

Great Lakes Water Levels in a Changing Climate: Vulnerabilities of the Recreational Boating Sector

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The Great Lakes

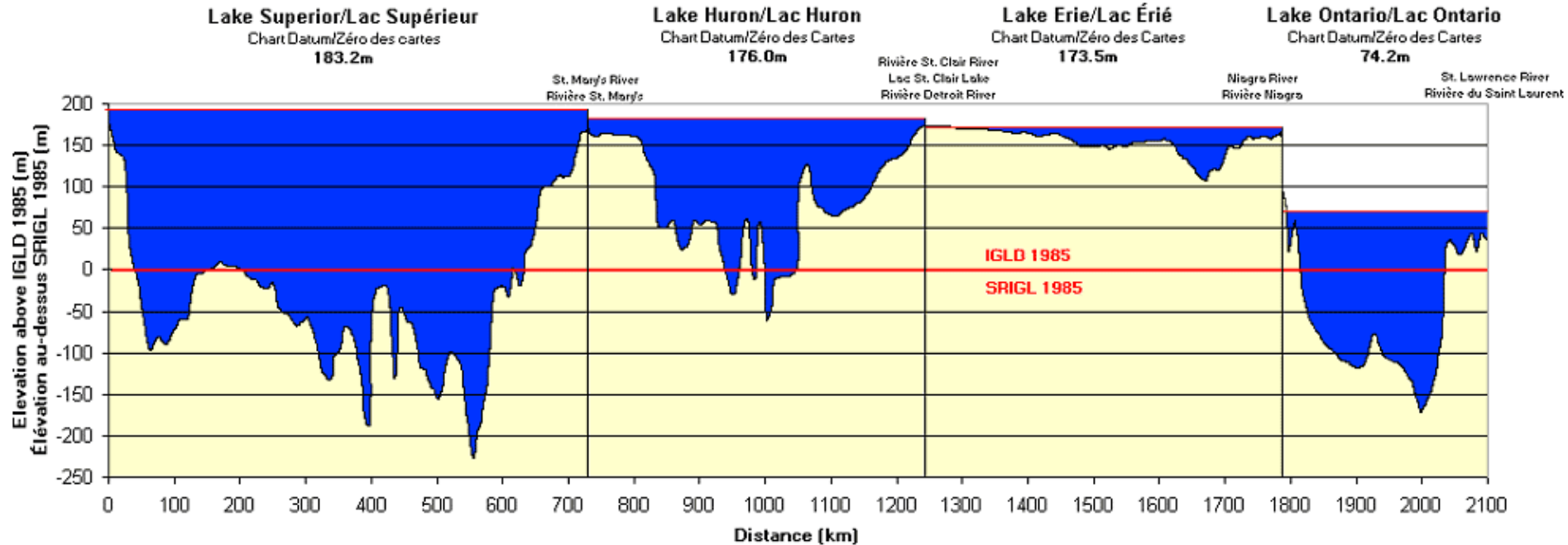
- 35 million live in the basin (US and Canada).
- Regional production of two trillion USD.
- Ontario parks located on the Great Lakes attract 11 million visitors a year.



The Great Lakes are Big

- Contain 6 quadrillion gallons of fresh water
 - Or about enough to cover the entire US to a depth of 9.5 ft.
- Cover 244,000 square kilometers
 - Or about the same surface area of the United Kingdom

