

Long-term Trends in Laurentian Great Lakes Ice Cover

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**Introduction.** The purpose of this report is to give a brief overview of nearshore and lake wide trends in Great Lakes ice cover over the past one-to-two centuries, to describe the contemporary seasonal and spatial progression of ice cover on the Great Lakes, and to provide an indication of potential change in Great lakes ice cover under various general circulation model global warming scenarios. This report is a contribution to the *Regional Analysis of Laurentian Great Lakes and Precambrian Shield* paper that is being written as part of the *Symposium on Regional Assessment of Freshwater Ecosystems and Climate Change in North America Symposium* (October 24-26, 1994, Leesburg, VA). That symposium was organized by the American Society of Limnology and Oceanography and the North American Benthological Society and sponsored by the U.S. Environmental Protection Agency and the U.S. Geological Survey.

**Nearshore Trends.** Freeze-up and ice-loss dates for bays of the Laurentian Great Lakes of Northern America and for inland lakes in that region correlate with autumn and winter air temperatures. Assel and Robertson (in press) show that a 1.5 degree C rise in late-autumn-to-mid-winter air temperature and about a 2.5 degree C rise in mid-winter-to-early spring temperatures between 1851 and 1993 are associated with approximately a 10 day retreat (later) in average freeze-up dates and about a 17-day advance (earlier) in average ice-loss date, respectively. The sensitivity of both freeze-up and break-up for sites with long-term records in the Great Lakes averages approximately 7 days per degree C. Analysis of the long-term trends in lake-ice freeze-up and break-up were made using 10-year moving averages, cumulative z-scores, and Auto-Regressive Integrated Moving-Averages to identify changes in mean ice cover date since 1851 at Grand Traverse Bay and Lake Mendota. Average freeze-up dates became 8-12 days later and average ice-loss dates became 7-11 days earlier from the 1850s to 1890, marking the end of the Little Ice Age around 1850 (Assel et al., in press). Average freeze-up date remained relatively steady after 1890, but average ice-loss dates again shift toward earlier dates, between 1940 and 1993 at Grand Traverse Bay (8 days earlier) and between 1980 and 1993 at Lake Mendota (7 days earlier). The timing of freeze-up and break-up at the two locations represents an integration of air temperatures over slightly different seasons (months). Thus, the second shift to earlier ice-loss dates at Grand Traverse Bay is associated with a trend toward warmer spring temperatures starting in the 1940s and 1950s (Hanson et al., 1992, Skinner, 1993) and the second shift in Lake Mendota's average ice-loss dates is associated with a warming of average January through March

Great Lakes, winters without freeze-up will occur at small inland lakes in the region, and the duration of the ice cover will decrease as freeze-up dates become later and ice-loss dates become earlier. Winter lake evaporation will increase due to the decreased ice cover. Global warming effects on lake ecosystems in the Great Lakes may be similar to those described by Schindler et al., (1990) for inland lakes in northwestern Ontario. Potential effects of reduced ice cover for shore areas of the Great Lakes (Assel and Robertson, in press) include: greater over-winter mortality of whitefish eggs (and thus potentially lower year class size) and lower diatom production, both due to loss of the stable environment afforded by formation of a continuous ice cover.

### Acknowledgements

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Table 1. Seasonal Maximal Ice Cover\*

Lake:	Superior	Michigan	Huron	Erie	Ontario
Winter					
1979	99	99	99	99	95
1983	21	17	36	25	10
Normal**	75	45	68	90	24

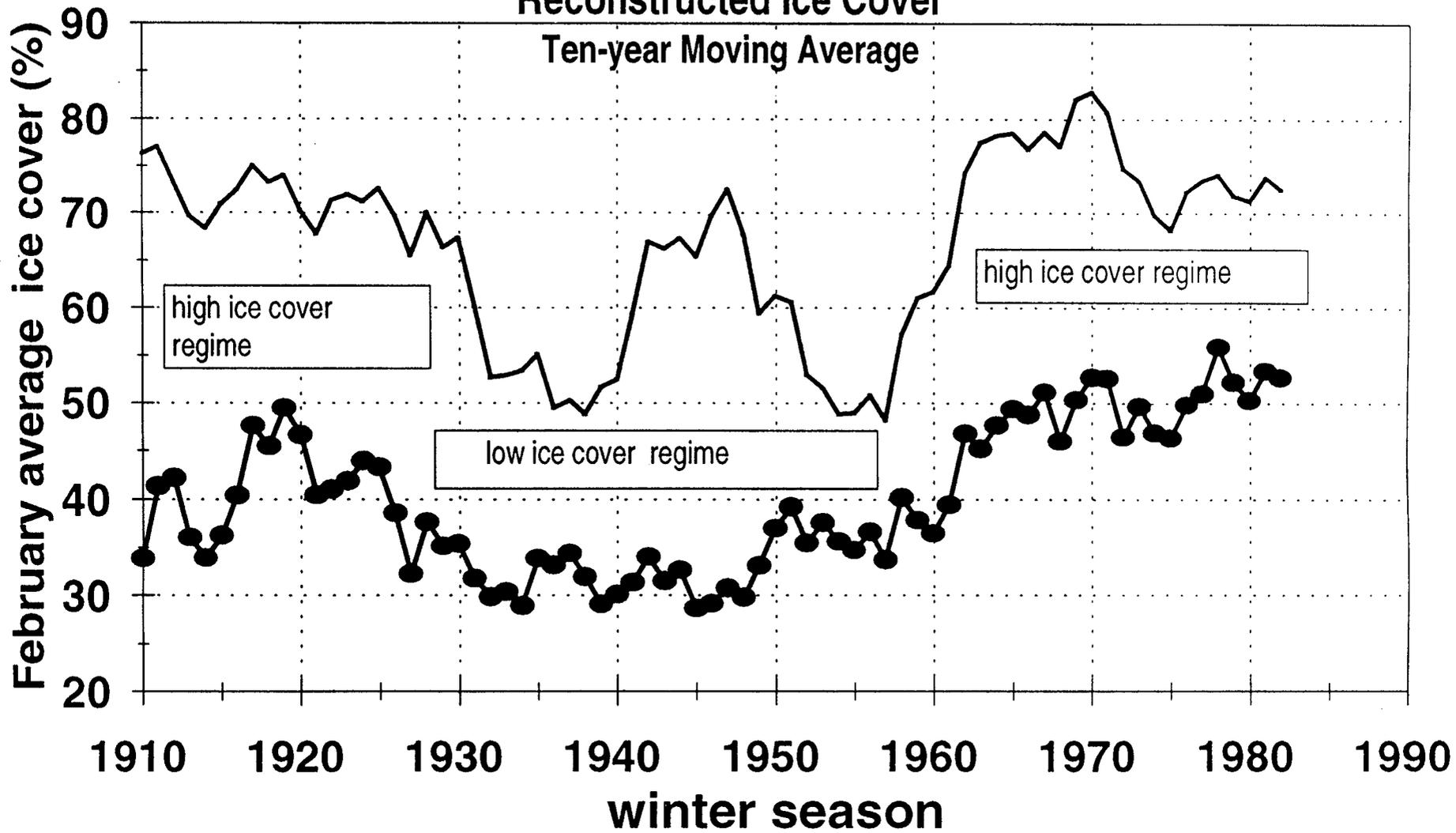
\* Percentage of lake surface covered by ice

\*\* From Assel et al, (1983)

### References

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# Reconstructed Ice Cover Ten-year Moving Average



● Lake Superior — Lake Erie