U.S. Department of the Interior
U.S. Geological Survey

SOUTHERN LAKE MICHIGAN COASTAL ICE AND SEDIMENT SAMPLE DATA: SHOREFACE AND ICE PROFILES (Winter 1990/91)

By

Michael McCormick[1]
Edward W. Kempema[2]
John W. Haines[3]
Peter W. Barnes[1]
Erk Reimnitz[1]

Open-File Report 91-619-A

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards or with the North American Stratigraphic Code. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government

[1] U.S.G.S. Menlo Park, CA 94025
[2] Univ. Washington, Seattle WA 98195
[3] U.S.G.S. St. Petersburg FL 33701

OPEN FILE REPORT 91-619

Southern Lake Michigan coastal ice and sediment sample data: Shoreface and ice profiles (Winter 1990/91), by Michael McCormick, Edward W. Kempema, John W. Haines, Peter W. Barnes, and Erk Reimnitz. 1991. 32 p. and one 3.5-inch diskette.

Part A of this report presents background material on this study, defines terms used in the report, and describes the methods used to collect and analyze the data. It also includes a Glossary of Terms used to describe different types of ice, and a listing of the data files contained in Part B.

Part B of the report is a 3.5-inch high-density (1.44 MB) MS-DOS formatted diskette containing the data from which bathymetric profiles can be constructed.

Requirements: IBM PC or compatible; 3.5-inch HD floppy disk drive; graphing software capable of importing ASCII, space-delineated column, data files.

MONTHLY LIST NOTE

Open File Report 91-619-A and -B. Southern Lake Michigan coastal ice and sediment data: Shoreface and ice profiles (Winter 1990/1991), by Michael McCormick, Edward W. Kempema, John W. Haines, Peter W. Barnes, and Erk Reimnitz. 1991. 31 p. and one 3.5 inch diskette.

Part A of this report presents background material on this study, defines terms used in the report, and describes methods used to collect and analyze the data. It also includes a glossary of terms used to describe different types of ice and a listing of the data files contained in Part B. Part B of the report is a 3.5 inch high-density (1.44MB) MS-DOS formatted diskette containing the data from which bathymetric profiles can be constructed.

Requirements: IBM PC or compatible; 3.5" HD floppy disk drive; graphing software capable of importing ASCII, spaced-delineated column, data files.

DISCLAIMER

TABLE OF CONTENTS

SOUTHERN LAKE MICHIGAN COASTAL ICE AND SEDIMENT SAMPLE DATA; SHOREFACE AND ICE PROFILES (Winter 1990/91)

By Michael McCormick, Edward W. Kempema, John W. Haines, Peter W. Barnes and Erk Reimnitz

ABSTRACT

This report contains data collected during the winter of 1990/91 in southern Lake Michigan. The data, collected as part of a continuing study, shows how the formation of a seasonal nearshore ice zone affects coastal processes and sedimentation. Data presented includes bathymetric profiles, *Nearshore Ice Complex* profiles, and sediment concentrations from ice and water samples. No interpretations are given or implied. The raw data used to generate the profiles is found on the MS-DOS disk composing part B of this Open-File Report.

INTRODUCTION AND BACKGROUND

The U.S. Geological Survey is participating in a continuing study (see Barnes, 1990; Kempema and Reimnitz, 1991; McCormick et al., 1990; Reimnitz et al., 1991; Barnes et al., in prep.) on the role of ice on coastal erosional processes affecting southern Lake Michigan. As part of this study, repetitive bathymetric and ice morphology profiles were collected during the winter of 1990/1991 at Gillson Beach, Wilmette, Illinois. In addition, numerous ice, water and sediment samples were collected at various locations (Fig. 1). These profiles and samples will be analyzed to quantify the role of ice in coastal erosion along the shores of southern Lake Michigan, and by extrapolation to other areas with similar geological/meteorological conditions.

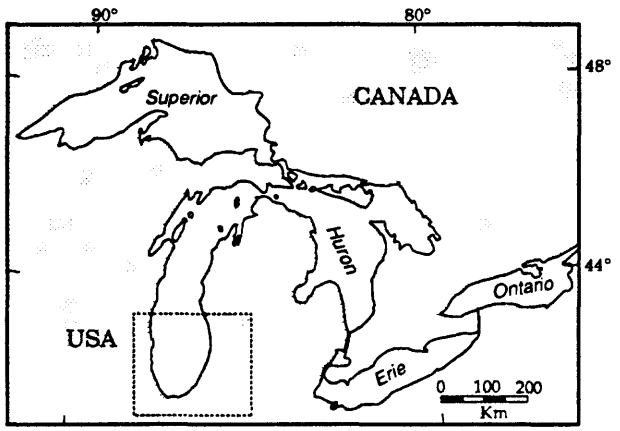
TERMINOLOGY

We use the terminology from Kivisild (1970) and Seibel, (1986), which parallels that being used for coastal ice in the arctic marine environment (Rex, 1964; Dionne and Laverdiere, 1972; McCann and Carlisle, 1972; Kovacs and Mellor, 1974; Short and Wiseman, 1974; Reimnitz et al., 1978). The term *Nearshore Ice Complex* (NIC) is used to describe ice zones fastened to the shoreline. From onshore to offshore, the NIC generally consists of: 1) an ice foot, 2) lagoonal ice, 3) ice ridges (commonly more than one; normally separated by lagoonal ice). In addition to the NIC a slush/brash ice zone is commonly present against the shore or the outermost ridge (Fig. 2). Not all ice types need be present at any given time, or at any given location. More detailed discussions of the ice types and the ice terminology may be found in the Glossary of Terms.

METHODS

BEACH PROFILES

Repetitive beach/ice profiles collected at Gillson Beach, Wilmette, Illinois during the period December 12, 1990 to March 16, 1991 monitored short-term variation in lakefloor/NIC morphology. All profiles are referenced to Low Water Datum (LWD=175.81m). Lake level readings were also taken on selected days (Table 1). Thirteen shore-normal profile lines were originally established (Fig. 3). These lines were spaced 15 m apart. Two surveyed lines of reference flags running shore-parallel (20 m apart) to the shore (back flag/ front flag) provided the reference grid for the shore-normal lines. The central survey line is named the Main Line (ML). This runs along a 033° M bearing from a reference mark consisting of a notch in the sidewalk by the beachhouse, through the central lamp post (Fig. 3). The reference grid was originally surveyed and referenced to LWD in McCormick et al. (1990). The central lamp post is the back flag on the ML. This ML is flanked by lines North Line 1 (NL1) through North Line 6 (NL6) to the North, and South Lines 1-6 (SL) to the South; the lowest number being most proximal to the Main Line (Fig. 3). Weather and/or time constraints occasionally prevented a survey of some lines. Complete site descriptions, and the details of the



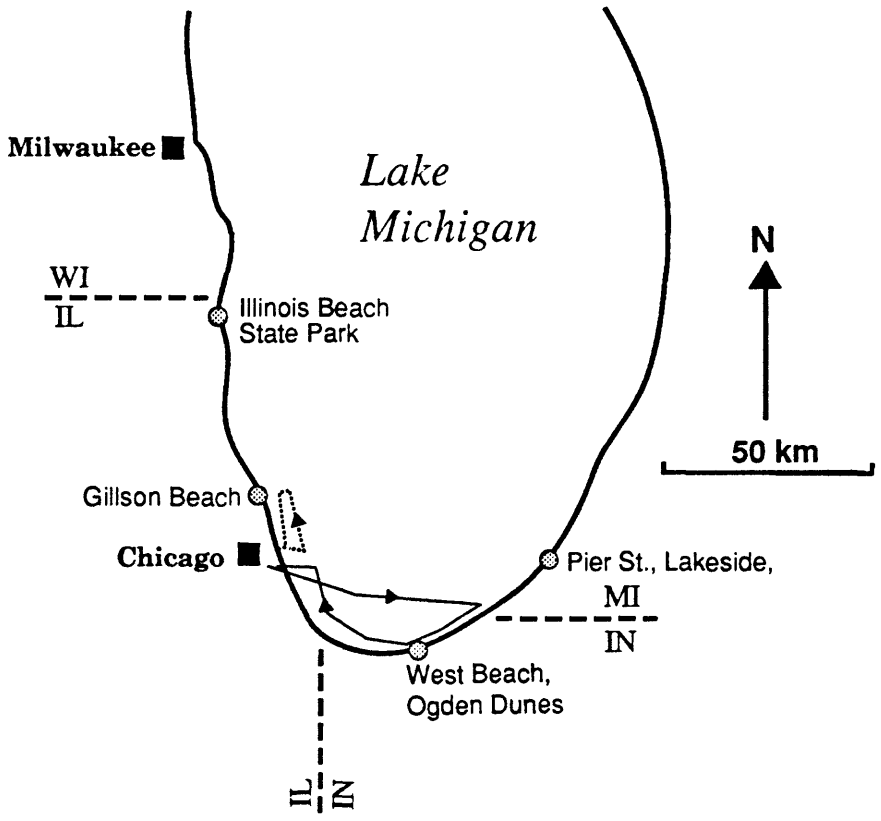


Figure 1: Locality map of southern Lake Michigan showing study sites, *Versluis* trackline (dashed) and helicopter flight path (solid).

