Response of Yellow Perch in Adirondack Lakes to Changes in Atmospheric Deposition of Mercury and Strong Acids

Jason A. Dittman[1], Charles T. Driscoll[1]

[1]Syracuse University, Department of Civil and Environmental Engineering, Syracuse, New York, USA

Introduction

The Adirondack region of New York has been heavily impacted by acidic deposition, however recent controls in emissions of SO_2 have resulted in decreases in precipitation and surface water SO_4^{2-}, and improvements in the acid-base status of some lakes. In addition, decreases in atmospheric Hg deposition have occurred largely due to controls on medical waste incinerators and municipal waste combustors (Fig 1). In 1992-1993 a survey of 25 lakes in the Adirondacks was conducted to analyze patterns of water column and fish Hg concentrations (Fig 2). This same set of 25 lakes were resurveyed in 2005-2006 to evaluate if changes in lake concentrations of Hg species or fish Hg have occurred in response to changes in atmospheric deposition of Hg and strong acids.

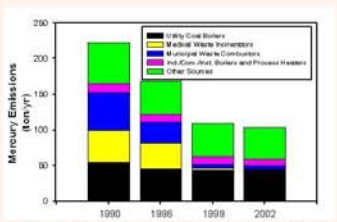

Figure 1. Anthropogenic U.S. mercury emissions. Source: www.epa.gov/mercury.com

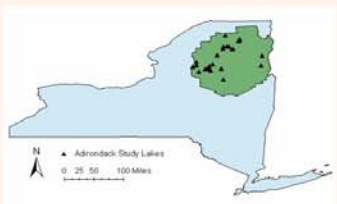

Figure 2. Map of Adirondack region of New York showing the 25 lake survey sites.

Study Objectives

1. Evaluate changes in water column and fish mercury concentrations from 1992-2006.
2. Evaluate potential mechanisms contributing to observed changes from 1992-2006.
3. Compare water column and fish Hg concentrations across a gradient of lakes in the Adirondacks.

Methods

The 25 lakes in this survey were selected to represent diverse watershed and geochemical characteristics that exhibit a range of lake and fish Hg concentrations. The yellow perch (*Perca flavescens*) was selected as an index species because it is widely distributed throughout lakes in the Northeast U.S. The resurvey was conducted in the late summer/early fall of 2005 and 2006.

Yellow Perch (*Perca flavescens*)

Water Chemistry

- Water column samples were taken using US EPA clean techniques and measured for Hg, CH_3Hg, and ancillary parameters.

Fish

- Fish were captured using variable-mesh experimental gill nets and Alaska-style net traps.
- Length & weight measurements were obtained from each selected fish.
- Scale samples and opercular bones were removed for age and growth analysis.

Fish Sampling at Sand Pond

- 60 yellow perch (*Perca flavescens*) from each lake, representative of the age distribution, were selected for tissue sampling.
- Fish tissue plugs were analyzed in duplicate using a Milestone DMA analyzer.

Results – Water Chemistry

Changes in water chemistry parameters varied by the lake surveyed. However, in general of the 25 lakes resurveyed, pH and ANC levels were greater and SO_4^{2-} were lower in 2005-06 than in 1992-93 (Fig. 3), while both total Hg and methyl Hg levels have decreased in almost all of the lakes. This preliminary data suggests that lakes have responded to decreases in SO_2 and Hg emissions over the past decade.

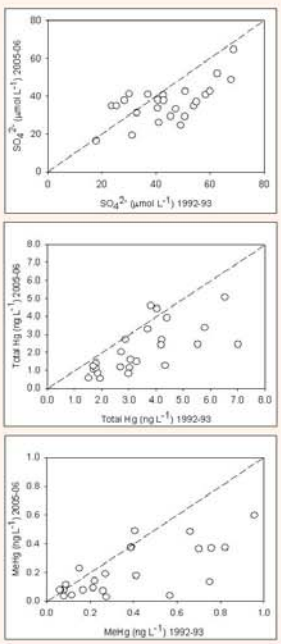

Figure 3. Water chemistry comparison for Adirondack Lakes originally surveyed in 1992-93 and then resurveyed in 2005-06. The dashed line represents a 1:1line.

