	0.15	0.06	0.15	0.09	0.06	0.10	0.03	0.18	0.02
	70/76	0.29	0.45	0.36	0.39	0.22	0.22	0.03	0.10	0.55	0.01
	SUM	1.21	1.57	1.63	1.67	1.17	1.25	0.88	0.48	1.98	0.09
PENTA	91	0.06	0.06	0.06	0.07	0.05	0.03	0.00	0.00	0.00	0.00
	84/89	0.05	0.06	0.05	0.05	0.04	0.01	0.02	0.00	0.07	0.00
	101	0.49	0.52	0.51	0.51	0.30	0.20	0.31	0.16	0.76	0.21
	99	0.13	0.13	0.14	0.14	0.06	0.05	0.10	0.19	0.28	0.01
	83	0.03	0.03	0.04	0.03	0.06	0.02	0.03	0.00	0.03	0.07
	97	0.15	0.17	0.16	0.16	0.09	0.06	0.13	0.00	0.13	0.01
	87	0.22	0.24	0.22	0.22	0.12	0.08	0.12	0.04	0.35	0.01
	85	0.07	0.07	0.07	0.06	0.04	0.02	0.04	0.02	0.11	0.00
	118	0.25	0.25	0.21	0.13	0.17	0.12	0.19	0.06	0.33	0.02
	105	0.04	0.05	0.05	0.03	0.04	0.00	0.01	0.00	0.01	0.02
	110	0.46	0.47	0.47	0.43	0.29	0.15	0.28	0.18	0.75	0.03
	SUM	1.96	2.04	1.98	1.82	1.26	0.74	1.23	0.66	2.82	0.37
HEXA	136	0.13	0.13	0.08	0.12	0.04	0.04	0.08	0.01	0.14	0.01
	149	0.36	0.33	0.28	0.24	0.14	0.08	0.14	0.03	0.47	0.02
	134	0.03	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00
	153	0.37	0.28	0.25	0.19	0.13	0.09	0.17	0.07	0.40	0.03
	132	0.07	0.05	-0.01	0.06	0.04	0.03	0.03	0.04	0.05	0.01
	141	0.11	0.10	0.09	0.06	0.04	0.03	0.06	0.02	0.12	0.01
	138	0.40	0.33	0.33	0.23	0.16	0.12	0.22	0.08	0.41	0.04
	158	0.05	0.06	0.05	0.03	0.01	0.01	0.00	0.00	0.00	0.00
	128	0.04	0.05	0.04	0.02	0.02	0.02	0.02	0.01	0.04	0.01
	SUM	1.55	1.36	1.14	0.97	0.60	0.41	0.70	0.27	1.62	0.11

Table 2. Continued.

CONGENERS		0.0 - 1.0	1.0 - 1.5	1.5 - 2.5	2.0 - 2.5	2.5 - 3.0	3.0 - 3.5	3.5 - 4.0	4.0 - 4.5	4.5 - 5.0	5.0 - 6.0
HEPTA	137	0.36	0.39	0.25	0.12	0.14	0.20	0.21	0.15	0.23	0.03
	178/129	0.09	0.07	0.08	0.05	0.01	0.00	0.08	0.04	0.06	0.00
	187	0.11	0.08	0.09	0.06	0.04	0.03	0.09	0.04	0.12	0.01
	179	0.06	0.03	0.03	0.02	0.01	0.01	0.03	0.00	0.08	0.01
	183	0.07	0.04	0.04	0.03	0.02	0.03	0.03	0.01	0.05	0.01
	185	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	174	0.08	0.05	0.05	0.03	0.01	0.02	0.03	0.03	0.07	0.01
	177	0.05	0.05	0.03	0.03	0.03	0.03	0.02	0.01	0.03	0.00
	156	0.04	0.05	0.04	0.02	0.06	0.00	0.02	0.00	0.03	0.00
	172/197	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	180	0.11	0.09	0.09	0.06	0.05	0.04	0.08	0.05	0.07	0.03
	193	0.07	0.06	0.04	0.03	0.03	0.04	0.05	0.03	0.03	0.02
	170	0.03	0.02	0.02	0.01	0.01	0.00	0.01	0.01	0.02	0.00
	189	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SUM	1.08	0.96	0.77	0.47	0.41	0.41	0.65	0.37	0.78	0.10
OCTA	201/157	0.04	0.03	0.02	0.01	0.04	0.01	0.02	0.00	0.00	0.00
	198	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	199	0.02	0.02	0.02	0.01	0.00	0.02	0.01	0.00	0.01	0.00
	196/203	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SUM	0.10	0.08	0.06	0.03	0.04	0.04	0.04	0.00	0.01	0.00
DECA	209	0.00	0.00	0.00	0.00	0.00	0.05	0.04	0.00	0.00	0.00
TOTAL PCB'S		8.66	9.01	8.54	7.58	5.06	4.64	5.83	3.13	10.00	1.02

