Climate Change and National Parks

Bob Krumenaker
Superintendent
Apostle Islands National Lakeshore

Marathon Venture Academy
November 19, 2015
Updated with ice data from 2016 and 2017
February 11, 2017

Photo by William Cronon

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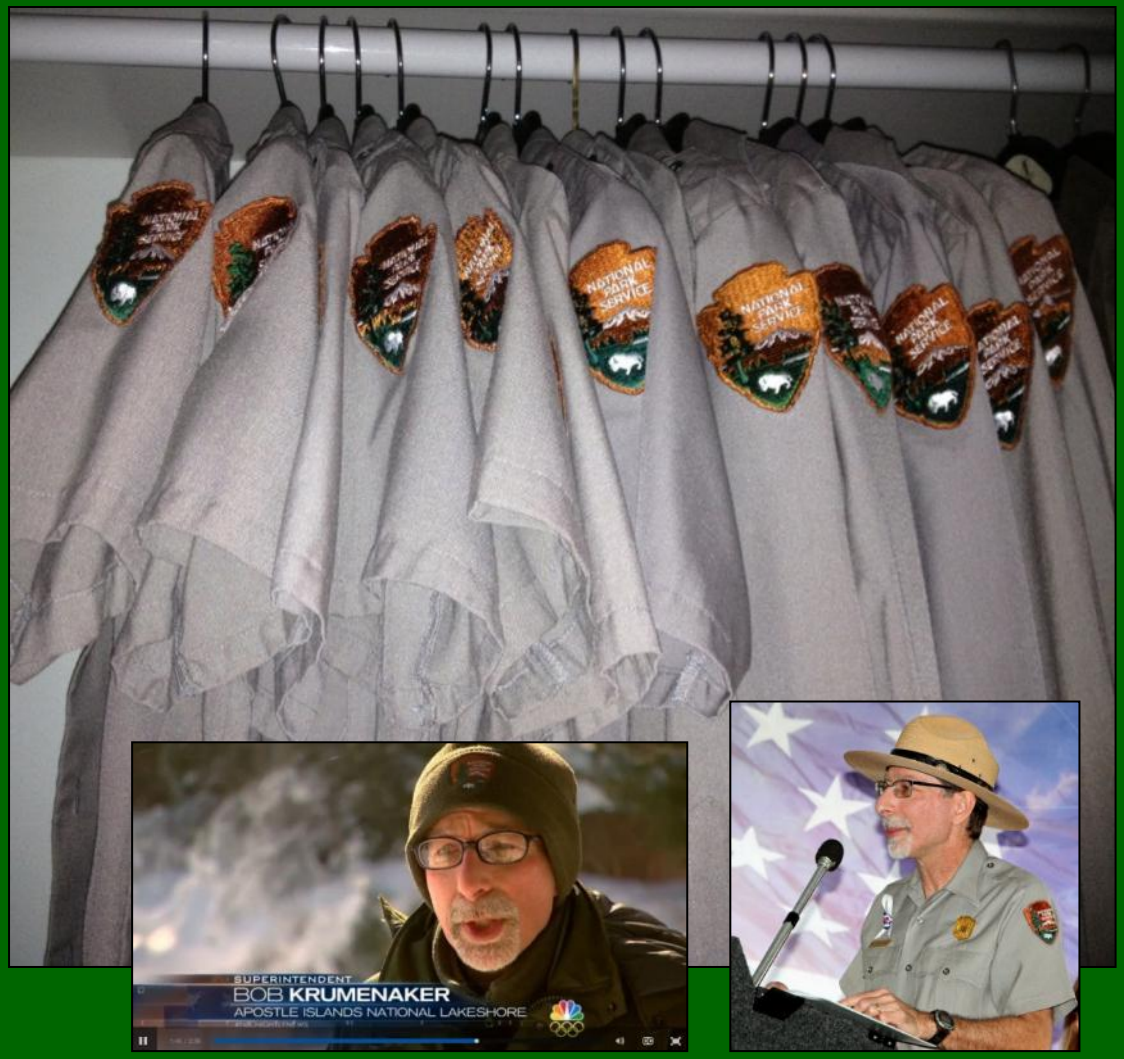
Why Here?

National Geographic Traveler named Apostle Islands National Lakeshore the nation's most sustainable national park in 2005.

It's a lot to live up to.

Photo by William Cronon

Weather vs. Climate in the National Parks



Traditional Ecological Knowledge (TEK) is found in many places

- Weather is indicated by what grey shirt I wear today
- Climate is indicated by the ratio of short to long sleeve shirts in my closet

Both were rather different at Everglades from the Apostle Islands…

Today's Plan

Climate Change and Great Lakes National Parks

- Climate change and national parks
- Climate change is already happening *here*
- Climate change projections for the Great Lakes
- Exploring the impact on the park experience – and what we can do

Stockton Island, Apostle Islands National Lakeshore
Photo by William Cronon

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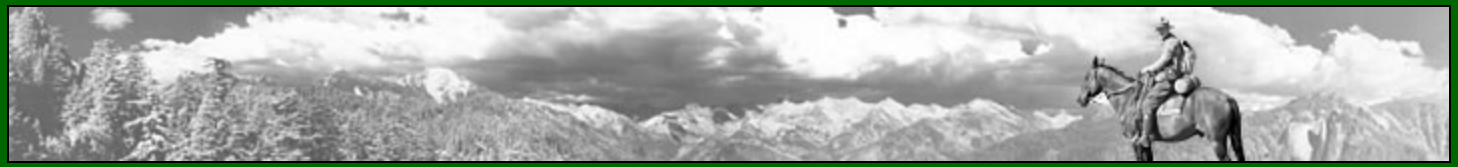
The National Park System

- There are 417 units of the National Park System, in all 50 states
- Conservation, recreation, communities, and economies

The National Park Service Mandate

- The National Park Service was established by an Act of Congress in 1916 (16 US Code 1)
- "… to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."
- What are the roles of the national parks and other protected areas in the face of climate change?



The National Parks are Changing - Fast

- Glacier National Park is likely to have no glaciers by ~2030 or sooner…

  From Hall and Fagre 2003 (http://www.bioone.org/perlserv/?request=get-abstract&doi=10.1641%2F0006-568(2003)053%5B0131%3AMCIGCI%5D2.0.CO%3B2&ct=1

- *"Our initial projection has proved too conservative. They're going faster than we thought."* – USGS ecologist Dan Fagre 10/1/07

  From http://www.missoulian.com/articles/2007/10/01/outdoors/out61.txt

- 2015: Historically low snowpack. Broke 7 high temp records by mid July – DF, pers. Comm. 7/13/15

  And more recently: http://ecowatch.com/2015/11/05/glacier-national-park-melting/

- Shrinking glaciers cause:
  - Less water in streams
  - Warming water
  - Changes in aquatic biota and fish
  - Declines in species that depend on fish
  - Major vegetation shifts
  - Loss of alpine habitat
  - Increase in fires
- Mountains are heating faster than lowlands, globally

The National Parks are Changing - Fast

- Joshua Tree National Park is likely to lose its Joshua Trees under the predicted 21st century doubling of CO_2 scenario

From http://www.climatescience.gov/workshop2005/posters/P-EC4.2_Cole.pdf

The National Parks are Changing - Fast

- Much of Everglades Nat'l Park will be flooded under predicted 21st century sea level rise scenarios (which do *not* include possible rapid melting of Greenland or Antarctic ice sheets).

(NPS/Everglades National Park)

Emissions Scenario	Temperature Increase (°C)	Sea Level Rise (m)
Constant Year 2000	0.6	
Minimum Likely	1.8	0.18 – 0.38 (**7**-15 in)
Maximum Likely	4.0	0.26 – 0.59 (10-**23** in)

IPCC 2007 Projections

(IPCC, 2007) http://www.ipcc.ch/SPM2feb07.pdf

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The National Parks are Changing - Fast

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(NPS/Everglades National Park)

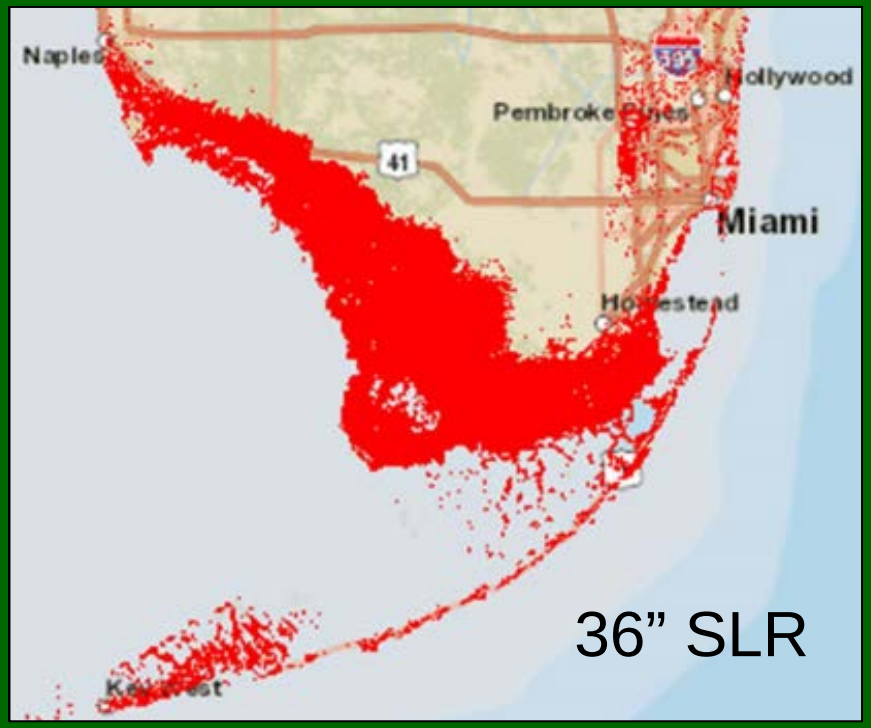
Emissions have increased beyond the 2007 IPCC worst-case projections … Greenland ice *is* melting rapidly … scientists are revising sea level rise estimates …

"An improved… estimate of the range of [sea level rise by] 2100 including ice dynamics lies between 0.8 and 2.0 m [3 to 6½ feet]."
-Pfeffer et al 2008

From http://www.sciencemag.org/cgi/content/abstract/321/5894/1340
Endorsed by UN Climate Change Science Compendium 2009

The National Parks are Changing – Faster than we thought

- Everglades under the 2007 IPCC report … up to 23” rise
- Everglades under the 2014 IPCC report … up to 39” rise



Emissions Scenario	Sea Level Rise (m)
Minimum Likely	0.28 – 0.61 (**11**-24 in)
Maximum Likely	0.52 – 0.98 (20-**39** in)

http://www.realclimate.org/index.php/archives/2013/09/the-new-ipcc-climate-report/
http://www.realclimate.org/index.php/archives/2013/10/sea-level-in-the-5th-ipcc-report/
http://www.evergladesrestoration.gov/content/bbrrct/minutes/2015_meetings/011415/misconceptions_on_sea_level_rise_in_sf.pdf

Wildfires are Increasing

Affecting National Parks and Other Public Lands

- Warming and earlier springs are increasing fire activity
  (Westerling et al. 2006)

Graphic from http://www.economist.com/daily/chartgallery/displaystory.cfm?story_id=9688989

- "Snow is melting much earlier in the year at very regular intervals now, and we're getting much longer fire seasons. It dries out much more than before." – Anthony Westerling, Scripps Institute of Oceanography, quoted by ABC News 6/21/06

The Preservation Predicament

The New York Times
Tuesday, January 29, 2008

The Preservation Predicament

By CORNELIA DEAN

Chip Litherland for The New York Times

Mangrove Trees amid oyster beds exposed at low tide in the Florida Everglades.

Ecologists fear that global warming will make protected landscapes inhospitable to prized species.

- "We have over a 100-year investment nationally in a large suite of protected areas that may no longer protect the target ecosystems for which they were formed," said Healy Hamilton, director of the California Academy of Sciences. "New species will move in, and the target species will move out."

2016 National Park Service CENTENNIAL

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Case in Point

Lake Superior and Apostle Islands National Lakeshore

Temperature & Phenological Changes

Spring Is Coming Earlier in Wisconsin

- Nina Leopold Bradley replicated her father Aldo's phenology studies at "The Shack" near Baraboo, WI.

