Project Update: Review of Conceptual Site Model of Mercury Cycling in South River

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HydroQual

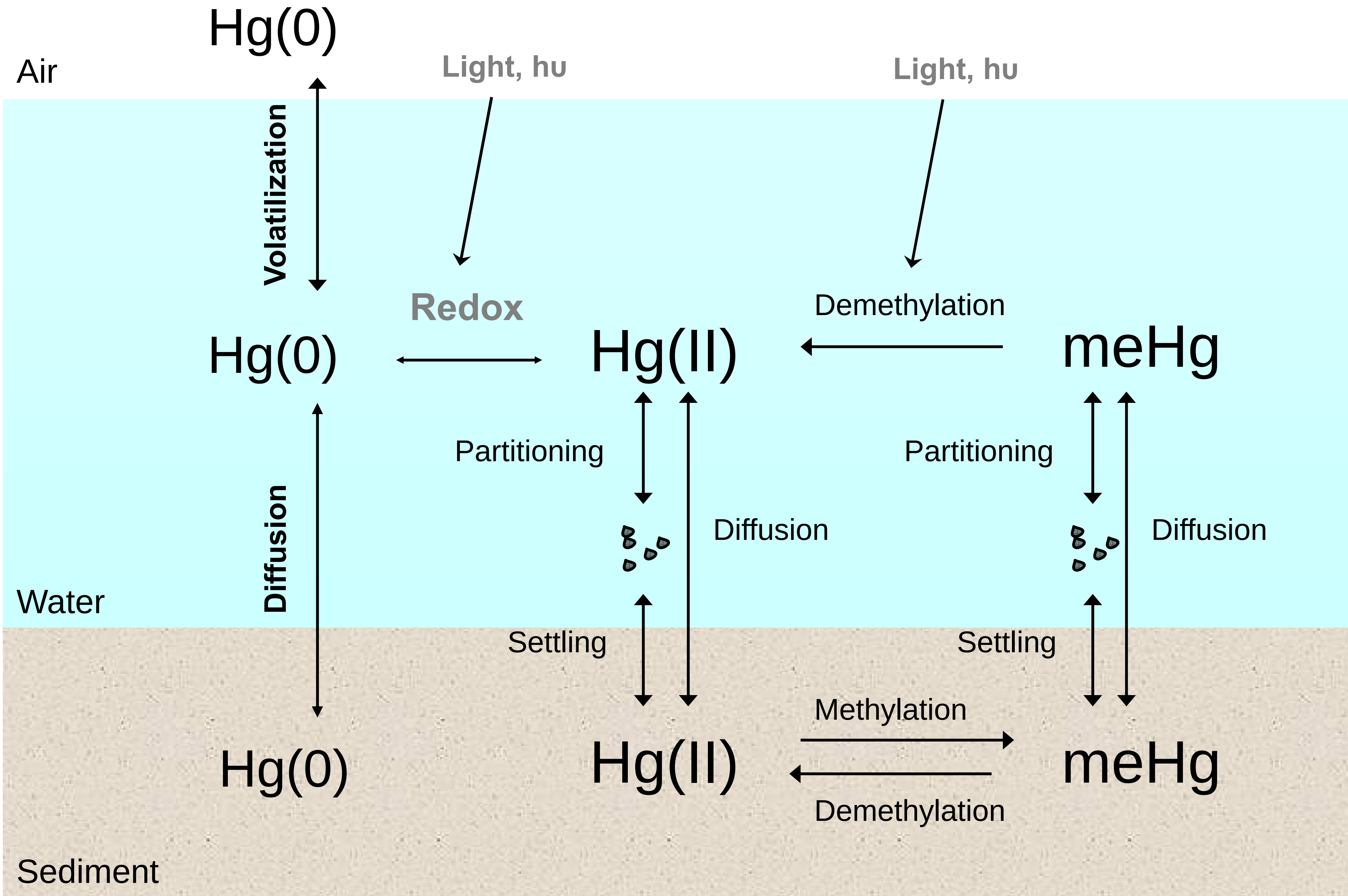
Goals and Objectives

A semi-quantitative approach is used to:

- Identify potential sources of mercury and methylmercury to the South River
- Identify important processes for migration and exposure pathways
- Identify data needs for further refinement of the CSM
- Recommend new or improved methodologies for collecting data to meet needs