Table 3. PAHs (ng/g dry weight) for Core 12B, Great Slave Lake, March 1994.

Depth (cm)	Naphthalene	2-Methyl naphthalene	1-Methyl naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene
0.0 - 1.0	150.7	223.9	112.4	2.4	5.1	25.6	110.8	15.7	43.3	122.5
1.0 - 1.5	140.9	231.4	109.0	2.5	5.8	26.2	124.6	25.6	76.5	257.0
1.5 - 2.0	106.4	170.3	89.4	2.2	4.7	20.8	97.3	14.2	33.4	90.2
2.0 - 2.5	102.7	157.2	80.1	2.1	4.1	21.5	102.6	15.4	38.6	108.9
2.5 - 3.0	118.0	190.8	96.1	2.3	4.0	22.7	109.5	16.9	49.0	149.5
3.0 - 3.5	141.5	207.4	100.9	2.2	2.7	20.0	106.4	12.3	42.9	125.6
3.5 - 4.0	313.5	401.3	165.9	4.0	3.3	29.1	172.9	37.8	79.0	268.8
4.0 - 4.5	137.0	212.4	106.5	2.2	3.8	27.0	123.9	15.4	40.2	108.8
4.5 - 5.0	79.9	140.0	77.3	2.4	3.8	24.8	115.1	4.4	37.3	90.2
5.0 - 6.0	63.6	112.7	66.4	1.9	3.3	17.4	90.7	3.3	25.3	48.6

Depth (cm)	Benzo(a)-anthracene	Chrysene	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Benzo(e)-pyrene	Benzo(a)-pyrene	Indeno(1,2,3-cd)-pyrene	Dibenzo(a,h)-anthracene	Benzo(g,h,i)-perylene	Total benzo-fluoranthenes	Total PAH
0.0 - 1.0	29.7	61.3	63.2	9.3	110.6	19.5	17.5	10.9	38.0	72.5	1172.4
1.0 - 1.5	79.7	180.6	64.0	10.0	114.0	16.4	16.0	10.8	32.9	74.0	1523.7
1.5 - 2.0	26.7	55.3	60.3	9.4	100.7	16.8	15.7	9.7	35.6	69.7	958.9
2.0 - 2.5	24.9	51.3	61.6	10.1	103.1	16.9	18.8	11.2	39.8	71.6	970.8
2.5 - 3.0	40.9	82.1	83.6	12.6	143.6	23.1	21.1	10.6	45.6	96.1	1221.6
3.0 - 3.5	45.2	102.4	67.6	10.2	116.8	15.9	22.1	15.8	51.2	77.7	1208.9
3.5 - 4.0	48.0	94.5	78.7	11.3	136.8	17.9	36.1	21.3	78.3	90.0	1998.3
4.0 - 4.5	33.6	70.3	79.6	10.5	139.3	20.3	20.9	12.9	47.1	90.1	1211.7
4.5 - 5.0	31.8	71.8	75.1	10.6	134.2	21.4	18.1	10.6	40.2	85.7	988.9
5.0 - 6.0	22.0	46.4	72.0	9.1	125.1	21.2	19.4	14.2	41.8	81.1	804.3

Table 4. Other PAHs (ng/g dry weight) for Core 12B, Great Slave Lake, March 1994.