Event	Average 1936-1947	Average 1976-1998
Robin arrival	March 20	March 12
Hepatica first bloom	April 15	April 8
House wren arrival	May 4	April 23
Columbine first bloom	May 19	May 10
Baptisia first bloom	June 14	May 29

- Spring has arrived 1.2 days earlier per decade since the 1930s, correlating with a gradual increase in regional temperature.

From the Proceedings of the National Academy of Sciences 96:9701-04 (1999) at http://www.pnas.org/cgi/reprint/96/17/9701 and the newsletter of the Aldo Leopold Foundation at http://www.aldoleopold.org/Publications/newsletters/winter2003.pdf

The Heat is Already On

Lake Superior States Rank #2,3, and 4 in Temperature Change Per Decade

The Heat Is On

U.S. Temperature Trends

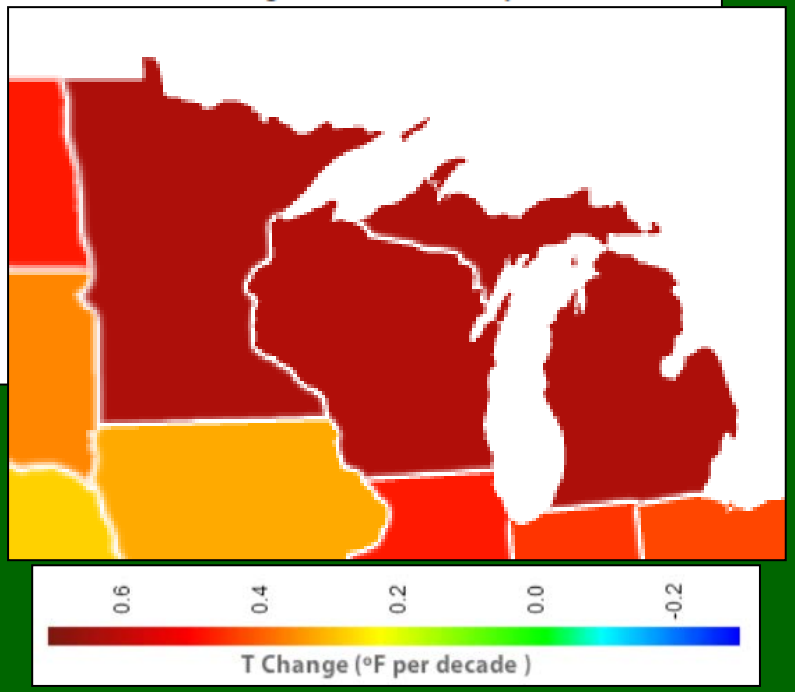
[Average Daily Temperatures]

Every State Has Warmed Since 1970

Table 2. Since 1970, every state has experienced a warming and the rates of warming were faster than they were over the past 100 years.

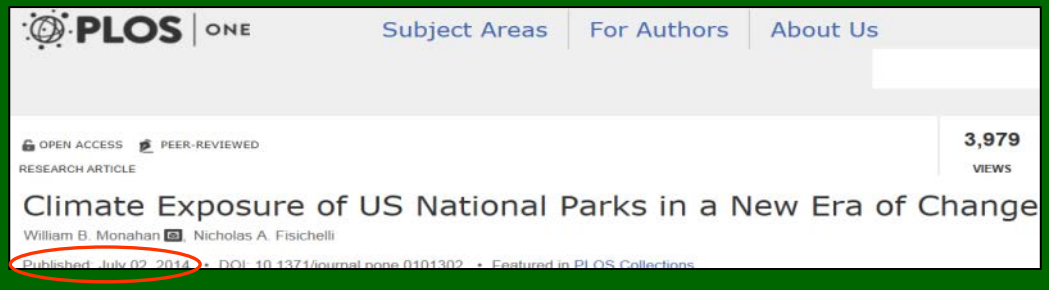
Rank	State	Temperature Change (°F per decade)
1	Arizona	0.639
2	Michigan	0.622
3	Minnesota	0.620
4	Wisconsin	0.616

CLIMATE CENTRAL



http://www.climatecentral.org/news/the-heat-is-on [June 2012]

It is Now the Warmest Here in Over a Century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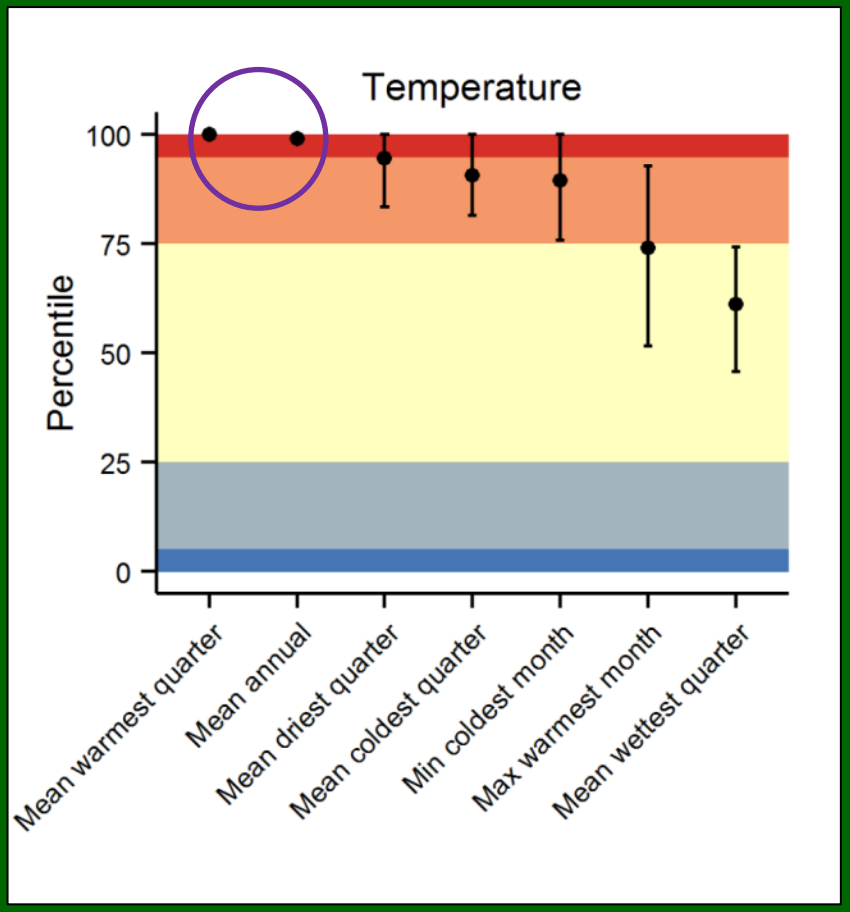
3,979 VIEWS

Climate Exposure of US National Parks in a New Era of Change

William B. Monahan, Nicholas A. Fisichelli

Published July 02, 2014 • DOI: 10.1371/journal.pone.0101302 • Featured in PLOS Collections

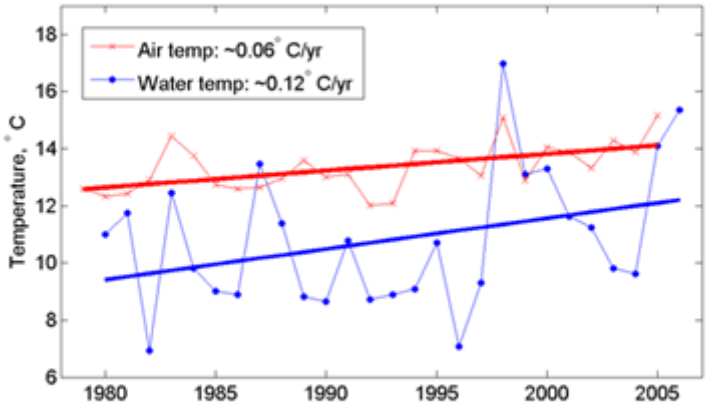
- "The recent average temperature of summer months at Apostle Islands … is at the highest point measured over the last 112 years (1901-2012); any continued increase in temperature will push the park's summer temperatures higher than it has experienced since 1901."

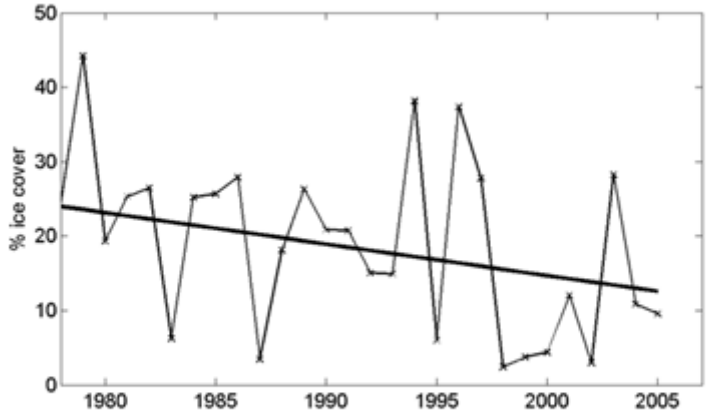


http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0101302

Great Lakes Water Temperature Increases

Lake Superior is Warming Rapidly





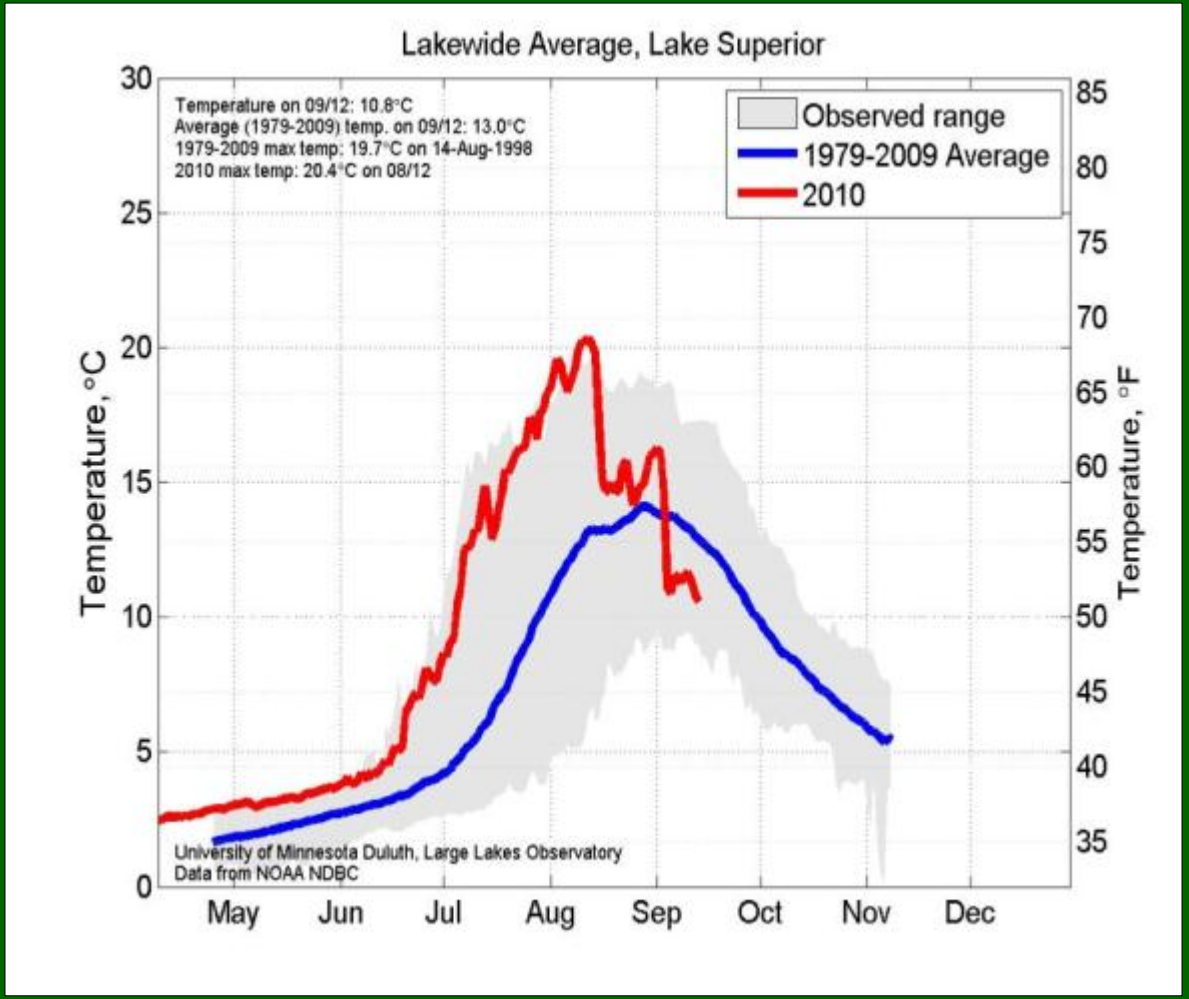
- Lake Superior water temperature is rising at twice the rate of air temperature since 1980.
- This correlates with decreasing ice cover over the same period. From http://www.d.umn.edu/~jaustin/ICE.html (Austin and Colman, 2007)
- A similar pattern has been noted in Lake Baikal (Russia). From http://www.planetark.org/dailynewsstory.cfm?newsid=48179, http://minnesota.publicradio.org/collections/special/columns/statewide/archive/2011/06/lake-superior-warming-is-global-trend.shtml

Great Lakes Water Temperature - Lake Superior

Early Turnover & Record Warm Surface Water in 2010

- Lake Superior "turned over" much earlier and warmed up much faster than usual, breaking the surface water temperature record (68˚F) set in 1998.