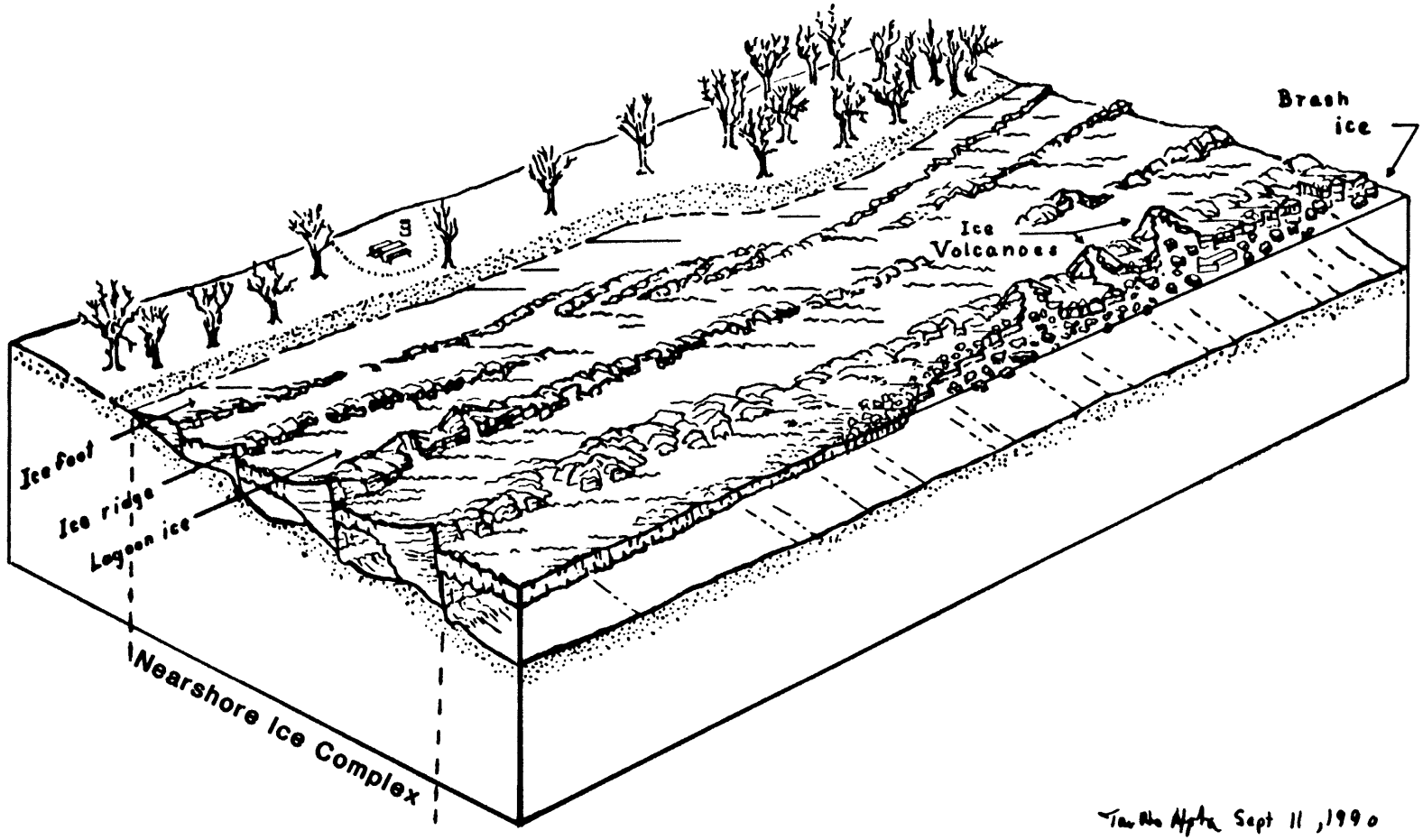


Figure 2: Skematic drawing of *Nearshore Ice Complex*. (Drawing by Tau Rho Alpha).

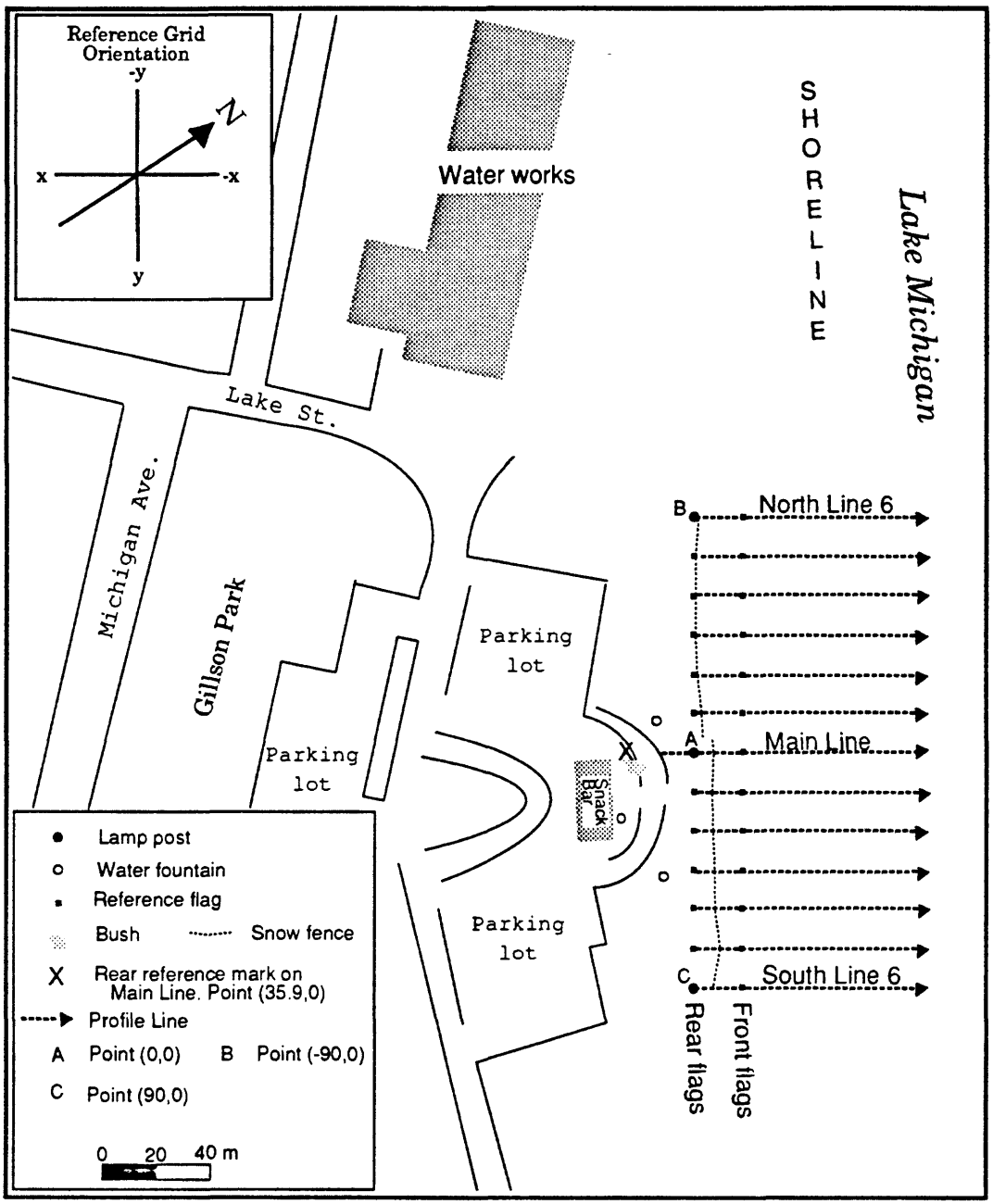


Figure 3: Map of Gillson Beach, Wilmette, Illinois, showing profile lines and reference grid.

original establishment of the profile grid may be found in McCormick et al., (1990).

The surveys used a leveled, acclimatized electronic distance meter (EDM). The EDM uses horizontal and vertical angle measurements with infra-red ranging to provide precise range, azimuth, and elevation information of a calibrated, rod-mounted prism. The angle measurements were translated into a X, Y, Z Cartesian coordinate system common for each profile, with the point X=0, Y=0, Z=2.838 (elevation established in McCormick et al., 1990) being the back flag of the Main Line (Fig. 3). The X values (shore-normal) decrease lakeward from the back markers along the profile lines, and the Y values (shore-parallel) decrease to the northwest. Z values are referenced to LWD.

Data was collected two ways. Onshore/nearshore data was collected by walking the prism at approximately 3 m intervals from the reference flags to water depths of 2-3 m. A fathometer scaled to measure depths of 0-30 ft mounted on an inflatable boat collected offshore bathymetric data. The onshore and offshore surveys overlapped so that the two data sets could be merged with each other. Wave noise was filtered out of the fathogram data before merging by a computer program using a reverse spectral analysis to delete fluctuations in bottom topography below a certain wavelength. This was related to wave height, period, and boat speed, and represents the smallest bedforms that may be resolved on each bathymetric record. The methods of data collection and interpolation are given in great detail in McCormick et al. (1990).

The examples of profiles presented in figure 4 were generated using the data on the accompanying disk (Part B of Open-File Report). This data is in ASCII format and may be imported into any graphing program. Table 2 indicates filename, date and profile type (onshore/merged/NIC) for all surveys. All data files follow the same column designations. Column 1 contains a point number and can be used for identification. Column 2 contains the X value; column 3, the Y value; and column 4, the Z value. Data files include 66 nearshore/onshore and 29 NIC profile lines taken with rod and prism, and 38 "merged" lines in which fathometer readings have been linked with the onshore lines to provide a continuous data set. Rounding off from five to two decimal places occurred during the processing of the boat portions of the merged data sets. In some cases, this results in two points with identical X, Y, values having different Z values in the same survey. This difference is never more than 2 cm. If a finer resolution is needed, the two values may be averaged or one point deleted. For this reason, when examining the nearshore areas, a more accurate representation may be possible using the walking, nearshore data sets. Further information may be found on the README.TXT file on the disk.

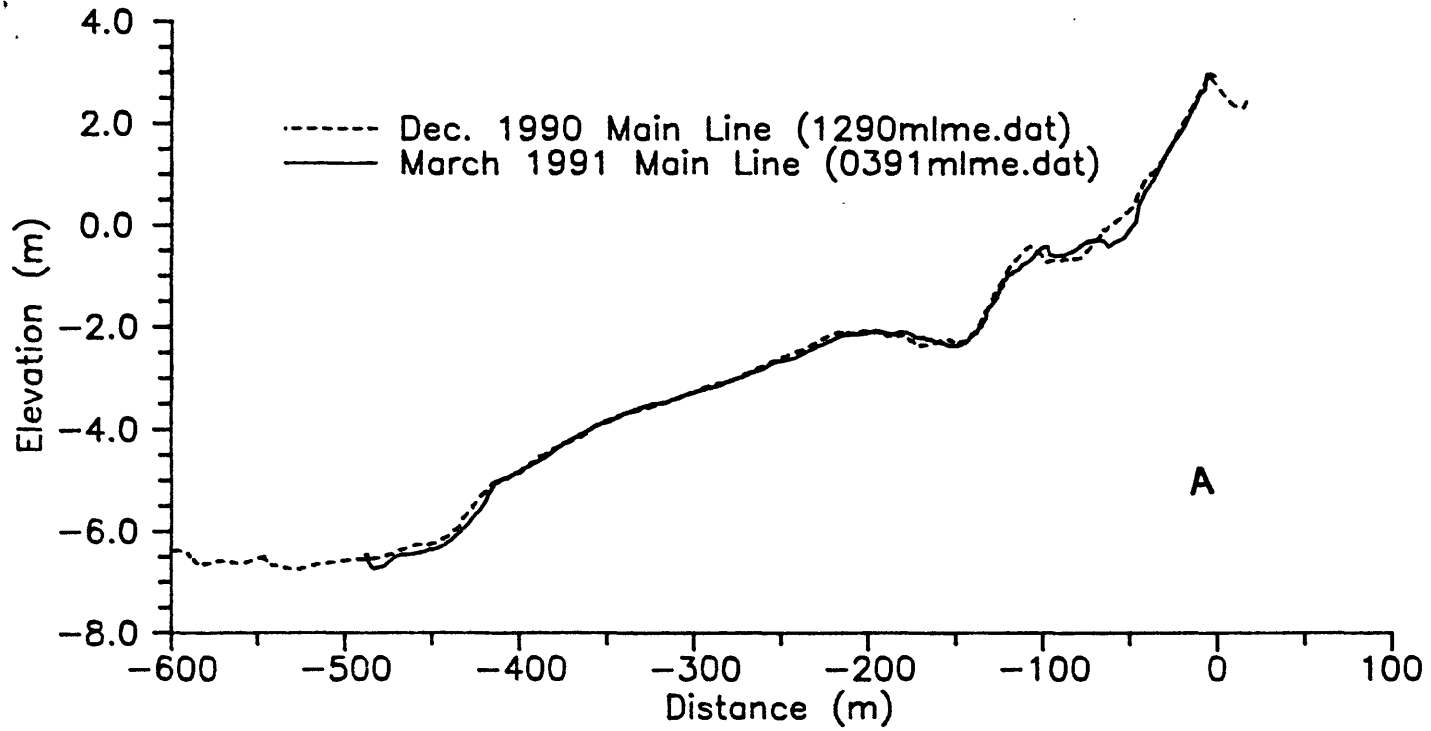
SAMPLE ANALYSIS

Sediment, ice, and water samples were collected to determine sediment content, grain size distribution, and ice density. Samples were taken from various locations on the NIC, the brash/slush zone, the beach, and offshore. Samples were collected by hand scoop nets, ice auger, and ice corer. Where collected by the corer, the core volume was noted to provide information on ice density.

