Mercury in Maryland Ecosystems

STACK April 10 2019

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Management Questions

If we reduce inorganic Hg emissions will it have an impact on methylmercury concentrations in fish?

How will we know if methylmercury concentrations in fish are responding to reductions in Hg emissions?

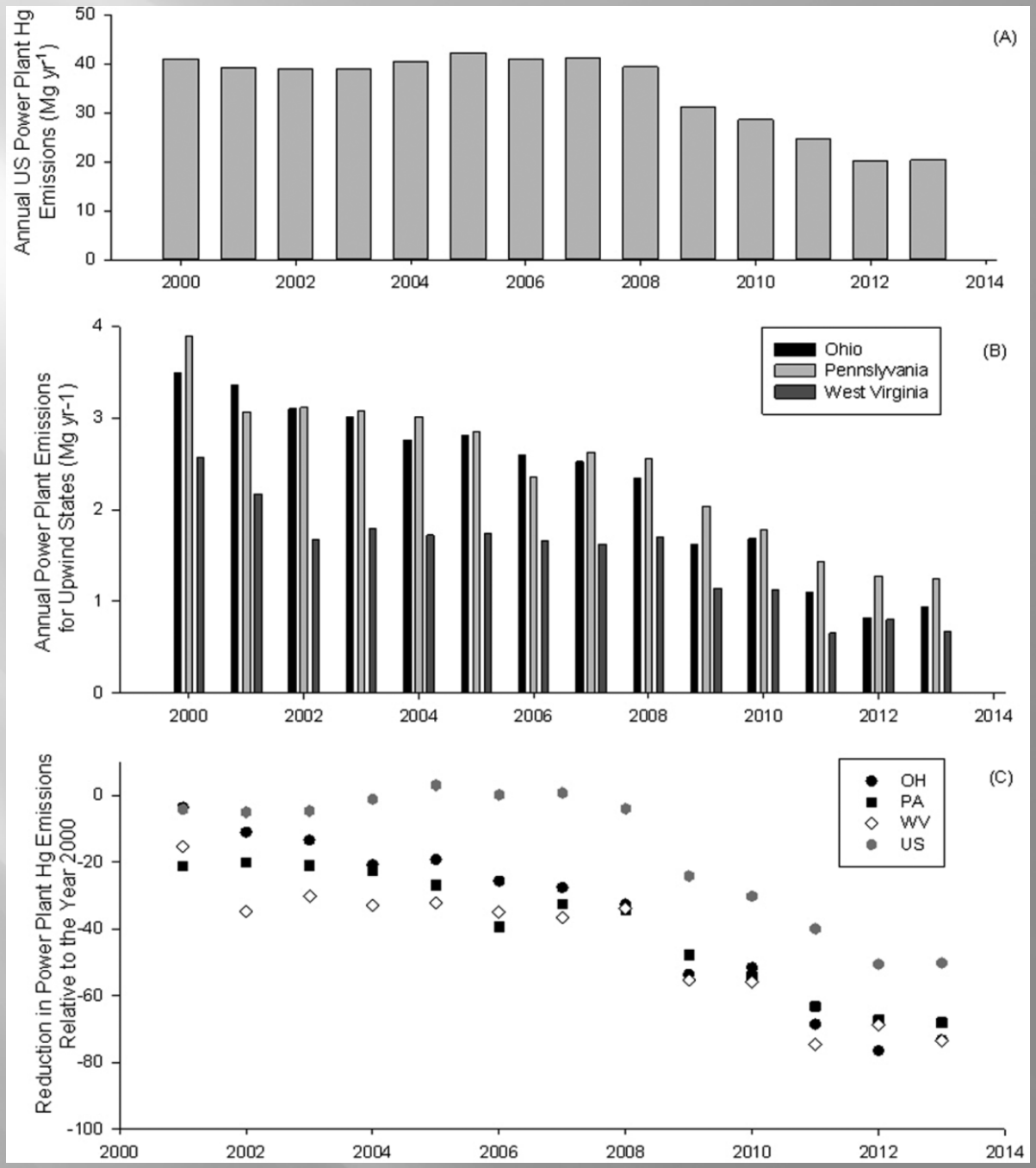
What else can we do to mitigate the impact of Hg on aquatic organisms and fisheries?

General Caveat's

How is mercury cycling responding to changes in climate?

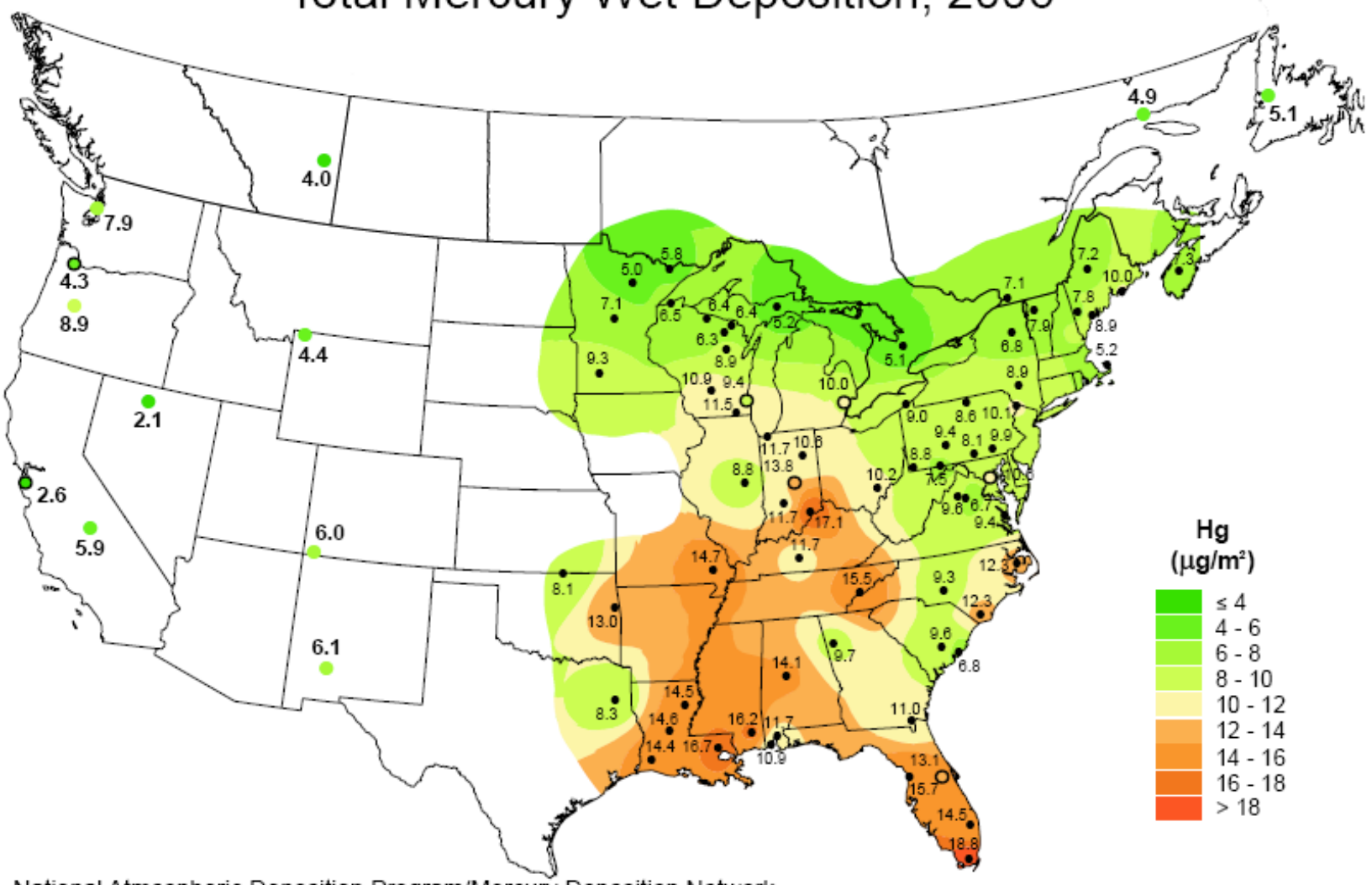
How are changes in land-use impacting Hg cycling?

Primarily – how is net Hg methylation impacted?



Castro and Sherwell 2016

Total Mercury Wet Deposition, 2006



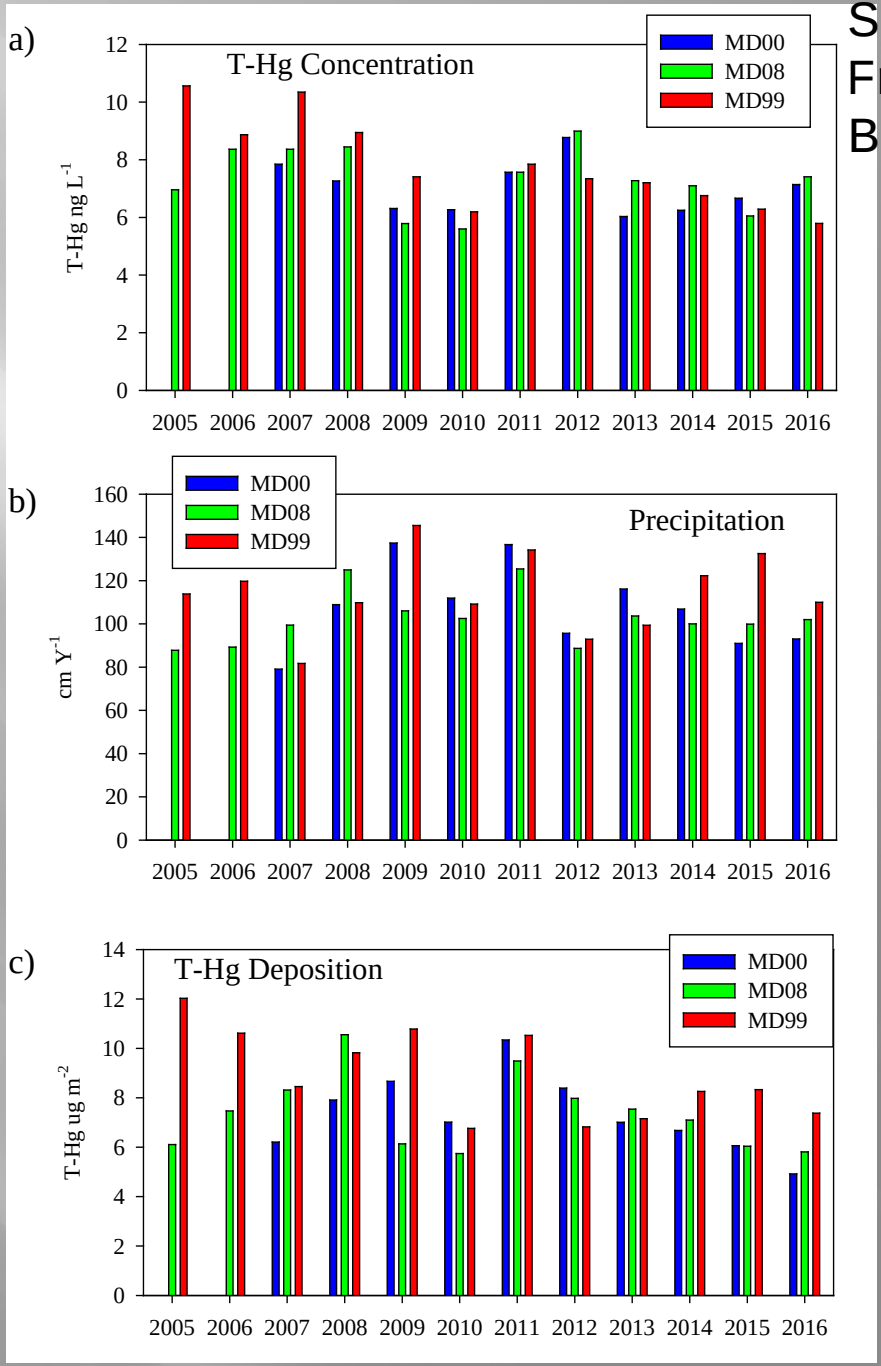
National Atmospheric Deposition Program/Mercury Deposition Network