Great Lake Depths

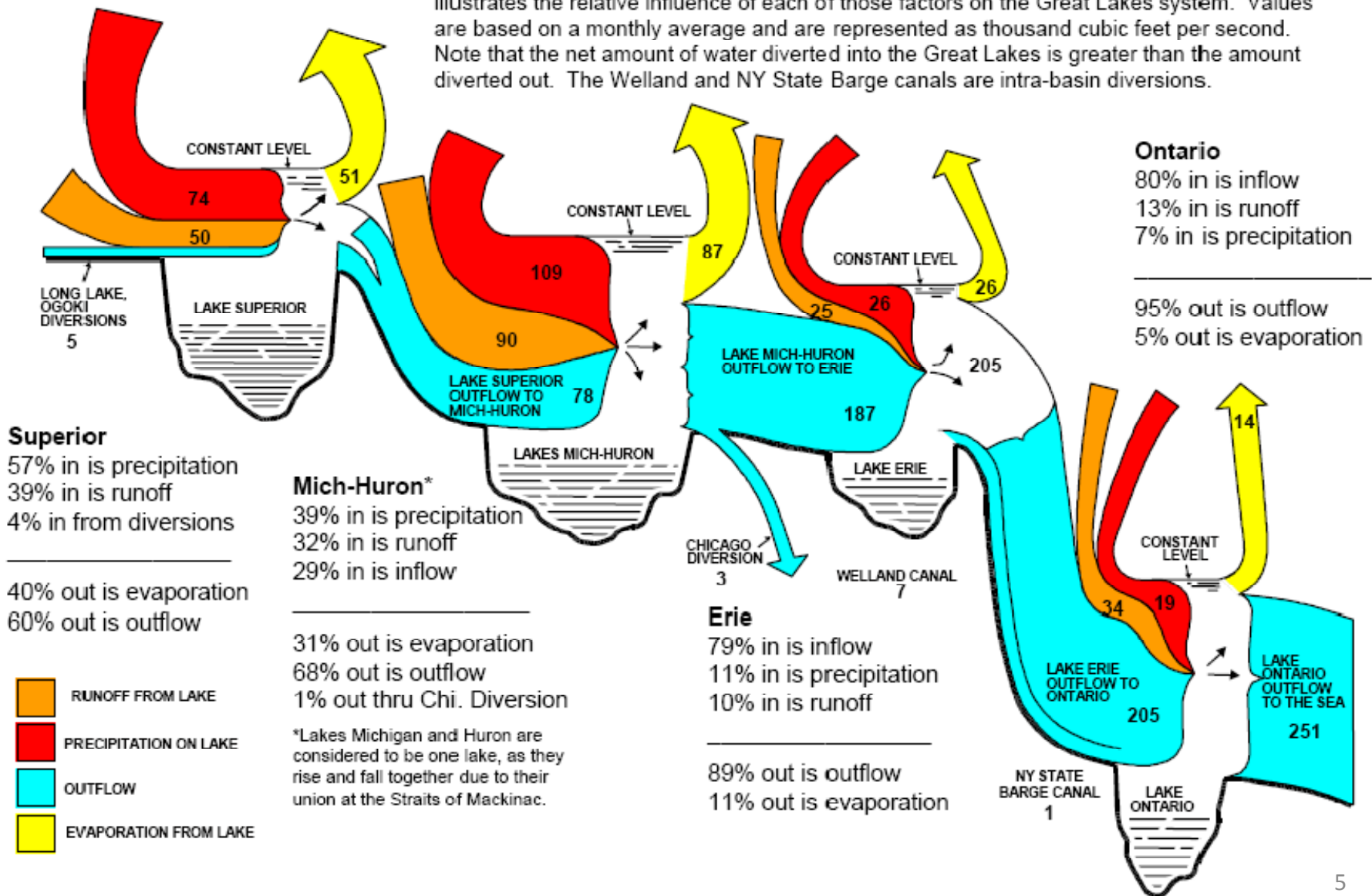




U.S. Army Corps of Engineers
 Detroit District
<http://www.lre.usace.army.mil>

Hydrologic Components

Flow from upstream lakes, evaporation and precipitation influence lake levels. This graph illustrates the relative influence of each of those factors on the Great Lakes system. Values are based on a monthly average and are represented as thousand cubic feet per second. Note that the net amount of water diverted into the Great Lakes is greater than the amount diverted out. The Welland and NY State Barge canals are intra-basin diversions.



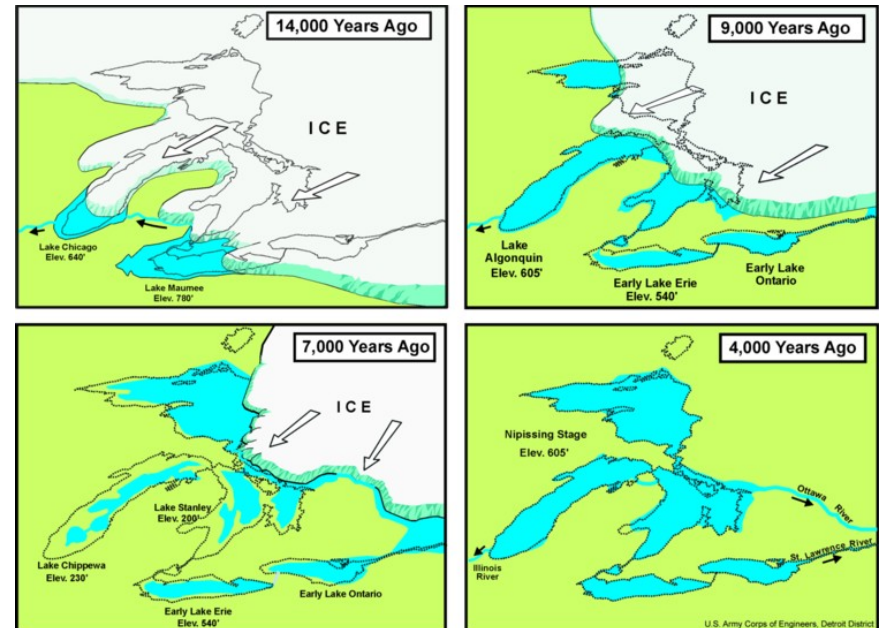
Other Impacts on Water Flow

- The Americans!
 - Chicago Diversion > 1 % of outflow from Huron/Michigan
 - Offset by Long Lac and Ogoki Diversions
- Lake St. Clair Dredging
 - There is increased conveyance
 - Responsible for 3.9 to 4.5 inches of water loss
 - Natural causes: ice jam in 1984
 - Results under further analysis

Con't

Glacial Isostatic Rebound

- Great Lakes formed as ice sheets retreated
- The Superior Lake Bed is still rebounding
 - Covered longer
- Causes shifts in water level
 - 1.5 inches lower in Huron/Michigan



USACE

The Sault Locks

- Controlled by the United States Army Core of Engineers (USACE)
- Balance between demands for hydroelectric power generation and sufficient water levels for Commercial Navigation
 - 10,000 ships traverse the locks a year
- Also can control between 5cm and 15cm of water level by releasing water from Superior.

