GREAT LAKES HEALTH

Reconstructing Low Lake Levels of Lake Michigan

Final Report

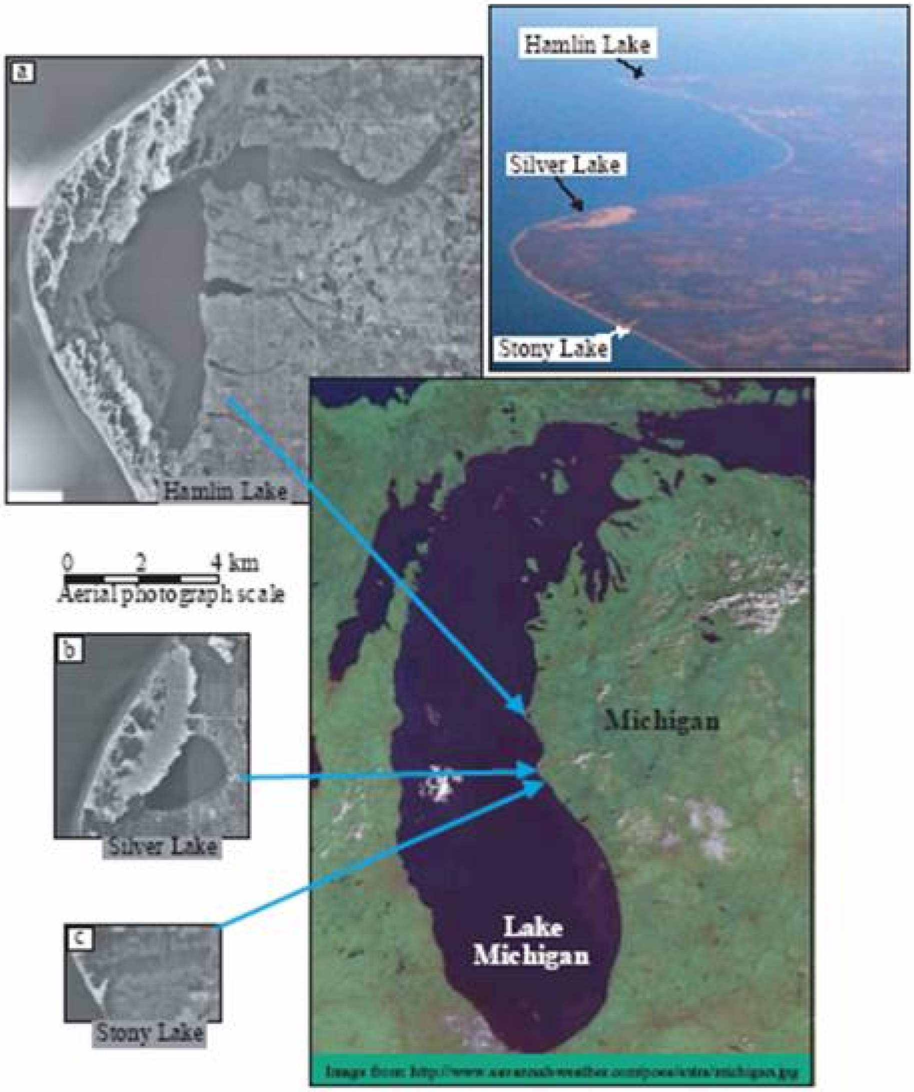
Abstract
To reconstruct low lake levels of Lake Michigan, 16 vibracores of lake sediment along the west coast of the Lower Peninsula of Michigan have been collected. The cores have been split and described and sedimentary contacts between wetlands and deeper water sediment are being radiocarbon dated to determine when the Nipissing transgression drown these lakes and estuaries. Eolian sand in lake cores is being quantified with peaks in sand % corresponding to high lake levels for the last 4700 years and a newly discovered ~600 year cycle. Because the sand record extends beyond 4700 years we are able to determine that a ~190 yr and ~600 cycle of lake level fluctuation extends back at least 6600 years, and perhaps further. Knowledge of lake levels will better equip industrial, civil and private activities along the Lake Michigan coastline.

Introduction
This research is intended to provide information on past low lake levels of Lake Michigan, to better understand why there have been lower lake levels in the past, and to better predict and thus prepare for future low lake levels. Lakes cored are along the west coast of Michigan (Fig. 1).

The objectives stated in the proposal are:

- to reconstruct lake level between the Chippewa Low and Nipissing High Phases.
- is to look for the ~160 year lake-level fluctuation or other quasi-periodic fluctuations in lake level between the Chippewa and Nipissing II Phases
- is to identify the low lake levels in estuaries of the western coast of Michigan since 1918 using sedimentologic indicators constrained by 210Pb and 137Cs dating.

Figure 1. Location map of the three lakes cores. From Weyer (2005.)



Methods

Seven field excursions resulted in 16 sediment cores collected for analysis. Some of the field-work was designed to collect information on lake bathymetry and sub-surface stratigraphy of the sediments, but was only partially successful due to the high amount of gas in the lake sediment that prevented penetration of the sound waves. The PI had a pontoon boat built from which to collect cores in the summer. Otherwise cores were collected from lake ice using the same coring equipment; a piston equipped vibracorer (Fisher, 2004).

The cores were split at the University of Toledo, photographed, broken down into units, and then analyzed for the following: unit thickness, color, sediment type, lower contact, sedimentary structures, disturbances, organic & inorganic content (LOI), and particle size. Radiocarbon dates were determined from wood close to contacts between wetland and lake sediments, as well as in the lake sediment. Radiocarbon ages were determined from a commercial lab (Beta) in Flordia and at the Centers for Mass Spectroscopy (CAMS) in California. Optically stimulated luminescence (OSL) dating was carried out by Dr. Steve Forman at University of Illinois, Chicago to date the length of burial of sand grains in the lake sediment. The equipment at the University of Toledo for dating the sediment using the 210Pb and 137Cs broke, and the owner did not repair it due to cost and changes in his research focus. A few OSL samples were run at the Great Lakes Water institute at the University of Wisconsin-Milwaukee to verify that the uppermost sediment in some cores was modern.

