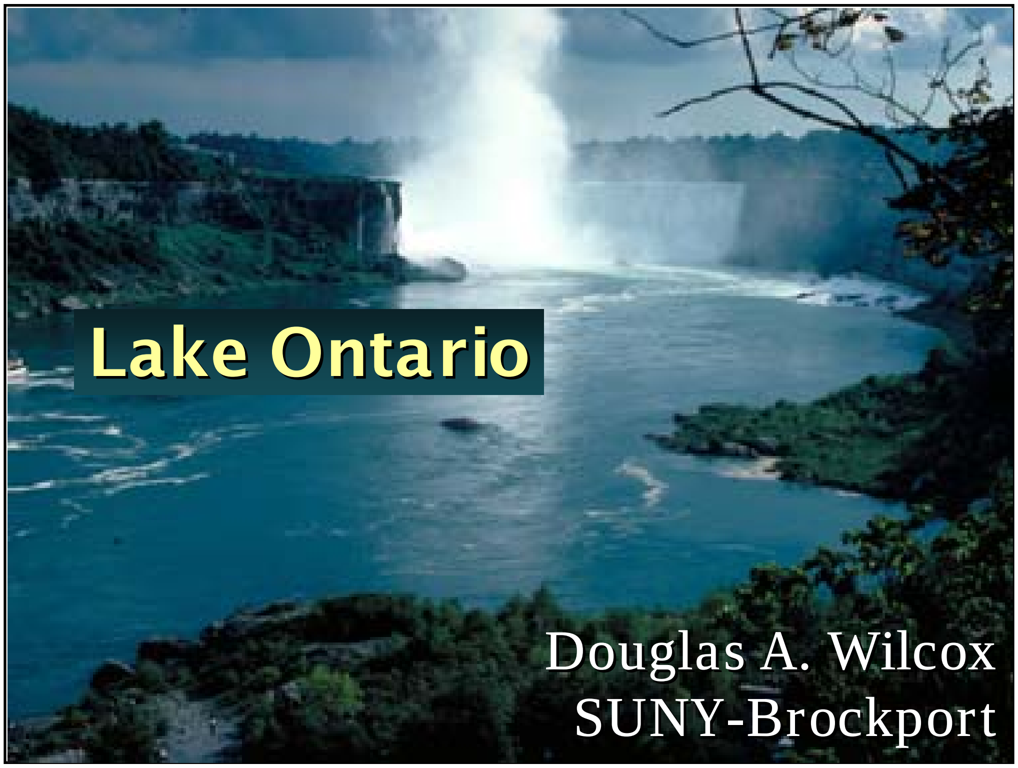
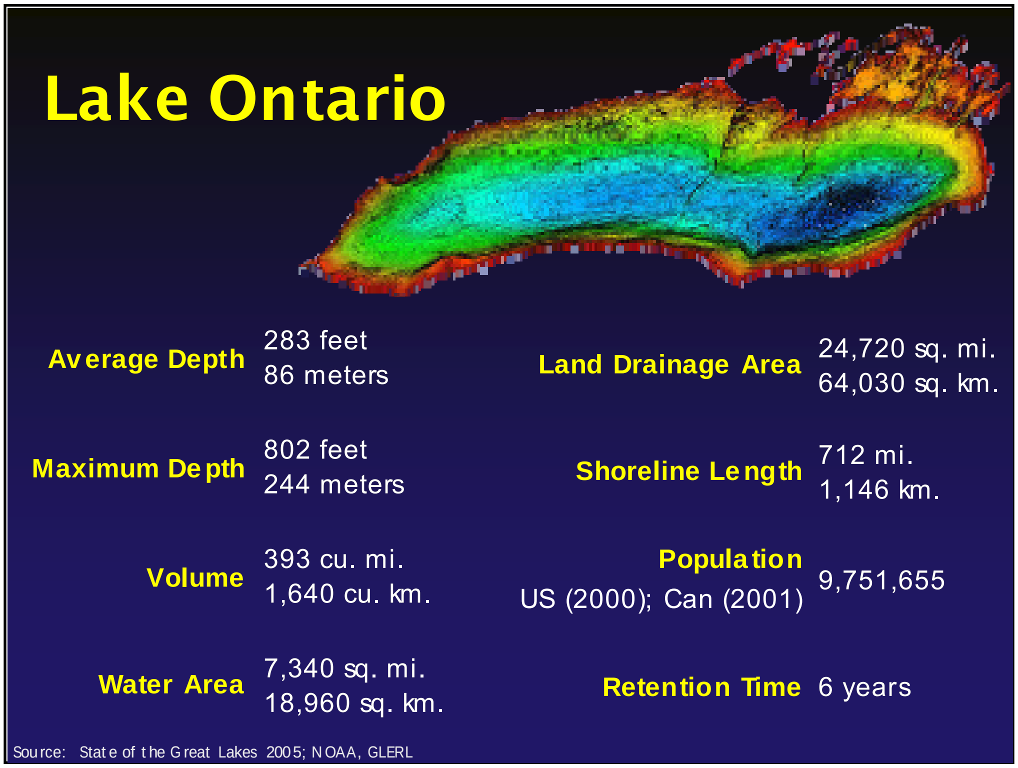

Lake Ontario
Douglas A. Wilcox
SUNY-Brockport



Today I will present an overview of the status of Lake Ontario and then I will focus on water level issues throughout the Great Lakes.

Lake Ontario is the smallest of the Great Lakes, but has the highest ratio of watershed area to lake surface area. It is relatively deep, second only to Lake Superior.

The Lake Ontario LaMP adopted 11 ecosystem indicators to measure the health of the Lake Ontario ecosystem—these are divided into three groups:

- critical pollutant indicators -- measuring concentrations of critical pollutants in water, young of the year fish, herring gull eggs, and lake trout;
- lower food web indicators—tracking nutrients, zooplankton and prey fish; and,
- upper food web indicators—measuring herring gull, lake trout, bald eagle, mink and otter populations.

The Lake Ontario indicators show that the reduction in contaminants continues to improve. Concentrations of many organic compounds in open waters are present in only trace amounts, with some below water quality objectives.

Upper food web indicators monitor the health of lake trout, herring gull, bald eagle, mink and otter populations. These top level predators are dependent on quality habitat and sufficient prey populations, free of problematic contaminant levels.

Bird populations are plentiful; mink and otter made a comeback and are present in significant numbers; bald eagles went from having no active nesting territories in the 1970s to 23 established nesting territories in the basin with three along the shoreline. The Lake Ontario LaMP's Binational Bald Eagle Project is actively working on increasing the number of nesting territories.

The Binational Biodiversity Conservation Strategy is a new important initiative for the Lake Ontario LaMP partners to enhance habitat management. It is a collaboration of 25 agencies, universities, and non-profit organizations integrating the natural resource information and habitat priorities in Ontario and New York into a binational action agenda for Lake Ontario.

The Project is selecting conservation targets and strategies. This map, for example, shows the condition of the nearshore zone. Other information includes identification of dams on key waterways for possible removal for the benefit of the fisheries.

The result will be a binational database, strategy, and actions for conservation. It will be a common vision of priority actions that partner organizations can pursue.

Lake Ontario has extensive wetlands, and the LaMP is working with partners to develop indicators to measure the health of the wetlands.

This work will be integrated into an adaptive management plan to assess the effects of water level fluctuations on the nearshore ecosystem. The LaMP has been cooperating with the International Joint Commission on its study of a possible change in water level control for Lake Ontario and the St. Lawrence River.

The LaMP's work in adaptive management and coastal wetlands indicators should achieve good results for the lake.

The LaMP's lower food web and lake trout population indicators are not meeting objectives. Nearshore nutrients, invasive species and humans are having an impact as are hydrological alteration, land development and land use practices, nutrient enrichment, legacy contamination, and continued invasive species introductions. Nearshore algal blooms result in beach closures and drinking water concerns.

The 2008 Binational Cooperative Monitoring Year focused on addressing the priority information needs of the LaMP and the Great Lakes Fishery Commission. The following priorities were developed with the generous support of the IJC's Council of Great Lakes Research Managers:

- Understanding nearshore-offshore nutrient transport mechanisms;
- Determining the status of the offshore food web;
- Conducting the first lakewide fishery assessment in more than a decade; and
- Using biomarkers such as stable isotopes and fatty acids to understand food web changes.

All of this information will be considered by the LaMP in evaluating the current impairment status of the lake and the need for any additional coordinated binational actions.

SOLEC Indicators
Coastal Wetlands

- Invertebrate communities
- Fish communities
- Amphibian communities
- Bird communities
- Plant communities
- Landscape extent and composition

And now onto a discussion of water level fluctuations and the effect on the nearshore environment.

A number of SOLEC indicators have been identified for coastal wetlands, many associated with the health of biological communities, including invertebrates, fish, reptiles, amphibians, birds, and plants.

