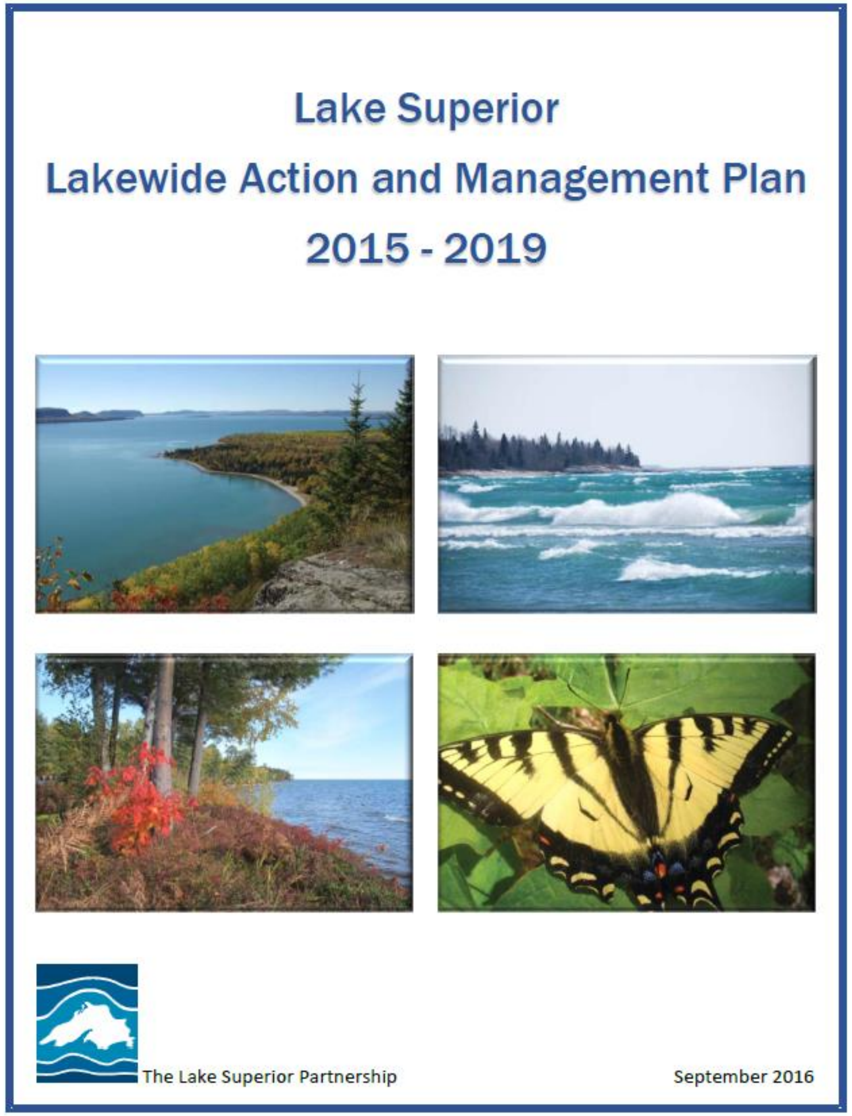
Lakewide Action and Management Plan (LAMP) Understanding and Reducing Mercury Impacts to Lake Superior

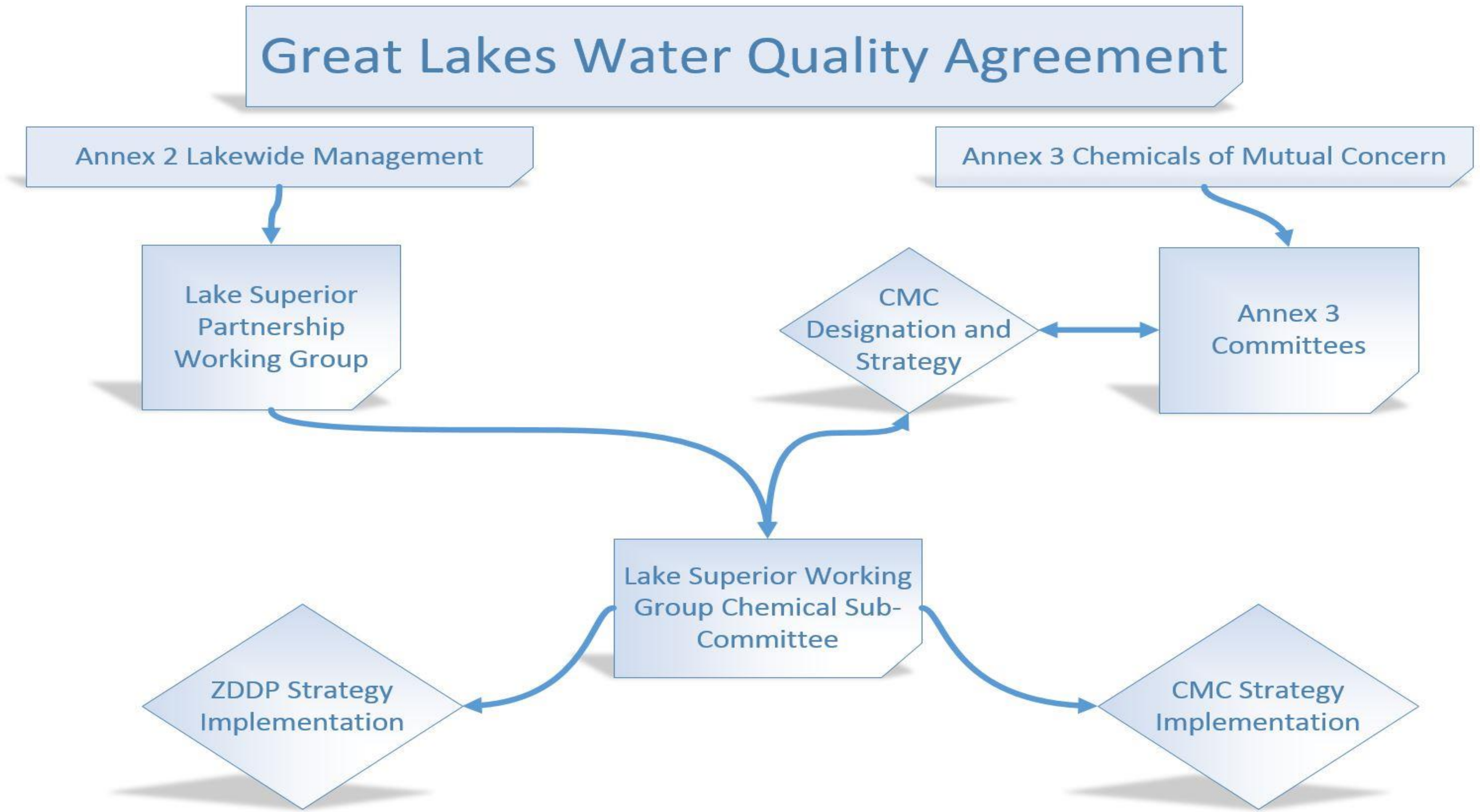
MINNESOTA POLLUTION CONTROL AGENCY

Jesse Martus
Lake Superior LAMP Coordinator
Winter 2021

wq-iw4-02i4

LAMP and Great Lakes Restoration Initiative




Great Lakes Water Quality Agreement
Annex 2 Lakewide Management
Annex 3 Chemicals of Mutual Concern
Lake Superior Partnership Working Group
CMC Designation and Strategy
Annex 3 Committees
Lake Superior Working Group Chemical Sub-Committee
ZDDP Strategy Implementation
CMC Strategy Implementation

Annex 3
mercury strategy

DRAFT

Great Lakes Binational Strategy for Mercury Risk Management

April 2018

A document to assist in the engagement of key stakeholders and the public in strategy development