From
http://www.seagrant.umn.edu/news/2010/07/09
Chart from Jay Austin,
University of Minnesota-Duluth



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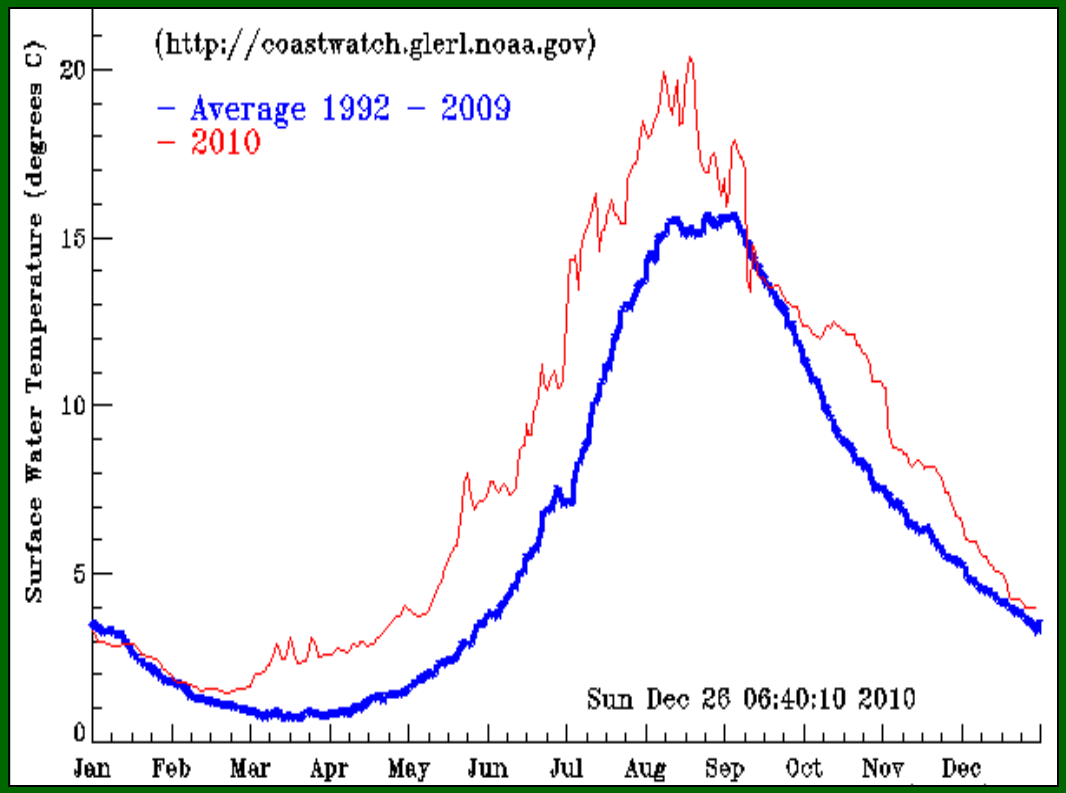


From
http://www.seagrant.umn.edu/news/2010/07/09
Chart from Jay Austin,
University of Minnesota-Duluth

End of Year Graph from
http://coastwatch.glerl.noaa.gov/statistic/gif/avgtemps-s_1992-2009.gif

Great Lakes Water Temperature - Lake Superior

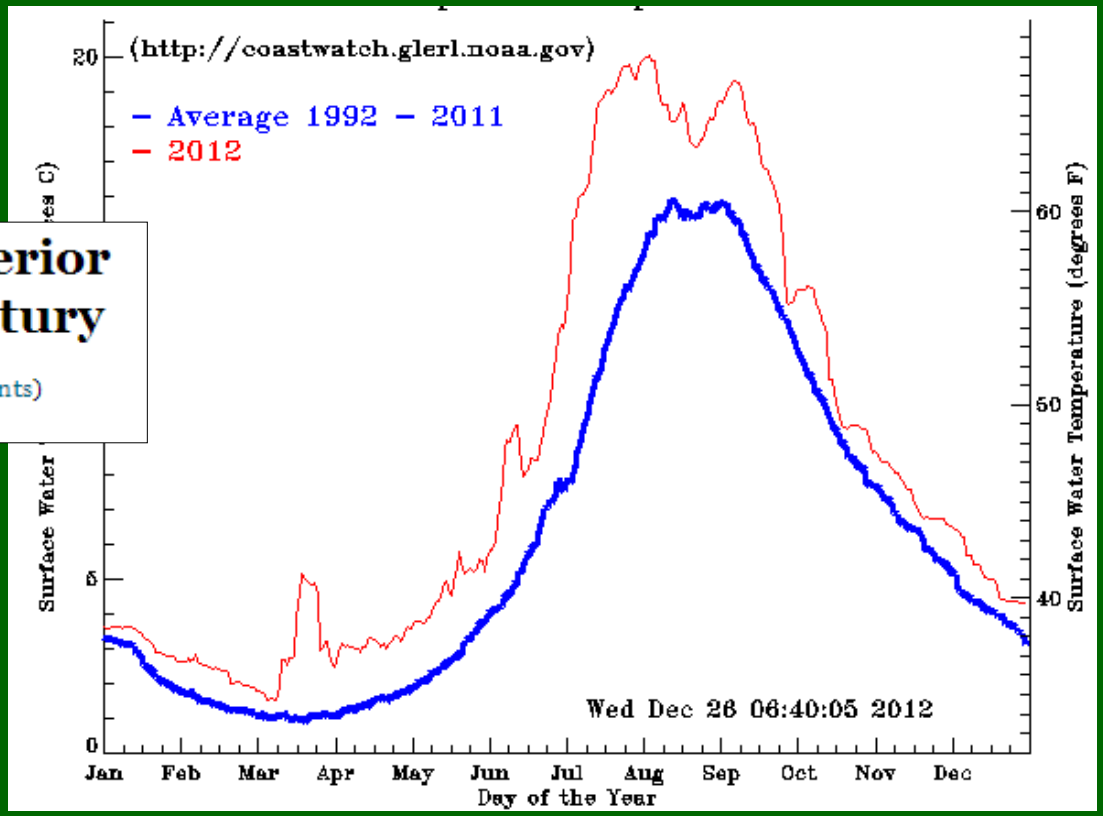
Early Turnover & Record Warm Surface Water in 2012

- Temps in early summer 2012 were 15-20°F above normal – because they were a month early!

Swimming anyone? Lake Superior water temps warmest in a century

Posted at 9:11 AM on July 25, 2012 by Paul Huttner (3 Comments)
Filed under: Climate change, Lake Superior

- Warm lake in summer increases chances of lake effect snow the next winter … > 50" after April 1, 2013!

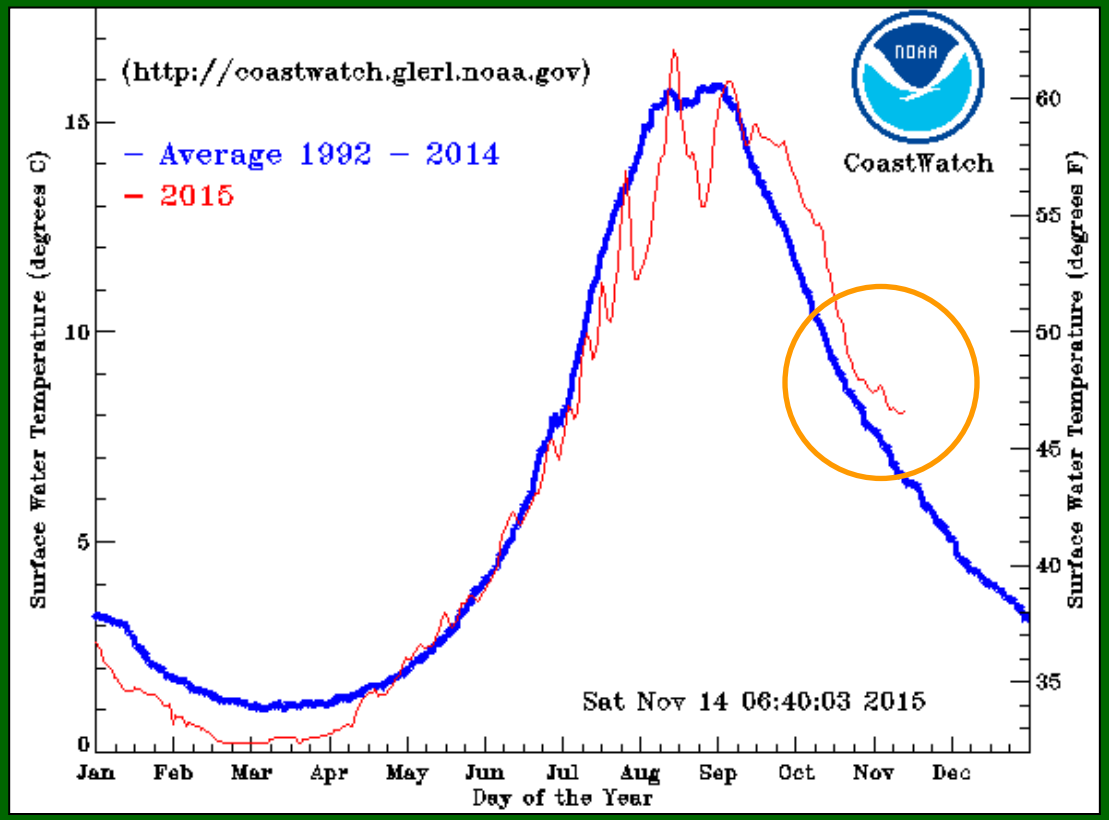


Graphic from http://coastwatch.glerl.noaa.gov/statistic/gif/avgtemps-s_1992-2011.gif
Headline from http://minnesota.publicradio.org/collections/special/columns/updraft/archive/2012/07/balmy_70s_2012_lake_superior_w.shtml
Quote from National Weather Service on http://www.climatecentral.org/news/great-lakes-water-temperatures-at-record-levels

Great Lakes Water Temperature - Lake Superior

2015

- Normal winter air temps after a cold start
- Lots of ice (again)
- Spring water temp started well below normal
- It caught up… and the warm fall has put us above average going into winter



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Headline from http://minnesota.publicradio.org/collections/special/columns/updraft/archive/2012/07/balmy_70s_2012_lake_superior_w.shtml

Comparing Water Temperature & Ice Cover

How Does Autumn Water Temperature Influence Winter Ice Cover?

The Importance of Spring and Autumn Atmospheric Conditions for the Evaporation Regime of Lake Superior

C. Spence

Environment Canada, Saskatoon, Saskatchewan, Canada

P. D. Blanken

Department of Geography, University of Colorado Boulder, Boulder, Colorado

J. D. Lenters

School of Natural Resources, University of Nebraska–Lincoln, Lincoln, Nebraska

N. Hedstrom

Environment Canada, Saskatoon, Saskatchewan, Canada

Abstract

Feedbacks between ice extent and evaporation have long been suspected to be important for Lake Superior evaporation because it is during autumn and winter when latent heat fluxes are highest. Recent direct measurements of evaporation made at the Stannard Rock Lighthouse have provided new information on the physical controls on Lake Superior evaporation, in particular that evaporation can react within hours to days to a change in synoptic conditions. However, the large heat capacity of the lake creates a strong seasonal cycle of energy storage and release. There is a complex interaction among heat storage, evaporation, and ice cover that is highly dependent on atmospheric conditions in the spring and autumn "shoulder seasons." Small changes in conditions in November and March caused by synoptic-scale events can have profound impacts on annual evaporation, the extent of ice cover, and the length of the ice-covered period. Early winter air temperatures in November and December dictate the nature of ice formation and much of the winter evaporative flux. Decreased ice cover, by itself, does not necessarily lead to enhanced annual evaporation losses. Rather, a combination of low ice cover and warm spring air temperatures, leading to an early breakup, can significantly lengthen the next evaporation season and cause greater cumulative water loss the subsequent year. The influence of individual synoptic events on annual evaporation is notable enough that the research community should ensure that their role is properly captured in numerical models to provide sound predictions of future Laurentian Great Lakes evaporation regimes.