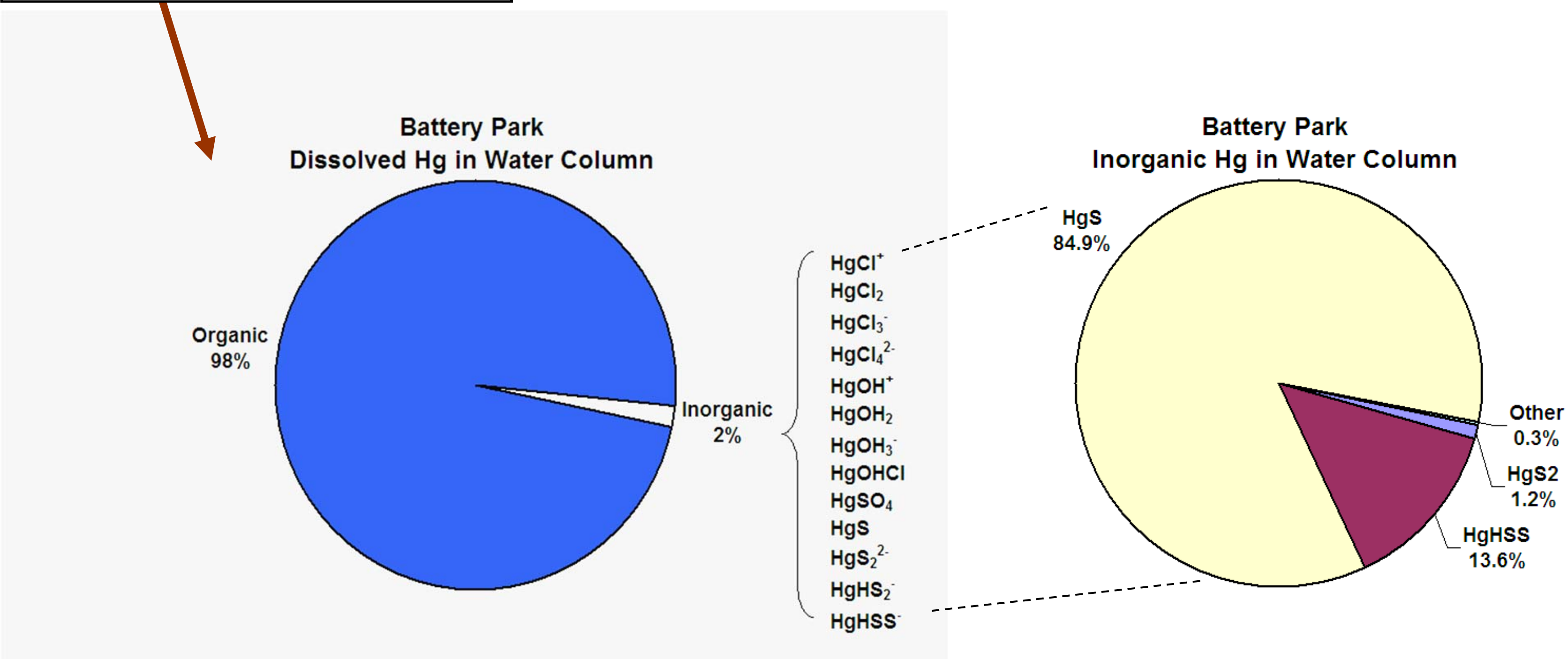
    - See last slide for citations on conceptual model for Hg bioavailability

Conceptual Mercury Model



Water Column Inorganic Hg Distribution – NY/NJ Harbor

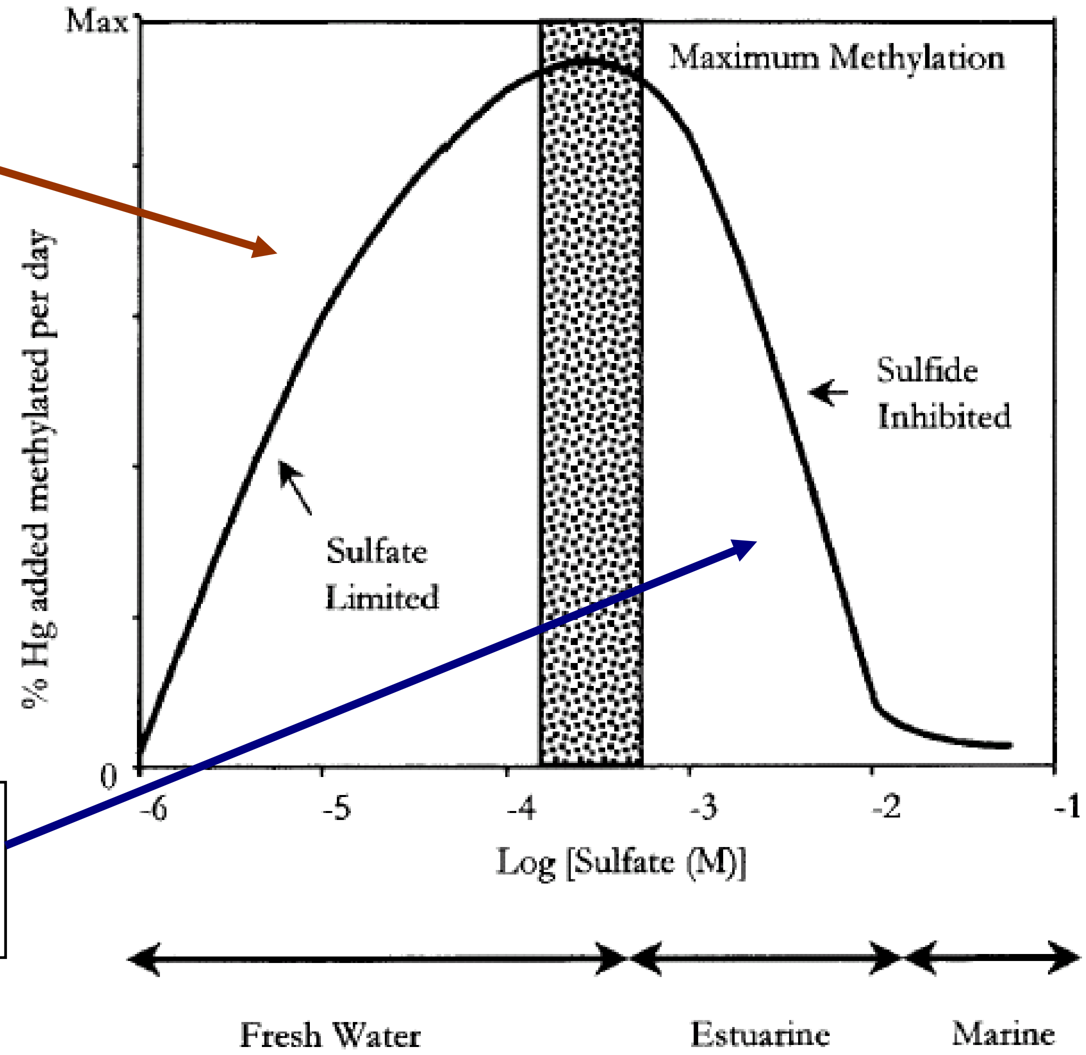
- Inputs: DOC, POC, Sulfide, pH and more