Depth (cm)	Dibenzofuran	Retene	Dibenzothiophene	Triphenylene	Perylene	Total PAH
0.0 -1.0	22.4	396.0	23.5	48.1	162.4	652.5
1.0 - 1.5	11.5	995.7	26.6	128.7	166.1	1328.6
1.5 - 2.0	19.3	339.6	20.4	47.8	155.2	582.3
2.0 - 2.5	20.1	402.1	21.4	42.4	162.6	648.5
2.5 - 3.0	21.5	555.3	23.8	67.0	162.1	829.6
3.0 - 3.5	20.4	629.1	21.7	74.6	149.9	895.7
3.5 - 4.0	30.6	1114.6	37.1	78.8	171.4	1432.4
4.0 - 4.5	23.3	389.4	28.8	55.6	153.8	650.9
4.5 - 5.0	20.0	361.5	27.9	51.2	149.5	610.1
5.0 - 6.0	15.5	166.5	18.9	33.0	164.0	398.0

Table 5. PAHs (ng/g dry weight) for Core 19B, Great Slave Lake, March 1994.

Depth (cm)	Naphthalene	2-Methyl naphthalene	1-Methyl naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene
0.0 -1.0	237.1	484.0	288.2	2.5	4.9	14.7	79.3	3.2	20.3	37.9
1.0 - 1.5	170.5	312.2	176.8	3.0	5.5	15.6	78.4	11.5	23.2	49.0
1.5 - 2.0	238.9	405.5	220.7	3.6	6.1	17.6	88.3	3.3	23.9	49.5
2.0 - 2.5	354.6	528.6	298.3	4.5	7.3	19.2	96.6	0.0	24.1	47.3
2.5 - 3.0	223.2	350.7	190.8	3.2	4.2	18.3	95.0	10.7	23.6	45.7
3.0 - 3.5	240.3	374.4	216.3	4.1	6.6	18.2	90.2	3.3	22.6	42.8
3.5 - 4.0	91.5	162.9	91.2	2.0	3.1	15.2	78.6	0.0	21.8	42.2
4.0 - 4.5	85.7	142.0	78.3	1.9	3.1	13.6	66.9	0.0	18.8	35.3
4.5 - 5.0	54.9	132.4	80.2	1.6	2.6	12.9	72.9	0.0	19.6	35.9
5.0 - 6.0	40.0	101.7	63.8	1.6	2.4	11.1	67.4	0.0	18.8	36.8
14.0-16.0	50.4	124.1	78.0	1.9	2.8	12.8	77.2	0.0	21.0	32.1

Depth (cm)	Benzo(a)-anthracene	Chrysene	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Benzo(e)-pyrene	Benzo(a)-pyrene	Indeno(1,2,3-cd)-pyrene	Dibenzo(a,h)-anthracene	Benzo(g,h,i)-perylene	Total benzo-fluoranthenes	Total PAH
0.0 -1.0	16.2	30.7	62.0	9.9	108.6	20.5	16.4	7.9	36.4	71.9	1480.6
1.0 - 1.5	15.1	34.8	55.1	10.1	99.5	14.5	18.3	13.0	46.4	65.2	1152.6
1.5 - 2.0	18.6	40.4	65.9	9.9	115.2	16.8	26.9	14.5	60.1	75.8	1425.7
2.0 - 2.5	18.1	38.9	66.0	11.0	121.5	17.0	19.3	11.9	49.7	76.9	1733.7
2.5 - 3.0	18.0	37.7	66.8	10.2	119.0	15.5	26.1	15.6	63.5	77.0	1337.8
3.0 - 3.5	18.4	38.5	67.7	10.0	118.0	17.3	17.8	8.3	42.7	77.8	1357.4
3.5 - 4.0	19.0	46.0	65.3	9.4	114.4	0.0	14.4	6.9	34.6	74.7	818.8
4.0 - 4.5	14.4	32.7	59.5	9.2	99.4	0.0	12.9	7.3	28.1	68.6	708.8
4.5 - 5.0	14.3	31.8	56.0	8.2	96.1	0.0	11.5	9.1	27.8	64.2	667.7
5.0 - 6.0	14.2	34.2	52.1	8.1	89.5	12.7	11.4	7.1	26.9	60.2	599.8
14.0-16.0	20.3	41.8	71.3	11.0	121.6	4.0	18.5	8.6	39.5	82.3	737.0

Table 6. Other PAHs (ng/g dry weight) for Core 19B, Great Slave Lake, March 1994.