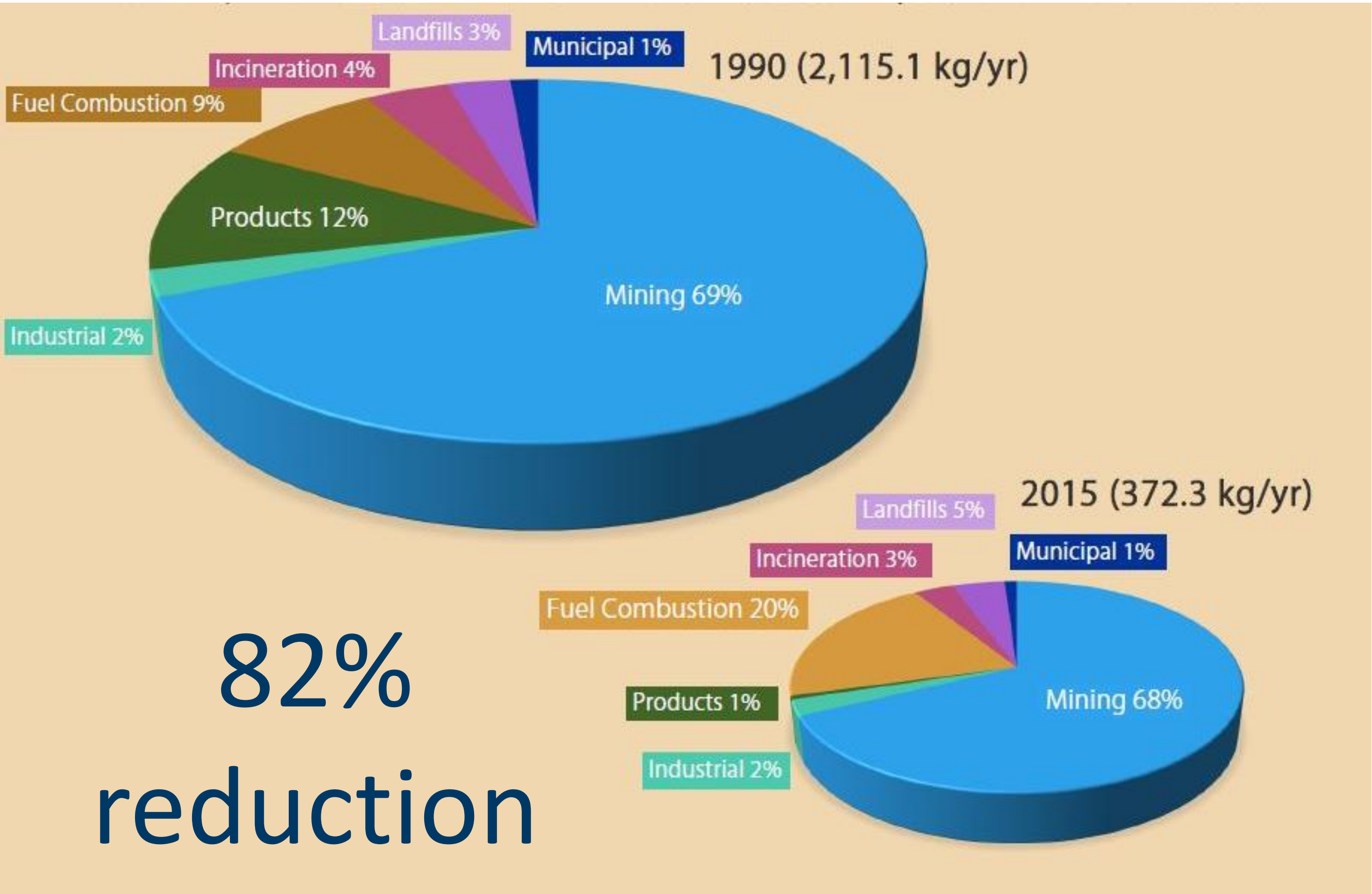
This draft was prepared by Environment and Climate Change Canada and the United States Environmental Protection Agency

Annex 3 strategy actions

ES Table A. Summary of the Canada-United States Strategy Options for Mercury

Category of Action				
Regulations and Other Risk Mitigation and Management Actions	**Compliance Promotion and Enforcement**	**Pollution Prevention**	**Monitoring, Surveillance, and Other Research Efforts**	**Domestic Water Quality**
Strategy Options				
Evaluate the effectiveness of existing regulatory programs to ensure maximum efficiency and overall positive implications on a global scale (Canada) Evaluate the effectiveness of existing emissions regulatory programs for addressing mercury pollution (US) Review and update actions to match current scientific understanding and regional context (Canada and US) Identify manufacturing processes or products that intentionally add mercury (US) Continue to reduce mercury emissions resulting from coal-fired generation of electricity (Canada) Continue implementation of domestic regulations and other risk management activities for mercury (Canada and US) Develop the National Strategy for Safe and Environmentally Sound Disposal of Lamps Containing Mercury (Canada) Continue remediation of mercury-contaminated sites and sediments (Canada and US) Amend the Products Containing Mercury Regulations to further reduce mercury in products (Canada)	Promote compliance with domestic and international mercury activities and initiatives (Canada and US) Continue implementation of respective obligations of the Minamata Convention on mercury (Canada and US)	Enhance public outreach and educate the public and facility staff on potential sources of mercury and proper actions to follow when handling mercury containing products(Canada and US) Enhance public outreach and educate the public on how to obtain and implement site-specific fish consumption advisories (Canada and US) Encourage industries to track their P2 activities and efforts in the National Pollutant Release Inventory (NPRI) or Toxics Release Inventory (TRI), or via P2 promotion activities (fact sheets, case studies) (Canada and US) Highlight pollution prevention successes (Canada and US) Implement best available techniques and best environmental practices for new and substantially modified sources (Canada and US)	Continue monitoring mercury in environmental media in the Great Lakes (air, precipitation, sediment, fish, and other wildlife) and publish results in a variety of publications (e.g., online and open data portals, government reports and scientific journals) to maximize the intended audience (Canada and US) Continue efforts to update and maintain mercury emissions inventories in a manner such that regional and global emissions can be tabulated (Canada and US) Conduct additional research on methylation dynamics and the differential impacts of mercury in nearshore versus offshore environments (US) Enhance existing models to track long-range atmospheric transport and the rate of methylmercury formation in the environment and its corresponding ecological risk (Canada and US) Develop cost-effective, reliable and effective tools (e.g., passive samplers) for collecting long-term mercury multi-media monitoring data (Canada and US) Develop and populate a structured data system to track mercury sources, manifests, waste, and products (Canada and US)	Review and update existing domestic water quality standards, if necessary (Canada and US)

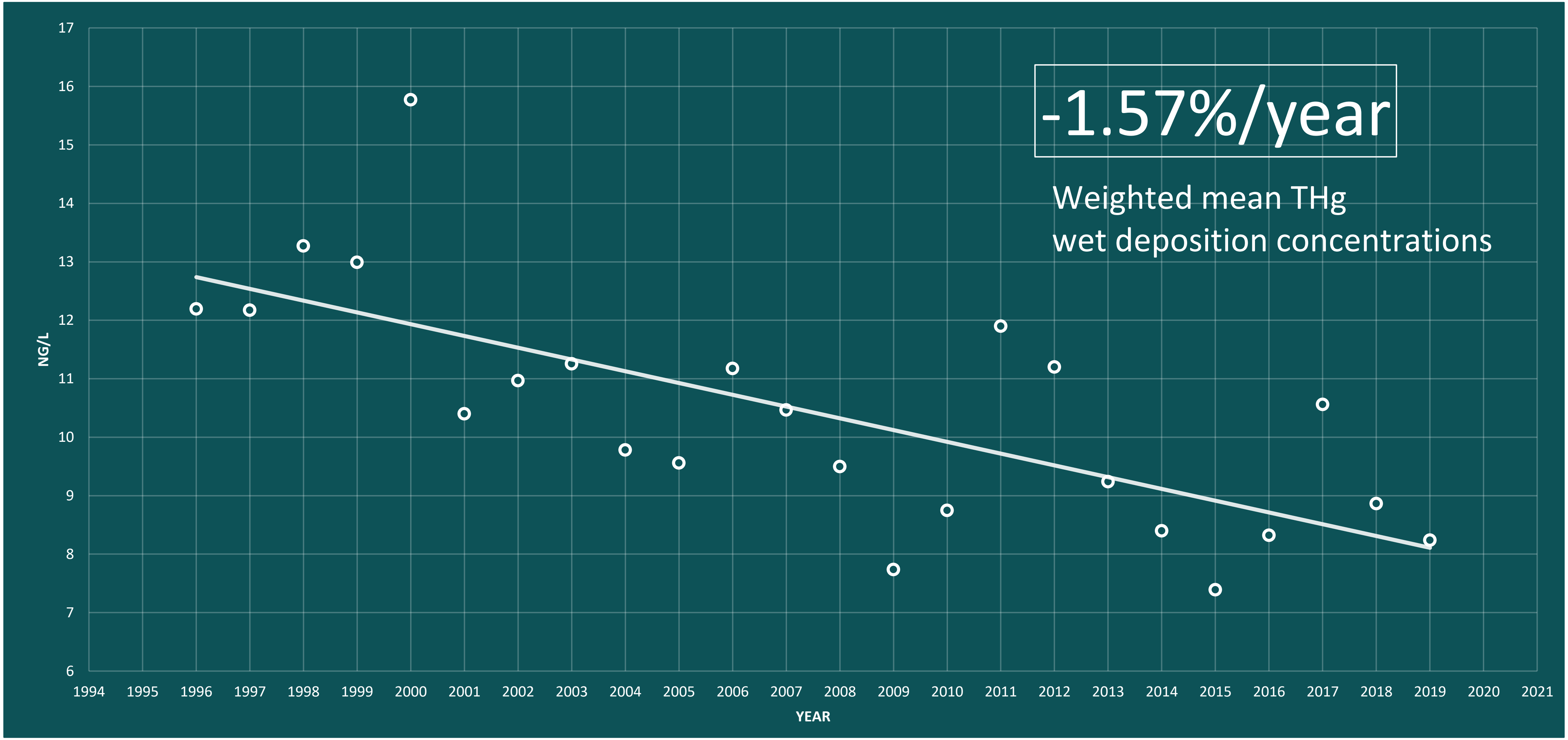
Mercury releases to air and water in basin 1990 - 2015



