

Synthesis and Integration of Multimedia Measurements of Mercury in the Great Lakes Region



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Jim Wiener, University of Wisconsin



Overall Project Description

- The Great Lakes Mercury Project, funded by the Great Lakes Commission (GLC), is a community-derived scientific effort that gathers mercury data, develops important informational products, and answers key scientific questions regarding mercury cycling in the Great Lakes region:
 - Ontario, New York, Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota and all Great Lakes.
 - 172 Scientists
 - Co-Pis: David Evers and Jim Wiener
 - Key Personnel: Kate Williams

Tangible outcomes of the project will include

1. Searchable database
2. Two journal issues with about 45 peer-reviewed papers applying the compiled data to key Hg-related questions for the Great Lakes region.
3. A policy and management relevant communications document

These papers will emphasize:

- (1) Mercury exposure and effects in sport fish and wildlife,
- (2) Spatial gradients of mercury including the identification of biological mercury hotspots,
- (3) Temporal trends of mercury, and
- (4) Discussion of past and future policies concerning mercury in the Great Lakes region.

In addition, the proposed project will lay the groundwork for further efforts, including development and testing of models, tracking of trends, and linkages to the environmental policy community and decision-makers.

Timetable for the final year of the Great Lakes Mercury Project

July 13-15, 2010	Second Great Lakes Mercury Workshop is held at the University of Michigan in Ann Arbor
July 16-October 29, 2010	Draft manuscripts are finished and undergo informal review by coauthors and workgroup members (and are processed for agency internal review & approval, if required)
November 3, 2010	Electronic manuscripts submitted to David Evers and James Wiener, who will manage the peer-review process, working with Niladri Basu and Drew Bodaly as guest editors for <i>Ecotoxicology</i> and Heather Morrison and David Gay for <i>Environmental Pollution</i>
December 30, 2010	Guest editors provide manuscript reviews to lead authors
March 4, 2011	Lead authors provide revised manuscripts and responses to reviewer comments to guest editors
April 2011	All accepted papers provided to Managing Editors for publication in journals
JUNE/JULY 2011	MERCURY CONNECTIONS

Environmental Pollution Series of Papers

Guest Editors: James Wiener, David Evers, David Gay, and Heather Morrison

AIR (6)

1. Mercury concentrations, precipitation, and mercury wet deposition in the Great Lakes region, 2001-2008; *Martin Risch et al.*
2. Spatiotemporal trends in mercury wet deposition in the Great Lakes region: 2002-2008; *David Gay et al.*
3. Synoptic climatology of extreme mercury wet deposition events in the Great Lakes region, 2001-2007; *Frank Marsik*
4. Analysis of modeled mercury dry deposition over the Great Lakes region
Leiming Zhang et al.
5. Mercury Speciation in Air, Foliar Accumulation, and Wash-off in Urban and Rural Forest Canopies; *G.W. Stupple et al.*
6. Evasion of mercury to the atmosphere: a critical review with emphasis on the Great Lakes region (tentative title of multi-authored paper; by-line to be determined).*

Environmental Pollution Cont'd

LITTERFALL, SEDIMENT, WATER (6):

7. Mercury in litterfall at selected National Atmospheric Deposition Program Mercury Deposition Network sites in the Eastern United States, 2007-2009
Martin Risch et al.
8. Temporal and spatial trends in sediment mercury fluxes across the Great Lakes region; *Paul Drevnick et al.*
9. Spatial patterns of total and methyl mercury in lakes across the Upper Midwest; *David Krabbenhoft et al.*
10. Factors affecting concentrations of sulfate and mercury in rivers draining a mining impacted watershed in northeast Minnesota; *Michael Berndt et al.*
11. Watershed and discharge influences on the phase distribution and tributary loading of total mercury and methylmercury into Lake Superior: *Christopher Babiarz et al.*
12. Anthropogenic and biogeochemical influences on the distribution of methylmercury in fish, surface waters, and sediments of lacustrine wetlands in the Grand Calumet Region (Indiana, USA); *Brian Vermillion et al.*

Environmental Pollution Cont'd

WATERSHEDS (5)

13. A regional analysis on the effects of watershed attributes on the recovery of inland lakes from excess mercury loadings; *Matthew Parsons et al.*
14. Spatial distribution and trends of total mercury in Great Lakes waters
Alice Dove et al.
15. Mass balance modeling of mercury in Lake Ontario; *Chris Knightes et al.*
16. Mercury in yellow perch: ecotoxicological significance and relation to aqueous mercury and ecosystem factors in the Great Lakes region. *James Wiener et al.*
17. Estimating mercury concentrations and fluxes within the water column and sediment of Lake Ontario with the general HERMES model *Adrienne Ethier et al.*

Environmental Pollution Cont'd

LAKE CHAMPLAIN (3):

18. Dynamics of Streamwater Inputs of Total Mercury and Methylmercury to Lake Champlain; *James Shanley et al.*
19. Temporal dynamics of mercury loading and assimilation into the Lake Champlain food web *Eric Miller et al.*
20. Spatial and temporal variation in mercury bioaccumulation by zooplankton in Lake Champlain; *Celia Chen et al.*

Ecotoxicology Series of Papers

Guest Editors: David Evers, Jim Wiener, Drew Bodaly, and Nil Basu

LOWER FOOD WEB (5):