Depth (cm)	Dibenzofuran	Retene	Dibenzothiophene	Perylene	Triphenylene	Total PAH
0.0 -1.0	14.6	97.7	14.7	172.6	23.4	323.0
1.0 - 1.5	16.2	143.4	14.5	241.9	28.8	444.9
1.5 - 2.0	18.6	156.7	15.8	158.3	25.9	375.4
2.0 - 2.5	18.9	132.9	17.7	174.6	28.1	372.2
2.5 - 3.0	18.8	133.5	17.8	167.2	28.2	365.5
3.0 - 3.5	18.8	118.7	16.4	184.2	28.4	366.5
3.5 - 4.0	16.2	151.1	14.7	0.0	28.4	210.5
4.0 - 4.5	14.0	129.3	12.9	0.0	26.1	182.1
4.5 - 5.0	13.7	108.9	13.4	0.0	24.2	160.2
5.0 - 6.0	12.3	127.2	12.5	23.6	22.2	197.8
14.0-16.0	13.7	105.8	14.7	20.3	29.0	183.4

Table 7. Carbon and Nitrogen Data for Core 13C and Core 19D, Great Slave Lake, March 1994.

	Site 13 Core C				Site 19 Core D			
Section midpoint	Pb-210 Deposition Date	Atomic C/N	TOC mg/g	TON mg/g	Pb-210 Deposition Date	Atomic C/N	TOC mg/g	TON mg/g
0.5	1992	8.68	18.6	2.5	1989	10.56	17.2	1.9
1.25	1987	8.80	18.1	2.4	1983	10.32	16.8	1.9
1.75	1983	8.46	17.4	2.4	1979	9.70	15.8	1.9
2.25	1979	9.12	17.2	2.2	1974	9.76	15.9	1.9
2.75	1975	9.11	16.4	2.1	1970	10.18	15.7	1.8
3.25	1970	8.64	16.3	2.2	1966	9.79	15.1	1.8
3.75	1966	9.68	16.6	2.0	1962	9.39	15.3	1.9
4.25	1961	9.72	15.0	1.8	1958	9.39	15.3	1.9
4.75	1956	9.58	15.6	1.9	1953	9.92	15.3	1.8
5.25	1951	9.58	15.6	1.9	1948	11.74	15.1	1.5
5.75	1947	10.29	15.0	1.7	1944	10.16	14.8	1.7
6.25	1942	10.02	14.6	1.7	1939	10.09	14.7	1.7
6.75	1936	9.61	14.0	1.7	1934	9.72	15.0	1.8
7.25	1931	9.99	13.7	1.6	1929	10.23	14.9	1.7
7.75	1926	9.99	13.7	1.6	1925	11.43	14.7	1.5
8.25	1922	9.40	13.7	1.7	1919	11.92	14.3	1.4
8.75	1917	10.14	13.9	1.6	1912	12.21	13.6	1.3
9.25	1912	10.97	14.1	1.5	1906	12.38	13.8	1.3
9.75	1907	9.40	13.7	1.7	1901	11.58	13.9	1.4
10.5	1900	10.06	13.8	1.6	1891	11.50	13.8	1.4
11.5	1890	9.76	13.8	1.7	1877	10.89	14.0	1.5
12.5	1879	9.72	12.5	1.5	1863	11.33	13.6	1.4
13.6	1866	9.93	14.1	1.7	1852	11.33	13.6	1.4
14.6	1855	10.97	14.1	1.5	1839	11.42	13.7	1.4
15.5	1845	10.66	13.7	1.5	1825	12.38	13.8	1.3
16.5	1833	10.57	14.5	1.6	1813	11.25	13.5	1.4
17.5	1821	10.43	14.3	1.6	1799	11.76	13.1	1.3
18.5	1809	11.28	14.5	1.5	1785	10.50	13.5	1.5
19.5	1798	10.21	14.0	1.6		10.11	13.0	1.5