Ice samples were melted in the field, and the water decanted and measured after the sediment had settled. Small amounts of silts and clays were lost during this stage, but very few of the samples contained any cloudy water after a few minutes of settling. Those that did exhibit significant amounts of cloudy water were filtered through pre-weighed .04 micron polycarbonate filter membranes. Subsequently, filters were oven-dried and weighed to determine sediment concentrations. Table 3 lists sample volumes, sediment contents, and locations. Appendix A contains a sample log with sample descriptions and locations.

ACKNOWLEDGEMENTS

The authors would like to thank those that contributed valuable support to this project. Scientific help was provided by M. Chrzastowski, M. Haines, and T. Reiss. N. Plant suggested many improvements to the manuscript. We would also like to thank B. Lawton and B. Duguid of the Wilmette Park District for their valuable logistical support.



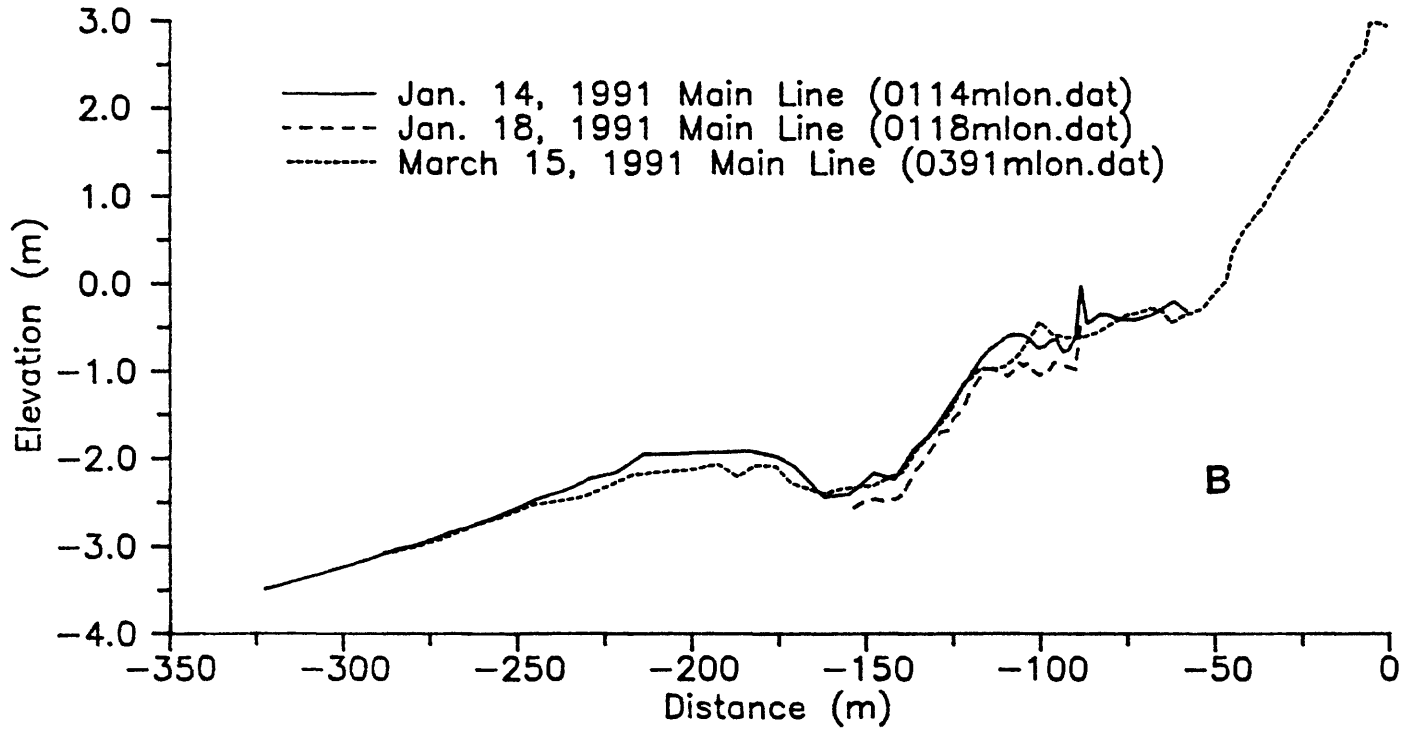
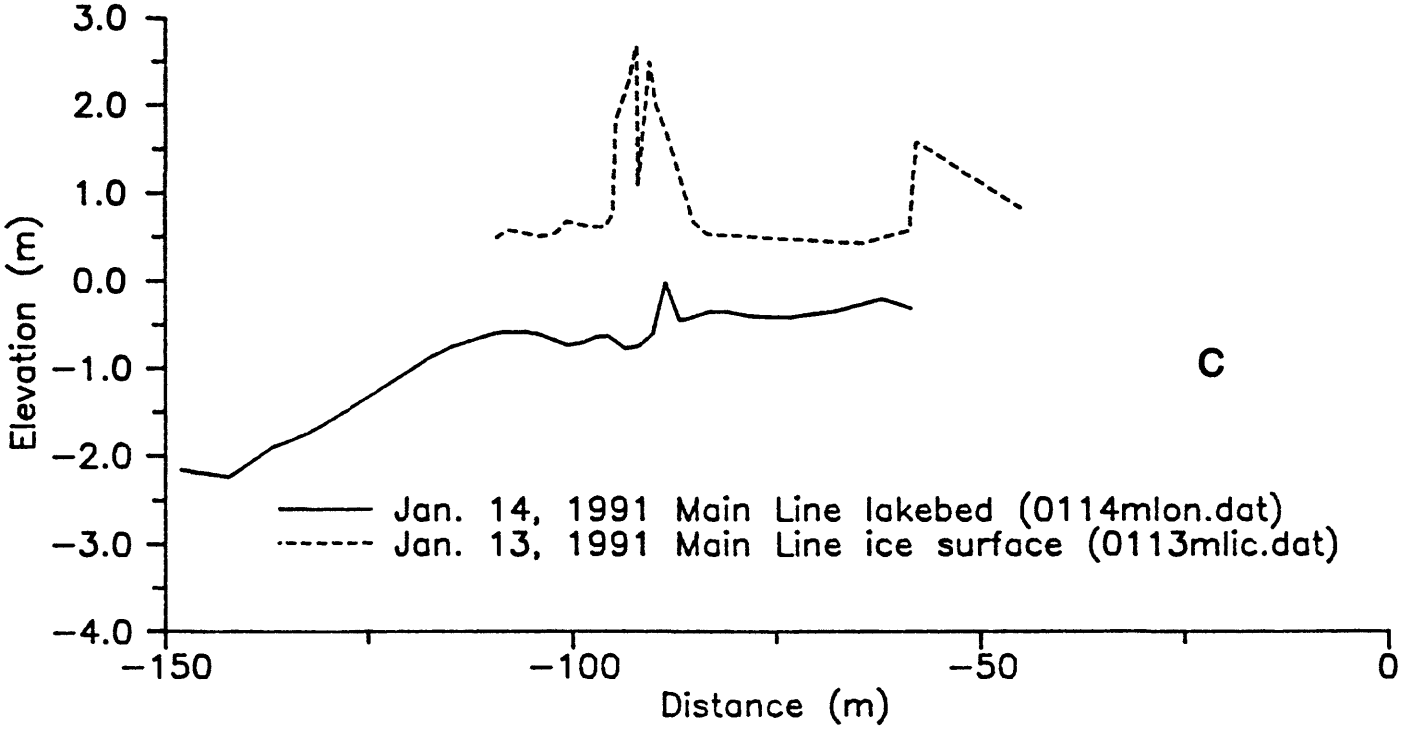


Figure 4: Samples of profile graphs generated with datafiles on accompanying diskette. Datafile names are shown in parentheses. A) Main Line profiles using fathogram data merged with nearshore data for two days; B) Main Line nearshore comparison of two days using nearshore datafiles; C) Comparison of NIC versus lakebed profiles. Elevation 0.0 is Low Water Datum (175.81m).


3.0
2.0
1.0
0.0
−1.0
−2.0
−3.0
−4.0
Elevation (m)
−150
−100
−50
0
Distance (m)
C
Jan. 14, 1991 Main Line lakebed (0114mlon.dat)
Jan. 13, 1991 Main Line ice surface (0113mlic.dat)

REFERENCES CITED

Barnes, P. W., editor, 1990, Coastal sedimentary processes in southern Lake Michigan: Their influence on coastal erosion (1989 progress reports and accomplishments): U.S. Geological Survey Open File Report 90-295, 55p.

Barnes, P. W., E. W., Kempema, Erk Reimnitz, Michael McCormick, W. S. Weber, and E. C. Hayden, in prep, Beach profile modification and sediment transport by ice: an overlooked process on Lake Michigan.

Dionne, J. C., and C. Laverdiere, 1972, Ice-formed beach features from Lake St. Jean, Quebec: Canadian Journal of Earth Sciences, v. 9, p. 979-990.

Gibbs, R. J., 1974, A settling tube system for sand-size analysis: Journal of Sedimentary Petrology, v. 44, p. 583-588.

Kempema, E. W., and Reimnitz, Erk, 1991, Nearshore sediment transport by slush/brash ice in southern Lake Michigan: Coastal Sediments '91, Seattle, Washington, June 25-27, American Society of Civil Engineers, p. 212-218.

Kivisild, H. R., 1970, River and lake ice terminology, *in* Ice and its action on hydraulic structures: IAHR Symposium, September, 1970, Reykjavik, Iceland, p. 1-13.

Kovacs A., and M. Mellor, 1974, Sea ice morphology and sea ice as a geologic agent in the southern Beaufort Sea, *in* J. C. Read and J. E. Sater, eds., The coast and shelf of the Beaufort Sea: Arctic Institute of North America, Arlington, Virginia, p. 113-161.

McCann, S. B., and R. J. Carlise, 1972, The nature of the ice-foot on the beaches of Radstock Bay, southwest of Devon Island, N.W.T., Canada: Institute of British Geographers Special Publication, n. 4, p. 175-186.

McCormick, Michael, E. C. Hayden, W. S. Weber, P. W., Barnes, Erk Reimnitz, and E. W. Kempema, 1990, Coastal ice and sediment samples; shoreface and ice profiles (Southern Lake Michigan, February, December 1989, & February, April 1990): U.S. Geological Survey Open-File Report 90-537, 186p.

Reimnitz, Erk, L. J. Toimil, and P. W. Barnes, 1978, Arctic continental shelf morphology related to sea-ice zonation, Beaufort Sea, Alaska: Marine Geology, v. 28, p. 179-210.