The sand signal in the cores was the focus of a MS thesis by Ms. Kelly Weyer with the following lab protocol taken from her thesis (Weyer, 2005): The sand signal refers to the variation in wt. % sand with depth in the lacustrine sediment. The sampling interval used was determined using the radiocarbon date at the base of the gyttja unit. The targeted interval was 33 years, since that was the highest-frequency beach ridge cycle in the LMRLLC (Lake Michigan relative lake-level curve). The steps involved in obtaining the sand signal are as follows. Ceramic crucibles were the dominant vessel for the sediment during this process. The processing began by recording the weight of the clean, dry crucible. The sample was removed from the core and placed into the crucible. The weight of the wet sediment and the crucible was recorded, although moisture content had declined between the time when the core was collected, and when it was analyzed. The crucible and the sediment were placed in the oven to dry at 100ºC for a minimum of 18 hours. The crucible and sample were taken out of the oven and allowed to cool, then the weight of the dry crucible and sample was recorded. The crucible with the sample was placed in the muffle furnace at 550°C for four hours to burn off the organics (loss-on-ignition, LOI). The crucible with the sample was again allowed to cool and the weight of the crucible with sample was recorded. Since the modern dune sand was tested with HCl and there was no reaction, HCl was used to remove any carbonate from the lake sediment. The acid was then diluted and the remaining sample wet sieved using a 63-micron screen (separation between very-fine sand and very-coarse silt) to remove all of the particles finer than very-fine sand. The final clean sand was put in the oven to dry at 100ºC for a minimum of 18 hours. Finally, the crucible with the clean sand was taken out of the oven, allowed to cool, then weighed.

Magnetic susceptibility was determined for three of the four cores in this study using a Barrington MS2E sensor connected to the Barrington MS2 meter, to evaluate whether the results would mimic the sand signal. The method was used since dune sand on the Michigan coast to the south, near Holland, MI, was determined to contain magnetic minerals (Hansen et al., 2003). Also, the sand from the cores and the modern Silver Lake dunes were tested with a magnet and were determined to contain magnetic minerals. If the sand signal and the magnetic susceptibility were in phase, with comparable amplitudes, then the magnetic susceptibility could be used a proxy for the sand signal. To measure magnetic susceptibility, the sediment had to be taken out of the aluminum tubing, since a test run on the sediment still in the aluminum coring tube produced spurious results. To remove the sediment from the coring tube, plastic wrap was draped over a piece of sheet metal cut to size. A slit was cut into the sediment from the widthwise middle toward the edge. The sheet metal was placed in the slit and the sediment was lifted out of the coring tube. The sheet metal was then placed on the lab countertop and the sediment underlain by plastic wrap was slid off the sheet metal. At this point, the sediment was wrapped with the plastic wrap. It was then placed on particleboard, approximately the size of the core, which had 1.25 cm markings used for the sampling interval. This sampling interval was chosen because it was half the diameter of the sensor surface. To avoid errors in the data due to temperature differences, the analysis did not proceed until the sediment and the sensor were at the same temperature (i.e. temperature of the room).

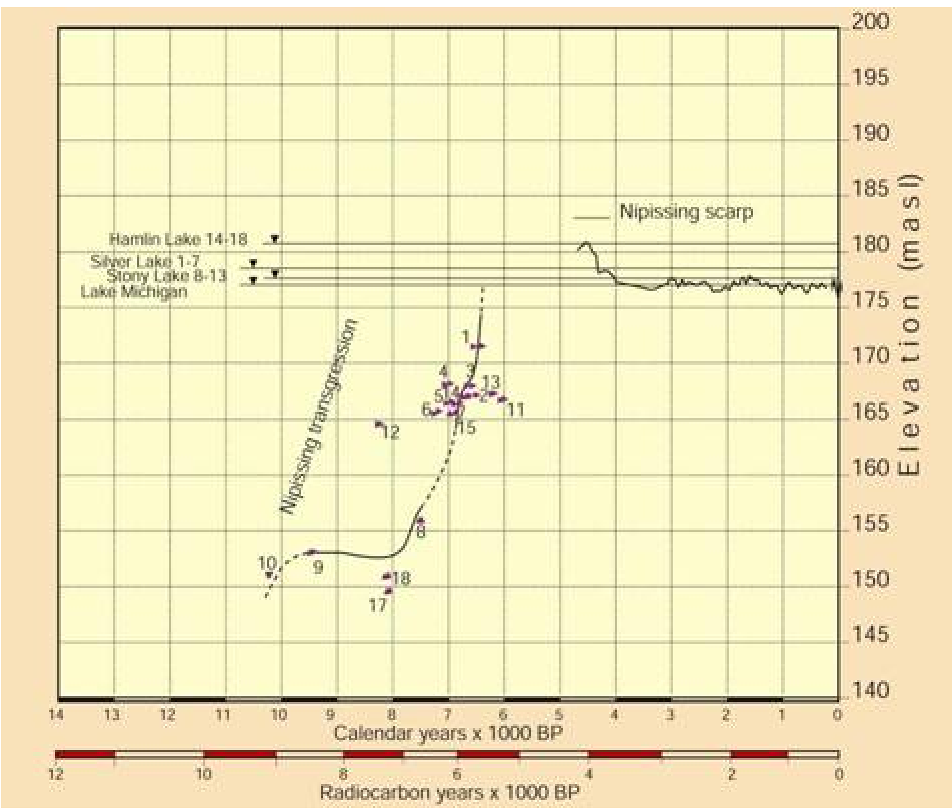
Once the materials were at room temperature, the Barrington MS2E sensor was connected to the Barrington MS2 meter and zeroed. Before the core was analyzed, the sensor was placed on the calibration sample and a reading was taken. The calibrated sample should always give the same value. It was checked before and after analysis of the core, to insure accuracy. After calibration, the magnetic susceptibility of the sediment was measured in 1.25 cm intervals, since this was ½ the width of the sensor. If the final calibration value was the same as the initial calibration value, that section of the core was finished and the previous steps were repeated the rest of the core was analyzed. Since the length of the sheet metal was 60 cm an entire core could not be completed a single run.

