Climate Change and Variability
Lake Ice, Fishes
and Water Levels

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UW-Madison

Edge of the Lake Seminars
Green Bay WI
April 13, 2010
Changes to Lakes and Streams
Trends, Variability, and Extremes

Effects Have Consequences to Humans
Winter Recreation and Economies
Fish and Fisheries,
Water Levels and Flows

Adaptation, a Required Component

Magnuson Photo
How Do We Deal With Change?

Magnuson Photos
Changes Occur Quickly and Slowly

Time Scales of Changes

Magnuson 2009
The Long-Term Changes (Decadal to Century):

✓ are handed down to us from earlier generations or
✓ we cause and pass them on to future generations,
✓ occur slowly and sneak up on us
   or
✓ we are unwilling to face them soon enough,
✓ we tend to see the short-term positives
   with little recognition that
   “everything is connected to everything else.”
The Invisible Present
The Invisible Place

Magnuson 2006
Ice-on Day
2007

Local Lake Mendota
Ice Breakup 2010
Lake Mendota
March 20
Ice Breakup 2010
Lake Mendota

March 21
Ice Breakup 2010
Lake Mendota
March 27
Ice Breakup 2010
Lake Mendota
March 28
Ice Breakup 2010

Lake Mendota

March 29
Interannual Variability

Ice Cover (Days)

1850 1875 1900 1925 1950 1975 2000

10 Years

Magnuson 2004
Dynamics from the Central Pacific

Ice Cover (Days)

El Niño Years

50 Years (1949 - 1998)

Magnuson 2004
Lake Mendota Ice Duration 1855-6 to 2008-9
The Story Continues - Trends Persist, Greater Extremes

Decrease 1.85 days per decade.
Proportion of variance accounted for 0.19.

Magnuson 2009
Lake Mendota Ice Duration 1855-6 to 2008-9
Inter-Year Differences in Weather versus Climate Change

Decrease 1.85 days per decade.
Proportion of variance accounted for 0.19.
The Invisible Present
The Invisible Place
Apostle Island Ferries run when water is open
Bayfield Harbor
Dates of last boat in fall and first boat the next Spring

Forrest Howk High School Science project 2007

Day of Year Relative to Dec. 31

1.6 days earlier / decade

1.5 days later / decade
The Longest Lake Ice Record
Suwa Ko, Japan

Shinto Shrine

Magnuson Photos
Omiwatari on Suwa Ko
Shinto Ceremony at Omiwatari on Suwa Ko

Shrine Photo
Lake Suwa, Japan, Ice-on Time Series from 1443 - 1993
(30 days subtracted from years before 1880)

1443-1825
1 day per 100 years

1800-1993
19 days per 100 years

Magnuson 2007 Preliminary
The Invisible Present
The Invisible Place
Extremes and Variability
Extremes Are What People Notice and They Have the Greatest Influence on Us
Increase in the Extreme Event of Lakes Not Freezing

Benson, Jensen & Magnuson  In process
Lake Mendota Ice Duration Trend and Extreme Events

Trend = 18.5 Days Less per Century

10 Longest

10 Shortest

Magnuson 2010
Breakup Dates for Lake Mendota

10-Year Running Mean

- April
- March
- February

Years:
- 1850
- 1900
- 1950
- 2000
Integrators of Climate Change IPCC (SPM WG 1)

Global Average Temperature

°C

1850  1900  1950  2000

IPCC WG 1, 2007
Cascade of Variability from Teleconnections, to Local Climate, to Lake Ice (Lake Mendota Wisconsin)

Among Years

Namdar-Ghanbari et al. in review
Winter is a part of our “Sense of Place.”

We are losing winter as we knew it!
Preferences about Outcomes

<table>
<thead>
<tr>
<th>Agree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computation in Bureaucratic Structure</td>
<td>Bargaining in Representative Structure</td>
</tr>
<tr>
<td>Judgment in Collegial Structure</td>
<td>Consensus Building</td>
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</tbody>
</table>

Settling

Kai Lee (modified from Thompson and Tuden 1959)
Challenges of Climate Change
Acting on Climate Change in Wisconsin

**Mitigation:**

Governor’s Task Force on Global Warming addressed ways to reduce greenhouse gas emissions.

**Adaptation:**

Wisconsin Initiative on Climate Change Impacts (WICCI) addresses ways to adapt to consequences of climate change.
Challenges of Climate Change.

How to.

