

## Mercury in Adirondack Wetlands, Lakes and Terrestrial Systems

### Principal Researcher

**RONALD MUNSON**  
Tetra Tech, Inc.

**CHARLES DRISCOLL**  
Department of Civil and Environmental Engineering, Syracuse University

### Project Location



Adirondacks and Catskills outlined.

### Contact Information

For more information on this project see:  
[www.nysERDA.org/programs/environment/emep](http://www.nysERDA.org/programs/environment/emep)

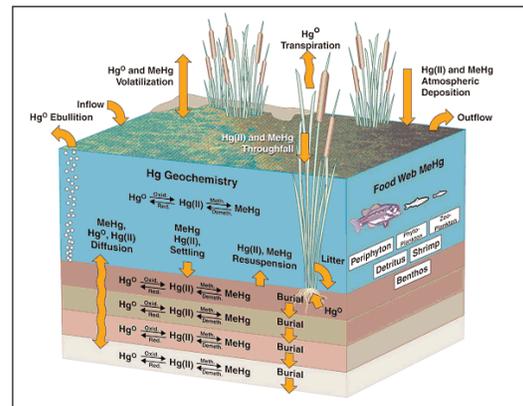
or contact Mark Watson at:  
[mw1@nysERDA.org](mailto:mw1@nysERDA.org)

### Keywords

- Bioaccumulation
- Biomagnification
- Drainage lake
- Mercury cycling
- Methylmercury
- Watershed hydrology

### PROJECT FOCUS

Few studies conducted to date have investigated mercury cycling in temperate drainage lake-watershed systems, which constitute 85% of Adirondack lakes. This project is the most comprehensive assessment to date of watershed mercury (Hg) cycling in the Northeast. Beginning with a full chemical and hydrological characterization of a representative lake-watershed system (Sunday Lake) and an analysis of mercury concentrations in fish, the project team has developed an integrated simulation model (MAWLTS) that accounts for terrestrial, wetland, and in-lake processes influencing mercury cycling and accumulation in fish tissue.



The geochemistry of mercury's interaction with the environment

### CONTEXT

Mercury, a naturally occurring element, cycles in the environment as a result of both natural and human activities. Major anthropogenic sources of mercury emissions are the combustion of mercury-containing fuels or materials, such as coal, in the production of electricity and in industrial processes. Mercury is deposited in water and on land, where humans and wildlife may be exposed to it. As it accumulates in exposed organisms (bioaccumulation), mercury also poses a danger to organisms higher up in the food chain (biomagnification), even at low exposures. An issue of particular concern for human health is the accumulation of mercury in the form of highly toxic methylmercury (MeHg) in fish muscle tissue, which is then eaten (and accumulated) by human beings. When its concentrations reach high enough levels, MeHg acts as a neurotoxin, impairing neurological development in fetuses and young children and damaging the central nervous system of adults. In response to these pronounced dangers, 45 states have issued fish consumption advisories, and the U.S. Food and Drug Administration has established a federal action level for fish containing 1.0 micrograms of mercury per gram (i.e., 1.0 ppm) of wet weight. Fish with higher mercury concentrations are considered to be hazardous and are banned from interstate commerce.

The Adirondack region of New York State, which is "remote" from point sources of mercury, is considered to be an area of concern by the New York State Department of Environmental Conservation (NYSDEC), owing to elevated mercury levels found in fish. Atmospheric deposition is the major source of mercury to lake-watershed systems in the region. Mercury cycling in drainage lake-watershed systems involves the interactions of a variety of complex processes. Previous research has indicated that, in these systems, terrestrial and wetland processes play a vital role in determining aqueous chemical characteristics and fish tissue mercury concentrations. Several correlations have been found between mercury concentrations in fish and water-quality parameters, such as pH, dissolved organic carbon (DOC), and calcium. Particularly important for the Adirondacks region, which has been subject to acidification, is the relationship observed in surface waters worldwide between high mercury concentrations in fish and low aqueous pH. A relationship has also been found between increasing concentrations of DOC and percentage of wetlands in the drainage basin.