Keywords: North America, Energy budget/balance, Evaporation, Hydrometeorology, Ice loss/growth, Radiative fluxes

Received: November 26, 2012; Final Form: June 6, 2013

"Small changes in conditions in November and March caused by synoptic-scale events can have profound impacts on annual evaporation, the extent of ice cover, and the length of the ice-covered period. Early winter air temperatures in November and December dictate the nature of ice formation and much of the winter evaporative flux."

From C. Spence, P. D. Blanken, J. D. Lenters, and N. Hedstrom, 2013: The Importance of Spring and Autumn Atmospheric Conditions for the Evaporation Regime of Lake Superior. *J. Hydrometeor*, **14**, 1647–1658.

http://dx.doi.org/10.1175/JHM-D-12-0170.1

http://journals.ametsoc.org/doi/abs/10.1175/JHM-D-12-0170.1

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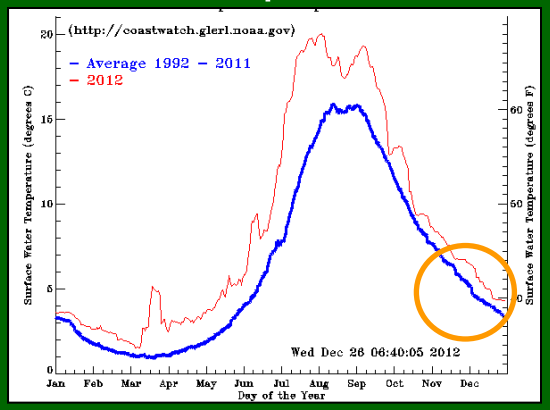
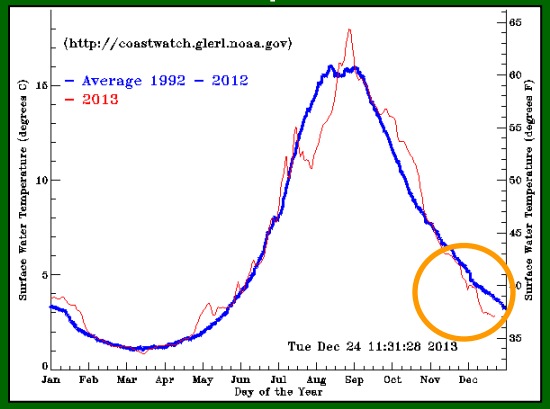
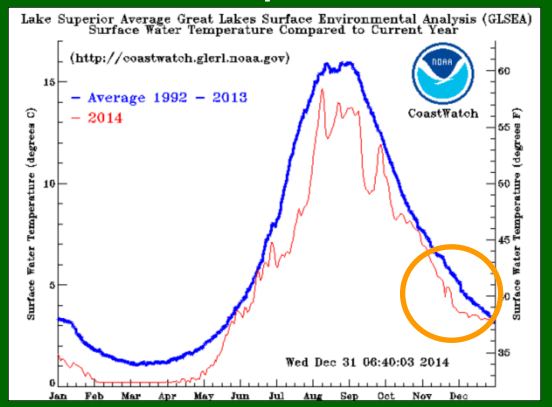
Water Temp 2012



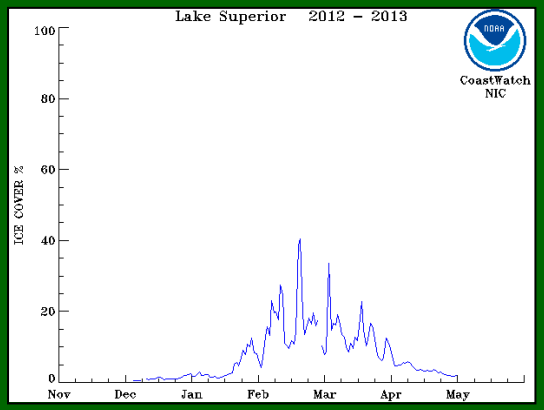
Water Temp 2013



Water Temp 2014



Ice Cover 2012-2013



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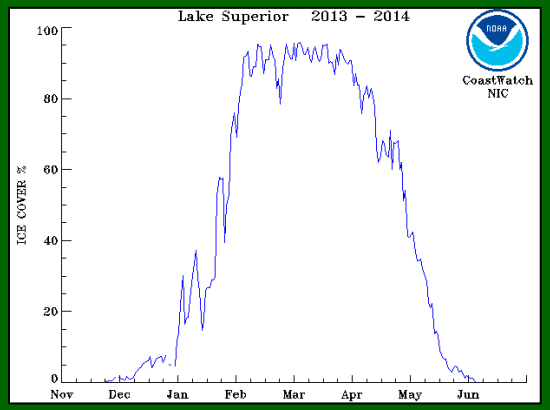
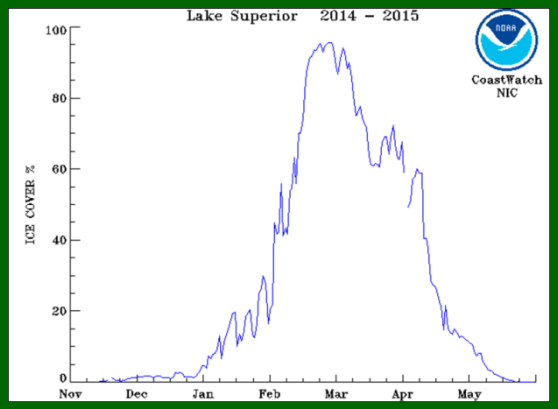


Ice Cover 2014-2015



Ice Caves Closed 2013

Ice Caves Open 2014

Ice Caves Open 2015

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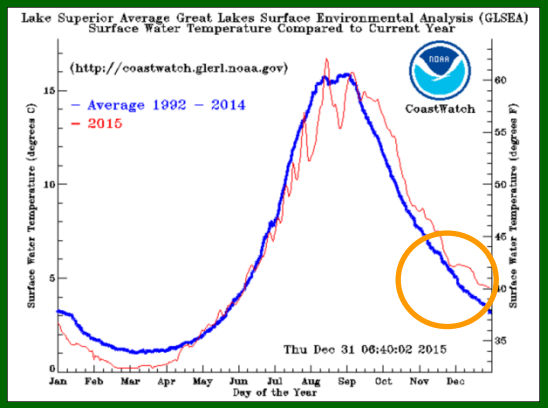
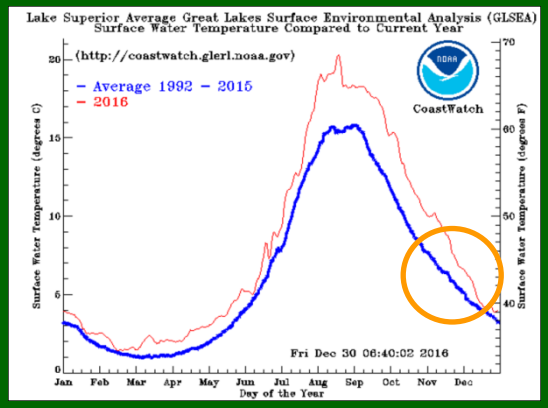
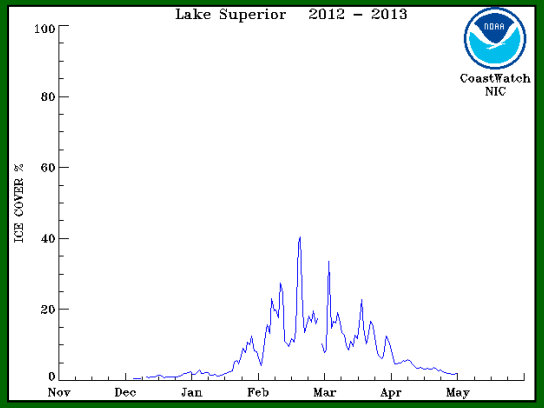
Water Temp 2015



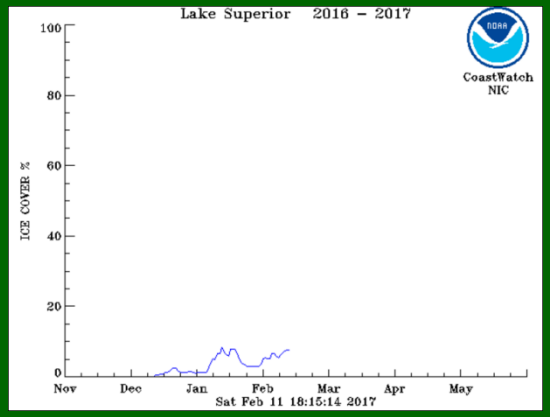
Water Temp 2016



Ice Cover 2015-2016



Ice Cover 2016-2017



Ice Caves Closed 2016

Ice Caves Closed 2017

As Lake Superior Warms…

Ice Cover and Lake Levels

It's Complicated!

- Winter evaporation, related to the amount and duration of ice cover, affects lake levels more than precipitation. Lofgren et al. 2002

- Less ice in winter →
- More evaporation →
- Lake level declines

From http://www.seagrant.umn.edu/news/2010/07/09

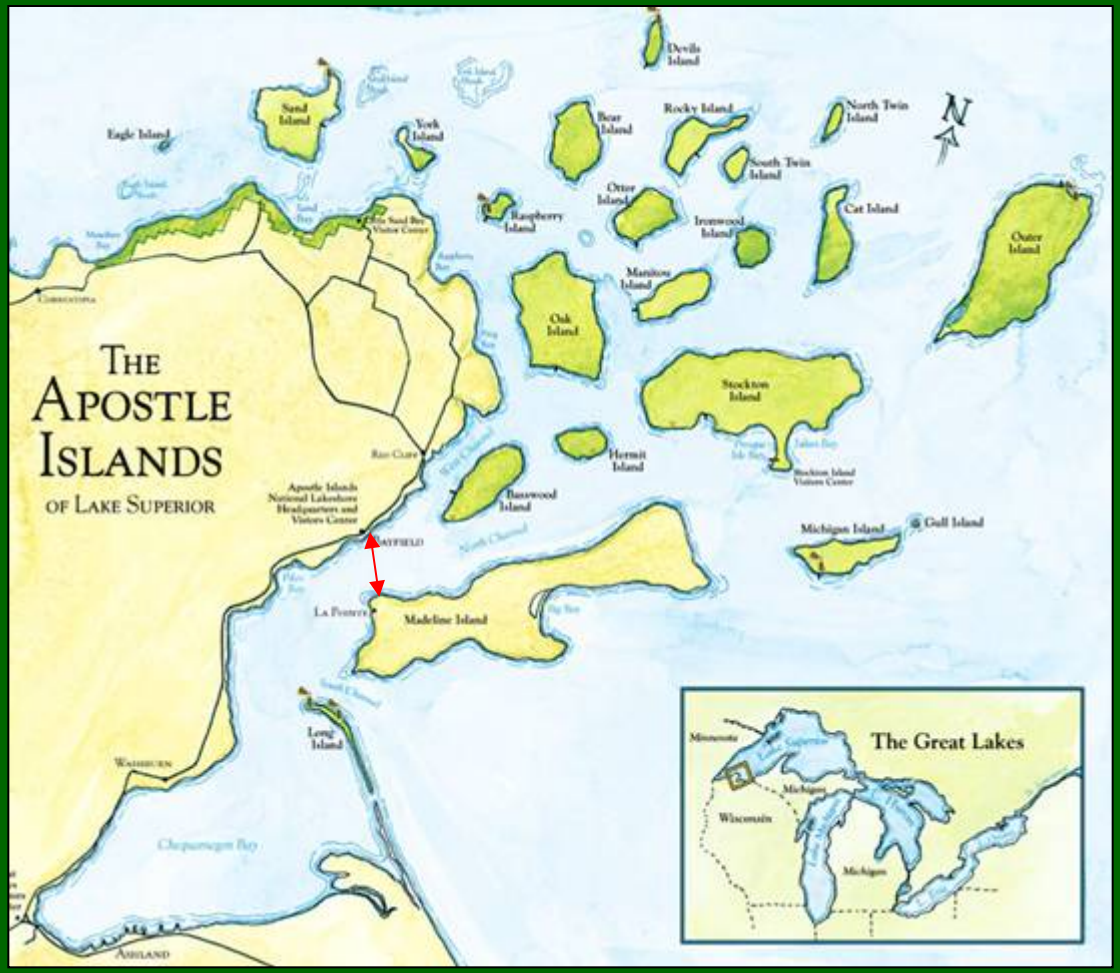
Or…

- Warm water in summer →
- More evaporation in fall →
- More heat loss →
- More ice
- But still, lake level declines