The Evolving Conceptual Model of Microbial Mercury Methylation

(Gilmour and Henry 1991 as redrawn by Langer et al 2001)

Sulfate, Carbon, Nitrogen, and Phosphorous (Mercury2006)

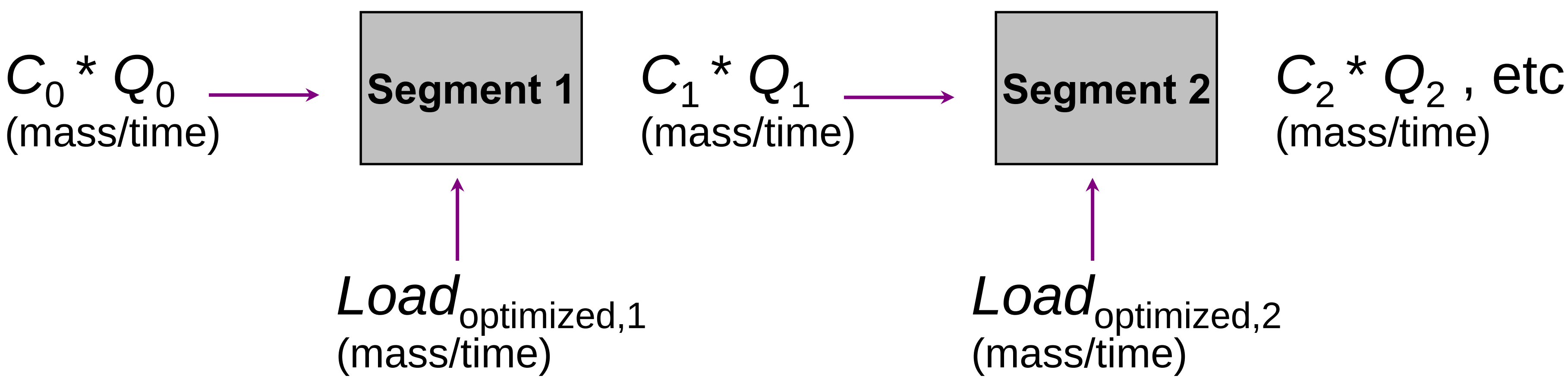


- Hg speciation affect bioavailability

Evaluating Potential Sources

Loading Model

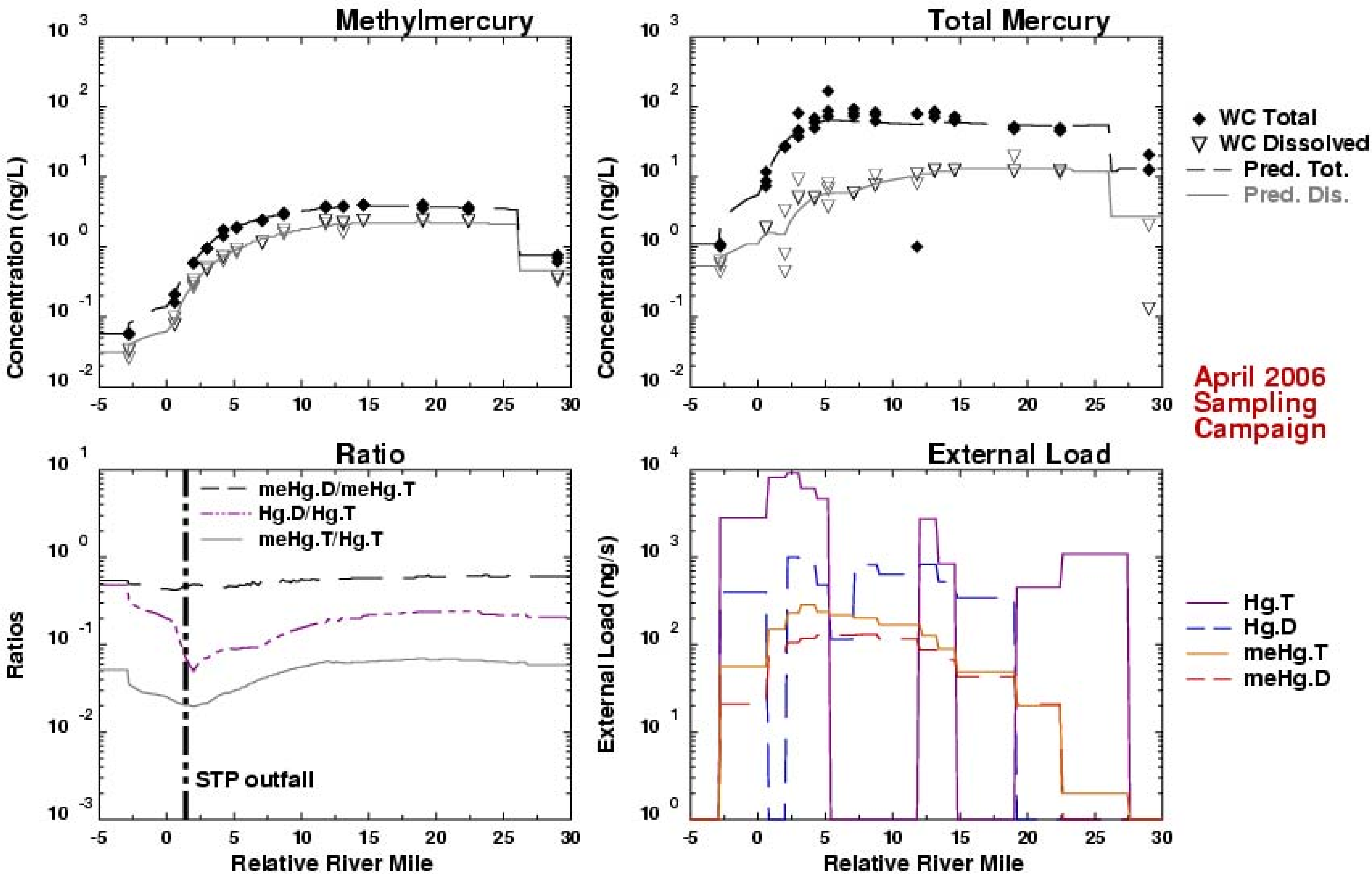
- Empirical loading model fitted to data (least squares) to identify regions of differential Hg/meHg inputs
- Also, areas of differential partitioning are identified
- Results related to physical and biogeochemical parameters that can affect fate of Hg and meHg
- Framework applied to filtered and unfiltered Hg, meHg measurements:



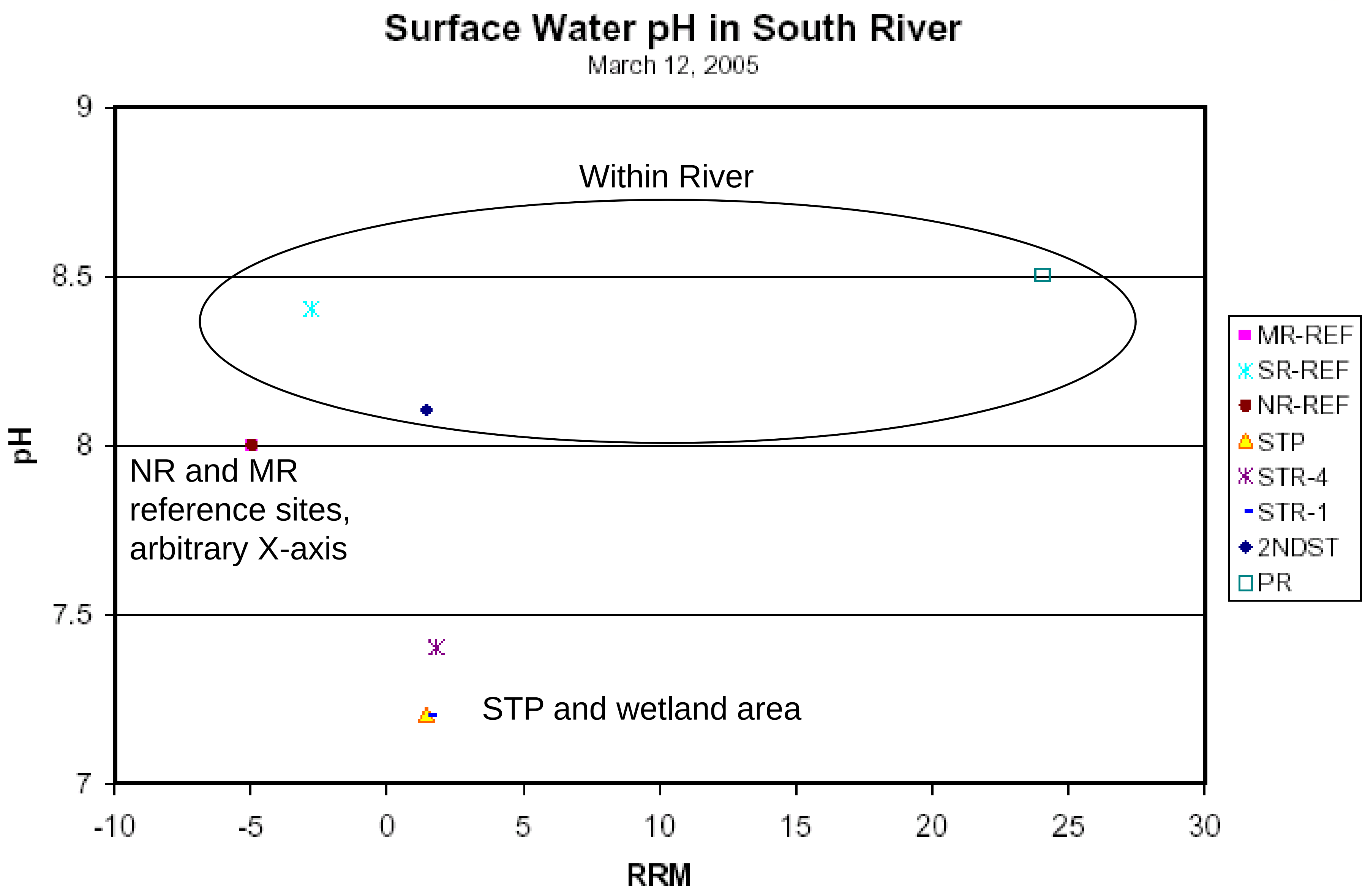
  – 0.2 mile increments, RRM -2.8 to 30, assuming linearly increasing flow

Transect of Water Column Dissolved and Total Concentrations along the South River

