Climate Change: Ice Duration on the Great Lakes

Indicator #4858

Overall Assessment

Status:	**Mixed**
Trend:	**Deteriorating (with respect to climate change)**

Lake-by-Lake Assessment

Individual lake basin assessments were not prepared for this report.

Purpose

- To assess the ice duration, and thereby the temperature and accompanying physical changes to each lake over time, in order to infer the potential impact of climate change

Ecosystem Objective

This indicator is used as a potential assessment of climate change, particularly within the Great Lakes basin. Changes in water and air temperatures will influence ice development on the Lakes and, in turn, affect coastal wetlands, nearshore aquatic environments, and inland environments.

State of the Ecosystem

Background

Air temperatures over a lake are one of the few factors that control the formation of ice on that surface. Colder winter temperatures increase the rate of heat released by the lake, thereby increasing the freezing rate of the water. Milder winter temperatures have a similar controlling effect, only the rate of heat released is slowed and the ice forms more slowly. Globally, some inland lakes appear to be freezing up at later dates, and breaking-up earlier, than the historical average, based on a study of 150 years of data (Magnuson *et al*. 2000). These trends add to the evidence that the earth has been in a period of global warming for at least the last 150 years.

The freezing and thawing of lakes is a very important aspect to many aquatic and terrestrial ecosystems. Many fish species rely on the ice to give their eggs protection against predators during the late part of the ice season. Nearshore ice has the ability to change the shoreline as it can encroach upon the land during winter freeze-up times. Even inland systems are affected by the amount of ice that forms, especially within the Great Lakes basin. Less ice on the Great Lakes allows for more water to evaporate and be spread across the basin in the form of snow. This can have an affect on the foraging animals (such as deer) that need to dig through snow during the winter in order to obtain food.

Status of Ice Duration on the Great Lakes

Observations of the Great Lakes data showed no real conclusive trends with respect to the date of freeze-up or break-up. A reason for this could be that due to the sheer size of the Great Lakes, it wasn't possible to observe the whole lake during the winter season (at least before satellite imagery), and therefore only regional observations were made (inner bays and ports). However, there were enough data collected from ice charts to make a statement concerning the overall ice cover during the season. There appears to be a decrease in the maximum ice cover per season over the last thirty years (Figure 1).

The trends on each of the five Great Lakes show that during this time span the maximum amount of ice forming each year has been decreasing, which correlated to the average ice cover per season observed for the same time duration (Table 1). Between the 1970s and the 1990s there was at least a 10% decline in the maximum ice cover on each lake, nearly 18% in some cases, with the greatest decline occurring during the 1990s. Since a complete freeze-up did not occur on all the Great Lakes, a series of inland lakes (known to freeze every winter) in Ontario were examined to see if there was

Lake	1970 - 1979	1980 - 1989	1990 - 1999	Change from 1970s to 1990s
Erie	94.5	90.8	77.3	-17.2
Huron	71.3	71.7	61.3	-10.0
Michigan	50.2	45.6	32.4	-17.8
Ontario	39.8	29.7	28.1	-11.7
Superior	74.5	73.9	62.0	-12.6

Table 1. Mean ice coverage, in percent, during the corresponding decade.
Source: National Oceanic and Atmospheric Administration