SOLEC Indicators
Coastal Wetlands

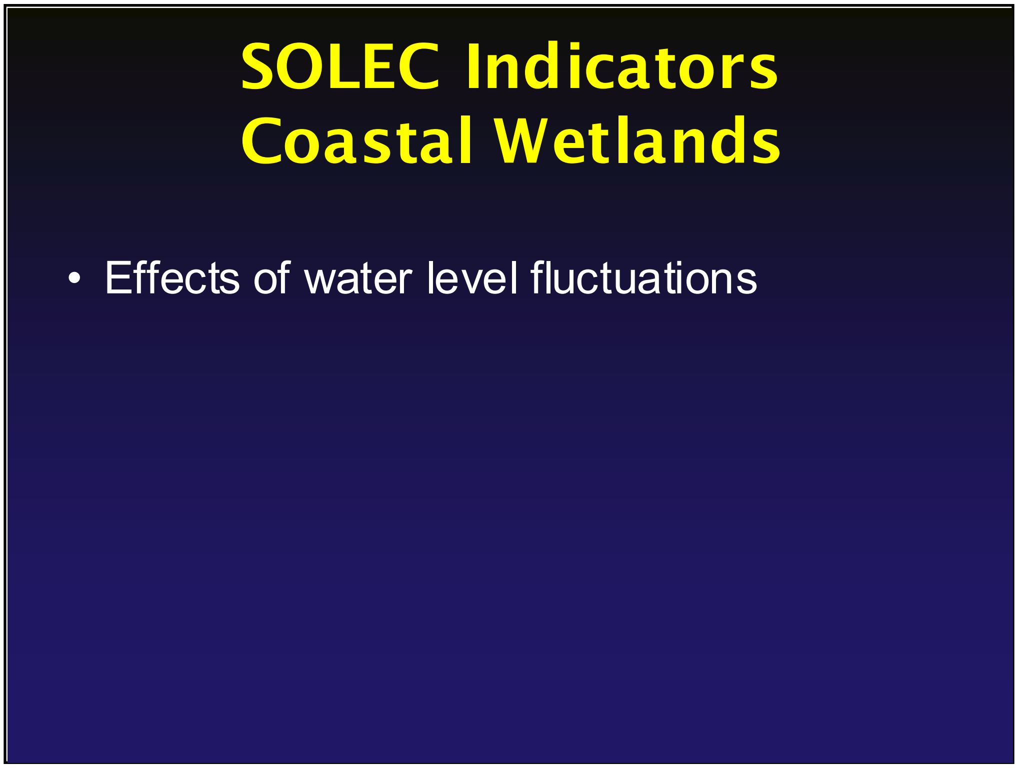
- Human impact measures
- Adjacent land cover
- Wetland area by type
- *Restored area by type*
- *Sediment inflow*
- *Sediment available for coastal nourishment*
- *Phosphorus and nitrogen levels*

and some associated with physical attributes; those in italics are not yet fully developed.

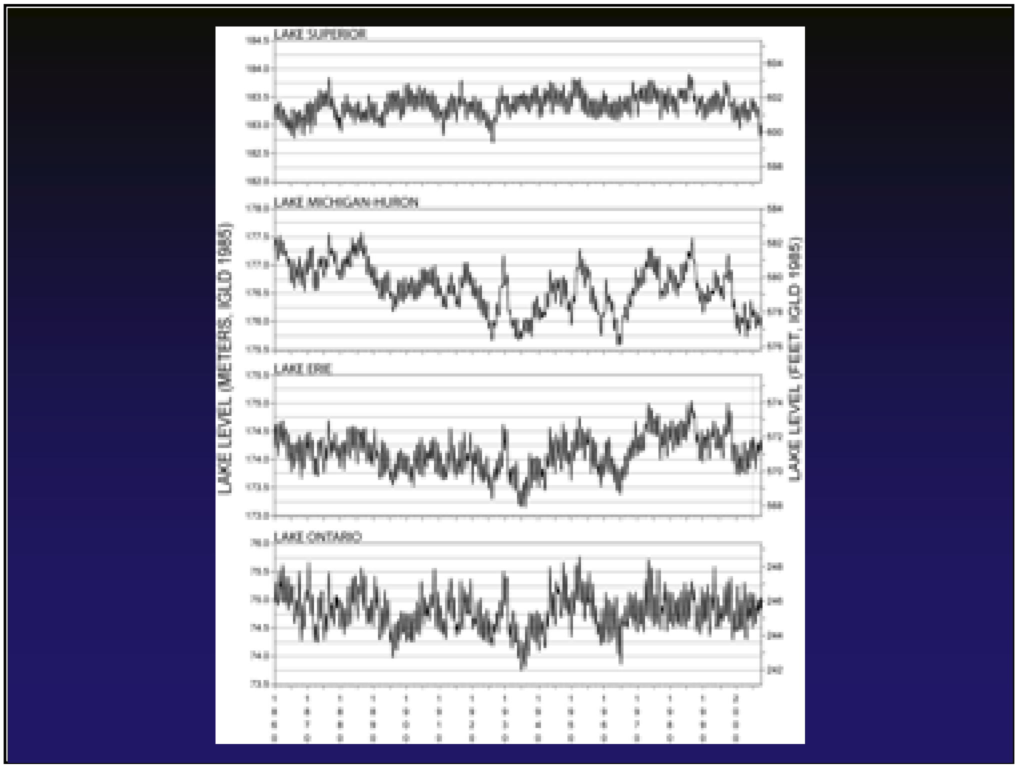
SOLEC Indicators
Wetland Related

- Non-native species
- Ground-water dependent plants/animals
- Base flow of ground-water discharge
- Extent of hardened shoreline
- *Artificial coastal structures*

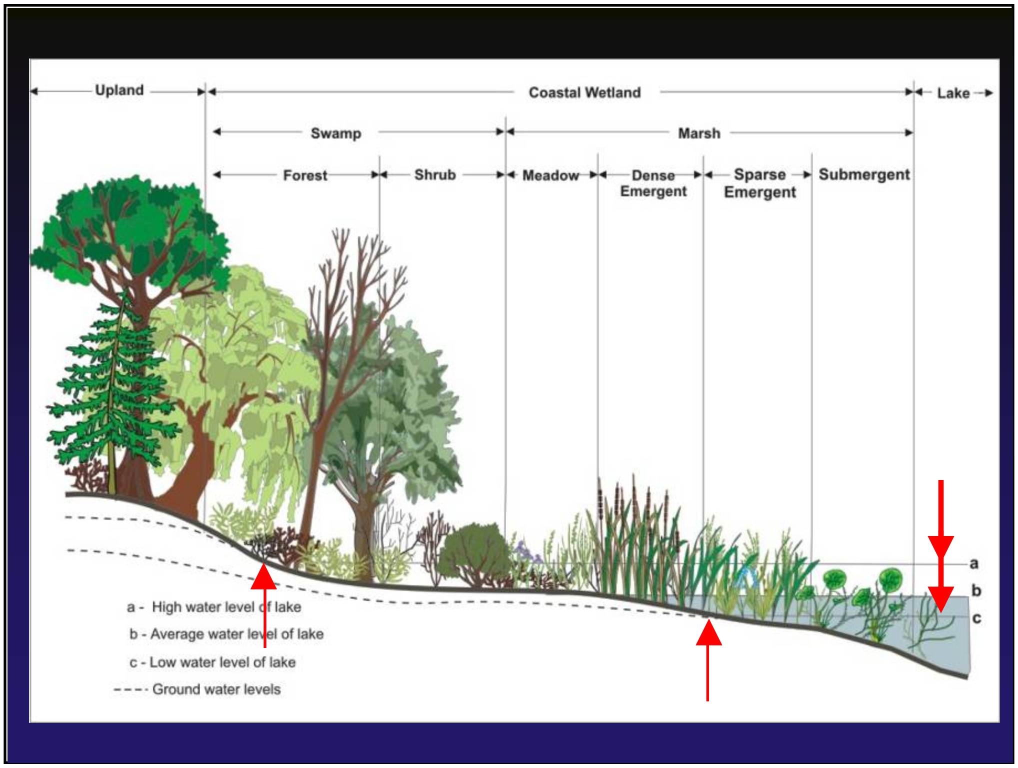
Other indicators, not specifically tied to wetlands, have major implications for wetlands, especially those relating to hydrology and alteration of coastal processes.



Which brings us to the indicator that is the subject of this presentation, the indicator that trumps all the others for coastal wetlands—water-level fluctuations.



The recorded lake-level histories of the lakes show some similarities, but there are also differences that are important to wetlands, and I will touch on some of them.

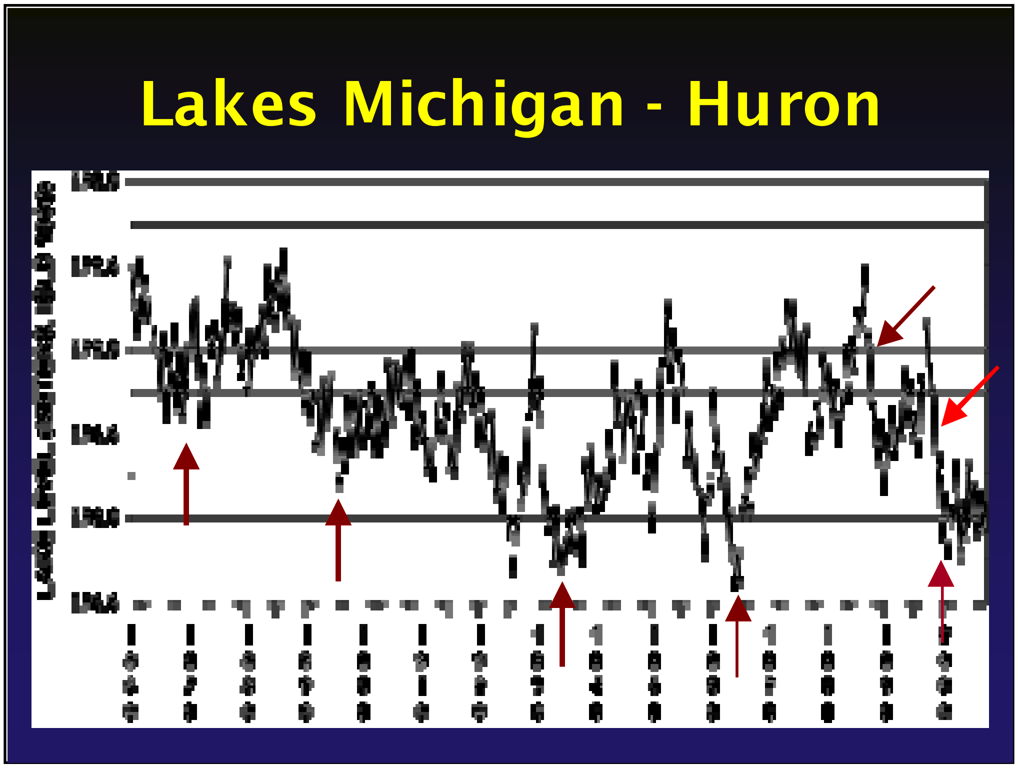


First, a primer on the role of lake-level fluctuations in developing and maintaining wetland plant communities.

Elevations above the highest high lake level, denoted by horizontal line a **(!)**, are never flooded and typically support upland vegetation, although ground-water discharge may allow wetlands to persist at somewhat higher elevations.