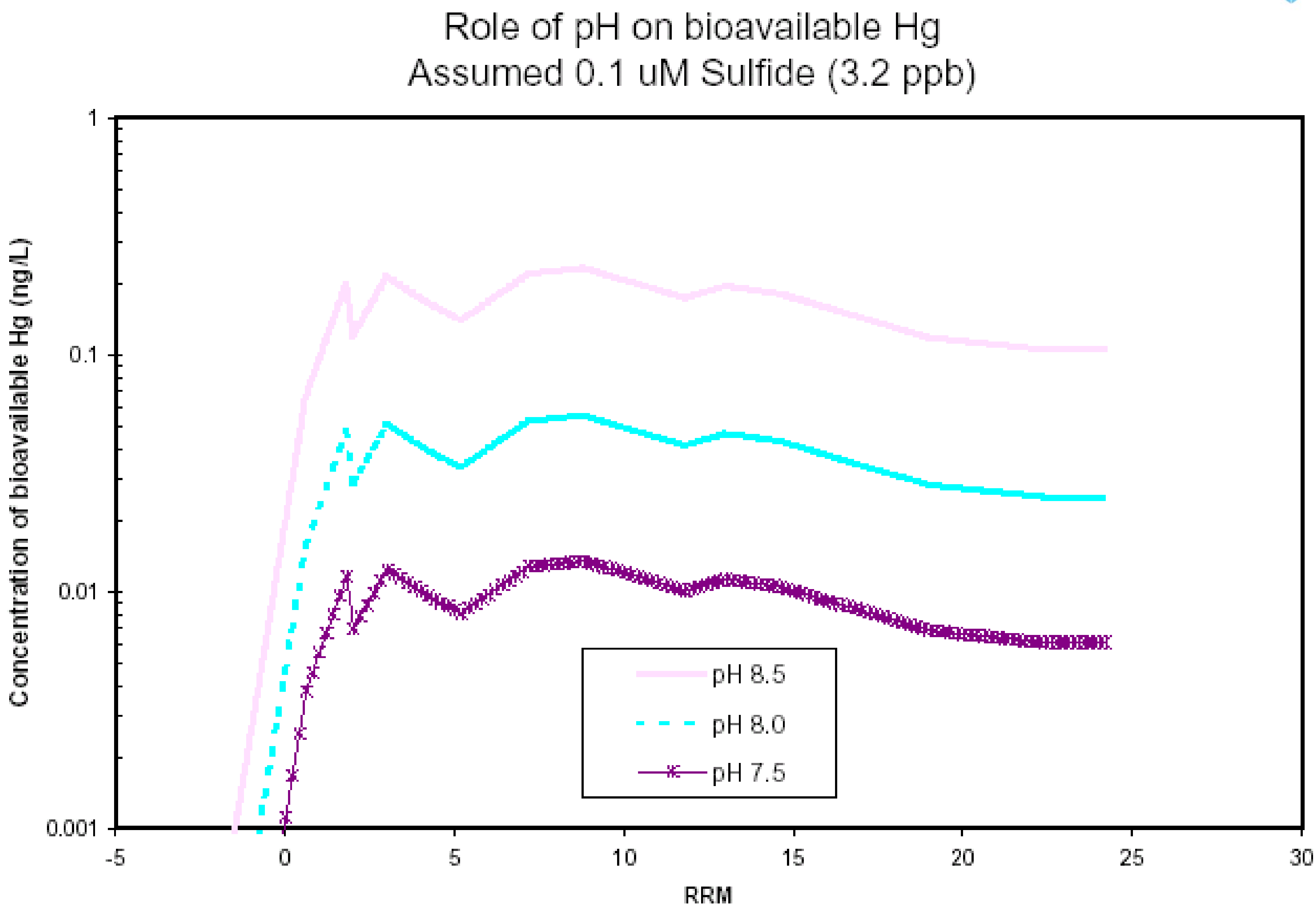
Assuming flow increases linearly and WC constituents behave conservatively