Results

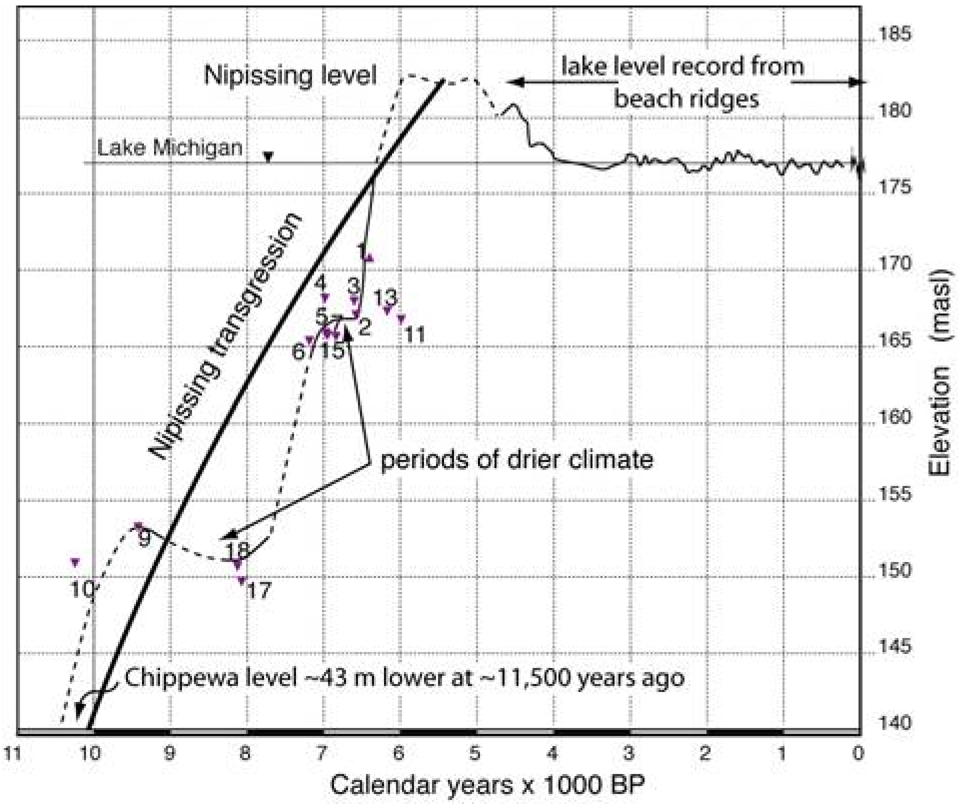
Nipissing Transgression

Numerous data points were collected that record a transition from a shallow wetland (peat or marl environment) to deeper water (gyttja sediment) in Silver, Hamlin, and Stony Lake basins, which was the focus of a MS thesis by Mrs. Amber Boudreau (nee Lahners). The ages and elevations were plotted after they were corrected for isostatic rebound (vertical movement of the crust responding to weight of the ice sheets). The data points are shown in Figure 2 and interpretations are indicated on Figures 2 and 3. On Figure 3, the dark line is the rising elevation of the North Bay sill driven by isostatic rebound. This sill controlled the elevation of lakes in the Michigan and Huron basin between 11,500–5500 years ago. If there were no changes in lake level caused by climate, this is what the lake level curve should have been. The dashed and solid thin line is the reconstructed lake level curve based on the collected data points, with the dashed lines being an extrapolation. With lower and flatter lake levels indicated by the data, we interpret that climate was drier, and that there were periods of warm climate and low lake levels during the mid-Holocene. Thus, the 1st objective of the research has been met, by reconstructing lake levels between the Chippewa Low and Nipissing II Phases. Although it should be noted that there are still gaps in the record, and the lake level curve presented is the first estimate for this time frame.

Figure 2. Lake-level curve for the central Lake Michigan Basin. Numbered points are the radiocarbon ages from this research and Fisher et al. (in press. From Boudreau (2005).



