University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

Smithsonian Environmental
Research Center

Tracking changes in Mercury Deposition to Maryland and Understanding the impact on its Biota

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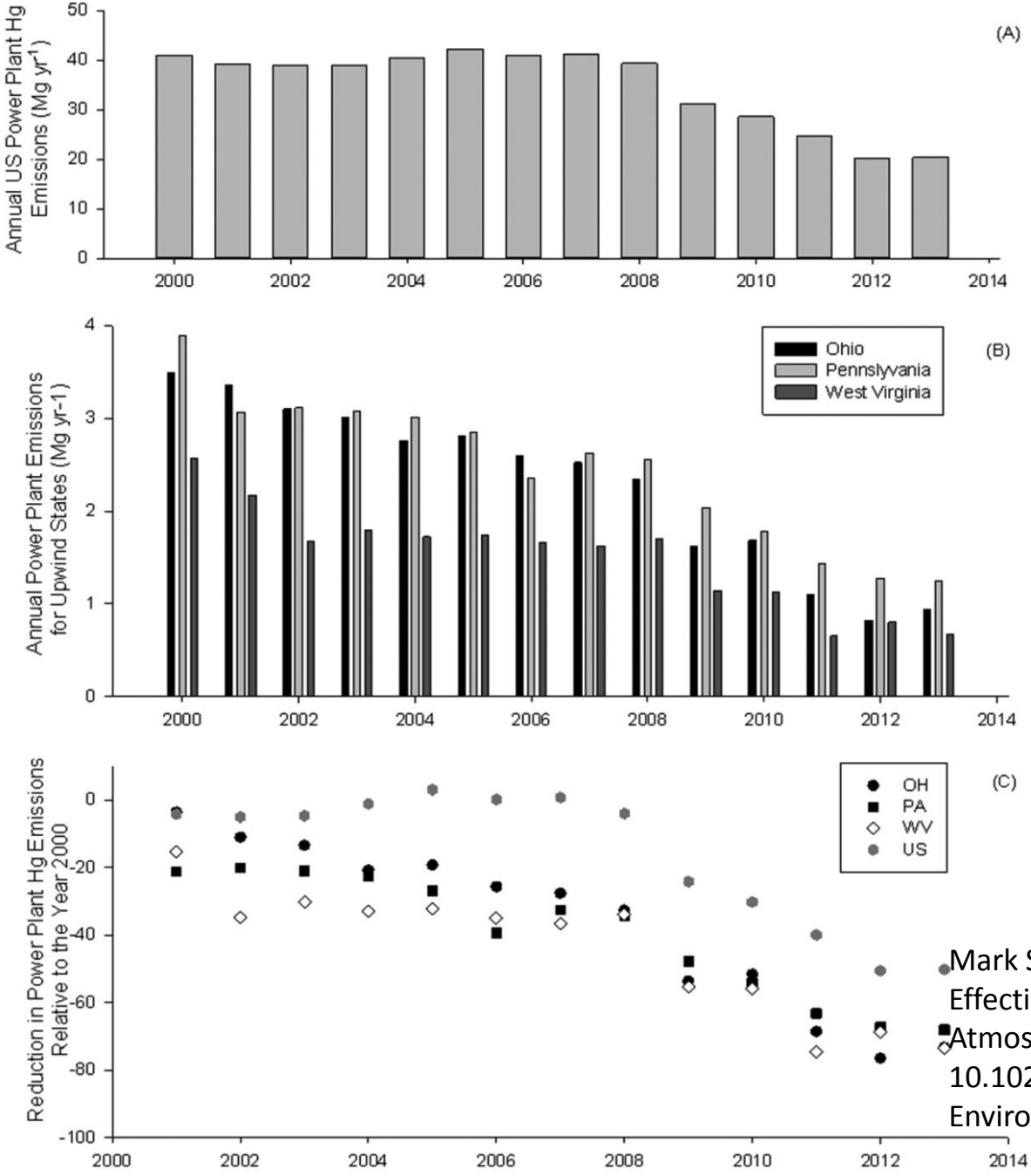
MDE

Tim Rule

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Tony Prochaska, Michael Kashiwagi, Helen Stewart, John Sherwell, Mark Castro



Mark S. Castro*,† and John Sherwell. 2016. Effectiveness of Emission Controls to Reduce the Atmospheric Concentrations of MercuryDOI: 10.1021/acs.est.5b03576
Environ. Sci. Technol. 2015, 49, 14000−14007

Management Questions for Regarding Mercury Deposition in the 1990's

If we reduce inorganic Hg emissions will it have an impact on mercury deposition and 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?

