State of the Great Lakes

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With over 5,500 cubic miles of fresh water and more than 10,000 miles of shoreline, the Great Lakes comprise the greatest single natural resource in North America. The following is an update of Great Lakes issues facing the U.S. and Canada. This compilation covers several issues that could greatly impact the Great Lakes in the coming years. While they seem at first to be separate issues, they are in fact all related. The first topic is a plan to engineer the separation of the Great Lakes from the Mississippi Watershed to help protect the Great Lakes from ecological damage that may result from the invasion of non-native species. Such a project has implications for coastal management, coastal laws, and coastal processes. Related issues are water quality, global warming and changing lake levels. Our understanding of these is all in transition, as noted in the following excerpts. The material does not necessarily represent the personal views of the team who compiled the information; however, it provides the reader with a better understanding of these issues and with the possible changes facing the Great Lakes. *Excerpted material is shown in italics.*

SEPARATION OF THE GREAT LAKES FROM THE MISSISSIPPI RIVER WATERSHED

From a 31 January 2012 Associated Press release by John Flesher, AP Environmental writer:

Groups representing states and cities in the Great Lakes region proposed spending up to $9.5 billion on a massive engineering project to separate the lakes from the Mississippi River watershed in the Chicago area, describing it as the only sure way to protect both aquatic systems from invasions by destructive species such as Asian carp.

The organizations issued a report suggesting three alternatives for severing an artificial link between the two drainage basins that was constructed more than a century ago. Scientists say it has already provided a pathway for exotic species and is the likeliest route through which menacing carp could reach the lakes, where they could destabilize food webs and threaten a valuable fishing industry.

"We simply can't afford to risk that," said Tim Eder, executive director of the Great Lakes Commission, which sponsored the study with the Great Lakes and St. Lawrence Cities Initiative. "The Great Lakes have suffered immensely because of invasive species. We have to put a stop to this."

From the Great Lakes Commission:

According to the NOAA Great Lakes En*vironmental Research Lab, by 2005 more than 182 non-native aquatic species have been reported in the Great Lakes, many causing serious economic losses. Asian carp are the latest, and potentially most damaging, aquatic invasive species (AIS) poised to enter the Great Lakes via the Illinois River. The carp are a hearty species that reproduce quickly and consume large quantities of zooplankton and phytoplankton. Their presence threatens the region's commercial, tribal and sport fisheries valued at $7 billion annually (ASA 2008). Similarly, AIS from the Great Lakes, such as the zebra mussels and round gobies, have damaged the Mississippi River ecosystem.*

The Great Lakes Commission (GLC) and the Great Lakes and St. Lawrence Cities Initiative (Cities Initiative) selected HDR Engineering, Inc. to conduct the $1.2 million 12-month study to develop and evaluate scenarios to separate the Mississippi River and Great Lakes watersheds and prevent the transfer of AIS, with a primary focus on the Chicago Area Waterway System (CAWS). There are two strategic objectives:

Evaluate the economic, technical, and ecological feasibility of separation by illustrating probable scenarios and associated costs, impacts and potential benefits of a re-engineered hydrologic system for greater Chicago.

Support and complement the U.S. Army Corps of Engineers mandated work to evaluate all aquatic connections to the Great Lakes by defining, assessing, and vetting scenarios for separation.

HDR considered 20 possible barrier locations in its analysis and presented 3 alternative solutions. No recommended alternative is identified. The separation alternatives include a down-river single barrier between the confluence of the Chicago Sanitary and Ship Canal and the Cal-Sag Channel and the Lockport Lock; a mid-system alternative of four barriers on CAWS branches between Lockport and Lake Michigan; and a near-lake alternative of up to five barriers closest to the lakeshore. All three include measures to improve the CAWS' role in flood management, wastewater treatment and maritime transportation, as well as stop-