Mercury Concentration in Precipitation

Precipitation

Mercury Deposition

SERC
Frostburg
Beltsville



Mercury Concentration in Precipitation

SERC

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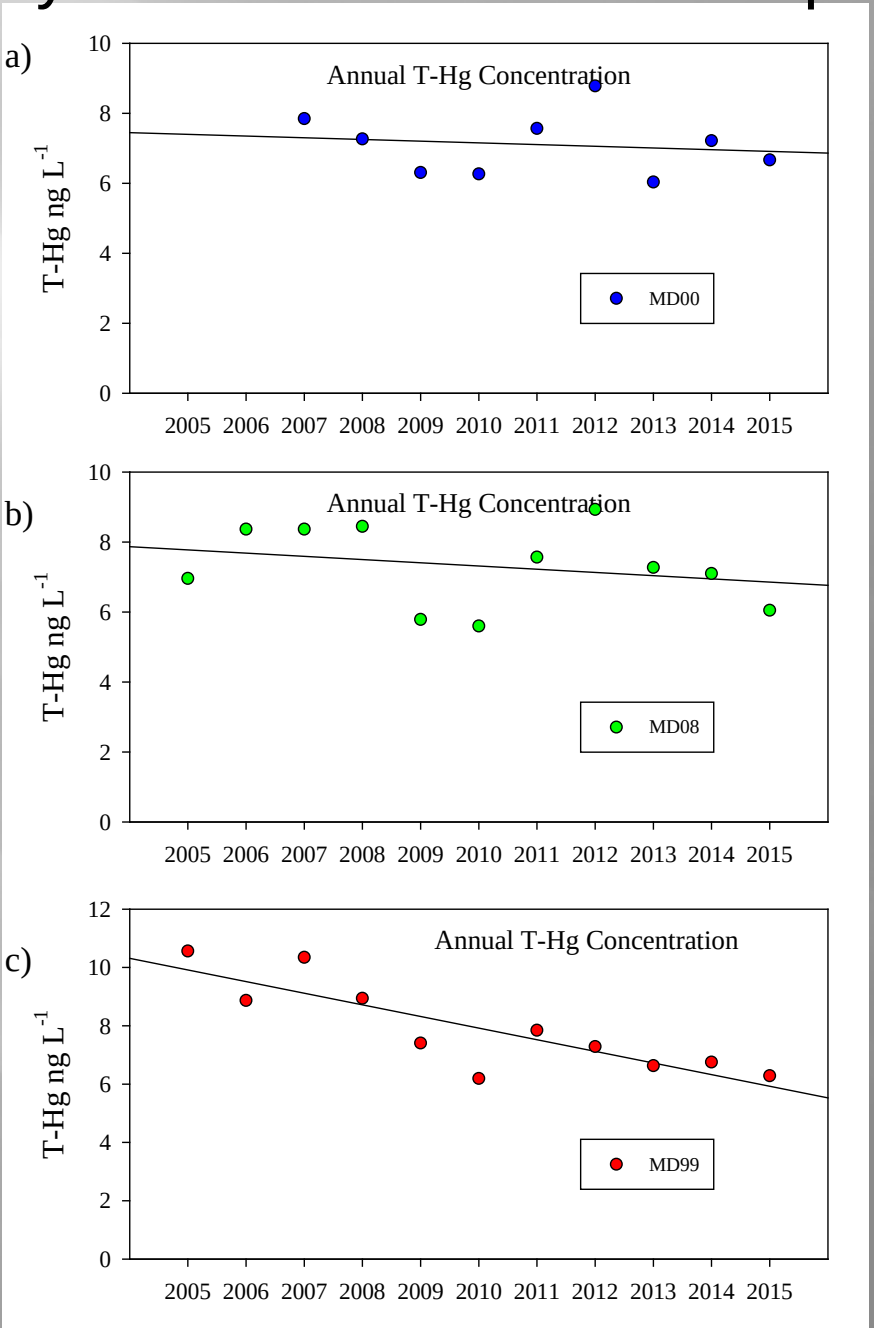
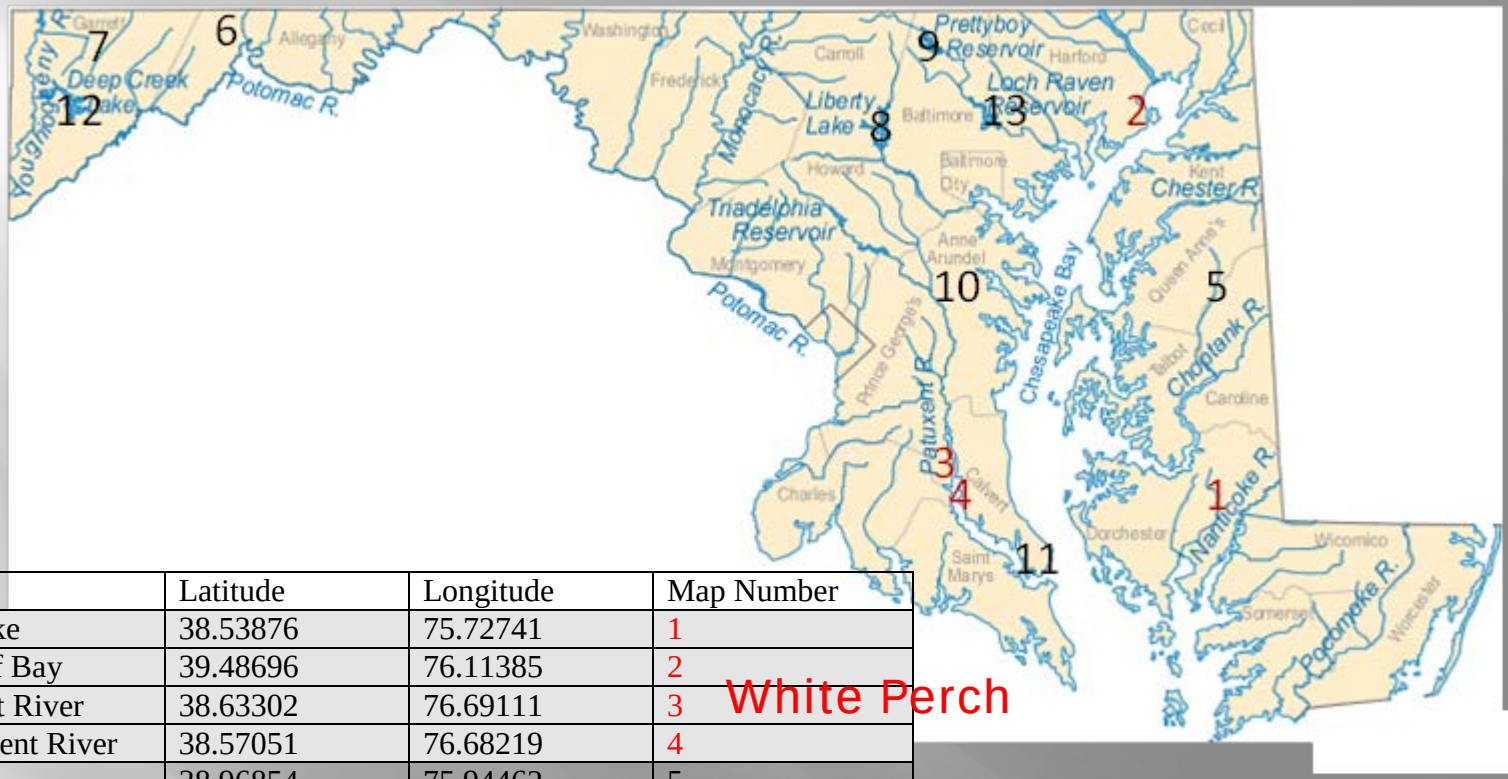


