



Conclusions from Five Years of Chemical and Biological Effects Monitoring around the Great Lakes Basin

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Overview

Under Action Plan I (2010–2014) of the Great Lakes Restoration Initiative (GLRI), Federal and Academic partners investigated the presence and distribution of contaminants of emerging concern (CECs) in the Great Lakes and potential impacts on fish and wildlife.



Four overarching goals:

1. Evaluate the sources, occurrence, and distribution of CECs across the Great Lakes Basin.
2. Examine associations between the distribution of CECs and land-use patterns.
3. Review both literature and field generated data to determine the potential for CECs to cause adverse effects on Great Lakes fish and wildlife populations.
4. Develop efficient strategies to survey and/or monitor for threats that CECs may pose in order to take effective management actions before those threats evolve into large scale impacts on Great Lakes ecosystems or the services they provide.

Organization	Activities / Approaches
U.S. Geological Survey, Upper Midwest Water Science Center	Organic Contaminants, Microplastics, Waterborne Pathogens, and Host-Associated Bacteria Surveillance and Potential Biological Effects in Great Lakes Tributaries
NOAA National Centers for Coastal Ocean Science	Monitoring of Contaminants of Emerging Concern by Great Lakes Mussel Watch
U.S. Geological Survey, Upper Midwest Environmental Sciences Center	Exposure and Effects of Bioaccumulative Contaminants of Emerging Concern in Tree Swallows Nesting across the Laurentian Great Lakes
U.S. Fish and Wildlife Service, Ecological Services & St. Cloud State University	Survey of Contaminants of Emerging Concern and Their Effects to Fish and Wildlife in Great Lakes Tributaries
U.S. EPA, Mid-Continent Ecology Division	Methods for Detecting and Evaluating Biological Effects of Contaminants of Emerging Concern
U.S. Army Engineer Research and Development Center	Transcriptional Effects-Based Monitoring of Contaminants of Emerging Concern

The findings and conclusions in this poster are those of the authors and neither constitute, nor necessarily represent the official views of the federal Agencies engaged in the work. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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Key Results

Organic Contaminants

- Insecticides (60% of sites); PAHs (43%); herbicides (37%); flavors and fragrances (31%).
- Land cover was related to occurrence and conc for many compound classes.
- Metolachlor, atrazine, DEET > in summer; HHCB > in winter.

Microplastics

- Plastic particles found in 100% of samples (n=107).
- 71% were fibers; 17% fragments.
- Fragments, pellets, beads, foam positively correlated with urban land cover and population density.

Microorganisms

- Human and bovine fecal pollution in all 8 watersheds surveyed.
- Human viruses detected in 16% of samples; bovine viruses in 14%.
- Loads generally related to land-use; human (urban); bovine (ag).

Dressinid Mussels



- Dressinid mussels accumulated CECs, not just legacy contaminants.
- PAHs were ubiquitous.
- PBDEs present in all mussel samples; PBDE 47, 99, 154, 206 dominant.
- PPCPs: Amitriptyline, sertraline (anti-depr) and DEET most common.
- Alkylphenols(ethoxylates) – detected; 3 of 4 at all sites.
- Contaminant concentrations in harbors and tributaries greater than nearshore and offshore areas of the Great Lakes.

Tree Swallows

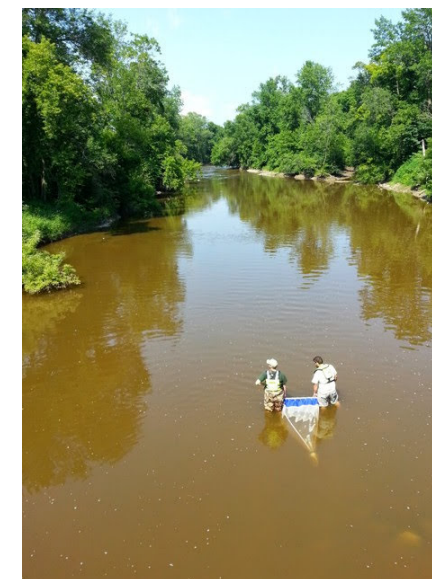


- One of the most extensive and exhaustive studies of both legacy and CECs in birds from such a large geographic area (100,000 sq. miles).
- PBDEs and PFASs not at exposure levels that affect reproduction or physiological responses in nesting birds.
- Reproductive success decreased as concentrations of PAHs in invertebrate food-base increased.