Elevations below the lowest low lake level, denoted by line c **(!)**, are never dewatered and support floating and aquatic vegetation.

The area between those lines **(!)**, is the action zone where lake-level fluctuations create habitat diversity.



First, let's look at Lake Michigan-Huron, all one lake hydrologically because the Straits of Mackinac are so wide.

There are low lake-level periods roughly every 30 years. The current low began in 1999 **(!)**;

there were lows in the mid-60s **(!)**,

in the dust-bowl days of the mid-30s **(!)**;

and as part of another scale, in late 1890s **(!)** and 1860s **(!)**.

In the next few slides, I will focus on the decreases in lake level following highs in 1986 **(!)** and 1997 **(!)**. In both cases, there was a drop of about ¾ meter within two years and an ultimate drop of about 1 meter.

I began an IJC-sponsored study at Fish Point in Saginaw Bay of Lake Huron in 1988 when lake levels had just plummeted. The 1986 shoreline would have been about where the shrubby vegetation begins, and broad expanses were then exposed. This allowed seeds in the seed bank to germinate and revegetate the wetland. Note the trees in the background to place yourself when looking at the next couple pictures.

One year later, bulrushes (the native vegetation of Saginaw Bay) had been reestablished,

and (from a slightly different angle) this is what it looked like one more year later.

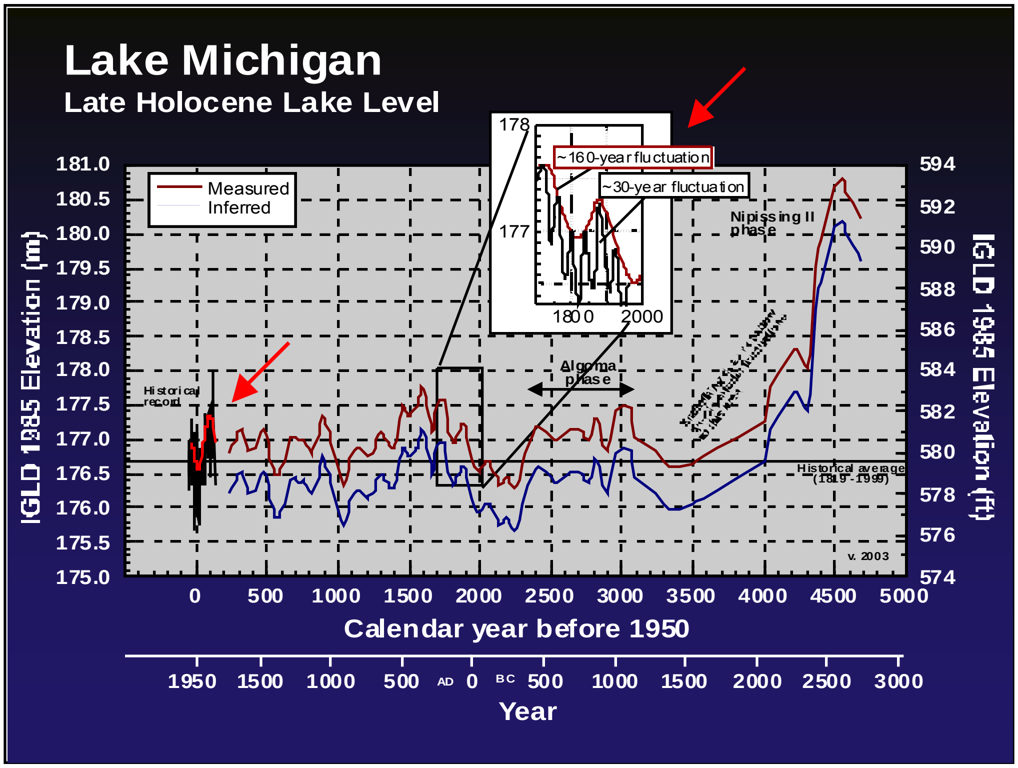
That is not the only location or lake-level drop where this happens. This is a drowned river mouth wetland at Port Sheldon, just north of Holland, MI on Lake Michigan.

In early 1999, lower water levels exposed barren substrates that had been flooded for a number of years.

Later in that same year, mud-flat annuals had colonized the area,

A year later, the area was dominated by perennial plants,

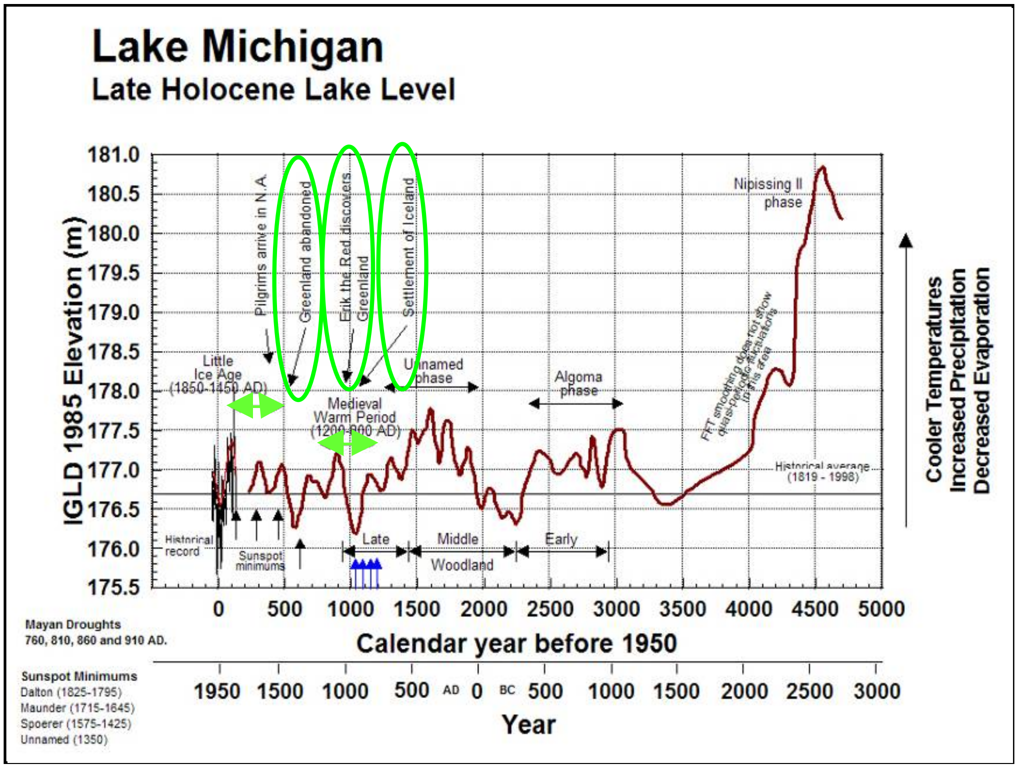
and in one more year had shifted to other perennials. When this vegetation is flooded by the next high lake level, it will be great habitat for invertebrates, small fish looking for a meal and protection from predators, and larger fish looking for small fish to eat. This is wetland restoration at no cost to the taxpayer.



Great Lakes wetlands have been doing this for centuries. This is a 4700-yr record of lake levels derived from sedimentological data as part of our global climate change study.

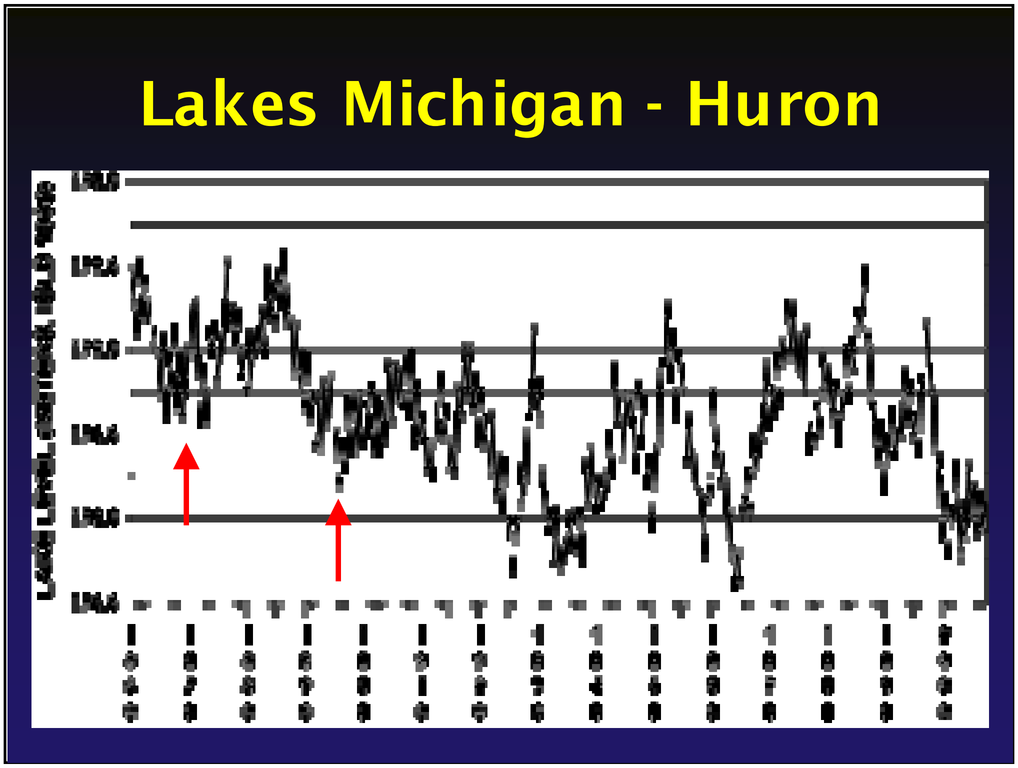
Roughly every 160 years, the lake has gone through a high water-level period, with intervening lows. As seen in the inset **(!)**, these 160-yr fluctuations are generally composed of about 5 smaller fluctuations occurring at 30-33 year intervals.

The recorded lake-level history on the left **(!)** is a continuation of this pattern.