82% reduction

Cleveland Cliffs Taconite Processing Facility, Silver Bay, MN

Basin mercury deposition concentrations 1996-2019



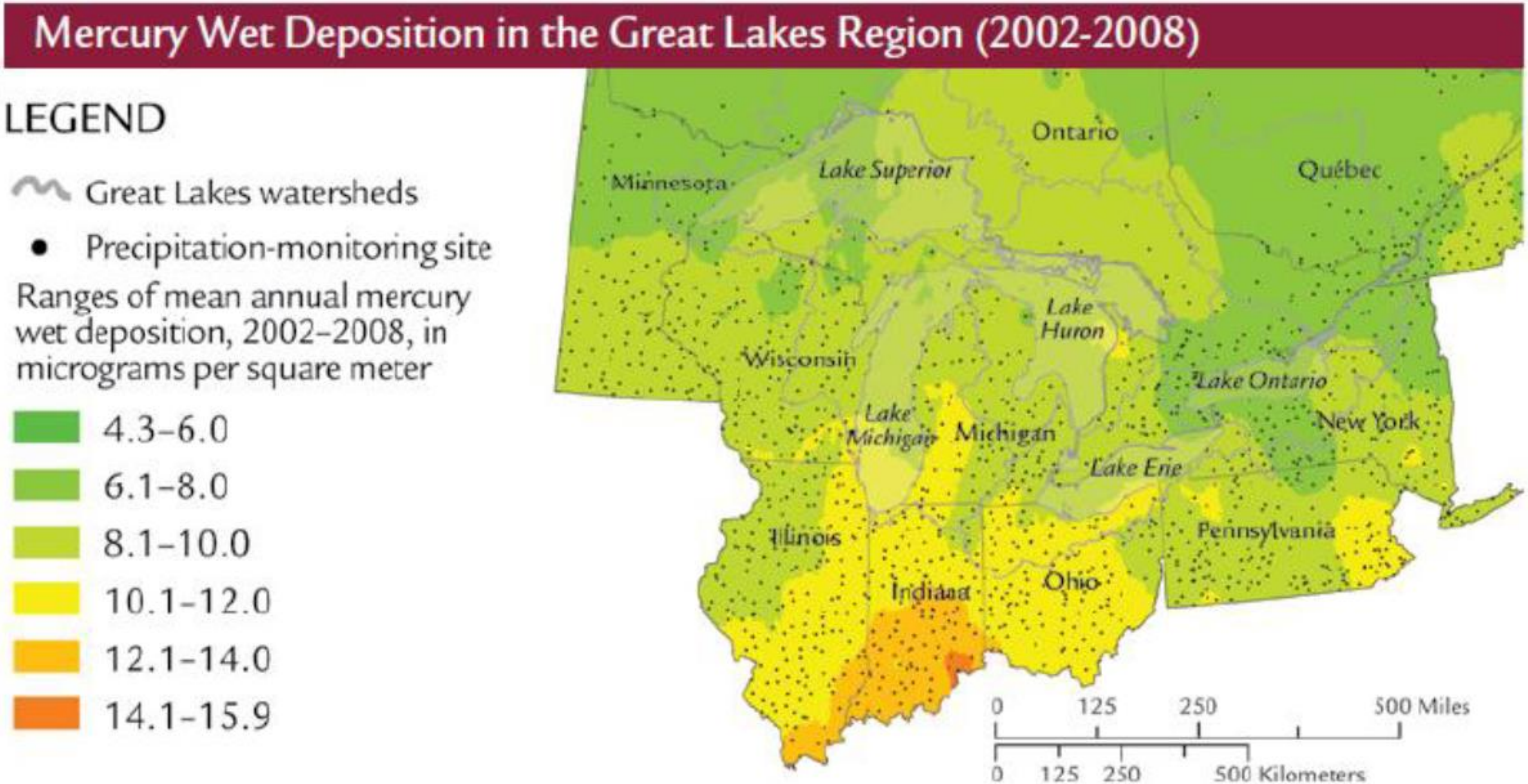


Figure 5. *Seven-year mean annual mercury wet deposition based on NADP/MDN monitoring data. Source: Evers et al. (2011)*

Landscape sensitivity to mercury deposition

M.R. Risch et al. / Environmental Pollution 228 (2017) 8–18

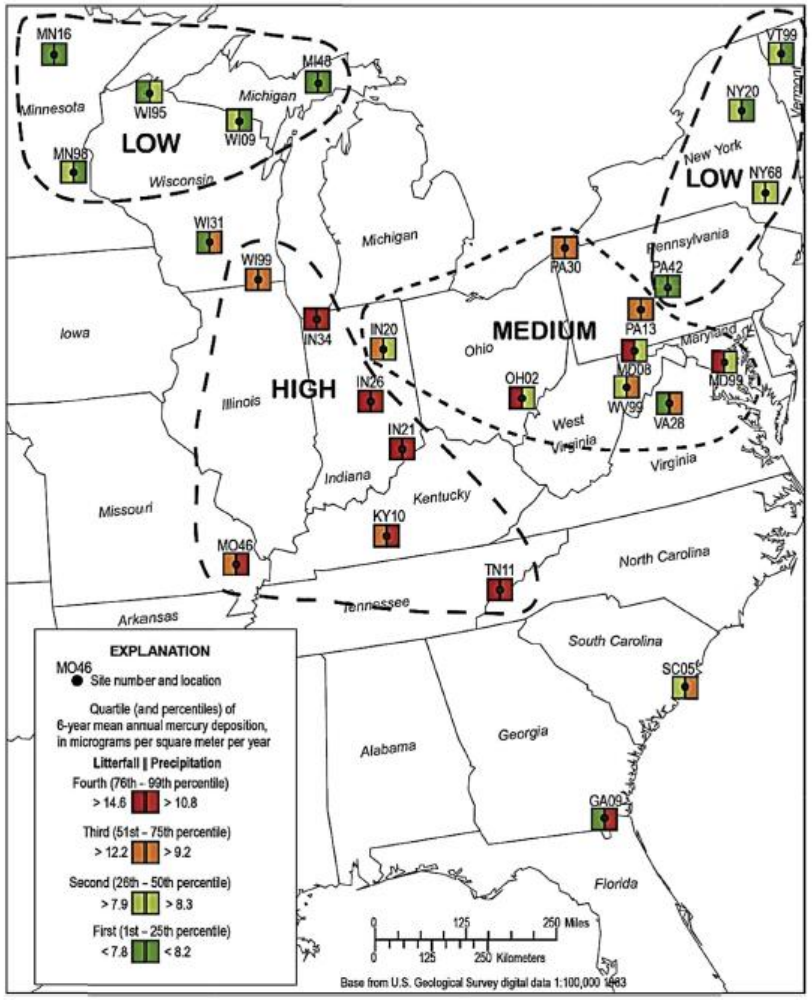


Fig. 3. Study sites with quartile distribution of mean annual litterfall-Hg and precipitation-Hg deposition, 2007–2014.