Reimnitz, Erk, E. C. Hayden, Michael McCormick, and P. W. Barnes, 1991, Preliminary observations on coastal sediment loss through ice rafting in Lake Michigan: Journal of Coastal Research, v. 7(3), p. 653-664.

Rex, R. W., 1964, Arctic beaches: Barrow, Alaska, *in* R. L. Miller, ed., Papers in marine geology: Macmillan, New York, p. 384-400.

Seibel, Erwin, 1986, Lake and shore ice conditions on southeastern Lake Michigan, *in* R. Rossman, ed., Impact of the Donald C. Cook Nuclear Plant: Great Lakes Research Division, Publication 22, University of Michigan, Ann Arbor, p. 401-432.

Short, A. D., and Wiseman, W. J., 1974, Freeze up processes on Arctic beaches: Arctic, v. 27, p. 215-224.

U.S. Navy, 1952, A Functional glossary of ice terminology, U.S. Navy Hydrographic Office, Washington D.C., H.O. Publication n. 609, 88p.

GLOSSARY OF TERMS

Many terms are modified from "A Functional Glossary of Ice Terminology" (U.S. Navy, 1952)

Nearshore Ice Complex (NIC): The coastal lake ice features which form nearshore during winter; including, but not limited to, the ice foot, ice ridge, and ice lagoon.

Location Terms

Brash/slush belt: A floating band of ice of varying width along the shore or outside the ice foot or ridge composed of brash and slush.
Fast ice: Ice which is in contact with, and attached to the shore.
Ice cone (volcano): Cone shaped pile of slush and brash built by wave eruption and overwash along an ice ridge exposed to breaking waves. Ice cones often coalesce to form the core of ice ridges.
Ice foot: A class of fast ice consisting of ice formed along and attached to the shoreline; caused by the action of water level changes, waves and spray.
Ice lagoon: An area of low ice relief between an ice foot and ice ridge, and between ice ridges.
Ice ridge: A grounded, shore-parallel, linear accumulation of ice often consisting of coalesced ice cones or volcanos. Several sub-parallel ridges may develop from successive freezing storm events.

Descriptive Terms

Anchor ice: Ice which forms on the lakebed, often incorporating sediment.
Brash: Small solidified fragments of lake ice less than 2 meters across; often the wreckage of other forms of ice.
"Dirty" ice: Used to refer to ice which includes high concentrations of sediment.
Pancake ice: Flat, circular, consolidated ice pans tens of centimeters in diameter, with upturned, or raised rims.
Slush: An accumulation of ice crystals and platelets which may or may not be slightly frozen together. Slush has no degree of hardness.

TABLE 1: Surveyed lake levels on selected days in relation to LWD.

Date	Time	Lake Level (m)
12/14/90	1608	0.361
1/13/91	1300	0.335
1/14/91	1310	0.387
1/18/91	1130	-0.050
1/22/91	1650	0.090

TABLE 2: BATHYMETRIC AND NIC PROFILE DATA FILE LOG
All data files are in ASCII format.
All data files have .DAT as a file extension.
Merged data files consist of offshore boat data which has been merged with onshore rod data.
Nearshore data files are rod and prism collected data. No offshore bathymetry exists for these data sets.
Icetop data files contain rod and prism collected data on the top surface of the NIC.
ML= Main Line; SL= South Lines; NL= North Lines

Filename.DAT	Profile dates		Description
	Onshore	Offshore	
1290mlme	12/14/90	12/18/90	ML merged
1290n1me	12/14/90	12/18/90	NL1 merged
1290n2me	12/14/90	12/17/90	NL2 merged
1290n3me	12/14/90	12/18/90	NL3 merged
1290n4me	12/14/90	12/18/90	NL4 merged
1290n5me	12/14/90	12/18/90	NL5 merged
1290n6me	12/14/90	12/17/90	NL6 merged
1290s1me	12/14/90	12/18/90	SL1 merged
1290s2me	12/14/90	12/17/90	SL2 merged
1290s3me	12/14/90	12/18/90	SL3 merged
1290s4me	12/14/90	12/18/90	SL4 merged
1290s5me	12/14/90	12/18/90	SL5 merged
1290s6me	12/14/90	12/17/90	SL6 merged
1290mlon	12/14/90		ML nearshore
1290n1on	12/14/90		NL1 nearshore
1290n2on	12/14/90		NL2 nearshore
1290n3on	12/14/90		NL3 nearshore
1290n4on	12/14/90		NL4 nearshore
1290n5on	12/14/90		NL5 nearshore
1290n6on	12/14/90		NL6 nearshore
1290s1on	12/14/90		SL1 nearshore
1290s2on	12/14/90		SL2 nearshore
1290s3on	12/14/90		SL3 nearshore
1290s4on	12/14/90		SL4 nearshore
1290s5on	12/14/90		SL5 nearshore
1290s6on	12/14/90		SL6 nearshore
0109mlon	1/9/91		ML nearshore
0109n2on	1/9/91		NL2 nearshore
0109n4on	1/9/91		NL4 nearshore
0109n6on	1/9/91		NL6 nearshore
0109s2on	1/9/91		SL2 nearshore
0109s4on	1/9/91		SL4 nearshore
0109s6on	1/9/91		SL6 nearshore
0110mlon	1/10/91		ML nearshore
0110n2on	1/10/91		NL2 nearshore
0110n4on	1/10/91		NL4 nearshore
0110n6on	1/10/91		NL6 nearshore
0110s2on	1/10/91		SL2 nearshore
0110s4on	1/10/91		SL4 nearshore
0110s6on	1/10/91		SL6 nearshore
0110mlic	1/10/91		ML ice top
0110n2ic	1/10/91		NL2 ice top
0110n4ic	1/10/91		NL4 ice top
0110n6ic	1/10/91		NL6 ice top
0110s2ic	1/10/91		SL2 ice top
0110s4ic	1/10/91		SL4 ice top
0110s6ic	1/10/91		SL6 ice top
0113mlon	1/13/91		ML nearshore

0113n2on	1/13/91		NL2 nearshore
0113n4on	1/13/91		NL4 nearshore
0113n6on	1/13/91		NL6 nearshore
0113mlic	1/13/91		ML ice top
0113n2ic	1/13/91		NL2 ice top
0113n4ic	1/13/91		NL4 ice top
0113n6ic	1/13/91		NL6 ice top
0114mlon	1/13/91		ML nearshore
0114n2on	1/13/91		NL2 nearshore
0114n4on	1/13/91		NL4 nearshore
0114n6on	1/13/91		NL6 nearshore
0114s2on	1/14/91		SL2 nearshore
0114s4on	1/14/91		SL4 nearshore
0114s6on	1/14/91		SL6 nearshore
0114mlme	1/13/91	1/14/91	ML merged
0114n2me	1/13/91	1/14/91	NL2 merged
0114n4me	1/13/91	1/14/91	NL4 merged
0114n6me	1/13/91	1/14/91	NL6 merged
0114s2me	1/14/91	1/14/91	SL2 merged
0114s2ic	1/14/91		SL2 ice top
0114s4ic	1/14/91		SL4 ice top
0114s6ic	1/14/91		SL6 ice top
0118mlme	1/18/91	1/19/91	ML merged
0118n2me	1/18/91	1/19/91	NL2 merged
0118n4me	1/18/91	1/19/91	NL4 merged
0118n6me	1/18/91	1/19/91	NL6 merged
0118s2me	1/18/91	1/19/91	SL2 merged
0118s4me	1/18/91	1/19/91	SL4 merged
0118s6me	1/18/91	1/19/91	SL6 merged
0118mlic	1/18/91		ML ice top
0118n2ic	1/18/91		NL2 ice top
0118n4ic	1/18/91		NL4 ice top
0118n6ic	1/18/91		NL6 ice top
0118s2ic	1/18/91		SL2 ice top
0118s4ic	1/18/91		SL4 ice top
0118s6ic	1/18/91		SL6 ice top
0118mlon	1/18/91		ML nearshore
0118n2on	1/18/91		NL2 nearshore
0118n4on	1/18/91		NL4 nearshore
0118n6on	1/18/91		NL6 nearshore
0118s2on	1/18/91		SL2 nearshore
0118s4on	1/18/91		SL4 nearshore
0118s6on	1/18/91		SL6 nearshore
0122mlon	1/22/91		ML nearshore
0122n2on	1/22/91		NL2 nearshore
0122n4on	1/22/91		NL4 nearshore
0122n6on	1/22/91		NL6 nearshore
0122s2on	1/22/91		SL2 nearshore
0122s4on	1/22/91		SL4 nearshore
0122s6on	1/22/91		SL6 nearshore
0122mlic	1/22/91		ML ice top
0122n2ic	1/22/91		NL2 ice top
0122n4ic	1/22/91		NL4 ice top
0122n6ic	1/22/91		NL6 ice top
0122s2ic	1/22/91		SL2 ice top
0122s4ic	1/22/91		SL4 ice top
0122s6ic	1/22/91		SL6 ice top
0125mlon	1/25/91		ML nearshore
0125mlic	1/25/91		ML ice top
0391mlon	3/15/91		ML nearshore
0391n1on	3/15/91		NL1 nearshore

0391n2on	3/15/91		NL2 nearshore
0391n3on	3/16/91		NL3 nearshore
0391n4on	3/15/91		NL4 nearshore
0391n5on	3/16/91		NL5 nearshore
0391n6on	3/15/91		NL6 nearshore
0391s1on	3/16/91		SL1 nearshore
0390s2on	3/15/91		SL2 nearshore
0391s3on	3/16/91		SL3 nearshore
0391s4on	3/15/91		SL4 nearshore
0391s5on	3/15/91		SL5 nearshore
0391s6on	3/15/91		SL6 nearshore
0391mlme	3/15/91	3/16/91	ML merged
0391n1me	3/15/91	3/16/91	NL1 merged
0391n2me	3/15/91	3/16/91	NL2 merged
0391n3me	3/16/91	3/16/91	NL3 merged
0391n4me	3/15/91	3/16/91	NL4 merged
0391n5me	3/16/91	3/16/91	NL5 merged
0391n6me	3/15/91	3/16/91	NL6 merged
0391s1me	3/16/91	3/16/91	SL1 merged
0390s2me	3/15/91	3/16/91	SL2 merged
0391s3me	3/16/91	3/16/91	SL3 merged
0391s4me	3/15/91	3/16/91	SL4 merged
0391s5me	3/15/91	3/16/91	SL5 merged
0391s6me	3/15/91	3/16/91	SL6 merged

TABLE 3: SAMPLE DATA

All samples were taken at Gillson Beach, Illinois with the exception of 33-35, 48-49, 68, 70-73, 77 which were taken at Illinois Beach State Park and those with the modifiers:

V# Taken offshore from the Chicago Water Department supply vessel *Versluis.*
H# Taken offshore by helicopter.
MI# Taken at Pier Street locale, Lakeside, Michigan.
IN# Taken at the West Beach Bath House locale, Odgen Dunes, Indiana.

For sample locations, see Figure 1.