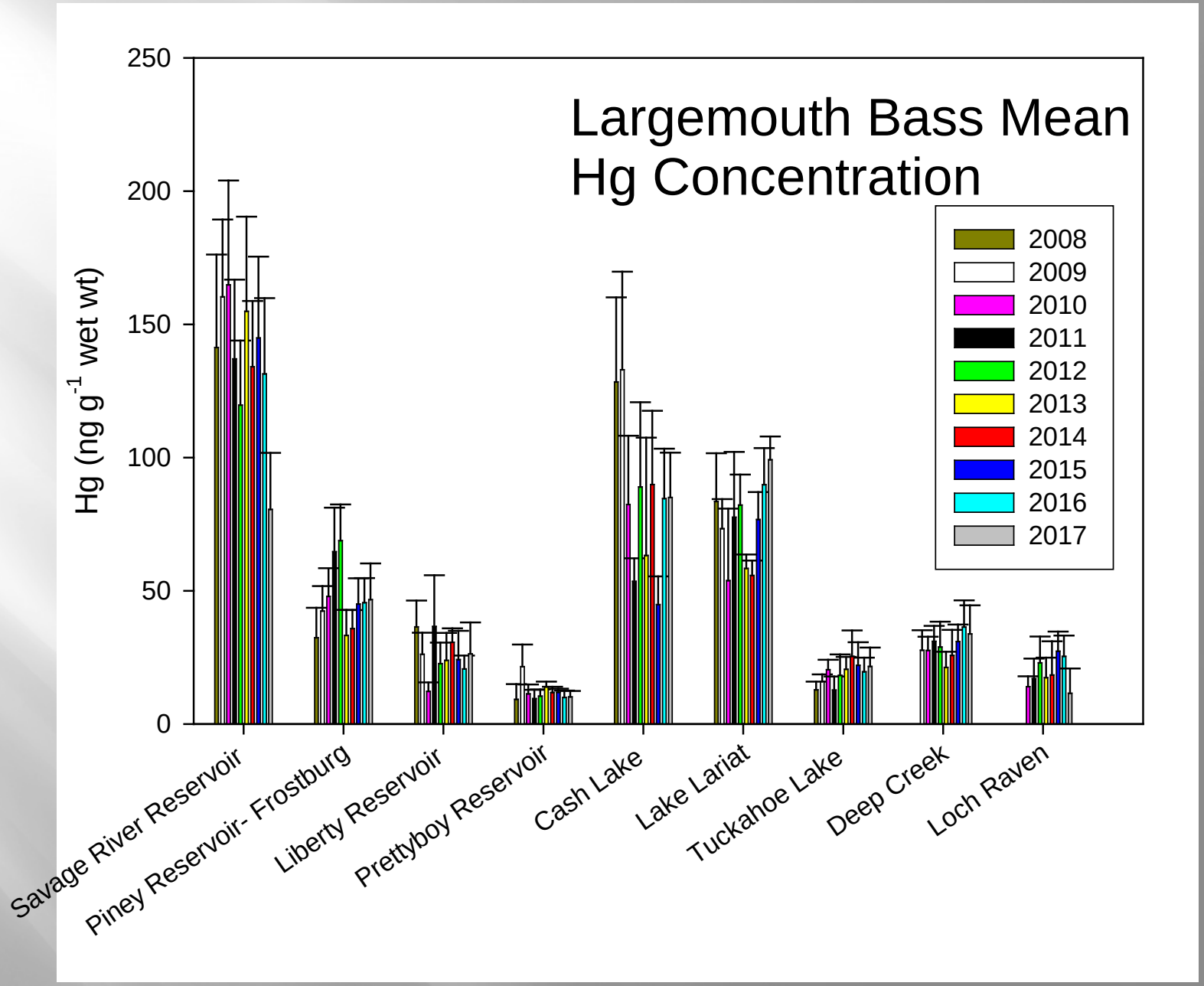
Young of the Fish Year Study



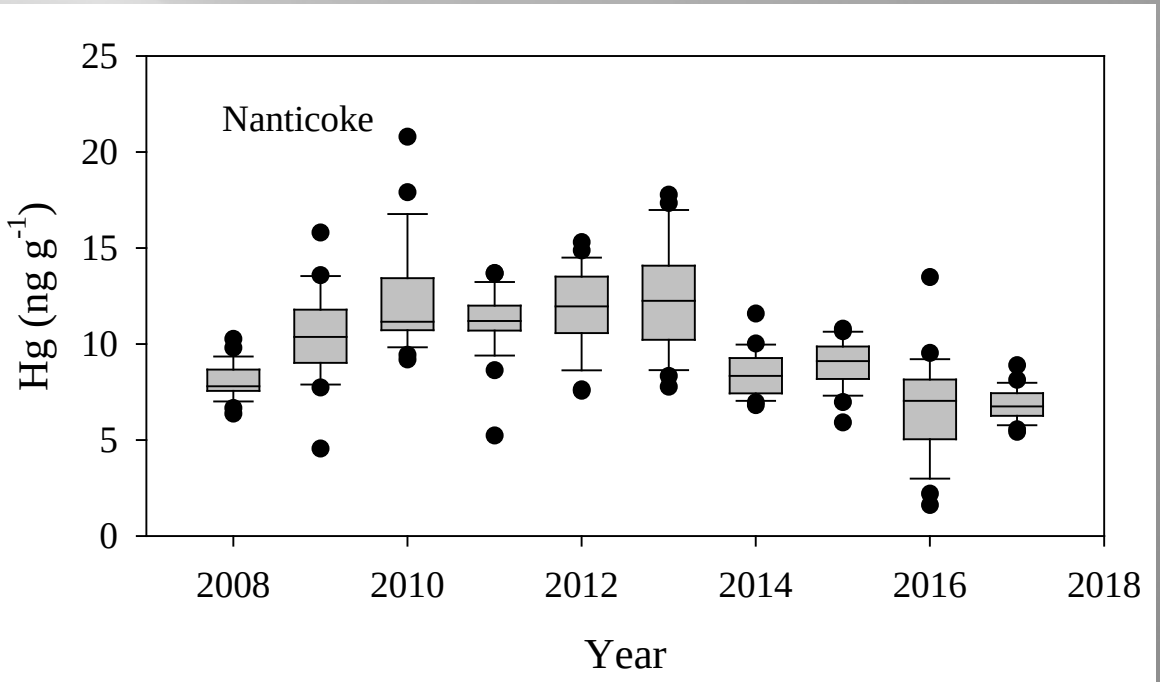
Site	Latitude	Longitude	Map Number
Sharptown-nanticoke	38.53876	75.72741	1
Plum-Point Head of Bay	39.48696	76.11385	2
Mill Town Patuxent River	38.63302	76.69111	3
Eagle Harbor Patuxent River	38.57051	76.68219	4
Tuckahoe Lake	38.96854	75.94462	5
Piney Reservoir	39.70842	79.0018	6
Savage River Reservoir	39.54327	79.13751	7
Liberty Reservoir	39.44576	76.88376	8
Prettyboy Reservoir	39.65239	76.74183	9
Cash Lake	39.03199	76.79729	10
Lake Lariat	38.37774	76.42265	11
Deep Creek	39.55807	79.35482	12
Loch Raven	39.46250	76.57814	13

White Perch

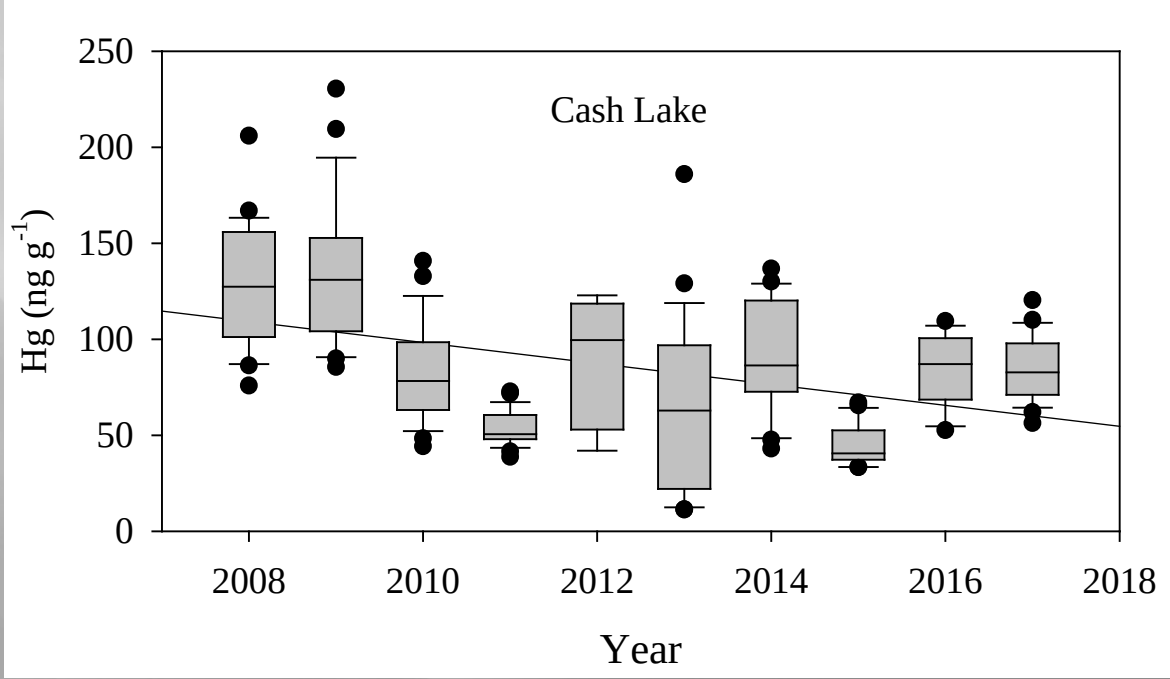
Bass


Largemouth Bass Mean
Hg Concentration
Hg (ng g-1 wet wt)
250
200
150
100
50
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Savage River Reservoir
Piney Reservoir- Frostburg
Liberty Reservoir
Prettyboy Reservoir
Cash Lake
Lake Lariat
Tuckahoe Lake
Deep Creek
Loch Raven