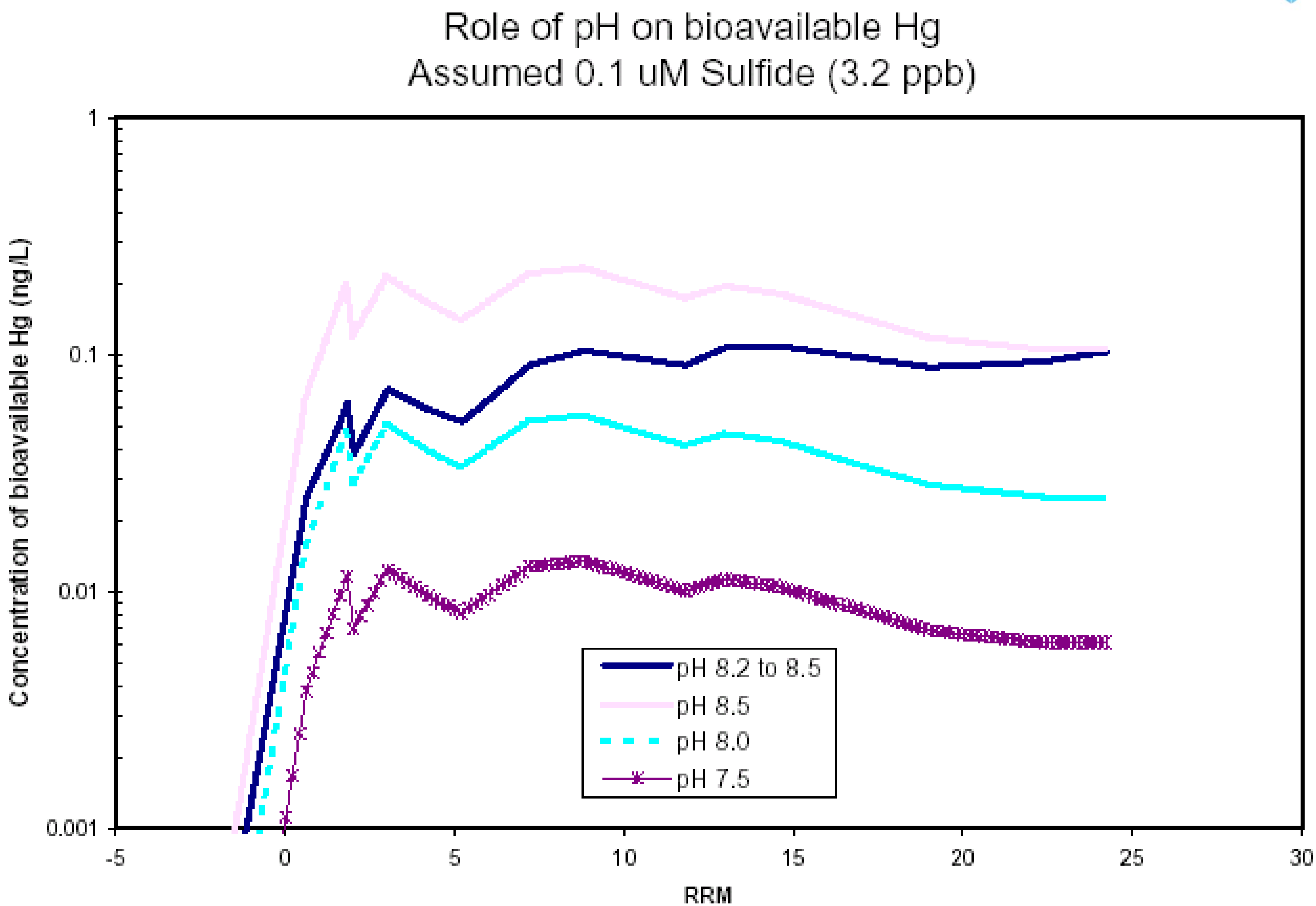
April 2006 Sampling Campaign


Surface Water pH in South River
March 12, 2005
9
8.5
8
7.5
7
pH
-10
-5
0
5
10
15
20
25
30
RRM
Within River
NR and MR reference sites, arbitrary X-axis
STP and wetland area
MR-REF
SR-REF
NR-REF
STP
STR-4
STR-1
2NDST
PR

