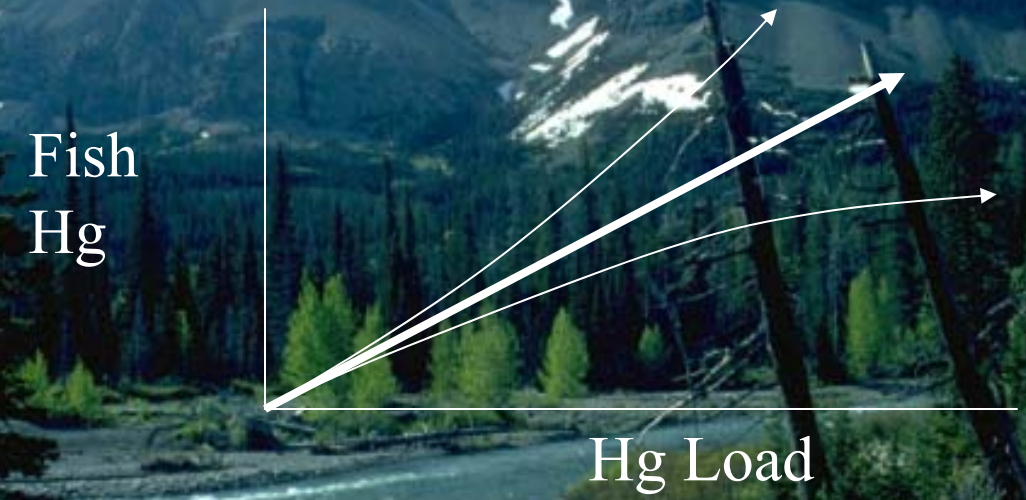
The Relationship Between Mercury Loading And Fish Mercury Concentrations: Some Modeling And Field Perspectives



Reed Harris
Tetra Tech Inc.

January 4, 2005

Lab experiment showing linear effect of HgII load on methylmercury production… to a point.. What about real world?

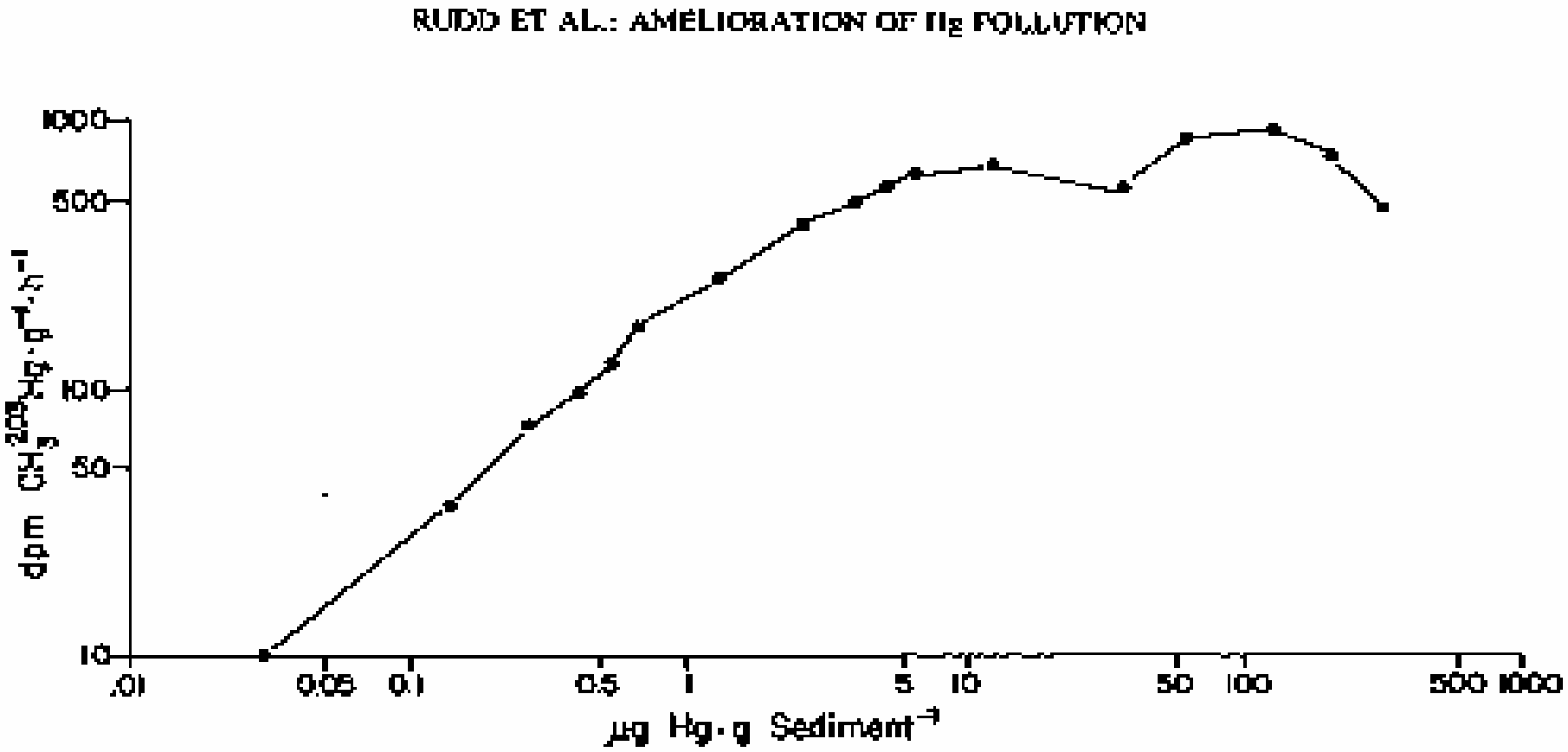
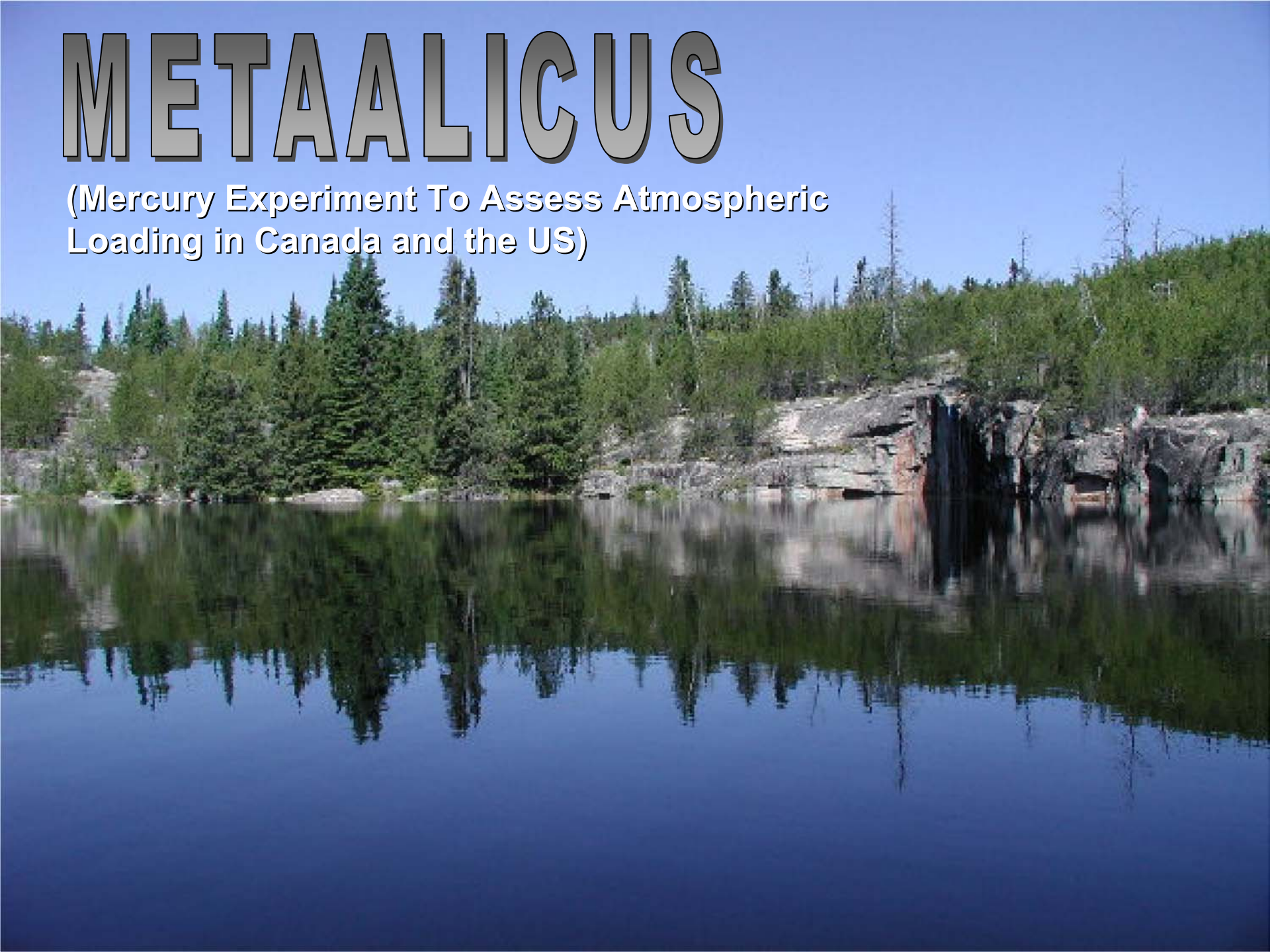