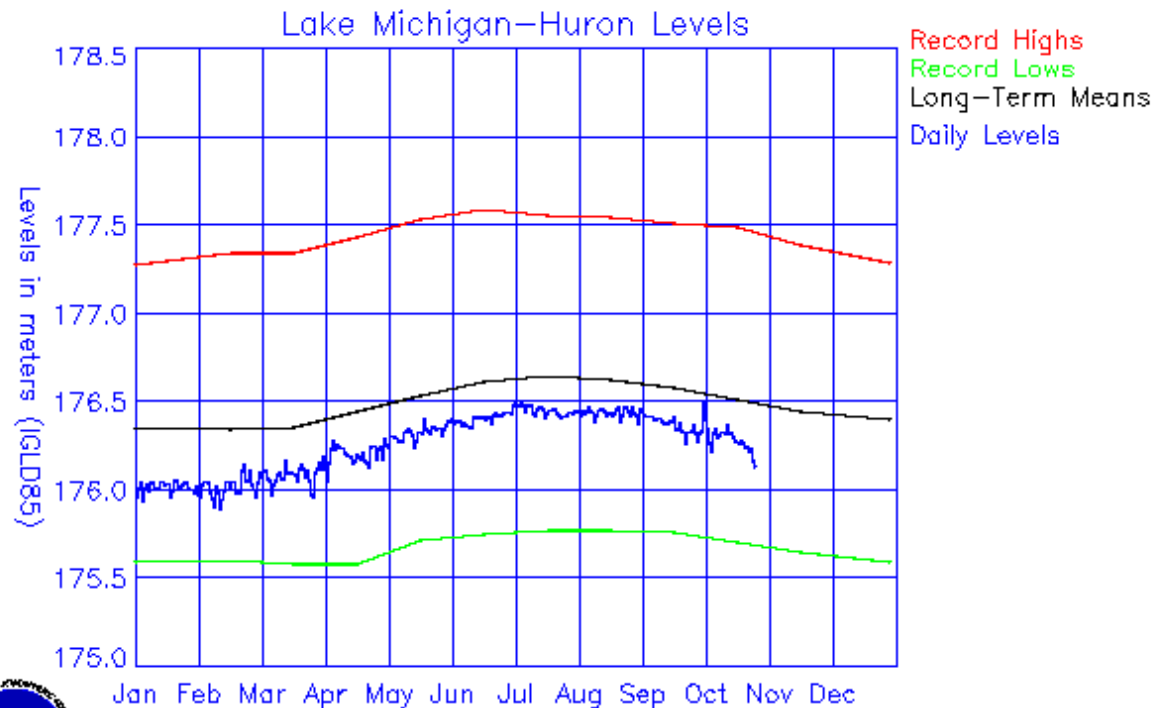
Release Plan 1977 A

- Determines when and how much water is released from Superior into the Lower Lakes
- Required to reach a monthly mean to cover:
 - Industrial and Municipal requirements
 - Navigational locks
 - Fish habitat requirements at St. Mary's rapids

Troubling Water Levels

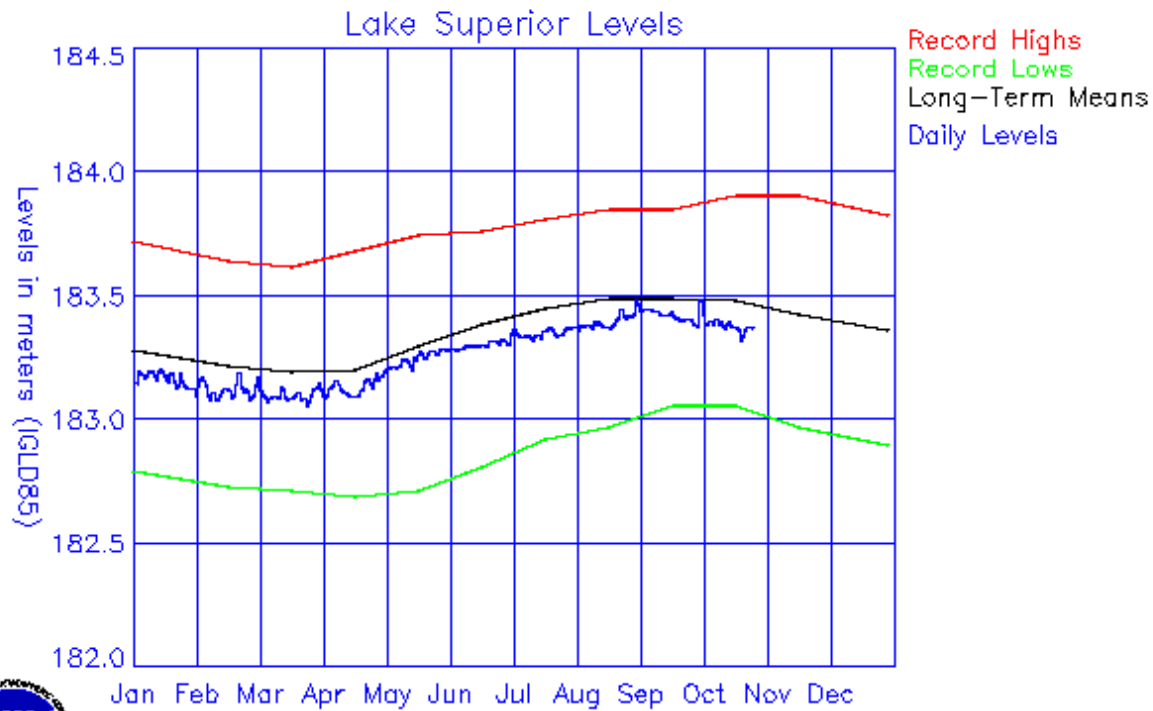
- Near Record Highs in 1986 and Near Record Lows 2001
 - Timing differs for each lake
- Of more concern are how Rapid the changes occurred.
- Recent Sustained lows have made the subject rather heated.
- Human consumption has changed, system under more stress.

Water Levels Today: Michigan/Huron



Oct 24, 2009
Great Lakes Environmental Research Laboratory/NOAA

Water Levels Today: Superior



Oct 24, 2009
Great Lakes Environmental Research Laboratory/NOAA

Can Climate Change affect water levels?

- Expected to reduce water levels by up to 1m
- OR: It may increase water levels by ½m
- Much Scientific Uncertainty
 - Extent of Climate Change on the Great Lakes depends on which Model is used
 - Lack of Regionally Specific Climate Models
- Variables:
 - Ice coverage
 - Precipitation Uncertainty
 - Rain and Snow run-off in the basin

Who is in Charge?