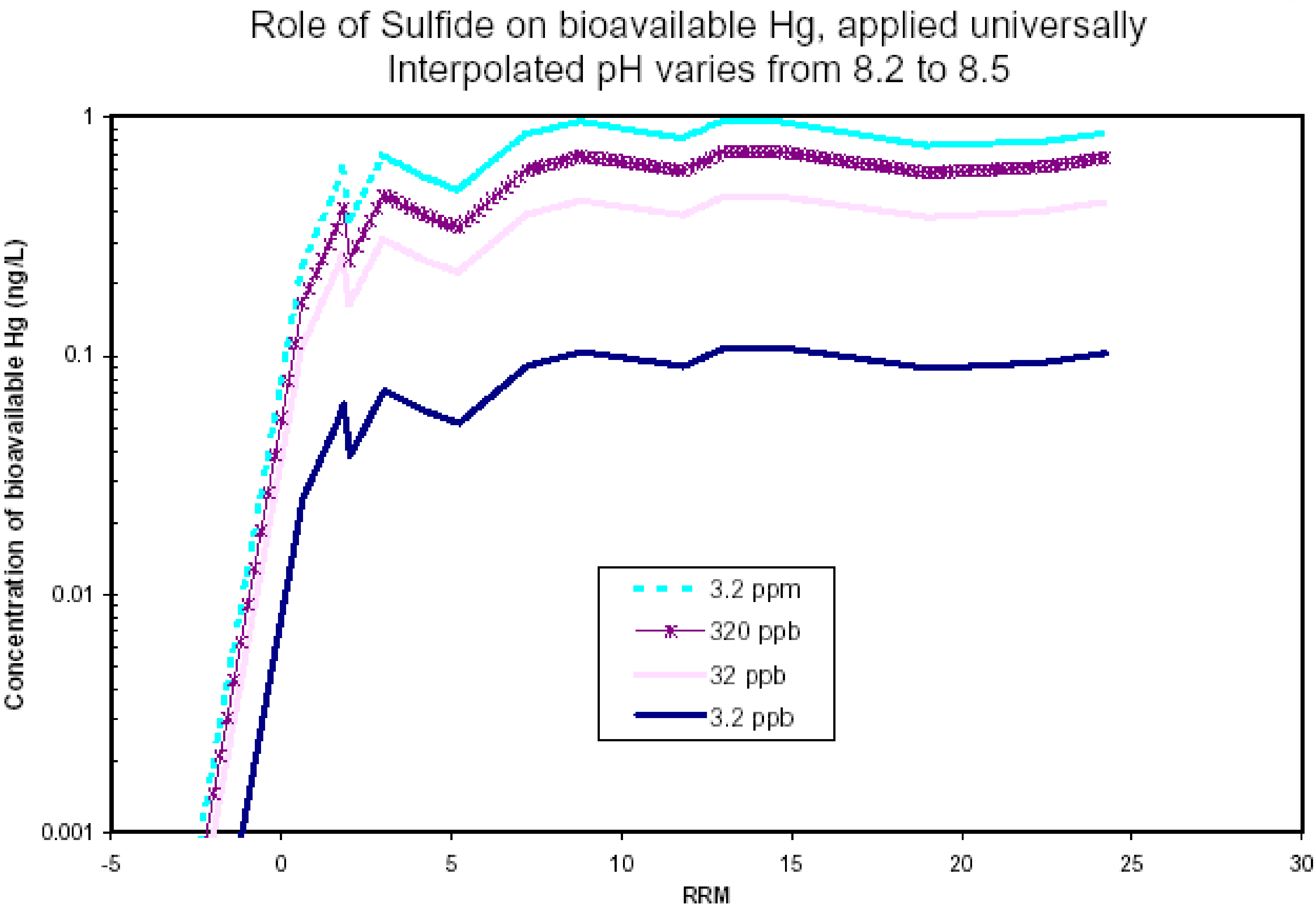
In sediments…



In sediments…

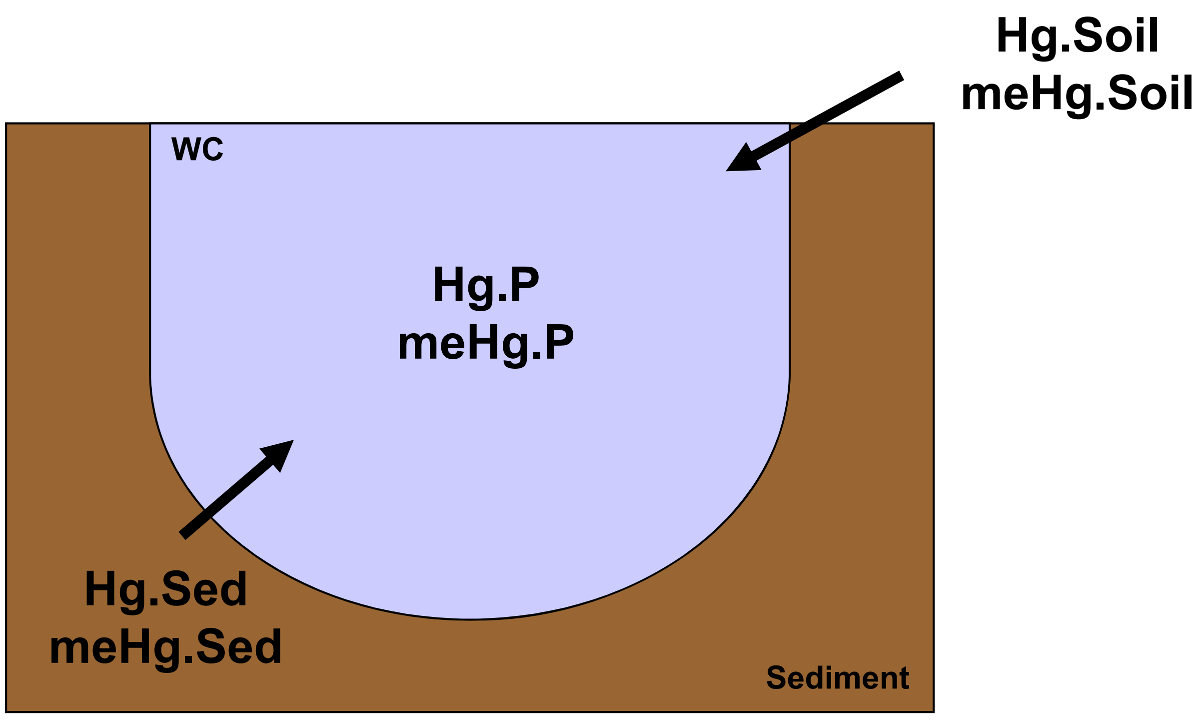


In sediments…

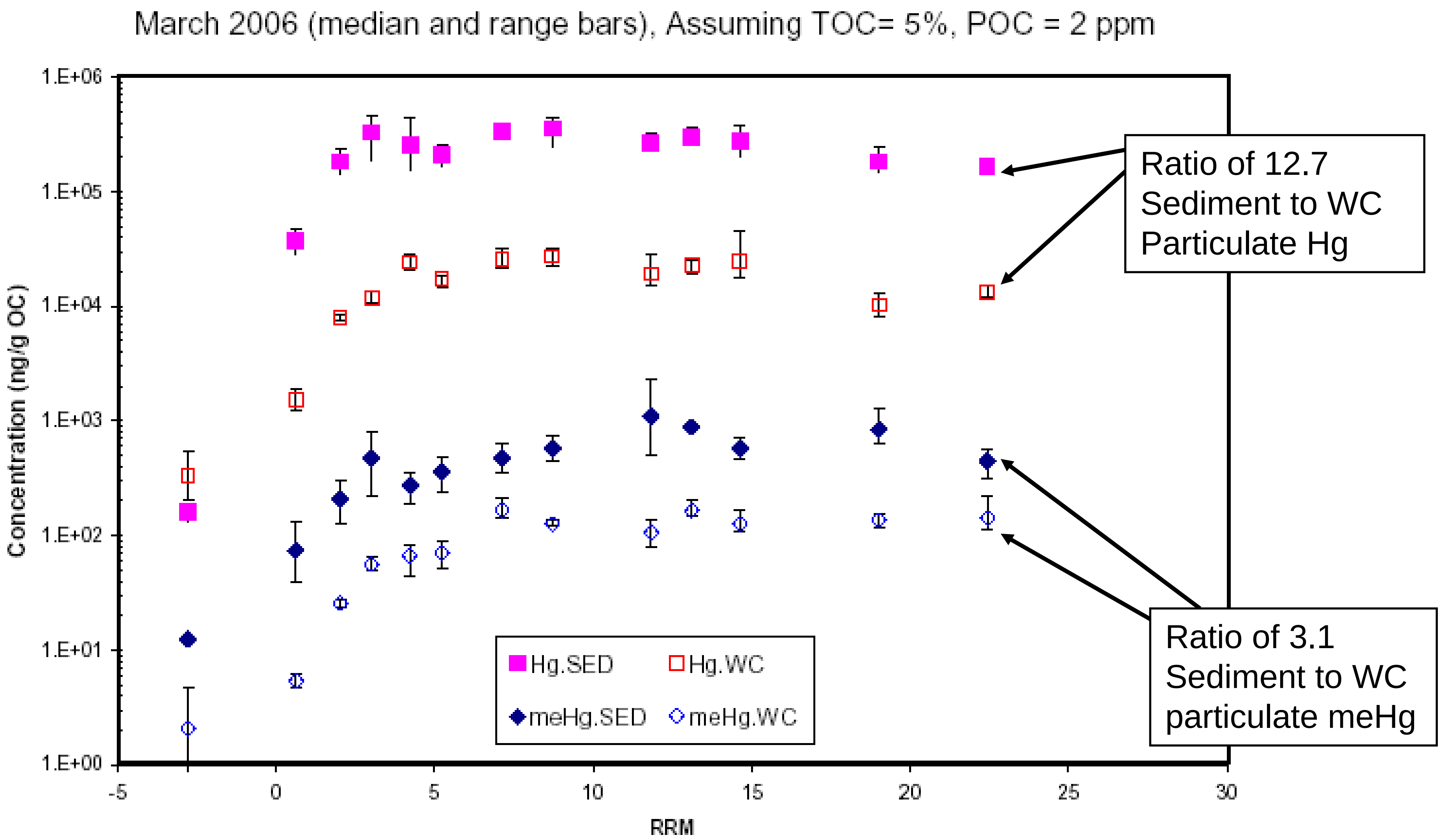


Evaluating potential sources of Hg and meHg into South River

- Hypothesis: Particulate Hg and meHg in WC are from resuspended sediments
  - Ratio of meHg/HgT in WC is proportional to sediment
  - Otherwise the ratio of meHg/HgT ???



Comparing Particulate Data



Parameters that are potentially useful for modeling mercury speciation and methylation

Analytes	Reasoning		Analytes	Reasoning
Water column			*Sediment*	
Primary			Primary	
DOC	speciation		Sulfide	speciation and bioavailability
POC	speciation		Sediment oxygen demand	microbial activity
pH	speciation		Methylation potential	calibration
Major Ions	ionic composition of water		pH	speciation and bioavailability
Temperature	chemical reactivity		POC	speciation and bioavailability
			DOC	speciation and bioavailability
Secondary			AVS	speciation and bioavailability
Nitrogen	nutrient levels		Temperature	chemical reactivity
Phosphorous	nutrient levels		Total Hg, meHg	calibration
			Dissolved Hg, meHg	calibration
			Secondary	
			Dissolved Fe, Mn	redox state of sediments
			ORP	redox state of sediments
			Nitrogen	nutrient levels
			Phosphorous	nutrient levels

Observations

- Widespread Hg input (RRM 0 to 10)
- Filtered meHg is 50-60% of meHg.T and generally constant throughout South River
- Filtered Hg is 6-21% of unfiltered Hg.T but variable and generally lower at RRM 0 to 10
- Difficult to identify point sources
  - Further analysis designed to test sensitivity of spatial sampling frequency and optimization methods is planned
- Sharper increase in Hg.T relative to meHg between RRM 0 to 10
  - A possible biogeochemical influence of the STP outfall or wetlands in area on Hg speciation and/or bioavailability?