Results – Fish

Similar to changes in water chemistry parameters, levels of Hg in fish tissue varied by the lake surveyed. For example, in Rainbow Lake (Fig. 4) fish Hg decreased in all age classes from 1992-93 to 2005-06 while other lakes, such as Oregon Pond (Fig. 5), Hg declined in earlier age classes and increased in older age class perch. In general though, preliminary data for length adjusted mean fish Hg concentrations show a significant decrease ($p < 0.05$) for 12 lakes, 6 lakes with increased fish Hg, and 7 lakes with no change in fish Hg (Fig. 6).

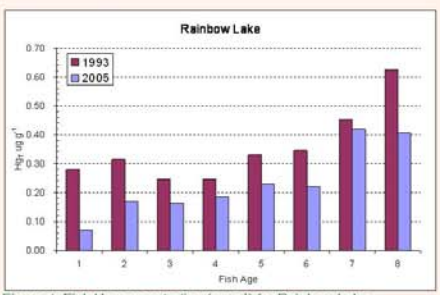

Figure 4. Fish Hg concentration (ug g^{-1}) for Rainbow Lake.

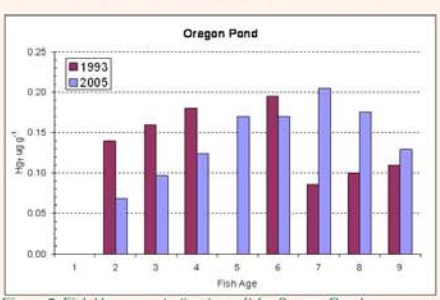

Figure 5. Fish Hg concentration (ug g^{-1}) for Oregon Pond.

Summary

- The acid-base status of the 25 lakes resurveyed in this study appear to have improved over the past decade.
- The concentration of Hg in fish tissue has declined in 12 lakes since 1992-93. The degree of change in Hg in fish tissue is dependent upon the lake, which is likely due to specific geochemical characteristics.
- The average concentration of Hg in perch for the 25 lakes show an increase in fish Hg with age for both the 1992-93 and 2005-06 survey, with Hg levels quickly exceeding the 0.3 ug g^{-1} US EPA action limit by age two (Fig. 7).
- A better picture of the actual response of fish in the Adirondacks to declines in Hg and strong acid deposition will be gained by further investigation into the factors controlling the recovery of Hg contaminated fisheries.

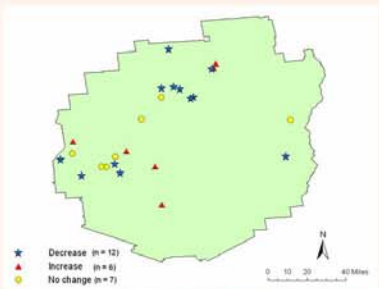

Figure 6. Map of the 25 Adirondack study lakes showing change in length adjusted mean fish Hg concentrations from 1992-93 to 2005-06.

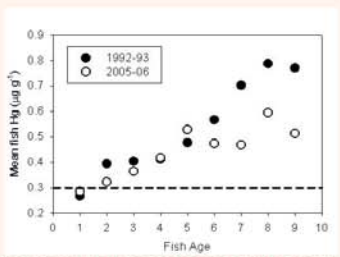

Figure 7. Mean Fish Hg concentration (ug g^{-1}) by age class for the 25 lakes analyzed in 1992-93 and 2005-06. The dashed line represents the US EPA action limit for fish Hg of 0.3 ug g^{-1}.

Future Work

- From the results of the 25 lake survey, 6 lakes will be chosen for detailed field measurements.
- Using the data from these 6 lakes, the Mercury Cycling Model for Headwater Drainage Lakes (MCM-HD) will be applied to better understand the response of fish Hg to changes in atmospheric Hg and acidic deposition across the Adirondacks.

Acknowledgments

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For further information

Please contact: Jason Dittman, *jadittma@syr.edu*.

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