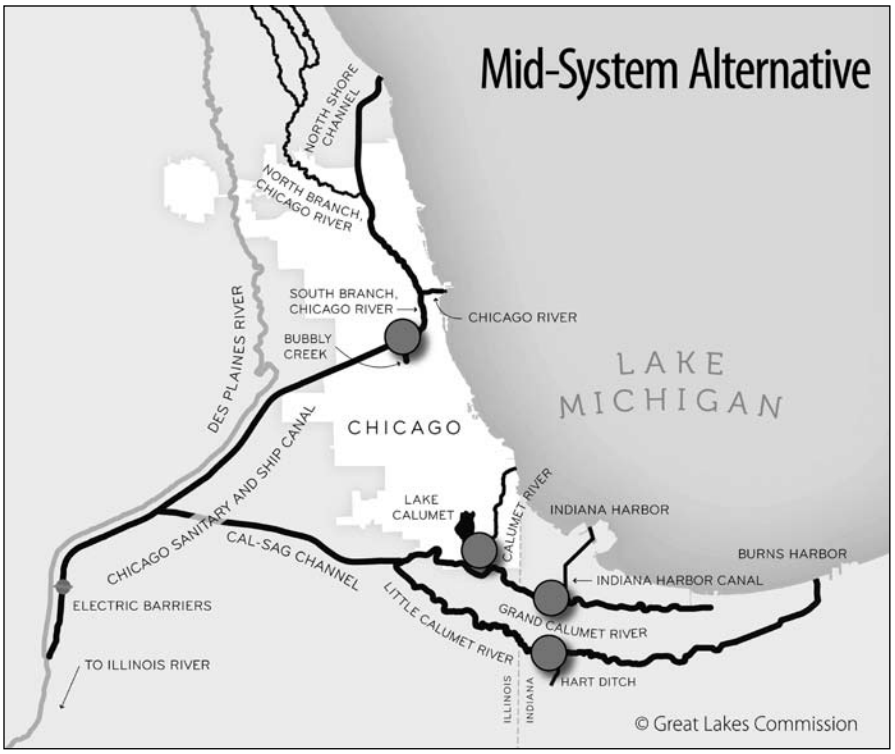


Figure 1. Locations of proposed barriers in the Chicago Area Waterway System (CAWS) to separate the Great Lakes Basin from the Mississippi River watershed. From: http://www.glc.org/caws/. Image credit: Great Lakes Commission and the Great Lakes and St. Lawrence Cities Initiative.

ping the interbasin movement of aquatic invasive species. However, one alternative, the mid-system solution, is the least costly and offers other advantages.

The Mid-System Alternative [Figure 1] *requires barriers located on the South Branch of the Chicago River just upstream of Bubbly Creek, north of T.J. O'Brien Lock on the Calumet River, and on the Grand Calumet and Little Calumet rivers. This alternative poses the fewest challenges for stormwater management, flood management, water quality and transportation when compared to the other two alternatives. The analysis concludes that preventing just a single invasive species from entering the Great Lakes can save as much as $5 billion over 30 years. The Corps of Engineers has identified 10 species that are poised to invade the Great Lakes from the Mississippi River. According to the report's economic analysis, the cost of the barriers themselves is as low as $109 million. The addition of all improvements to address water quality, flood prevention and transportation brings the cost to between $3.2 billion and $9.5 billion, depending on the location and the degree to which the wastewater treatment plants on the system are improved to meet future Clean Water Act requirements. The work is expected to be completed in stages with upstream barriers completed in 2022 and downstream barriers completed in 2029.*

The Mid-System Alternative would improve the region's resiliency to large floods and provide stormwater management capability equal to or better than existing capacity. Water quality in the CAWS would be improved and discharges from the North Side WWTP [waste water treatment plant] *would meet Lake Michigan standards, including the removal of nutrients such as phosphorous. A portion of the water diverted from Lake Michigan would be returned. Recreational vessels and tour boats would have open access to Lake Michigan in downtown Chicago and from the North Shore Channel at Wilmette. Expanded port facilities on the Calumet River would improve intermodal connections, facilitate container traffic, and help reduce congestion on local roads and rail lines.*

The analysis also finds that households in the Great Lakes basin would have to be willing to pay, on average, about $1 a month from now through 2059 to cover the cost of the mid-system alternative, based on a projected cost of $4.27 billion (that's $564 each for 7.57 million households). The GLC and the Cities Initiative point out that the construction costs to build the current CAWS in today's dollars would be $11 billion. Asian carp have been migrating up the Mississippi River system since the early 1990s and were detected in 2009 to have breached electronic barriers operated by the U.S. Army Corps of Engineers in the CAWS. In 2010 a live Asian carp was captured in Lake Calumet just six miles from Lake Michigan. "The current efforts by the state of Illinois, the Corps of Engineers and others to monitor and slow the carp migration are critical and are buying us time to implement a long-term solution," said Eder. See http://www.glc.org/announce/12/01caws.html for more details. The full report and supporting materials are available at www.glc.org/caws.

The U.S. Army Corps of Engineers is conducting its own study of the connections between the two systems, including the Chicago waterways. Eighteen other potential pathways for aquatic nuisance species have been identified and are shown in Figure 2. Termed GLMRIS (Great Lakes Mississippi River Interbasin Study), the study is due to be completed within the next three years.

On May 1, 2012, the USACE GLMRIS Team released the "Commercial Fisheries Baseline Economic Assessment - U.S. Waters of the Great Lakes, Upper Mississippi River, and Ohio River Basins" (Commercial Fisheries Report). "This baseline report provides a thorough summary of the most recently available commercial fisheries data in the GLMRIS study area," said GLMRIS Chicago Area Waterway System Project Manager Dave Wethington. "We will use this and other baseline reports to further our understanding of existing conditions, as well as to help forecast impacts from potential aquatic nuisance species transfer."