- The International Joint Commission (IJC)
 - Independent bi-national organization
 - Established by the United States and Canada under the Boundary Waters Treaty of 1909
- Govern water bodies on the U.S. Canadian border
- Set the regulations for Water Release Plans at the Locks in Sault Ste Marie

Is There a Better Way to Regulate Water Levels?

- **The International Upper Great Lake Study**
 - Commercial Navigation
 - Hydropower
 - **Recreational Boating and Tourism**
 - Municipal, Domestic and Industrial Water Uses
 - Eco-Systems
 - Coastal Zone
- **How will changing Plan 1977A affect these groups?**

Our Contribution to the Study:

- Q: How vulnerable is the recreational boating sector to fluctuating water levels?
- Gathered data to help answer:
 - **Empirical Data**: Depth Measurements at Marinas.
 - **Attitudinal Data**: Marina Operators Completed a questionnaire to assess baseline experience under Plan 1977A, and likely damages and adaptations to hypothetical fluctuations in water levels.

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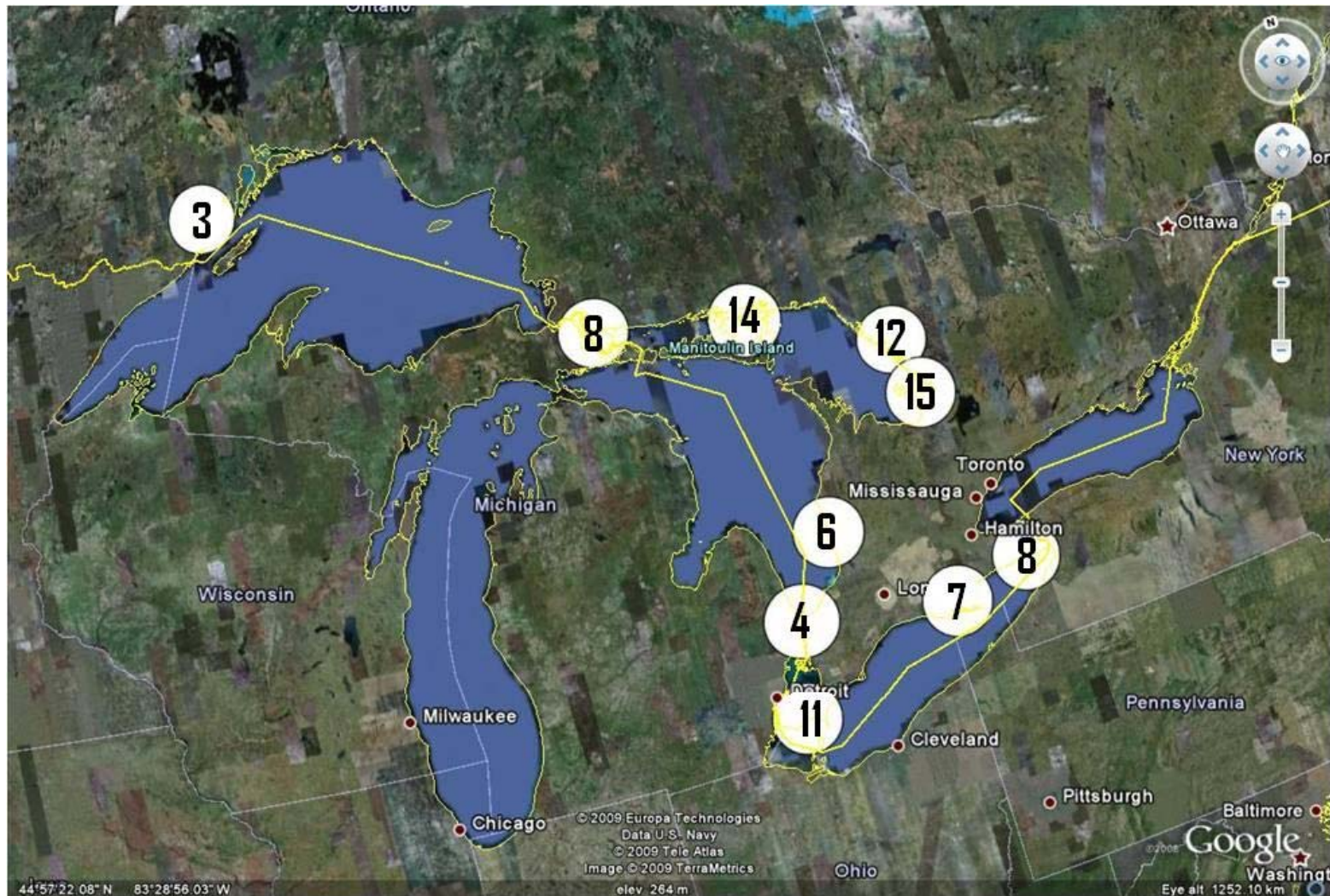