From Lenters et al 2013. Summarized in http://phys.org/news/2014-01-great-lakes-evaporation-dispels-misconceptions.html

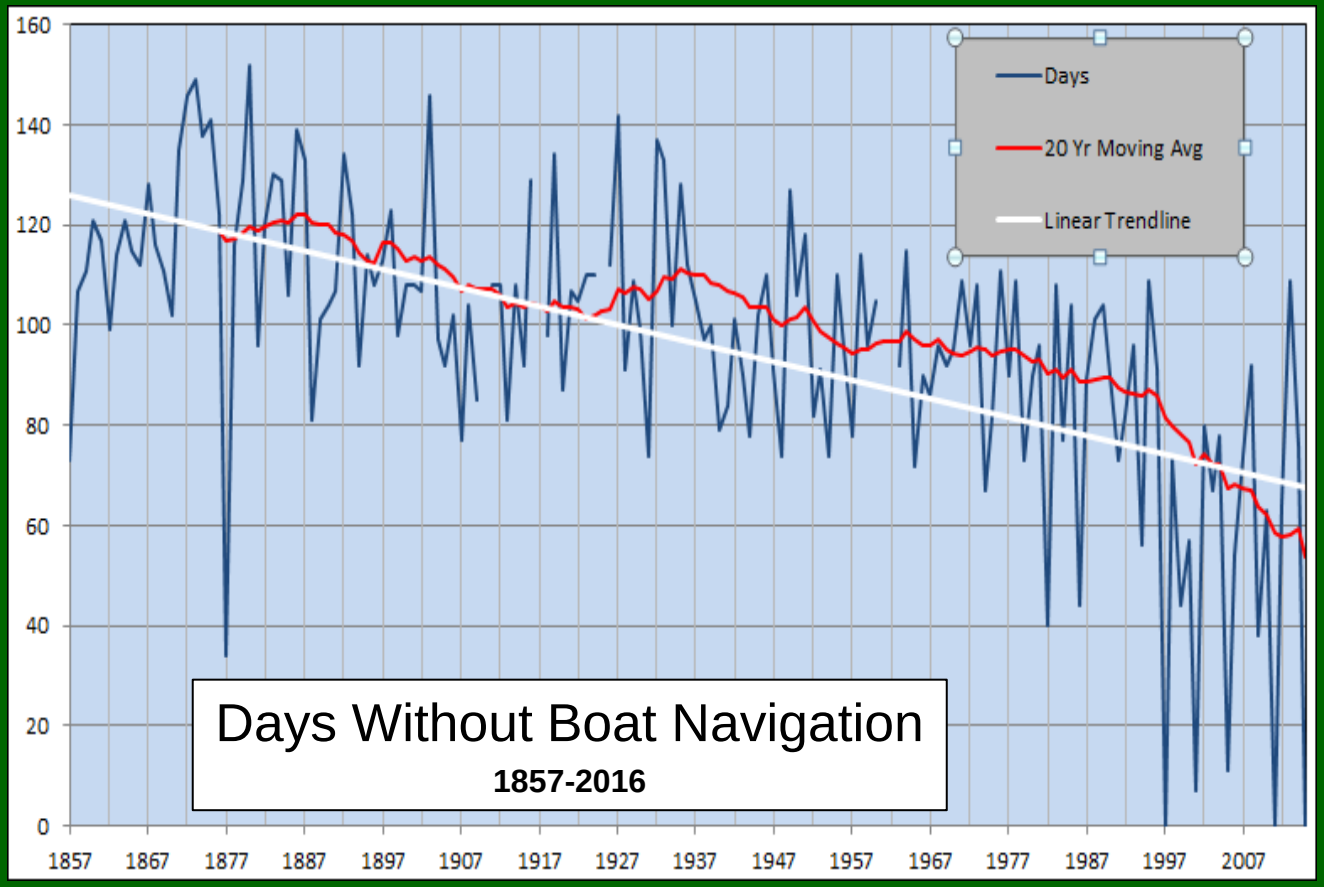
Ice Decline on the Great Lakes

Madeline Island Ice Road, Lake Superior



Ice Decline on the Great Lakes

Madeline Island Ice Road, Lake Superior



Ice <u>duration</u> *HERE* has declined:

- 3.4 days/decade since 1857
- 14.7 days/decade since 1975

From Howk, 2009
Changes in ice cover at Bayfield, Wisconsin.
Journal of Great Lakes Research
35(1):159-162

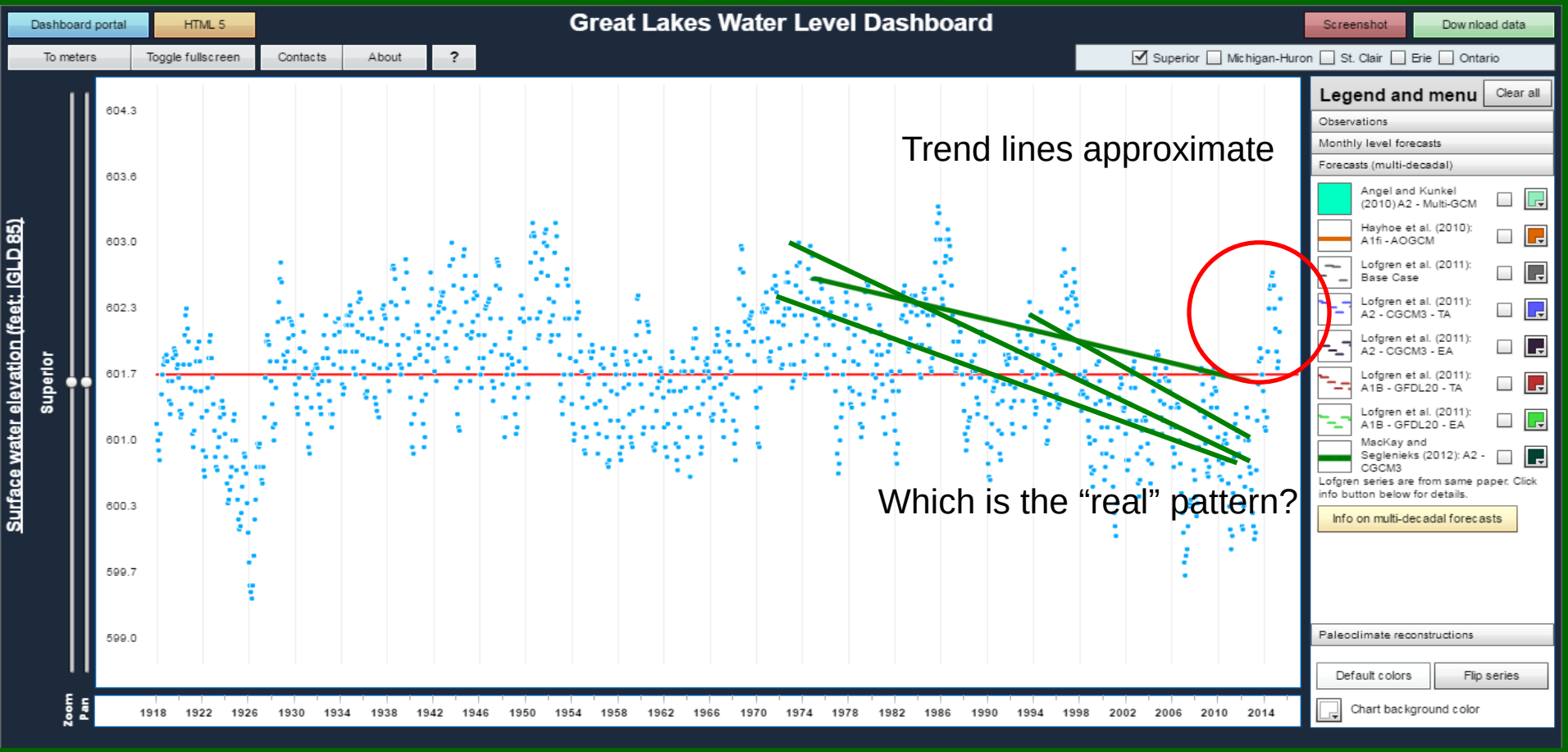
Chart updated since 2009 by NPS staff

Ice <u>cover</u> has declined on Lake Superior 79% since 1973 Wang et al., 2012
Especially since the El Niño of 1997-98! Van Cleave et al., 2014

Lake Superior Water Levels

Have They Been Declining for Years?

Data downloaded 7/13/2015



From http://www.glerl.noaa.gov/data/now/wlevels/dbd/

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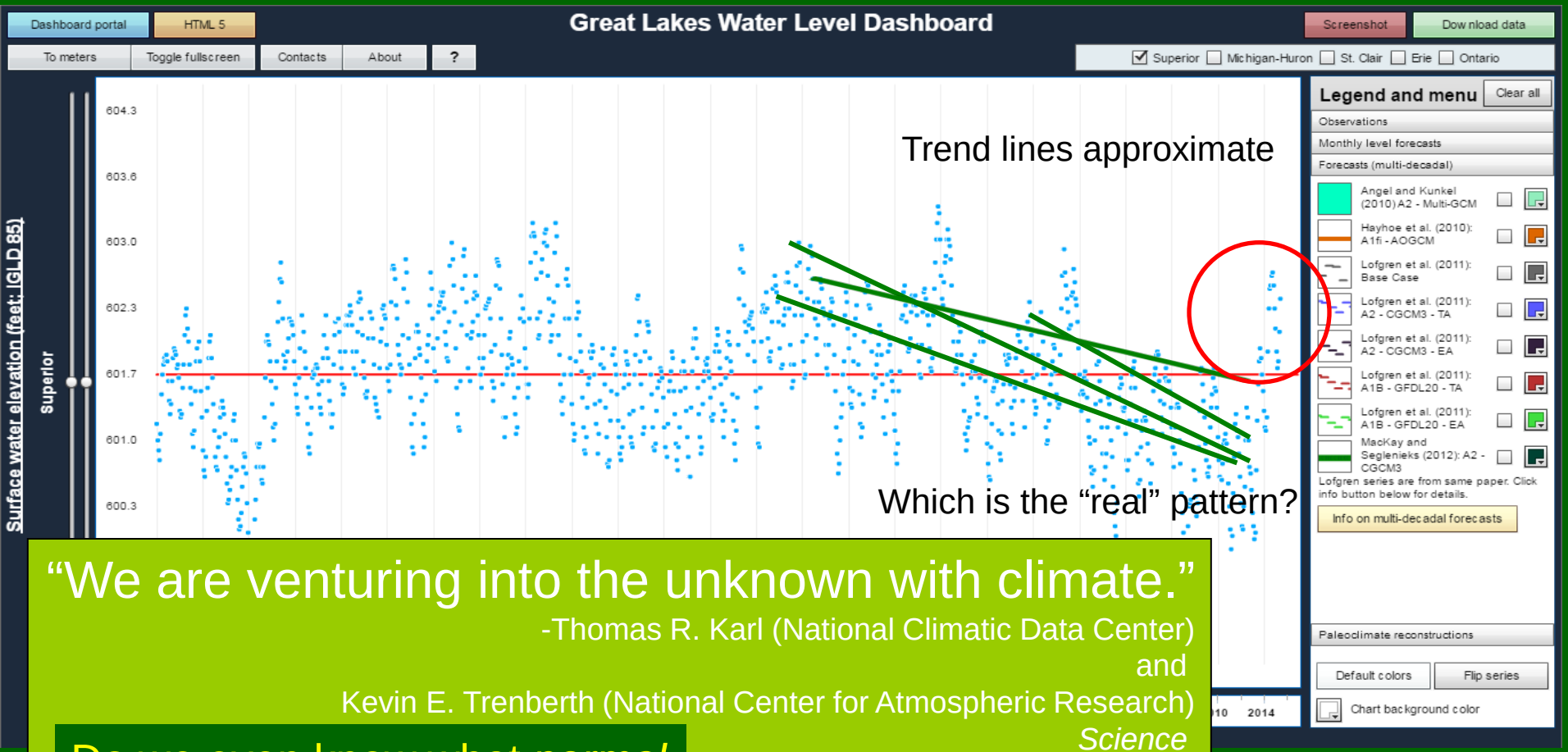

"We are venturing into the unknown with climate."

