



Toxic Substances and Areas of Concern Projects for the Great Lakes Restoration Initiative

The Great Lakes Restoration Initiative (GLRI) is an interagency program that addresses the most significant environmental problems in the Great Lakes ecosystem. Results from U.S. Geological Survey (USGS) scientific studies and monitoring are helping guide the restoration effort. The GLRI is made up of five focus areas that address these issues:

- Cleaning up toxic substances and areas of concern
- Combating invasive species
- Promoting nearshore health by protecting watersheds from polluted runoff
- Restoring wetlands and other habitats
- Tracking progress and working strategically with partners

USGS project results are presented here for the toxic substance and areas of concern focus area. More information is available on the USGS GLRI Web page (<http://cida.usgs.gov/glri/>).

Mercury Cycling and Bioaccumulation in the Great Lakes



As of 2006, mercury was responsible for 80 percent, or 3,080, of the fish consumption advisories posted in the United States. USGS scientists are conducting sampling surveys in the Great Lakes and establishing the relations between the various chemical forms of mercury and their concentrations in the water column and key positions in the food web. Information is needed to

determine whether significant environmental regulations will have the desired impact on Great Lakes food webs and what the expected timing for the response may be.

Results include the following:

- Completed three basin-wide sampling events across the entire Great Lakes Basin to collect samples of the water column, bottom sediments, benthic fauna, and zooplankton at about 80 sites during each event. Data revealed a previously unknown methyl mercury source that likely is the dominant source leading to elevated concentrations throughout the Great Lakes.
- Began writing up results to publish in scientific journals.
- Made numerous presentations to stakeholders and partner agencies.

Baseline and Sources of Toxic Contaminant Loadings

USGS is conducting new water quality analyses for toxic substances and estimating the amount (load) of these substances flowing down stream tributaries to the Great Lakes. Information on the occurrence and distribution of contaminants is needed to provide baseline information, measure progress towards restoration goals, and assess new threats. This information will provide an understanding of how contaminants reach the Great Lakes, and where they come from, so that the effects of future actions can be assessed and predicted.

Results include the following:

- Samples of bed sediment, water, and from passive sampling devices were collected at 59 stream sites to establish current conditions and to provide a baseline for comparing restoration outcomes. Sediment and water samples were analyzed for both historical and emerging contaminants (chemical and microbial constituents not historically considered contaminants).
- Ongoing sampling at 17 monitoring sites is providing information about the distribution of emerging contaminants and changes over time and will provide sufficient information to calculate loads.
- During storm events and lowflow periods, virus samples were also collected at eight of the sites.

Birds as Indicators of Contaminant Exposure in the Great Lakes

The USGS is determining the level of exposure and effects of historical and emerging contaminants on Great Lakes food chains by examining tree swallows and colonial waterbirds, such as herons and cormorants. Birds are ideal sentinel indicators because of their sensitivity to the presence and changes in chemical concentrations in the environment. This project is identifying the significant sources and impacts of emerging toxins such as chemicals that resist sticking and stains (perfluorinated chemicals or PFCs) and flame retardants (polybrominated diphenyl ethers or PBDEs) to the Great Lakes ecosystem through surveillance and lab and field research. It also expands our understanding of environmental distribution and the effects of little-studied legacy contaminants, such as polychlorinated biphenyls (PCBs), mercury, dioxins, and furans. The USGS is measuring progress in cleaning up toxics and, through monitoring, will help determine whether restoration efforts are producing the desired result.



Results include the following:

- Baseline contaminant information was collected from all five of the Great Lakes at a total of 32 sites, and samples were analyzed for legacy and emerging contaminants.
- At each active nest box in the 32 sites, 14 independent measures of exposure and effects for legacy contaminants and new and emerging contaminants are being measured, including genetic damage to population-level effects on reproduction.
- A Web page was established to present preliminary results, http://www.umesc.usgs.gov/wildlife_toxicology/glri_project80.html.

Methods for Conducting Whole-Sediment Toxicity Tests with Freshwater Invertebrates

Since 2004, the USGS has provided research support for contaminated sediment assessment and remediation as part of the Great Lakes Legacy Act and is continuing these activities as part of the Great Lakes Restoration Initiative. This project will assist the Great Lakes National Program Office in evaluating the relationship between sediment contamination and adverse biological effects at selected sites(s) and preparing for sediment remediation. It also critically evaluates and refines standard methods for conducting whole-sediment toxicity tests with freshwater invertebrates.

Results include the following:

- Based on existing U.S. Environmental Protection Agency (USEPA) and American Society for Testing and Materials (ASTM) methods, a guidance document was written for labs seeking to demonstrate their ability to conduct whole-sediment toxicity tests with freshwater invertebrates.
- Highly contaminated field-collected sediment was diluted in various proportions to conduct:
 - acute toxicity tests with a midge (a gnat-like fly) and an amphipod (a shrimp-like crustacean)
 - chronic reproductive tests with midge and amphipods
 - chronic toxicity tests with freshwater mussels



Toxicity Studies

The USGS is working on a series of projects focused on toxicity studies to develop and standardize test methods for assessing the sensitivity of aquatic organisms to toxic contaminants that will assist USEPA, states, and tribes in the establishment of water quality criteria for the protection of these aquatic organisms under the Clean Water Act. The individual USGS projects are described on this page.