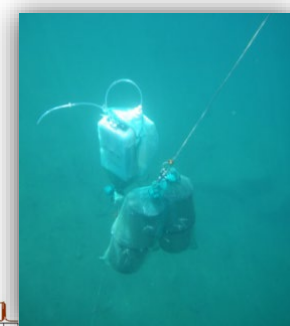
Resident and Caged Fish



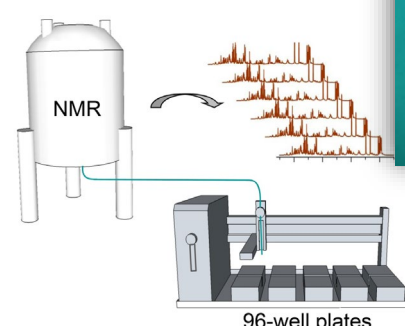
- Fish from AOCs had higher prevalence of skin tumors.
- Hazard screening values developed for 14 CECs.
- Resident and caged fish - greater blood glucose associated with higher CEC. presence and concentrations – particularly PAHs and pharmaceuticals.
- Presence of PAHs and pharmaceuticals explained most of the variation in blood glucose.
- Different patterns of biological response observed in different fish species.



Methods for Effects-based monitoring



- Time-integrated composite sampling device developed.
- Pilot application of Attagene multi-factorial; common bioactivities identified.
- Proof of concept for in vitro and mucus-based metabolomics analyses.
- Exposure-activity-ratios (EARs) developed as screening and prioritization tool.
- SeqAPASS tool, publicly available [<https://seqapass.epa.gov/seqapass/>].
- Little evidence for significant disruption of reproductive endocrine physiology.
 - Although exogenous conversion of estrone (E1) to 17β-estradiol (E2) was shown to result in elevated E2 in males.



Key Results Continued

Transcriptomics-based monitoring



- Adverse outcome pathway (AOP) framework was used to link altered gene expression to tumor formation, a beneficial use impairment (BUI) of concern in the Great Lakes.
- Based on a case study in the Maumee and Detroit River AOCs, PAHs had greatest co-variance with gene expression changes; fluoranthene exceeded hazard quotient and was associated with the greatest number of gen expression changes.
- Gene expression changes associated with steatosis AOP network were also detected.

Priority Chemicals

- Eleven chemicals exceeded water quality benchmarks.
 - Five PAHs (anthracene, benzo[a]pyrene, fluoranthene, phenanthrene, pyrene).
 - Nonylphenol.
 - Five pesticides (atrazine, metolachlor, pentachlorophenol, dichlorvos, carbaryl).
- Two pharmaceuticals (ibuprofen and venlafaxine) exceeded concentrations expected to be hazardous to fish.

PAHs are a contaminant class of particular concern:

- Widespread detection across the basin.
- Frequently exceed water quality benchmarks.
- Evidence for uptake into organisms (dressinid mussels, invertebrate food base).
- Association with reproductive failure in tree swallows.
- Responses in mussels and fish consistent with PAH exposure and effects.
- Relatively well studied, but there are on-going sources / new inputs to the Great Lakes basin.



High Level Conclusions

1. **CECs were found throughout the monitored Great Lakes tributaries but vary in association with regional land use.**
2. **There were over 20 contaminants for which concentrations detected at one or more field sites approached or exceeded those reported to cause toxicity in laboratory experiments.**
3. **Results suggest that concentrations of CECs presently found in Great Lakes tributaries are not overtly toxic to current communities of fish and wildlife but may, in combination with other stressors, reduce reproductive success and/or impair important ecosystem functions.**

Further Details

A summary report, access to data, interactive maps, and primary publications will be made available through <https://communities.geoplatform.gov/glri/>.

Additional monitoring and research are being conducted under GLRI action Plan II.