1. Characterizing methylmercury bioaccumulation and biomagnification in streams across large environmental gradients: *Lia Chasar et al.*
2. Spatial patterns of mercury in macroinvertebrates and fishes from streams of contrasting forested catchments in the eastern United States; *Karen Riva-Murray et al.*
3. Assessment of mercury bioaccumulation within the lower food web of lakes in the western Great Lakes region; *Kristofer Rolffhus et al.*
4. Identifying an invertebrate sentinel organism to study methylmercury bioaccumulation in aquatic systems; *Britt Hall et al.*
5. Patterns of mercury in the aquatic food chain in lakes of the Adirondack region of New York *Xue Yu et al.*

Ecotoxicology series, cont'd

FISH (6):

6. Mapping of sport fish mercury data in Canada: regional and national perspectives; *Eric DeLong et al.*
7. Temporal trends of mercury in fish from the Great Lakes region; *Bruce Monson et al.*
8. Watershed, atmospheric and physicochemical influences on mercury in fish within the Great Lakes region; *Chad Hammerschmidt et al.*
9. Total mercury trends in top predator fish (1999-2008) determined as part of the Great Lakes Fish Monitoring Program; *T. Zonarski et al.*
10. Risk assessment of mercury levels in Great Lakes region to piscivorous fish; *Mark Sandheinrich et al.*
11. Ontario fish consumption advisories; *Satyendra Bhavsar et al.*

Ecotoxicology series, cont'd

WILDLIFE (7):

12. Mercury, selenium, and neurochemistry in Common Loons from the Great Lakes; *Melanie Hamilton et al.*
13. Patterns of *in ovo* mercury exposure in Wisconsin Common Loons
Kevin Kenow et al.
14. Spatial and temporal trends in mercury levels in Great Lakes Herring Gulls, 1974-2007; *Chip Weseloh et al.*
15. Mercury in wild mink of the lower Great Lakes Basin, Canada, 1998-2006
Pamela A. Martin et al.
16. Mercury exposure and neurochemical impacts in Bald Eagles across several Great Lakes states; *Jennifer Rutkiewicz et al.*
17. Temporal trends of mercury exposure in Common Loons of the Great Lakes states; *Michael Meyer et al.*
18. Spatial gradients of available methylmercury to avian piscivores in the Great Lakes basin; *David Evers et al.*

Ecotoxicology series, cont'd

WILDLIFE (4) AND POLICY (3):

19. Factors driving mercury concentrations in snapping turtles

Madeline Turnquist et al.

20. Mercury in Swamp Sparrows in acidic and non-acidic wetlands in Wisconsin*

Sean Strom et al.

21. Twenty years of mercury in eagles from Voyageurs Park; *Bill Bowerman et al.*

22. Historical trends of mercury in Michigan as determined via museum specimens; *Nil Basu et al.*

23. Mercury policy in the Great Lakes: past successes and future opportunities

Joy Taylor Morgan et al.

24. Environment Canada's Mercury Science Program; et al. *Heather Morrison*

25. The U.S. national mercury monitoring network: evaluating impacts of reduced emissions; *David Schmeltz et al.*

Outline

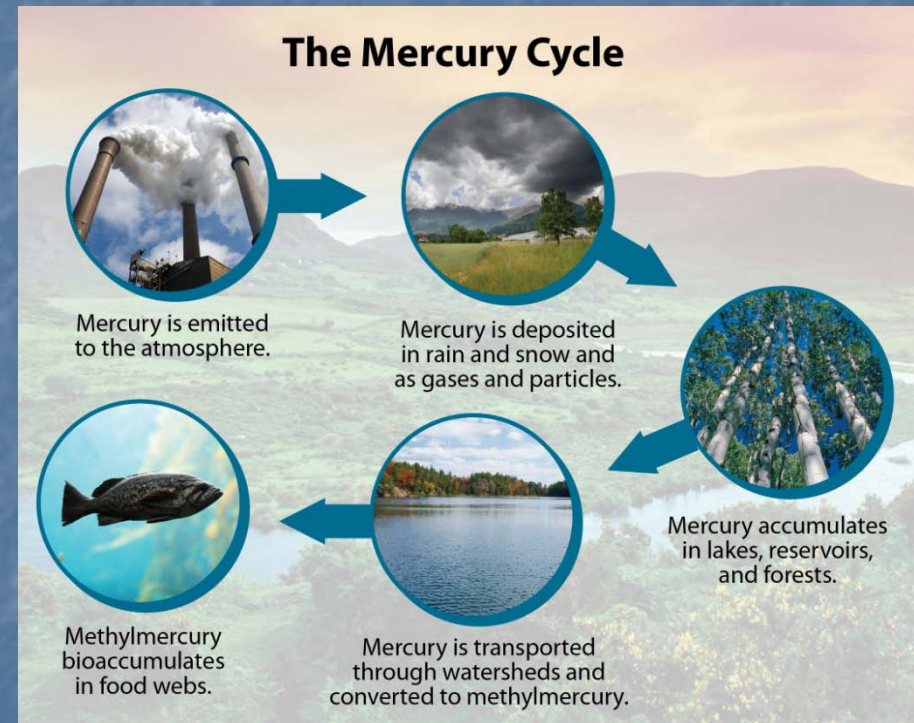
- MercNet - A National Framework for Monitoring Spatial and Temporal Changes in Environmental Mercury Loads
- Context
- Timeline of Milestones
 - Monitoring Methods Development
 - Legislation
 - Related Publications
 - Regional Hg Summaries
- MercNet Database

Mercury monitoring network goal

- “Establish an integrated, national network to systematically monitor, assess, and report on policy-relevant indicators of atmospheric mercury concentrations and deposition, and mercury levels in land, water, and biota in terrestrial, freshwater, and coastal ecosystems in response to changing mercury emissions over time”

Why do we need comprehensive, long-term mercury monitoring information?