7.2° F
Mitigate

3.2° F
Adapt

Modified from IPCC 2007
Climate Change
Is a Pervasive Influence
Current & Developing Working Groups

Wisconsin Climate

- Agriculture
- Human Health
- Milwaukee
- Coldwater Fish & Fisheries
- Stormwater
- Wildlife
- Green Bay
- Coastal Communities
- Forestry
- Natural Areas
- Central Sands
- Northern Highlands
- Milwaukee
Do Fishes Care about Climate Change?

Warm Water Fishes

Cool Water Fishes

Cold Water Fishes

Magnuson 2007
Temperature Preference

Fish controlled the tank temperature by swimming back and forth between sides.
Precision of Bluegill as a Thermostat

Preferred Range
6.7° F

Upper Avoidance 92° F
Midpoint 88° F
Lower Avoidance 85° F

Magnuson
Warm, Cool, and Cold Water Fishes

- Green Sunfish: 82°F
- Yellow Perch: 75°F
- Rainbow Trout: 64°F

Temperature (°F)
Climate Change and Trout in Wisconsin Streams

Photo Matt Mitro WDNR
Stream Trout in Wisconsin

Brown Trout

Brook Trout

Photos by Matt Mitro Wisc. DNR
17,900 km of stream
Present

12,500 km of stream
Present

Matt Mitro & John Lyons WDNR
4,800 km of streams -73%

16,000 km of streams +28%

Matt Mitro & John Lyons WDNR
Expect the Unexpected

John Lyons Wisc. DNR
Lake Trout in Lake Michigan
Thermal Habitat or Niche of Lake Trout
Coldwater
Lake Trout
Lake Michigan

Magnuson, Meisner, and Hill 1990
Example Adaptations for Cold Water Stream Fishes
Adaptation Strategies for Climate Change

Protect groundwater and promote land conservation and conservation tillage methods for improving groundwater recharge
Adaptation Strategies for Climate Change

Eliminate Hot Spots

Storm Sewer Inputs
Remove Small Dams

<table>
<thead>
<tr>
<th>Location</th>
<th>Peak Temp in 1982</th>
<th>Changes 1983 vs. 1982</th>
<th>Changes 1986 vs. 1982</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headwater</td>
<td>19.0</td>
<td>-0.6</td>
<td>-1.8</td>
</tr>
<tr>
<td>Stream mouth</td>
<td>23.8</td>
<td>-1.2</td>
<td>-4.3</td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>-0.6</td>
<td>-2.5</td>
</tr>
</tbody>
</table>

Ed Avery 1991
Adaptation Strategies for Climate Change

Plan for Extreme Events

Mormon Coulee Creek

Matt Mitro & John Lyons WDNR
Adaptation Strategies for Climate Change

1.8° F

Consider Triage

Present
Gain
Loss

Matt Mitro & John Lyons WDNR
Great Lakes Water Levels

Magnuson photo
Lake Michigan Water Levels

- Oscillatory Dynamics
- Channel Erosion at Outlet of Lake Huron/Michigan
- Climate Change
Maximum Extent of Ice Cover

Lake Superior

% Covered


Lake Michigan

% Covered


EPA State of the Lakes 1999

Austin & Colman 2007
Transient Simulations of Lake Michigan levels for the Chicago Climate Report 2008

Lower Emissions
Competing effects of warmer temperatures and higher precipitation result in little net change

Higher Emissions
Temperature changes are so large that they begin to dominate over precipitation effects by end-of-century

Present Level
1 Foot Lower
2 Feet Lower

1961-1990  2010-2039  2040-2069  2070-2099

Preliminary
Don Wuebbles, U. Illinois

SESE
Levels with Different Climate Scenarios

The response of Lake Superior was the smallest of the Great Lakes.

Lakes Michigan-Huron, Erie, and Ontario were similar in their response.

For Lakes Michigan-Huron, the median changes in lake levels at 2080-2094 were:

B1      -0.45 feet
A1B    -0.50 feet
A2       -0.74 feet

But there was a lot of variability among models.

Angel and Kunkel 2009
Confronting Climate Change in the Great Lakes Region

Past, Current, and Future Climate Change

http://www.ucsusa.org/greatlakes

2003 updated 2005
Wisconsin Migrating Climate

Winter
- 2003
- 2030

Summer
- 2095
- 2095

http://www.ucsusa.org/greatlakes/
Artists View of Climate Change
Think Ahead!
Climate Change
Adaptation & Mitigation