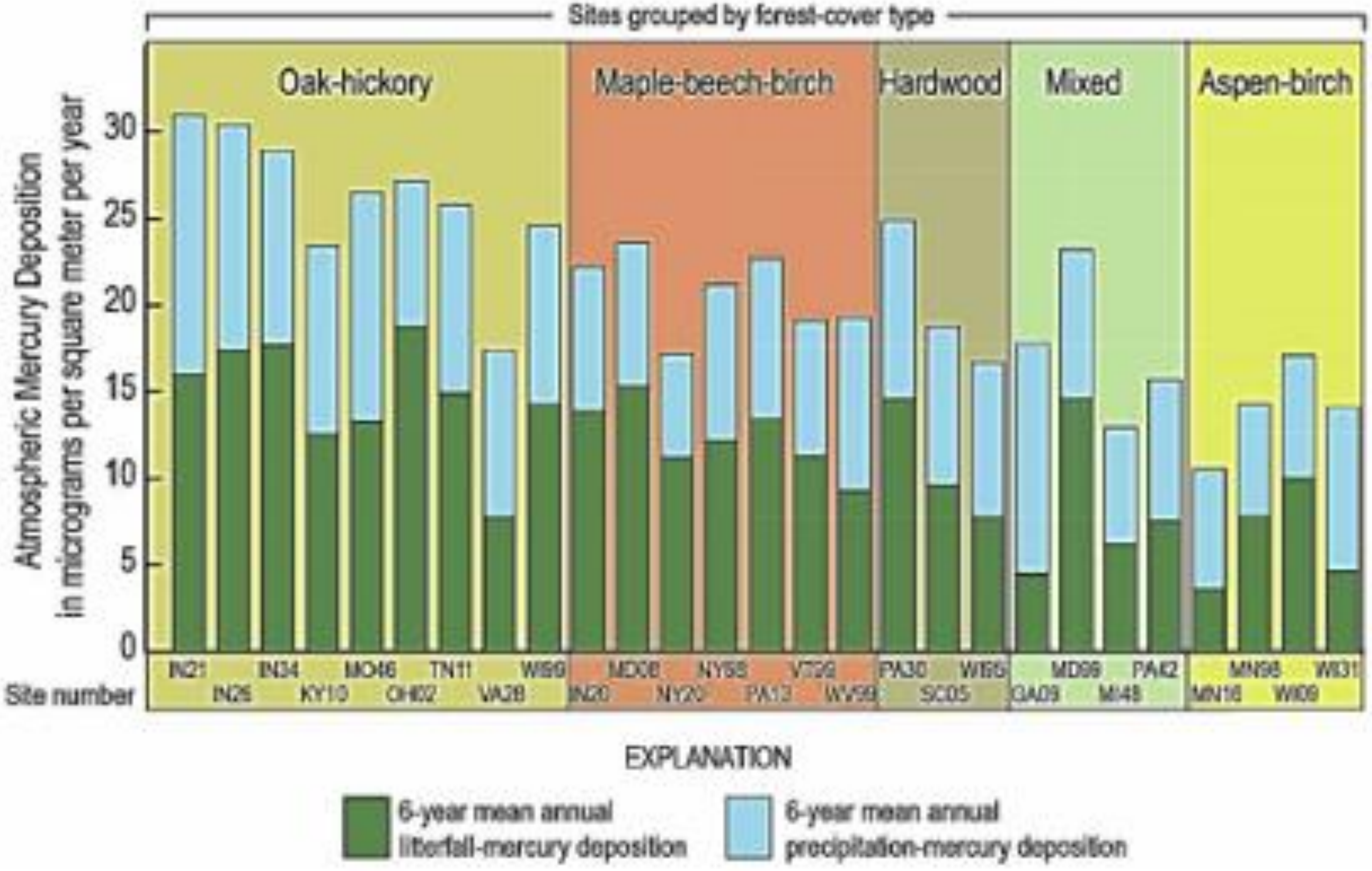


Fig. 4. Mean annual litterfall-Hg and precipitation-Hg deposition by forest-cover type, 2007–2014.