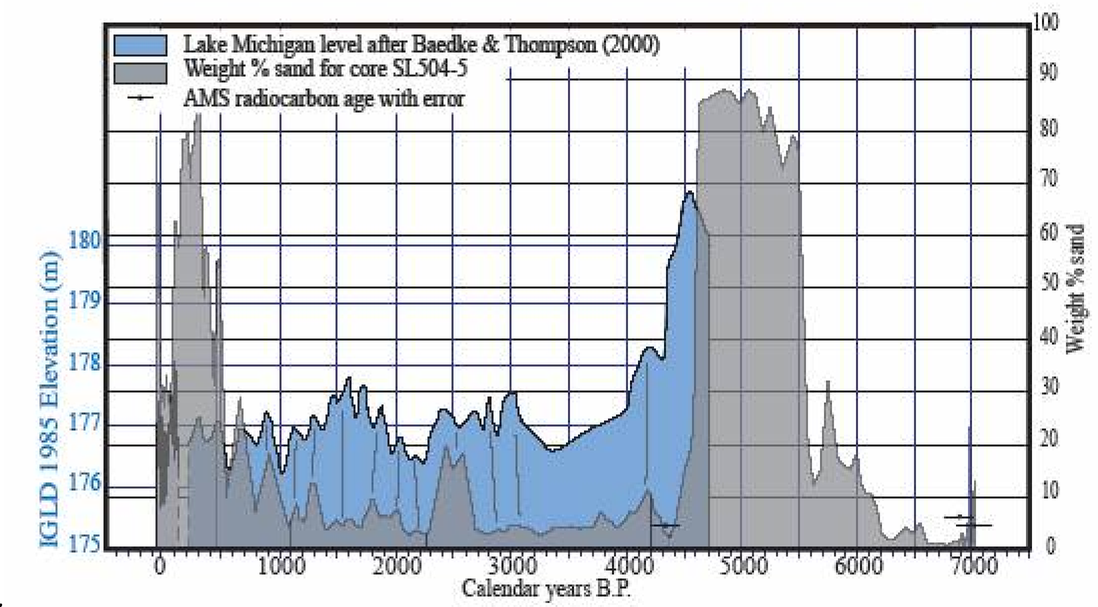
ure 3. Reconstructed lake level curve for the Nipissing transgression between the Chippewa and Nipissing II Phases.



Sand Percentage in lake sediment

From the four cores analyzed for a sand signal, the sand was directly measured, and indirectly measured using the magnetic susceptibility technique. The sand percentage in the cores varied and was similar to the signal observed by Fisher and Loope (2005). The following analysis comes from Weyer (2005). Peaks in sand coincide in time with high levels of Lake Michigan with two examples shown in Figure 4. Analysis of the data using time series methods revealed numerous cycles in all of the sand datasets (Table 1). The period with the highest magnitude and lowest frequency was between 466-588 years/cycle in all of the cores. A high magnitude cycle was found in core SL704-12 of 676 years/cycle. The next lower magnitude, higher frequency period ranged from 224 to 294 years/cycle in the cores. The lowest magnitude, highest frequency period determined in all of the datasets ranged from 182-196 years/cycle in the cores. Thompson and Baedke (1997) suggested that the highest frequency period is a ~160 year cycle in which 4-6 beach ridges formed every 120-200 years based on field evidence. Using the spectral analysis results, it was confirmed that a periods of 120-121, 148-156, and 182-196 years/cycle exist in the sand signals. Thus, the second objective has been met, that the ~160 year lake-level fluctuation and other cycles was found between the Chippewa and Nipissing II Phases, as well as from the Nipissing II Phase to modern. And perhaps most importantly, evidence for quasi-periodic cycles longer then 200 years have been found.

Figure 4. Sand signals for SL504-5 and SL704-12 compared to the LMRLLC. The ages were honored and constant sedimentation rate was assumed constant between the dates. From Weyer (2005).



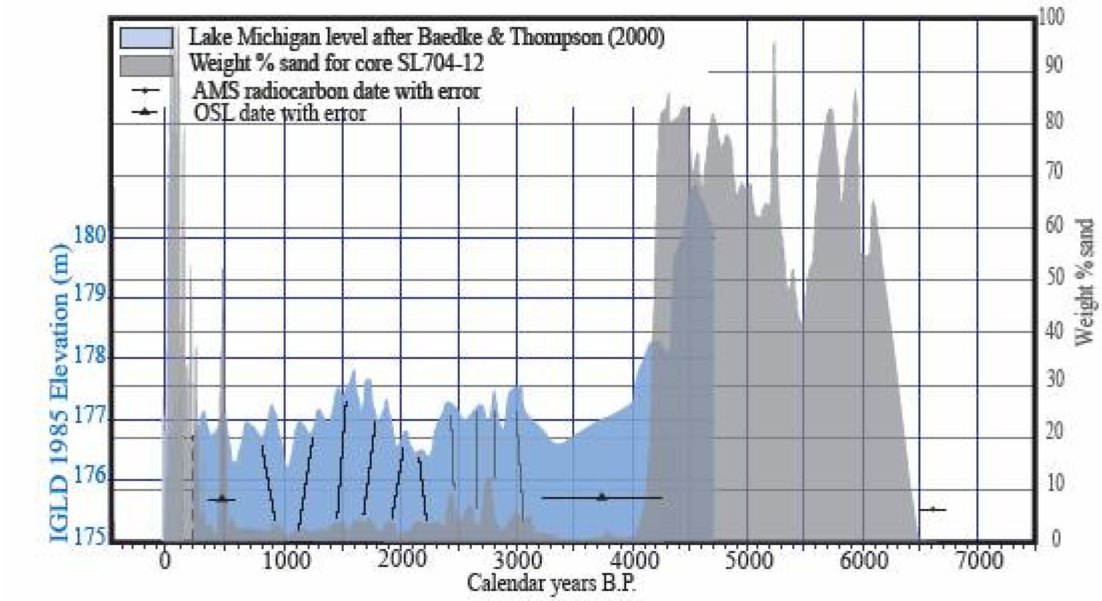


Table 1: Results of the spectral analysis for each core, the LMRLLC, and the combined raw beach ridge data from the Toleston beach and Sturgeon Bay locations and the Bailey Harbor embayment and the Sturgeon Bay embayments. Nyquist refers to the lowest period that can be obtained from the data (1/sample interval times 5). From Weyer (2005).