1. Current programs monitor portions of the mercury cycle;
 - But major data gaps and limited coordination exists
2. Insufficient information for many areas of the U.S. to fully and accurately assess the benefits and effectiveness of mercury reduction measures
3. Need to assess the linkages between emissions and deposition with:
 - fish,
 - wildlife and
 - people;
4. Need to determine spatial and temporal trends



Milestones for the National Mercury Monitoring Network: Meetings and Methods Publications

EPA/SETAC
North American Workshop on
Mercury Monitoring and
Assessment, Pensacola, FL

EPA Office of
Inspector General Report on
mercury "Hotspots"



**National Mercury
MONITORING WORKSHOP**

Tracking mercury concentrations in air, land, water, and biota

May 5 - 7, 2008, Annapolis, MD

2000

2001

2002

2003

2004

2005

2006

2007

2008

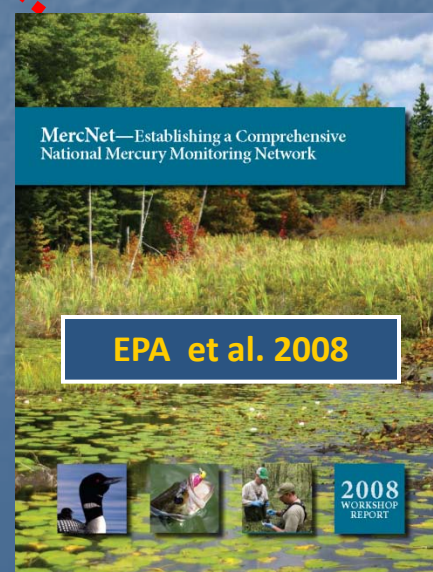
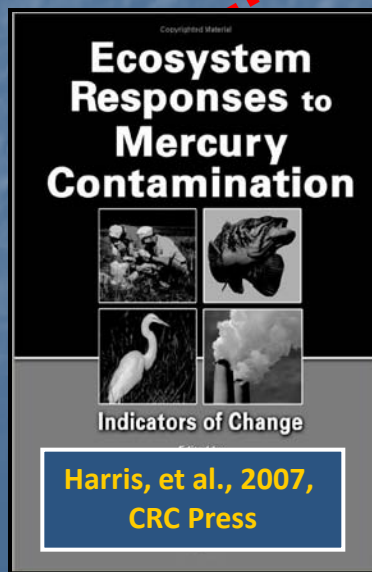
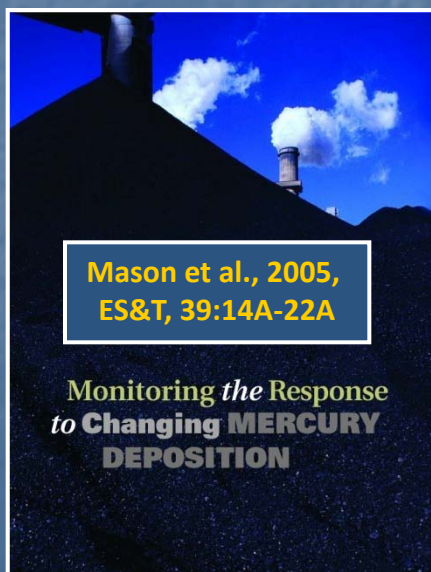
2009

2010

2011

2012

2013



Mercury monitoring objectives (trends and causality)

1. Establish baseline Hg concentrations in multiple ecosystem compartments
2. Track spatial patterns and long-term trends
3. Assess linkages between mercury emissions and methylmercury concentrations in biota
4. Document trends in biological indicators of Hg exposure and effects
5. Provide Hg and ancillary data to support model development and evaluation
6. Assess ecological harm and linkages among mercury emissions, deposition, and wildlife exposure
7. Connect national mercury monitoring efforts to other monitoring programs

Major design elements

- National distribution of sites
- A network of approximately 20 intensive sites, accompanied by ~ 10 cluster sites for each intensive site
- Monitoring sites would be multi-media (e.g., air, water, fish, wildlife)
- Network must run for an extended period to quantify the range of responses expected in many ecosystem types
- Network should build on existing monitoring efforts, where possible

The Indicators

Air & Deposition

- Continuous speciated atmospheric concentrations
- Total wet and dry Hg deposition & flux
- Total Hg weekly wet deposition/flux
- Total and MeHg in throughfall
- Total and MeHg in litterfall
- Total Hg in snowpack
- Mercury evasion/flux
- Watershed inputs/yields



Indicators in yellow would be monitored at intensive sites only. Black would be monitored at cluster sites, when feasible

Water & Sediment

- Total and MeHg in soil
- Forest floor surveys
- Total and MeHg, %MeHg in sediments (seasonal)
- Instantaneous sediment methylation/demethylation rate
- Total and MeHg accumulation in cores
- Total and MeHg in surface water (seasonal)
- Water column Hg & MeHg profiles



The Indicators, cont.

