Site Needs for Program Objectives

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On behalf of many!
Types of Sites Needed

- **Trend Sites:** Documents change in concentrations w/out focusing on causal factors or explanations

- **Causality Sites:** Critically assess the role of changes in emissions and other key factors driving changes in environmental Hg concentrations
Trend Sites Continued

- Answer the question “Has there been a change?”
- Apply a core set of indicators to document change
- Minimal emphasis on ancillary data
Trend Sites & Program Objectives

- Establish baselines in multiple ecosystem components prior to anticipated emission control
- Track spatial and long-term temporal changes
- Co-locate with other complimentary monitoring programs
Causality Sites Continued

- Answer the question “What is causing the change?”
- Apply a suite of indicators that can link observed changes to key processes and/or mechanistic models
- Enhances the ability to interpret spatial and temporal trends and provide added confidence in ecosystem benefit assessments
Cauality Sites & Program Objectives

- Provide scientific understanding links between emissions tracking → environmental trends → MeHg in biota and effects
- Assess ecological harm to organisms of concern (threatened and endangered) with links to emissions and other important factors
Siting Criteria

- National distribution, including a wide range of settings (urban to remote); proximity to and inferred impact from local sources; and, ecosystem type/mercury sensitivity (but not too complex).
- Sites exhibiting a wide range of anticipated responses (magnitude and timing): perched lakes, seepage lakes, drainage lakes and reservoirs, streams, and estuaries.
- Sites expected to show maximal and minimal responses and not thought to be confounded by co-factors (other than emissions) → test our current conceptual models and scientific understanding.
- Reference sites: probably not a valid concept for Hg contamination (all sites are contaminated to some degree). Only applicable if the intent is to track and quantify impacts from global emissions sources.
Response to a Declining Load

50% reduction in Hg loading rate

Asymptotic
Linear, not directly proportional
Linear, directly proportional

50% reduction

[Hg]
Hg loading rate
The Mercury Cycle

Deposition

Emissions

Methylation

SRB

Bacteria

Bioaccumulation

Sulfate

Sulfide

Demethylation

MeHg

CH₂O

CO₂

Hg

Hg(II)

MeHg
Using Mercury Sensitivity to Anticipate Response
What is “Mercury Sensitivity”? 

**Whole yellow perch Hg**

- Max (pH 5.2)
- Vandercook (pH 6.1)
- Pallette (pH 7.2)

From Wiener et al., 2003
Dissolved HgT Concentrations in L658 Surface Waters (2001-2005)

Data source: The METAALICUS project
Watershed mercury exports will have a dominating impact on the response at certain ecosystems.
Importance of Non-Direct, Atmospheric Hg Loads

![Graph showing mercury load to lake over different periods]

- **Mercury load to lake (ug m^-2 lake yr^-1)**

- **Sources:***
  - Lake Spike
  - Ambient Wetland Export
  - Ambient Upland Export
  - Ambient Dry Deposition
  - Ambient Wet Deposition

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**Legend:**
- Lake Spike
- Ambient Wetland Export
- Ambient Upland Export
- Ambient Dry Deposition
- Ambient Wet Deposition
Do we include reservoirs?

Source: Paterson et al. 1998
Walleye Hg concentrations in Clay Lake, Canada, following reduced releases of Hg from a chlor-alkali facility 80 km upstream (standardized 50 cm fish)
Swedish study of fish Hg following 50% drop in wet Hg deposition

Were fish Hg decreases driven by less Hg deposition or other less acid deposition.. or less sulfate, or..?

Source: Johansson et al. 2001
An Example from Wisconsin, Little Rock Lake

From Watras and Morrison, 2008
An Example from Wisconsin, Little Rock Lake

From Watras and Morrison, 2008
Siting Needs for Model Development

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Siting needs for modeling

What questions will the models try to answer?

- Predict, then explain, the observed magnitude and timing of the response of MeHg in fish to changes in Hg emissions
- Separate these effects from confounding factors (climate, land use, etc.)
Current capability of Hg models

R&D tool to improve understanding

- Conceptual model development and incorporation of new R&D
- Model calibration
- Model validation

Predictions & explaining observed trends
Intensive sites well suited to process model development:

- Process level research
- Many steps from Hg emissions to fish. The more compartments that are monitored, the better to evaluate each step in models
- Ancillary data to deal with confounding factors
- Manageable scale
- Long term datasets
- Mutually benefit to modelers and researchers
One type of site is not enough....

Models can be forced to fit any one system

Calibrated model

Observed

1:1

Perfect

...
Need multiple sites to test model ability to predict without retuning each time........
Multiple sites should encompass an anticipated range for the:

- Magnitude of response
- Rate of response
Hg modeling: Scaling up to national scale

Models will likely be applied to intensive sites to help explain trends but what approach and data are needed to extrapolate to regions or nationally?
Fig. 2. Annual cycle of waterborne Hg$_T$ in LRL (●) and annual cycle of wet Hg deposition (shaded bars), 1994–2004: (a) stratified north basin; (b) unstratified south basin. Precipitation data are the seasonal running averages (13 weeks).
Fig. 3. Weekly changes in (a) atmospheric Hg\textsubscript{T} deposition (□) and (b) waterborne Hg\textsubscript{T} (●) and meHg (○) in LRL, 2002–2004. Shaded bars in (a) are annual atmospheric Hg\textsubscript{T} deposition. Lake data in (b) are whole-lake masses for the unstratified south basin.
Percent increase in methylmercury concentration due to the 120% extra loading of Hg(II) to the lake.
Examples from the METAALICUS project

**THg (µg/g ww)**

Yellow Perch (age 1)

Northern Pike

percent increase

Yellow Perch (age 1)

Northern Pike

99 00 01 02 03 04 05 06

00 01 02 03 04 05 06
From Watras and Morrison, 2008
Emissions controls start

Terrestrial Hg keeps rising after controls and stays above current levels

Possible response of terrestrial Hg export after 25% reduction in Hg deposition