The harvest level in the U.S. waters of the Great Lakes is estimated at 19.3 million pounds of commercially-caught fish with an associated value of $22.5 million. The report further shows 10 million pounds with an associated value of $4 million for the Upper Mississippi River Basin and 1.4 million pounds with an associated value of about $2 million in the Ohio River Basin. The harvest level is calculated from the average of the most recent five years of state-licensed and

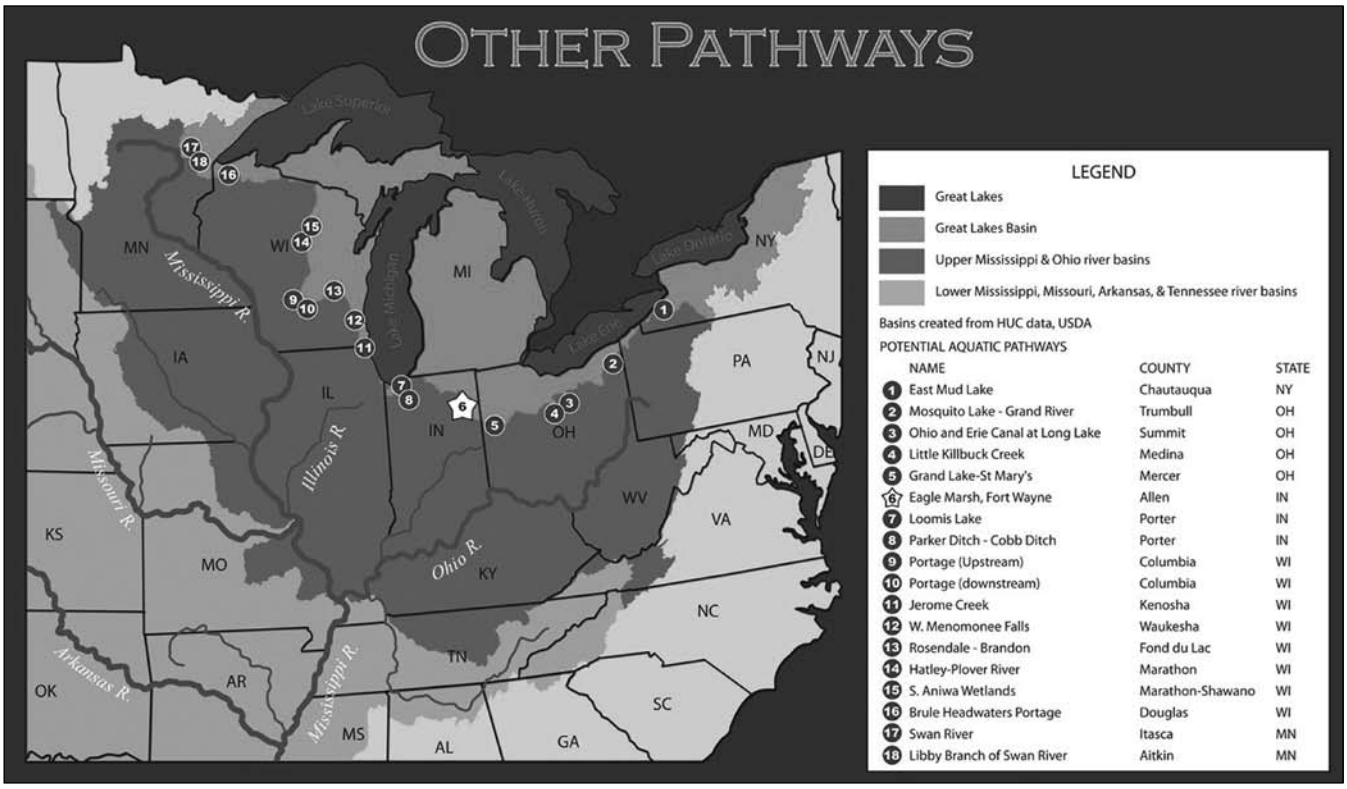


Figure 2. In addition to the Chicago Area Waterway System (CAWS), the Corps of Engineers is studying 18 other potential pathways for aquatic nuisance species (ANS) to move between the Great Lakes and Mississippi River Basins. From: GLMRIS Newsletter, Vol. 2, No. 2, 2012. (For more information, see www.glmris.anl.gov.) Image credit: Great Lakes and Mississippi River Interbasin Study (GLMRIS).

tribal commercial fishing annual harvest data available. See www.glmris.anl.gov for more details.

Separating the Mississippi and the Great Lakes Watersheds won't solve the invasive species problem, however. There is another access way for invasive species to the Great Lakes.

*The first non-native species detected in the Great Lakes was the sea lamprey (*Petromyzon marinus*), that came via the Erie and Welland canals, in the 1830s. And in 1959, the Saint Lawrence Seaway opened allowing large ships to enter the Great Lakes from the Atlantic Ocean. The Saint Lawrence Seaway opens the Atlantic to the Great Lakes through two sections:*

The Saint Lawrence River at Montreal is connected to Lake Ontario by a system of 7 locks that was completed in 1959.

Welland Canal connects Lake Ontario to Lake Erie through a system of 8 locks, the first constructed in 1824 and the latest upgrade in 1973.

For the last 50 years, international ships through the Saint Lawrence have been the primary source of new non-native aquatic invasive species such as the zebra and quagga mussels. Invaders like these have caused serious damage to Great Lakes ecosystem. A study for the USEPA by Notre Dame University and the University of Chicago estimates that the species that gained access to the region through the Seaway cost citizens, businesses, and cities in the eight Great Lakes states alone at least $200 million per year in damage to the commercial and recreational fishery, wildlife watching and water infrastructure. While exact economic data does not exist for the Great Lakes region in Canada, similar damages can be estimated.