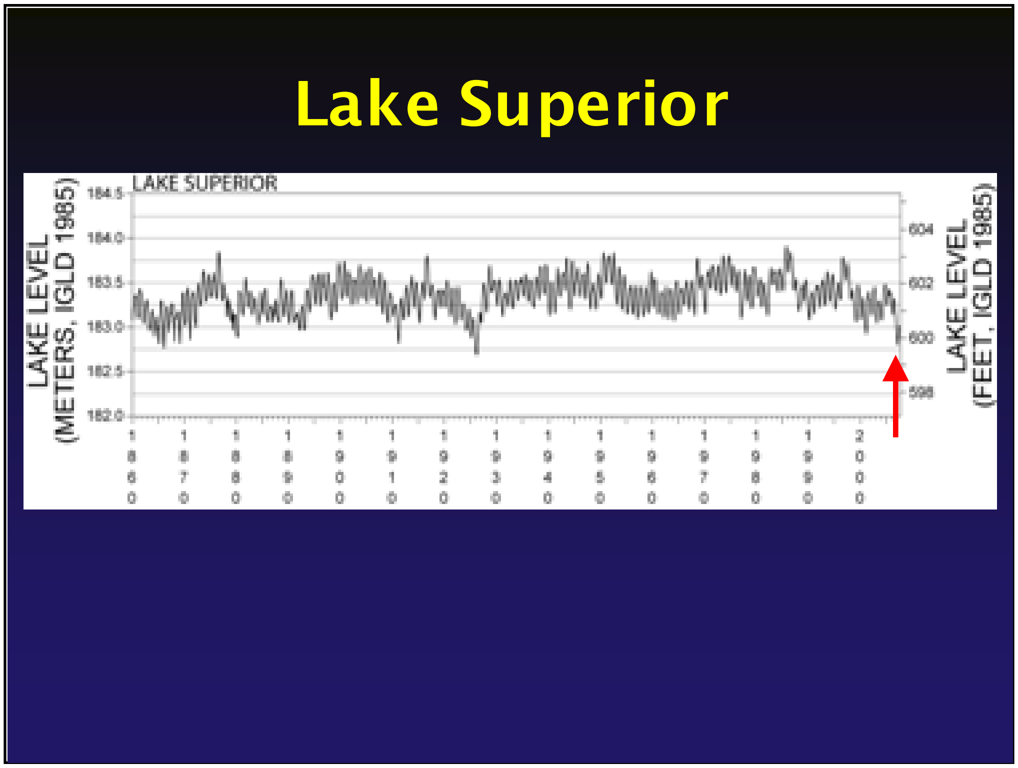


But what causes it? Climate. This version of the hydrograph overlays some human events that you might connect to climate changes, including the Medieval Warm Period **(!)**. The lakes are lower during warm climate periods and higher during cool periods.

Iceland was settled **(!)** and Greenland was discovered by Erik the Red **(!)** during a warm period. When the Little Ice Age began **(!)**, Greenland was abandoned. Lake levels respond to climate change.



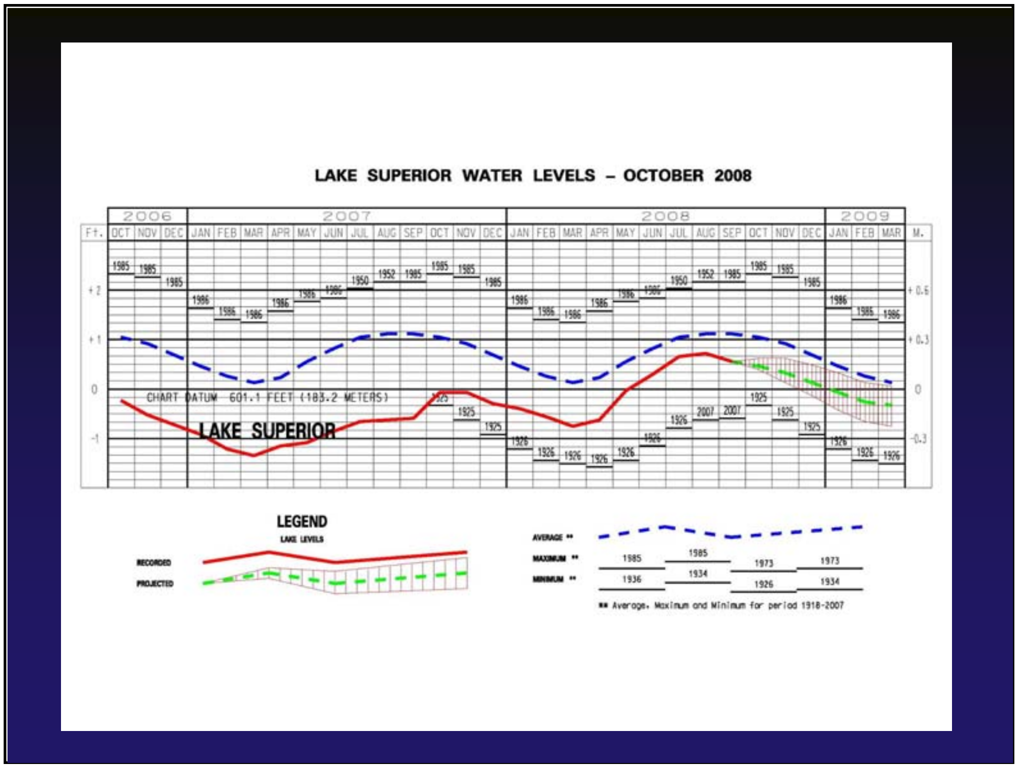
The historical record shows this same pattern, with the early lows in the late 1800s **(!)** occurring part way up the slope of a longer-term high.



What about the other upper Great Lakes? My colleagues and I are nearly finished with a long-term history of Lake Superior, but the modern record doesn't look much like Lake Michigan-Huron. When water levels were low last year **(!)**,

Lake Superior got a lot of press coverage. The typical comment came from an 80-yr-old man who said, "I have lived on Lake Superior all my life and have seen everything it has ever done. This is the lowest it has ever been."

The man is not old enough to make that statement. The lake lives in geological time. If he was just a decade older, he might have seen the lake lower than last year. More importantly, what he nor the press ever mentioned is that Lake Superior water levels have been regulated by humans since the early 1900s (which is one reason they don't look like Lake Michigan-Huron).



Incidentally, the regional drought that resulted in those low lake levels last year was alleviated by some late summer/early fall rains, and lake levels came back up.

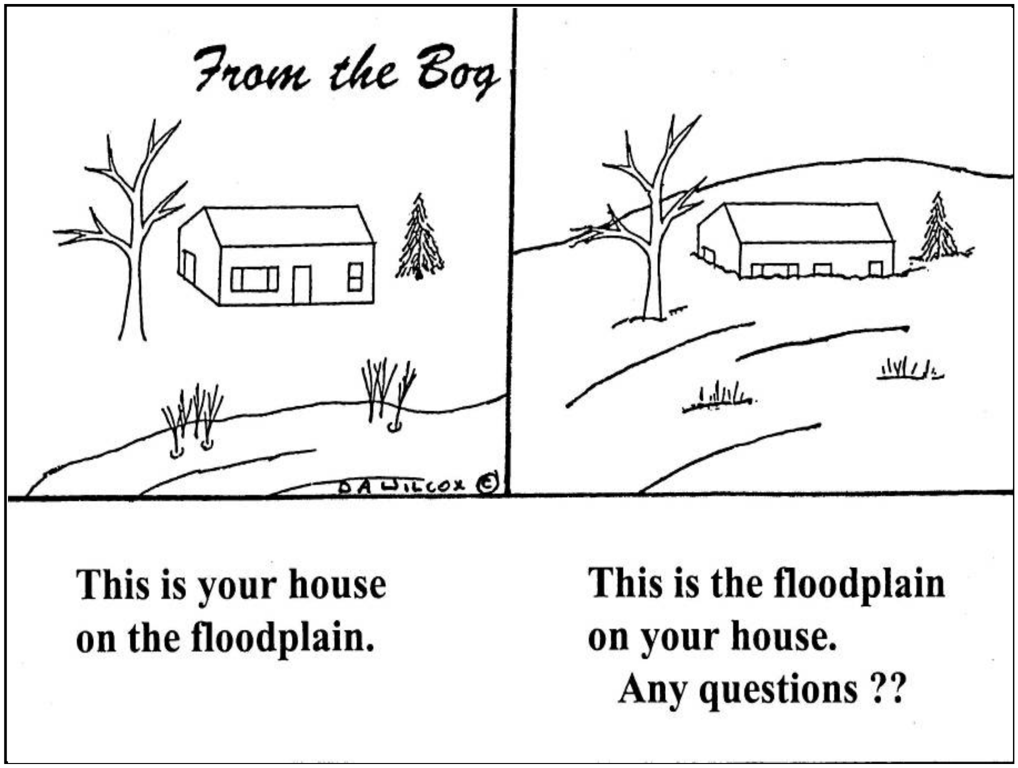
Who cares about low lake levels? The shipping industry,

and recreational boat marinas that were built during high lake levels,

and now need to be dredged.