Determination of the Appropriate Duration of Toxicity Tests with Native Freshwater Mussels

Through toxicity tests using glochidia, the larval stage of native freshwater mussels, the USGS is helping resolve questions about the ecological relevance of the glochidia test method—appropriate duration and results of the tests. This will inform USEPA about the role of glochidia in the development of criteria protective of mussels.



Results include the following:

- Completed comparison of glochidia viability and infectivity for four mussel species representing the major glochidia infection strategies.
- Conducted and completed initial trials to determine probability of infectivity with and without sediment.
- Completed initial trials to compare infectivity when viability is reduced by energy depletion and when viability is reduced by toxicant exposure.

Conditions Used to Culture or Conduct Toxicity Tests with the Amphipod *Hyaella azteca*

The USGS is developing a standard test method for the amphipoda *Hyaella azteca*, a shrimp-like crustacean. The project is designed to help resolve questions about the appropriate test culturing conditions for the amphipod—the test water, food-substrate combinations, and sensitivity of brood stocks to test water.



Results include the following:

- Completed two of three studies evaluating various reconstituted waters in 42-day reproductive studies with the amphipods.
- Demonstrated that the addition of bromide, but not iodide, at environmentally relevant concentrations improved amphipod survival, growth, and reproduction.
- Established that increasing food ration improved performance of the amphipod.

Chronic Toxicity Data for Sulfate

The USGS is collecting the data needed to determine the relative risk of toxicity from chronic exposures to sulfate in the early life stages of fish, mussels, cladocera (water fleas), and midge that will be used by Great Lakes States and Tribes to develop or refine standards for sulfate to protect aquatic life.

Results include the following:

- Completed all toxicity testing.
- For the four tested species, preliminary analyses indicate:
 - the acute LC50s ranged from about 1,000 to 10,000 milligrams sulfate per liter (mg SO₄/L) (LC50 or Lethal Concentration 50 is the concentration of a substance required to cause death in 50 percent of the test organisms in a specified time period)
 - the chronic EC20s ranged from about 100 to 1,000 mg SO₄/L (EC20 or Effective Concentration 20 is the concentration of a substance that has a specified non-lethal effect on 20 percent of the test organisms within a specified time period)
- Dissolved sulfate has chronic effects on fish and mussels at concentrations below the draft Canadian water quality guideline of 644 mg SO₄/L.
- Data and results were summarized in a memo to USEPA.



Sediment Toxicity Test Method with Freshwater Mussels to Assess Sediment Contaminants

USGS is developing and demonstrating a sediment toxicity test method with native freshwater mussels that may lead to an American Society for Testing and Materials (ASTM) standard guide for conducting whole-sediment toxicity tests with juvenile mussels. Results of this project can be used in inter-laboratory testing of sediments with mussels by multiple laboratories.

Results include the following:

- Procedures were developed to evaluate the behavior of various life stages of juvenile mussels in sediment to determine exposure differences in sediment, in water, and at the sediment/water interface.
- Published results of acute and chronic ammonia toxicity testing with mussels exposed with and without the presence of sediment.

Sensitivity of Two Frog Species to the Toxicity of Nitrate, Nitrite, Ammonia, Chlorides, and Sulfate



The USGS is testing the relative sensitivity of frogs to acute and chronic levels of nitrate, nitrite, ammonia, chlorides and sulfate. The test results are used to evaluate the current ammonia and



and chloride criteria and could be used in the development of water-quality criteria for nitrite, nitrate, and sulfate to protect amphibians and other aquatic life.

Results include the following:

- Completed acute toxicity tests of all chemicals with gray tree frogs and wood frogs, which were found to be highly tolerant.
- Ammonia, nitrate, and nitrite chronic toxicity tests with gray tree frogs and chronic ammonia toxicity tests with wood frogs were completed and they were found to be highly tolerant.
- Multi-stage exposures reveal that gray tree frog tadpoles are much more tolerant of sulfate and chloride exposures than are embryos and hatchlings.

Contaminants of Emerging Concern in the Great Lakes Basin: Modes of Action and Reproductive Effects in Freshwater Mussels

The USGS is testing the toxicity of emerging contaminants, such as hormones and chemotherapy drugs, to freshwater mussels after long-term exposure in conditions that mimic their natural habitat. This project is identifying contaminants that may limit mussel survival, recruitment, and recovery and provide information needed to assess mussel sensitivity to emerging contaminants.

Results include the following:

- Conducted two 12-day toxicity tests with 22-month-old freshwater mussel males and females (with eggs). One test was for the emerging contaminant ethynyl estradiol (an oral contraceptive) and another with fadrazole (a drug used to treat ovarian and breast cancer).
- Gill samples were analyzed for breakdown products of chemicals tested. Significant differences in glycogen (molecule that stores energy) metabolism and increases in amino acids connected with egg production were found in the test mussels.
- Documented behavioral effects of ethynyl estradiol.



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