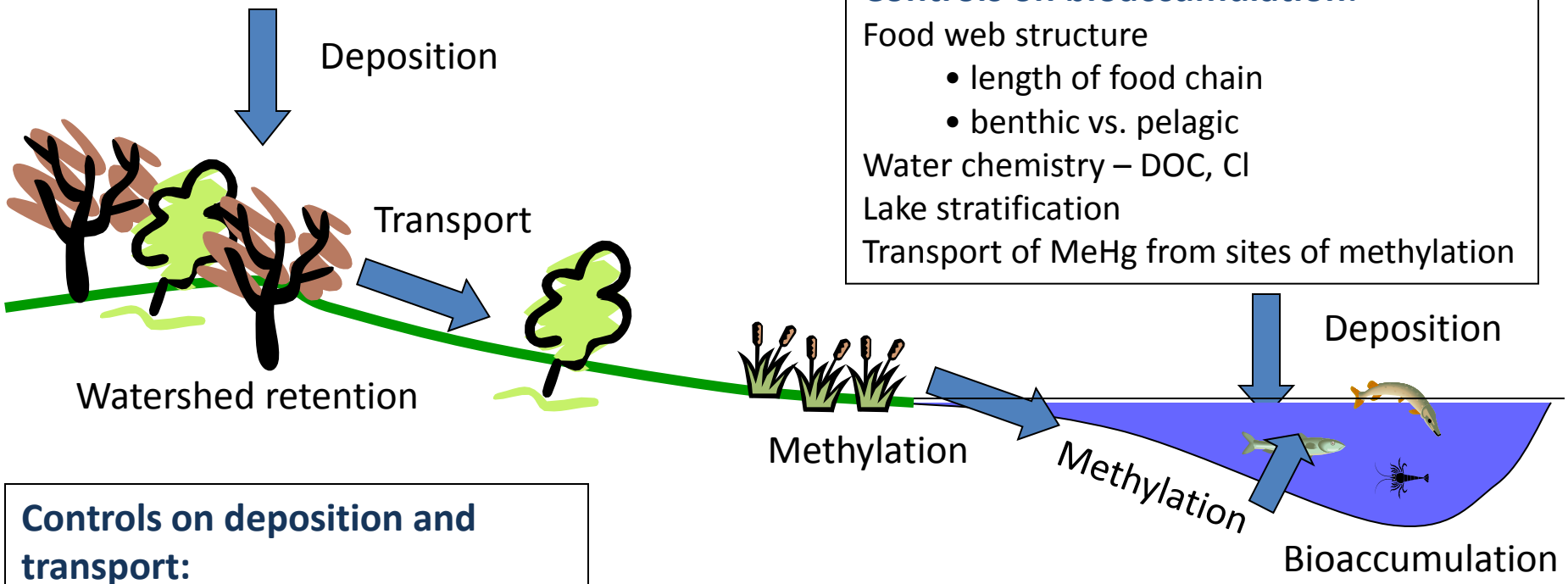
Mercury Monitoring Program 2006

Approach follows:
Mason et al. “Monitoring the Response to Mercury Deposition”
Environ. Sci. Tech 2005

And

Harris, R., Krabbenhoft, D., D. Engstrom, C. Gilmour,, J. Hurley, R. Mason et al. 2005. “Recommendations For Monitoring And Assessing Environmental Response To A Change In Mercury Loading Using Water- And Sediment- Based Indicators.” In: R.Harris, Ed. “Recommendations for Long-term Mercury Monitoring and Assessment,” SETAC publications.

Conceptual Diagram of the Controls on MeHg in Fish



Controls on bioaccumulation:

Food web structure
- length of food chain
- benthic vs. pelagic

Water chemistry – DOC, Cl
Lake stratification
Transport of MeHg from sites of methylation

Controls on deposition and transport:

Deposition:
Strength and proximity of sources
Source type
Atmospheric chemistry

Transport:
Landuse
Geology/soil type
Catchment:lake area ratio

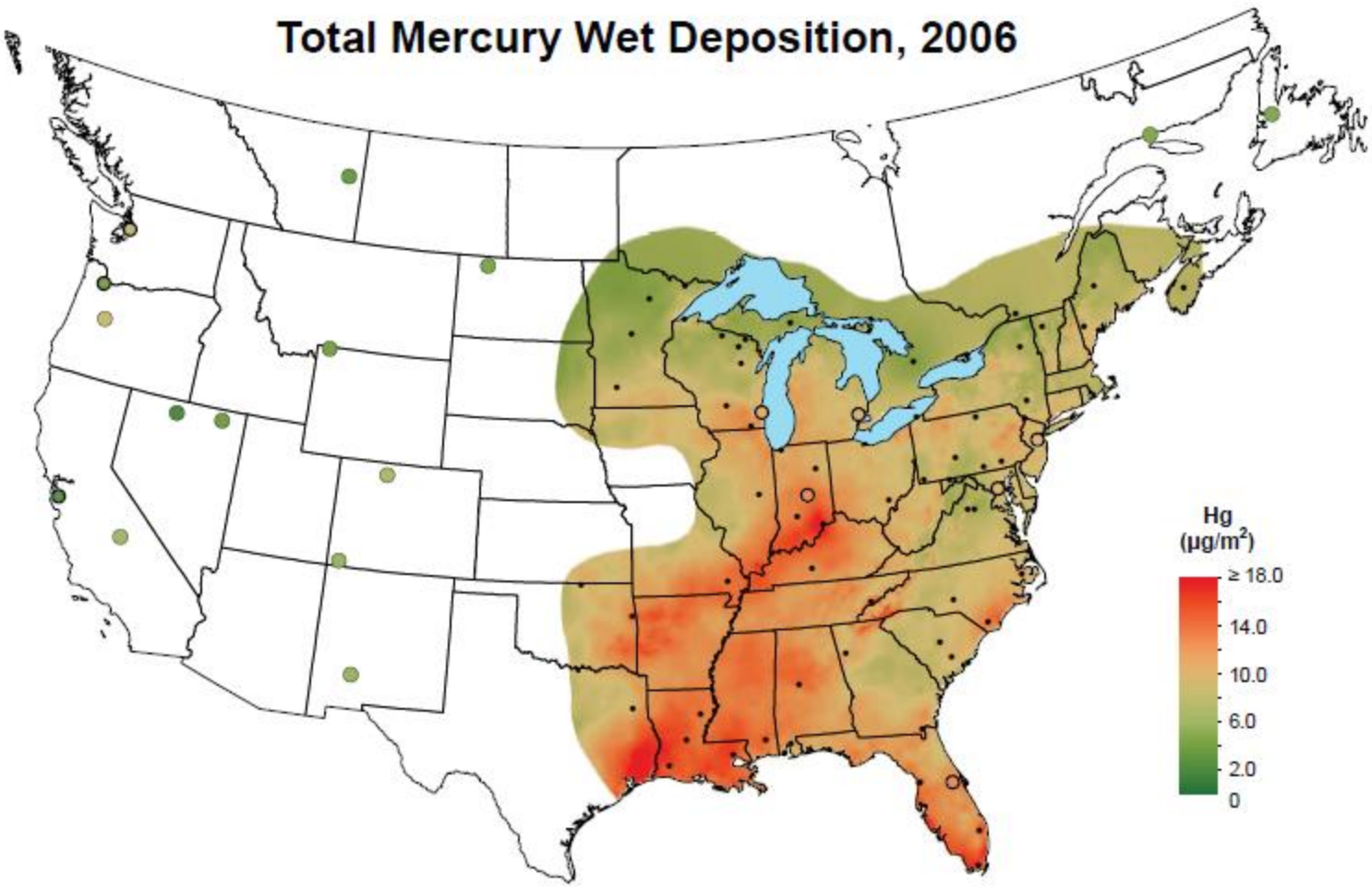
Controls on net methylation:

"Age" and complexation of Hg
Basin morphometry -
- extent of shallow sediments and wetlands
- surface to volume ratio