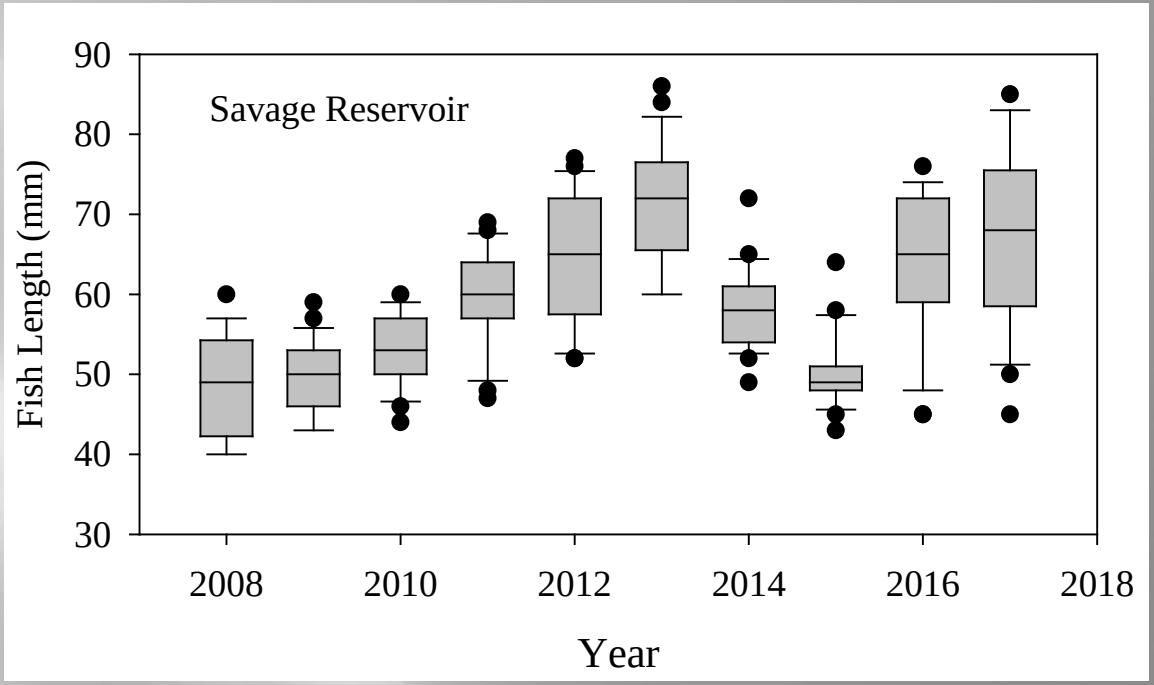
White Perch



Largemouth Bass

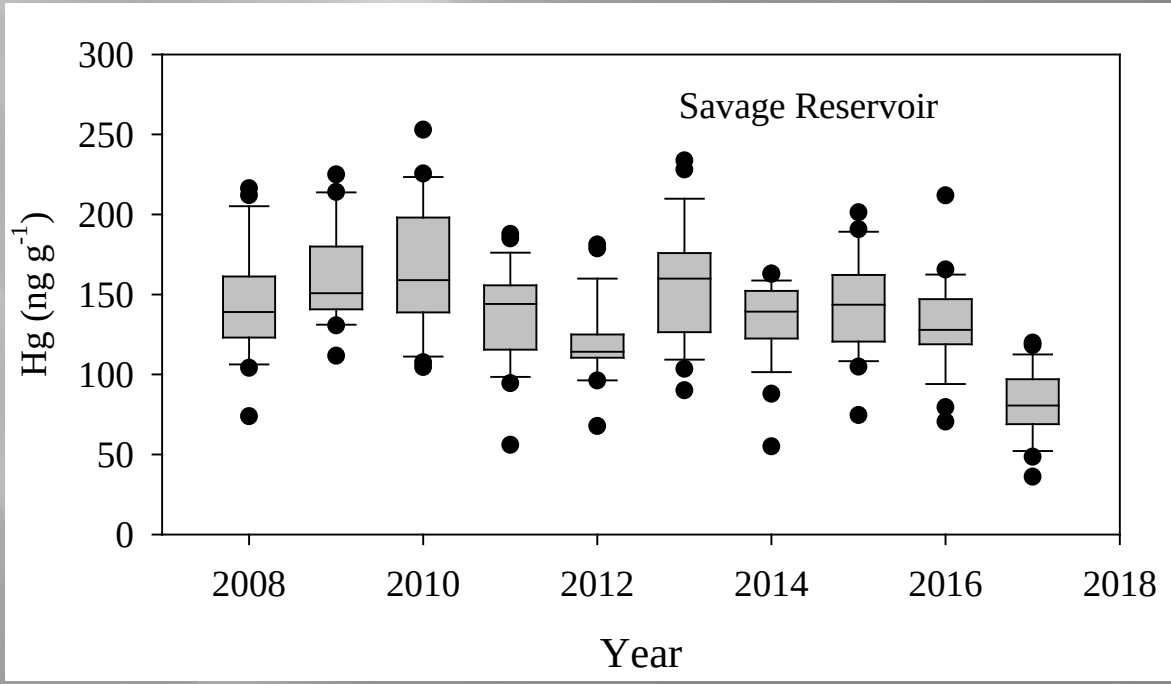


Fish Size



Largemouth Bass

Fish Hg



Factors that control mercury methylation and methylmercury in biota

1) Activity of Hg methylating bacteria
2) Availability of mercury for methylation
3) Connectivity of sites of methylation to food web
4) Length and structure of the food web

Mercury Methylation

Mercury methylation is a biological process performed by bacteria and some fungi.

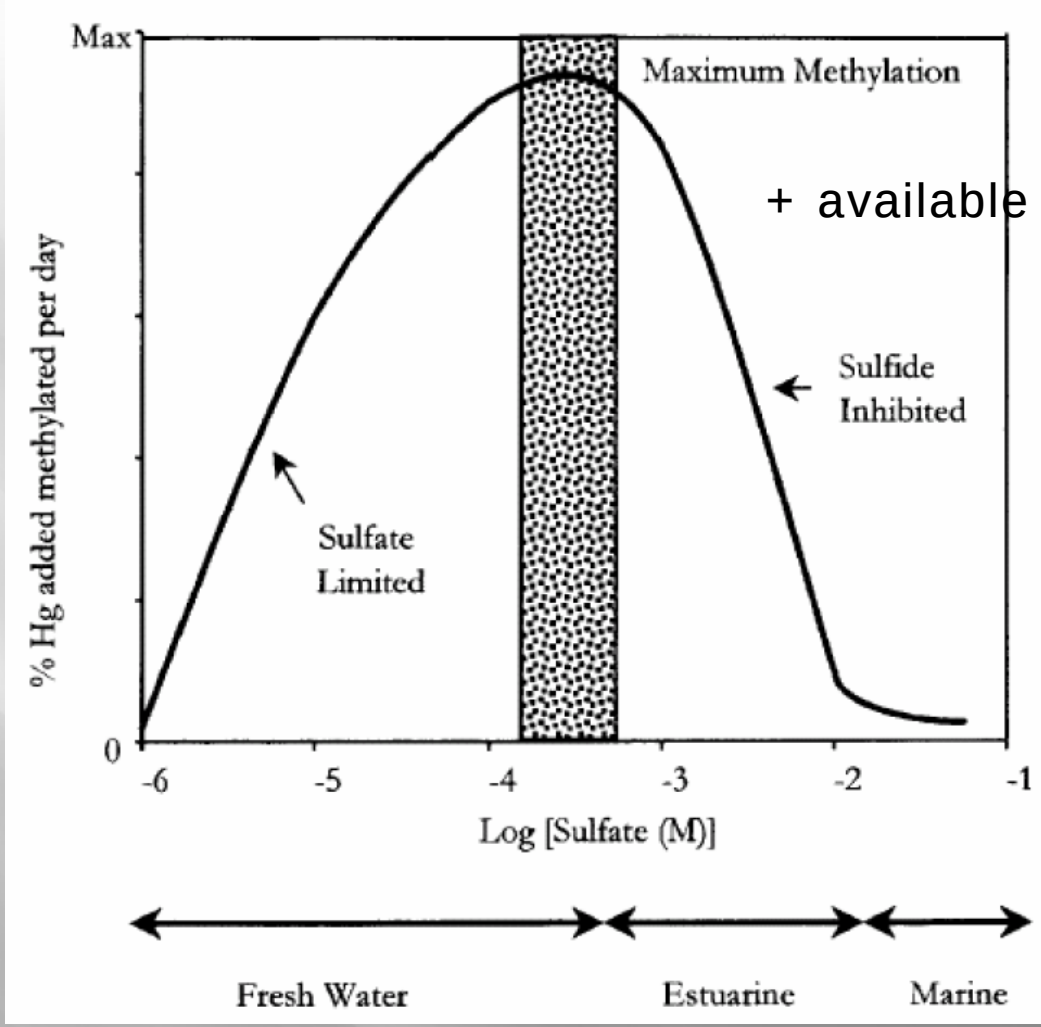
Hg methylation primarily occurs in anaerobic bacteria such as sulfate and iron reducers and methanogens.

Methylating bacteria are in competition with other bacteria for available carbon and electron acceptors such as sulfate and iron.

The availability of mercury to bacteria is controlled by chemical ligands such as sulfide and organic ligands such as thiols.

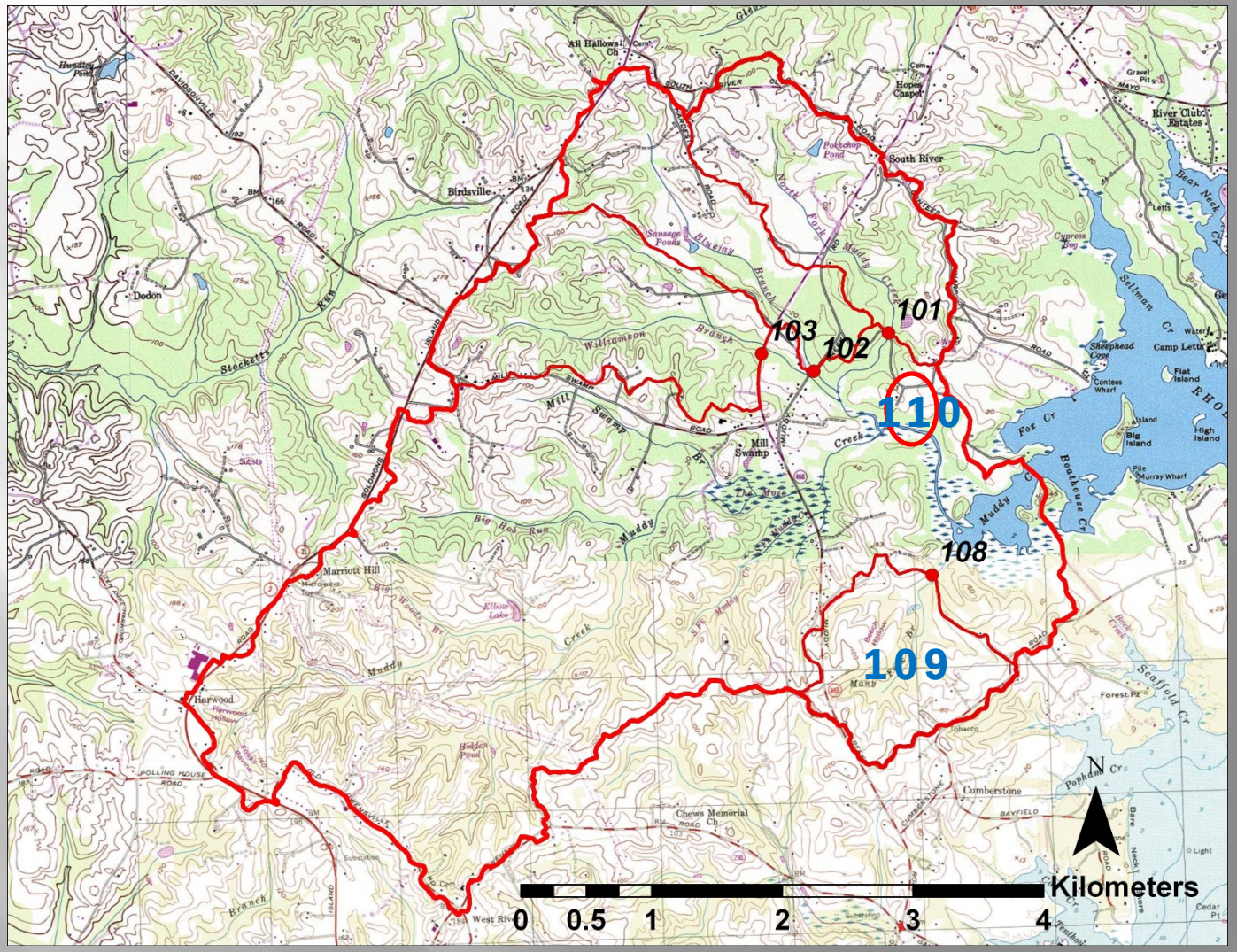
Need to create the ideal setting for methylation to occur.

What is that setting?