Mercury in Great Lakes sediments

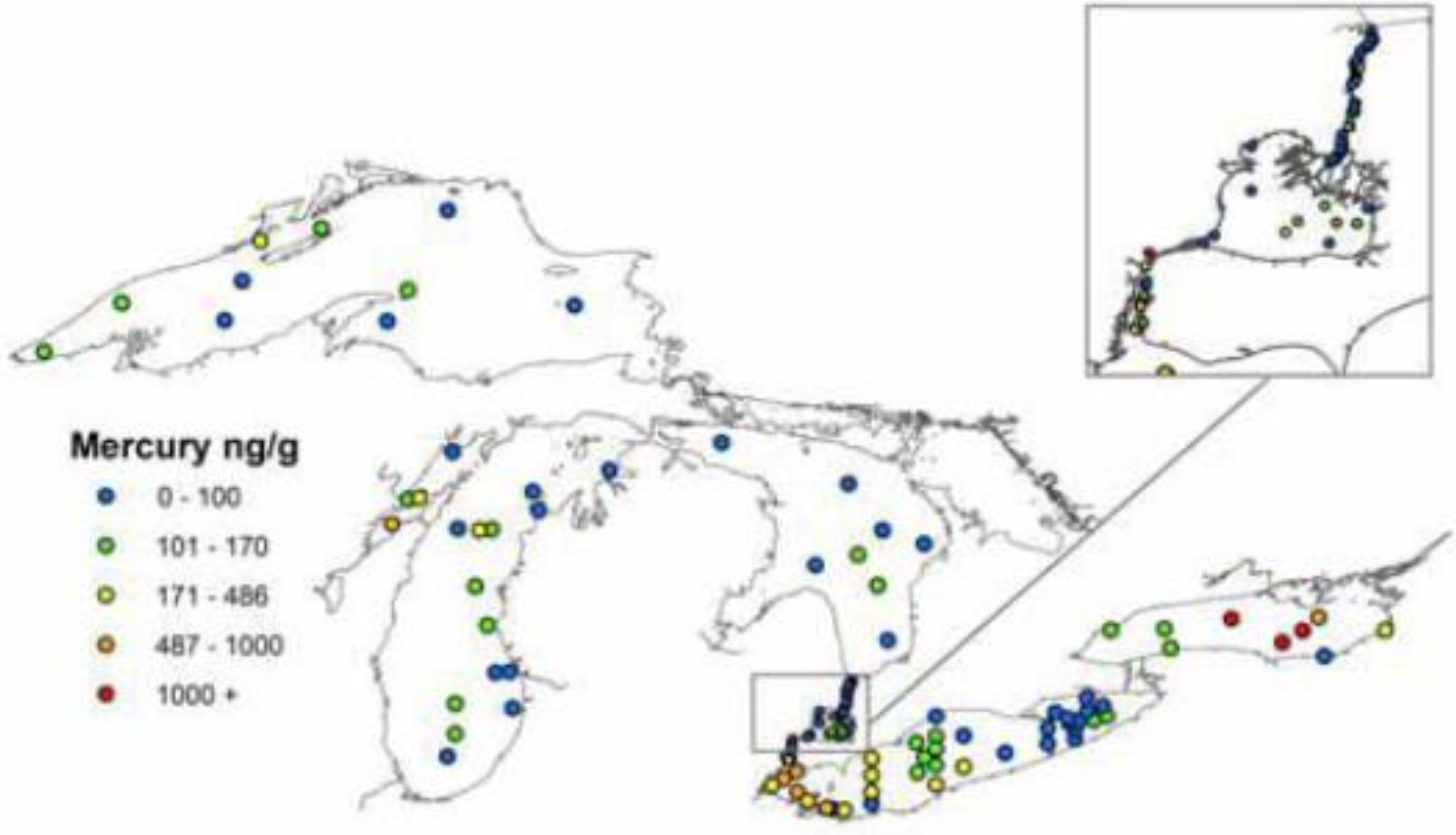
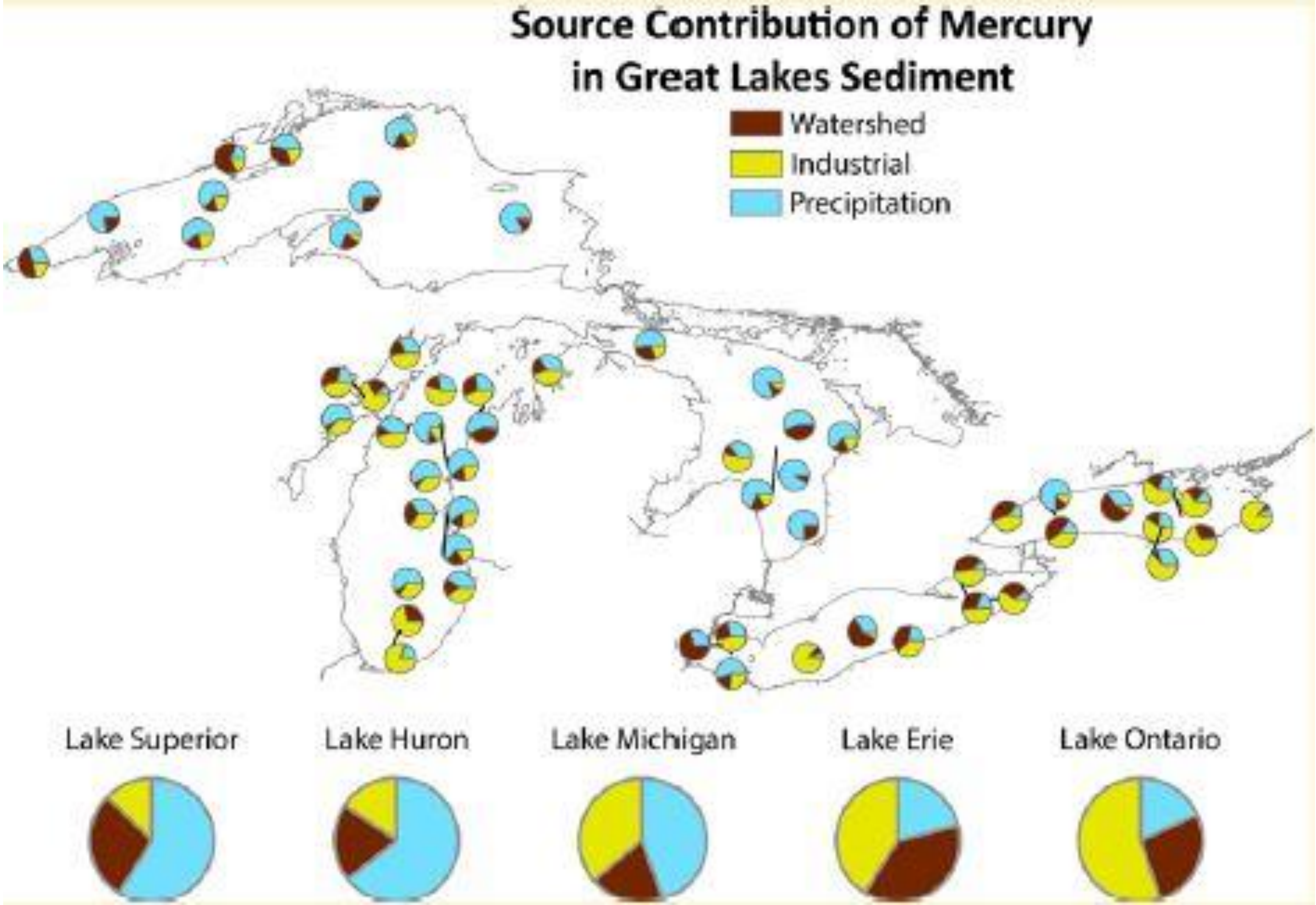
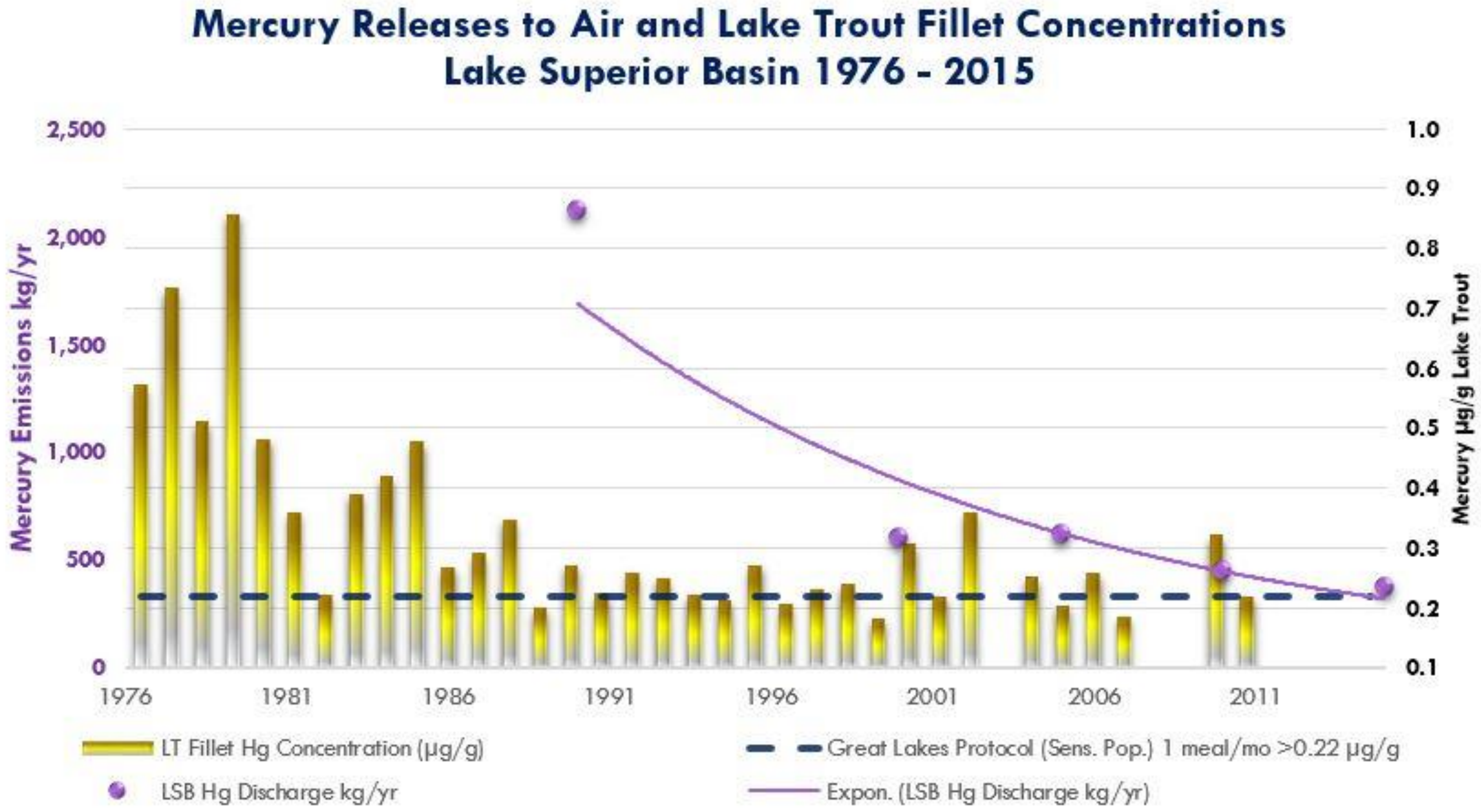


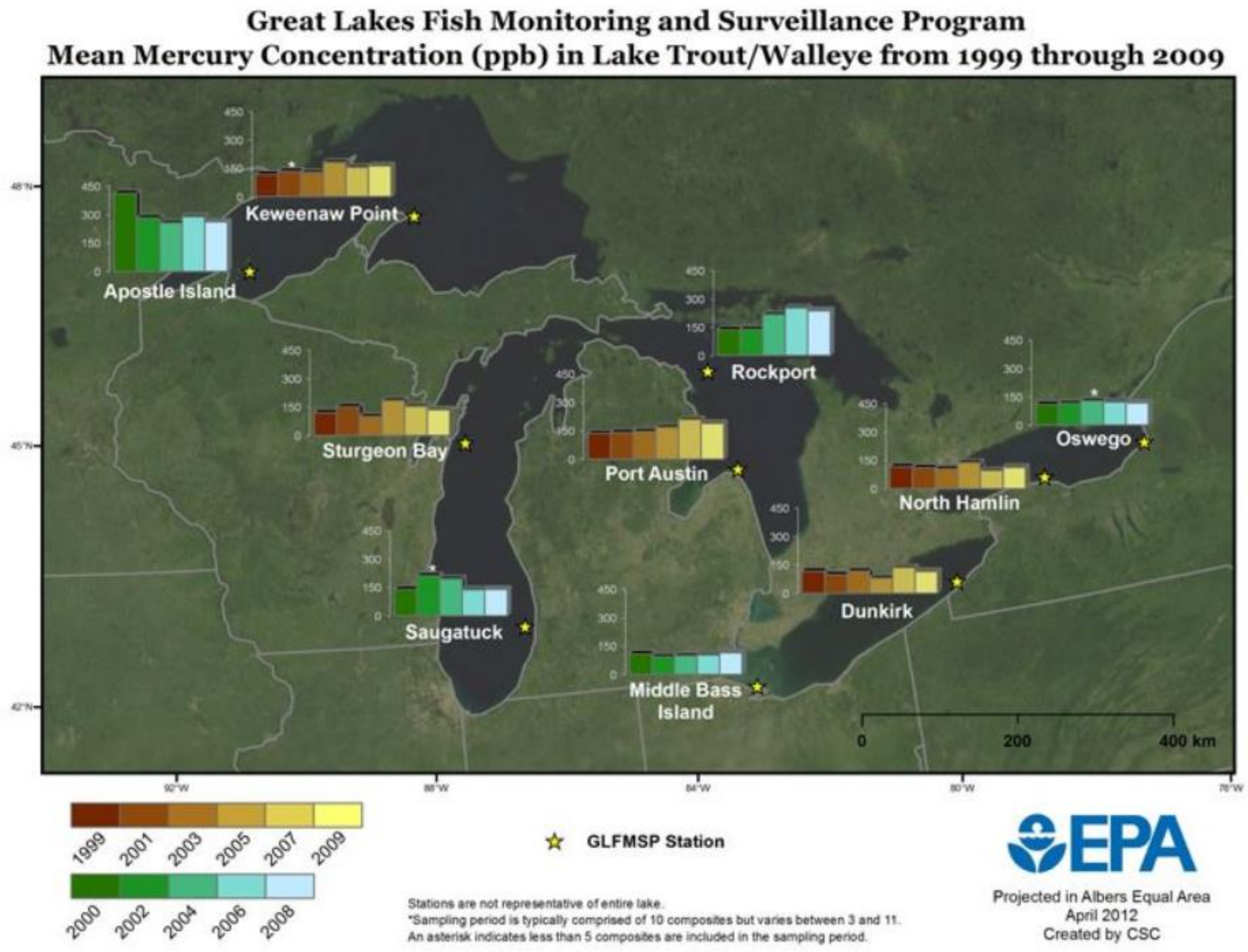
***Figure 6**. Spatial Distribution of Mercury in Great Lakes Sediments. Inset is Lake St. Clair Corridor.*
Source: State of the Lakes Technical Report (2017)