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Fieldwork: Where We Went

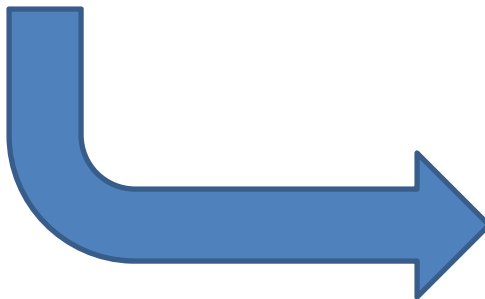


Example: Marinas in the Little Current Area of Survey



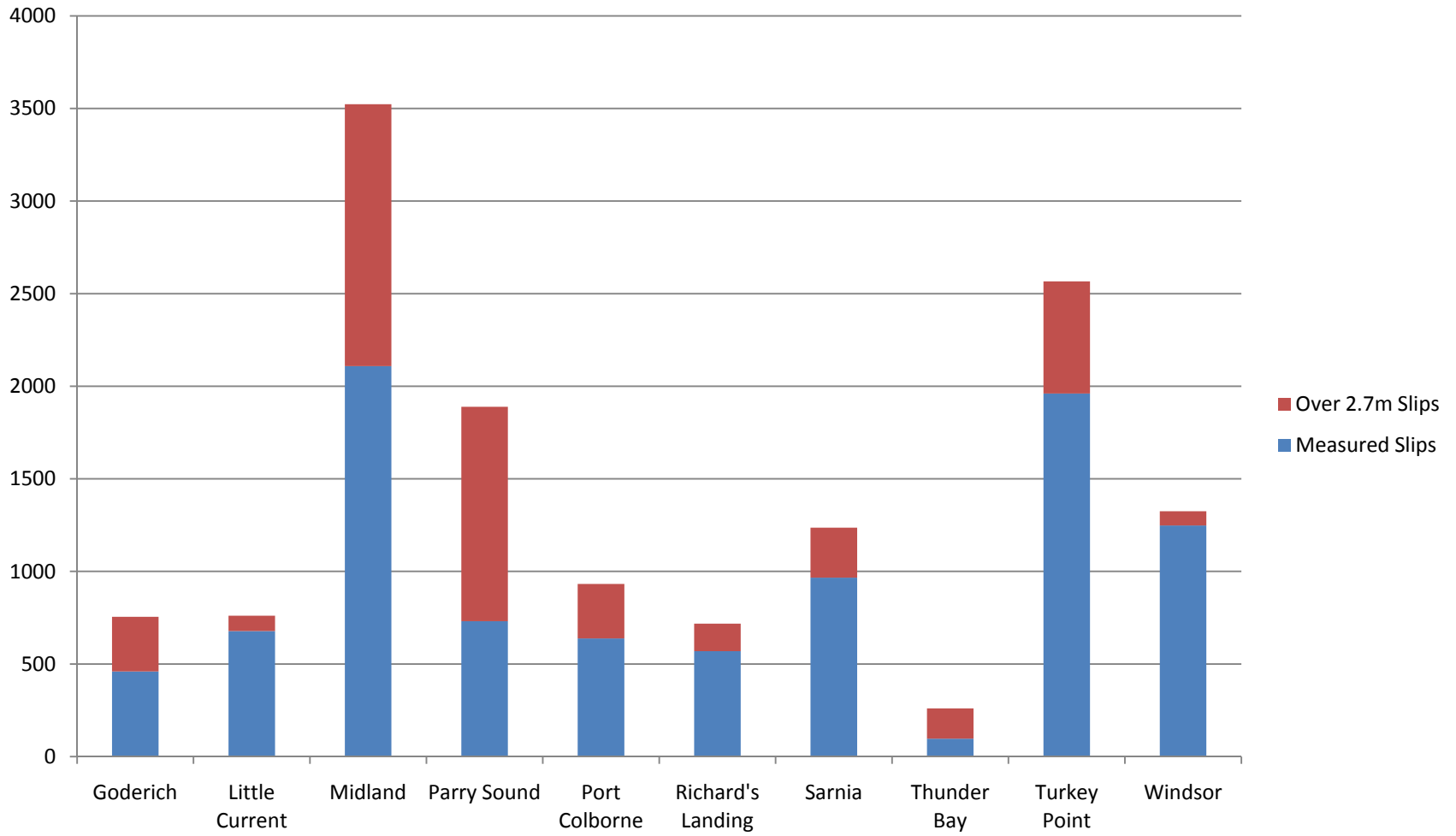
Empirical Data: Depth Measurements

Marinas Identified	148
Marinas Surveyed	88



Total Slips	13965
Slips Measured	9457

Slips Measured in the 10 Sample Areas

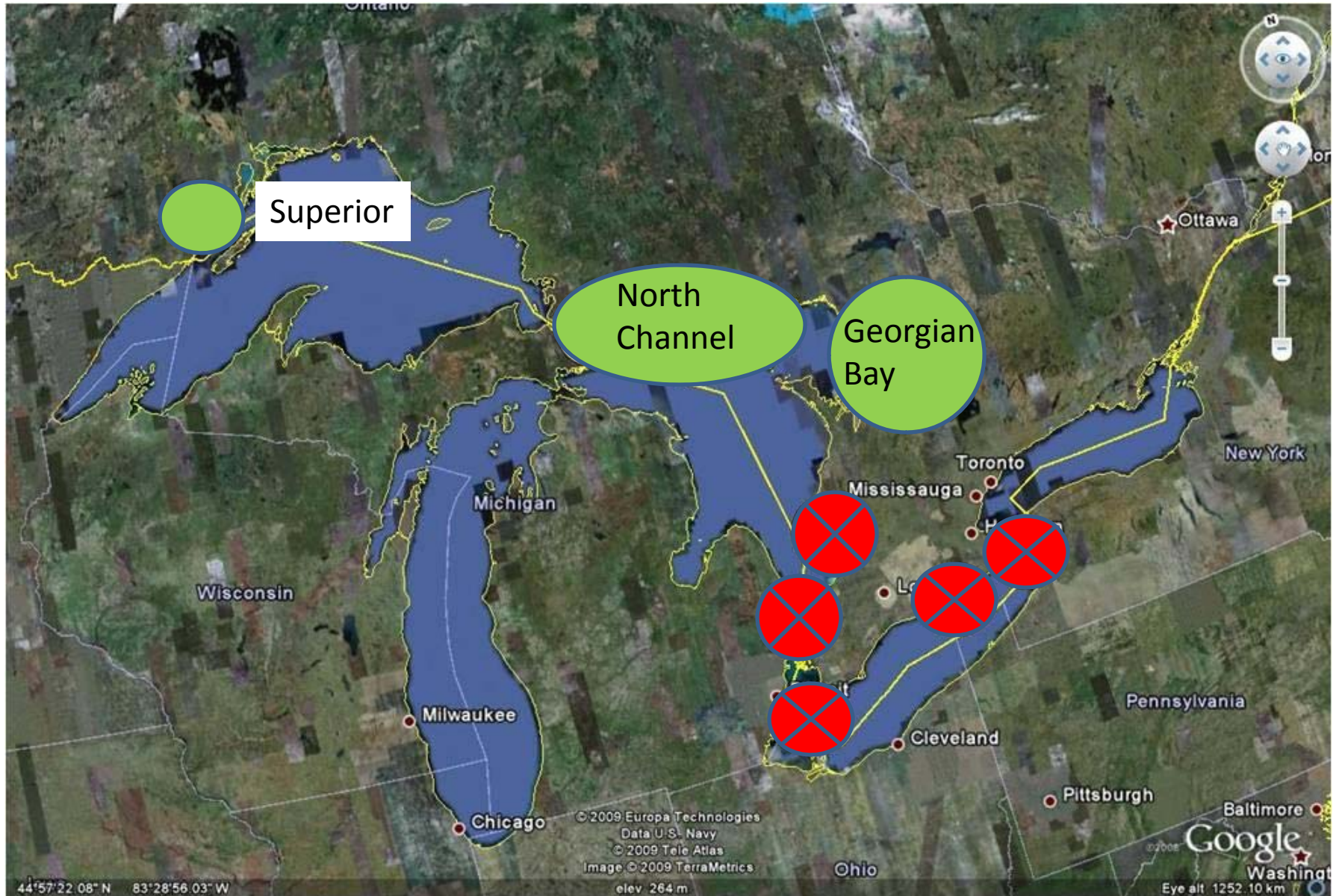


Slips were not measured if over 2.7 meters (~ 9 ft). With three foot drop that would leave 6 feet of depth which is a typical sailboat keel depth.

Attitudinal Data: The Questionnaire

- **Interviewed 75 Marina Operators:**
 1. **Industry Characteristics**
 - Dockage, services, etc...
 2. **Past Experience with Fluctuations**
 - Damages? Who was able to adapt? Costs?
 3. **Hypothetical Drop/Rise Scenarios**
 - Likely Damages and Adaptations; Cost Estimates
 4. **Barriers to Adaptation**
 - dredging permits? Fish habitats?

Focus on Northern Ontario



Marinas Surveyed in the three regions

Region	AOS	Questionnaires Completed	Depth Measurements Completed
Georgian Bay	Midland	15	16
	Parry Sound	11	12
	Total	26	28
North Channel	Little Current	12	15
	Richards Landing	8	9
	Total	20	24
Superior	Thunder Bay	2	3
	Total	2	3

Georgian Bay Region

- Specialize in Cottage Commuters, Cruise and Sail Boats
- More dockage, services and storage than the other two regions
- Steep rocky shores and naturally deep waters
- 3000 Islands, Honey Harbor, Cottage Country

North Channel Region

- Specializes in Sports Fishing, Cruise and Sail boats.
- Remote boating locations
- More space between marinas

- Manitoulin Island, St Josephs Island, Killarney Provincial Park, Spanish River

Superior Region