Aquatic Biota

- Total and MeHg in phyto/zooplankton
- Total and MeHg in estuarine benthic invertebrates
- Total and MeHg in whole prey fish (YOY)
- Total Hg in muscle of piscivorous fish



Indicators in yellow would be monitored at intensive sites only. Black would be monitored at cluster sites, when feasible

Wildlife

Total Hg in blood, feathers, eggs (as appropriate)

Potential Indicator Species

- Comparison across habitats: Belted kingfisher
- Terrestrial: Raccoon, Bicknell's thrush
- Riverine: Mink
- Lake: Common loon
- Lake/coastal: Herring gull, Common tern
- Wetland: Tree swallow
- Estuarine: Sharp-tailed & seaside sparrows
- Marine nearshore: Harbor porpoise
- Marine off-shore: Storm petrel

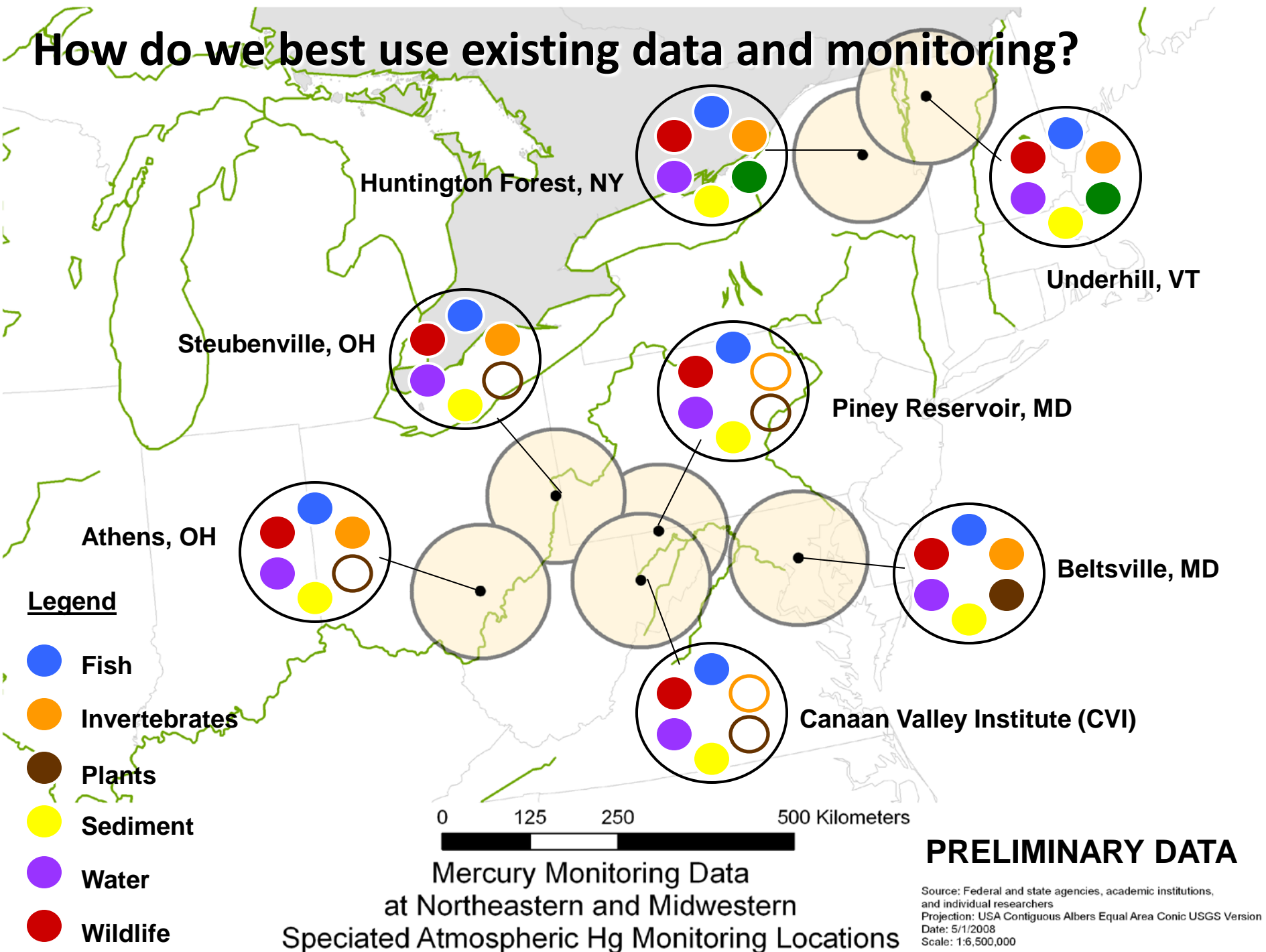


National Mercury Monitoring Workshop



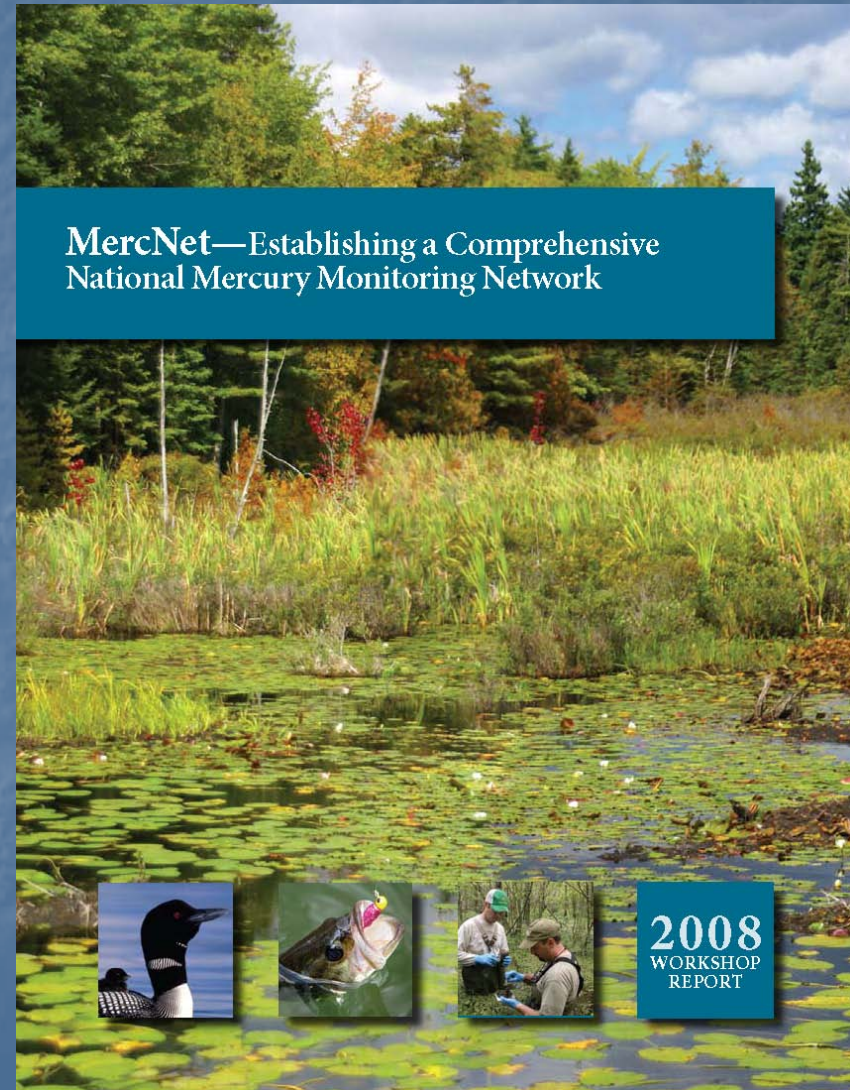
- Distill recommendations from previous work on measurement parameters for tracking ecological responses to mercury