U.S. Coast Guard and Saint Lawrence Seaway ballast water regulations require vessels with ballast water to exchange ballast water at sea and vessels without ballast water to flush their tanks before entering the Seaway. These regulations make it less likely that non-native species will enter the Great Lakes. Yet, a few may still get in from ballast water discharges or from other pathways such as aquaculture, imported bait, and the construction of new canals. For more details, see: http://www.epa.gov/glnpo/invasive/.

"The damage invasive species have caused to the Great Lakes is astounding. But, what's most frustrating is that we still haven't closed this door." said Dennis Schornack, former U.S. Chair of the International Joint Commission. See http://www.glu.org/en/press/future-st-lawrence-seaway- hinges-sustainability for more details.

SUSTAINABLE COASTS AND COASTAL MANAGEMENT

In 2011, Illinois became the last coastal state to formally adopt the federal Coastal Management Program. The Illinois Coastal Management Program received Federal approval from the National Oceanic Atmospheric Administration, Office of Ocean and Coastal Resource Management on 31 January 2012.

According to the Illinois Department of Natural Resources (IDNR):

Illinois is dedicated to protecting and managing the natural and cultural resources along its 63-mile stretch of Lake Michigan shoreline. During the last two centuries, Illinois' coast has undergone nearly a complete metamorphosis with its monumental hydrologic modifications, enormous industrial impacts, building

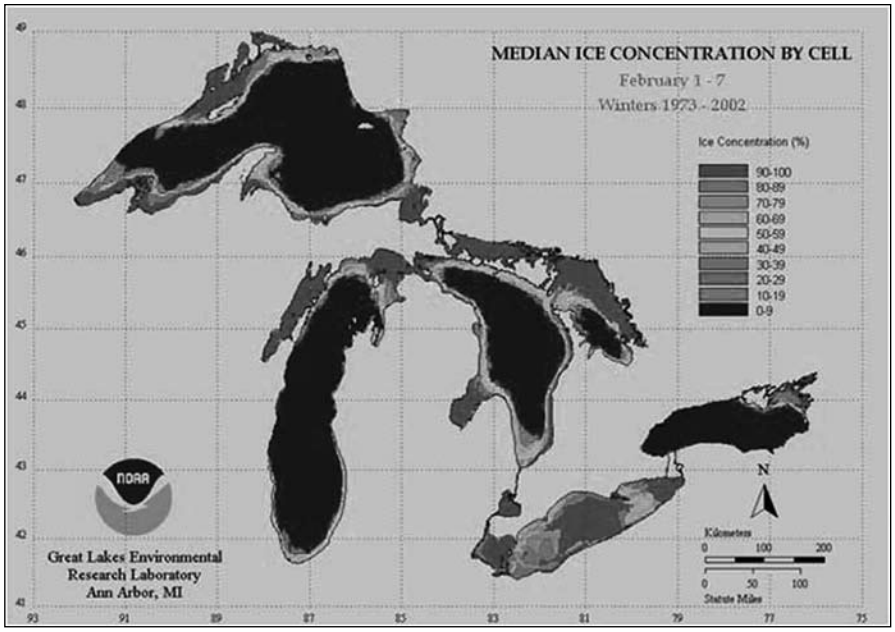
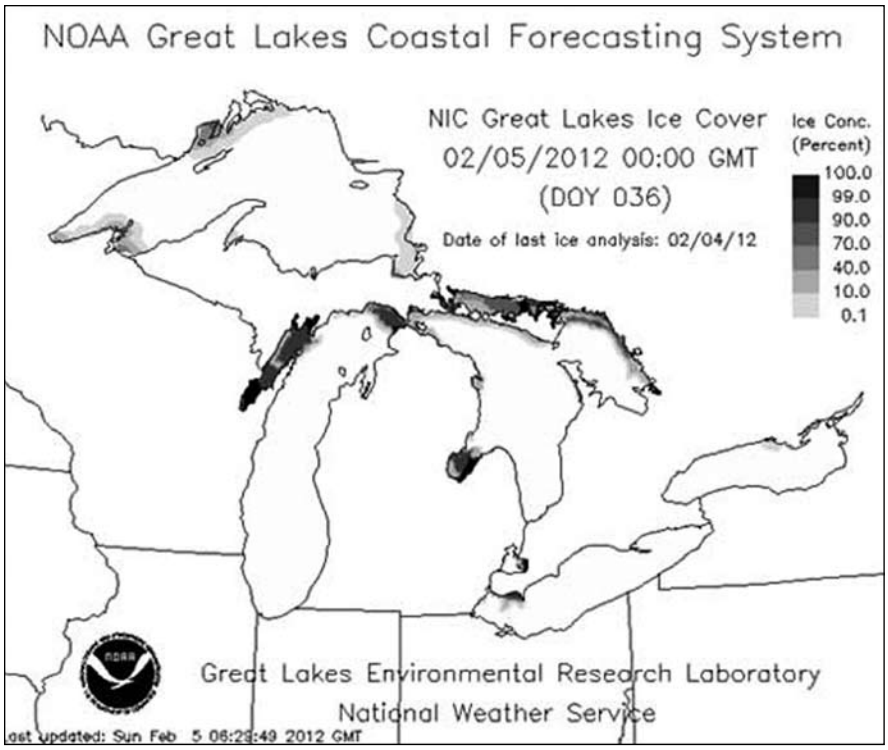


Figure 3. Median ice cover concentration during the first week of February 1973-2002. Image credit: NOAA GLERL.

Figure 4. Great Lakes ice cover 5 February 2012. The darker the areas of the Great Lakes, the more ice cover. Notice that the ice concentration of the majority of the Great Lakes is minimal as compared to 2011. Image credit: NOAA GLERL.



of an excellent transportation infrastructure, and creation of skyscrapers that grace our shoreline. With all these changes, it is remarkable that our coastal resources still contain some of the richest, rarest and most diverse complex of plant and animal species and natural habitat areas in the state.

The Illinois shoreline is highly urbanized and has been subject to considerable stress from intense land use and competition to serve the economic and workforce needs and demands of this densely populated area. The 1909 Burnham Plan, implemented over 40 years, changed an unplanned waterfront sprawl of commercial harbors, railyards and apartment buildings into 5.5 square miles of lakefill including parkland, marinas, museums and more than 30 public beaches. Lake and Cook counties are currently home to 6 million people and are projected to be home to nearly 6.8 million people by 2030. It is estimated that more than 20 million visitors visit the Illinois Lake Michigan shoreline each year. Illinois Beach State Park alone has over 2 million visitors annually. Lake Michigan provides water supply to nearly 7 million Illinois residents (over half of the state's entire population). See www.dnr.illinois.gov/cmp/Pages/default.aspx for more information.

In November 2004, the IDNR announced it would seek to join the National Coastal Zone Management Program. Since its inception in 1972, a total of 29 coastal states and five island territories have developed CZM programs representing most of the nation's 95,000 miles of ocean and Great Lakes coastline. Illinois tried to become a Coastal Management state in the 1970s but was beaten by a well-funded campaign of a small group of citizens who felt that riparian rights would be lost. Although Illinois didn't get Coastal Management then, the IDNR developed management guidelines that have served the public and coastal property owners well. Another benefit was the decision of regulatory agencies including the IDNR, the U.S. Army Corps of Engineers, and the Illinois EPA to streamline the permitting process. Over the years, permitting has again become unwieldy with state and federal permits for shore protection, typically taking at least one to two years for approval. Despite coastal management, in 2012 the permitting process has not yet improved, but citizens of Illinois remain optimistic.

BEACH CLOSINGS, SAND, AND HUMAN HEALTH

Water quality is a critical issue facing Great Lakes as well as ocean recreational beach managers and users. While we've seen great advances in reduction of sewage loading to the Great Lakes over the last 100 years, pathogenic bacteria analysis and control continue to be a problem. Stormwater runoff combined with bird and animal droppings and leaking sanitary sewers appear to be the primary cause of Great Lakes beach closings. Research on rapid and reliable methods for detecting pathogens is a hot topic in the

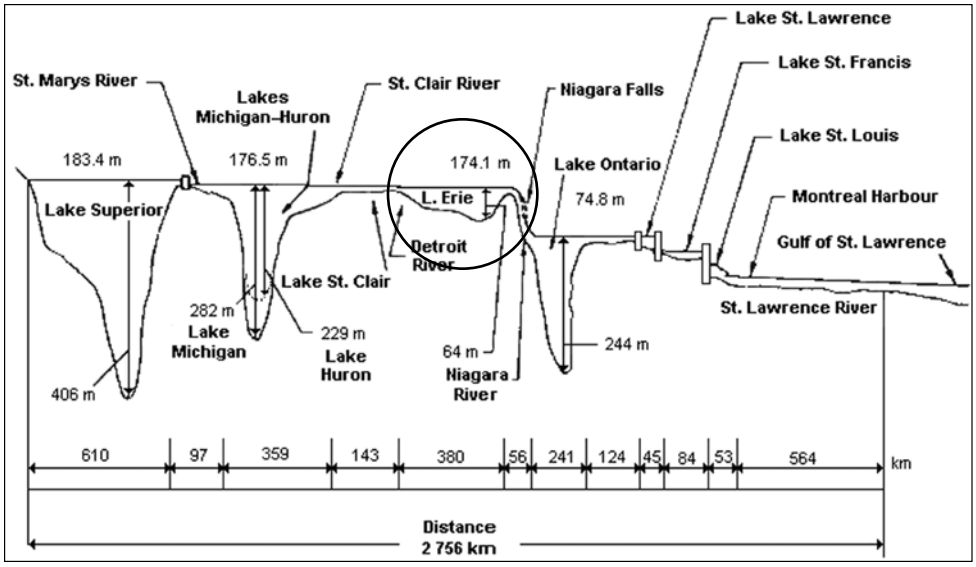


Figure 5. Cross section of the Great Lakes and St. Lawrence Seaway. Notice how shallow Lake Erie is compared to the rest of the Great Lakes. Image credit: Natural Resources Canada.