Source Contribution of Mercury in Great Lakes Sediment
Watershed
Industrial
Precipitation
Lake Superior
Lake Huron
Lake Michigan
Lake Erie
Lake Ontario

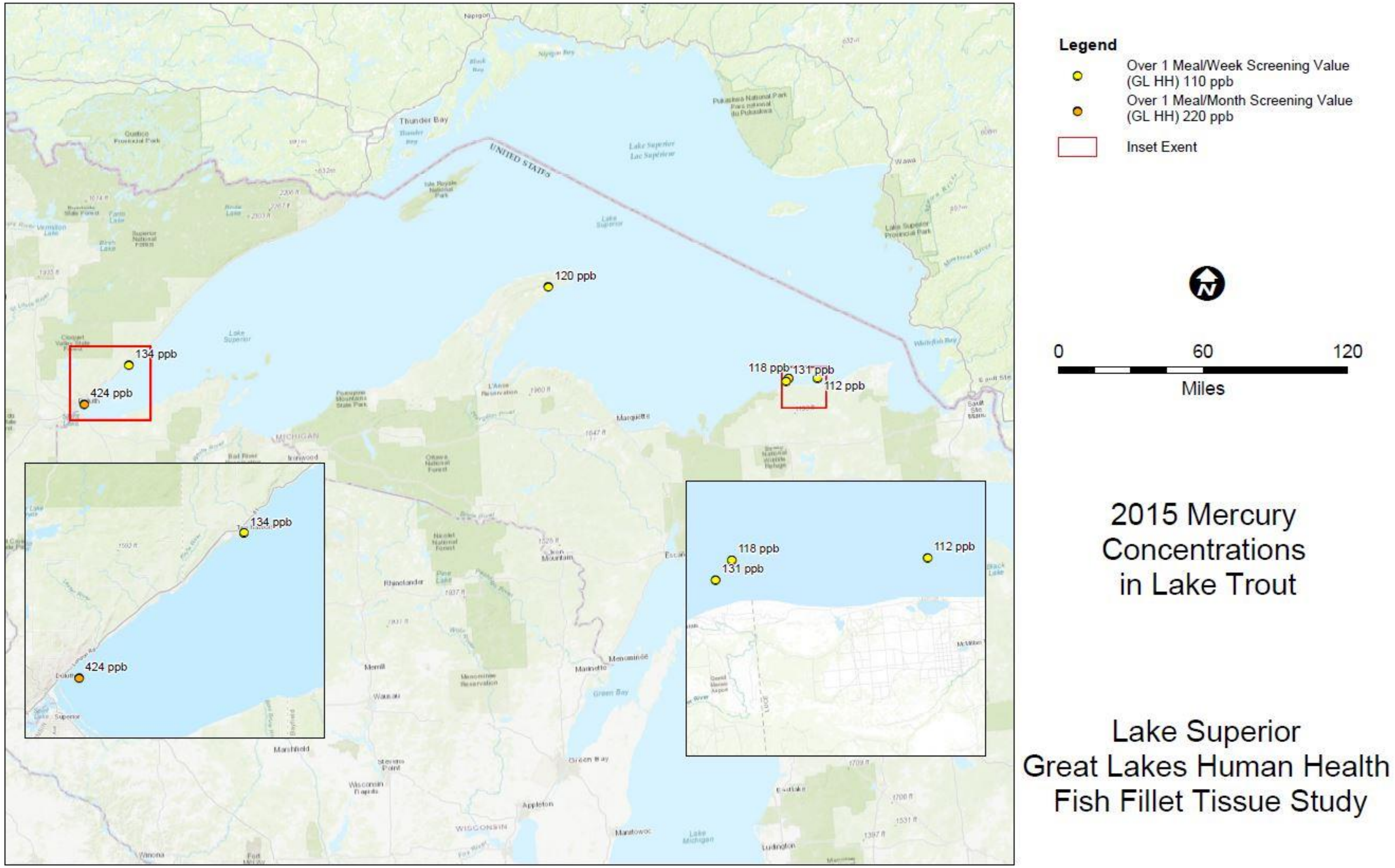


Mercury Releases to Air and Lake Trout Fillet Concentrations
Lake Superior Basin 1976 - 2015
Mercury Emissions kg/yr
2,500
2,000
1,500
1,000
500
0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Mercury µg/g Lake Trout
1976
1981
1986
1991
1996
2001
2006
2011
LT Fillet Hg Concentration (µg/g)
Great Lakes Protocol (Sens. Pop.) 1 meal/mo >0.22 µg/g
LSB Hg Discharge kg/yr
Expon. (LSB Hg Discharge kg/yr)

