Planning for Coastal and Climate Trends

The Importance of Planning in Coastal Communities

It is no secret that the Great Lakes are one of the most unique and precious environmental systems in the world. In fact, “the Great Lakes basin contains more than 20% of the world’s surface freshwater supplies and supports a population of more than 30 million people.”[1] Michigan is home to nearly 3,300 miles of Great Lakes shoreline, along with 36,000 miles of rivers and streams, and 11,000 inland lakes.[2]

Yet in general, riparian land (land adjacent to a water body) throughout Michigan is not adequately protected from development pressures.[3] Coastal communities especially have an important role to play in protecting the Great Lakes. In 2001, the Michigan Department of Environmental Quality (DEQ) acknowledged “fragmentation of coastal habitats, loss of agricultural and forest lands, increased impervious surfaces and resulting stormwater runoff, and the increased development in coastal hazard areas, wetlands, and Great Lakes Islands, could be improved through better coastal land-use planning.”[4]

Planning for coastal areas at the local level requires knowledge of both local conditions and state and federal regulations. This chapter aims to address these needs for Port Austin and provide clear, well-founded recommendations for future land-use planning.

Overview of Coastal Dynamics and the Great Lakes

The Great Lakes function differently than other inland water bodies and tidal oceans. Understanding these dynamics can help Port Austin plan for naturally occurring changes along the shoreline.

How are Great Lakes Water Levels Measured?

Great Lakes water levels are measured via the International Great Lakes Datum (IGLD), a reference system of benchmarks at various locations on the lakes that approximate sea level. Great Lakes water levels are expressed as measurements above this reference

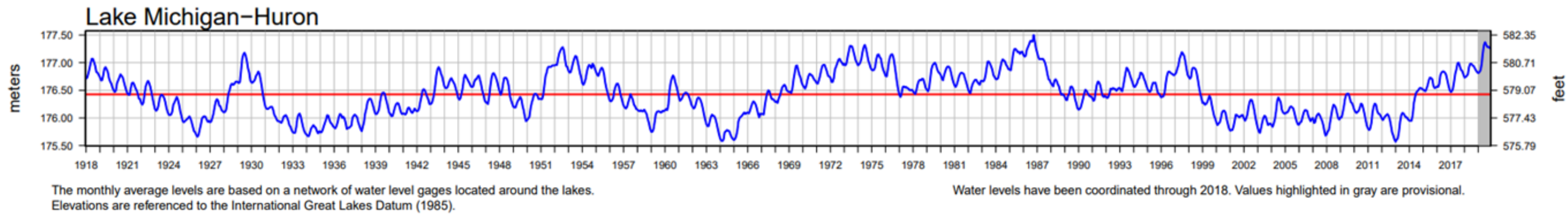
[1] Mackey, S.D. 2012: Great Lakes Nearshore and Coastal Systems. In: U.S. National Climate Assessment Midwest Technical Input Report. J. Winkler, J. Andresen, J. Hatfield, D. Bidwell, and D. Brown, coordinators

[2] Ardizone, Katherine A. and Mark A. Wyckoff, FAICP. Filling the Gaps: Environmental Protection Options for Local Governments, 2nd Edition. 2010.

[3] As cited by Norton 2007 – Michigan Department of Environmental Quality. 2001. 309 Enhancement Grants Assessment/Strategy. Lansing, MI: DEQ Coastal Management Program.

[4] Ibid

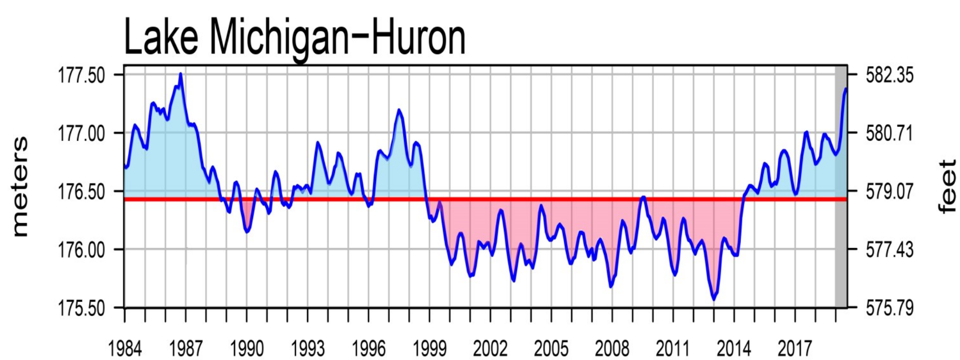
Figure 5: Lake Michigan-Huron Water Level Changes, 1918-2019