Explanation

Melt Water Volume: Water volume of melted ice sample.
Ice Volume: Volume of unmelted ice collected when known.
Sed. Conc. Water: Sediment concentration in melt water.
Sed. Conc. Ice: Sediment concentration in unmelted ice.
Sample Types:

Anchor	Anchor Ice Sample
Brash	Brash Ice
Eolian	Wind-deposited Sand
Iceft.	Ice Foot Sample
Lagoon	Lagoonal Ice
Lakebed	Bottom Sediment Sample
Pancake	Pancake Ice
Ridge	Ice Ridge
Slush	Slush Ice (Water drained)
Volcano	Ice Volcano
W&S	Water and Slush Ice Sample
Water	Water Column Sample

SAMPLE 91-SLM-#	Melt Water Volume (l)	Sediment Weight (gr.)	Ice Volume (l)	Sed. Conc. Water (gr/l)	Sed.Conc. Ice (gr/l)	Sample type	Lat./Long. North/West (Deg.-min.)
Gillson Beach, Illinois Samples							42-4.9N/87-41.2W
1	1.160	1.797		1.5491		W & S	
2	0.892	3.746		4.1996		SLUSH	
3	1.835	0.249		0.1357		LAGOON	
4	1.145	3.691		3.2236		RIDGE	
5	1.397	1.485		1.0630		W & S	
6	2.500	50.98		20.3920		LAGOON	
7	3.672	9.546		2.5997		LAGOON	
8	2.500	38.05		15.2200		LAGOON	
9	0.937	39.42		42.0704		SLUSH	
10	3.672	134.8		36.7102		RIDGE	
11	1.095	2.824		2.5790		RIDGE	
12	2.100	3.747		1.7843		W & S	
13							
(0-20cm)	0.320	5.051	1.006	15.7844	5.0209	VOLCANO	
(20-60cm)	1.312	14.773	2.011	11.2599	7.3461		
14	2.105	7.857		3.7325		W & S	
15	2.125	10.697		5.0339		SLUSH	
16							
(0-20cm)	0.625	8.186	1.006	13.0976	8.1372	VOLCANO	
(20-40cm)	0.640	9.567	1.006	14.9484	9.5099		
(40-60cm)	0.687	10.527	1.006	15.3231	10.4642		
17	1.965	16.381		8.3364		VOLCANO	
18							
(0-50cm)	0.769	10.786	2.514	14.0260	4.2904	RIDGE	
(50-100cm)	0.570	6.002	2.514	10.5298	2.3874		
19							
(0-40cm)	0.687	11.909	2.011	17.3348	5.9219	RIDGE	
(40-85cm)	0.690	16.046	2.263	23.2551	7.0906		
(85-110cm)	0.955	15.935	1.257	16.6859	12.6770		
20							
(0-35cm)	0.605	9.903	1.760	16.3686	5.6267	RIDGE	
(35-90cm)	0.780	0.706	2.766	0.9051	0.2552		
(95-110cm)	0.340	22.212	0.754	65.3294	29.4589		
21	1.760	5.7		3.2386		W & S	
22							
(0-5cm)	0.181	3.17	0.251	17.5138	12.6295	VOLCANO	
(5-10cm)	0.220	3.564	0.251	16.2000	14.1992		
(10-60cm)	1.045	12.452	2.514	11.9158	4.9531		
23	1.935	10.646		5.5018		SLUSH	
24	1.350	9.04		6.6963		SLUSH	
25	1.550	10.08		6.5032		SLUSH	
26	1.625	3.913		2.4080		SLUSH	
27	1.497	5.157		3.4449		SLUSH/BRASH	
28	1.410	4.978		3.5305		SLUSH/BRASH	
29	1.387	7.806		5.6280		SLUSH/BRASH	
30	1.695	16.828		9.9280		SLUSH/BRASH	
31	1.300	7.017		5.3977		SLUSH/BRASH	
32	1.281	3.529		2.7549		SLUSH/BRASH	
36	0.956	1.884		1.9707		SLUSH/BRASH	
37	1.649	0.462		0.2802		SLUSH/BRASH	
38	1.408	6.249		4.4382		SLUSH/BRASH	
39	1.680	425.69		253.3869		LAKEBED	
40	1.650	1.198		0.7261		BRASH	
41	0.708	0.462		0.6525		BRASH	
42	1.090	3.19		2.9266		BRASH	
43	1.360	5.795		4.2610		BRASH	
44	0.135	3.244		24.0296		BRASH	

SAMPLE 91-SLM-#	Melt Water Volume (l)	Sediment Weight (gr.)	Ice Volume (l)	Sed. Conc. Water (gr/l)	Sed.Conc. Ice (gr/l)	Sample type	Lat./Long. North/West (Deg.-min.)
45	0.615	0.871		1.4163		BRASH	
46	1.280	8.899		6.9523		BRASH	
47	0.310	0.00535		0.0173		PANCAKE	
50							
(0-3cm)	0.090	7.653	0.151	85.0333	50.6821	VOLCANO	
(3-12cm)	0.290	16.358	0.453	56.4069	36.1104		
(12-13cm)	0.100	6.474	0.050	64.7400	129.4800		
(13-20cm)	0.240	10.725	0.352	44.6875	30.4688		
51							
(0-3cm)	0.095	8.348	0.151	87.8737	55.2848	VOLCANO	
(3-8cm)	0.150	10.108	0.251	67.3867	40.2709		
(8-10cm)	0.100	5.048	0.101	50.4800	49.9802		
(10-17cm)	0.180	9.571	0.352	53.1722	27.1903		
52	0.302	0.011018		0.0365		SLUSH	
53							
(0-20cm)	0.650	3.409	0.884	5.2446	3.8563	SLUSH/BRASH	
(120-140cm)	0.968	10.781	0.884	11.1374	12.1957		
54	0.748			0.0000		MISSING	
55	0.850	18.826		22.1482		ICEFT.	
56	1.660	0.080454		0.0485		WATER	
57	0.202	0.26		1.2871		SLUSH	
58	1.895	46.33		24.4485		BRASH	
59	2.105	1.973		0.9373		SLUSH	
60	2.110	0.048		0.0227		WATER	
61	0.750	0.12197		0.1626		WATER	
62	2.200	0.037934		0.0172		WATER	
63	0.890	1.447		1.6258		ANCHOR	
64	0.780	11.604		14.8769		ANCHOR	
65	0.550	1.543		2.8055		ANCHOR	
66	0.840	45.963		54.7179		ANCHOR	
67	0.900	13.571		15.0789		ANCHOR	
69	1.060	8.552		8.0679		BRASH	
74	4.735	109.87		23.2038		ANCHOR	
75	2.780	78.13		28.1043		ANCHOR	
76	0.675	37.77		55.9556		ANCHOR	
77	0.120	8.544		71.2000		ANCHOR	
78	0.300	0.024303		0.0810		WATER	
79	0.500	0.019143		0.0383		W & S	
80	1.160	62.65		54.0086		ANCHOR	
81	2.060	35.196		17.0854		ANCHOR	
82	0.500	0.041796		0.0836		ANCHOR	
83	2.090	10.894		5.2124		ANCHOR	
84	0.250	0.01212		0.0485		WATER	
85	2.120	0.287		0.1354		W & S	
86	0.053	36.282		684.5660		ANCHOR	
87	0.830	12.273		14.7867		ANCHOR	
88	0.450	0.030355		0.0675		SLUSH	
89	0.450	0.014032		0.0312		WATER	
90	0.450	0.048246		0.1072		W & S	
91	0.330	0.063252		0.1917		WATER	
92	0.390	0.027225		0.0698		WATER	
93	2.695	8.927		3.3124		PANCAKE	
94	1.210	273.77		226.2562		BRASH	
95	0.810	2.472		3.0519		BRASH	
96	0.320	0.013057		0.0408		BRASH	
97	0.315	0.015277		0.0485		WATER	
98	2.200	37.547	3.801	17.0668	9.8782	RIDGE	
99	2.570	25.45	5.635	9.9027	4.5164	RIDGE	
100	1.900	9.37	2.696	4.9316	3.4755	RIDGE	
101	1.680	7.935	1.967	4.7232	4.0341	LAGOON	
102	1.310	0.45	1.414	0.3435	0.3182	LAGOON	

SAMPLE 91-SLM-#	Melt Water Volume (l)	Sediment Weight (gr.)	Ice Volume (l)	Sed. Conc. Water (gr/l)	Sed.Conc. Ice (gr/l)	Sample type	Lat./Long. North/West (Deg.-min.)
103	5.110	33.863	6.143	6.6268	5.5125	RIDGE	
104	4.600	79.26	4.110	17.2304	19.2847	ICEFT.	
105	1.015	1.286093		1.2671		ANCHOR	
106	0.000	226.95				EOLIAN	
107	0.895	0.545		0.6089		ANCHOR	
108	1.200	8.463		7.0525		ANCHOR	
109	0.000					LAKEBED	
110	2.360	56.072	4.066	23.7593	13.7905	RIDGE	
111	2.875	47.607	4.022	16.5590	11.8366	RIDGE	
112	2.570	26.683	3.801	10.3825	7.0200	RIDGE	
113	2.295	27.348	4.022	11.9163	6.7996	RIDGE	
114	2.300	18.539	3.315	8.0604	5.5925	RIDGE	
115	2.475	34.725	3.978	14.0303	8.7293	RIDGE	
116		24.568	3.845		6.3896	RIDGE	
117	1.415	44.972	1.945	31.7823	23.1219	LAGOON	
118	2.880	18.445	3.933	6.4045	4.6898	VOLCANO	
119						ANCHOR	
Water & Grannule wgt.		3.661			96.0123		
Water Vol.	0.003						
Grannule Wgt.		0.313					
120	0.265	3.03		11.4340		ANCHOR	
121	4.525	25.657		5.6701		ANCHOR	
122	4.205	16.812		3.9981		ANCHOR	
123	4.545	166.87		36.7151		BRASH	
124	4.355	6.634		1.5233		ANCHOR	
125	2.695	25.081	3.978	9.3065	6.3049	VOLCANO	
126	2.745	27.533	3.978	10.0302	6.9213	VOLCANO	
127	2.750	19.028	3.978	6.9193	4.7833	VOLCANO	
128	2.560	126.1	3.978	49.2578	31.6993	VOLCANO	
129	2.595	79.036	3.933	30.4570	20.0956	VOLCANO	
130	2.535	32.917	3.801	12.9850	8.6601	VOLCANO	
131	2.620	69.841	3.978	26.6569	17.5568	VOLCANO	
132	2.365	21.655	2.917	9.1564	7.4237	VOLCANO	
133	4.295	1052.63		245.0827		ANCHOR	
134	1.385	9.401		6.7877		ANCHOR	
135	0.500	0.004939		0.0099		WATER	
136	3.385	45.85	3.978	13.5451	11.5259	VOLCANO	
137	2.970		3.536	0.0000	0.0000	VOLCANO	
138	2.750	30.197	3.713	10.9807	8.1328	VOLCANO	
139	3.065	31.518	3.978	10.2832	7.9231	VOLCANO	
140	2.790	125.62	3.978	45.0251	31.5787	VOLCANO	
141	2.920	36.445	3.978	12.4812	9.1616	VOLCANO	
142	1.825	22.36	3.492	12.2521	6.4032	VOLCANO	
143	1.270	5.24		4.1260		SLUSH	
144	1.975	0.132877		0.0673		W & S	
145	0.505	0.01338		0.0265		WATER	
146	0.610	1.437		2.3557		BRASH	
147	0.950	0.149561		0.1574		SLUSH	
148	1.625	0.202		0.1243		SLUSH	
149	2.170	0.235433		0.1085		WATER	
150	2.260	0.109924		0.0486		WATER	
151	1.940	0.949		0.4892		W & S	
152	1.420	15.465		10.8908		SLUSH	
153	2.180	0.313372		0.1437		W & S	
154	0.720	50.52		70.1667		BRASH	
155	1.510	0.549491		0.3639		W & S	
156	2.070	0.795		0.3841		W & S	