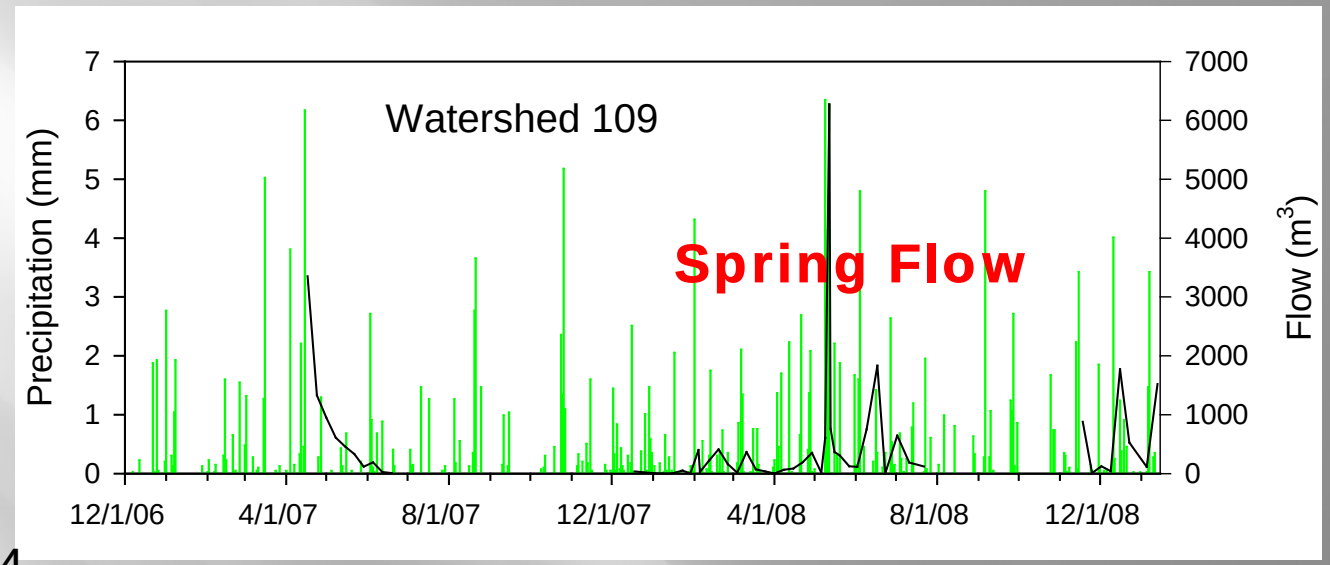
+ available carbon for bacteria

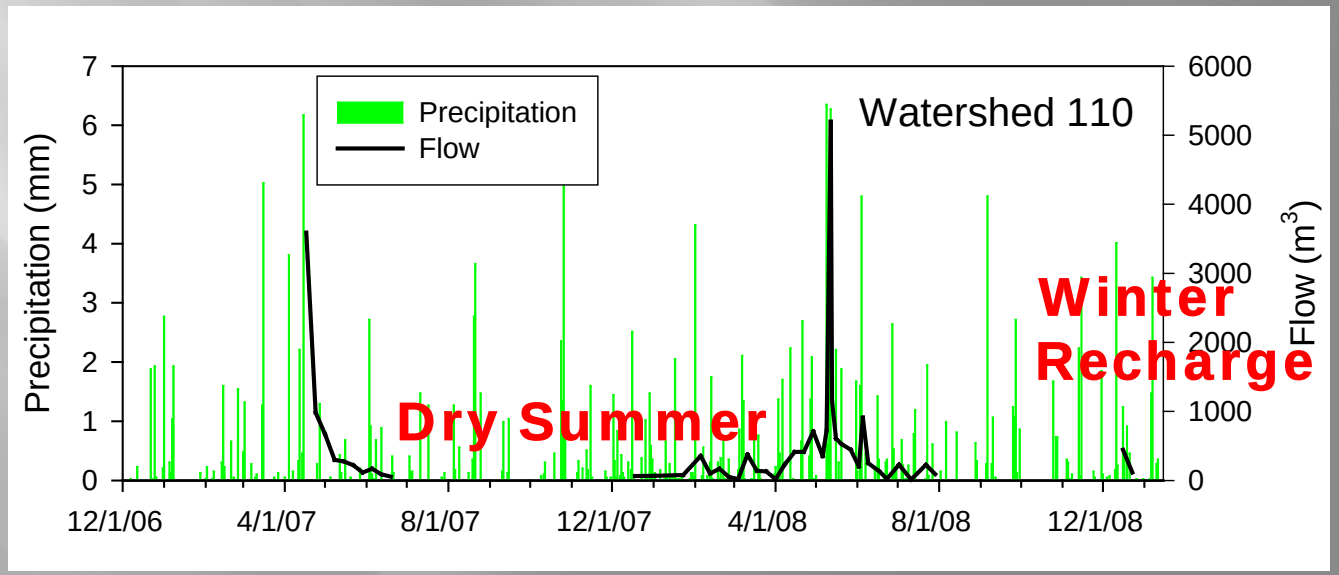
Impact of Land-use



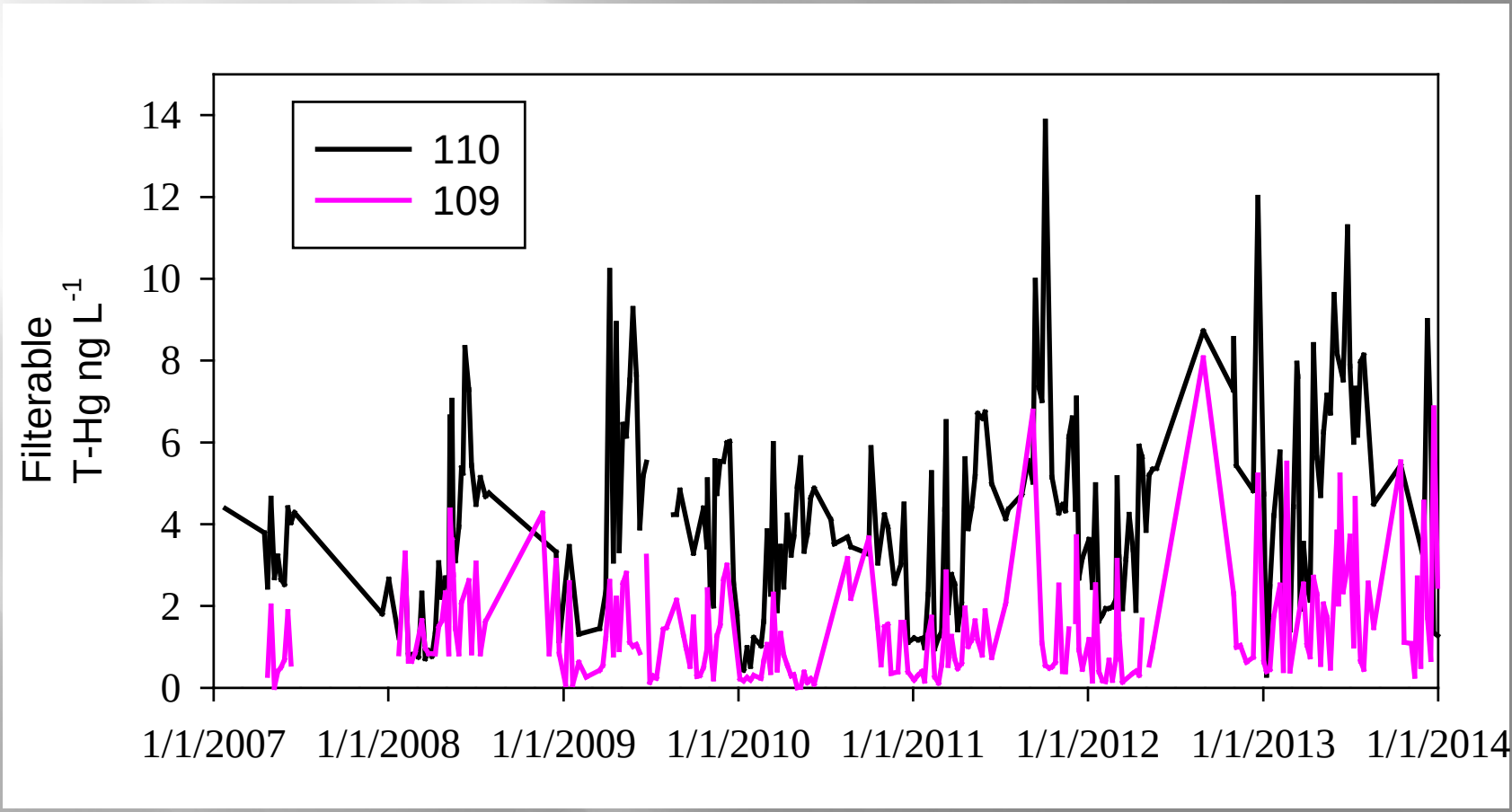
Hydrology of the Streams

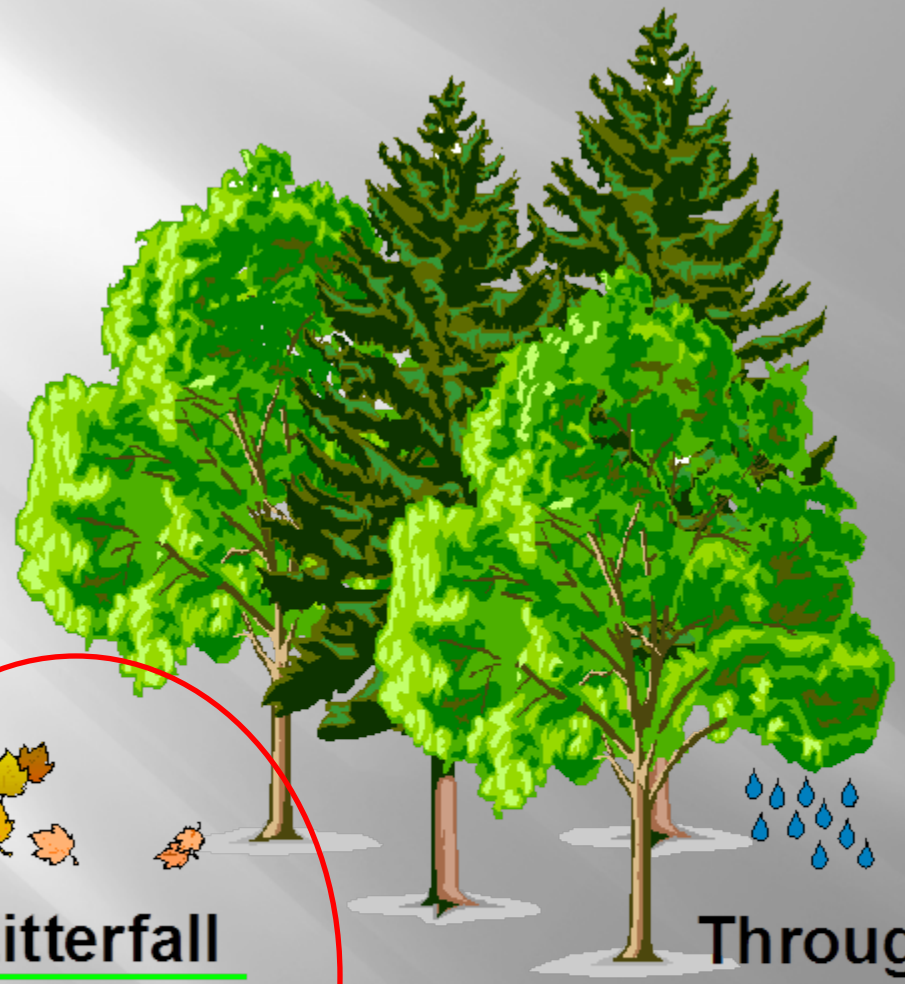
Started Ag Reforestation Started in 2014