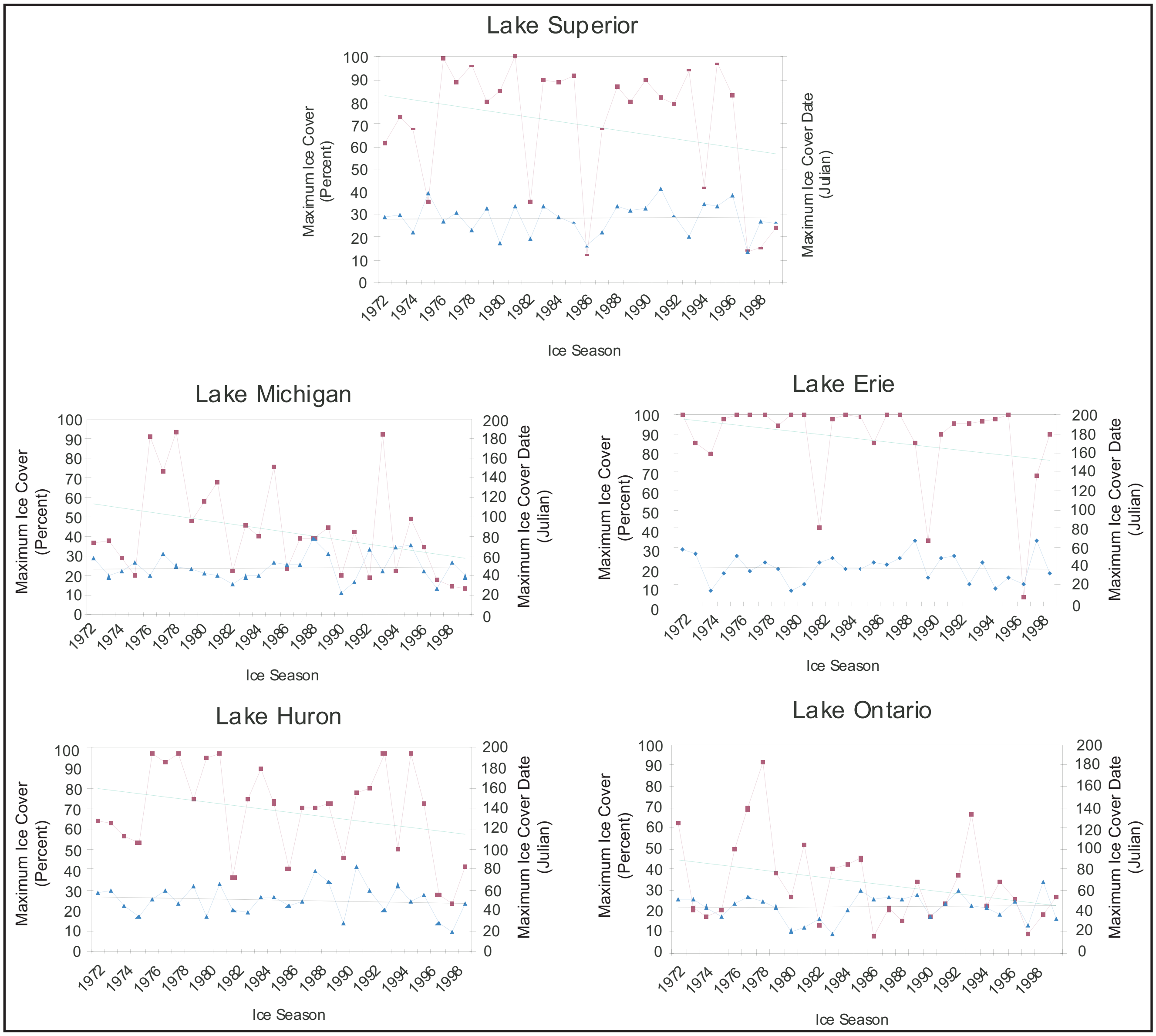

Figure 1. Trends of maximum ice cover and the corresponding date on the Great Lakes, 1972-2000.
The red line represents the percentage of maximum ice cover and the blue line represents the date of maximum ice cover.
Source: National Oceanic and Atmospheric Administration

any similarity to the results in the previous studies. Data from Lake Nipissing and Lake Ramsey were plotted (Figure 2) based on the complete freeze-over date (ice-on date) and the break-up date (ice-off date). The freeze-up date for Lake Nipissing appears to have the same trend as the other global inland lakes: freezing over later in the year. Lake Ramsey however, seems to be freezing over earlier in the season. The ice-off date for both however, appear to be increasing, or occurring at later dates in the year. These results contradict what is said to be occurring with other such lakes in the northern hemisphere (see Magnuson *et al.* 2000).