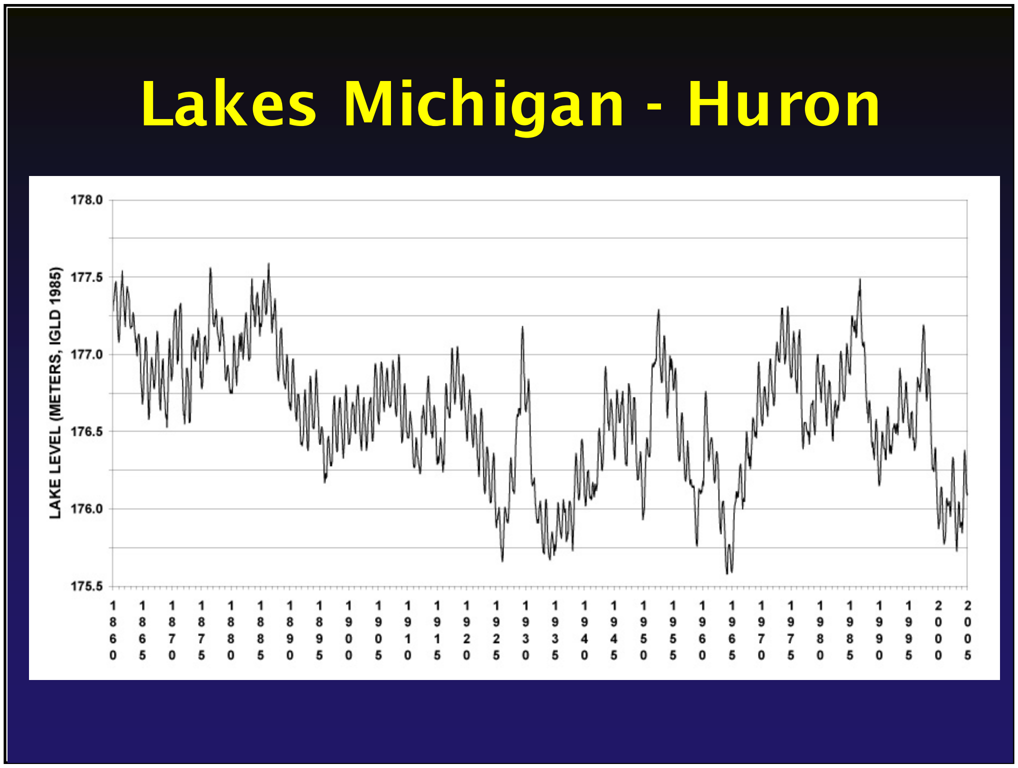
However, nobody mentions the great expanses of beach and shoreline dunes that result from low lake levels and provide protection from erosion during the next high lake level.

Low lake levels should be considered friends by these folks.

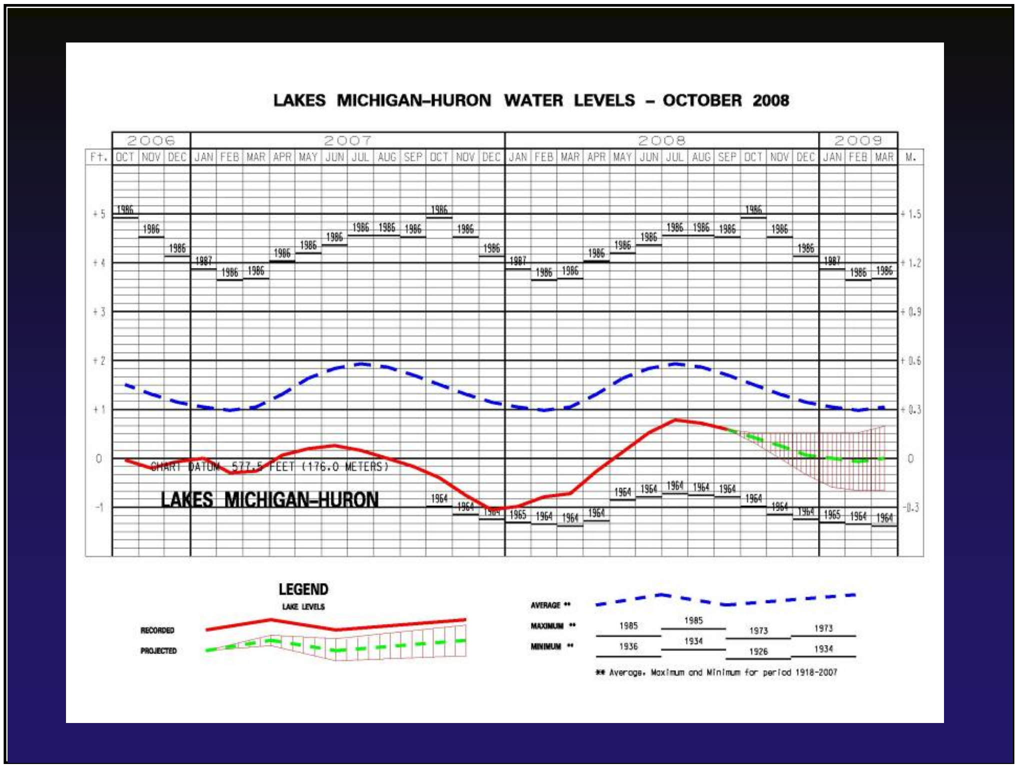


Then again, nature might say that perhaps they should not be living there.

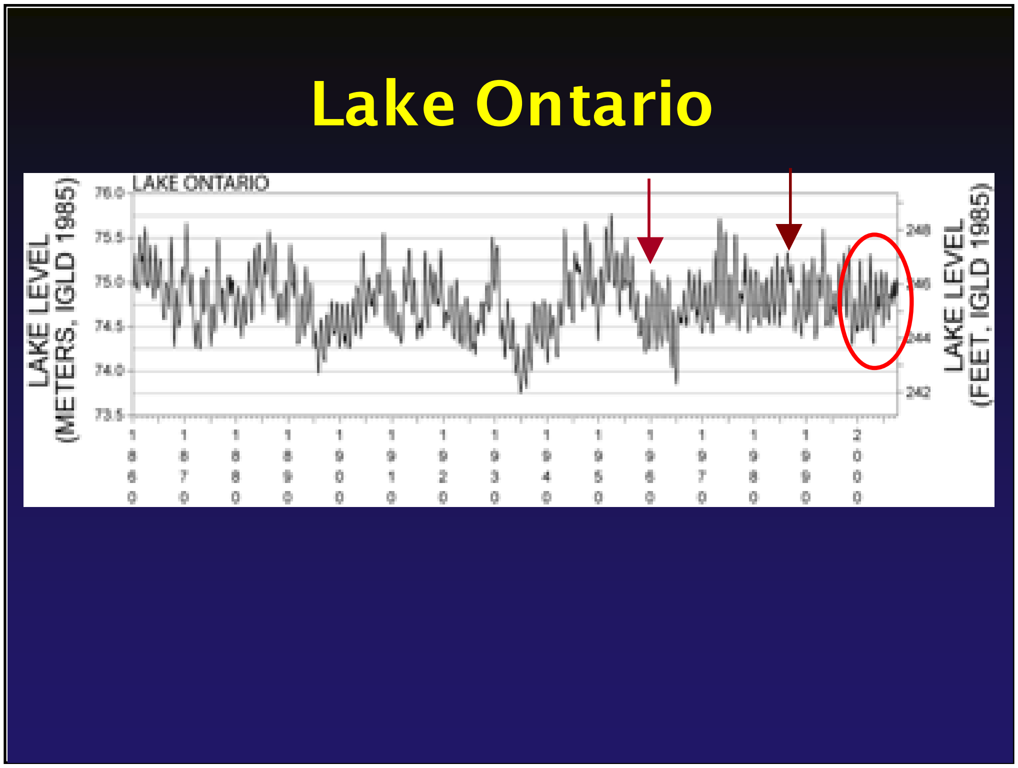
There have been reports that low water levels in Lake Michigan-Huron are the result of erosion in the St. Clair River **(!)**, which has become a major topic in the IJC upper lakes study.



However, the low levels do fit into a natural pattern. The real question is whether current low levels have gone lower and lasted longer than natural as a result of anthropogenic climate warming. Time will tell.

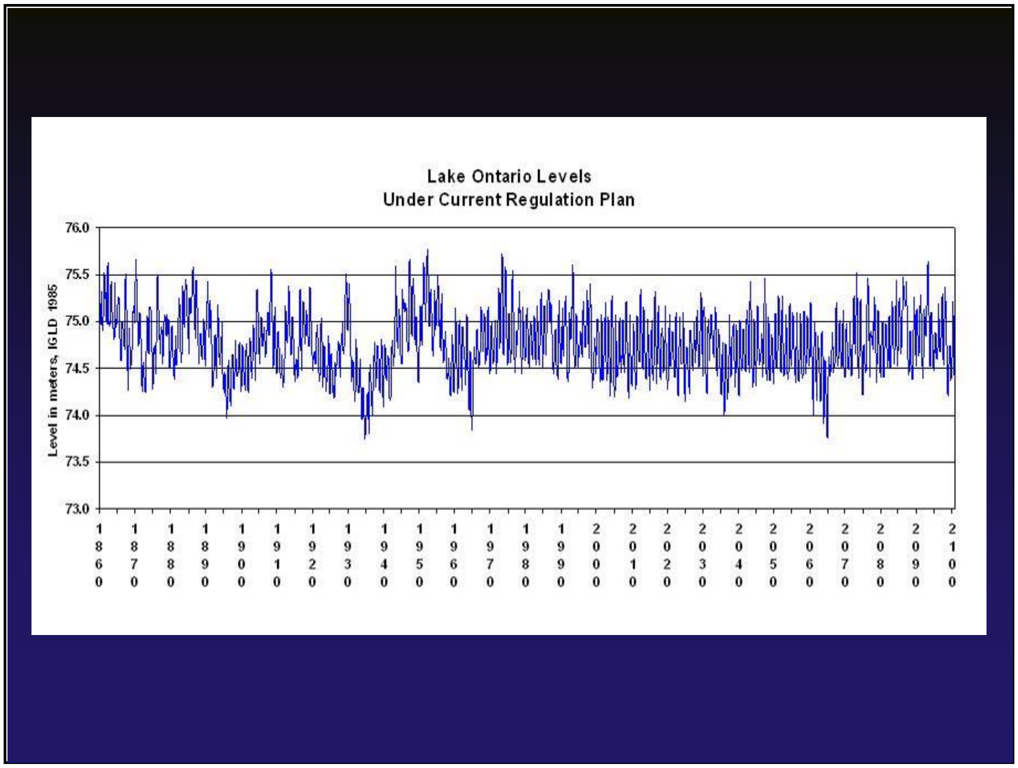


Although there is some evidence that Lake Michigan-Huron levels may be on the upswing again.



With all that background, on to Lake Ontario. The hydrograph is somewhat comparable to Lake Michigan-Huron until about 1960 **(!)**, at which time the St. Lawrence Seaway was put into operation and Lake Ontario became a regulated reservoir also. The natural inter-annual fluctuations mostly disappeared, the 1986 high never occurred **(!)**, and lake levels did not decrease during the past few years **(!)**.