FIG. 3. Influence of inorganic Hg concentration on methyl mercury production rate. Aliquots of a surface sediment sample were incubated for 18 h in 250-mL ground glass stoppered bottles in the presence of increasing concentrations of $^{201}Hg^{2+}$. Analyses of the quantities of $CH_3^{203}Hg^+$ were carried out as described in Furutani and Rudd (1980).

Effect of Hg deposition on fish Hg

- Some datasets suggest a link
- Difficult to isolate effects of Hg loading


METAALICUS
(Mercury Experiment To Assess Atmospheric Loading in Canada and the US)

Principal Investigators:

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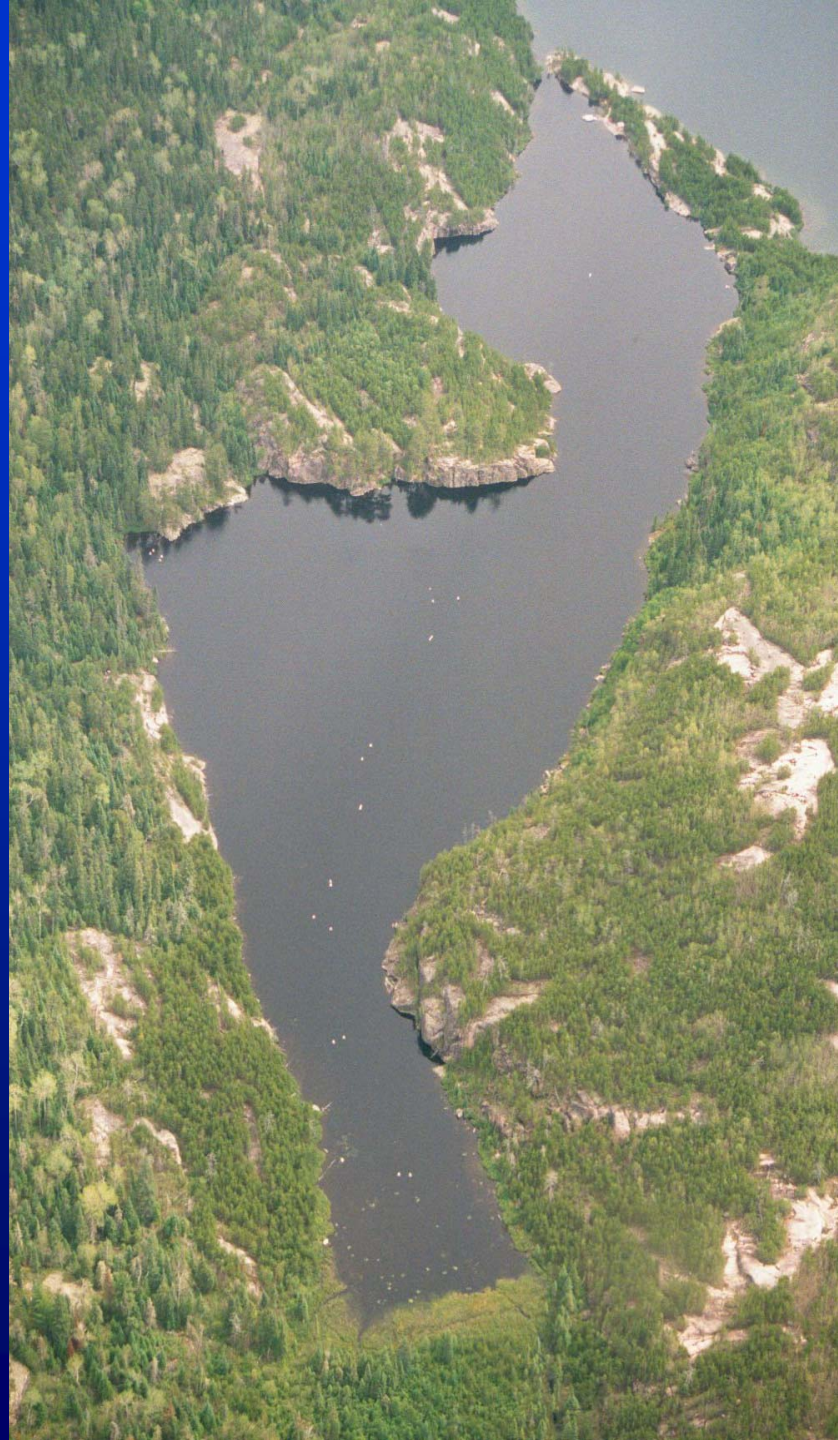
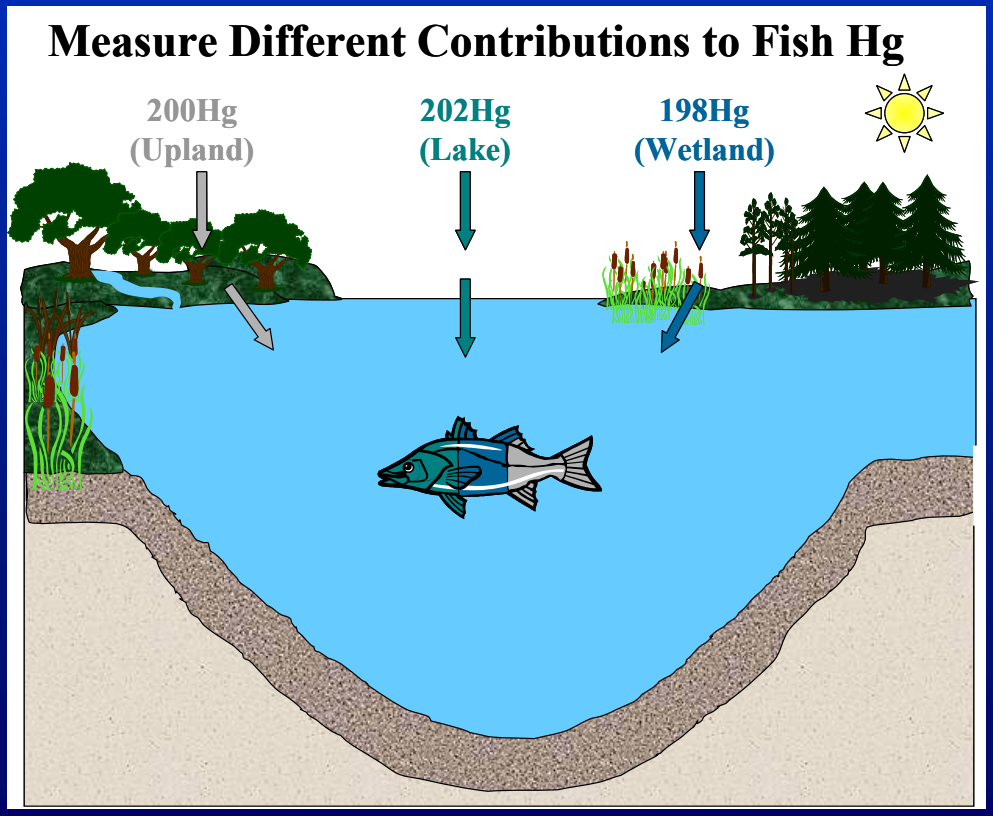
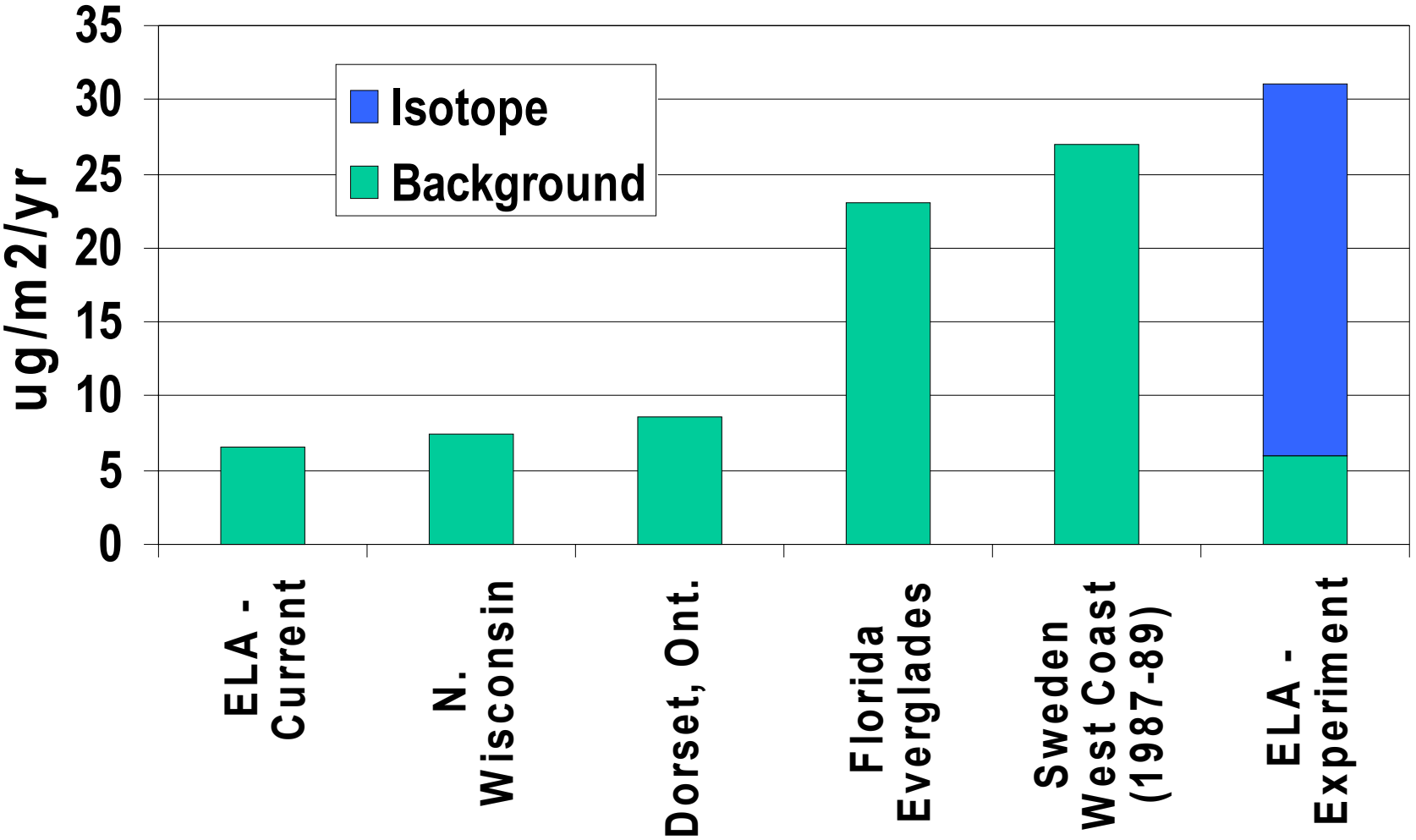