- Share information on existing North American sites and programs that monitor ecological endpoints of Hg contamination (e.g., air, water, watershed, sediments, biota)
- Identify Hg monitoring data gaps and establish options for filling those gaps

How do we best use existing data and monitoring?

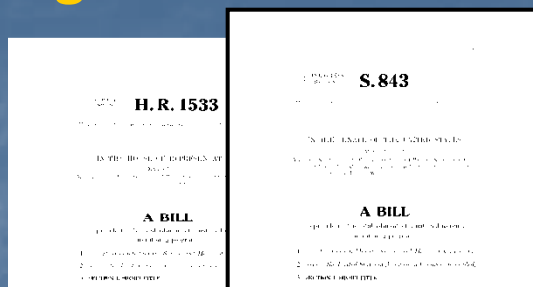


Mercury Monitoring Workshop Report

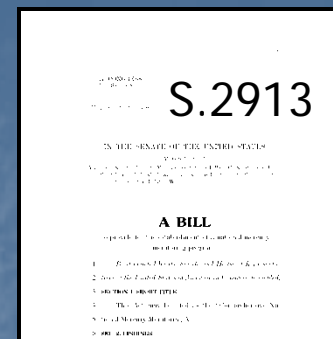
- Collaborative effort led by Steering Committee consisting of representatives of federal, state and tribal agencies, academic scientists, and research and monitoring organizations
- Highlights major areas of agreement for a national mercury monitoring network
 - Goal, Objectives, Major Design Elements
- Posted on the NADP Website
<http://nadp.sws.uiuc.edu/>



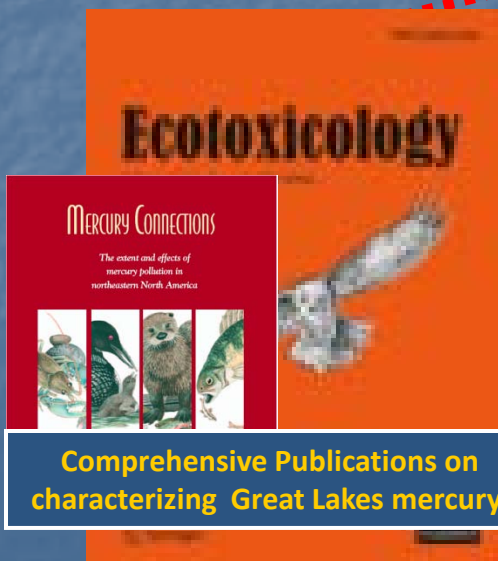
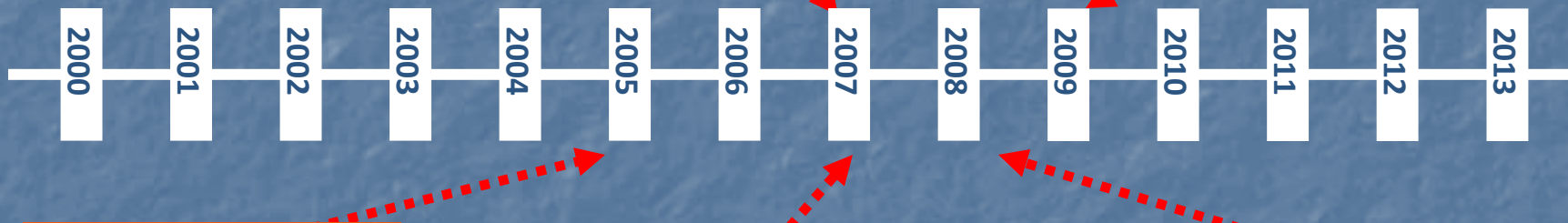
Milestones for the National Mercury Monitoring Network: Legislation and Publications