SL504-5	SL704-12	HL605-2	STL104-7	LMRLLC	Toleston and Sturgeon	Bailey Toleston Sturgeon
periods years/cycle	periods years/cycle	periods years/cycle	periods years/cycle	periods years/cycle	periods years/cycle	periods years/cycle
542	676	588	483	463	550	543
403	466	363	268	363	440	422
266	356	217	193	289	367	335
224	294	182	148	268	256	224
196	246	156	120	237	205 Nyquist	207
181 Nyquist	185	137	81	215		194 Nyquist
	170 Nyquist	121	76 Nyquist	200 Nyquist		
		104				
		92				
		84				
		78				
		51 Nyquist				

Wetland Cores

The first two sets of results used the vast majority of the IISG resources. The third objective was to identify the low lake levels in estuaries of the western coast of Michigan since 1918 using sedimentologic indicators constrained by 210Pb and 137Cs dating. A difficulty first arose because the analytical equipment owned by a colleague in the department broke and was not fixed. Nevertheless, a core was collected from Muskegon Lake, MI and was examined, but not dated. The coring site was against emergent macrophytes at a site called the Devils Kitchen in Snug Harbor in the NW corner of Muskegon Lake in 87 cm of water. A 69 cm core dominated by wood fragments and sand was examined.

The first appearance of zebra mussels in Muskegon Lake was in 1989 (Bydstun and Benson, 1992), and they appear at 28 cm from the top of the core. Some large layers of reworked 'clasts' of wood resembling driftwood on the swash zone of a beach made up the lower half of the core. The low stand in the Michigan basin at the same elevation of this wood was in 1964–1965. These results are speculative without more dating control and require replication, nevertheless, I am encouraged that finding stratigraphic evidence for low lakes levels is possible in estuaries along the Michigan coastline.

Conclusions

Cores from estuaries and former embayments of lakes in the Lake Michigan basin along the western coast of Michigan contain information on paleo lake levels. Two objectives were met with the lake level curve extended further back in time, and a ~160 yr and longer period of lake level change documented. The third objective was not met, but some preliminary data suggest that it could be met by future research.

Recommendations

Any recommendations for predicting future lake level would be premature at this stage, without developing a more robust data set, even though the research was successful in identifying cycles in lake-level change within the Lake Michigan basin. It is recommended that additional data be collected from Hamlin Lake and other lakes to the north and south of the study area within the same geomorphic environment. The additional data could be used to test the existing data and its interpretations, as well as augment the existing sand % and lake level data. The single core taken from Muskegon Lake offers some promise to directly measure past low-lake levels. Additional coring and geophysical transects (e.g., high resolution [frequency] ground penetrating radar) would determine if this is the case or not.

Potential Applications or Benefits

Pragmatic outcomes from this research will be the first estimate of a detailed lake level curve beyond 4700 years. From this curve, cycles in lake level were found which may aid in forecasting future lake levels. Moreover, without knowing the effects of anthropogenic alterations of the atmosphere (climate change underway in the last 100 years) future predictions of lake levels (and climate) become more challenging. One of the outcomes from the 1999 Great Lakes Paleo-Levels Workshop (Sellinger and Quinn, 1999) sponsored in part by NOAA Great Lake Environmental Research Laboratory were to develop methods to accurately determine low lake levels, and they found that research into low lake levels is important for water resource studies and to elucidate the linkage between climate and lake level. This research has collected data to begin addressing issues of low lake levels in the Great Lakes.

For industry and the concerned public, low lake levels reduce the carrying capacity of freighters, affect location of water intake pipes, dredging at marinas, boat ramps left high and dry, exposed littoral zones, and lake access during low levels.

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Keywords

Lake Michigan, Nipissing Phase, Chippewa Phase, eolian sand, vibracoring, lake levels, radiocarbon dating

Lay Summary

Lake levels in the Lake Michigan basin have changed by approximately 80 meters since 12,000 years ago. Evidence for lower lake levels are presently underwater, with only water level indicators, such as beach ridges, forming in specialized areas that record lake level change in the past 4700 years. The beach ridge record indicates lake level changes of about 2 meters over a ~160 year cycle, and of ~ 1 meter over a shorter cycle of about 33 years. This research using a record of changes in sediment type, and variability in wind-blown sand in small lakes downwind of coastal sand dunes revealed the following: 1) The rise in lake level from 10,000–6000 years ago was not constant but fluctuated, likely in response to changes in climate, perhaps sever enough that Lake Michigan was a closed basin for short periods of time. 2) Superimposed upon this rise in lake level were cycles approximately 200 and 600 years in length. Other than historical measuring of lake levels for about the past 150 years, past lake levels are poorly known. Knowing past low, and high, lake levels will better enable planning for future fluctuating lake levels.