What is METAALICUS?

- *A loading experiment*: Mercury is being added to a lake and its surrounding watershed.



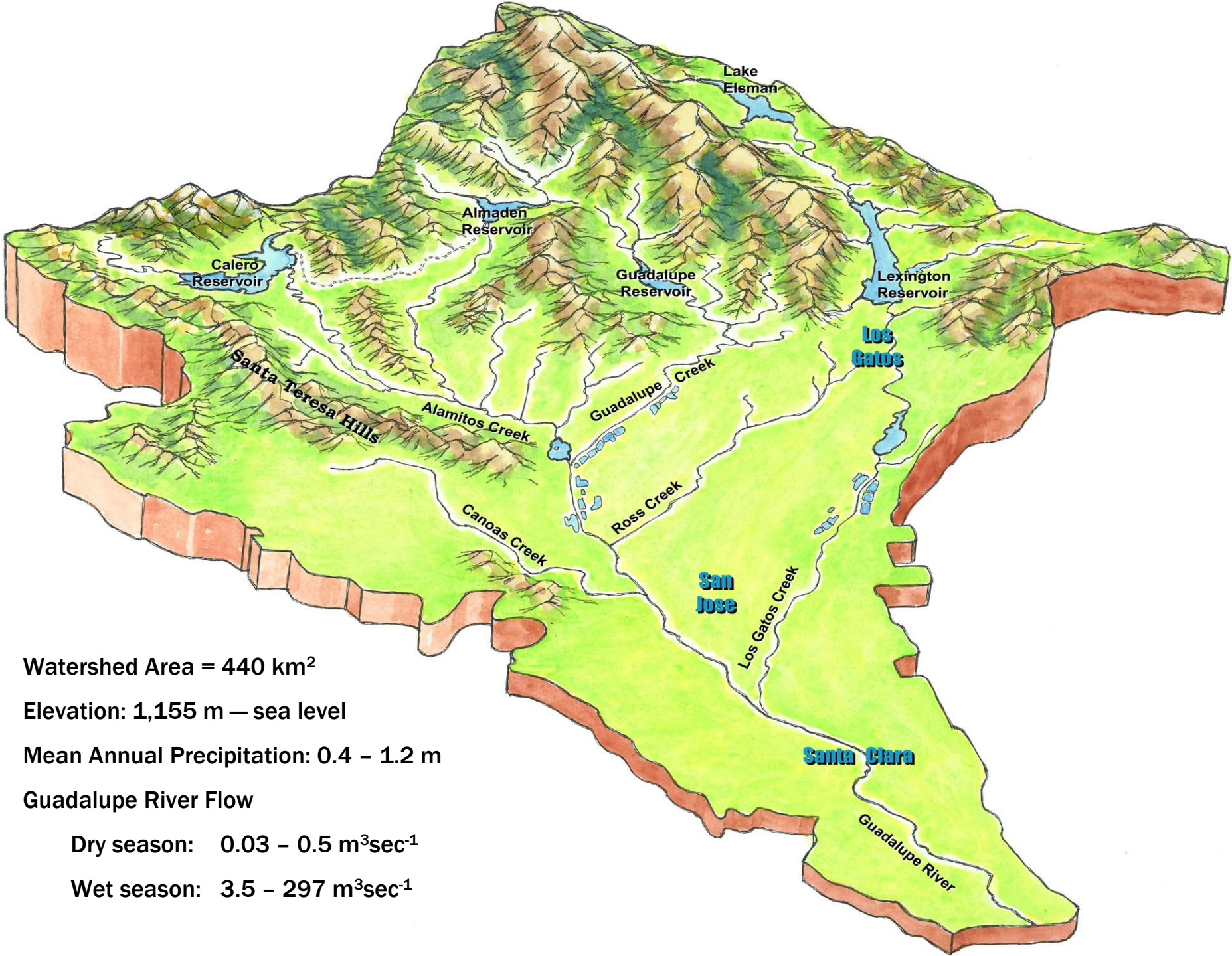
How much is wet Hg deposition being increased?