Mercury in Great Lakes whole fish



Mercury in Lake Superior lake trout fillets



Mercury in Great Lakes fish

STATE OF THE GREAT LAKES 2017

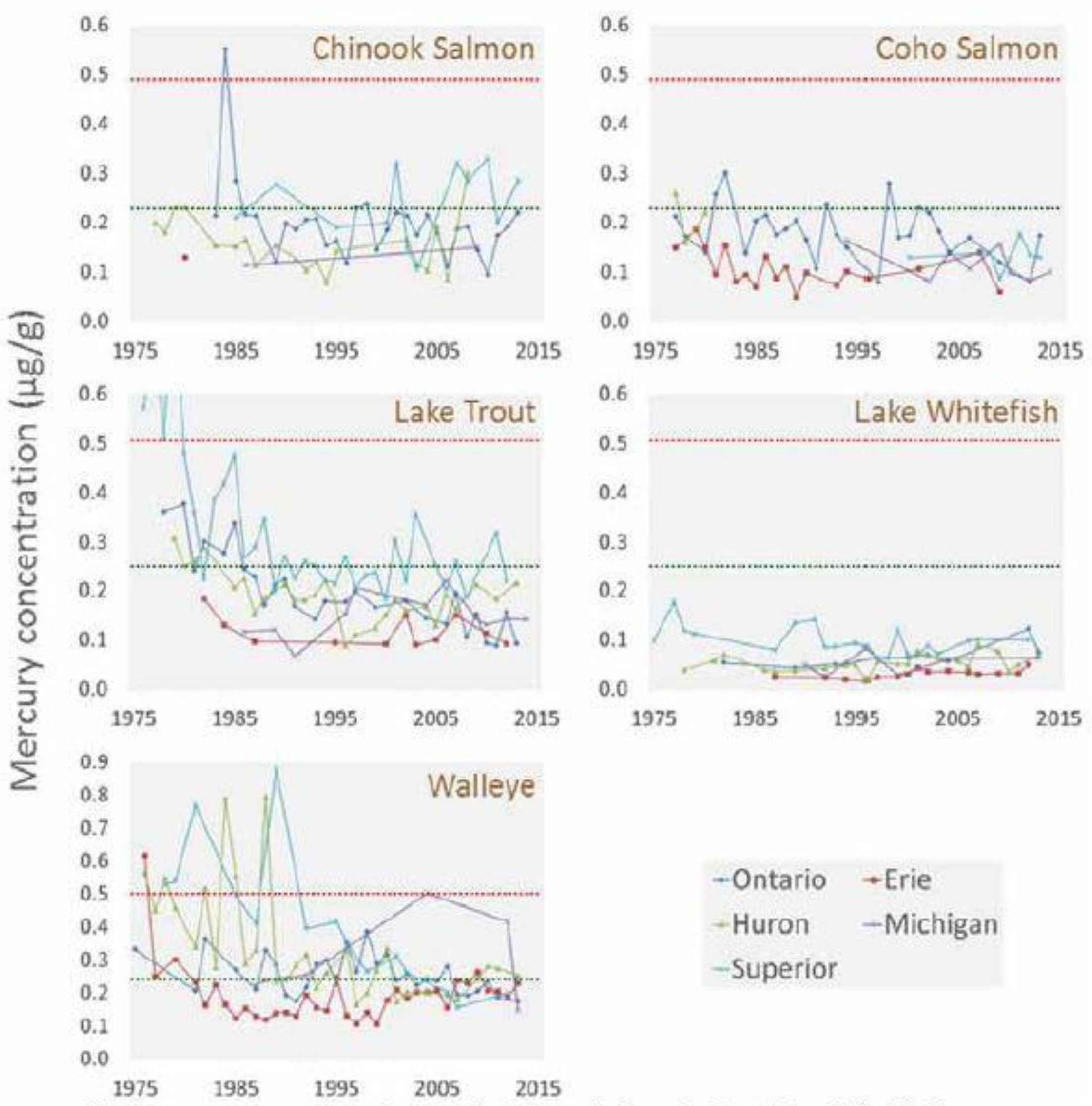


Figure 2. Total mercury concentrations (µg/g) in five fish species from the Great Lakes. Lake Michigan measurements were for skin-on fillets, while skin-removed fillets for the other lakes. Dashed red and green lines represent an estimated binational health related benchmark for the general and sensitive populations, respectively (see Table 1). Source: Ontario Ministry of the Environment and Climate Change, and U.S. Environmental Protection Agency.

Mercury in Great Lakes sediments and fish

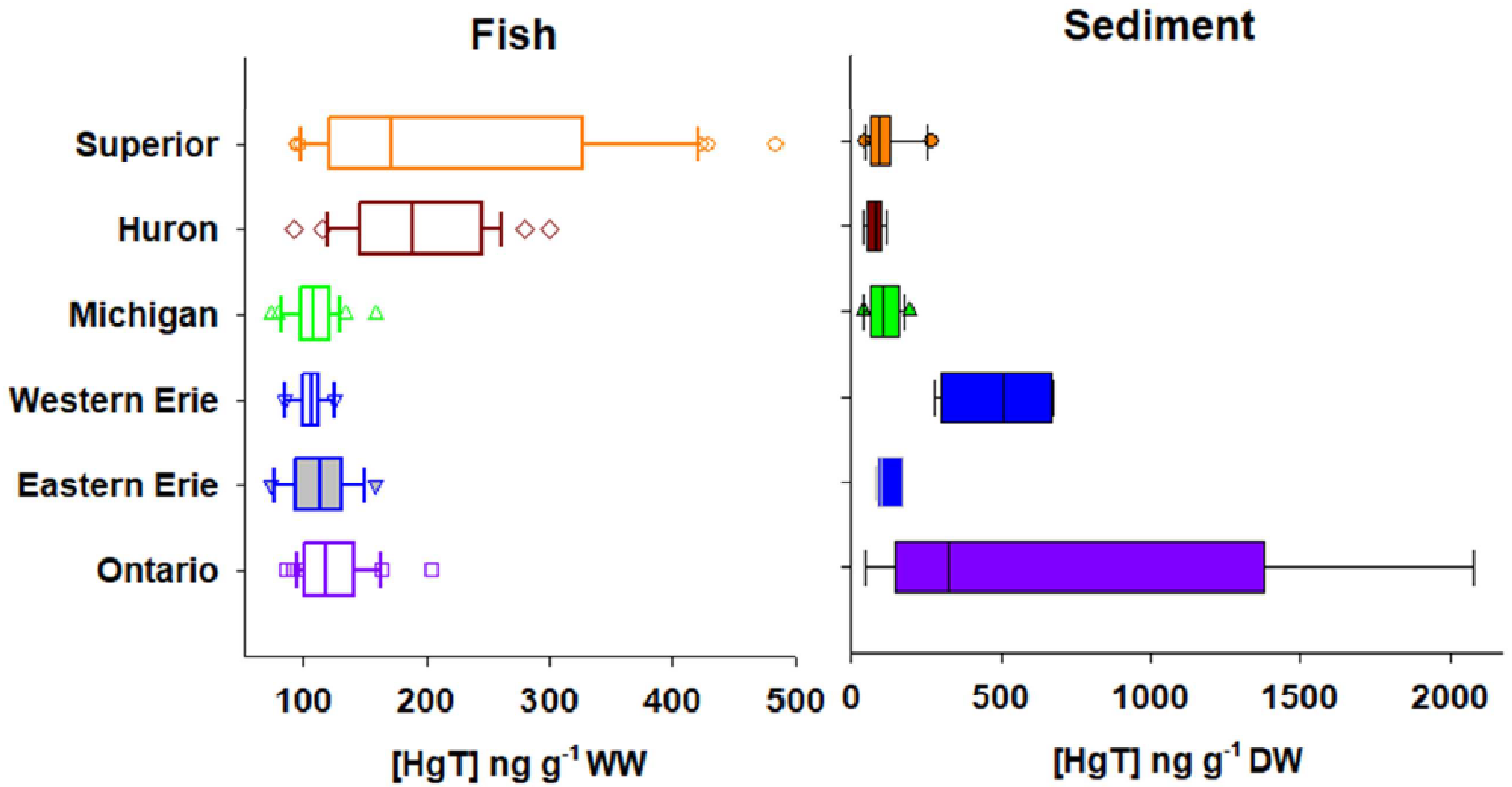
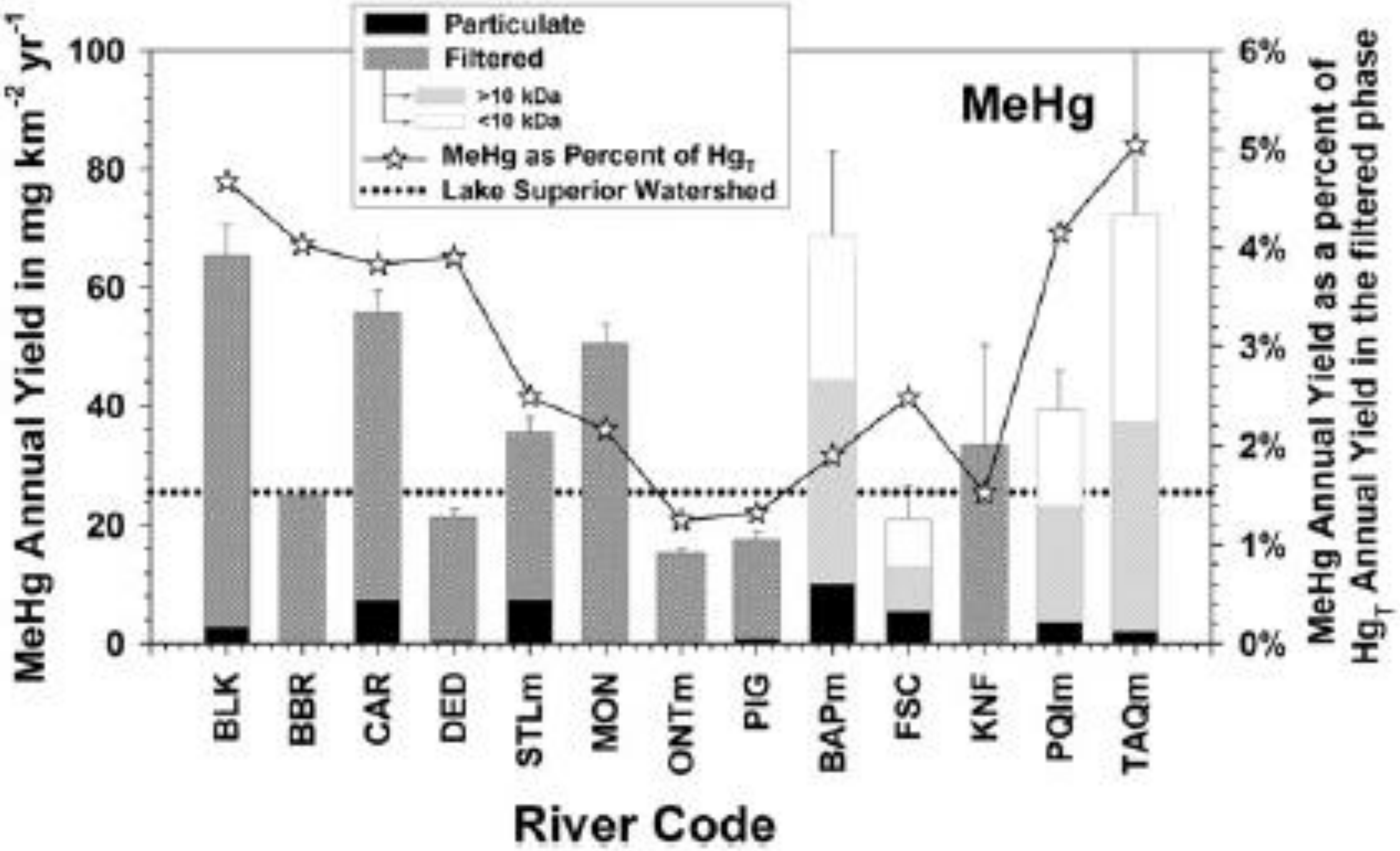