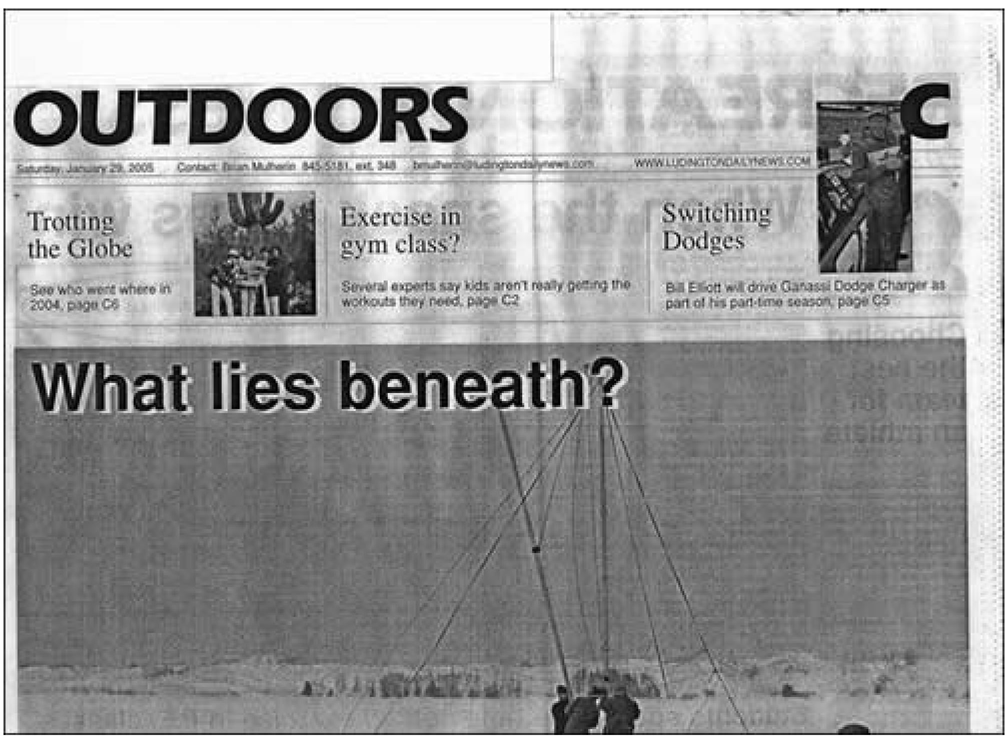
Partnerships

An additional graduate student, Ms. Brittany Fussell has begun examining the marl deposits within the cores collect for the IISG research. Brittany's interest is in reconstructing the paleoenvironments recorded in the marl in an effort to search for evidence of climate change associated with times of known climate change in the North Hemisphere. Specifically, the Younger Dryas (13,000–11,500 years ago), the 8200 year cold event (brief cooling 8200 years ago), and a warming and drying trend in the upper Mid-west during the mid Holocene. Tentative results are that there was a brief cooling around 8200 years ago (Fussell et al., 2006). The Illinois Geological Survey carried out isotope analysis of shells, and some of their researchers have expressed continued interest in this project.

My work over the past few years of coring lakes in western Michigan, in part funded by IISG, has resulted in new collaborative research with Dr. Ed Hansen of Hope College in Holland, Michigan (which has not been funded by IISG). I have collected a series of vibracores from lakes downwind of sand dunes in the Holland area with Dr. Hansen and his students. The sand dunes have been extensively studied and their paleosols dated. There appears to be a good relationship between dune reactivation and eolian sand deposited in the lake sediment. The lake sediment provides a higher resolution record of eolian activities and thus is providing more information of the history of the coastal dune complexes, which has management implications of dune age, migration rates, and landscape stability.

Media Coverage

Two newspaper articles were written about the research. One in the *Ludington Daily News*, the other in the *Kalamazoo Gazette*.



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Saturday, January 29, 2005 Contact: Brian Mulherin 845-5181, ext. 348 bmulherin@ludingtondailynews.com WWW.LUDINGTONDAILYNEWS.COM

Trotting the Globe
See who went where in 2004, page C6

Exercise in gym class?
Several experts say kids aren't really getting the workouts they need, page C2

Switching Dodges
Bill Elliott will drive Ganassi Dodge Charger as part of his part-time season, page C5

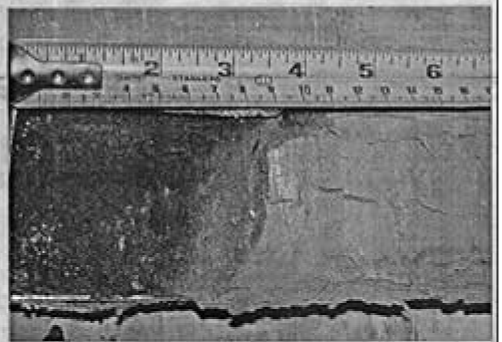
What lies beneath?

Researchers hope to better understand lake history

By BRIAN MULHERIN
Daily News Staff Writer

Daily News/BRIAN MULHERIN

DR. TIM FISHER of the University of Toledo prepares to cap a coring that was taken in 50 feet of water. The sample section extended 6.2 meters below the bottom.



CHANGE — This photo, provided by University of Toledo graduate student Amber Lahners, shows a distinct change in the color and type of material being deposited at the bottom of Hamlin Lake. This is a picture from the core taken at 75.3 feet of water. This sediment change occurs roughly 82 feet beneath the surface ice, or 7 feet below the bottom of the lake at this depth.

HAMLIN TOWNSHIP — It looked more like an arctic expedition than geology research.

Dr. Tim Fisher of the University of Toledo, Dr. Walt Loope of the U.S. Geological Survey, graduate student Henry Loope and graduate student Amber Lahners huddled around a 24-foot tall aluminum mast on the frozen surface of Hamlin Lake last Friday.

Bundled in Carhartt outfits, hats, facemasks and multiple pairs of gloves, the researchers squinted against blinding sun one minute and cringed with their backs to biting wind the next.

Working methodically, they filled a 30-foot section of aluminum irrigation tubing with water, then lowered it into the lake. Near the bottom of the tube was a rubber stopper that would turn it into a long-sized sediment syringe.

As minutes passed, another 30-foot section was bolted to the top of the first section, then another section was added to the second.

When the tube had reached the bottom of the lake, 75 feet below, the researchers bolted a piece of equipment normally used to vibrate concrete to their 90-foot-long probe. The vibrator, driven by a gasoline generator, allowed the tube to sink about eight feet deeper into the muck and marl at the bottom of Hamlin Lake's deepest hole.

As the irrigation tubing descended, the stopper inside the tubing worked its way up the tube, holding the sediment in the tube with vacuum action like that used in a syringe.

The core from that first effort probably won't be deep enough for their needs, Lahner said Tuesday. The purpose of the expedition was to better document, through the strata or layers of the lake bottom, just when the glaciers receded across Michigan 12,000 years ago.