  - Preliminary Hg bioavailability calculations in sediment were performed

Pathforward

- Screening calculations of Hg and meHg bioaccumulation for fish and clam
  - In context of prey/predator relationships and Hg/meHg concentrations with recent and historic data
- Loading sensitivity analysis to identify optimal spatial sampling frequency and possible point sources
- Identify regions with physical or biogeochemical conditions in South River that could impact partitioning and methylation activity

Citations on conceptual model of mercury bioavailability for methylation

- Benoit, J., Gilmour, C. and Mason, R., 2001a. Aspects of Bioavailability of Mercury for Methylation in Pure Cultures of Desulfobulbus propionicus (1pr3). Applied and Environmental Microbiology(51-58).
- Benoit, J., Gilmour, C. and Mason, R., 2001b. The Influence of Sulfide on Solid-Phase Mercury Bioavailability for Methylation by Pure Cultures of Desulfobulbus propionicus (1pr3). Environmental Science and Technology, 35: 127-132.
- Benoit, J., Gilmour, C., Mason, R. and Heyes, A., 1999a. Sulfide Controls on Mercury Speciation and Bioavailability to Methylating Bacteria in Sediment Pore Waters. Environmental Science and Technology, 33: 951-957.
- Benoit, J., Mason, R. and Gilmour, C., 1999b. Estimation of Mercury-Sulfide Speciation in Sediment Porewaters Using Octonal-Water Partitioning and Implications for Availability to Methylating Bacteria. Environmental Toxicology and Chemistry, 18(10): 2138-2141.
- Gilmour, C. and Henry, E., 1991. Mercury Methylation in Aquatic Systems Affected by Acid Deposition. Environmental Pollution, 71: 131-169.
- Langer, C., Fitzgerald, W., Visscher, P. and Vandal, G., 2001. Biogeochemical Cycling of Methylmercury at Barn Island Salt Marsh, Stonington, CT, USA. Wetlands Ecology and Management, 9: 295-310.
- WWW.Mercry2006.com