- Specializes in Larger Cruise and Sail boats.
- The most remote Great Lakes boating
- Colder Water
- Sleepy Giant Provincial Park, Rugged Beauty

Past Experience with Changes in Water Levels

- Periods of **Low Water** (1999-2008) had more significant effects than Periods of High Water (1985-1987).
- Periods of Low Water had affected a majority of the marinas in all three regions.
- Reduced capacity to accommodate larger boats, specifically sailboats.
- In response, lots of dredging and dock modifications; especially in Georgian Bay.
- Both types of adaptations were costly (\$).
- Reports that marinas failed in Severn Sound Area

Hypothetical Drop Scenarios

- 1ft, 2ft, 3ft Drops: Likely Damages and Adaptations?
- Results suggest that North Channel Marinas would be more vulnerable than Georgian Bay Marinas (to 2 and 3 ft drops)
- Why?
 - Higher slip-loss
 - Shallower slips and basins
 - Lower capacity to dredge:
 - Dredging prohibitively costly due to bedrock and finances

Hypothetical Rise Scenarios

- 1ft, 2ft, 3ft Rises: Likely Damages and Adaptations?
- Results suggest that most of the marinas in all three regions would be quite resilient (even to a 3ft rise).
- Why? Better for business
 - More water =more customers & larger boat access (\$)
- Realistic adaptation costs
 - Dock adjustments rather than Dredging
 - Cambrian Shield = steeper shores=less Flooding

Out of Business Thresholds, and Preferred Water Levels

- Results suggest that...
- **Georgian Bay**: relatively few marinas could go OOB at a 3ft drop. Many would prefer water to be 1ft higher.
- **North Channel**: Significant amount of marinas could go OOB at a 3ft drop. Many would prefer water to be 1 to 2ft higher.
- **Superior**: Incomplete data.