The Experimental Lakes Area Research Facility

What about effects of point source Hg loads?

- 10 tonnes of Hg released to Wabigoon River from 1962-69



Watershed Area = 440 km^2

Elevation: 1,155 m — sea level

Mean Annual Precipitation: 0.4 – 1.2 m

Guadalupe River Flow

Dry season: 0.03 – 0.5 $m^3 sec^{-1}$

Wet season: 3.5 – 297 $m^3 sec^{-1}$

Modeling

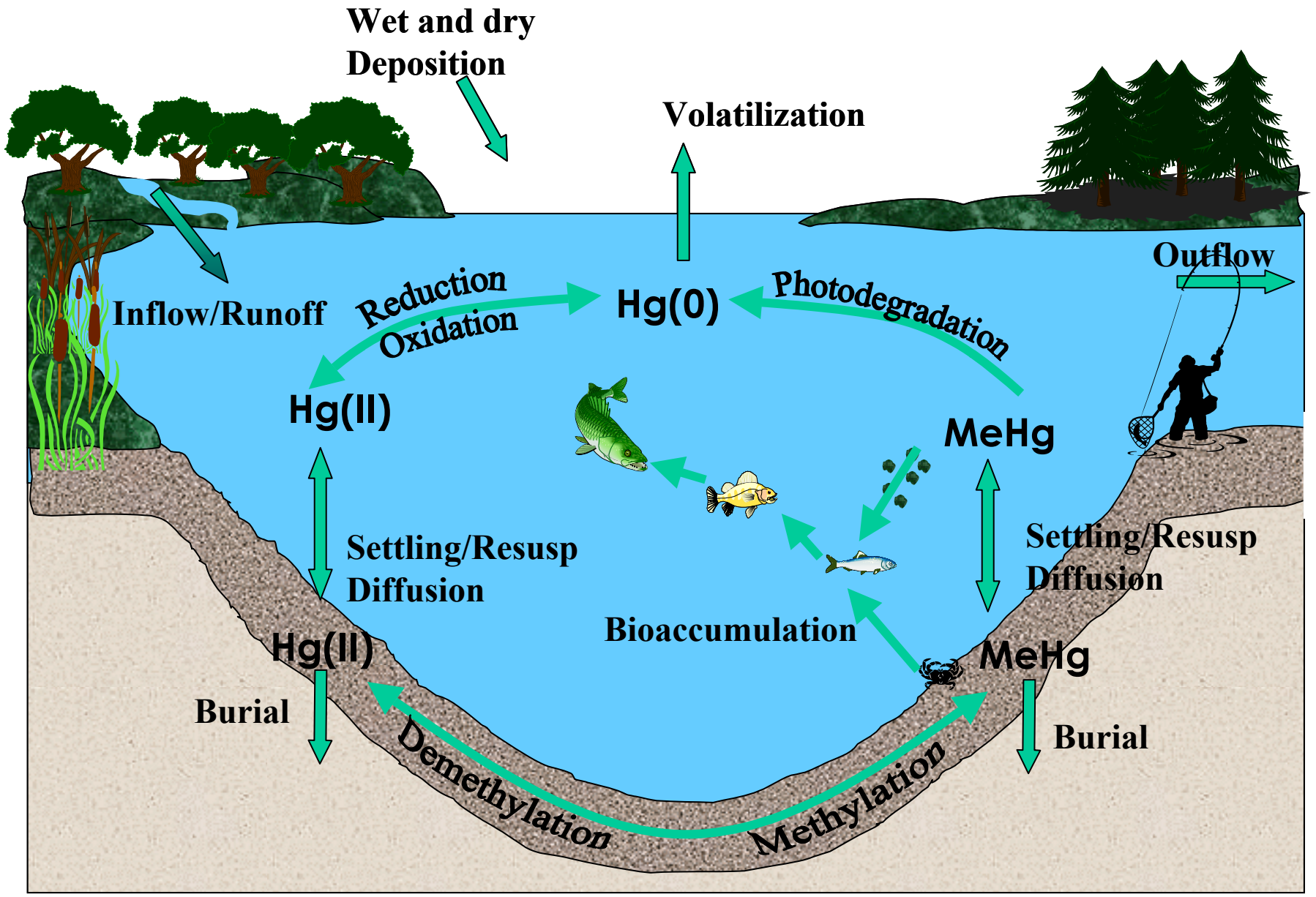
What are the "MCM" Models?

- Models to predict the behaviour and bioaccumulation of mercury in lakes or wetlands

← End point of concern is typically fish Hg

- Process, mass balance approach to follow important forms of Hg
- Developed by EPRI, Wisconsin DNR, EPA, Florida DEP, South Florida Water Management District

Mercury Cycling in D-MCM



MCM Applications

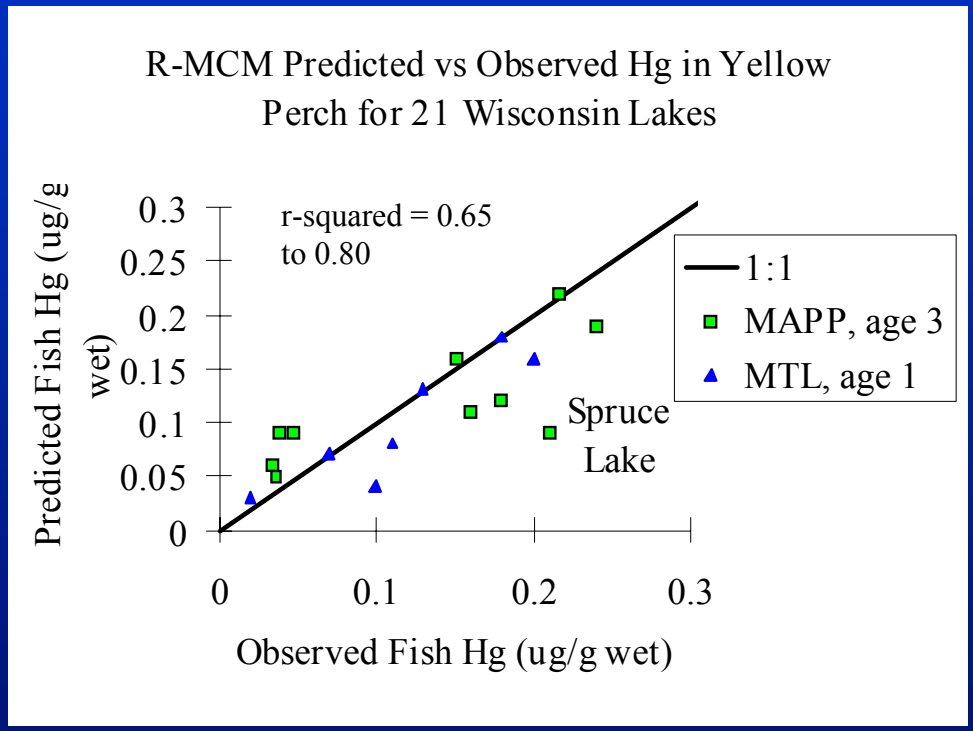
Initial model development based on intensive studies in Wisconsin

1) Mercury in Temperate Lakes Study (MTL)

- Original model developed and applied to 7 Wisconsin Seepage Lakes

2) Mercury Accumulation Pathways and Processes (MAPP)