SAMPLE 91-SLM-#	Melt Water Volume (l)	Sediment Weight (gr.)	Ice Volume (l)	Sed. Conc. Water (gr/l)	Sed.Conc. Ice (gr/l)	Sample type	Lat./Long. North/West (Deg.-min.)
Illinois Beach State Park, Illinois Samples							42-24.2/87-48.0
33	0.673	1.336		1.9851		SLUSH	
34	0.749	15.247		20.3565		PANCAKE	
35	1.295	0.548		0.4232		ICEFT.	
48	1.490	1.188		0.7973		SLUSH	
49	0.880	7.056		8.0182		BRASH	
68	0.730	24.926		34.1452		BRASH	
70	0.750	0.151604		0.2021		WATER	
71	2.005	1.713335		0.8545		W & S	
72	2.007	1.092857		0.5445		W & S	
73	0.355	0.074348		0.2094		WATER	
Samples taken from C.D.W. Versluis							
V1	1.500	2.621		1.7473		SLUSH/BRASH	41-53.8/87-33.7
V2	1.590	0.319		0.2006		SLUSH/BRASH	41-51.8/87-33.4
V3	1.570	1.411		0.8987		BRASH	41-48.3/87-31.7
V4	1.660	0.166		0.1000		BRASH	41-48.2/87-28.7
V5	0.940	0.16		0.1702		BRASH	41-50.8/87-30.7
V6	0.500	0.002925		0.0059		PANCAKE	41-50.8/87-30.7
V7	1.380	9.844		7.1333		BRASH	41-55.0/87-30.5
V8	1.170	0.223		0.1906		PANCAKE	41-59.4/87-31.7
V9	1.120	0.967		0.8634		BRASH	42-3.9/87-33.0
V10	1.410	0.42		0.2979		PANCAKE	42-3.9/87-36.6
V11	1.520	0.802		0.5276		PANCAKE	42-6.0/87-37.5
V12	0.740	83.22		112.4595		SLUSH	42-3.0/87-36.8
Samples taken by helicopter							
H1	1.660	6.552		3.9470		SLUSH/BRASH	41-42.3/86-56.8
H2	0.500	0.030366		0.0607		PANCAKE	41-38.6/87-10.9
H3	0.500	0.026032		0.0521		PANCAKE	41-38.6/87-13.5
H4	0.250	0.0147		0.0588		SLUSH	41-39.1/87-16.5
H5	0.280	0.010571		0.0378		PANCAKE	41-40.1/87-20.4
H6	0.240	0.013723		0.0572		PANCAKE	41-42.4/87-26.9
H7	0.257	0.006116		0.0238		PANCAKE	41-45.3/87-30.5
H8	0.305	0.018602		0.0610		SLUSH/BRASH	41-48.2/87-32.0
Samples taken at West Beach Bathouse, Ogden Dunes, Indiana							41-37.6/87-12.5
IN1	0.480	15.744	0.884	32.8000	17.8100	RIDGE	
IN2	0.820	9.124	1.193	11.1268	7.6479	BRASH	
IN3	1.320	13.915	1.856	10.5417	7.4973	RIDGE	
IN4	1.540	2.261	2.000	1.4682	1.1305	SLUSH/BRASH	
IN5	0.740	1.013	1.105	1.3689	0.9167	ICEFT.	
Samples taken at Pier St. Lakeside, Michigan							41-51.2/86-40.4
MI1	0.290	25.305	0.432	87.2586	58.5764	ICEFT.	
MI2	0.645	3.34	1.192	5.1783	2.8020	RIDGE	
MI3	0.570	0.907	0.972	1.5912	0.9331	BRASH	
MI4	0.630	2.965	0.735	4.7063	4.0340	RIDGE	
MI5	1.590	1.688	2.000	1.0616	0.8440	SLUSH/BRASH	

APPENDIX A: SAMPLE LOG

JANUARY 2, 1991

91-SLM-1 GILLSON BEACH
Bulk sample of slush ice and water from surface slush ice layer. Collected 5 m lakeward of NIC.

91-SLM-2 GILLSON BEACH
Selected pieces plate-shapped brash ice from same location/time as sample #1.

91-SLM-3 GILLSON BEACH
Laggonal ice sample collected near ice surface.

91-SLM-4 GILLSON BEACH
Collected from lakeward face of an ice ridge about 1/2 meter above lake level. Ridge had about 2 m of freeboard.

91-SLM-5 GILLSON BEACH
Slush ice sample collected about 7 m lakeward of NIC where sample #4 was collected. Samples #1-5 were collected within 1/2 hour of eachother, and all with 5 m of ML.

JANUARY 10, 1991

91-SLM-6 GILLSON BEACH
Piece of a relatively dirty block of brash ice from a zone of semi-consolidated slush/brash ice near the outer ice ridge.

91-SLM-7 GILLSON BEACH
Piece of relatively dirty brash ice from slush/brash ice belt. Collected 1 m from #6.

91-SLM-8 GILLSON BEACH
Dirty piece of pancake ice from slush/brash belt. Sample was covered by a 1 cm layer of clean ice. Collected within 1 m of sample #6, and 2 m of sample #7.

91-SLM-9 GILLSON BEACH
Dirty brash ice collected from slush/brash zone.

91-SLM-10 GILLSON BEACH
Sample of grounded ice ridge. Collected from above the water line.

91-SLM-10 GILLSON BEACH
Sample of same grounded ice ridge as #10. This sample was collected 1 m higher in the ridge and appeared to contain less sediment.

JANUARY 11, 1991

91-SLM-12 GILLSON BEACH
91-SLM-14
91-SLM-21
These 3 samples are overwash from an ice volcano on the ML. The samples were collected by holding the open sample jars about 50 cm from the edge of the volcano and collecting slush and water as it splashed up out of the volcano mouth. The ice in the samples was fairly coarse. These samples should represent sediment concentrations in the slush at the ice/water interface.

91-SLM-15 GILLSON BEACH

Overwashed slush about 3 m from the edge of volcano. This material may or may not have been in contact with the slush of the volcano, and some of the water may have percolated out. Elevation here was about 50 cm lower than at ice edge.

91-SLM-17 GILLSON BEACH
Sample from bottom of ice volcano; elevation ~50 cm lower than #15.

91-SLM-13 GILLSON BEACH
0-20 cm
20-60 cm

91-SLM-16
0-20 cm
20-40 cm
40-60 cm
Cores #13 and #16 cores were collected on the ice volcano, about 1.5 m back from the edge, to see how filtration worked. Sample #16 was taken at about 1330, 1/2 hour after 13. The start horizon is marked by methyl blue. The upper 20 cm of core #16 was new ice deposited above the methyl blue horizon. See also core #22 taken at the same location later in the day.

91-SLM-18 GILLSON BEACH
0-50 cm
50-100 cm
Top of core was about 2 m above lake level. Sample location was 2.5 m from ice edge. Core is 1 m long, sediment is evenly distributed throughout, with no gradations. Ice contained several 1-cm-wide solid, clear, hard ice masses in a relatively fine grained matrix. From 50-100 cm there were fine silts.

91-SLM-19 GILLSON BEACH
0-40 cm
40-85 cm
Top of core is 40 cm lower (down lee face) and 5 m inshore of #18, 2.5 m from edge of ice. 1 meter long core with sand disseminated throughout; in the upper 40 cm with occasional small ice crystals. 40-85 cm gradually becoming more turbid with larger clear ice crystals up to 7 mm. 85-110 cm softer ice. May have been taken below lake level; cleaner than above with no obvious clear ice crystals.

91-SLM-20 GILLSON BEACH
0-35 cm
35-90 cm
95-110 cm
Core #20 taken 5 m inshore of core #19 where the ice surface was 40 cm above the lake level. 0-35 cm granular with large ice crystals (like the middle of core 19). Section 35-95 cm had a sharp upper boundary and consisted of remarkably unconsolidated clean ice, larger granules (5 mm) than at top and bottom (0.5 mm?). 95-110 cm sediment-rich granular, slush ice increased toward the base.

91-SLM-22 GILLSON BEACH
0-5 cm mostly above dye
5-10 cm with dye
10-60 cm below dye
Core 22 was taken at same spot as #13, 3 hrs later where 30 cm of slush had built up on top of dye.

91-SLM-23 GILLSON BEACH
91-SLM-24
91-SLM-25
91-SLM-26

Slush ice samples collected with a dip net lakeward of the ice ridge. All of the samples were collected within 2 m of ice/water boundary, and were drained for about 30 seconds before sampling

JANUARY 12, 1991

91-SLM-27 GILLSON BEACH
91-SLM-28
91-SLM-29
91-SLM-30
91-SLM-31
91-SLM-32
Samples #27-32 were taken at the end of the pier north of the Wilmette Harbor entrance. They are representative of the slush in the dense mobile slush belt.

91-SLM-33 ILLINOIS BEACH STATE PARK
91-SLM-34
91-SLM-35
These samples were all collected along a transect across and lakeward of a 30-m-wide icefoot at Illinois Beach State Park. #33 is slush ice from between pancakes offshore of the icefoot. #34 is from the surface of a 2-m-diameter pancake that was immediately adjacent to the fast ice edge. #35 is a piece of the icefoot. The icefoot appeared to be considerably dirtier than the pancake ice offshore.

JANUARY 13, 1991

91-SLM-36 GILLSON BEACH
91-SLM-37
91-SLM-38
Samples #36-38 were taken from slush/brash belt remnants off Gillson Beach after most of the ice had pulled away from the NIC during a day of westerly wind. This belt was only loosely attached to the NIC. All 3 samples represent dirty slush balls submerged below clean looking, surficial pancake ice. #36 taken about 8 m lakeward of major ice ridge. #37 taken about 50 m lakeward of major ridge. #38 as #37, just inside of ridge remnant.

JANUARY 14, 1991

91-SLM-39 GILLSON BEACH
Sample #39 was taken from lake bottom along Main Line about 142 meters from central lamp post(Point 0,0 in survey). Large "ball" surrounded by halo of plate-shaped ice which dislodged when "ball" was moved. "Ball" was negatively buoyant.

91-SLM-40 GILLSON BEACH
Brash/slush sample taken from end of line SL2 where shorefast ice was breaking up into large (>1.5 m diameter) pancakes. As ice pancakes separated, large balls (up to .5 m in diameter) were dislodged and accumulated between pancakes. Three smaller balls were sampled. Larger balls appeared to be "dirtier" but could not be easily broken up by hand.