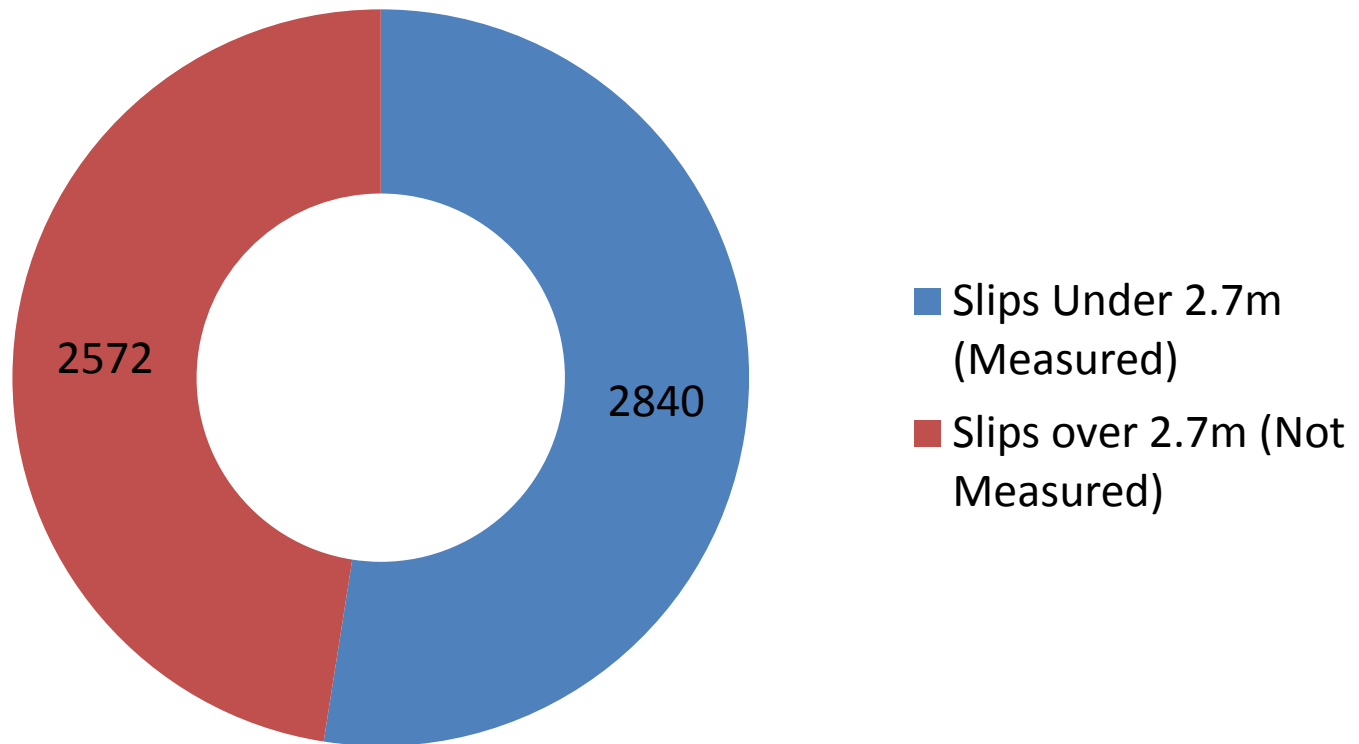
Barriers to Adaptation?

- **Red Tape** associated with obtaining Dredging Permits
 - Multiple levels of government approval
 - Protected Fish Habitats
- Bedrock makes Dredging Prohibitively Costly

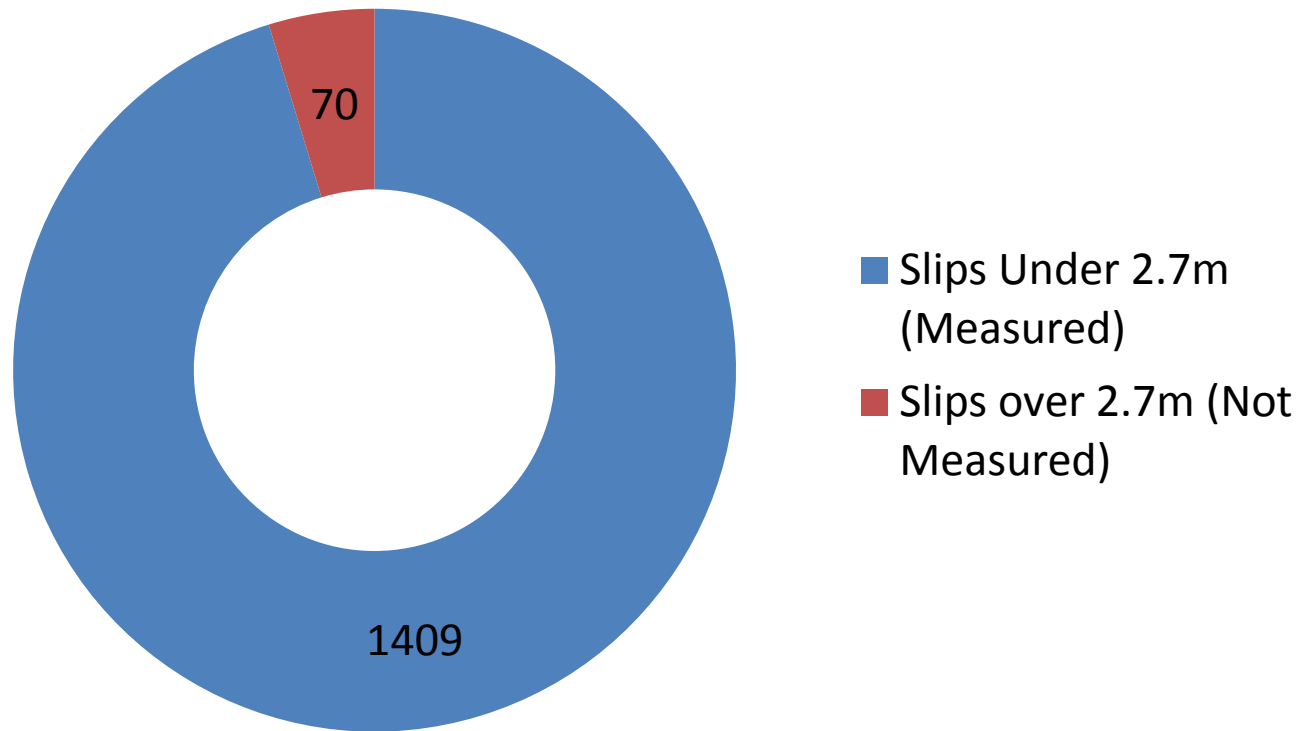
Slip-Depth Measurements

- To assess slip-loss in hypothetical scenarios of 1ft, 2ft, and 3ft drops in water level.
- When a slip reaches a depth of 2ft, it is considered 'unusable'.
- Rationale for using 2ft cutoff?
 - Common draft for the smallest type of Great Lakes power boat.
 - To put in context, sail boats commonly require a draft of 5 feet.