- Extension of model to wider set of 21 Wisconsin seepage lakes

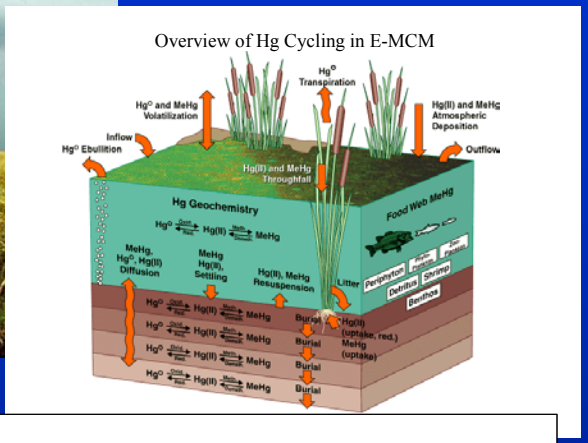


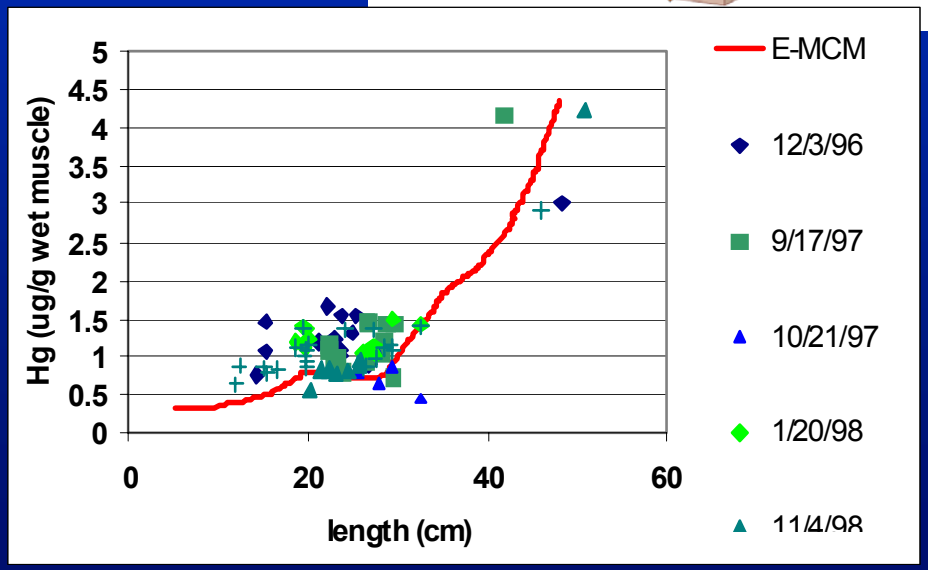
1988-95

Pilot Hg TMDL for Florida Everglades:

Everglades MCM (E-MCM)

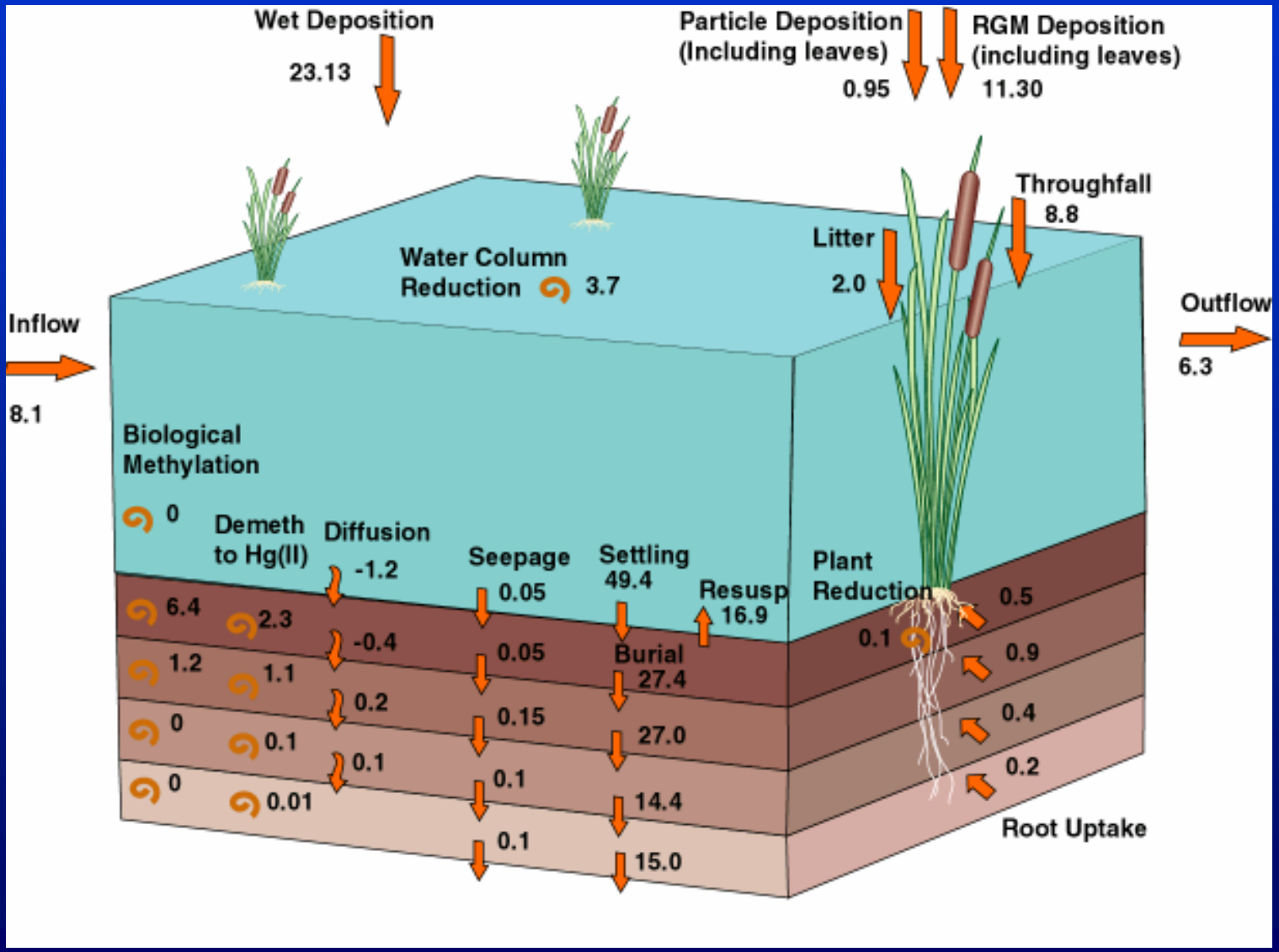
- Lake model adapted for Everglades marshes
- Closely tied to ACME and other R&D programs
- Model applied to several sites ranging from low to high fish Hg
- E-MCM used in pilot Hg TMDL at hot spot





Modeled Hg in largemouth bass in WCA 3A-15 (calibration is better description than prediction)

Estimate Hg loads to system and model what happens under different loading regimes..



Calibrate Hg concentrations in fish of interest..