scientific community, with new advances appearing in the literature regularly. Until we have a quick analytical tool, predicting conditions that are likely to require beach closings is a promising approach to the problem. Mark Pfister, with the Lake County Illinois Health Department, reports using the computer model SwimCast to successfully predict beach closings on three beaches in Illinois (Mark Pfister, director of Population Health Services, Lake County Health Department and Community Health Center, Lake County, Illinois, pers. comm. 2012). And according to Richard Whitman, USGS, mathematical modeling (also used on five beaches in Chicago, one in Indiana and three in Cleveland, OH) is "*an order of magnitude better than testing yesterday's water. E-coli testing is easy for site characterization and analysis but useless for protection of swimmers.*" (See: Beachnet founded and operated by Whitman and hosted by Great Lakes Information Network (GLIN) http://mailman.great-lakes.net/mailman/listinfo/beachnet). As a rule-of-thumb, if there are no formal swim alerts for a beach, staying out of the water for several days after a heavy rainfall has worked for many of us.

To further complicate the beach closing issue, bacterial communities including *E. coli* are known to inhabit ocean as well as fresh water beach sand (Shabica *et al.* 2010). Those of us who have dug into the wet beach know the tell-tale smell of bacteria, especially on high-organic marine beaches close to where seagulls habitually roost. According to a 2012 paper by Shibata and Solo-Gabriele, there is currently no U.S. federal guideline available for assessing the risk of illness from sand at recreational sites. The authors used EPA standards for marine water exposure to develop reference level guidelines to assess risk from Cryptosporidium, enterovirus and *S. aureus* in beach sand. According to the authors:

In order to reach an equivalent level of risk of illness as set by the U.S. EPA for marine water exposure (1.9×10^{-2}), levels would need to be at least about 10 oocysts/g (about 1 oocyst/g for a pica child) for Cryptosporidium, about 5 MPN/g (about 1 MPN/g for pica) for enterovirus, and less than 10^6 CFU/g for S. aureus.

Using these standards, the authors measured pathogen levels in sand at a nonpoint source impacted recreational beach and found them to be lower than the reference level standard for beach sand**.** They conclude:

More research is needed in evaluating risk from yeast and helminth exposures as well as in identifying acceptable levels of risk for skin infections associated with sand exposures.

Whitman *et al.* (2009) studied the health risks of human contact with beach sand containing fecal indicator bacteria. They examined the transferability of *E. coli* and MS2 coliphage from sand to hands at a Great Lakes beach with high concentrations of bacteria. Their research has shown that hand rinsing after contact with contaminated sand is an effective method for reducing exposure to sand-borne pathogens. In summary, a prudent beach user will stay out of the water within a few days after a heavy rainfall, and wash their hands after digging in wet sand, especially before eating.

COASTAL LAW AND THE GREAT LAKES

Ohio and Illinois Beach Access: In 2011, *Merrill v. ODNR*, the Supreme Court of Ohio set the private property limits at the water's edge allowing no beach walking from there to the Ordinary High Water Mark (OHWM). In Illinois, although private property limits are similar, IDNR allows beach walking across the dry beaches on private property.

Wisconsin Coastal Structures: Mark Bell applied for a permit to build a 60-ft extension to an existing 45-ft-long rubble mound breakwater (pier). Bell was denied a permit by the Wisconsin DNR, filed suit and got all the way to the Seventh Circuit of the United States Court of Appeals in 2004 before losing his case. The ruling specified that the structure had to be flow-through to be permitted.

Michigan High Water Mark: In 2006, the Detroit District of the U.S. Army Corps of Engineers sued Marion Kincaid for bulldozing sand below the OHWM on the Michigan shore of Lake Huron. The Federal District Judge ruled that there are no federal regulations that establish, authorize, or condone an administrative ordinary high water mark, so the Corps voluntarily dismissed themselves. The penalty was to be $25,000 per day.

A new law has been established by the Michigan Supreme Court on 13 November 2011 which determines that the natural ordinary high water mark (NOHWM) is 578.8 ft (IGLD 1955)