Changing Water Levels of the Great Lakes

Great Lakes water level changes result not from the moon's gravitational pull, but from cyclical changes in rainfall, evaporation, and river and groundwater inflows.[5] These factors work together to raise and lower the water levels of the Great Lakes in small increments daily, and larger increments seasonally and over the course of years and decades. Long-term water levels fluctuate by multiple feet. Figure 5 illustrates the water level of Lake Huron from 1918 to 2019 (Lake Michigan and Lake Huron are technically considered one lake). However, under certain climate conditions, water levels can dramatically fluctuate over short periods of time. For example, following the extreme winters of 2014 and 2015, water levels in Lake Huron rose between three to four feet from an all-time low (576 feet) set just a year earlier.

Figure 6: Lake Michigan-Huron Water Levels



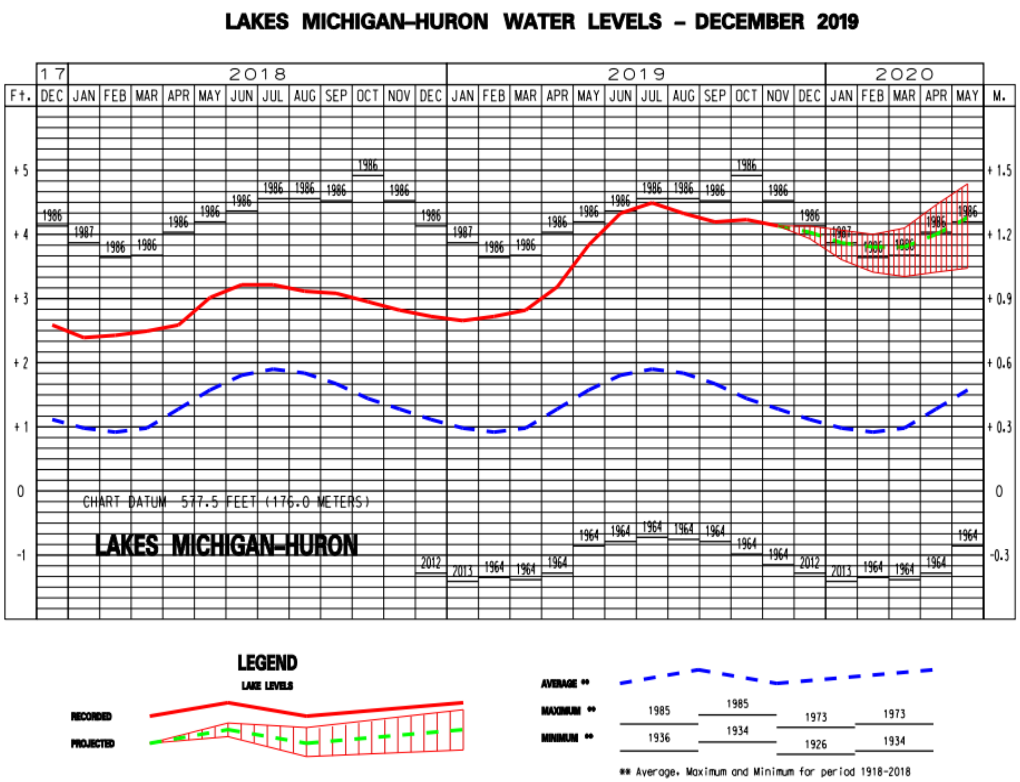
The Great Lakes are in a period of rising lake levels (see Figure 6). Since the early 2000s, water levels had remained low, but historical patterns over the last century indicated that higher water