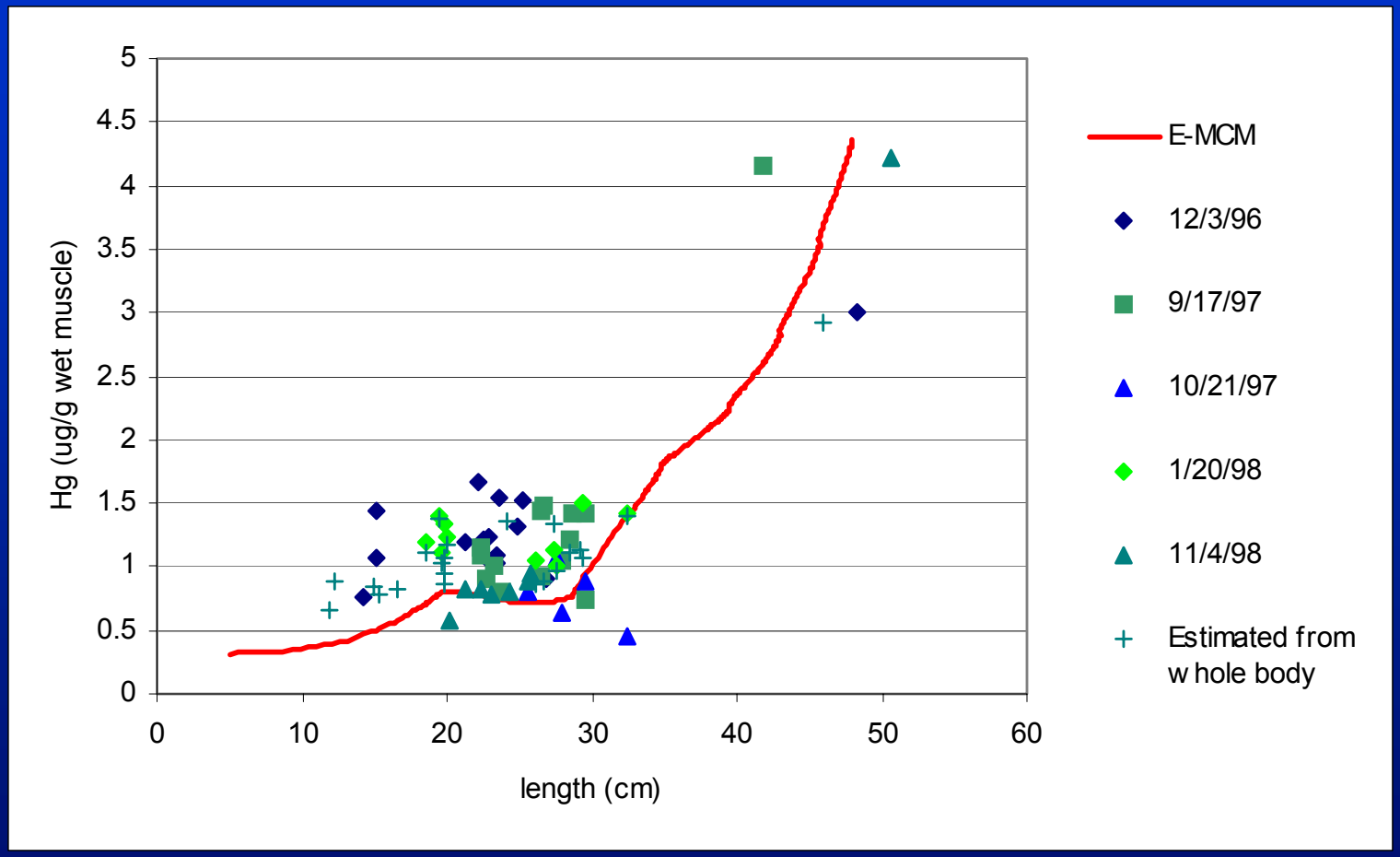
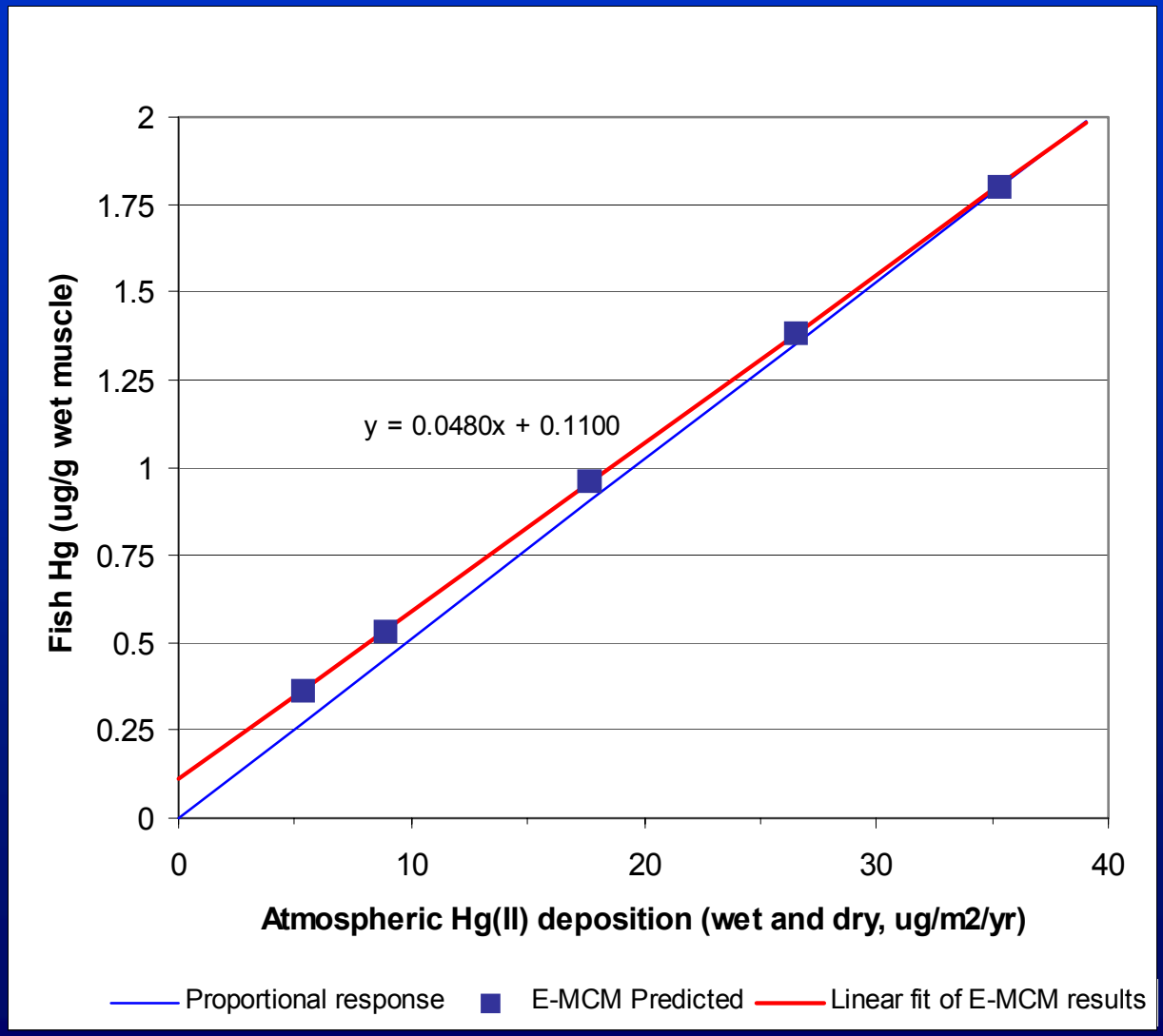


Figure 20. Predicted long-term methylmercury concentrations in largemouth bass in WCA 3A-15 for calibration with current atmospheric Hg(II) deposition = 35.32 mg/m2/yr. Observations: Lange et al., unpublished data

Make predictions about long term magnitude of response to changes in loading..



Make predictions about timing of response to changes in loading..