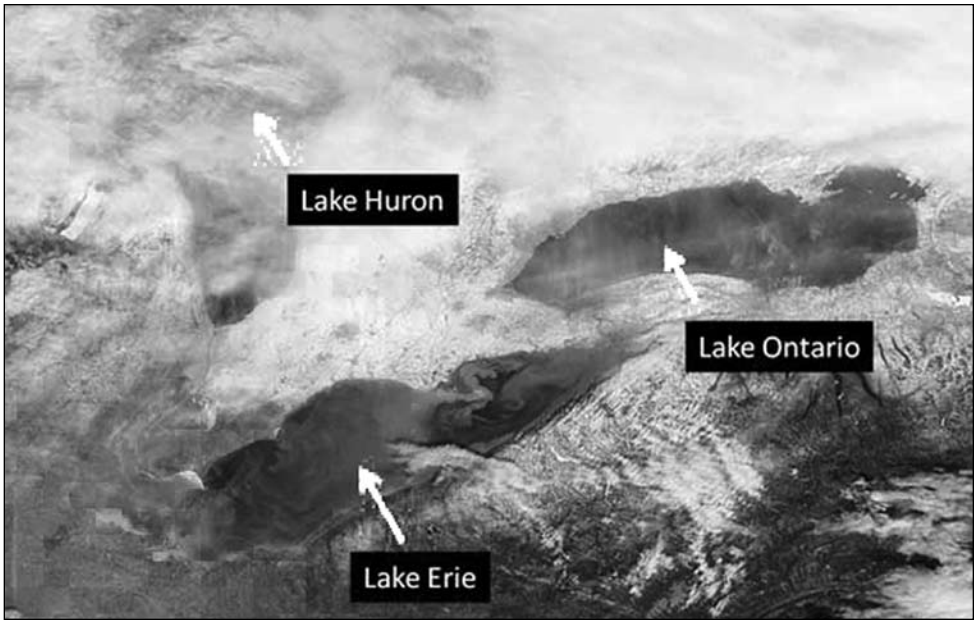


Figure 6. Ice cover on 3 February 2012 across the eastern Great Lakes. Notice the turbidity in the water on Lake Erie but almost a total lack of ice cover. Image credit: NOAA LANCE.

as measured by the land in its natural state unaltered by humans, i.e. without US Army Corps of Engineers jetties or dams in the St Joseph River (Burleson v. MDEQ, 490 Mich. 917.)

Michigan Impacts of Coastal Inlets: The lawsuit *Banks* et al. *v. United States*, filed in the U.S. Court of Claims for damages caused by St. Joseph Harbor was thrown out of court in December 2011. The case began in 1999 when nearly 40 plaintiffs from Shoreham Michigan sued the U.S. Army Corps of Engineers, claiming that construction of entrance channel jetties at St. Joseph Harbor and maintenance activities disrupted the flow of littoral drift sands, thus causing accelerated erosion to downdrift properties. Judge Emily Hewitt initially dismissed the case but revisited it again after her decision was reversed by the U.S. Court of Appeals. The liability trial, held in Niles, Michigan in 2007, ended when Judge Hewitt ruled that the federal government was 30% liable for damages suffered by the plaintiffs. Not until 2008-2010 did plaintiffs learn that the St. Joseph River sand bedload was the primary source of sand to their downdrift properties. In April 2011, Judge Hewitt spent eight days conducting a trial on the amount of damages that the federal government would pay the plaintiffs. After more than six months, she reversed her 2007 opinion and ruled they had filed their claims too late because the statute of limitations had run out. She stated in her 143-page opinion that damages had accrued earlier than 1952, well before the property owners' lawsuit.

Mark Christensen, the plaintiffs' lawyer in an interview with Debra Haight of the *Herald Palladium News of SW Michigan,* said that Hewitt went back to her initial position of dismissal in the case even though she had earlier been reversed on appeal. "So I don't think the federal circuit court will look kindly on her ruling," Christensen said, adding that he plans to file an appeal. A crucial component of this case, not addressed elsewhere on Great Lakes coasts, is loss of river sand either through sand mining in the rivers tributary to Lake Michigan, or loss of river sand to deep water beyond the depth of closure (jetted or dredged). The case is based on the Federal Circuit Court of Appeals 1988 Owen case constraining the Navigational Servitude of the federal government to build structures that interfere with the flow of littoral sand. It is also based on Michigan State law (1994 Peterman case) regarding private property interests and lateral support with regard to littoral drift sand. Plaintiffs maintain that this case is a physical taking of private property for which they are entitled to due process just compensation. The Banks plaintiffs' damage claims were based on past, present and reasonable future damages (1950 to 2050) to approximately 6,500 front feet of Lake Michigan property that has an assessed true cash value of $9,000 to $14,000 per front foot.

LAKE LEVELS, ICE COVER, AND CLIMATE CHANGE

Like their ocean counterparts, Great Lakes coastal managers are concerned about the effects of climate change on lake levels. Geologic evidence shows Great Lakes water levels have stayed within a narrow range for the last 2,000 years (Chrzastowski *et al.* 1991). In historic times, Great Lakes water levels constitute one of the longest high-quality hydrometeorological data sets in North America with reference gage records beginning about 1860 and sporadic records dating back to the early 1800s. These levels are collected and archived by NOAA's National Ocean Service.

Since the late 1990s, Great Lakes water levels have been in a low-cycle where water levels are below average and are typically only a foot or so above the long-term record low. Mild winters with higher than average evaporation are primary suspects, and last winter is no exception. Uncertainties about climate change have led to speculation that lake levels may drop precipitously due to accelerated global warming. However, a study recently released by the International Joint Commission found that "*changes in lake levels may not be as extreme over the next 30 years as previous studies have predicted. This finding reflects a trend of increasing evaporation, likely due to lack of ice cover, and increasing water temperatures and wind speeds, with the resulting reduction in water supplies largely offset by increased precipitation. Projections suggest that lake levels will remain within a relatively narrow historical range with lower levels likely though higher levels are possible at times."* See www.IUGLS.org for the full text of the 2012 International Upper Great Lakes Study.