[5]Norton, Richard K., Meadows, Lorelle A. and Meadows, Guy A. (2011) "Drawing Lines in Books and on Sandy Beaches; Marking Ordinary High Water on Michigan's Great Lakes Shorelines under the Public Trust Doctrine." Coastal Management, 39: 2, 133 – 157, First published on 19 February 2001 (iFirst).

levels were sure to return.[6] Lake Huron's water level in November of 2019 averaged 581.58 feet, which is nearly 16 inches above its level from last year and 34 inches above its long-term average level for the month. According to a recent U.S. Army Corps of Engineers summary, based on current conditions, Lake Huron is expected to continue its seasonal rise again in July, 2020, decreasing slightly in August and September. During the month of July, 2020, water levels on Lake Huron are predicted to reach 583.15 ft, which is 30 inches above the lake's July 2018 levels and almost four feet (45 inches) above the month's long-term average[7] (see Figure 7).

It is important to note that changes in water levels are not solely responsible for the movement of the shoreline landward and lakeward over time. The velocity and height of waves, erosion of shorelines, and the pace of fluctuating water levels also contribute to coastal dynamics on the Great Lakes.

Figure 7:



Wave Energy and Height

The Great Lakes experience high-energy waves and wave setup along the coastline. High-energy waves are high in speed and strong in intensity and are primarily created as fast winds move across the surface of the water for extended distances.[8] "Wave setup" is the

[6]Meadows, Guy A., and Meadows, Lorelle, A., Wood, W.L., Hubertz, J.M., Perlin, M. "The Relationship between Great Lakes Water Levels, Wave Energies, and Shoreline Damage." Bulletin of the American Meteorological Society Series 78:4. (1997): 678-683. Print.
[7]http://www.lre.usace.army.mil
[8]National Oceanic and Atmospheric Administration. "Coastal Currents" Ocean Services Education, NOAA, 25 March 2008. Web. Accessed July 2015.

height of the water as waves reach the shore. High wave setup results as regional storms create high winds on the Great Lakes.[9] Powerful and tall waves can quicken the rate of erosion and damage structures near the shoreline.[10] In Port Austin, the prevailing winds are predominantly from the west (June to August and October to March) and north (March to June).

Erosion

The shorelines of Lake Huron are mostly made of gravel and sands that easily erode during times of high-energy waves.[11] Coastal erosion can cause flooding and damage infrastructure along bluffs and beaches. Erosion is caused mainly by storms and winds, and is exacerbated when lake levels are high.[12]

Quickly Changing Conditions

The Great Lakes are contained in gradually shifting and tilting basins. This tilting results as the Earth slowly decompresses and rebounds from the immense weight of the glaciers that created the Great Lakes.[13] This shifting causes water levels to change more quickly in some places than others, because the shape of the water basin varies along the coast.[14] This attribute of the Great Lakes makes it difficult to predict the pace of shoreline movement. Therefore, it is safest to plan for great variability and rapid change in water levels.[15]

Climate Change and the Great Lakes

Powerful waves, erosion, and changing shorelines on the Great Lakes have been well-documented throughout history, and each has implications for planning efforts along the coast. Climate change exacerbates these natural processes and requires preemptive planning in coastal communities. This section will discuss climatologist predictions of increased precipitation and storminess in the Great Lakes region, variable lake water levels, and rising water temperatures. First, it is important to understand the global context of climate disruption.

Global Changes in Climate

Climate and weather are directly related, but not the same thing. Weather refers to the day-to-day conditions in a particular place, like sunny or rainy, hot or cold. Climate refers to the long-term patterns of weather over large areas. When scientists speak of global climate

[9]Norton, Richard K, Meadows, Lorelle A. and Meadows, Guy A. (2011) “Drawing Lines in Law Books on Sand Beaches: Marking Ordinary High Water on Michigan’s Great lakes Shorelines under the Public Trust Doctrine’, Coastal Management, 39: 2, 133 – 157, First published on: 19 February 2001 (iFirst)

[10]Ibid.