-Thomas R. Karl (National Climatic Data Center)

and

Kevin E. Trenberth (National Center for Atmospheric Research)

Science

5 December 2003

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Do we even know what *normal* is any more?

http://www.sciencemag.org/cgi/content/abstract/302/5651/1719

Today's Plan

Climate Change and Great Lakes National Parks

- Climate change and national parks
- Climate change is already happening *here*
- Climate change projections for the Great Lakes
- Exploring the impact on the park experience – and what we can do

Stockton Island, Apostle Islands National Lakeshore
Photo by William Cronon

National Climate Assessment (2014)

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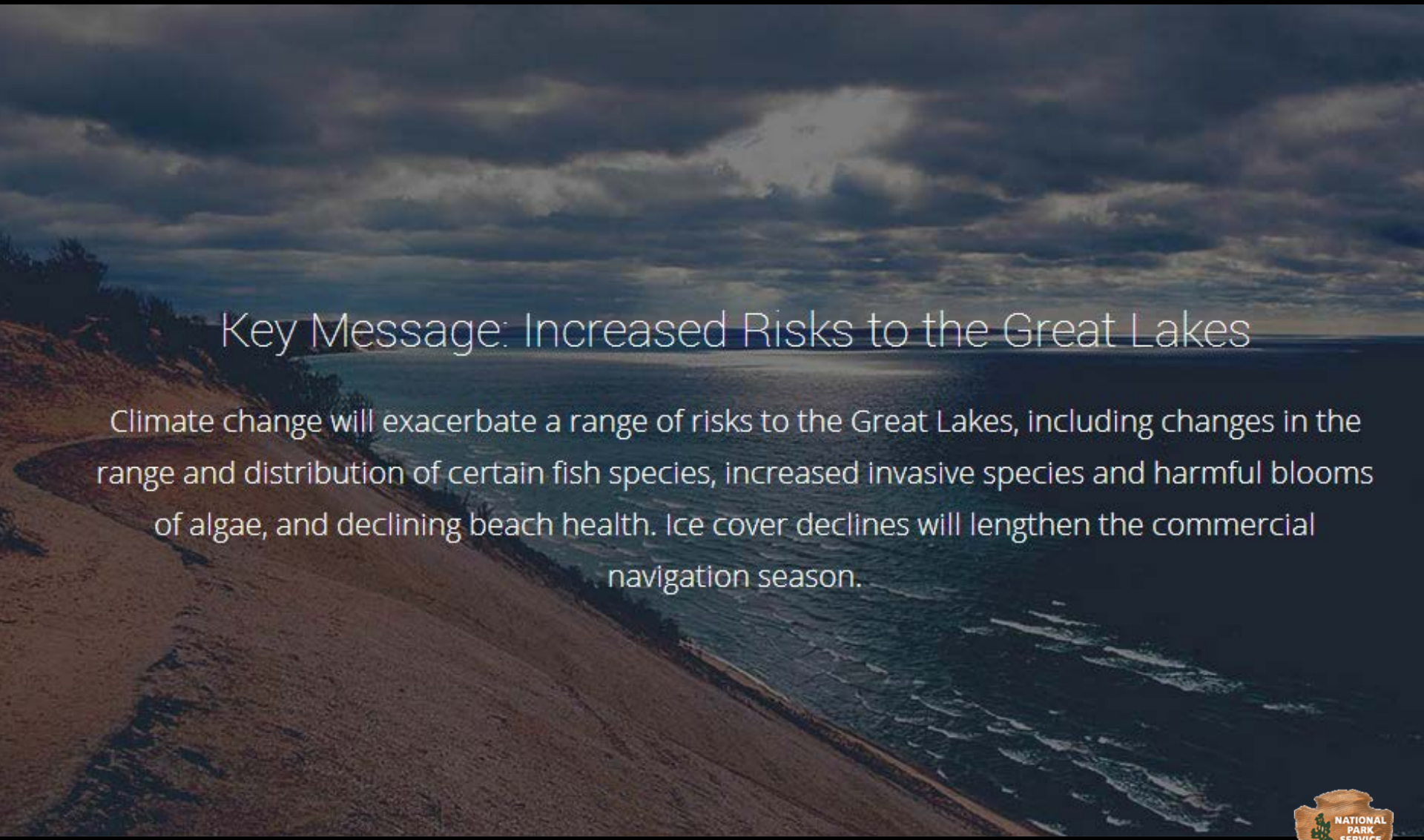
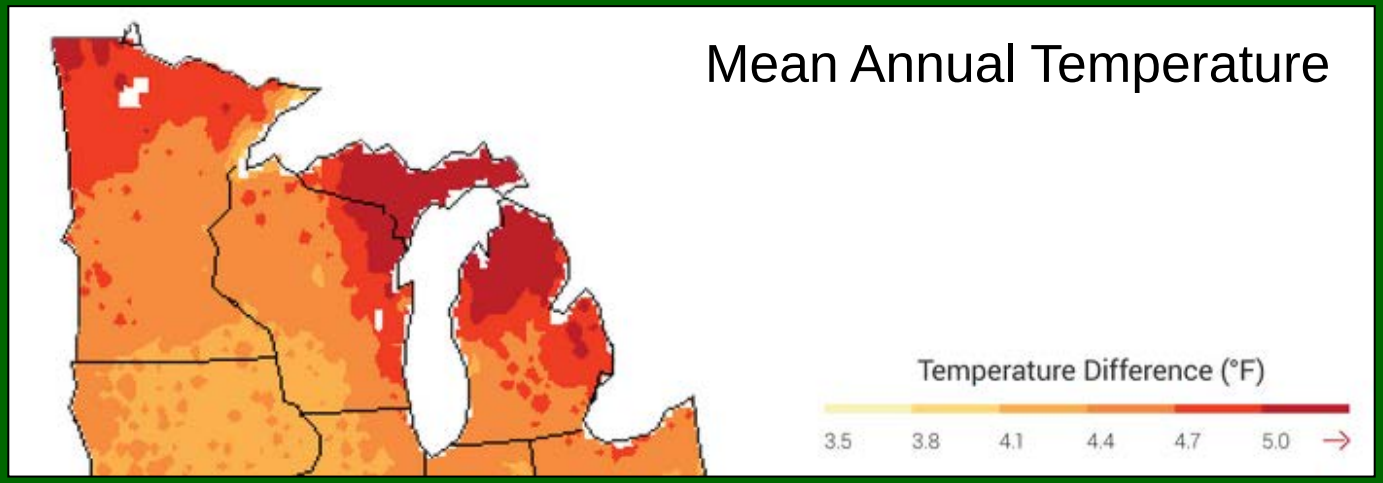


Temperature Change by Mid-Century (2041-70)

Great Lakes States -- Compared to 1971-2000



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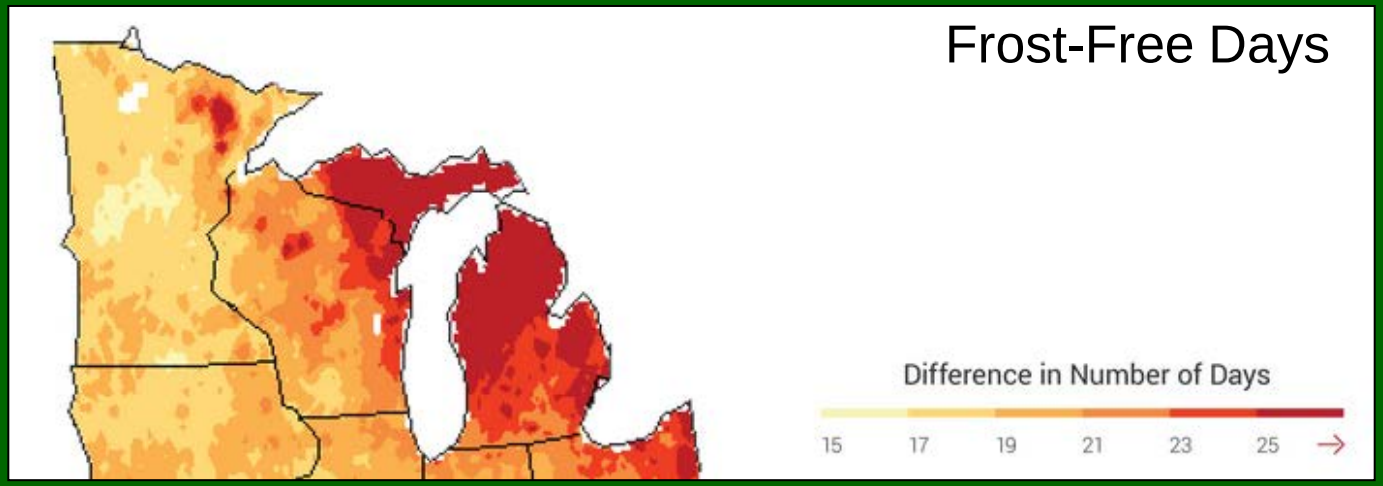

Climate Change Projections for the Great Lakes

- Warmer, drier summers
- Warmer winters
- Shorter cold season
- More winter precipitation as rain
- Warmer water
- Less ice
- Later freeze-up, earlier ice-out
- More evaporation from lakes
- Lower lake levels
- Irregular, higher intensity storms
- More flooding, esp. in spring

Outer Island, Apostle Islands National Lakeshore

Climate Change Projections for the Great Lakes

- Warmer, drier summers (IPCC, 2001)
- Warmer winters (IPCC, 2001)
- Shorter cold season (International Joint Commission, 2003)
- More winter precipitation as rain (Wuebbles and Hayhoe, 2004)
- Warmer water (Lehman, 2002)
- Less ice (International Joint Commission, 2003)
- Later freeze-up, earlier ice-out (International Joint Commission, 2003)
- More evaporation from lakes (Nat'l Assessment Synthesis Team, 2000)
- Lower lake levels (Nat'l Assessment Synthesis Team, 2000)
- Irregular, higher intensity storms (International Joint Commission, 2003)
- More flooding, esp. in spring (Kling et. al, 2003)

Great Lakes Water & Ice Levels In 2100

Projections Vary

- Models have inherent scientific uncertainty but are limited by non-scientific uncertainty over future emissions, making it seem like the models are less precise than they are. (Pollack, 2007)
- 11 of 12 models project significant reductions in levels of the Great Lakes, ranging up to 5 feet. (National Assessment Synthesis Team, 2000)
- More recent published models project lesser declines. (MacKay and Seglenicks, 2012; Lofgren et al., 2011)

- Lake Superior, by 2090:
  - Evaporation will increase up to 39%.
  - Ice cover will decrease to only 2-11% of current February average levels. (Lofgren et al. 2002)

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Stockton Island, Apostle Islands National Lakeshore
Photo by William Cronon

Warmer and Longer Summers

- More boats & boaters ill prepared for the cold, treacherous waters of Lake Superior.
- “Shoulder” seasons will begin earlier, end later, and see more activity.
- Warm waters will change the cold water fishery.
- Increased turbidity and algae.
- Shipwrecks and other submerged cultural resources will deteriorate faster.

More Intensive Storms

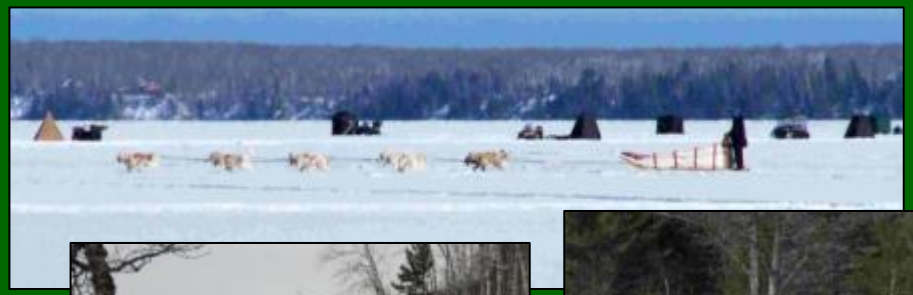
More Dangerous Boating

Coupled with warmer temperatures, there will likely be more boaters unprepared for storms on the lake, leading to more groundings, capsizings, and more need for rescues.