Total-Filterable-Hg concentrations in surface water of two SERC watersheds





Direct deposition

MeHg	IHg
0.9	70

Litterfall

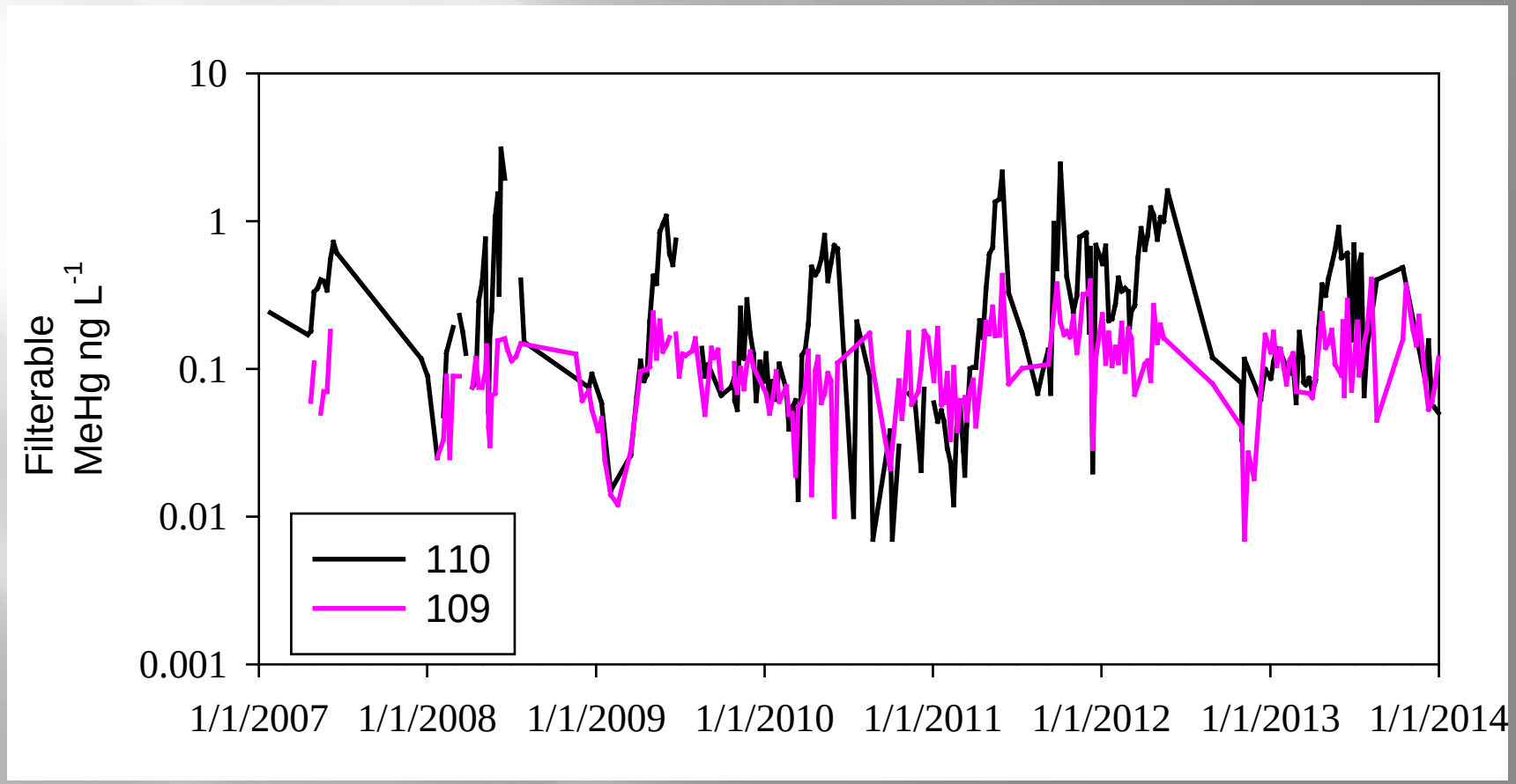
MeHg	IHg
0.8	113

Throughfall

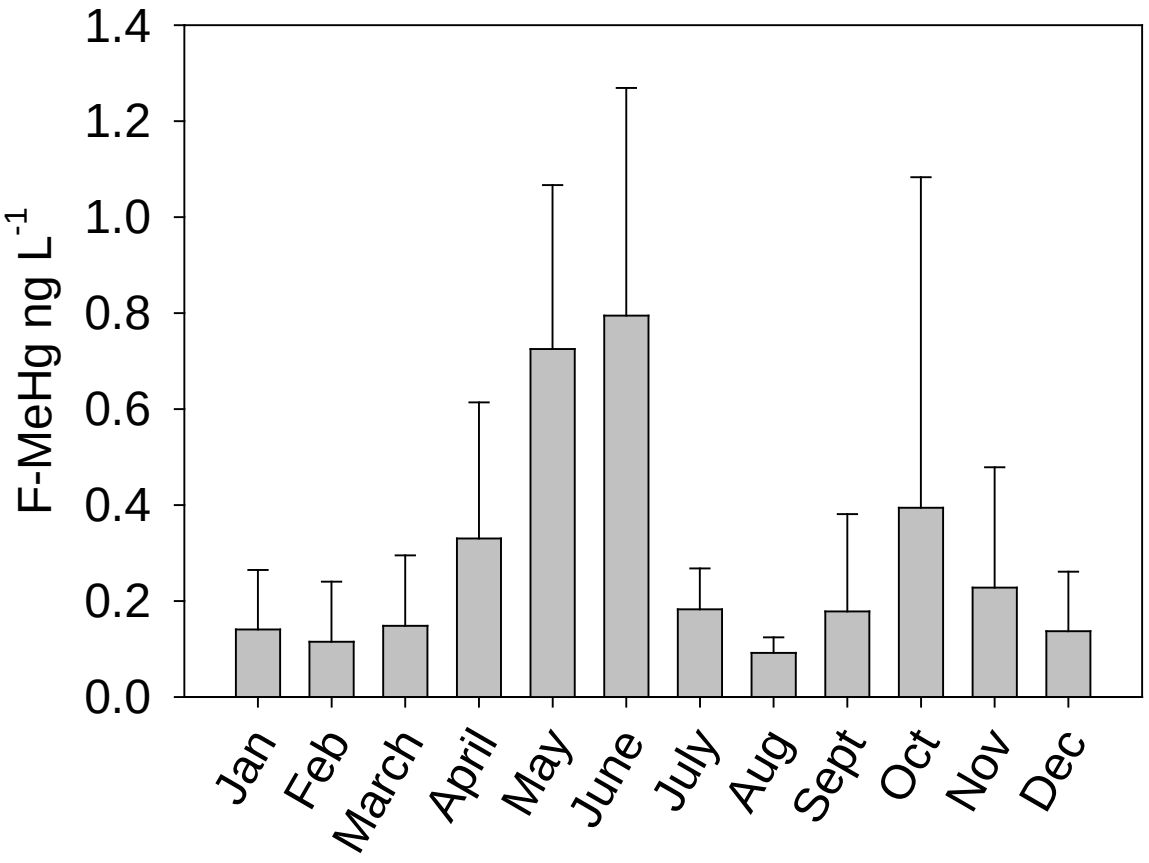
MeHg	IHg
0.9	80

Fluxes in mg/ha/yr

Filterable MeHg Concentrations in Stream water 2007-2013



Average Filt-MeHg 2007-2013 W110



Schematic Model of Biogeochemical Proces in Riparian Zone

Forested

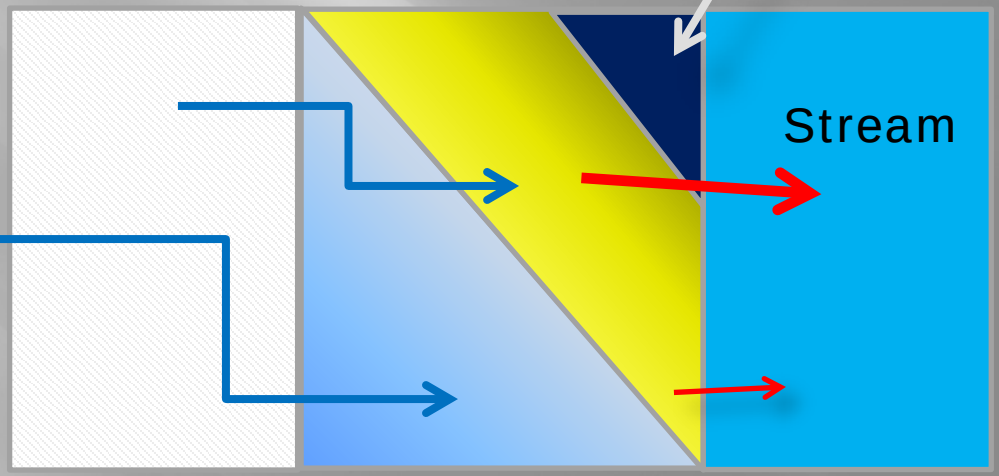
Decrease in Hg Bioavailability with reduction of DOC?

Low nitrate
High Hg

Agriculture

High nitrate
Lower Hg

Carbon Pool Transformations



Timing of processes are different between the two watersheds

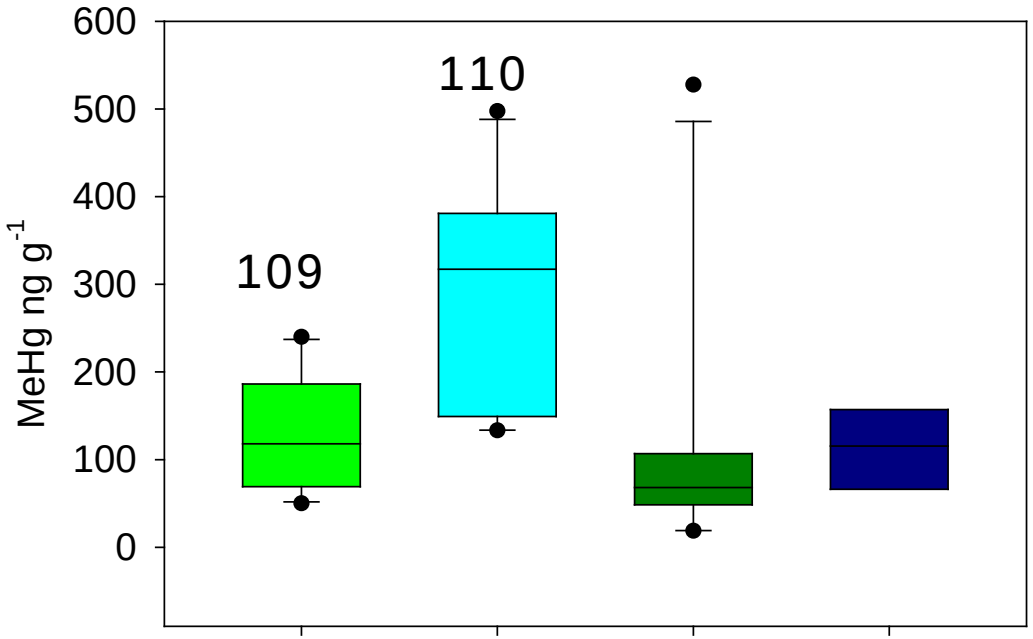
We do not have a good handle on fluxes to Bay from small streams