[11]Ibid.

[12]Meadows, Guy A., and Meadows, Lorelle, A., Wood, W.L., Hubertz, J.M., Perlin, M. “The Relationship between Great Lakes Water Levels, Wave Energies, and Shoreline Damage.” Bulletin of the American Meteorological Society Series 78:4. (1997): 675-683. Print.

[13]Dorr, J. A. and D. F. Eschman. 1970. Geology of the Great Lakes. Ann Arbor: University of Michigan Press.

[14]Wilcox, D. A, Thompson, T.A., Booth, R.K., and Nicholas, J. R., 2007, Lake-level variability and water availability in the Great Lakes: U.S. Geological Survey Circular 1311, 25 p

[15]Ibid.

change, they are referring to changes in the generalized, regional patterns of weather over months, years and decades. Climate change is the ongoing change in a region's general weather characteristics or averages. In the long term, a changing climate will have more substantial effects on the Great Lakes than individual weather events.

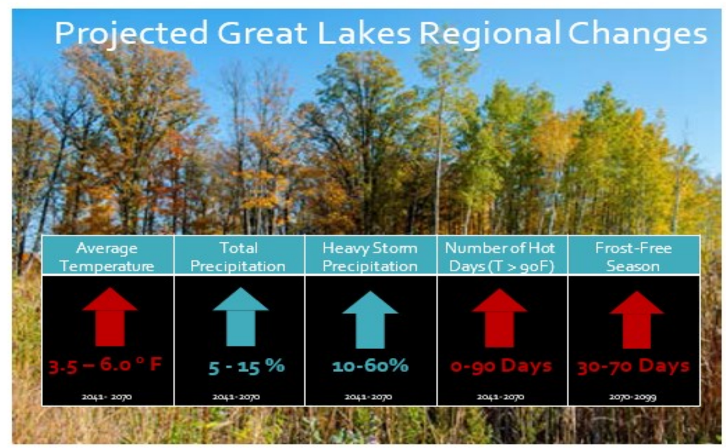
Evidence collected over the last century shows a trend toward warmer global temperatures, higher sea levels, and less snow cover in the Northern Hemisphere. Scientists from many fields have observed and documented significant changes in the Earth's climate.[16] Warming of the climate system is unequivocal and is now expressed in higher air and ocean temperatures, rising sea levels, and melting ice.[17]

To help predict what the climate will be in the future, scientists use computer models of the Earth to predict large-scale changes in climate. These General Circulation Models (GCMs) have been improved and verified in recent years, resulting in relatively reliable predictions for climate changes over large regions.[18] Scientists downscale these techniques to predict climate change for smaller regions.

Climate Change on the Great Lakes

The Great Lakes Integrated Sciences and Assessments Program (GLISA) is a consortium of scientists and educators from the University of Michigan and Michigan State University that provides climate models for the Great Lakes region in support of community planning efforts like this Master Plan. Figure 8 illustrates the historical and predicted climate changes from GLISA for the Great Lakes region. According to GLISA, the Great Lakes region experienced a 2.3° Fahrenheit increase in average air temperatures from 1951 to 2017.[19] An additional increase of 3° to 6° F in average air temperatures is projected by 2050. Although these

Figure 8: Great Lakes Climate Changes

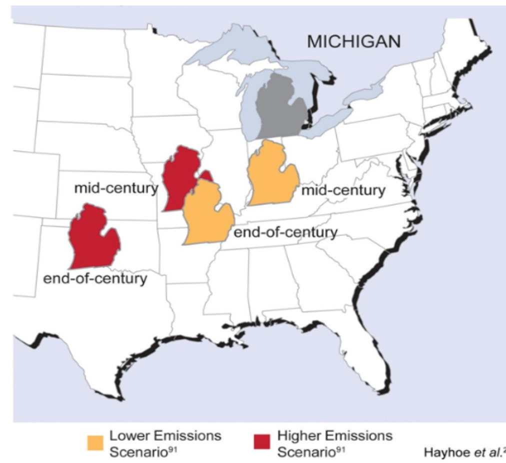


[16]Intergovernmental Panel on Climate Change. (2007). Observed changes in the climate and their effects. Eb. Accessed July 2015.
[17]Ibid.
[18]Intergovernmental Panel on Climate Change (2013). What is a GCM? Web. Access July 2015
[19]Great Lakes Integrated Sciences and Assessments (2019) Temperature. Web. Accessed April 2019.

numbers appear relatively small, they are driving very dramatic changes in Michigan's climate and greatly impact the Great Lakes.