### METHODOLOGY

The analysis of mercury in drainage lake-watershed systems included the hydrological and chemical characterization of Sunday Lake, to determine water inputs/outputs and flowpaths and to track mercury movement and transformations. Water samples were analyzed for total mercury, MeHg, major anions and cations, pH, ANC, DOC, dissolved inorganic carbon, and aluminum. Mercury concentrations in litterfall and through-fall (dry deposition) and mercury concentrations in zooplankton (indicating mercury concentrations moving up the food chain) were also analyzed. As several mercury transformation rates are dependent on the concentrations of other aqueous constituents, pH, ANC, and various chemicals were measured.

# PROJECT UPDATE

August 2005



*Sunday Lake*  
Photograph by: Robert Newton

## Project Status

- Initiated 1999
- Project ongoing



Since 1975, the New York State Energy Research and Development Authority (NYSERDA) has developed and implemented innovative products and processes to enhance the State's energy efficiency, economic growth, and environmental protection. One of NYSEDA's key efforts, the Environmental Monitoring, Evaluation, and Protection (EMEP) Program, supports energy-related environmental research. The EMEP Program is funded by a System Benefits Charge (SBC) collected by the State's investor-owned utilities. NYSEDA administers the SBC program under an agreement with the Public Service Commission.

An integrated model (MAWLTS), calibrated based on the Sunday Lake data, was produced to simulate the terrestrial, wetland, and in-lake processes that influence the levels of Hg in fish tissue. The model integrates all available information into a single, coherent framework, which can be used to assess impacts of potential regulatory options on mercury behavior in drainage lake systems.

The project also included the following components:

- Establishment of a mercury deposition monitoring station at Biscuit Brook in the Catskills. This station, part of the National Atmospheric Deposition Network/Mercury Deposition Network (NADP/MDN), will help broaden understanding of mercury deposition across NYS.
- Surveys of water and fish mercury concentrations in the Catskills to assist evaluation of high fish mercury concentrations in reservoirs that supply drinking water to New York City. Three regional surveys of mercury concentrations in water and sediment in the Neversink and adjacent watersheds, as well as a one-time sampling and analysis of fish for tissue mercury concentrations at ~20 locations in Catskills reservoirs, were conducted.
- A modeling study to evaluate the relative impacts of changes in acidic deposition versus changes in mercury deposition and fish mercury concentrations.



Dr. Robert Newton of Smith College makes streamflow measurements in the outlet stream from Sunday Lake during high-flow conditions.  
Photograph by: Ron Munson, Tetra Tech, Inc.

## RECENT FINDINGS

- Calculations during the analysis of Sunday Lake indicated that dry deposition, which is not currently being measured, may be an important mercury input to the watershed.
- Preliminary calibration of the model shows that simulated and observed values match well, except for a slight deviation during the summer. The model accurately simulates the dynamic range of total mercury concentrations, but the timing of the summer maximum concentration is slightly off. For MeHg, the simulated concentrations match the general pattern of observations, but the range of observed concentrations is slightly greater than the simulated range.
- Based on the preliminary calibration, a scenario analysis was conducted to determine the response of total and MeHg concentrations to a 50% reduction in atmospheric mercury deposition. The response is a nearly linear decline in fish mercury concentrations over the five-year simulation period.



Dr. Robert Newton of Smith College downloads hydrologic data from the outlet of Sunday Lake.  
Photograph by: Ron Munson, Tetra Tech, Inc.

## PROJECT IMPLICATIONS

Models such as MAWLTS, verified through data from environmental monitoring, are a vital tool for policy-makers in assessing the processes and timescales of effects on fish mercury concentrations of changes in emission, deposition, water chemistry, and watershed hydrology. Since studies have indicated a relationship between decreased pH levels in lakes and elevated mercury concentrations in fish, a prevailing regulatory question facing federal and state policymakers is how decreased sulfur and nitrogen emissions, which would reduce acidification, would impact fish mercury concentrations, in comparison with direct decreases in mercury emissions. The MAWLTS model will be used to conduct a rigorous scenario/sensitivity analysis to provide answers to such questions.

Further analyses through this project will contribute to the development of regulations for mercury and related pollutants that adequately protect human health and the environment. Mercury-related health advisories issued by the NYS Department of Environmental Conservation for all lakes in the Adirondacks reflect the additional negative economic impact of elevated mercury concentrations in fish, which affects recreational fishing and tourism in the region. The optimal effectiveness of the regulatory regimes developed at the state and federal levels for the Adirondacks will require better knowledge of mercury cycling and accumulation in drainage lake systems.