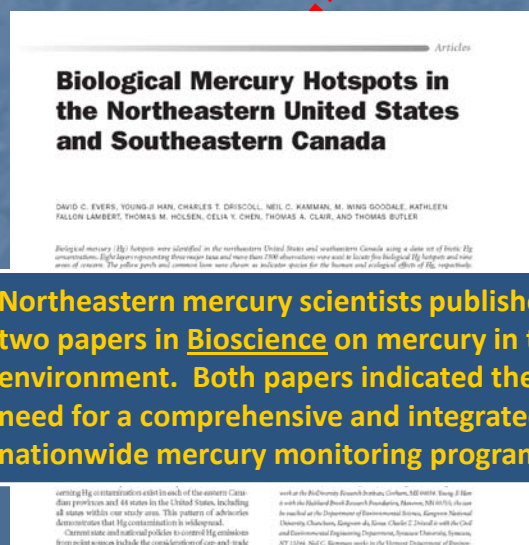
**Comprehensive Mercury Monitoring
Bills introduced in
House and Senate**



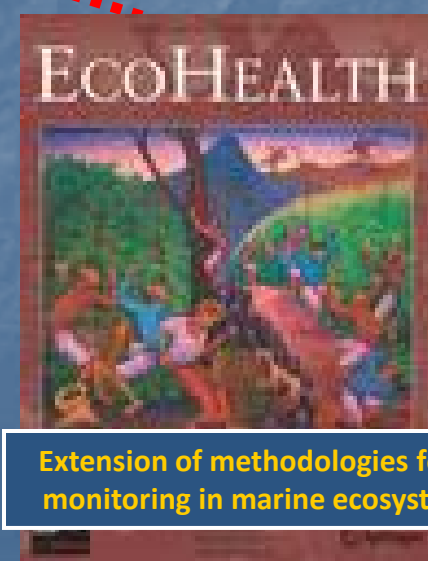
**Comprehensive Mercury Monitoring
Bills introduced in Senate**



**Comprehensive Publications on
characterizing Great Lakes mercury.**



**Northeastern mercury scientists published
two papers in Bioscience on mercury in the
environment. Both papers indicated the
need for a comprehensive and integrated,
nationwide mercury monitoring program.**

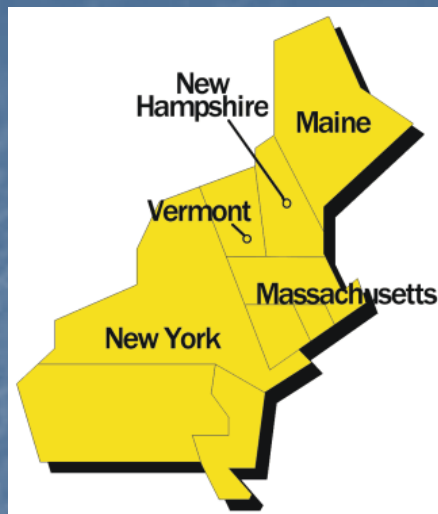


**Extension of methodologies for Hg
monitoring in marine ecosystems.**

Comprehensive National Mercury Monitoring Act

- ◆ Legislative bill includes USEPA to administer network in collaboration with USFWS, USGS, NPS, and NOAA
- ◆ Legislation includes, in detail, the structure and methodologies covered in peer-reviewed publications
- ◆ Legislation first introduced in March 2007
 - Collins, Lieberman, Clinton – Environment and Public Works
 - Allen and Walsh – Energy and Commerce
- ◆ Legislation introduced – December 18, 2009
 - Collins and Carper – Environmental and Public Works
 - Pingree (anticipated) – Energy and Commerce
- ◆ Legislation calls for \$95 million for 3 years

Milestones for the National Mercury Monitoring Network: Regional Hg Summaries



Northeast

Co-PI
David Evers, BRI
Tom Clair, Environment Canada

Great Lakes

Co-PI
David Evers, BRI
Jim Wiener, Univ. of Wisconsin

Western U.S. / Alaska

Co-PI
David Evers, BRI
Elsie Sunderland, Harvard University

MercNet Database: Online Library

MercNet | Tracking mercury in air, water, land, fish and wildlife - Windows Internet Explorer

http://mercnet.briloon.org/

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Google Search

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MercNet Monitoring Inventory: Online Library (in BETA)

Welcome to the MercNet monitoring inventory, a meta-database of mercury datasets from the United States and Canada. Explore the database using the search options below. Source datasets may be available through this website, or by using the MercNet data request form.

The MercNet monitoring inventory is maintained by the BioDiversity Research Institute.

Search by Keyword

Hint: Start with a basic search and refine it on the next page.

Search by Medium

[atmospheric deposition](#) (2) [birds](#) (9) [fish](#) (20) [invertebrates](#) (8) [herpetiles](#) (4) [mammals](#) (1) [plants](#) (1) [sediment cores](#) (5) [water](#) (7)

Search by Region

To view projects within a specific region, select from the list or map below.