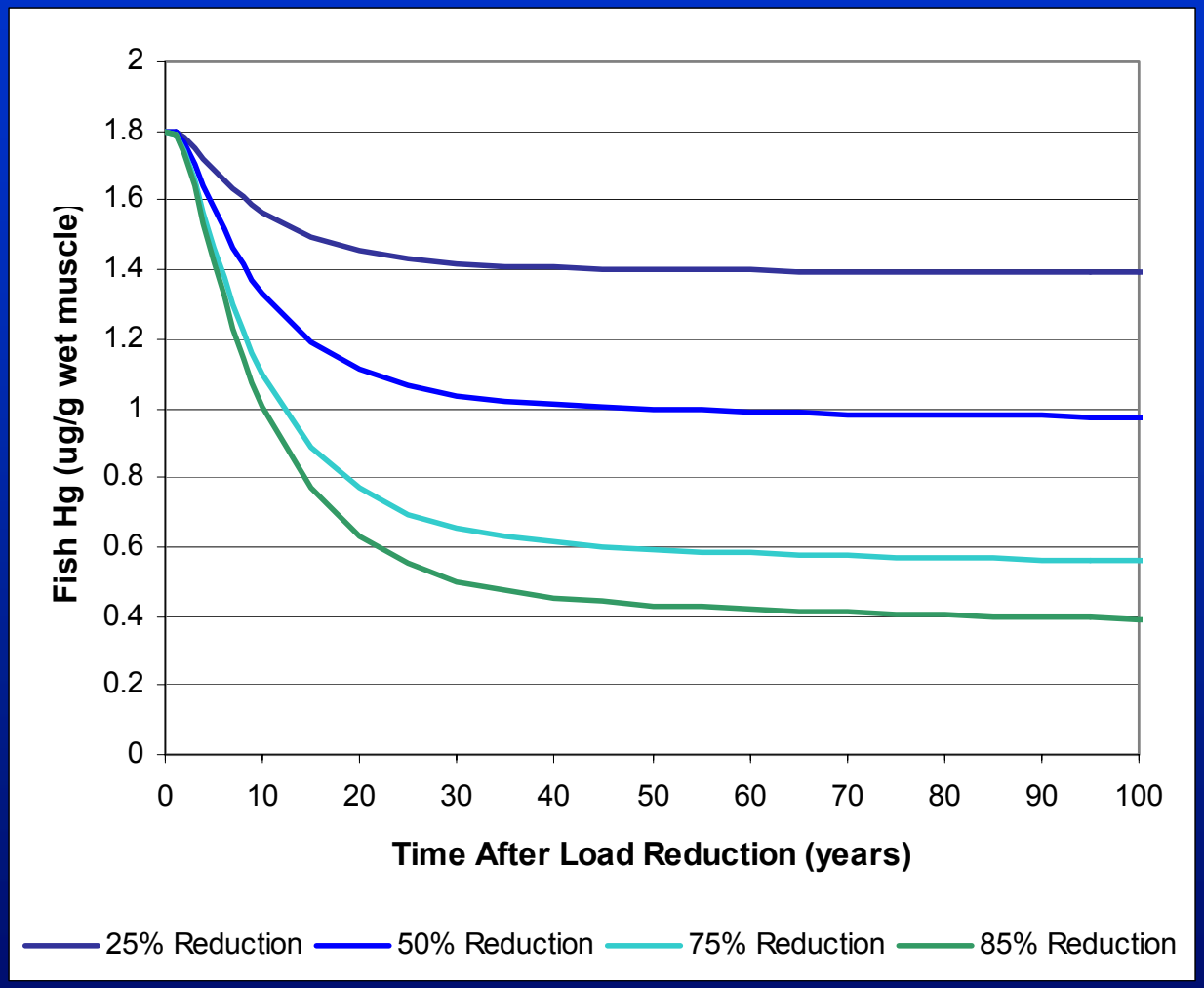
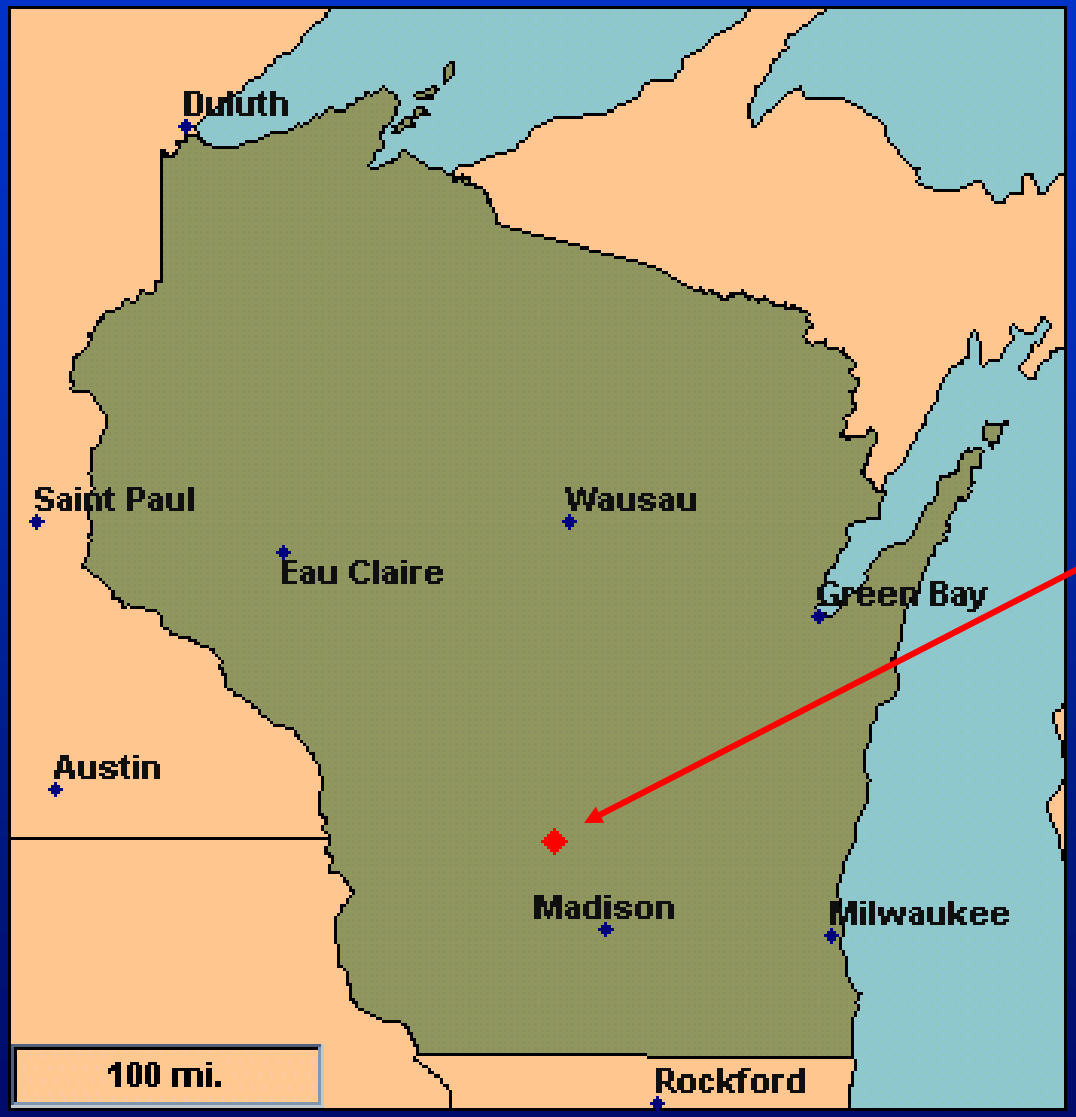