Figure 1: Comparison of total mercury (HgT) in fish tissue (left) and sediment (right) from the Great Lakes. In fish[36], HgT concentrations represents wet weight (ng g^{-1}) where the box ends and whiskers are quartiles, the center line the median and outliers are shown. Right side bar graphs are mean dry weight HgT concentrations (ng g^{-1}) in sediment, previously published in Lepak et al[2].

Zones of mercury methylation on landscape

- Water residence time and flow pathways of runoff
- Land cover
  - Affects dry deposition rates
  - Affects degree of interaction between water and both methylating and non-methylating soils
- Land-use
  - Sediment transports – in watersheds with mostly ag and erodible soils, contribute larger amounts of Hg to sites of methylation than forested watersheds
  - Forestry operations shown to increase the load of MeHg to the aquatic ecosystem
- Wetlands in watershed may also produce MeHg which could be transported to the reservoirs

Mercury loading from Lake Superior tributaries



Effect of wetlands on the watershed

Large wetland areas in the watershed will increase methylmercury:

- More microorganism activity resulting in more humic acid, or tannic acid material, dissolved organic matter, leaching out of the wetlands
- Abundant hydrologically connected wetlands contributes to MeHg production

LAMP projects

Projects underway:

- Mercury load monitoring in ditched peatlands
- Mercury in Lake Superior sediments

Projects under consideration:

- Mercury load monitoring in lake superior tributaries
- Identifying isotopic signatures of mercury in fish, air, and sediment to characterize fate and transport of mercury in Lake Superior Basin

Monitoring mercury loading from peatlands

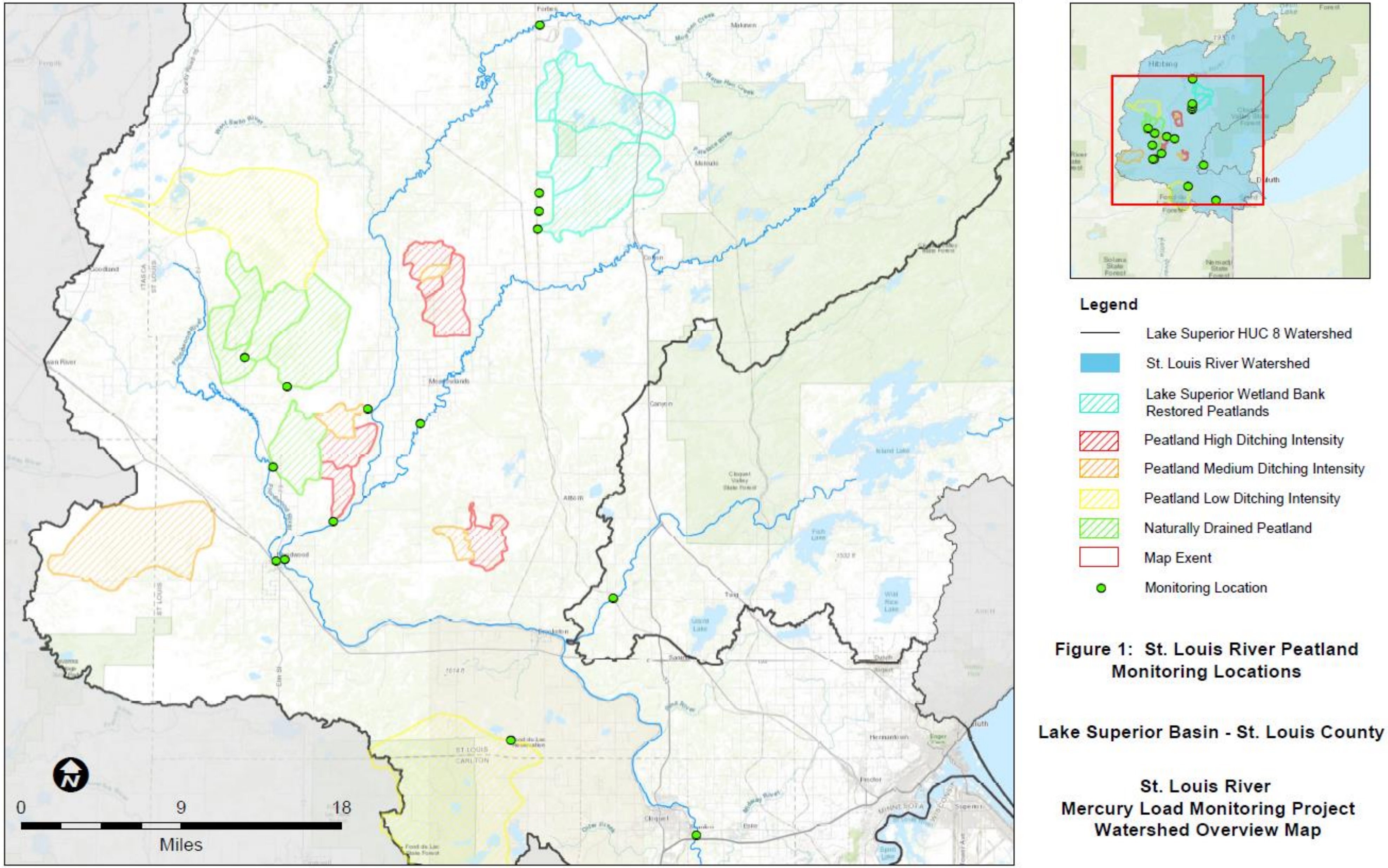


Figure 1: St. Louis River Peatland Monitoring Locations

Lake Superior Basin - St. Louis County

St. Louis River
Mercury Load Monitoring Project
Watershed Overview Map

Monitoring mercury loading from peatlands

USEPA Great Lakes Sediment Surveillance Program (GLSSP)

- Project will measure mercury and other persistent bioaccumulative toxic contaminants in Great Lake sediments
- Spatial and temporal trends, advancing understanding of contaminant fate and transport processes

Mercury load monitoring in Lake Superior tributaries

Monitor total mercury and methyl mercury in ~20 Lake Superior tributaries:

- US and Canada
- Understand sources of methyl mercury to Lake Superior
- Compile with empirical data and assess temporal trends
- Identify landscapes and ecosystems that are drivers of MeHg loading
- Establish management recommendations

Mercury source identification via isotopes

Isotope ratios in mercury sources need to be established to tease out source contributions of mercury to Lake Superior fish:

- Identify mercury isotopes in air, and mercury isotope composition in rain, snow, and runoff in Lake Superior Basin
- Identify a signature for taconite industry
- Conduct targeted sampling of air and soils/sediments in downwind trajectory of several taconite production facilities
    - Integrated one-week air samples collected from 4 locations at 6-week intervals for1 year
    - Soil and sediment samples will be collected from 25 locations in around the iron-processing facilities

Recommendations

- Identify feasible landscape habitat projects that reduce the methylation of mercury
- Monitor mercury in the lower food web to understand mercury pathways to Lake Trout
- Minimata Convention On Mercury – Designate Lake Superior as a Minimata Effectiveness Evaluation Site – 2023, the convention goes into action
  - World class fish archive
  - Long-term atmospheric monitoring records
  - Use Lake Superior to measure the effectiveness of the Minimata Convention
- Watershed monitoring in US and Canada by USGS

Thank you!

Jesse Martus

jesse.martus@state.mn.us

MINNESOTA POLLUTION CONTROL AGENCY