Winter Recreation Opportunities Are Changing

Skiing, dog sledding, ice fishing, and exploring unique winter scenery are likely to be constrained to shorter and shorter seasons – and in poor ice years, severely limited.

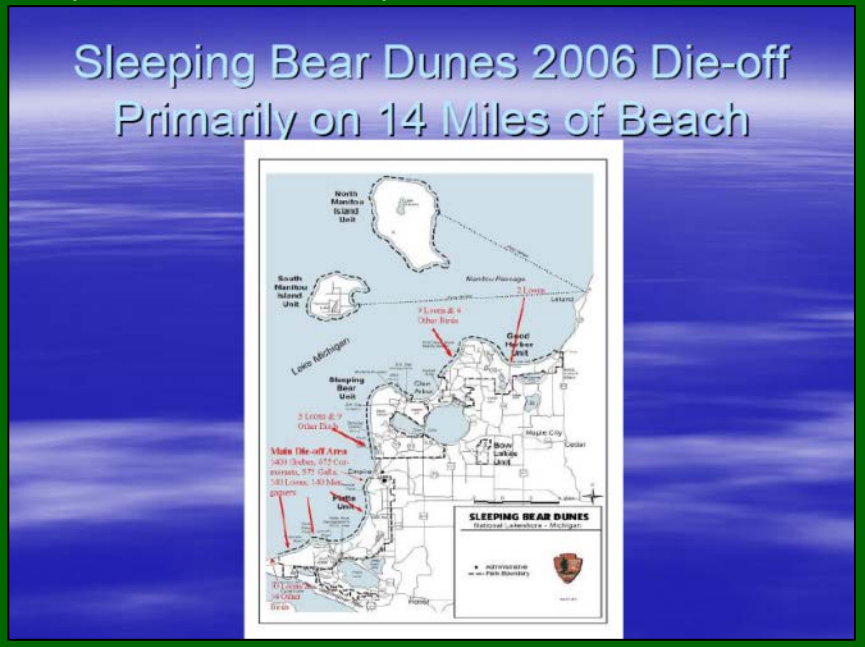
(Notwithstanding 2014-15!)



Visiting the ice caves may be an endangered experience…

Bird Die-offs & Beach Closures

- 2006-7 Botulism outbreak at Sleeping Bear Dunes National Lakeshore on Lake Michigan
- Not caused by climate change… but conditions leading to outbreak are likely to be more common as climate warms (Lafrancois et al. 2010)



Slides from http://www.miseagrant.umich.edu/downloads/habitat/botulism-workshop/MichCoordMtg-2007-Bird-Die-off.pdf

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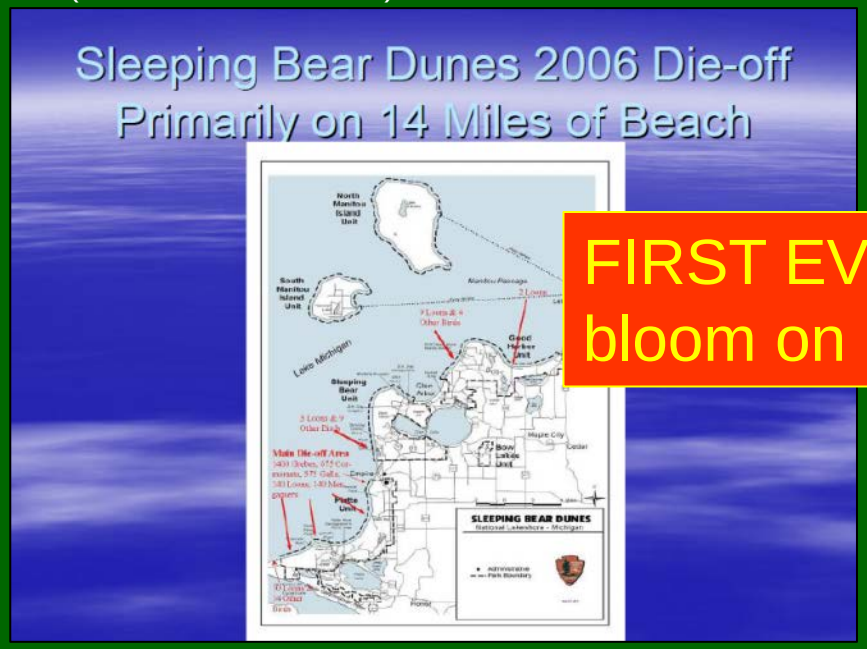


FIRST EVER Blue-green algal bloom on Lake Superior in 2012!

Slides from http://www.miseagrant.umich.edu/downloads/habitat/botulism-workshop/MichCoordMtg-2007-Bird-Die-off.pdf

So What Do We Do Now?

Mitigation

Linking Climate Change to Sustainability – Ramping Up – Leading by Example

Apostle Islands National Lakeshore

National Park Service
U.S. Department of the Interior

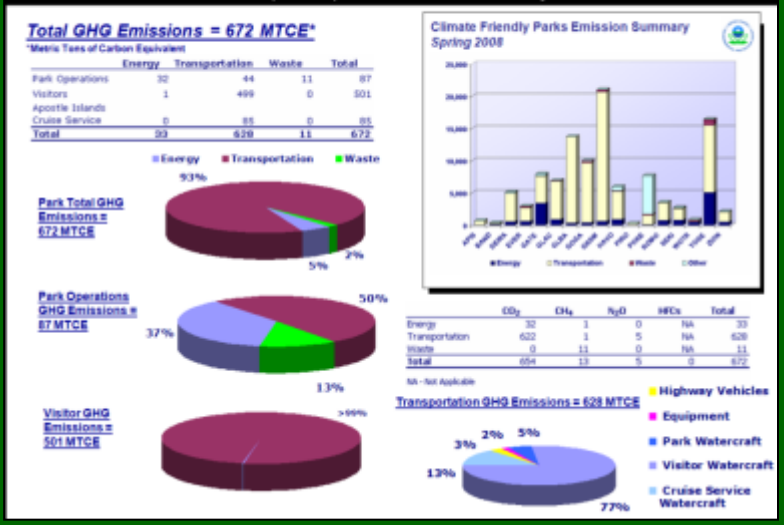
Superintendent's Order # 31

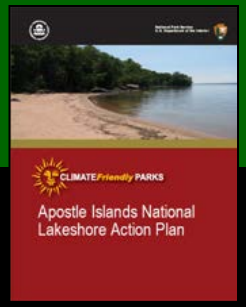
Safety, Environmental Management, and Sustainability

Effective Date of this Order:	January 8, 2010

Apostle Islands National Lakeshore

2006 Greenhouse Gas (GHG) Emission Inventory Results

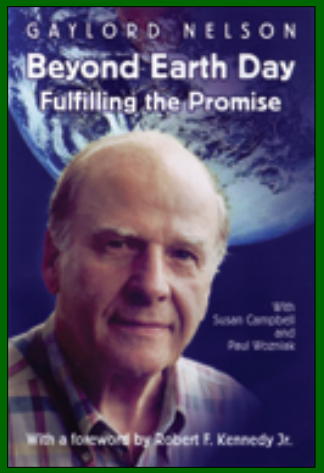




Increase Commitment to Sustainability

and then Lead By Example

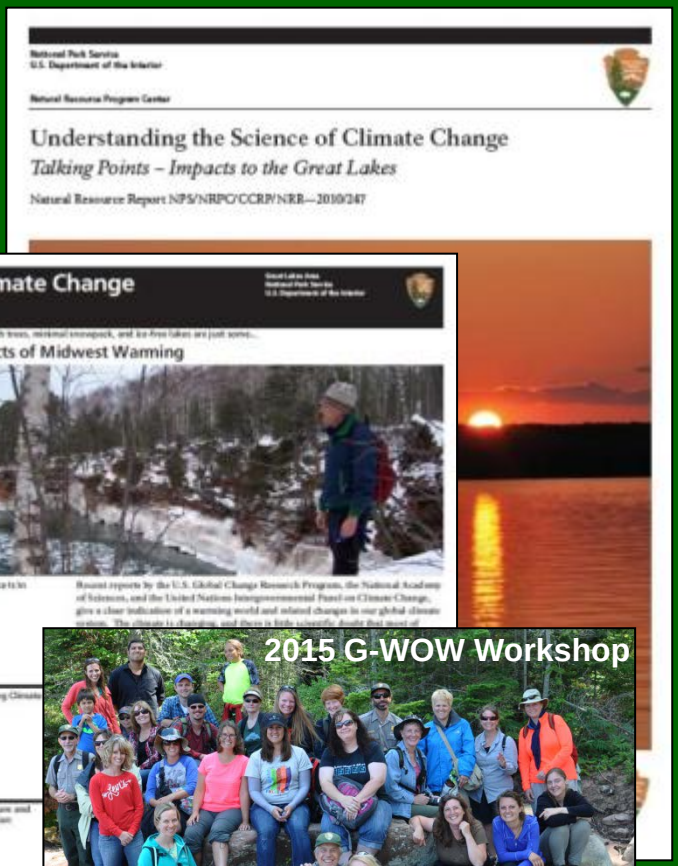
"Without vigorous and persistent leadership …the goal of sustainability can not be achieved… A way to make environmental problems appear to be less daunting is to relate them to our communities and convey their relevance to our daily lives – as they unquestionably are relevant."

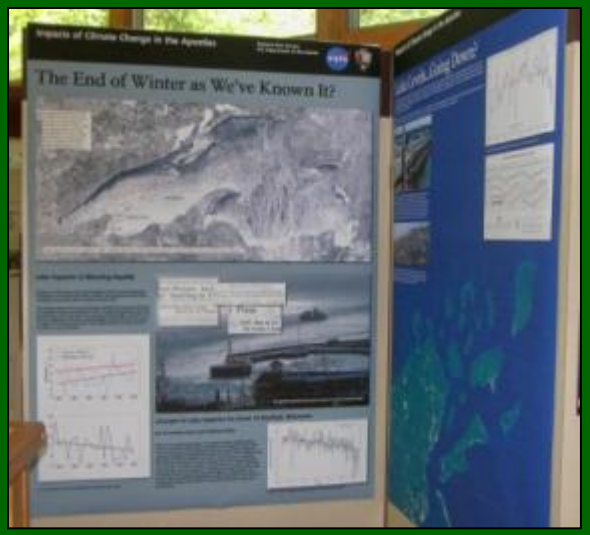


-- Gaylord Nelson
Beyond Earth Day
2002

Communication

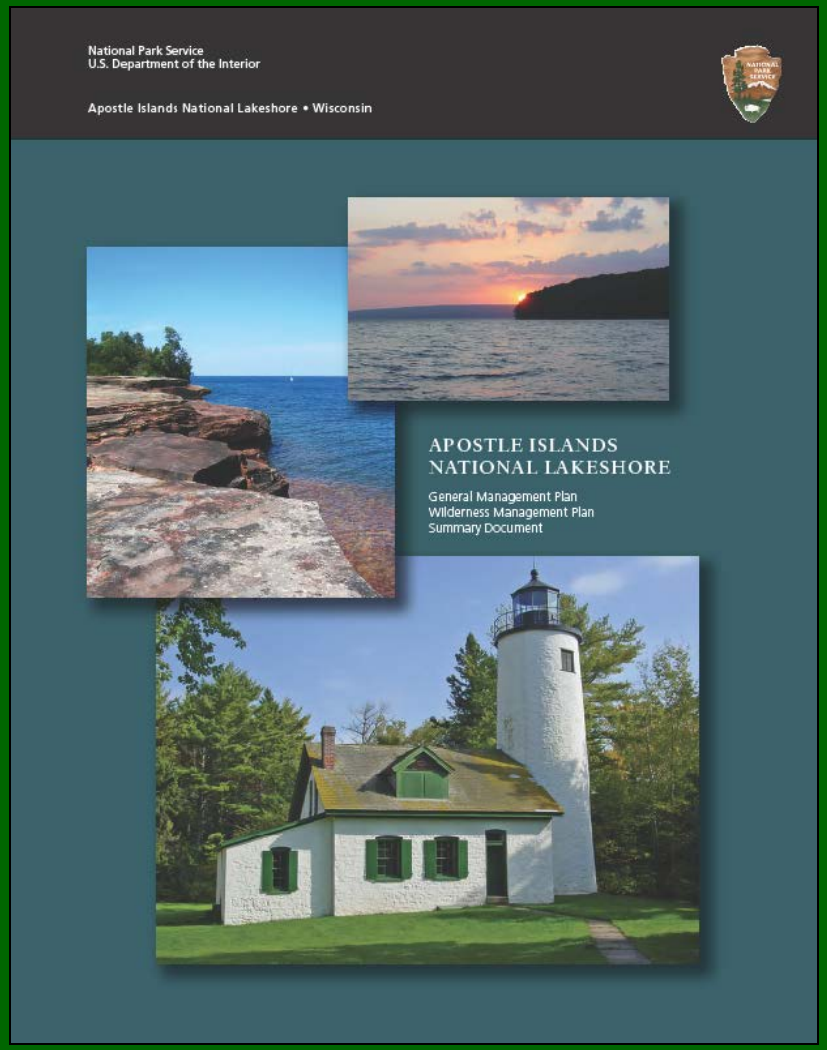
Educate Ourselves, then Deliver a Clear, Credible, Consistent Message





Adapting Facilities and Infrastructure

Planning with Climate Change in Mind



CLIMATE CHANGE
in the 2011
APOSTLE ISLANDS NATIONAL LAKESHORE
GENERAL MANAGEMENT PLAN / WILDERNESS MANAGEMENT PLAN[1]

CHAPTER 1: BACKGROUND

SCOPE OF THE GENERAL MANAGEMENT PLAN/ WILDERNESS MANAGEMENT PLAN

Planning Issues and Concerns Addressed

Climate Change[2]

Climate change refers to any significant changes in average climatic conditions (such as mean temperature, precipitation, or wind) or variability (such as seasonality and storm frequency) lasting for an extended period (decades or longer). Recent reports by the U.S. Climate Change Science Program, the National Academy of Sciences, and the United Nations Intergovernmental Panel on Climate Change provide clear evidence that climate change is occurring and will accelerate in the coming decades. While climate change is a global phenomenon, it manifests differently depending on regional and local factors.