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- 2 [Region 2](#) (13)
- 3 [Region 3](#) (10)
- 4 [Region 4](#) (8)
- 5 [Region 5](#) (31)
- 6 [Region 6](#) (4)
- 7 [Region 7](#) (3)
- 8 [Region 8](#) (6)
- 9 [Region 9](#) (5)
- 10 [Region 10](#) (5)
- 11 [Region 11: Pacific and Yukon](#) (0)
- 12 [Region 12: Prairie and Northern](#) (1)
- 13 [Region 13: Ontario](#) (8)
- 14 [Region 14: Quebec](#) (2)
- 15 [Region 15: Atlantic](#) (2)
- 16 [Region 16: Other](#) (0)



[Region Glossary](#)

Internet 75%

MN PCA - Minnesota Fish Contaminant Database | MercNet | Tracking mercury in air, water, land, - Windows Internet Explorer

http://mercnet.briloon.org/projects/MN_PCA_-_Minnesota_Fish_Contaminant_

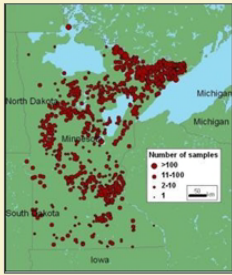
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Google Search

MN PCA - Minnesota Fish Contaminant Database | Me...

MercNet Monitoring Inventory: Online Library

MN PCA - Minnesota Fish Contaminant Database



Click map for larger view

Overview

Minnesota state fish contaminant database, a cooperative effort from the Minnesota Department of Natural Resources, Minnesota Department of Health, and Minnesota Pollution Control Agency. Initiated 1967. THg and ancillary data on sportfish fillets, with emphasis on northern pike and walleye.

Source Agency: Minnesota Department of Natural Resources, Minnesota Department of Health, Minnesota Pollution Control Agency
Agency/Project Website: <http://www.pca.state.mn.us/>
Medium: fish
Start Date: 1967

Contact
Bruce Monson, Environmental Information and Reporting
bruce.monson@state.mn.us

Address
520 Lafayette Rd. N
St. Paul, MN 55155
Phone: 651-757-2579 **Fax:** 651-297-8676

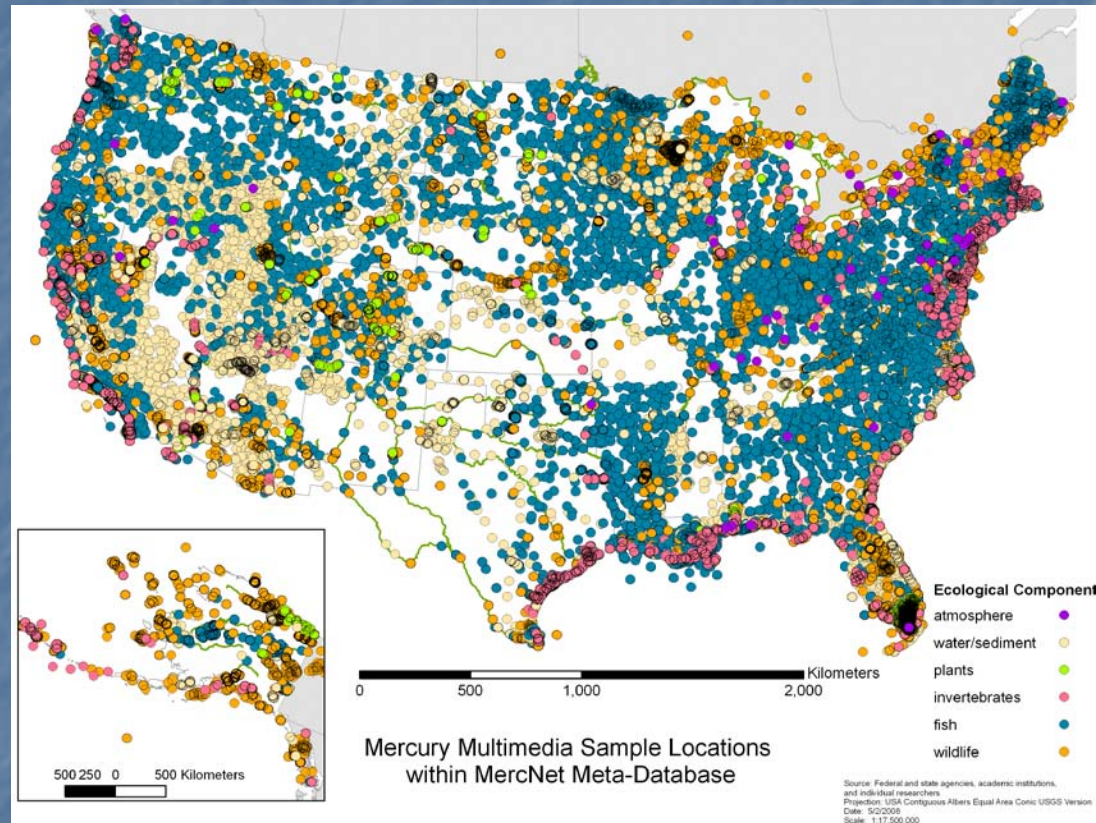
Summary

	Collection Details	Data Details	Datasets
Name of dataset	Minnesota Fish Contaminant Database		
Geographic area	Minnesota		
State/Province	MN		
Activity Category	Monitoring		
Medium	fish		
Focal species	all sportfish, but emphasis on northern pike and walleye		
Tissue Types	fillet		
Approximate size of dataset	31000		
Positional data available?	yes		
Start Date	1967		
End Date	2008		
Status	Ongoing		

Internet 75%

MercNet database: A broad mix of Hg data

- Based on major environmental monitoring databases from EPA, USGS, USFWS, NOAA BioDiversity Research Institute
- ~ 600,000 mercury sampling events across the U.S.
- Various media: Atmosphere, Water, Sediment and soil, Vegetation, Invertebrates, Fish, Birds, Reptiles and Amphibians, Mammals
- Time span of records is from 1896 to 2009



Current list of site selection considerations

Baseline data and infrastructure



- Longer-term mercury data
- Existing facilities and infrastructure to support the monitoring program

Will we see and be able to understand a change?