After taking their first core, researchers set up the monopod that supports the tubes at another location and returned a day later to colder weather, higher winds and sometimes blinding snow. But weather problems aside, things went well for that core and a subsequent core. The researchers were able to pull a 6.6-meter core up from the bottom in an area where the lake was 50 feet deep and a 6.2-meter core up from an area where the lake was 42 feet deep.

Lahners, who is working on her masters' degree thesis "Constrain of the Nipissing Transgression" using the cores collected from Hamlin Lake and Oceana County's Silver and Stony Lakes, said there's likely enough stratification in the third core to tell her what she needs to know about Hamlin Lake.

"I think with that one, that might signify the deepening of Hamlin Lake due to the Nipissing transgression," she said. "Whether or not I can find any wood to carbon date is another thing."

Wood from the various layers of sediment is carbon dated to better establish more precisely when the Nipissing transgression occurred. The Nipissing transgression was the event that brought about the Nipissing phase in North America and filled the Great Lakes.

Previous studies have established that the glaciers from the great ice age receded through the straits of Mackinac area about 12,000 years ago. That left a Lake Michigan that was about 200 feet lower than what it is today. About 5,000 years ago, the water was high enough on Lake Michigan that it was one lake, together with Lake Superior and Lake Huron. That era, which featured a water surface about 20 feet higher than it is today, is called the Nipissing phase of the lakes.

By establishing when certain layers of soils were deposited using small pieces of wood present in the strata, Lahners will be able to better define, or "constrain," the Nipissing transgression.

By determining the ages of layers from three different lakes, Lahners should be able to document the recession of the glacier and how the waters of Lake Michigan rose more accurately.

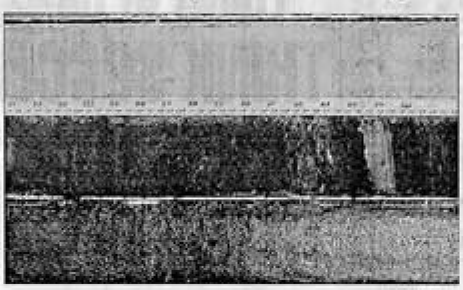
"All the ice was sitting on us, then it left and we've been rising since then," Lahners said. "Basically the idea is … they would have all refilled at different rates."

Although Lahners said she doesn't plan on a return trip to Hamlin Lake for another look at a core from the deepest hole in the lake, she wouldn't rule out further research by someone else.

"What I've figured out in science is that the next person that comes along is trying to prove you wrong, so I'm sure there's going to be more research," Lahners said.

bmulherin@ludington
dailynews.com
843-1122, ext. 348

Core samples teach geologists about Silver Lake



Courtesy photo

A PHOTOGRAPH shows a core taken from Silver Lake by Tim Johnson of the University of Toledo. The upper third is marl; the middle third is peat, note the circular and long piece of wood, and the bottom is mostly organic rich muck.

By BRIAN MULHERIN
Daily News Staff Writer

MEARS — How old is Lake Michigan?

What can the lake's history tell us about its future?

Those questions are at the heart of Tim Fisher's research on Silver Lake in Oceana County.

Geologists have determined that Lake Michigan is roughly 12,000 years old and its water levels have had cyclical pattern since the glaciers receded to leave us a lake.

But to learn more about the cycle of water levels of Lake Michigan, you have to be able to find out what has happened in the 12,000 years since it took shape.

Fisher, a professor at the University of Toledo, and Walt Loope of the U.S. Geological Survey in Munising, took core samples of the bottom of Silver Lake in February 2000 with a specific goal in mind.

"We were looking to find out when the dunes were active," Fisher said.

But Fisher found that Silver Lake wasn't always the clear water getaway surrounded by golden sands that it is today.

"Instead we found buried soils, peat and marl deposits," Fisher said. "In essence, it tells us Silver Lake was very, very shallow or just a wooded swamp."

How does knowing that Silver Lake was once Silver Swamp assist the researchers? Well, the bottomlands of that swamp were found significantly below the current water level of Lake Michigan, which in turn tells researchers that Lake Michigan was once quite a bit lower than it is today.

Some of Lake Michigan's life cycle is already known. Filling in the blanks tells researchers more about the two cycles Lake Michigan's water levels follow. Lake Michigan is believed to have a one-meter fluctuation about every 30 years and a 2.5-meter fluctuation about every 200 years.

See SILVER LAKE, page A3

Courtesy photo

A photograph of the mast used to take corings from Silver Lake just prior to a coring being taken. From left are Kelly Weyer, Amber Lahners, Walt Loope, Peter LundBorg and Bill Pierce.

SILVER LAKE: Geologists seek history of dunes

Continued from page A1

But confirming how rigid those cycles are is difficult.

About 12,000 years ago, Fisher said, the Lake Michigan lobe of the great glacier uncovered the straits of Mackinac.

"When that happened, drainage for Michigan and Huron was at what we call the North Bay outlet, near North Bay, Ontario, " Fisher said. "It didn't go through Port Huron."

Lake Michigan was about 260 feet lower than it is today during that time, known as the Chippewa phase of the lake.

About 5,000 years ago, the lake level was about 20 feet higher than it is today, during what is called the Nipissing phase.

"When that happened, Lakes Huron, Michigan and Superior were all one lake," Fisher said. "Water was draining out the Chicago outlet, draining out the Port Huron outlet and draining out North Bay outlet all at the same time.

"What no one really has a handle on is what was Michigan like between this Chippewa low stage and Nipissing high stage," Fisher said. "Most of that information is below the level of Michigan today, so it's hidden."

The Silver Lake core samples uncovered a small piece of the puzzle. The researchers found that peat was deposited in what was once the Silver Swamp between 7,760 and 7,000 years ago while Lake Michigan was at its low Chippewa phase.