Climate change is expected to result in many changes to the Lake Superior region and Apostle Islands National Lakeshore in particular. Some of these changes are already occurring. There are documented increases in air and lake temperature and reductions in ice cover locally, and evidence that spring events are happening earlier regionally. Changes that are expected to occur in the future in the area include hotter, drier summers; warmer winters; less winter ice; warmer water; lower lake levels; rapidly increasing range of nonnative species like gypsy moths; increases in the frequency, size, and intensity of forest fires; reductions or disappearance of species at the edges of their ranges (which includes almost all of the unique species on the Great Lakes islands), among other changes (Schramm and Loehman 2010).

Climate change will also affect the visitors' park experience in a variety of ways, including • changes in wildlife-dependent activities, such as

- bird-watching
- longer summer season
- shorter winter recreation season
- infrastructure problems (e.g., fixed docks may be too high and water may be too shallow to access some docks)
- new navigational hazards (e.g., sand bars)
- increasing frequency and intensity of severe storms, which may lead to more rescues
- longer mosquito and black fly seasons
- changes to recreational fishing opportunities due to fish habitat changes as water warms, the season length changes, and the depth of warm surface waters expands

Climate change may have potential impacts on cultural resources. For example, lower water levels in Lake Superior could result in the exposure of submerged archeological resources near the shorelines of the islands. Exposure of these resources, including historic shipwrecks and currently unidentified prehistoric sites, could

[1] Pages refer to September 2011 Apostle Islands National Lakeshore General Management Plan / Wilderness Management Plan Summary Document (http://www.nps.gov/apis/upload/APIS-GMP-short-version.pdf). Additional background climate change information is found in Chapter 4 (Affected Environment) of the full document (http://www.nps.gov/apis/upload/APIS-FINAL-GMP-WMP-EIS-April-2011-Chapters-1-6.pdf).
[2] Pages 18-19

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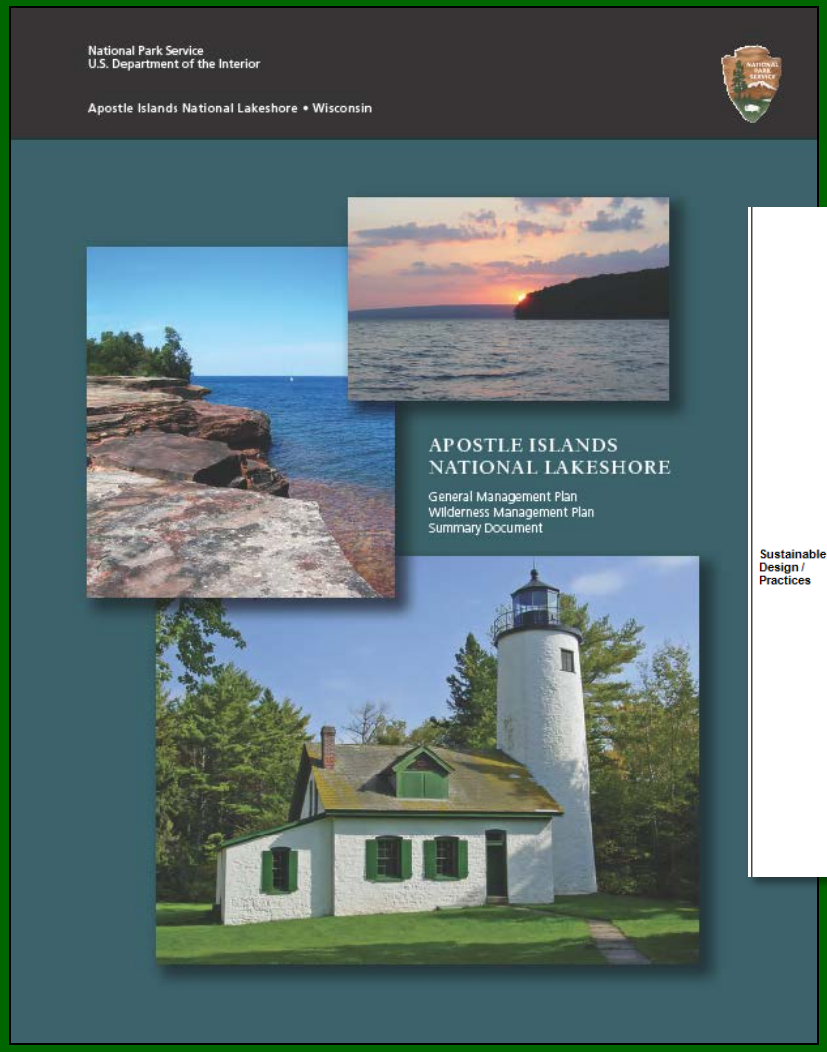
Adapting Facilities and Infrastructure

Planning with Climate Change in Mind



CLIMATE CHANGE
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APOSTLE ISLANDS NATIONAL LAKESHORE
GENERAL MANAGEMENT PLAN / WILDERNESS MANAGEMENT PLAN[1]

Sustainable Design / Practices

Sustainability can be defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." Sustainable practices and principles are those choices, decisions, actions, and ethics that will best achieve ecological/biological integrity; protect qualities and functions of air, water, soil, and other aspects of the natural environment; and preserve human cultures. Sustainable practices allow for use and enjoyment by the current generation, while ensuring that future generations will have the same opportunities. Sustainable practices consider local and global consequences to minimize the short- and long-term environmental impacts of human actions and developments through resource conservation, recycling, waste minimization, and the use of energy efficient and ecologically responsible materials and techniques.

The federal government has been emphasizing the adoption of sustainable practices. In particular, Executive Order Executive Order 13423 strengthens federal environmental, energy, and transportation management. In addition, NPS *Management Policies 2006* (§1.8, 9.1), Director's Order 13 ("Environmental Management Systems"), and Superintendent's Order #31 provide direction regarding sustainability.

Desired Conditions: The park is a leader in sustainable practices. All decisions regarding park operations, planning, facilities management, and development in Apostle Islands National Lakeshore, from the initial concept through design and construction, reflect principles of resource conservation. Thus, all park developments and operations are sustainable to the maximum degree possible and practical. New developments and existing facilities are located, built, and modified according to the "Guiding Principles of Sustainable Design" (NPS 1993) or other similar guidelines. All new facilities are built to qualify for silver LEED (Leadership in Energy and Environmental Design) designation. The park's land, water, soil, wildlife, and other natural resources are managed in ways that improve their condition and mimics or restores natural conditions wherever possible. The park has state-of-the-art water systems for conserving water, and energy conservation technologies and renewable energy sources whenever possible. Biodegradable, nontoxic, and durable materials are used in the park whenever possible. The reduction, use, and recycling of materials is promoted, while materials that are nondurable, environmentally detrimental, or that require transportation from great distances are avoided as much as possible. The park's carbon footprint is minimized as much as possible.

Strategies: Superintendent's Order #31, "Safety and Sustainability" will be fully implemented. This order describes the park's objectives, goals, commitments, and processes for sustainability (see http://www.nps pdf)

NPS staff will w and programs s the park. NPS s environmental l

NPS managers to examine the developments.

NPS staff will s sustainable pra

Climate Change

Climate change is occurring and is expected to affect the park's weather, resources (e.g., shorelines, vegetation, fish and wildlife, submerged cultural resources), facilities (e.g., docks), and visitors (e.g., use seasons, recreational fishing, navigation hazards). These changes will have direct implications on resource management and park operations, and on the way visitors use and experience the park. Although climate change will affect the park during the life of this plan, many of the specific effects, the rate of changes, and the severity of impacts are not known.

While there are no laws or policies that provide direct guidance on addressing climate change, there is guidance that indirectly addresses climate change, including the NPS Organic Act, Executive Order 13423 (includes requirements for the reduction of greenhouse gases and other energy and water conservation measures), Department of the Interior Secretarial Order 3226 (ensures that climate change impacts be taken into account in connection with Departmental planning and decision making), and NPS *Management Policies 2006* (including sections on environmental leadership [§1.8], sustainable energy design [§9.1.1.6],and energy management [§9.1.7].

Desired Conditions: Apostle Islands National Lakeshore is a leader in its efforts to address climate change, reducing its greenhouse gas emissions and increasing its use of renewable energy and other sustainable practices so it is a carbon neutral park. Education and interpretive efforts help park visitors understand the process of global warming, climate change, the threats to the park, and how they can respond. Park staff promote innovation, best practices, adaptive management, and partnerships to respond to the challenges of climate change and their effects on park resources. Park staff proactively monitor, plan, and adapt to the effects of climate change by using the best information as it becomes available.

Strategies: Apostle Islands National Lakeshore will continue as a member of the Climate Friendly Parks program, measuring park-based greenhouse emissions, developing sustainable strategies to mitigate these emissions and adapt to climate change impacts, educating the public about these efforts, and developing future action plans.

Lake Level Decline Has Affected Infrastructure

Adaptation at Little Sand Bay, Apostle Islands National Lakeshore

Lake Level Decline Has Affected Infrastructure

Adaptation at Little Sand Bay, Apostle Islands National Lakeshore

Adaptation Requires Changing the Paradigm

- Climate change is not simply about the changes to natural environments and regional ecosystems…or some other place
- We need to consider changes to, and rethink:
  - Experiences & expectations
  - Facilities & infrastructure
  - Human health and safety
- Climate change is not just a natural resource issue
  - Communities, both human and natural
  - It's a quality of life & economic issue
  - Especially for this area, whose sense of identity is so tied to the land and waters
  - Parks, protected places, and the communities they are part of will be different places in the future

Climate Change and the National Parks

"For the past 25 years, I have been doing field work at high elevations in the … premier national parks, including Glacier, Yellowstone, Mt. Rainier, Yosemite, and Sequoia. In all of these parks, we are seeing the fingerprint of global climate change. Glaciers are disappearing and plants, animals and insect pests are moving upslope at unprecedented rates.

"Our national parks can no longer be protected from human influence by building a fence or hiring park rangers. Recall that national parks are an American invention. In fact, the writer Wallace Stegner often remarked that the idea of national parks was the best idea that we ever had. *It's my fervent hope that we find the will to address global climate change in order to ensure that the parks and wild places … continue to delight and inspire future generations.* "

Lisa Graumlich
Former Director, School of Natural Resources
University of Arizona

From http://www.earthsky.org/article/50989/20-scientists-speak

Opportunity in a Crisis

NPS Climate Change Case Study – Apostle Islands

Working to Make Sure Apostle Islands Deserves to be Called “The Most Sustainable National Park” in the US

Lake Superior and the Apostle Islands From Space

QUESTIONS? FOR MORE INFORMATION

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Lake Superior and the Apostle Islands From … Home