The satellite data used in this analysis can be supplemented by on-the-ground citizen-collected data. The IceWatch program of Environment Canada's Ecological Monitoring and Assessment Network and Nature Canada have citizen scientists collecting ice-on and ice-off dates of lakes throughout the Ontario portion of the Great Lakes basin. These volunteers use the same criteria for ice-on and ice-off as does the satellite data, although the volunteers only collect data for the portion of the lake that is visible from a single vantage point on the shore. The IceWatch program began in 2000 as a continuation of a program run by the Meteorological Service of Canada. Data from this program date back to the 1850s. An analysis of data from this database and the Canadian

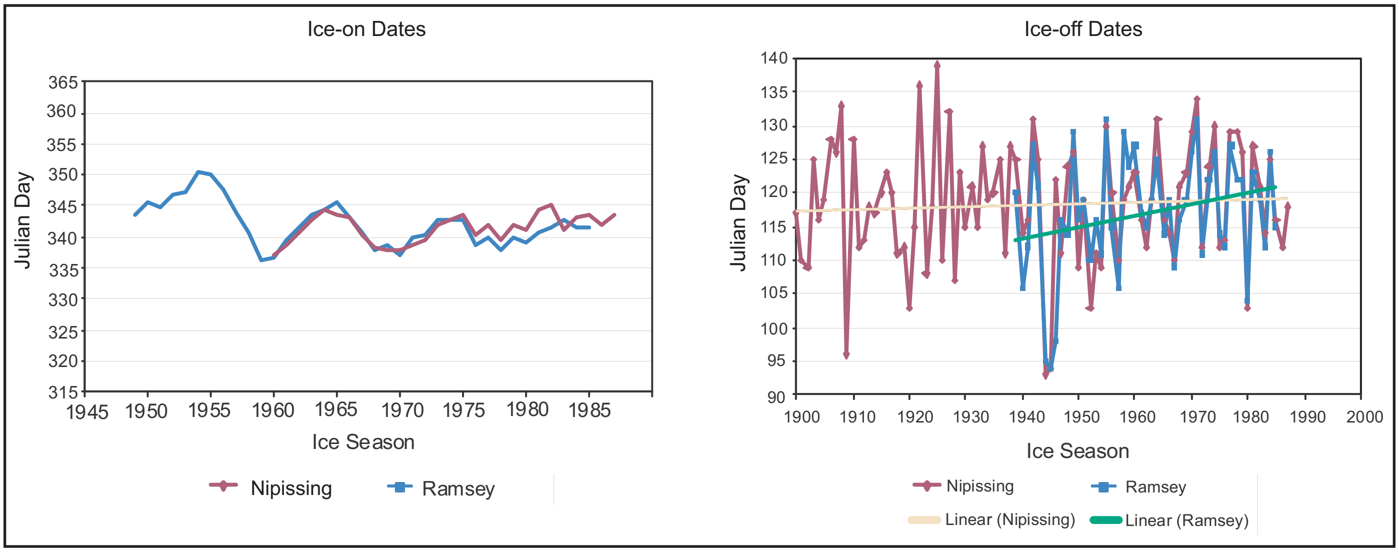

Figure 2. Ice-on and ice-off dates for Lake Nipissing (red line) and Lake Ramsey (blue line). Data were smoothed using a 5-year moving average.
Source: Climate and Atmospheric Research and Environment Canada

Ice Database (Canadian Ice Services/Meteorological Service of Canada) showed that ice break-up dates were occurring approximately one day earlier every seven years between 1950 and 2004 for 341 lakes across Canada (Futter *et al*. 2006). The data from IceWatch are not as comprehensive as the satellite-collected data, but they do show some trends in the Great Lakes basin. From two sites with almost 100 years of data, Lake Nipissing is shown to be thawing later in the season (Figure 3). IceWatch data from near Lake Ramsay indicate that lakes have been freezing later over the past thirty years.