91-SLM-41 GILLSON BEACH
91-SLM-42
91-SLM-43
Samples #41-43 collected from a boat, consist of small drifting brash balls drifting lakeward under offshore winds, several hundred meters from the coast and at a water depth of about 6 m.

91-SLM-44 GILLSON BEACH
91-SLM-45
Samples #44 and #45 were taken from two ice balls that were sampled along the edge of at a fast slush/brash zone. After cutting in half with a saw is was obvious

that there was a thin rind (1-5 mm) of sediment on the outer edge. The samples are to demonstrate that difference. Sample #44 is the ice ball exterior 1-5 mm. Sample #45 is the interior and appeared siltier.

JANUARY 15, 1991

91-SLM-46 GILLSON BEACH
Sample #46 was brash ice taken at the outer edge of the fast slush/brash belt between pancakes: a very dirty piece that appeared to have pellets and fine grained material rather than sand. Dirty water ran out when we lifted out the sample. Was the biggest, dirty piece in area, but not unique.

91-SLM-47 GILLSON BEACH
This sample is composed of the thin sheets of pancake ice that formed on the water outside of the fast ice. It appeared very clean.

91-SLM-48 ILLINOIS BEACH STATE PARK
91-SLM-49
Samples #48 (slush) and #49 (brash) were taken from a narrow slush/brash belt at Illinois Beach State Park Resort. They are both typical of the material from this belt.

JANUARY 16

91-SLM-50	GILLSON BEACH
0-3 cm	sandy surface layer
3-12 cm	cleaner (siltier than above)
12-13 cm	sandy layer
13-20 cm	cleaner

91-SLM-51	
0-3 cm	sandy surface layer
3-8 cm	cleaner
8-10 cm	dirty layer
10-17 cm	cleaner

Samples #50 and #51 were taken to see if any layers could be seen in a core inserted perpendicularly into the interior side of a volcano. The layers would be caused by sand being deposited on the interior of the cone by slush swashing around in a circular motion plastering sediment to the inside.

91-SLM-52 SOUTH OF GILLSON BEACH
Sample #52 is a dip net sample of slush/brash from the 1 cm thick or less drift ice that was moving along shore to the south offshore and to the north inshore. There were also bigger pieces of ice that were dirtier but they composed only about 1-2% of the brash/slush belt.

91-SLM-53 GILLSON BEACH
0-20 cm
120-140 cm
Sample #53 was a core taken in the slush/brash belt that had accumulated in the morning against the ice ridge. This ice formed not as a volcano or an overwash process, but as gentle push against the grounded ridge. The lower segment appeared to have more sediment. Water level was about half way down the core.

91-SLM-54
Missing.

91-SLM-55 GILLSON BEACH
Samples of ice from bottom of ice foot cores.

JANUARY 17

91-SLM-V1	station 1 *VERSLUIS*
91-SLM-V2	station 2
91-SLM-V3	station 3
91-SLM-V4	station 4
91-SLM-V5	station 5
91-SLM-V6	station 5
91-SLM-V7	station 6
91-SLM-V8	station 7
91-SLM-V9	station 8
91-SLM-V10	station 9
91-SLM-V11	station 10
91-SLM-V12	station 11

Samples labeled 91-SLM-V# were taken from the City of Chicago Water Department vessel *Versluis* as it transited bands and patches of ice up to 10 km from the Illinois coast (See Table 3 for latitudes/longitudes). All samples are representative of the ice at that particular station, with the exception of #V5 and #V12. #V5 was composed of the thin, clean pancakes that formed some streamers. #V12 was composed of one of the dirtiest pieces of ice encountered.

91-SLM-55 GILLSON BEACH
Surface sample of slush ice and water from the inner edge of the slush ice band moving offshore. The inner edge of the slush ice layer was about 30 cm thick. Samples #55-60 were all collected at the same time and in the same general area. The ice was unconsolidated, small pieces of brash and slush.

91-SLM-56 GILLSON BEACH
Water sample from 30 cm depth. Collected near #55.

91-SLM-57 GILLSON BEACH
Slush ice sample from 30 cm diameter pancake; looked very clean.

91-SLM-58 GILLSON BEACH
From a 75-cm-diameter brash ice block cored with a sample bottle.

91-SLM-59 GILLSON BEACH
Small pieces of slush ice collected from the water surface.

91-SLM-60 GILLSON BEACH
Water sample collected from 30 cm depth. Samples #55-60 were all collected within 5 m of each other, but during the ~ 10 minutes it took to collect them, ice drifted about 90 m to the east. This suite of samples should be a fair representation of the material that was moving obliquely alongshore at the time.

91-SLM-61 GILLSON BEACH
Water sample collected from 70 cm depth (~50 cm above lakebed) 1 m from the ice edge.

91-SLM-62 GILLSON BEACH
Water sample collected near the fast ice edge to compare to #63 and #64.

91-SLM-63 GILLSON BEACH
Anchor ice sample that broke from the bottom and floated to the surface. Collected within 5 m of the ice edge.

91-SLM-64 GILLSON BEACH
Anchor ice sample is very poorly sorted. There is everything from coarse sands (granules or pebbles) to clays and silts. There is also a clam. This ice sample floated to the surface during diving operations.

JANUARY 19, 1991

91-SLM-65 GILLSON BEACH
91-SLM-66
91-SLM-67
These 3 anchor ice samples were collected within 2 m of the offshore edge of the NIC. These samples are atypical because they were much bigger than the typical anchor ice masses we saw. The crystals in these masses were up to 5 cm in diameter and 1 mm thick. Sediment was found scattered on the surface of these crystals, and sediment concentration appeared to be highest near the bed where the anchor ice was attached or growing into the sand substratum.

JANUARY 20, 1991

91-SLM-68 ILLINOIS BEACH STATE PARK
Collected from the sparse drifting brash within 3 m of the shoreline and undercut ice foot. The sample was taken just north of the Park Office and consisted of large brash broken from the ice foot further north and small brash of less than 10 cm diameter.

JANUARY 21, 1991

91-SLM-69 GILLSON BEACH
Slush/brash sample taken at the base of the ice ridge wall forming the outer ridge of the NIC.

91-SLM-H1 HELICOPTER SAMPLES
91-SLM-H2
91-SLM-H3
91-SLM-H4
91-SLM-H5
91-SLM-H6
91-SLM-H7
91-SLM-H8
Samples 91-SLM-H# were taken from a helicopter offshore of the southern Illinois and western Indiana shoreline (See Table 3 for latitudes/longitudes).

91-SLM-70 ILLINOIS BEACH STATE PARK
Water sample taken 60 cm above the lakebed.

91-SLM-71 ILLINOIS BEACH STATE PARK
91-SLM-72
91-SLM-73
These 3 samples were collected lakeward of the Park Office. #71 and #72 were combined slush ice and surface water collected about 8 m offshore within a mass of moving slush ice. Sample #73 is a surface water sample collected just outside the ice mass (and at the surface).

JANUARY 22, 1991

91-SLM-74
91-SLM-75
91-SLM-76
Air temperatures this morning were about 7 degrees F, with a weak offshore wind, and therefore, no waves. On the surface were numerous masses of brownish ice, 20 to 50 cm in diameter, and very fragile, composed of small ice crystals. Three samples where skimmed off the surface with the dip net. #74 from a 100 square meter surface sweep. #75 from one 15 m x 20 cm sweep 4 m from NIC scarp. #76 from a floating batch of anchor ice.

91-SLM-77 GILLSON BEACH

6 cm diameter ball of anchor ice that was floating on the surface in 1 m of water. This anchor ice was in a tongue of cleaner looking (but still dirty) anchor ice that was drifting slowly to the NW.

91-SLM-78 GILLSON BEACH
91-SLM-79
These 2 samples were collected 12 m off the ice edge on the ML. #78 was a water sample that was gathered from about 20 cm depth just outside the slush ice band. #79 was a representative sample of ice and water that was floating on the surface.

91-SLM-80 GILLSON BEACH
Floating anchor ice sample containing lots of organics collected with dip net after traversing about 10 m of the surface offshore of the NIC.

JANUARY 23, 1991

91-SLM-81 GILLSON BEACH
Anchor ice sample collected in 80 cm water depth, 10-15 m off NIC just south of ML.

91-SLM-82 GILLSON BEACH
Water sample collected with 2 liter bottle on sandbar where anchor ice (#81) was collected, 10 cm above the lake bottom in 80 cm water (bottle was inverted and brought to 10 cm from bottom before filling).

91-SLM-83 GILLSON BEACH
Anchor ice sample collected in 80 cm of water, 10-15 m off NIC ridge on ML. This sample was collected by wafting anchor ice into a 2 liter bottle. This anchor ice was dislodged from the bottom, not found floating.

91-SLM-84 GILLSON BEACH
Water sample collected on the surface in the same way and within a minute of sample #82. Collected in the area where anchor ice was seen on the bottom.

91-SLM-85 GILLSON BEACH
Slush & water sample collected from 60 cm water depth. It contained water and very little slush. This sample was collected about 20 m off the NIC on the ML.

91-SLM-86 GILLSON BEACH
This was a representative sample of crystalline anchor ice that was picked up from the lake bottom at 70 cm water depth, about 25 m offshore (on a sandbar) This hand sized piece was retrieved from a mass that covered an area of over a square meter, and is representative of the entire mass. The ice crystals at the bed were about 1 cm in diameter at the bed, and increased to 2.5 cm at the surface of the mass (about 8 cm thick. The crystals were randomly oriented, and sand was concentrated in the interstices between crystals. Sand also adhered to the clear, thin crystal faces. There was little decay of the ice once it was taken from the water, because the air temperature was well below freezing. This sample was well drained before processing, so it represents the sand incorperated in anchor ice. The bottom part of the sampled ice mass was discarded to ensure that the sand at the base was the result of anchor ice growth.

91-SLM-87 GILLSON BEACH
Anchor ice sample that floated to the surface. Collected with dip net. Contains lots of organic material.

JANUARY 24, 1991

91-SLM-88 GILLSON BEACH
91-SLM-89
91-SLM-90

These 3 samples were collected about 100 m offshore, in about 3 m of water. 40% of the surface was covered with slush. However, the slush ice layer was thin and not densely packed, so the amount of ice in the water column was very low. #88 was a typical sample of slush and interstitial water collected with a 2 liter bottle. #89 was water collected from 50 cm below the water surface. The sample was collected by placing the inverted bottle into the water and then turning it right-side-up. #90 was part of a condensed ball of slush and water about 30 cm in diameter. These balls were rare.

91-SLM-91 GILLSON BEACH
91-SLM-92
These 2 water samples were collected at 10 cm depth (#91), and at 100 cm (#92) depth. Collected 8 m lakward of the NIC. There was no ice in these samples.

91-SLM-IN1 OGDEN DUNES, INDIANA
91-SLM-IN2
91-SLM-IN3
91-SLM-IN4
91-SLM-IN5

Samples 91-SLM-IN# were collected as a transect across the NIC at the Bath House at Ogden Dunes, Indiana. #IN1= inner ridge, IN2= Lagoon and brash ice between inner and outer ridges, IN3= outer ridge, IN4= slush/brash belt, IN5= ice foot.