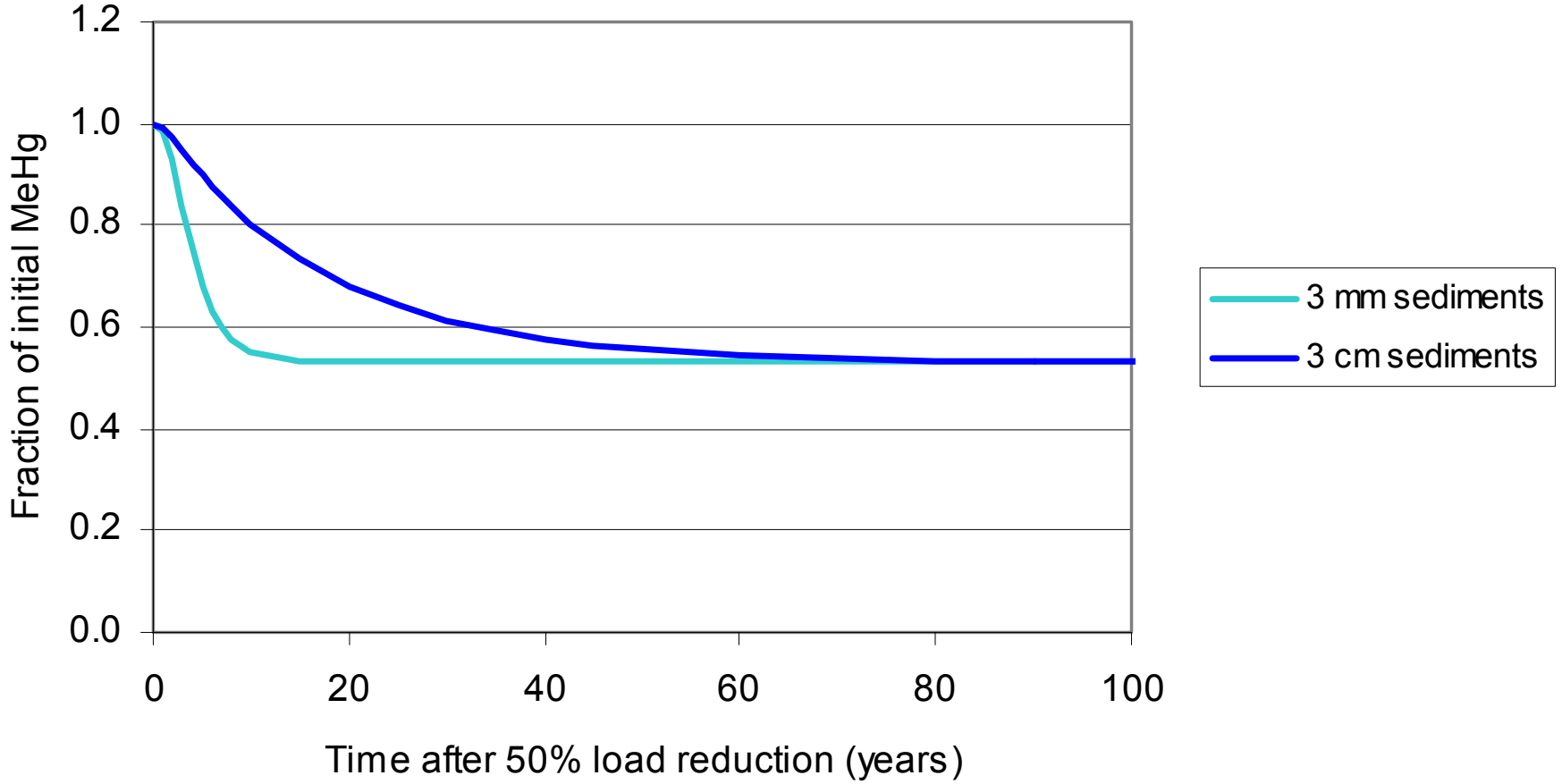
Figure 25. Predicted dynamic response of Hg concentrations in largemouth bass in WCA 3A-15 following different reductions in Hg(II) deposition.

Aquatic Modeling for Devil's Lake, WI
Pilot Mercury TMDL

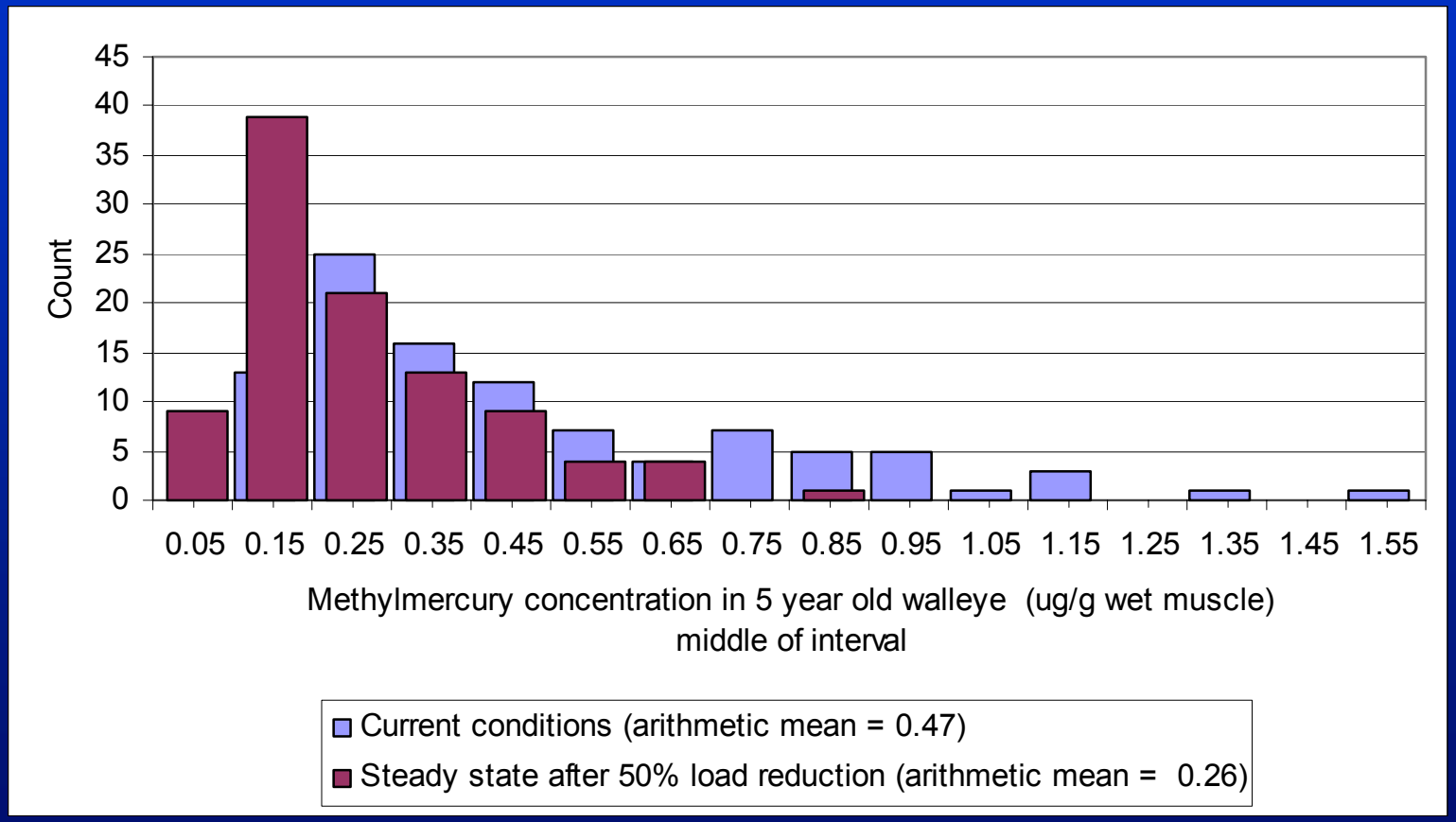


Devil's Lake, WI

Effect of assumed sediment depth on predicted timing of response for Devil's Lake..



Handling uncertainty: Monte Carlo approach



Current capability of Hg models

R&D tool to improve understanding

Terrestrial models

Marine models

Rivers

Lake models

Atmospheric models

Fish Bioenergetics

➔ Model development and incorporation of new R&D

➔ Model calibration

➔ Model validation

Predictions and mitigation testing

Modeling challenges for Hg TMDLs

- **Predicting the magnitude of the response:**
  - Are the assumptions resulting in a near-linear response to Hg loading true?
  - What Hg species are methylated and where?
- **Predicting the timing of the response:**
  - How big are the pools of Hg involved (new/old Hg, depth of sediments..)
  - What time lags are imposed by the terrestrial system
- **Data:**
  - Establishing baselines
  - Getting models to work with reasonable amount of data.
- **Uncertainty** associated with predictions

River Hg modeling..
Peak effect for MeHg may not be at point of release?

Dissolved oxygen analogy, but dealing with a source instead of a sink: