



Module 6: Ports and Shoreline Management

THE CHANGING CLIMATE'S IMPACT ON PORTS, HARBORS AND MARINAS IN THE GREAT LAKES REGION

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Background

Background

- 130 U.S. coastal communities have structures such as channels, breakwaters and piers to safeguard navigation.
- Such structures also provide critical storm and flood protection – particularly for coastal power plants, water supply intake systems and wastewater treatment facilities.
- More than half of these structures were built prior to WWI, and over 80% are older than their typical 80-year lifespan.
- Thus, most coastal infrastructures are vulnerable to changes in climate, such as increased or decreased precipitation.



Lighthouse structure and pier in Manistee, Michigan.

Adapted from: OSU Webinar “Economic Implications of Climate Change Impacts on Great Lakes Ports, Harbors and Marinas”: <http://changingclimate.osu.edu/webinars/archives/2011-03-01/>.

Background

Ports are critical to the trade and transportation networks of the United States.

- Ports handle 78% of all U.S. foreign trade by weight and 44% by value.
- Ports represent billions of dollars in capital improvements and new investments.
- While the risk that climate change poses to ports is unclear, what is clear is that ports will be impacted and shoreline managers should plan for ports' continued resiliency and reliable operations.

Primary needs:

- Port and shoreline authorities need additional information about specific impacts they may face
- Data and recommendations are not yet scaled down to be useful at the regional/local level

Adapted from: EPA White Paper "Planning for Climate Change Impacts at US Ports":
<http://www.epa.gov/sectors/pdf/ports-planing-for-cci-white-paper.pdf>.



The Port of Detroit is the largest seaport in Michigan.

Quick Facts and Statistics

There are...

- 610 miles of channels in the Great Lakes
- 117 harbors that are federally serviced by the Corps of Engineers
- 104 miles of breakwaters, with \$3.3 billion investment in breakwaters alone
- 20 dredge disposal facilities, which may be valued at \$20-35 million USD **each**
- There are locks in Chicago, Sault Ste. Marie and Buffalo, New York
- Marinas have a shorter lifespan than other infrastructures, at approximately 40-50 years

Adapted from: OSU Webinar “Economic Implications of Climate Change Impacts on Great Lakes Ports, Harbors and Marinas”: <http://changingclimate.osu.edu/webinars/archives/2011-03-01/>.



Breakwater in Michigan made from salvaged materials.

Impacts of climate change on ports, marinas, harbors and shorelines in the Great Lakes Region

Climate impacts

to ports, marinas, harbors and shorelines

Climate change impacts may include:

- Changes in rainfall and increases in storm intensity
- Increased erosion and sediment load
- Water-level changes in Lakes
- Increased wave height and speed
 - Greater wave heights will be associated with higher water levels and could result in damage to port structures, harbor infrastructure and marina docks and boats



A storm surge can damage coastal infrastructure considerably.

Climate impacts

Three primary

According to Wisconsin Sea Grant, **the three major** climate change impacts that are most relevant to Great Lakes ports, harbors and marinas are:

1. Water level changes
2. Storm water
3. Precipitation and temperature changes



Impacts can be wide-ranging in the Great Lakes, and can vary regionally.

Climate impacts

Lake level variability

Prepare for lake level variability.

Water-level changes that are different than historic Great Lakes ranges can affect coastal facilities and structures in several ways. Generally, lake levels are at their lowest in winter and highest in summer and fall. For the last 15 years, the Great Lakes region experienced lower lake levels than average; however, that trend has since reversed.

According to NOAA-GLERL, since September 2014, all of the Great Lakes have been **above** their average monthly levels for the first time since the late 1990s. Levels are anticipated to remain high at least through the Spring of 2015.

- High levels of precipitation in late 2013-2014 ended the 15-year below-average trend for Lake Michigan, Huron and Superior.
- NOAA-GLERL reported in February 2015, *“The net rise in water levels on Lake Superior from January 2013 through December 2014 was roughly 2 feet, the highest net increase ever recorded for a 2-year period starting in January and ending the following December.”*



Lake Superior waves in Fall of 2014, when lake levels had returned to above average.

Climate impacts

Lake level variability

Benefits of higher lake levels may include enhanced hydropower capacity, the potential for increased tourism from recreational boating, and ease of commerce via shipping. Drawbacks can include shoreline property damage, coastal erosion, flooding, reduced beach access/beach tourism and impacts to the fishing industry.

- When levels are low, ships cannot be fully loaded and must carry less cargo per trip. Vessels may become damaged by hitting the channel bottom, or become stuck beneath structures when water levels rise. Lower water levels may also reduce access to shipping channels and ports.
- As levels fluctuate, harbor structures may become unstable. Beaches may become exposed, thus affecting the aesthetic quality and tourism potential of the area.
- If sedimentation occurs, additional dredging may be required, which is costly and may take up to several years to complete. This can result from both higher or lower than average lake levels.

Environmental journalism agency Circle of Blue discussed the economic costs of low lake levels in 2012:

“Every centimeter of lost draft equates to 95 fewer metric tons of cargo...That’s lost revenue for companies and less efficiency...When lake levels were high, the biggest ships carried 70,000 tons...The biggest loads this summer are 64,000 or 65,000 tons.”



Exposed docks during low lake levels on Lake Michigan and Lake Huron in 2012.

Climate impacts

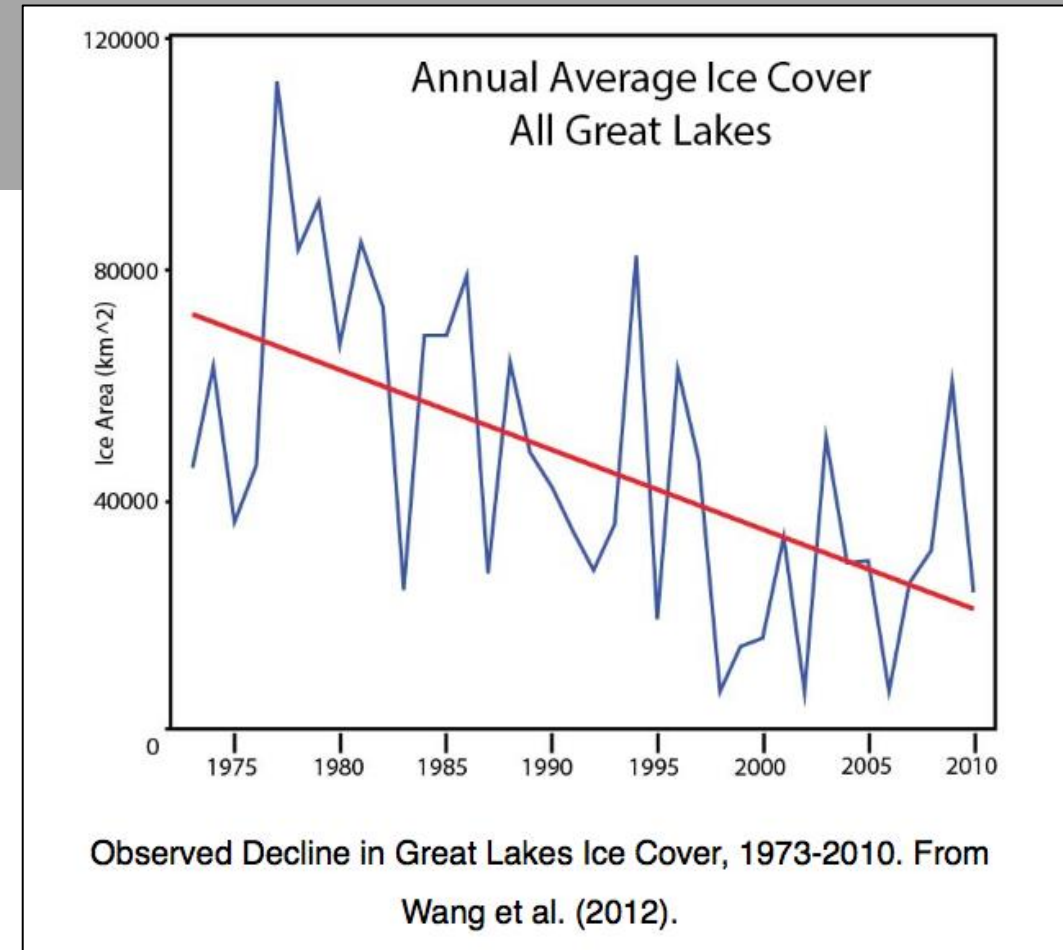
Lake level forecasting

Water level forecasting for the Great Lakes is a complex process and accounts for a variety of factors, including “over-lake precipitation, evaporation and runoff” (NOAA-GLERL). Hydrologic simulation models are often used – for example, the AHPS (Great Lakes Advanced Hydrologic Prediction System) combines historical data on climate and weather patterns, with emergent forecasting methods.

Still, weather anomalies (such as the polar vortex that hit the Midwest in 2014) can make lake level prediction more difficult. Also, each lake is unique in its geology, watershed, volume and size, yet all lakes are interconnected, which further compounds forecasting ability.

Data from GLISA demonstrates that ice coverage on the Great Lakes – as well as how early in the season the ice forms - has a direct effect on evaporation from the lakes and is a factor in overall water levels. Ice cover is key for the health of many species and ecosystems in the Lakes. From 1973-2010, there was an average 71% decline in ice levels across all Great Lakes.

Given forecasting uncertainties, it is best to prepare for both higher and lower lake levels in the future.



This chart from GLISA reflects ice coverage trends over the last 30+ years.

Climate impacts

Lake levels and resiliency planning

Because it is difficult to anticipate Great Lakes water levels into the future, municipalities may wish to engage in resiliency planning for both higher and lower lake levels. Many communities have already begun drought and flood contingency planning. Strategies can include:

- Installing “floating” docks that can move with varying water levels
- Incorporating softshore engineering practices to stabilize and protect coastal areas against wave erosion. This includes the use of natural features and vegetation, rather than “hard” infrastructures such as sea walls. Softshore engineering offers added aesthetic benefits.
 - Softshore engineering often incorporates habitat for fish and wildlife, whereas hard engineering does not.
 - Softshore engineering is not appropriate for all vulnerable areas and is best used where hard infrastructure is not needed.
- Shoreline setbacks
- Plans for navigation and dredging in adverse conditions



Softshore engineering at the Detroit River offers aesthetic and ecological benefits.

Climate impacts

Storms, waves and high winds

A changing climate may result in increased severity and frequency of storms, causing:

1. Larger waves and storm surges, which can damage infrastructure and docked watercraft. This can also cause shoreline erosion and coastal property damage. Bluffs are particularly vulnerable.
2. Reduced vessel mobility and hindered harbor operations. Human health threats and shipping delays may result.
3. Heightened sedimentation, requiring additional dredging.
4. Infrastructure and sensitive harbor / port equipment damage from high winds.
5. Spreading of contaminated materials. Beach closures from excessive storm runoff may result, causing health impacts, loss of tourism, and reduced quality of life.
6. Varying water levels can warp wooden structures and/or cause them to rot once they are exposed to oxygen.



Credit: Timothy Wenzel

Hurricane Sandy caused about \$17.7 million in damages to federal navigation structures in the Great Lakes region.

Stormwater impacts

Highs and lows

Marine transport and shipping may be negatively affected in the following ways:

- Higher temperatures and/or increased sediment deposition from flooding may lead to reduced channel depth and lessened clearance under bridges. Costly dredging may be required.
- With shallower channels, more stringent size and weight restrictions may be enforced. Similarly, with flooded channels, navigation may be temporarily halted, resulting in economic losses.
- Harbors and docks are also vulnerable to higher storm surges

Resiliency planning that includes more pervious surfaces, as well as diversion channels and subsurface stormwater holding tanks, are some of the municipal strategies that have been successful in managing stormwater.

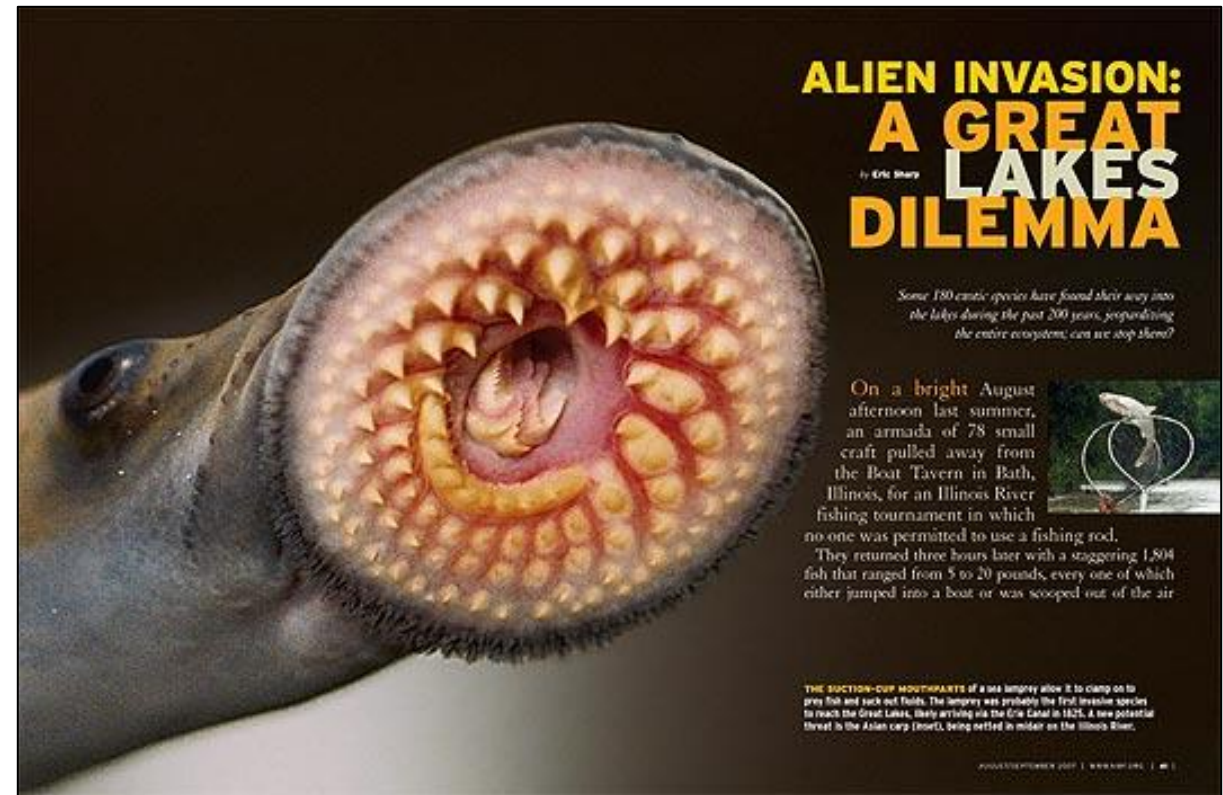
Leland Harbor in Leland, Michigan: differences in water levels threatened the summer tourism economy.



Climate impacts

Precipitation and temperature changes

- Extreme heat and cold may require additional energy to protect cargo being stored at harbors and ports
- Port employees who work primarily outside may be exposed to harsher and more dangerous conditions
- Warmer temperatures heighten the risk of invasive species spread
- Excessive freezing and thawing can crack breakwaters and other structures
- Changes in lake ice cover can impact sensitive species such as whitefish and trout



The invasive sea lamprey disrupts food webs in the Great Lakes.

Climate impacts

Water Quality

- According to GLISA, “Rising carbon dioxide concentrations, warming lake temperatures, a longer stratified-lake season, increasing extreme precipitation, and an abundance of nutrients are conspiring to increase the risk of harmful algal blooms, particularly on Lake Erie.”
- These blooms increase the risk of hypoxic “dead zones”, fish kills, beach closures and threats to human and ecosystem health.
- Lake Erie is especially vulnerable to HABs, because roughly 63% of its watershed is used for agriculture. Phosphorus from fertilizers is a contributor to algal blooms.
- Economic losses stemming from reduced recreational boating and beach usage can be significant; Lake Erie’s harmful algal bloom of 2011 caused a \$2.4 million loss to Ohio’s recreational fishery alone, and a \$1.3 million loss to the State Park system because of fewer visitors.
- NOAA-GLERL has developed a HAB bulletin that offers the most current information on HABs in Lake Erie.



Harmful algal blooms in the Great Lakes threaten human health, harm ecosystems and wildlife, and cause considerable economic losses.

Climate impacts

Water Quality

- Many strides have been made in protecting and improving water quality in the Great Lakes.
- Measures such as wastewater infrastructure improvements and sewage treatment plant upgrades, pollution prevention, site restoration, enhanced monitoring and more stringent environmental standards can be credited.
- The EPA has identified key Areas of Concern (AOCs) that are environmentally degraded. These remaining areas may have contaminated sediment and/or restrictions on dredging activity, restrictions on drinking water, fish and/or wildlife consumption.
- The EPA has developed Remedial Action Plans (RAPs) to help restore these areas.
- At present, 43 AOCs have been identified, with 26 in the US, 12 in Canada and 5 that span the borders of both nations.
- The ultimate goal is to clean up and “de-list” these sites.



The map above depicts the locations of the 43 remaining AOCs in the US and Canada.

Dredging

The facts

Climate change may result in an increased need for dredging to avoid bottoming out of commercial ships and recreational boats. Low water levels may adversely affect boat launches at marinas and public access points as well, but both increasing AND decreasing water levels can necessitate dredging, which is costly and time-consuming.

- For the 58 docks in the Duluth/Superior harbor (the largest port in the Great Lakes), dredging would cost \$12/cubic yard, totaling \$37.6 billion.
- For Toledo's harbor, which is much smaller, the cost would be \$11-12 million. Dredging also poses an additional problem: what to do with the waste??
- Contaminated materials may be brought to the surface, creating environmental risks and requiring additional expenditures



Lake dredging.

Dredging

Repurposing

The average annual dredging volume in Great Lakes is 3-5 million cubic yards of material, half of which is contaminated.

- Contaminated material is placed in CDFs (confined disposal facilities) which are costly to build and are filling rapidly
- Per Wisconsin Sea Grant, non-contaminated dredged material can have many beneficial uses:
 - Provides “fill” for new developments, like parks, planned communities and beaches
 - Can be used to cover landfills and cap / seal off hazardous sites and inactive mines
 - Can be used to create valuable topsoil for agricultural and urban greening use
 - Habitat restoration and mineland reclamation



Wetland created from dredged material. Source: Wisconsin Sea Grant, photo credit: Richard Price, US Army Corps of Engineers

Primary challenges facing Great Lakes shoreline managers

Primary challenges

- Climate models' inability to supply dependable modeling information on which to make predictions.
- Need dependable data to get investors and local governments to start allocating more funding toward adaptation.
- Difficulties in time frame and scale – threats are long-term, therefore effects may not be seen immediately – which can make it difficult to sustain interest in and funding for adaptation efforts. For example, IPCC predictions may take full effect in 80-90 years, but port authorities typically have 5-10 year planning horizons.



Source: Forum for the Future. <http://sd.defra.gov.uk/2010/12/insurance-central-to-global-agreement-on-climate-change/>

Primary challenges

- Higher insurance premiums for ports and municipalities
- Oftentimes, port authorities themselves do not own or have control over the infrastructure they depend on, nor are they able to secure funding sources independently.
- Each state defines its coastal management practices differently. There is variation between municipalities in terms of coastline jurisdiction and how to best operate a coastal management program. 34 states currently have approved coastal management programs. The goal of these programs is to:
 - Protect natural resources;
 - Manage development in high hazard areas;
 - Give development priority to coastal-dependent uses;
 - Provide public access for recreation;
 - Coordinate state and federal actions.

For more information, see the National Coastal Zone Management website at www.coastalmanagement.noaa.gov.



The National CMZ program strives to balance water-dependent coastal uses, like fishing and recreation, with preservation, so that all residents can continue to enjoy coastal resources in the future.

Recent municipal efforts to create more resilient shorelines

Case Study

Goderich, Ontario

Issues

- Climate change, ecosystem disruption and unsustainable development were identified as three major issues facing Goderich
- In 2011, a massive tornado swept through Goderich causing \$110 million in damage and the Town wished to rebuild – but to do it better than before, in a more climate-resilient way
- Maitland Valley Conservation Authority identified that coastal activities like tourism and fishing were threatened by climate change
- 66 gully watersheds drain into Lake Huron. They are increasing in size and rate of erosion. Potential loss of land due to gully erosion: 1,897 acres or 767.7ha.
- Value of land and development that would be potentially lost: \$89.5 million.

Adaptation Measure: Maitland Watershed Resiliency Challenge

- In 1988, Rotary Beach Cove was created from 300,000 m³ of dredged sediment from the harbor as a way to control erosion and improve wildlife habitat.
- Groynes, jetties, and recent installations of beach grass are continuing to improve erosion to this day
- MWRC will potentially establish 30,000 acres of stream buffers and connections across the watershed
- Will potentially reforest or create permanent cover for 58,340 acres of fragile land.
- Demonstration sites are a key piece in educating landowners and municipalities of the value gained from using rural storm water management, natural infrastructure and erosion-control measures to develop a more resilient landscape and coast.



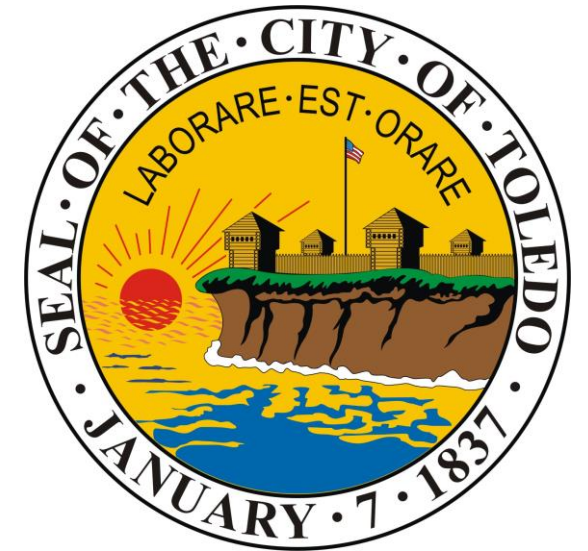
Aerial view of Goderich coastline. The Maitland River flows into Lake Huron.

Case Study

Port of Toledo

Issues

- Port of Toledo is one of the busiest ports in Great Lakes, and is also the most heavily dredged
- US Army Corps of Engineers dredges 700,000 cubic meters (900,000 cubic yards) of mud and sand, or 1 million metric tons, per year.
- In the past, for every 10-11 metric tons of cargo that moved into and out of the Toledo port, about one metric ton of sediment left the channel. (Last year, 10.4 million metric tons of cargo were handled at the port.)
- With climate change, more mid-winter snow melts and more frequent heavy rainfalls may lead to higher soil-erosion rates, with more soil ending up in the channel. Higher air temperatures are warming the Great Lakes, blocking ice from forming and increasing rates of evaporation that may lead to lower lake levels.
- This all equates to more frequent dredging to keep the Port operating smoothly, which could require tens of millions of dollars in port planning and operations costs.
- The Port and the Toledo economy depend on a better understanding of weather and water conditions over the next several decades.



Adaptation Measure: Sediment Management and Use Plan

- Combined approach that incorporates wetland restoration and shoreline protection, agricultural field protection, deposition in pre-identified areas and other beneficial uses.

Case Study

St. Joseph, Michigan



Issues

- In 2012, a resident requested a permit to build a seawall that would protect his beachfront property, which was located within a potentially hazardous “wave fetch” zone, where high storm surges could occur
- A study was conducted and findings suggested a need to build a “setback”, with zoning restrictions that would prohibit further construction in the area
- Public outcry brought the issue to the forefront of city discussion.

Adaptation Measure: Public Engagement and Zoning Restrictions

- Public hearings were conducted. Consensus was reached to instate a “No-build” zoning ordinance, a pivotal decision.
- The recommended elevation for building was calculated by adding a two-foot storm surge and a 50-year wave run to the record high water level. Any construction within the danger zone was prohibited.
- Excerpt from case study: “Sound science, in conjunction with public participation, was effectively used during the public engagement process to improve public awareness of coastal hazards and ultimately, generate support for a zoning ordinance that was designed to preserve public trust lands and protect both public safety and private property along the shore into perpetuity.”
- Four best practices:
 - **Craft resilience strategies for natural resources when the public expresses concern, awareness and knowledge of value.**
 - **Engage in joint problem definition and fact-finding to build trust and promote informed decision-making.**
 - **Educate the general public and political decision-makers together to foster communal learning and discussion.**
 - **Present all materials in simple and engaging terms such that an individual with no prior knowledge could understand easily.**

Tools to assist shoreline managers

Tools and Funding

NOAA Sectoral Applications Research Program Grant (SARP)

•5 objectives:

- Climate change modeling: bringing global climate change aspects down to Great Lakes region;
- Economic impacts for ports, harbors and marinas;
- Geospatial tools to visualize impacts - in particular, water level changes;
- Communications products;
- Integrating results into municipal strategic plans

CE Dredge, US Army Corps of Engineer's database

<http://ce-dredge.usace.army.mil/>

Great Lakes Maritime Research Information Clearinghouse (very helpful)

<http://www.maritime.utoledo.edu/>

WEPPCAT: EPA's tool for sediment loading prediction

<http://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=153583>



Tools and Funding

Clean Marinas Program

The program is a collaboration between Michigan, Ohio and Wisconsin Sea Grant, and is funded through Great Lakes Restoration Initiative (US EPA). Six of the eight Great Lakes states offer Clean Marina certification.

In this program, participating marinas voluntarily pledge to maintain and improve local waterways by reducing or eliminating releases of harmful substances and phasing out practices that can damage aquatic environments. Per the Michigan Clean Marina's program website, "In Michigan to date, more than 40 marinas have been awarded certification. Since the program began in 2005, 30 Michigan marinas have been recertified, showing continued commitment to keeping Michigan waters clean."

According to the program website, the benefits of certification include reducing insurance and waste disposal costs, reducing pollution, improving water quality, protecting fish and wildlife habitat, and enhancing public image and relations through the promotion of environmentally sound practices.

The Great Lakes Clean Marina program also offers educational webinars on topics such as stormwater management, boat bottom washing to reduce invasives spread, and increasing resiliency for harbors and marinas.

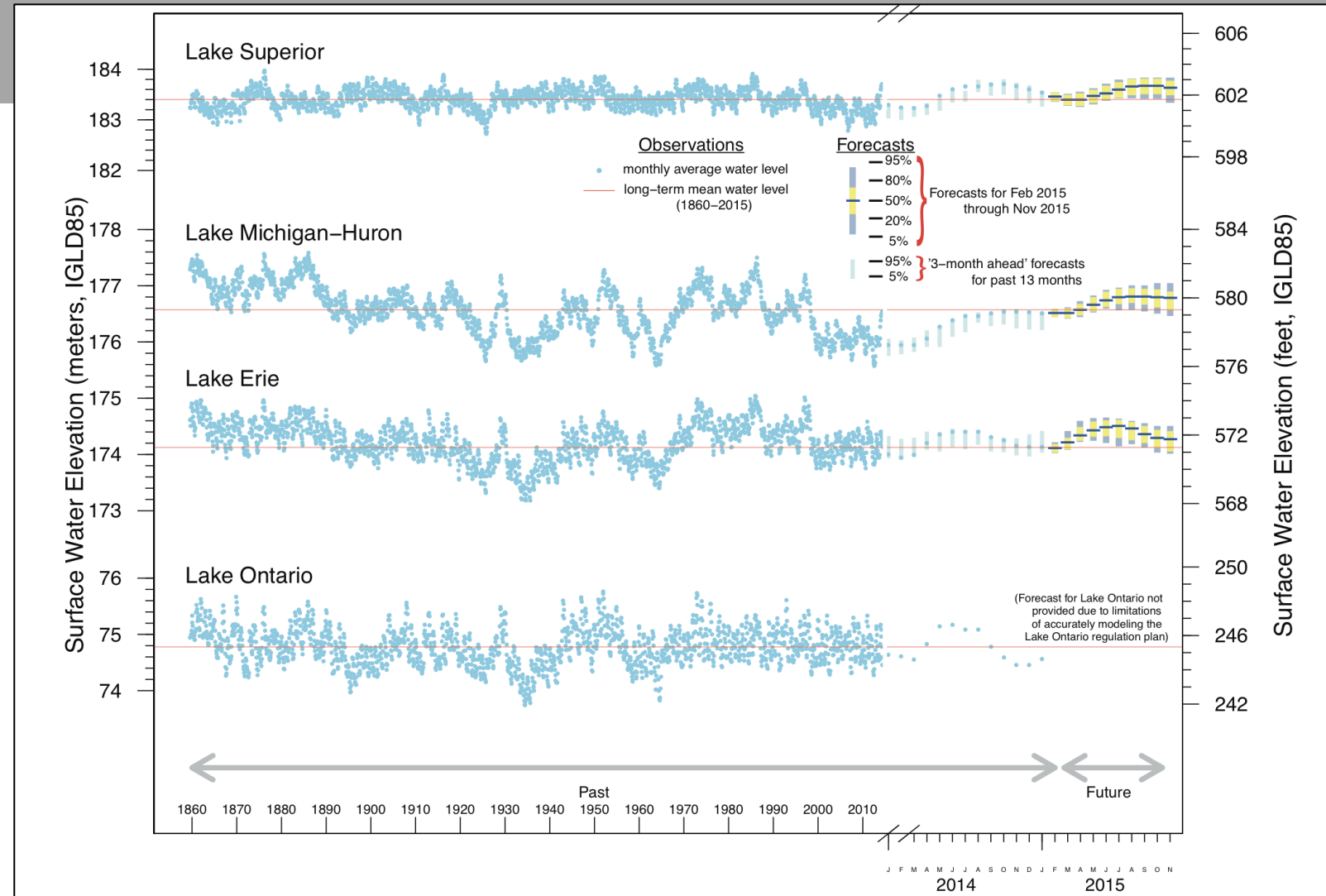
They provide pollution and recycling kits for marina operators and boaters, and have compiled a Best Practices Management Guide for Great Lakes. The Clean Marina Classroom is an online educational tool for marina owners and operators hoping to pursue Clean Marina certification.



Tools and Funding

The NOAA-GLERL AHPS (Great Lakes Advanced Hydrologic Prediction System) forecasts are used by the U.S. Army Corps of Engineers and Environment Canada as part of their operational water level forecasting.

- The US Army Corps of Engineers' Detroit District website shows recorded, projected, and average water levels for each lake in a Monthly Bulletin report.
- Bulletins are uploaded on the 5th or 6th day of every month.
- The Army Corps offers funding for dredging through their Operation and Maintenance budget (O&M), through the Harbor Maintenance Tax. Projects with a Great Lakes Area of Concern (AOC) are eligible.



Tools and Funding

Nature Conservancy's Climate Wizard

- Explores future climate scenarios to assist with planning, prioritization and development

The Association of Floodplain Managers Great Lakes Coastal Resilience Planning Guide

- Offers analysis tools for coastal managers

NOAA's Coastal Services Center

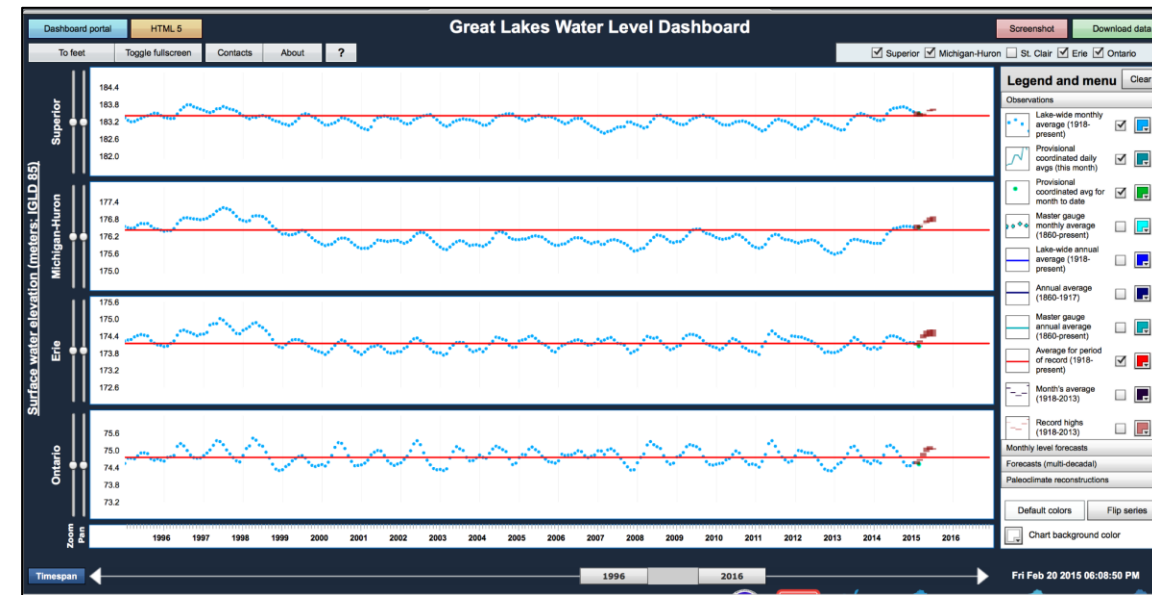
- Provides geospatial data on Digital Coast. Offers tools, training and resources for municipal officials.

The Collaboratory for Adaptation to Climate Change

- Offers tools and case studies and provides a collaborative framework where municipal decision-makers can connect with one another

Halifax Climate SMART: Sustainable Mitigation & Adaptation Risk Toolkit

- Kit includes risk management, community-based vulnerability assessment, cost-benefit, environmental impact analysis, and communications/outreach tools. Combines mitigation and adaptation.



The Great Lakes Environmental Research Laboratory's Great Lakes Water Level Dashboard (pictured above) visualizes historic and future lake levels, with user-specified time scales.

Tools and Funding

- NOAA Office for Coastal Management offers a list of **grant opportunities** on its website: <http://www.coast.noaa.gov/funding/resource-management.html>
- The Michigan State Waterways Commission has **emergency funding for dredging**: http://www.michigan.gov/dnr/0,4570,7-153-58225_37985-124962--,00.html
- In Michigan, the Michigan Department of Natural Resources (DNR) offers several **grants for coastal managers**. Other Great Lakes states have similar programs through their respective DNRs. These grants assist with everything from aquatic invasive species control to dam removal to targeted runoff management.
 - Per the Michigan DNR's website, **Waterways Program Grants** provide “funding assistance for design and construction of public recreational harbor/marina and boating access site/launch facilities throughout the state. Only local units of government (city, village, township, or county) and public universities are eligible” to apply.
- Great Lakes Restoration Initiative through the EPA: <http://www.epa.gov/grtlakes/fund/index.html>
- Association of Marina Industries offers **boating access grants** for public construction projects and Clean Vessel Act grants for marina sewage/pumpout stations
 - Also offers “BIG” grant program (Boating Infrastructure Grant Program), which provides funding to States for construction, renovation and maintenance of public boating infrastructure for transient boats 26’ or longer



Benefits and drawbacks of tools

Considerations for municipal planners

Benefits:

- These tools can help provide a very valuable starting point for discussion and planning
- May assist in envisioning multiple scenarios, with various adaptation strategies, to gauge which are most effective at the least cost
- Offer quantifiable metrics that community members and municipal officials can easily understand and budget for
- Empower users to take immediate action in their own localities

Drawbacks:

- Tend to oversimplify – can't capture all aspects of a scenario completely
- Some tools tend to rely heavily on data that may or may not be fully complete
- Can undermine credibility if used incorrectly
- Tools need to be scalable

Best Practices

From EPA's "Planning for Climate Change Impacts at US Ports":

"Ports can adopt **capital improvements, maintenance projects, or operational changes** to adapt to climate change.

For example, the construction of a protective sea wall would be a capital improvement. Reinforcing existing structures against stronger wind and waves would be a maintenance project. Reducing cargo loads in the face of lower water levels would be an operational change.

Likewise adaptation measures can **protect, adapt, or retreat**. Raising docks and warehouses would protect those assets. Developing more robust emergency procedures for storms would accommodate climate change. Relocating a port operation, as the Port of New Orleans is considering, would be a retreat measure."



Sea wall.

Best Practices

Summary

1. Assess risks and impacts in your area. Variable water levels, changes in precipitation and temperature, and increased storm frequency and severity are among the most likely climate-related outcomes to consider.
2. Conduct routine monitoring of shorelines and infrastructure to catch any issues or erosion early. Consider how facilities may operate in extreme temperature and weather conditions, and plan to stabilize or even relocate critical infrastructures as necessary.
3. Invest in long-term planning. This can include the installation of larger breakwaters, reinforced sea walls, and updated stormwater systems. Prioritize dredging in the most key areas first.
4. Form community partnerships and alliances. This helps with securing funding and enhancing/encouraging participation and buy-in from other stakeholders. Consider creating a Marine Investment Fund, wherein non-marine users pay a tax to help allay maintenance and adaptation upgrades.
5. Seek out solid data from reputable sources, and be honest with stakeholders about the degree of uncertainty in the projections used. Strive for transparency to minimize potential liability.
6. Look for scalable tools with a good usage track record.
7. Plan for the unknown. Projections for the Great Lakes region are useful but incomplete by their very nature. **Having contingency plans in place for unexpected variability is the most sensible approach.**



Additional Resources

1.) GLISA has compiled a guide for Great Lakes coastal managers on how to best increase resiliency in the face of climate change. This is an invaluable resource:

<http://glisa.msu.edu/media/files/projectreports/14-728%20Increase%20Resilience%20at%20Marinas%20and%20Harbors.pdf>

2.) Climate Change and Water Quality in the Great Lakes Region

http://www.ijc.org/rel/pdf/climate_change_2003_part3.pdf

3.) The Gulf Coast Study

Transportation Research Board

Miami-Dade Climate Change Action Plan:

http://www.miamidade.gov/greenprint/pdf/climate_action_plan.pdf