- Sensitive to mercury inputs
- Expected to exhibit large changes due to changes in Hg deposition
- Near emission sources and may receive elevated Hg deposition
- Clearly defined response – few if any confounding factors

Model evaluation



- Useful testbed for evaluation of atmospheric Hg models
- Useful testbed for evaluation of ecosystem Hg models

Want a range of site types



- Overall, want nationwide geographical distribution
- Overall, want range of characteristic response times
- Overall, want some background sites for characterizing global Hg inputs

Other site issues



- Within common loon breeding range
- Endangered, threatened or candidate species at risk to Hg

Conceptual National Mercury Monitoring Network Design -- preliminary intensive sites discussed

Ohio River Valley

Steubenville, OH
Frostburg, MD
Canaan Valley Institute, WV
Athens, OH

Upper Midwest

Voyageurs National Park, MN
Experimental Lakes
Area, Canada
Dexter, MI
Marcell Experimental Forest, MN
Northern Highland Forest, WI

West

Rocky Mountain
National Park, CO
Toolik, AK
Glacier Bay, AK
Stillwell, OK
Sierra Nevada, CA/NV
Mt. Ranier, WA
Four Corners-Mesa Verde, CO
Mt. Bachelor, OR as a “global
background” site

Southeast

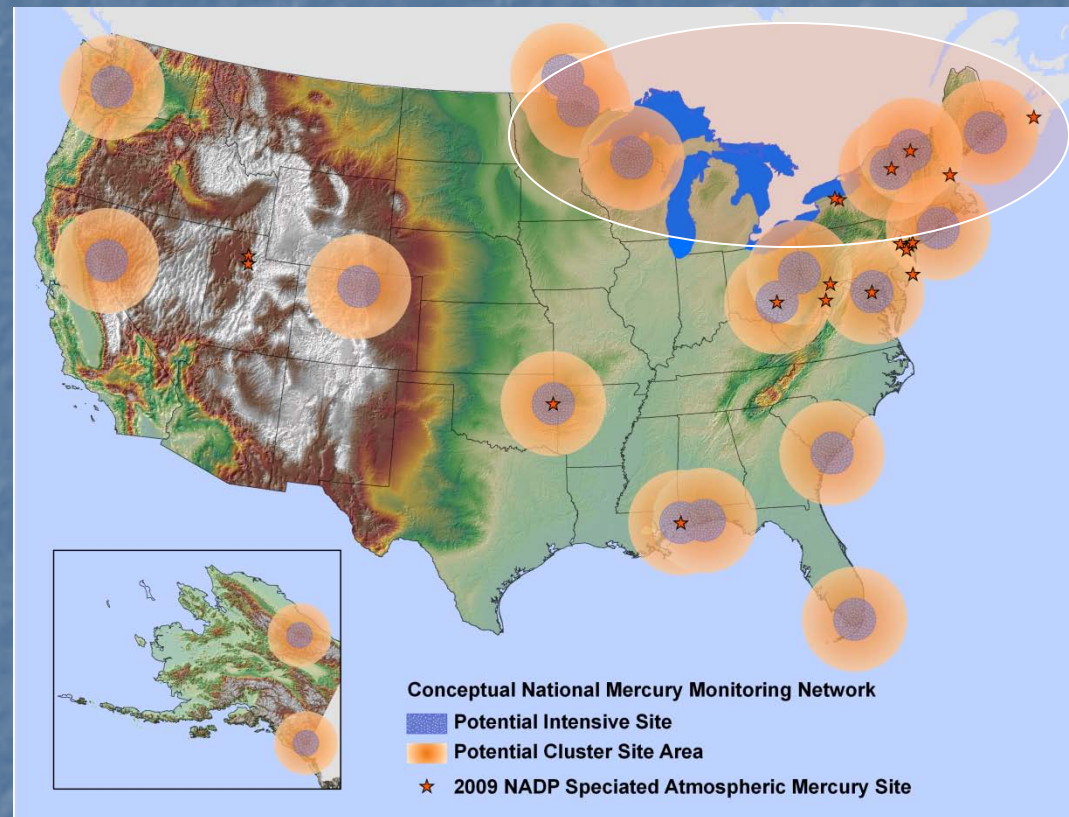
Everglades National
Park, FL
Coastal South
Carolina [Ace Basin]
Northern Gulf Coast
Grand Bay NERR, MS
Pensacola, FL
Atlanta/Yorkville, GA

Mid Atlantic

Chesapeake Bay
[Beltsville, SERC]

Northeast

Huntington Wildlife Forest, NY
Acadia, National Park, ME
Proctor Center, Underhill, VT
Neversink Watershed, NY
Cape Code National
Seashore, MA
Long Island Sound, NY
Mt. Washington, NH
Kejimikujik, NS



Demonstration stations proposed in Great Lakes, NY and Maine

UNEP Global Mercury Programme

- Seven Partnership Areas
- Mercury Air Transport and Fate Research Partnership Area
 - BioDiversity Research Institute
- Interest in using the U.S. National Mercury Monitoring Program as a template for an international program.