The National Climate Assessment for 2009 included a number of illustrations to help us understand the extent and character of anticipated climate change impacts.[20] One of these illustrations, Figure 9, shows Michigan under several emissions scenarios, each leading to changes in Michigan's climate. Just by maintaining current emission levels, Michigan's climate will feel more like present-day Arkansas or Oklahoma by the end of the century.[21]

Figure 9: Temperature Changes in the U.S.



Model projections of summer average temperature and precipitation changes in Illinois and Michigan for mid-century (2040-2059), and end-of-century (2080-2099), indicate that summers in these states are expected to feel progressively more like summers currently experienced in states south and west. Both states are projected to get considerably warmer and have less summer precipitation.

Increased Precipitation and Storminess

There is strong consensus among climate experts that storms greater in number and intensity will occur in the Great Lakes region as a result of climate change.[22] This is already happening as "the amount of precipitation falling in the heaviest 1% of storms increased by 35% in the Midwest from 1951 to 2017."[23] As storms drop more precipitation and generate stronger sustained winds, the Great Lakes will see stronger and higher waves. In addition to direct damage caused by storms, sustained increases in the number of storms and their intensity can both directly and indirectly pollute waters by overloading sewage and stormwater capabilities.[24] Increases in the intensity of storms also quickens the pace of erosion on Great Lakes shorelines. In fact, the Federal Emergency Management Agency (FEMA) projects approximately 28% of structures within 500 feet of a Great Lake shoreline are susceptible to erosion by 2060.[25]

Variability of Lake Water Levels

The natural ups and downs in the water levels of Lake Huron will continue regardless of the impacts of climate change.[26] However, climate change is likely to augment this natural process, resulting in more variable water levels as warmer air temperatures result in fewer days of ice cover and faster evaporation.[27] In other words, lake levels will rise and fall faster and with less predictability than in the past. Fortunately, much of Michigan's coastal

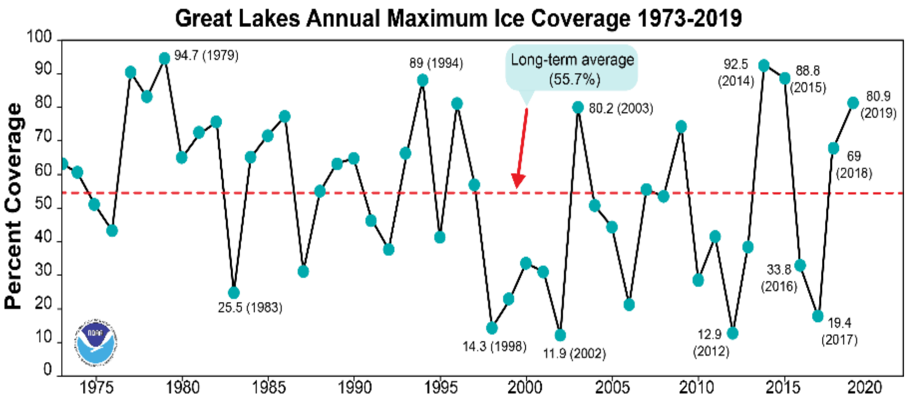
[20] U.S. Global Change Research Program. Global Climate Change in the United States, 2009. Cambridge University Press, Cambridge, MA.
[21] Ibid.
[22] Great Lakes Integrated Sciences and Assessments (2019) Temperature. Web. Accessed December 2019.
[23] Ibid.
[24] Crice, T., & Yurkovich, E. (2011). Adapting to climate change: A planning guide for state coastal managers – a Great Lakes supplement. Silver Springs, MD: NOAA Office of Ocean and Coastal Resource Management.
[25] The Heinz Center. (2000). Evaluation of Erosion Hazards. Web. Accessed July 2015.
[26] Dinse, Keely. Preparing for extremes: The Dynamic Great Lakes. Michigan Sea Grant. Web. Accessed July 2015.
[27] Cruce, T., & Yurkovich, E. (2011). Adapting to climate change: A planning guide for state coastal managers – a Great Lakes supplement. Silver Springs, MD: NOAA Office of Ocean and Coastal Resource Management.

infrastructure was built in previous decades during times of high water levels.[28] However, fast-rising waters can erode shorelines, damage infrastructure, and cause extensive flooding in inland rivers.[29] When lake levels fall, access to infrastructure like docks may be restricted and navigation hazards in shallow waters may be exposed. Low lake levels pose a threat to coastal vegetation and can reduce the pumping efficiency of drinking water intake pipes.[30] Additional ramifications of changing lake levels include a drop in water supply,[31] restricted fish habitats,[32] more invasive species,[33] faster erosion, and an overall decline in beach health.[34] Climate change is likely to augment the natural highs and lows of lake levels, causing more variability and a faster rate of change, making each of these potential ramifications both more likely and less predictable.

Water Temperature

Climatologists predict there will be fewer days below freezing in Michigan and other Great Lakes states. As temperatures remain warm for a greater part of the year, the winter season will shorten and the lake ice cover that accompanies winter weather will decline. In general, annual average ice cover on the Great Lakes underwent a shift from higher amounts prior to the 1990s to lower

Figure 10.



[28]Dinse, Keely. Preparing for extremes: The Dynamic Great Lakes. Michigan Sea Grant. Web. Accessed July 2015.
[29]Ibid.
[30]Ibid.
[31]Cruce, T., & Yurkovich, E. (2011). Adapting to climate change: A planning guide for state coastal managers – a Great Lakes supplement. Silver Springs, MD: NOAA Office of Ocean and Coastal Resource Management.
[32]Ibid.
[33]Ibid.

amounts in recent decades. However, there remains strong year-to-year variability, and high ice years are still possible.[35] Figure 10 illustrates the variability in ice coverage in the Great Lakes between 1973 and 2019.

Lake ice cover allows heat radiation from the sun to be reflected, so when ice declines, the surface water temperature will increase as more heat is absorbed by the water. In the Great Lakes, average summer lake surface temperatures have been increasing faster than the surrounding air temperatures, with Lake Superior surface temperatures increasing by 4.5°F between 1979 and 2006.[36]

The associated impacts of rising water temperatures include changes to where fish and other aquatic animals can live, increased vulnerability to invasive species, and increased risk of algae blooms.[37] Rising water temperatures also enable winds to travel faster across the surface of the lake, increasing the vulnerability of coastal communities to damaging waves as storms and winds increase.[38] Lastly, ice cover protects the shoreline during winter storms. With less ice cover, the shoreline is more susceptible to erosion and habitat disruption.

According to the Rockefeller Foundation's City Resilience Index, a Resilient Community has…

1. *Minimal human vulnerability*
2. *Diverse livelihoods and employment*
3. *Effective safeguards to human life and health*
4. *A collective identity and mutual support*
5. *Comprehensive security and rule of law*
6. *A sustainable economy*
7. *Reduced exposure and fragility*
8. *Effective provision of critical services*
9. *Reliable mobility and communication*
10. *Effective leadership and management*
11. *Empowered stakeholders*

[35]Great Lakes Integrated Sciences and Assessments (2019) Temperature. Web. Accessed April 2019.
[36]Ibid.
[37]Dinse, Keely. Preparing for extremes: The Dynamic Great Lakes. Michigan Sea Grant. Web. Accessed July 2015.
[38]Cruce, T., & Yurkovich, E. (2011). Adapting to climate change: A planning guide for state coastal managers – a Great Lakes supplement. Silver Springs, MD: NOAA Office of Ocean and Coastal Resource Management.