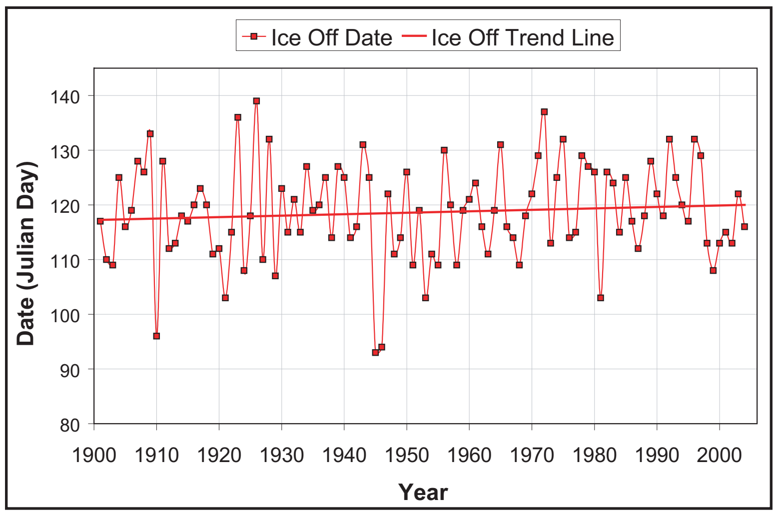

Figure 3. Ice-off dates and trend line from 1900-2000 on Lake Nipising.
Source: Ecological and Monitoring Assessment Network (EMAN)

Pressures

Based on the results of Figure 1 and Table 1, it seems that ice formation on the Great Lakes should continue to decrease in total cover if the predictions on global atmospheric warming are true. Milder winters will have a drastic effect on how much of the lakes are covered in ice, which in turn, will have an effect on many aquatic and terrestrial ecosystems that rely on lake ice for protection and food acquisition.

Management Implications

Only a small number of data sets were collected and analyzed for this study, so this report is not conclusive. To reach a level of significance that would be considered acceptable, more data on lake ice formation would have to be gathered. While the data for the Great Lakes is easily obtained from 1972 through the present, smaller inland lakes, which may be affected by climate change at a faster rate, should be examined. As much historical information as is available should be obtained. This data could come from IceWatch observers and the IceWatch database from throughout the Great Lakes basin. The more data that are received will increase the statistical significance of the results.

Comments from the author(s)

Increased winter and summer air temperatures appear to be the greatest influence on ice formation. Currently there are global protocols, which are being introduced in order to reduce the emission of greenhouse gases.

It would be convenient for the results to be reported every four to five years (at least for the Great Lakes), and quite possibly a shorter time span for any new inland lake information. It may also be feasible to subdivide the Great Lakes into bays and inlets, etc., in order to get an understanding of what is occurring in nearshore environments.

Acknowledgments
Author:
Gregg Ferris, Environment Canada Intern, Downsview, ON.

Updated by:
Heather Andrachuk, Environment Canada, Ecological Monitoring and Assessment Network (EMAN); Heather.Andrachuk@ec.gc.ca.

All data analyzed and charts created by the author.

Sources

Futter, M., Buckland, B., Kilvert, E., and Andrachuk, H. 2006. Earlier break-up dates of lake ice: an indicator of climate change in Canada. submitted to *Canadian Journal of Fisheries and Aquatic Sciences*.

Magnuson, J.J., Robertson, D.M., Benson, B.J., Wynne, R.H., Livingston, D.M., Arai, T., Assel, R.A., Barry, R.G., Carad, V., Kuusisto, E., Granin, N.G., Prowse, T.D., Stewart, K.M., and Vuglinski, V.S. 2000. Historical trends in lake and river ice covering the Northern Hemisphere. *Science* 289(9):1743-1746.

Ice charts obtained from the National Oceanic and Atmospheric Administration (NOAA) and the Canadian Ice Service (CIS).

Data for Lake Nipissing and Lake Ramsey obtained from Walter Skinner, Climate and Atmospheric Research, Environment Canada-Ontario Region.

Last Updated
State of the Great Lakes 2007