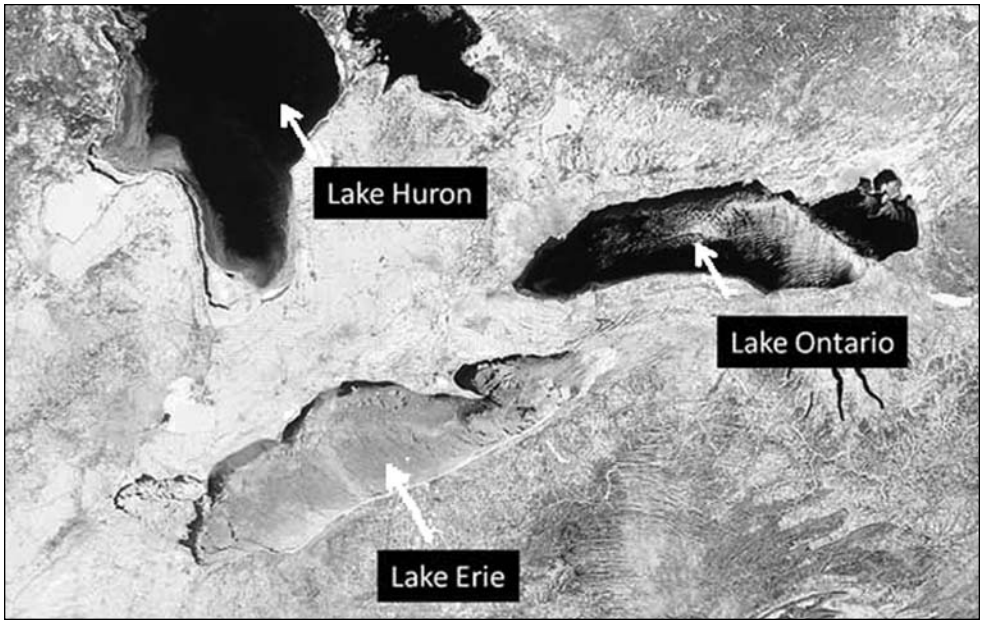


Figure 7. Ice cover on 3 February 2011 across the eastern Great Lakes. Note that Lake Erie is completely iced over, and fresh snow cover highlights the other geographic features around each lake. Image credit: NOAA LANCE.

Tom Niziol, winter weather expert with The Weather Channel, reported on the lack of ice-cover on the Great Lakes in an online report from 7 February 2012. The following information and figures are available at http://www.weather.com/outlook/weather-news/news/articles/great-lakes-lacking-ice_2012-02-06

It's been a very mild winter for the most of the Great Lakes Region. Temperatures are up [and] snowfall is down... Figure [3] *shows the average* (1973 to 2002) *ice concentration on the Great Lakes during the first week of February and Figure* [4] *shows the ice concentration for this year. [Compared to last year] there is very little ice on the Great Lakes...*

This means evaporation will be higher, resulting in lower lake levels. Further, ice cover and ice revetments provide good shore protection from winter storm waves. Intense coastal erosion especially in the Lower Great Lakes, may be the result of loss of ice due to warmer winters.

Niziol goes on to say: "*Lake Erie develops most of its ice cover in the first week or two of February while the deeper Great Lakes take most of the winter season to develop appreciable ice cover... Lake Erie is the shallowest of the Great Lakes as shown in Figure* [5]*, therefore it has the least volume of water by far of any Great Lake. Therefore it tends to cool down and develop ice more quickly than any of the other lakes."*

Figure 6 shows an image of Lake Erie as of 3 February 2012. In comparison, Figure 7 from 3 February 2011 shows the same area when the entire lake was frozen over.

According to WBEZ 91.5 Radio reporter Gabriel Spitzer:

Jia Wang, an ice climatologist with the National Oceanic and Atmospheric Administration, said the changes are stark. In a year like 1979, ice covered about 94 percent of the lakes in the dead of winter. "This winter the maximum ice cover is about 5 percent," Wang said. "It's the lowest ever since the satellite era."

Wang says losing winter ice can cause a number of problems for the Great Lakes ecosystem. It can speed up wintertime evaporation from the lakes, which could reduce water levels. The trend could also fuel more and earlier algae blooms, which damage water quality and habitat. And it leaves shoreline more exposed to waves, accelerating erosion. See http://www.wbez.org/story/great-lakes-ice-down-dramtically-over-40-years-97104 for more information.

While it might be appealing to some to see this as evidence for global warming, the scientists' view is that this phenomenon is a function of natural meteorological cycles. The following quote is from the Wang *et al.* (2012) abstract:

The total loss for overall Great Lakes ice coverage is 71%, while Lake Superior places second with a 79% loss. ... Lake ice mainly responds to the combined Arctic Oscillation and El Niño–Southern Oscillation patterns.

See http://journals.ametsoc.org/doi/abs/10.1175/2011JCLI4066.1 for further detail.

There is a message for Great Lakes states coastal managers: Be prepared! Many areas of the Great Lakes are currently suffering serious shore erosion, despite relatively low water levels. Intense Great Lakes storms are the culprit. States, municipalities, and private property owners are seeing shore protection and beach nourishment costs rise and this is not likely to change regardless of lake levels or presence of winter ice cover.

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