The researchers believe the lake got deeper after that not because of climate change, but because Lake Michigan started to rise and the groundwater table rose right along with it.

Knowing when Silver Lake was formed helps researchers understand a little more about the Lake Michigan water level cycle, so the researchers aren't stopping with Silver Lake. They took corings at Stony Lake last weekend and hope to do more in the future.

"Basically, we discovered all this and what we could do from our coring at Silver Lake. Now we're sort of branching out going down to Stony, and we're going to other lakes," Fisher said. "We would like to go to Hamlin, possibly Pentwater."

The National Oceanographic and Atmospheric Administration is funding the studies.

"Part of what's driving all of this is, sure it's academically interesting, but the interesting thing is, did the level of Michigan rise from Chippewa to Nipissing in a slow fashion or were there a series of fluctuations?" Fisher said. "If there were these fluctuations, then they're probably climate driven.

"We know from other people's work on Lake Michigan that for the last 4,700 years there are these two-century cycles of high and low periods and we also know there's a 30-year cycle of one-meter change.

"If we can go past 4,700 can we also find these same cycles? These same 200-year cycles where the lake varies by two and a half meters? Most importantly, are there other cycles that we're not aware of?"

Ideally, someday researchers will be able to better predict long-term lake levels.

As for the short term?

Fisher said the 30-year cycle of rising water levels peaked in the late 1980s then started to fall. With any luck and no other climate change "we should start to see a rise," Fisher said.

bmulherin@ludingtondailynews.com
845-5181, ext. 348

Publications

Boudreau, A.M. (nee Lahners) 2005. Constraining the Nipissing transgression in the Central Lake Michigan Basin. Unpublished MS thesis, Department of Earth, Ecological, and Environmental Sciences, University of Toledo 119 p.

Fisher, T.G., Lahners, A.M., Weyer, K.A., Loope, W.L. 2004. A methodology for, and preliminary results of, constraining the Nipissing transgression in Lake Michigan. 47th Annual Conference of the International Association for Great Lake Research. May 24-28, Waterloo, Ontario, p. 43-44.

Fussell, B., Fisher, T.G., Camp, M., Curry, B.B. 2006. Reconstructing late Holocene paleoenvironments based on fauna and isotopes from two inland lakes on Michigan's west coast North Central Geological Society of American annual regional meeting, Akron, OH April 20-21. GSA Abstracts with Programs vol. 38, No.4

Weyer, K.A. and Fisher, T.G. 2004. Eolian sand in lacustrine sediments: a proxy for relative water levels of Lake Michigan. Geological Society of America Annual Meeting Geological Society of America, Abstracts with Programs Vol. 36, No. 5, Denver, CO, November 7–10. p. 36.

Lahners A.M. and Fisher T.G. 2004. Constraint of the Nipissing Transgression. 1st Annual Research Conference, Indiana University Northwest. November 11-12. p. 19.

Weyer, K.A., 2005. Eolian sand signals in lacustrine sediment: A proxy for water levels in the Lake Michigan Basin. Unpublished MS thesis, Department of Earth, Ecological, and Environmental Sciences, University of Toledo 110 p.

Weyer, K.A., Fisher, T.G. and Loope, W.L. 2004. Eolian sand in lacustrine sediments. 1st Annual Research Conference, Indiana University Northwest. November 11-12. p. 25.

Note that Weyer, Boudreau, and Fussell are presently working on three papers based on their thesis results. Reprints will be sent to IISG.

Students

- Ms. Abby Norton was hired for one month to assist with summer coring and lab work. 2004. Undergraduate
- Mr. Richard Mackenzie worked on the Muskegon Lake core. 2005. MS candidate, Bowling Green University.
- Boudreau, A.M. (nee Lahners) 2005. Constraining the Nipissing transgression in the Central Lake Michigan Basin. Unpublished MS thesis, Department of Earth, Ecological, and Environmental Sciences, University of Toledo 119 p.
- Weyer, K.A., 2005. Eolian sand signals in lacustrine sediment: A proxy for water levels in the Lake Michigan Basin. Unpublished MS thesis, Department of Earth, Ecological, and Environmental Sciences, University of Toledo 110 p.
- Ms. Brittany Fussell. Tentative MS thesis title: “Paleoenvironmental reconstructions from marl in drowned estuaries of eastern Lake Michigan” 2004-2006.

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Research Information

- **Principal Investigator**: Timothy Fisher
- **Initiation Date**: March 1, 2004
- **Completion Date**: February 28, 2006
- **Affiliation**: University of Toledo

Contacts

Tomas Höök (/staff/hook.php)
Associate Director of Research
765-496-6799
thook@purdue.edu (mailto:thook@purdue.edu)

Carolyn Foley (/staff/foley.php)
Assistant Research Coordinator
765-494-3601
cfoley@purdue.edu (mailto:cfoley@purdue.edu)

Leslie Dorworth (/staff/dorworth.php)
Aquatic Ecology Specialist
219-989-2726
dorworth@calumet.purdue.edu (mailto:dorworth@calumet.purdue.edu)

Caitie McCoy (http://www.iiseagrant.org/staff/mccoy.php)
Environmental Social Scientist
312-886-1430
cmccoy2@illinois.edu (mailto:cmccoy2@illinois.edu)

Kristin TePas (/staff/tepas.php)
Great Lakes Community Decisionmaking Specialist
312-886-6224
ktepas@illinois.edu (mailto:ktepas@illinois.edu)

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Illinois-Indiana Sea Grant
Purdue University
195 Marsteller Street
West Lafayette, IN 47907-2033
765-496-6009
iisg@purdue.edu (mailto:iisg@purdue.edu?subject=IISG Inquiry)

(http://web.extension.uiuc.edu/state/)

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