Lake levels are controlled mostly at the Moses-Saunders Power Dam on the St. Lawrence River between Cornwall, ON and Messina, NY.



This is what the future would hold if the current regulation plan remained in place, which would not be very good for wetlands,

and there are some great wetland complexes along the shore of Lake Ontario.

International Joint Commission

- Lake Ontario-St. Lawrence River Study

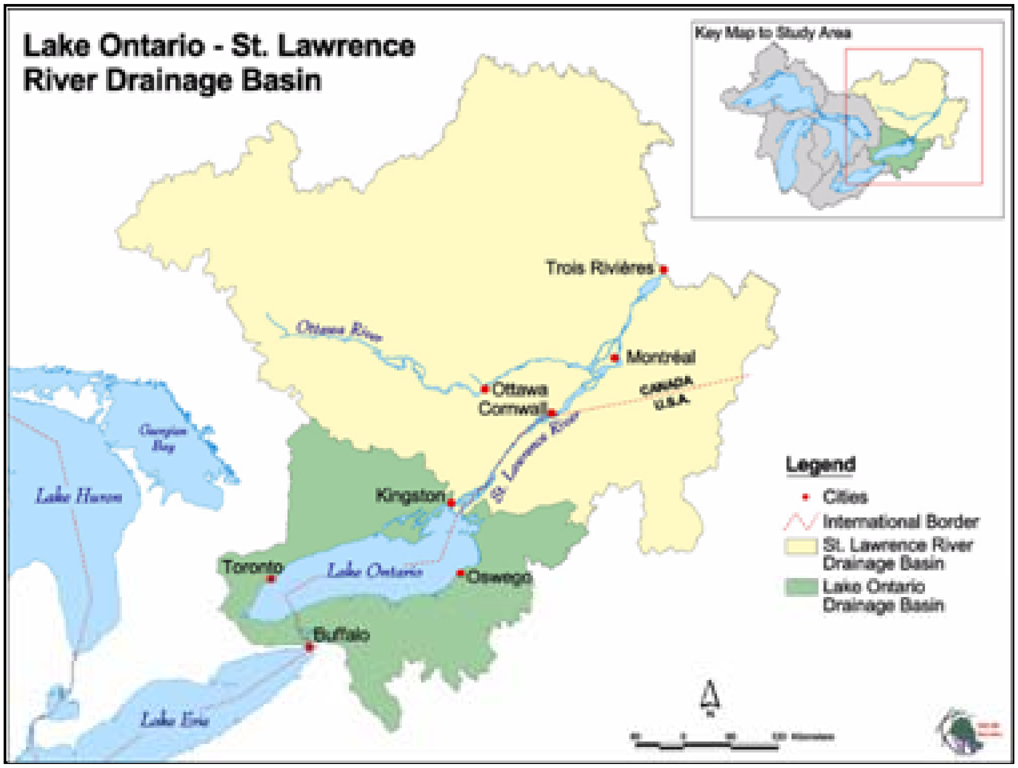
The International Joint Commission recently completed a study to evaluate the current regulation plan 1958D with Deviations and develop other potential plans for regulating lake levels. Beyond the environment, interests included hydropower generation at the dam,

industrial water users,

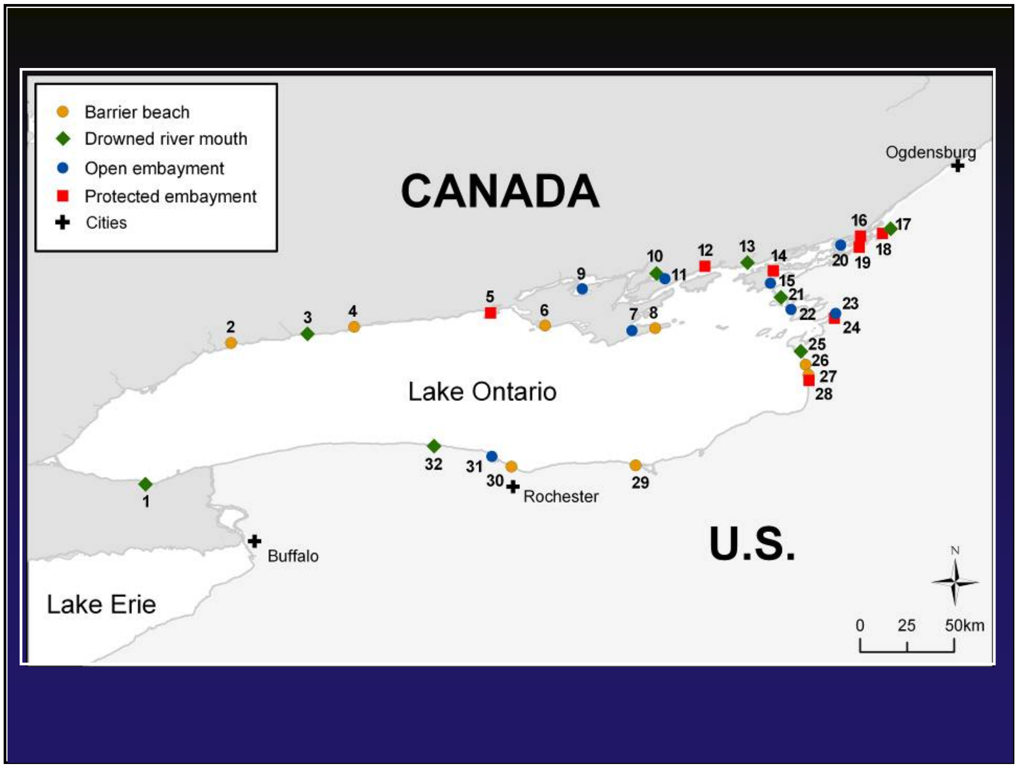
the shipping industry,

recreational boaters **(!)**,

and shoreline property owners **(!)**.



The task was made more difficult because every drop of water that goes past the dam adds water to the Lower St. Lawrence River, so downriver impacts to these interests had to be avoided also



Along with Canadian counterparts, we undertook the wetland portion of the IJC study, using 32 wetlands (8 each in four geomorphic types):

barrier beach,

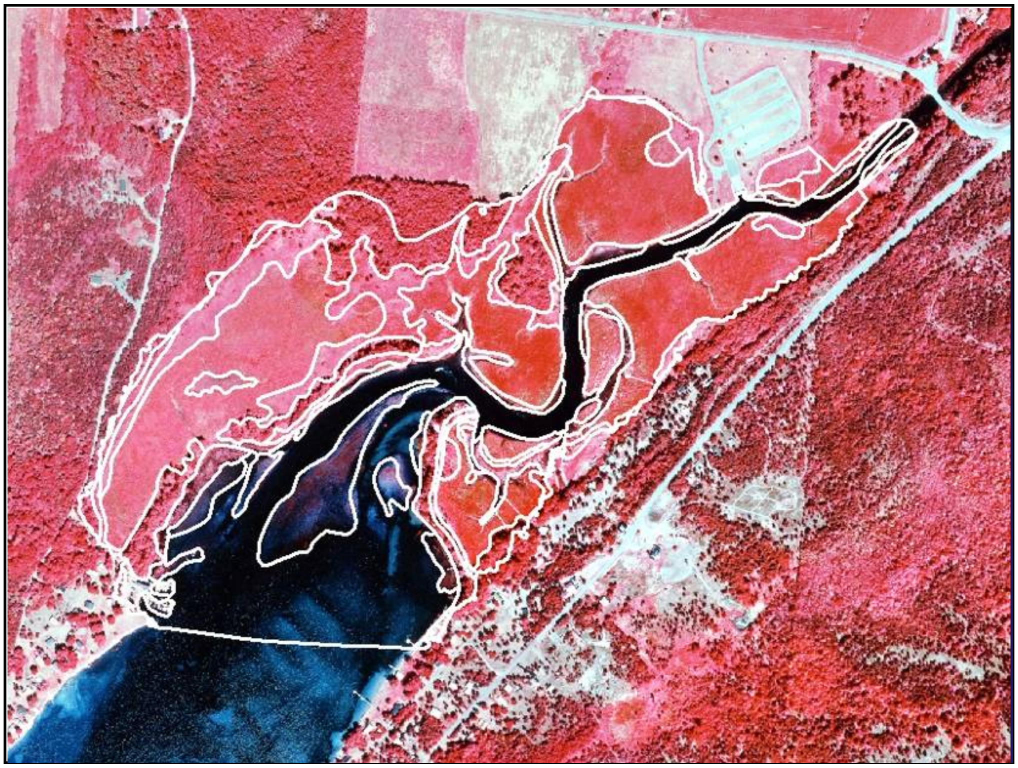
drowned river mouth,

open embayments subject to wave attack,

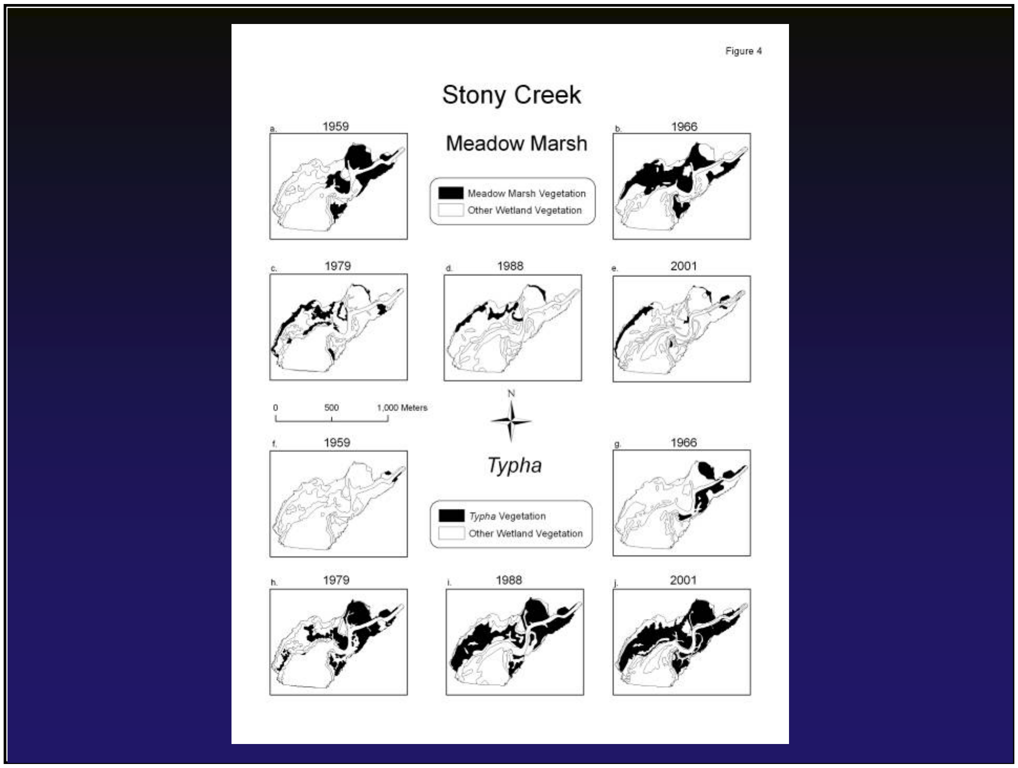
and protected embayments.