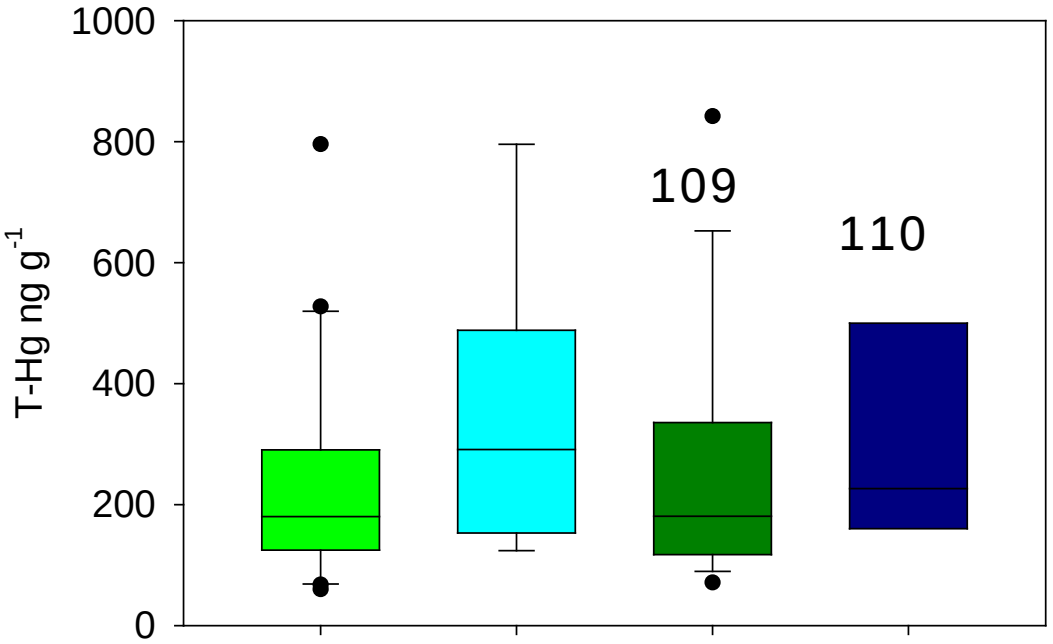
Estimates of 18,000 small streams

How representative are the two SERC streams?

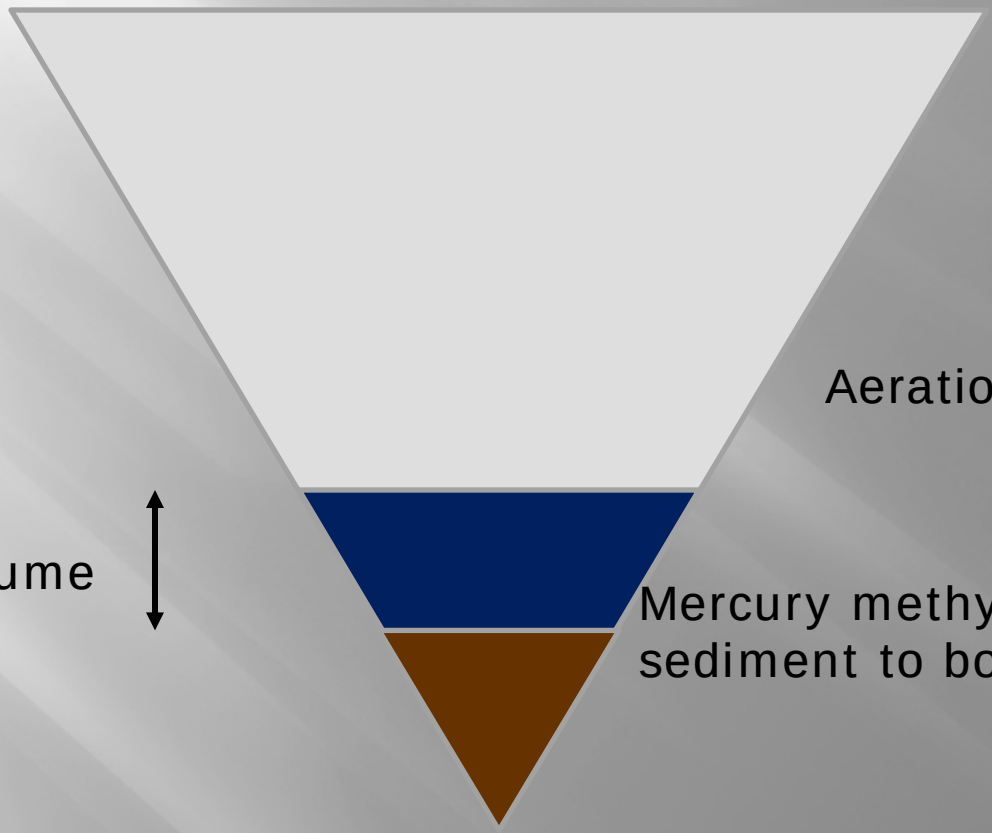
Is the between difference in watershed methylmercury production reflected in the biota?

2016 Data


600
500
400
300
200
100
0
MeHg ng g-1
110
109
Amphipods
Isopods


1000
800
600
400
200
0
T-Hg ng g-1
109
110

What about Lakes, Reservoirs and Chesapeake Bay?



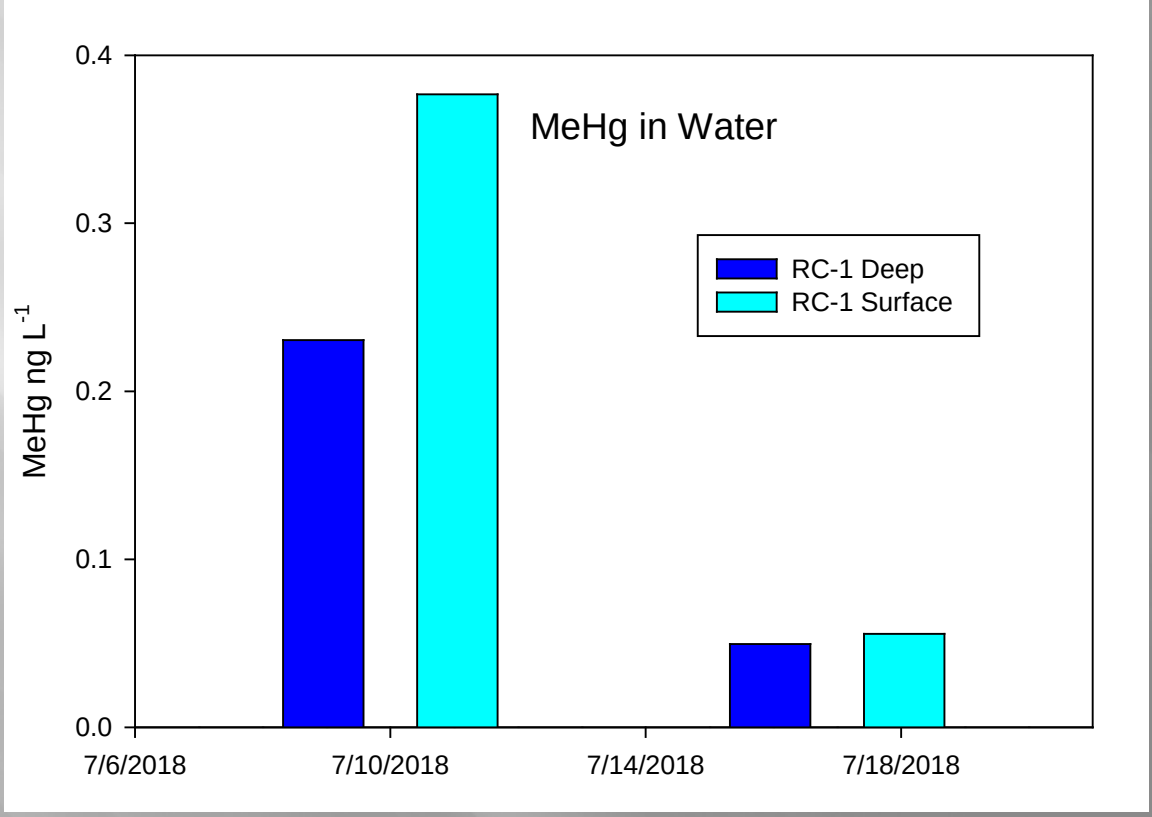
Aeration of bottom water?

Hypoxic Volume

Mercury methylation moves from sediment to bottom water?

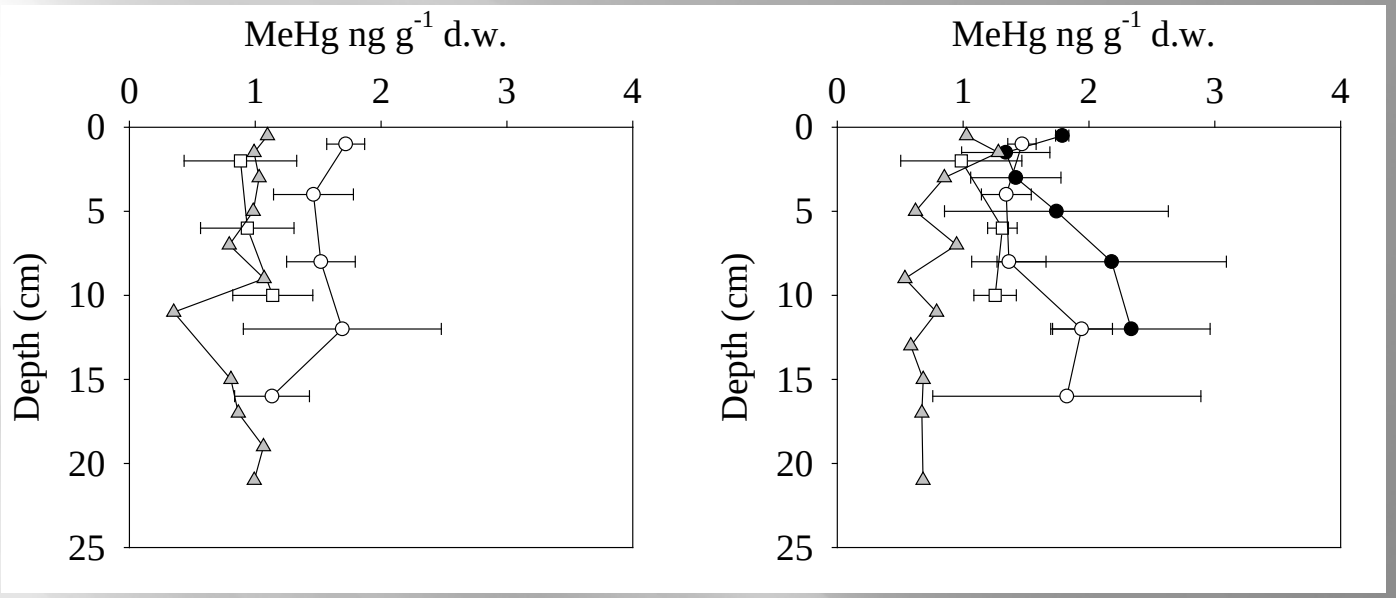
H1- Aeration decreases net MeHg production by reducing hypoxic volume
H2 - Aeration increases MeHg because of mixing of increased circulation through sediment porewater.