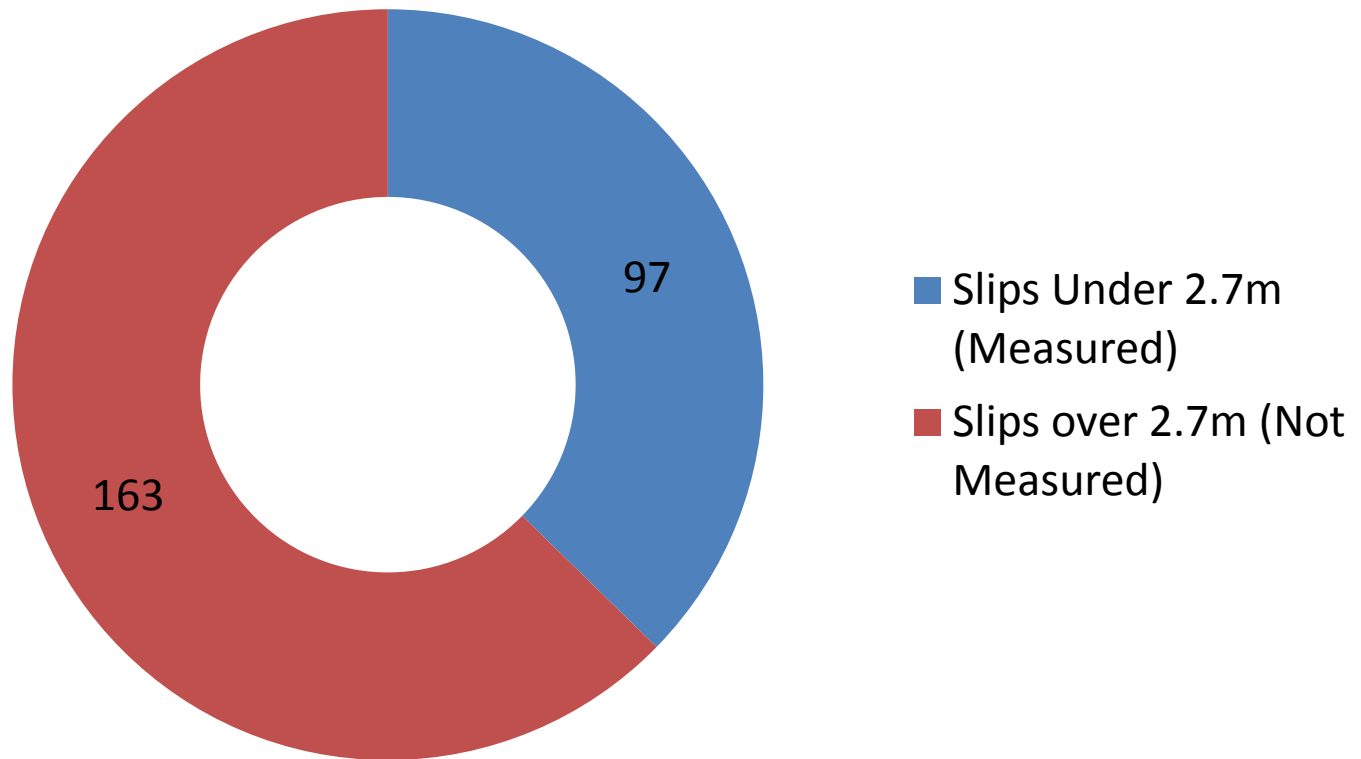
Depth Measurements: Georgian Bay (28 Marinas)



Physical Measurements: North Channel (23 Marinas)



Physical Measurements: Superior (3 Marinas)



Empirical Slip-Loss Scenarios

Results:

1. A minority of slips lost in all three regions (even at a 3ft drop).
2. Marinas in North Channel may be more vulnerable than those in Georgian Bay.
3. Superior may be the most resilient by far.

Shallow Access Channels?

- Used Navigational Maps to follow up on shallow access channels reported by marina operators
 - 4 reported in North Channel region
 - 8 reported in Georgian Bay region

Results?

- One marina in North Channel region may be vulnerable to 100% slip loss at drops of 2ft and 3ft.

Further Applications

- Research uncovered vulnerabilities and adaptive capacities of Marinas of the Upper Great Lakes
- Inland Lakes are also affected by fluctuating water levels
- These same methods could be used to gather information about inland lake Marinas

Application to Inland Lakes

- Inland lakes used for many things:
 - Drinking Source Water
 - Industrial Water Use (Hydro power dams)
 - Transportation
 - Fishing
- Understanding vulnerabilities and knowing ways to adapt could be vital

Next Steps

- Integrating results from parallel research project on U.S. marinas on Upper Great Lakes
- Converting our results to economic data
 - Attributing dollar values to damages and adaptations associated with fluctuating water levels.
 - Using other studies to estimate the regional economic impacts of recreational boating, in terms of boater spending and job creation in the Great Lakes basin.

Economic Significance of Recreational Boating

According to a 2008 U.S. Army Corps of Engineers' study,

“The 911,000 [American] recreational boaters on the Great Lakes:”

- spend \$2.36 billion per year on boating trips;
- spend \$1.44 billion per year on boats, boating equipment and supplies;
- create 60,000 jobs with \$1.77 billion in personal income.