As in my previous studies, we found cattails invading landward along the shore,

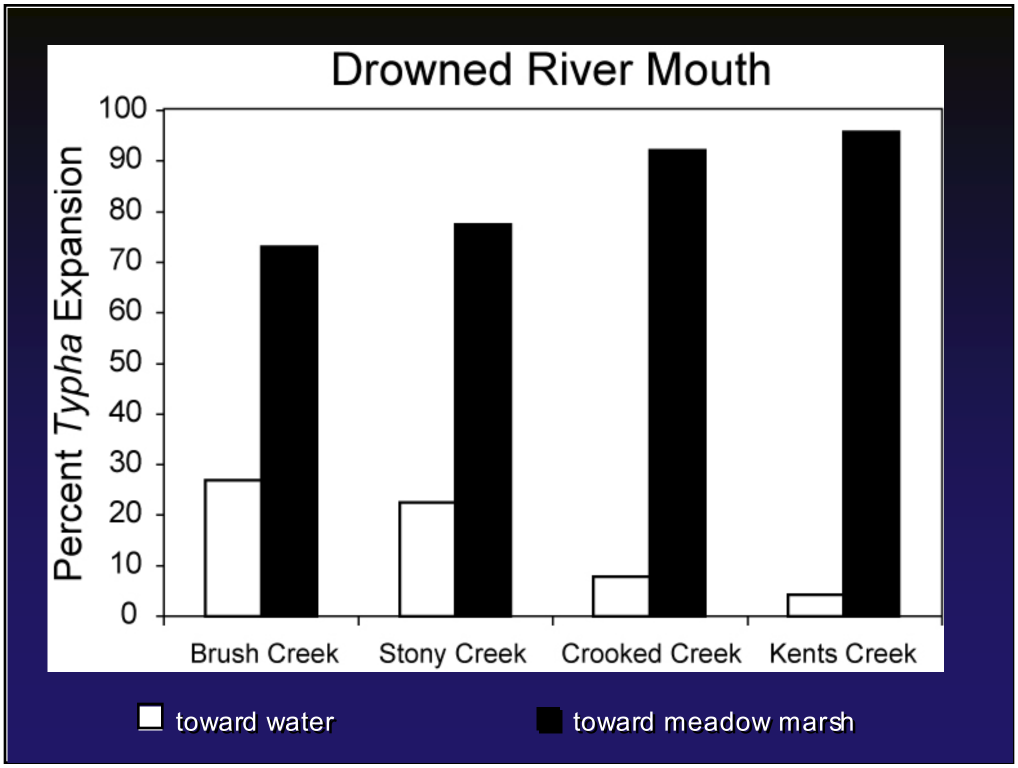
and lakeward into the water—seas of cattails.



We undertook two general types of studies. Photointerpretation analyses tracked changes in vegetation types at decadal intervals back to pre-regulation.



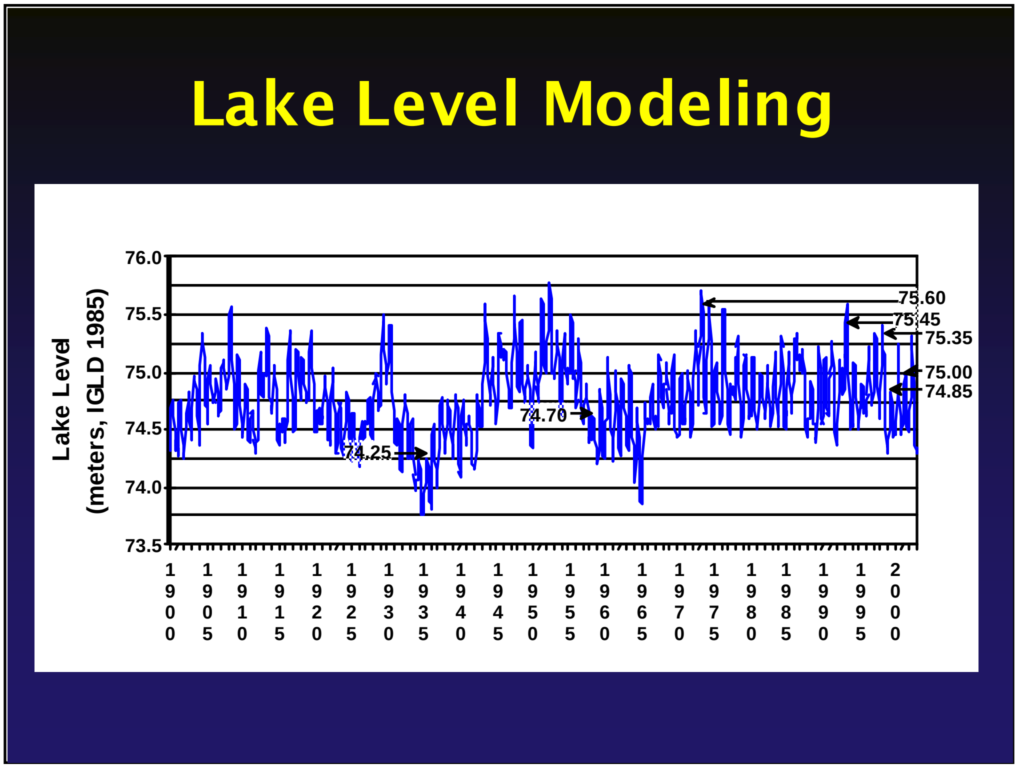
Looking at the drowned river mouth wetlands, the area of wetland dominated by sedges and grasses (meadow marsh) decreased following regulation, and the area dominated by cattails increased. The same pattern was seen in the other geomorphic types.



Further analyses demonstrated that much of the cattail invasion was landward rather than lakeward.

This can be explained biologically because sedges and grasses are tolerant of periodic dry periods (like the grass on your lawn), while larger, fleshier cattails require more moisture.

Regulation has eliminated the low lake levels that would dry out the upper elevations of the wetlands where the sedges and grasses grow. They then lose their competitive advantage and the larger, canopy-dominating cattails are able to take over.

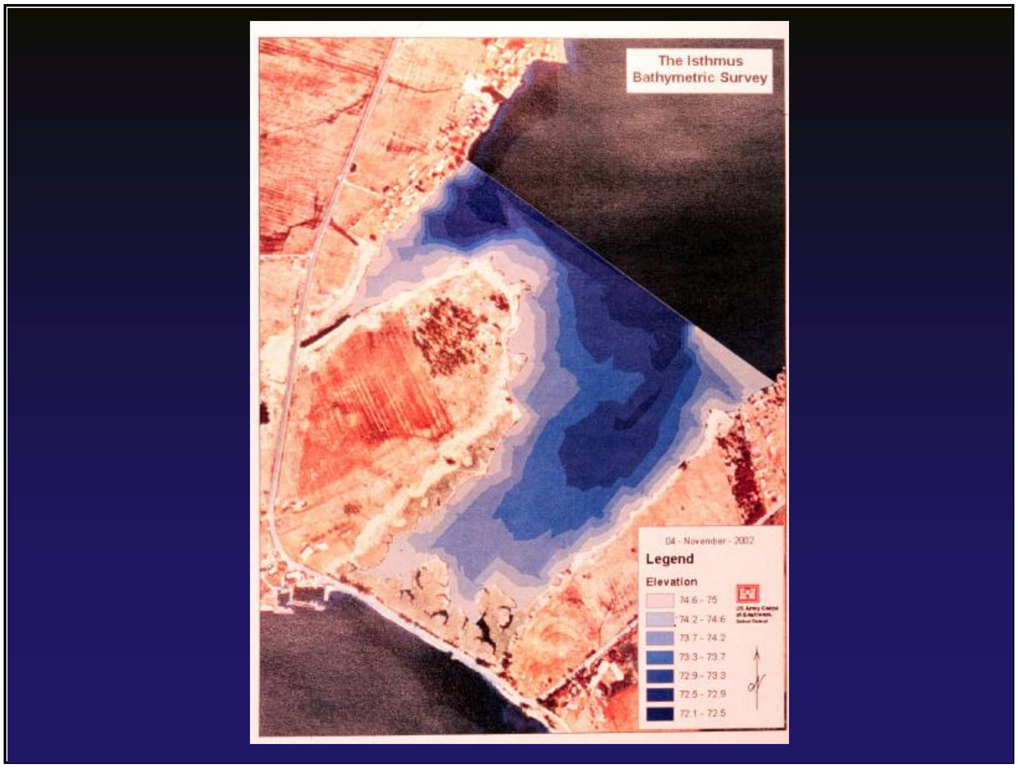


The other part of the study required development of models to predict the response of these vegetation types to any new regulation plans that were developed. To do this, we segregated the wetlands into elevation zones with different water-level histories—different numbers of years since last flooded or last dewatered.