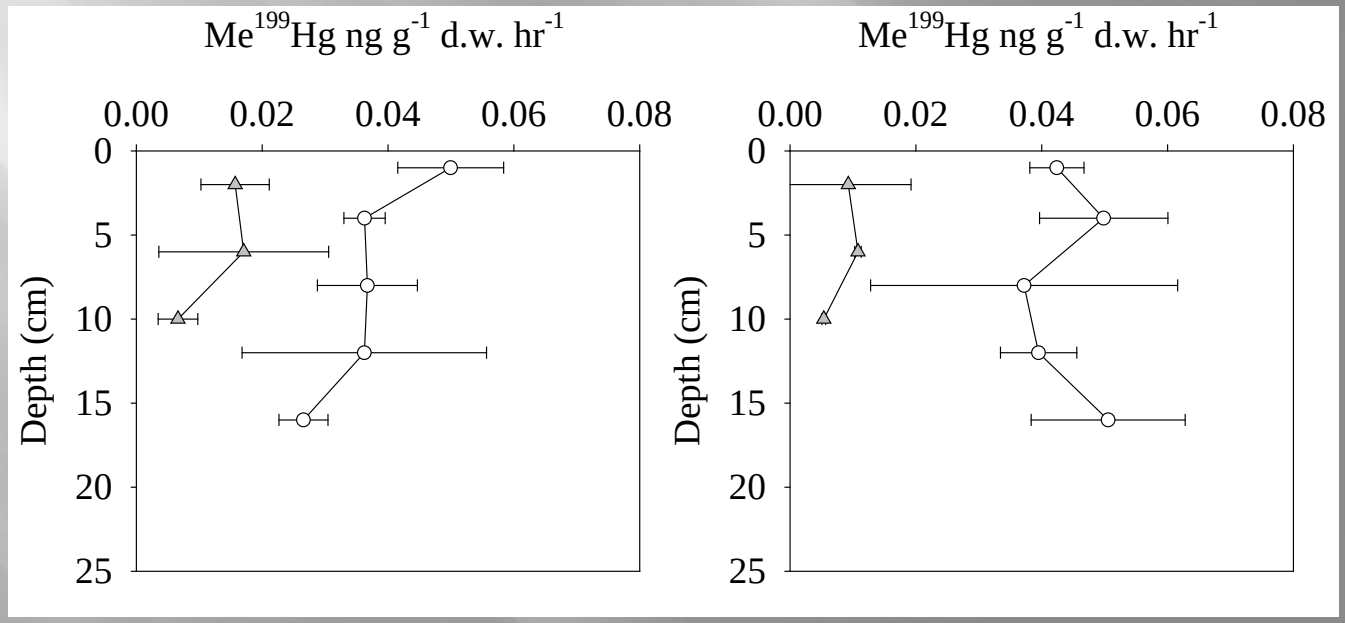
Current Study in Rock Creek



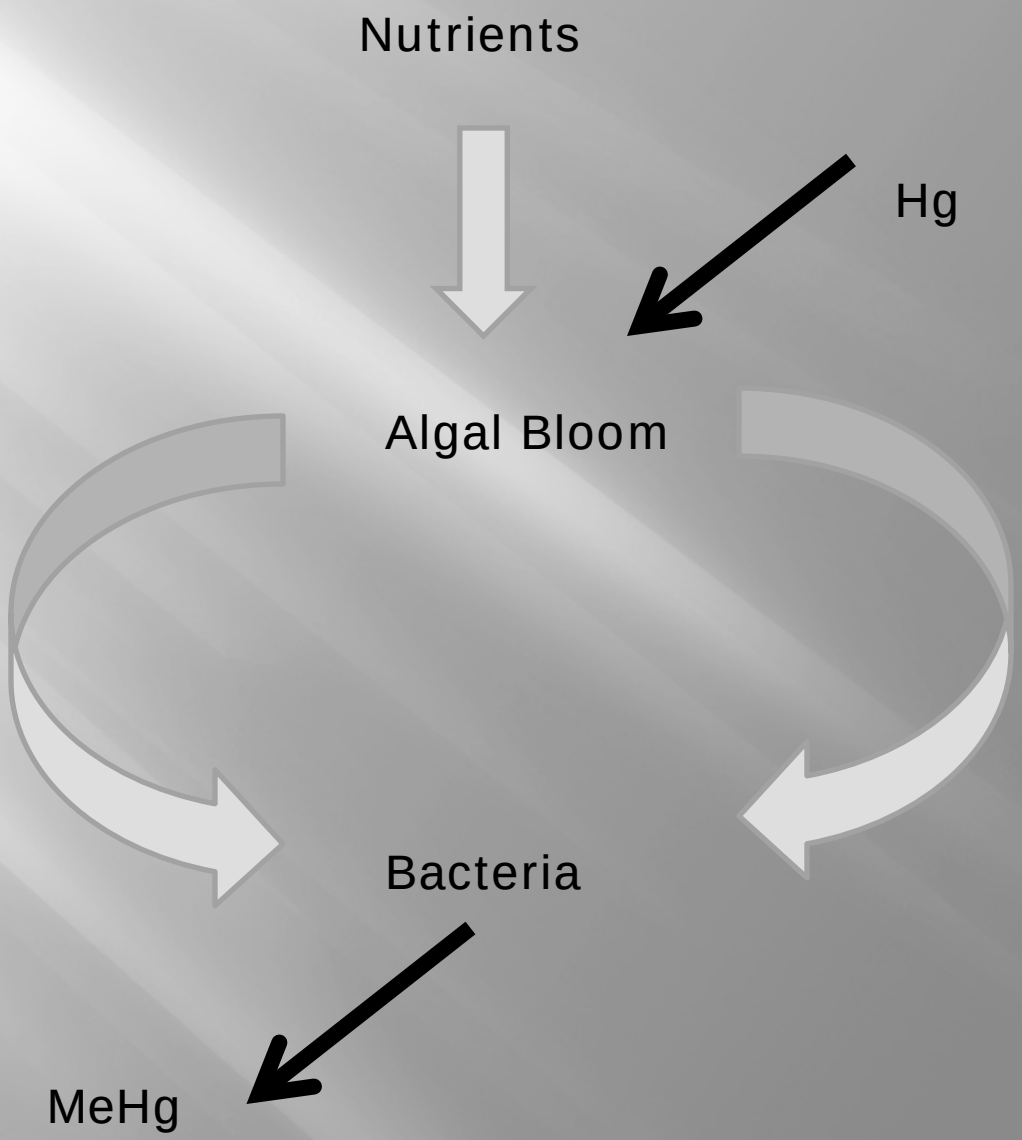
Low Resuspension

High Resuspension





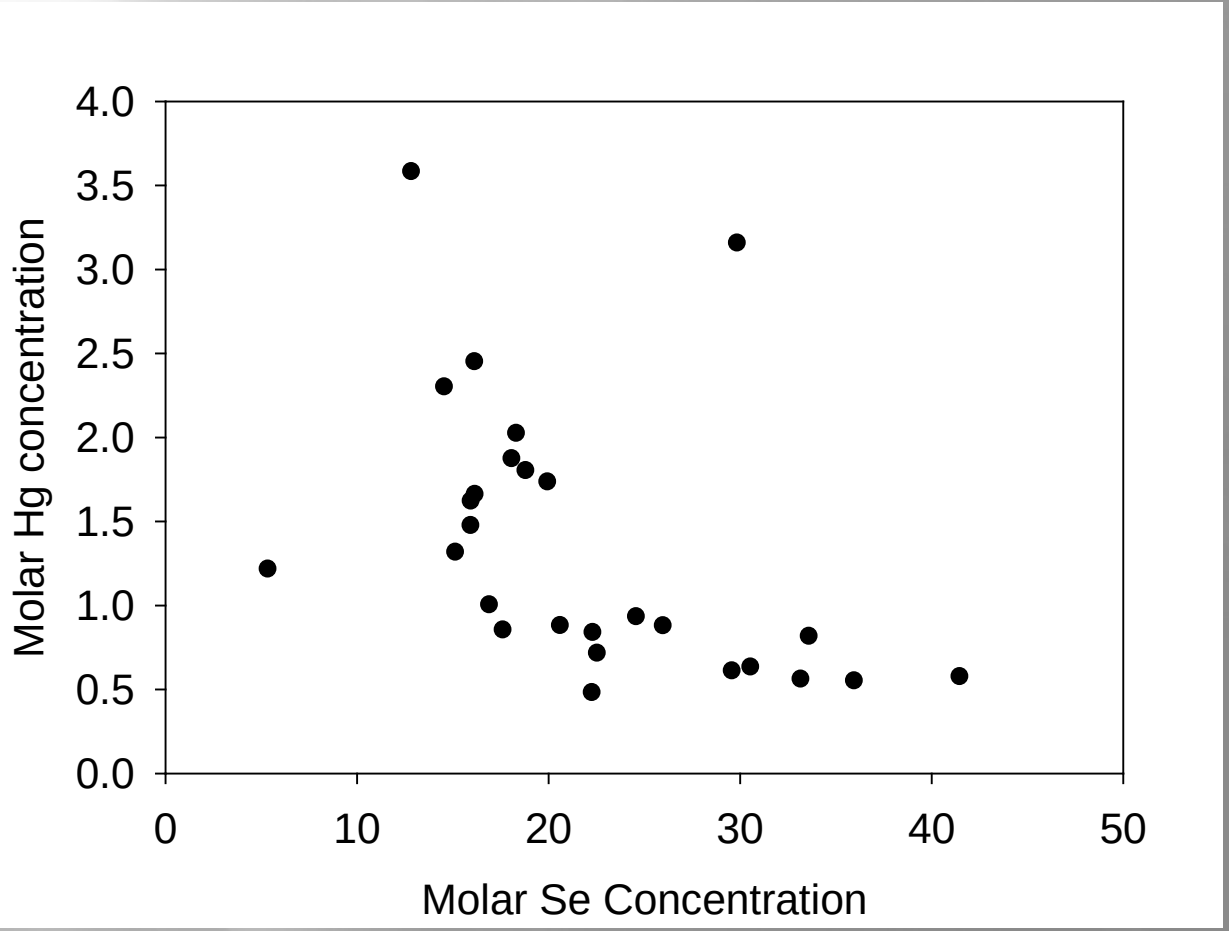
Phytoplankton Blooms



Other factors of interest?

How about selenium?

YOY study
Mercury in fish and Se:Hg Molar Ratios



Missing information

Dry deposition – throughfall?

Stream and reservoir food webs?

Chesapeake Bay food web?

Current importance of anoxic bottom water?

Climate change?

Shift in nutrient status and methylation?

Impact of restoration activities?

Urban loading?

Conclusions

We have made some progress in understanding mercury cycling but we need to do a lot more to make informed management decisions