91-SLM-MI1 PIER ST., LAKESIDE, MICHIGAN
91-SLM-MI2
91-SLM-MI3
91-SLM-MI4
91-SLM-MI5
Samples 91-SLM-MI# were collected as a transect across the NIC at the Pier Street locale, Lakeside, Michigan. #MI1= ice foot, MI2= lagoon and brash ice between the inner and outer ice ridges, MI3= inner brash belt, MI4= outer ridge, MI5= slush/brash belt.

JANUARY 25, 1991

91-SLM-93 GILLSON BEACH
Sample #93 consisted of thin (2-5 mm) ice sheets from under surface of 2-3 cm thick nearshore ice which formed overnight. These sheets formed a loose mass on the undersurface of that ice. Loose interlocking mass was 5-10 cm thick. Much dirtier than the surface congealed ice.

91-SLM-94 GILLSON BEACH
Large dirty brash collected in a ice ridge re-entrant along the NIC edge. It was rolling on the bottom adjacent to the juncture of the ice ridge and the lake bed and represents a dislodged piece of the ridge that was laden with sediment. 2-5 cm masses of crystalline ice occured in the matrix of slush ice and sediment.

91-SLM-95 GILLSON BEACH
91-SLM-96
91-SLM-97
Three samples collected on NL2 at about 0930. All of these samples were in the zone between a new NIC ice ridge and the offshore ice from an area of 15 cm to 1 m wide clean ice bands. Ice was 1 to 4 cm thick. #95 is parts of several different pieces of broken-up brash ice that were specifically chosen because sand was readily apparent in them. This sand was usually concentrated on the surface. #95 represents 10 to 25% of the ice 6 m of the NIC edge. #96 consists of randomly collected pieces of the floating brash ice. #97 is a water sample collected by inverting a 2 liter water sample and turning it over at 20 cm depth in 1.5 m of water. There was > 90 percent ice cover at this time, but the ice was generally only 1 layer (i.e. 1-4 cm thick), although occasional larger pieces drifted past.

91-SLM-98 GILLSON BEACH
91-SLM-99
91-SLM-100
91-SLM-101
91-SLM-102
91-SLM-103
91-SLM-104
Samples 91-98 are core samples collected along the ML to determine the amount of sediment in the NIC. The core's location was surveyed in (0125mlon.dat and 0125mlic.dat). All samples were collected with a 8.4 cm internal diameter Cipre corer. #98= ice ridge, #99= ice ridge core, #100= ice ridge core, #101= lagoonal ice, #102= lagoonal ice, #103= ridge ice, #104= ice foot (removed 1 cm from bottom of core #104 because of possible contamination from lakebed.

JANUARY 26, 1991

91-SLM-105 GILLSON BEACH
Anchor ice sample collected about 15 m offshore from NIC at 0900. The sample had just broken free from the lake bottom. This is a drained sample. Dimensions were 20 x 25 x 20 cm, and individual ice crystals were 10 cm in diameter and about 1 mm thick. Many of the crystals had a shape reminiscent of a Christmas tree. This anchor ice was unusual because of its large size (both dimensions and crystal sizes) and because of the relatively small amount of sediment seen in the sample. The sediment was adhering to crystal faces.

91-SLM-106 GILLSON BEACH
Strong offshore winds deposited this sample on the lagoonal ice by eolian transport from the beach. No water was associated with this material.

91-SLM-107 GILLSON BEACH
Anchor ice sampled from offshore bar crest (70-80 cm depth) during dive. This sample was collected by breaking anchor ice masses loose from the bottom and collecting whatever material floated to the surface. The sediment concentration is conservative, because in addition to anchor ice, a fair amount of water was collected. The samples consisted of crystals up to 5 cm in diameter and < 1 mm thick, collected by carefully scooping them up with the lid of the collecting bottle. Both crystals and water were placed in the bottle. Estimate about 50% water and 50% ice included in sample.

91-SLM-108 GILLSON BEACH
This anchor ice sample was collected in the same area and at the same time as #107, but each crystal was allowed it to drain before being put it into sample bottle.

91-SLM-109 GILLSON BEACH
Lakebed samples from the 70 cm deep bar crest where anchor ice sample #108 was collected.

91-SLM-110 GILLSON BEACH
91-SLM-111
91-SLM-112
91-SLM-113
91-SLM-114
91-SLM-115
91-SLM-116
91-SLM-117
91-SLM-118
Samples #110-118 consists of cores collected along the outer NIC ice ridge to get a larger statistical sample for sediment distribution in the NIC. All of the samples were collected from the upper 94 cm of the NIC and, thus, most of the cores did

not penetrate the base of the ice ridge. #110= 10 m west of ML, midway up ice ridge; #111= on NL2, midway up a ridge behind a small re-entrant; #112= on NL4 on ice ridge; #113= on outer ice ridge on NL6; #114= On SL6; #115= 4 m from edge of ice on SL2; #116= On SL4; #117= lagoonal ice exposed to waves; sediment in this core was not uniform, sand was concentrated in the top 2 cm where it was washed up by wave action during the last 2 days; #118= collected from throat of a recently formed large ice volcano.

JANUARY 27, 1991

91-SLM-119 GILLSON BEACH
A single anchor ice crystal that was 7 cm x 3 cm x 2 mm thick. This crystal, which was floating on the surface, had a 7 mm by 3 mm granule attached to it.

91-SLM-120 GILLSON BEACH
A compact piece of "anchor ice" composed of crystals 2 cm in diameter and < 1 mm thick that was collected from 40 cm water depth at the edge of the NIC by the ML. The term "anchor ice" is used advisedly, because this ice was attached to the NIC below the water level. However, it is obvious that this sample grew *in situ* overnight. The ice in this sample was different from the anchor ice collected from the lakebed offshore in that the individual crystals were smaller, and appeared to be more densely packed together. This type of ice appeared to be growing more or less continuously along the outer edge of the NIC.

91-SLM-121 GILLSON BEACH
Loose floating anchor ice that had a semi-consolidated cap 1 cm or less thick. Below this cap were randomly oriented anchor ice crystals. Collected with a dip net and drained before processing.

91-SLM-122 GILLSON BEACH
Similar to #121. This sample is all the floating anchor ice from a 1/3 m square area on range SL2. Collected with a dip net and drained before processing.

91-SLM-123 GILLSON BEACH
Loose brash ice from base of ridge complex collected from 40 cm water depth. The ice crystals in this sample were much smaller than the anchor ice crystals. Had a look of a "mushy ball" when floating.

91-SLM-124 GILLSON BEACH
Floating anchor ice mass collected from under the solid congealed ice. Collected with a dip net and drained before processing.

	GILLSON BEACH
91-SLM-125	upper core
91-SLM-137	lower core
91-SLM-126	upper core
91-SLM-138	lower core
91-SLM-127	upper core
91-SLM-139	lower core
91-SLM-128	upper core
91-SLM-140	lower core
91-SLM-129	upper core
91-SLM-141	lower core
91-SLM-130	upper core
91-SLM-142	lower core

91-SLM-131 upper core
91-SLM-136 lower core

91-SLM-132 upper core
Samples #125-132 (upper) were cores collected on an ice volcano in a cross pattern with the axes running shore-normal and shore-parallel. Only one length (90 cm) of corer was used. A second length of core (lower) was taken on Jan. 28 (samples #136-142)in all of these holes except for #132 . These cores did not necessarily penetrate to the base of the ridge; most only penetrated to about lake level. Core #132 cored into the water at the lakeward toe of the volcano.

JANUARY 28, 1991

91-SLM-133 GILLSON BEACH
Piece of anchor ice that was 92 x 63 x 15 cm found on lakebed where glacial till is exposed. Sample is stratified granular material in an ice matrix. Piece was nearly neutrally buoyant, and buried flush with the bed. This sample was unusual and atypical.

91-SLM-134 GILLSON BEACH
Pieces of anchor ice; mostly individual crystals collected with a dip net. These samples were collected from 75 m to 175 m offshore. Most of the crystals were less than 5 cm in diameter, and had granules only along 1 edge or in the middle. These ice crystals were more or less ubiquitous.

91-SLM-135 GILLSON BEACH
A surface water sample collected in the same area as #133.

JANUARY 29, 1991

91-SLM-143 GILLSON BEACH
Pieces of slush ice collected from the surface at 1000. This ice was collected at a distance of 8 m offshore from a new ridge. Ice at the sample location was in contact with the lakebed at a depth of 1.2 meters.

91-SLM-144 GILLSON BEACH
Water and slush ice collected from the same area as #143. This water was ponded in low spots in the ice (in the center of pancakes?).

JANUARY 30, 1991

91-SLM-145 GILLSON BEACH
Water sample collected from 30 cm water depth between pancakes located 230 m offshore.

91-SLM-146 GILLSON BEACH
Piece of the dirty ice that floated free from the underside of an ice pancake; probably from about 1 m depth. Same location as #145. This piece was about 10 x 15 x 5 cm and very hard. Only 5% of the pieces were this dirty.

91-SLM-147 GILLSON BEACH
91-SLM-148
These two samples were drained slush ice broken from pancakes and collected 230 m offshore. These samples are typical of the subaqueous part of the drifting pancakes.

JANUARY 31, 1991

91-SLM-149 GILLSON BEACH
Water sample collected 8 m off the NIC edge from 20 cm depth.

91-SLM-150 GILLSON BEACH
Water sample from 20 cm below the water surface.

91-SLM-151 GILLSON BEACH
A sample of combined slush and water collected at the surface 8 m off the NIC edge (collected within 1 minute of #149).

91-SLM-152 GILLSON BEACH
Slush ice collected 12 m off NIC edge, representative of dirtiest 20% of the slush ice zone. Water was drained from this sample. The ice was predominantly plates of solid ice about 1 cm thick and several cm in diameter, with sand attached to its outer surface. This sand would fall off the ice if when moderately agitated.fx

91-SLM-153 GILLSON BEACH
Surface water and slush ice sample collected 75 m offshore.

91-SLM-154 GILLSON BEACH
Piece of an extremely dirty piece of brash 1 m in diameter. This piece consisted of ice plates held together by a matrix of slush ice. The mass could be readily broken up with only moderate pressure (it was not frozen together). This piece represented ice found in the lower part of the ice ridge that was breaking up under wave action: the ice at the top of the new ridge did not appear to be nearly as dirty.

91-SLM-155 GILLSON BEACH
Bulk slush/water sample 75 m offshore. Consisted of floating ice and surface water.

91-SLM-156 GILLSON BEACH
Bulk slush/ice water sample collected from about 50 m past NIC edge.

FEBRUARY 1, 1991

91-SLM-157 GILLSON BEACH
A lakebed sample of sand collected 100 m offshore. Sample was collected by dragging 2-liter jar across ~1 m of bottom, never penetrating more than 5 cm. Sand was rippled, with wavelength of 10 to 15 cm and a height of 2-4 cm.

91-SLM-158 GILLSON BEACH
Bottom sample in glacial till 75 m offshore. Sample was collected by dragging jar across 2 ripple wavelengths (wavelength = 50 to 70 cm, height to 15 cm). This material is very representative of all the till along the ML, and of the till/lag seen elsewhere, except where boulders are present.