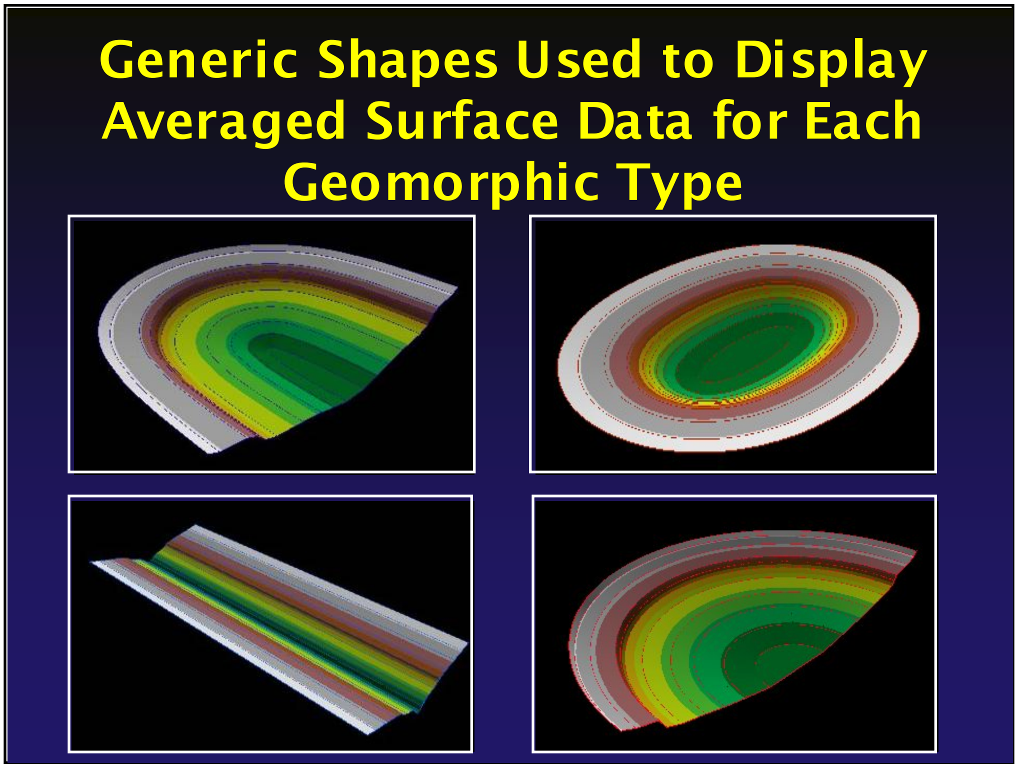
Lake Level Modeling

Transect	Elevation	Rationale
A	75.60m	Last flooded 30 years ago
B	75.45m	Last flooded 10 years ago
C	75.35m	Last flooded 5 years ago
D	75.00m	Flooded & dewatered last 5 years
E	74.85m	Last dewatered in growing season 4 years ago
F	74.70m	Last dewatered in growing season 38 years ago
G	74.25m	Last dewatered in growing season 68 years ago

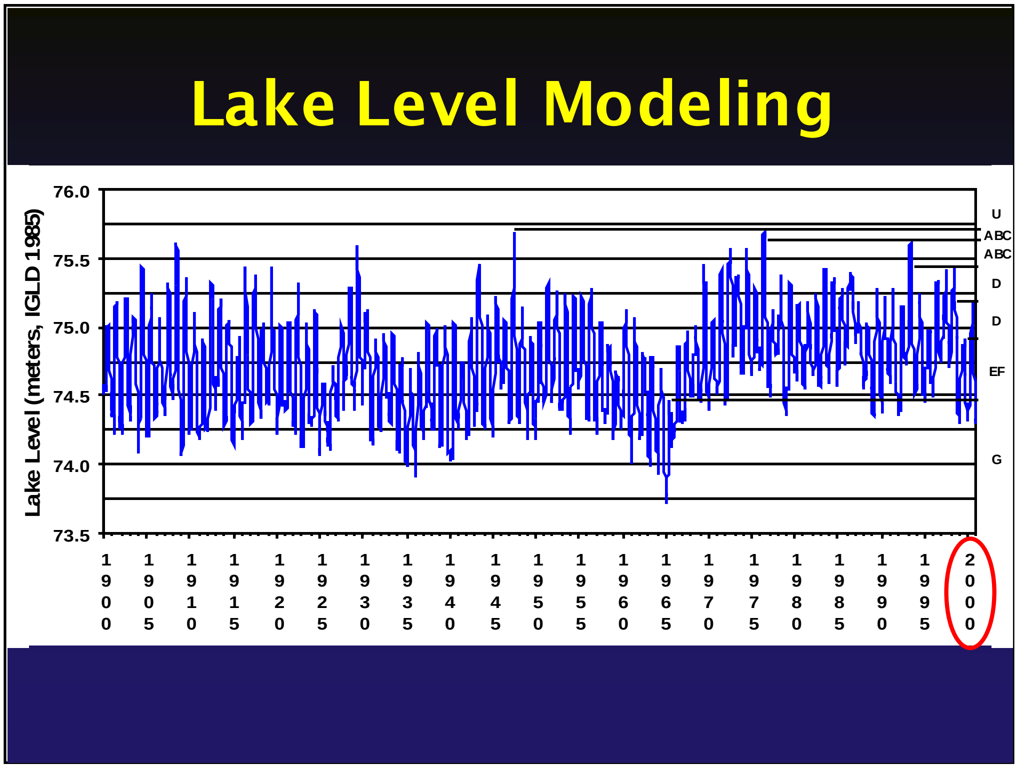
The upper and lower limits of the zones were determined by actual past lake levels.



Topographic and bathymetric mapping of each wetland

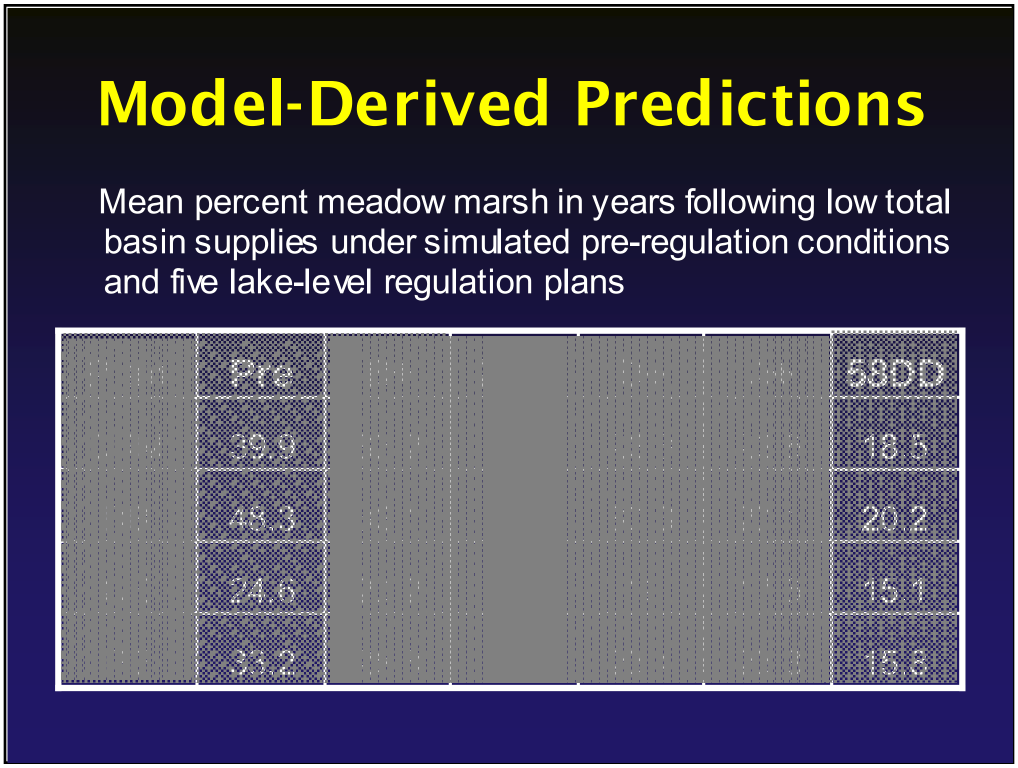


allowed us to construct geometric models for each wetland type. The models depict relative area of wetland with given water depths at any lake level imposed.



When a new regulation plan is evaluated, the models start with the most recent year **(!)**,

determine the flooding or dewatering history of all elevations, and assign them to different plant community types that were characterized by sampling in the field. The models then proceed to each year in the 101-yr sequence depicted in the hydrograph.



In a very brief summary of the results, we see that simulated pre-regulation lake levels **(!)**

would result in the most meadow marsh, followed by Plan B+ **(!)**,

and three rather similar plans (2007, D+, and A+) **(!)**.

The current regulation plan **(!)** would result in the least meadow marsh.

Model-Derived Predictions

Predicted Area of Meadow Marsh (hectares)

Plan	Pre	B+	2007	D+	A+	58DD
United States						
DRM	1026	828	692	676	607	476
BB	1976	1477	1260	1252	1109	827
OE	130	122	103	100	93	80
PE	609	528	437	429	428	290
Canada						
DRM	2187	1765	1474	1442	1294	1014
BB	1628	1217	1038	1032	914	681
OE	367	346	293	281	263	225
PE	2193	1903	1572	1546	1539	1044
TOTAL	**10116**	**8186**	**6869**	**6761**	**6247**	**4637**

Converting these percentages to area of wetland based on our inventory of Lake Ontario wetlands, the same pattern appears. The International Joint Commission originally selected Plan 2007 for further consideration but has since dropped it because there was little support. A U.S.-Canadian panel will determine the next path to take.

Specific to Lake Ontario, the metrics that might be useful in evaluating the Water-Level-Fluctuation Indicator include targeted frequency and duration of low lake level periods, percentages of vegetation types, invasion patterns of cattails, and assessments of overall diversity of wetland plant communities.

Lake-Level Variability and Water Availability in the Great Lakes

by

D.A. Wilcox, T.A. Thompson, R.K. Booth, J.R. Nicholas

http://pubs.usgs.gov/circ/2007/1311/

If you wish to read more about lake levels in the Great Lakes, you can download the report at this URL at no cost.