Water and sediment chemistry –
- sulfate, DOC, nutrients

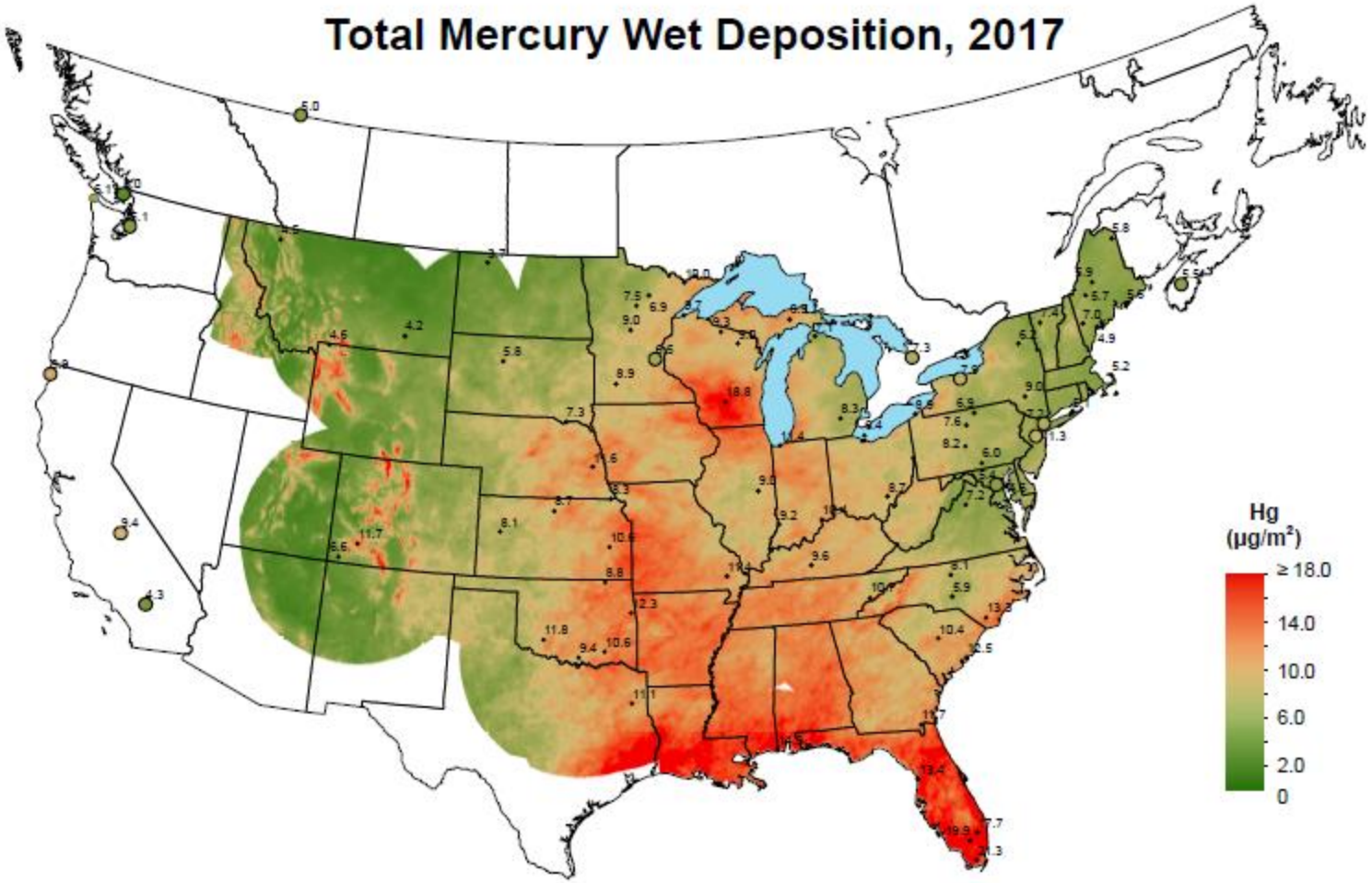
Temperature
Drying and rewetting of soils/sediments

Mercury Deposition



National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu

Total Mercury Wet Deposition, 2017



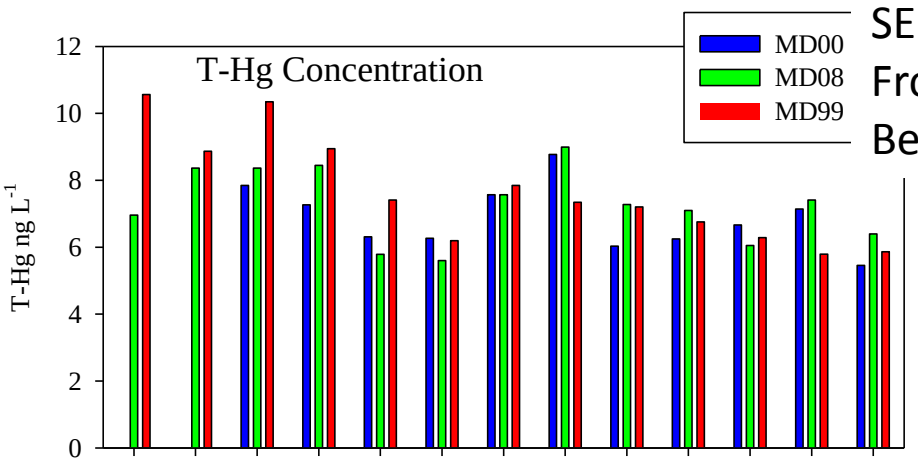
Sites not pictured:

Alaska 02	3.8 µg/m²
Saskatchewan 27	4.9 µg/m²

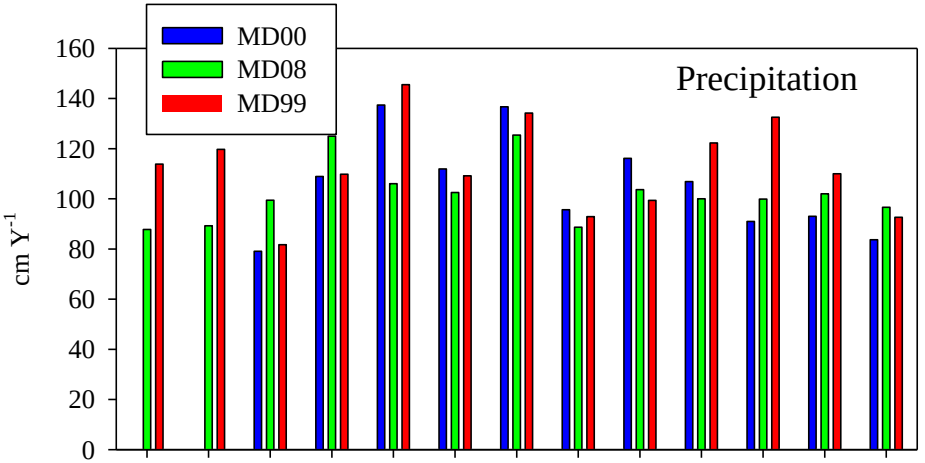
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.slh.wisc.edu

SERC
Frostburg
Beltsville

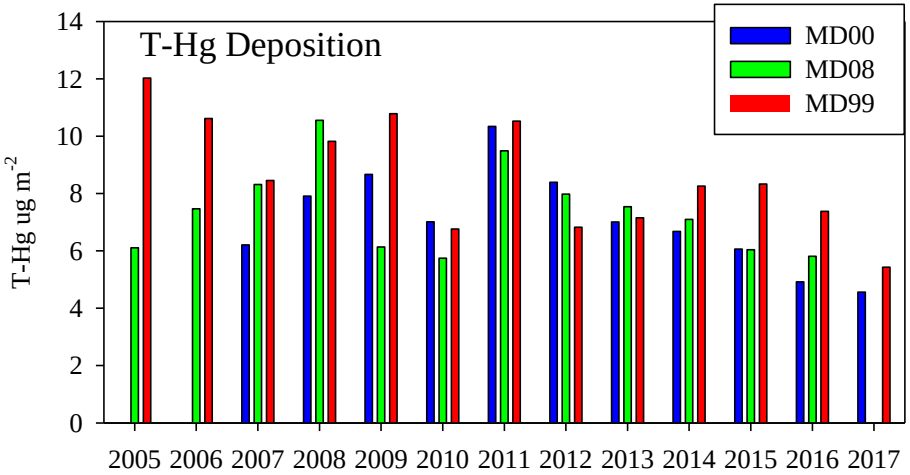
Mercury Concentration in Precipitation



Precipitation



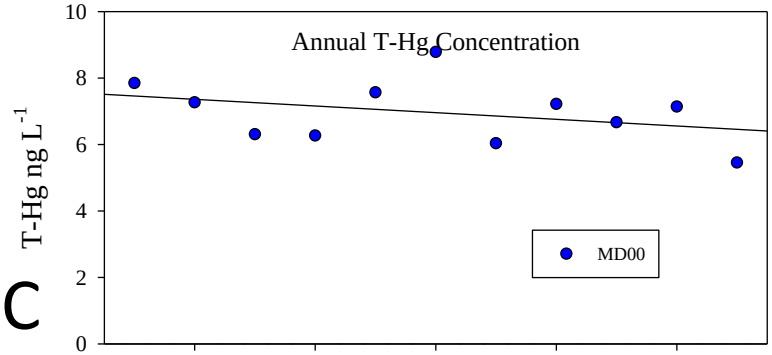
Mercury Deposition

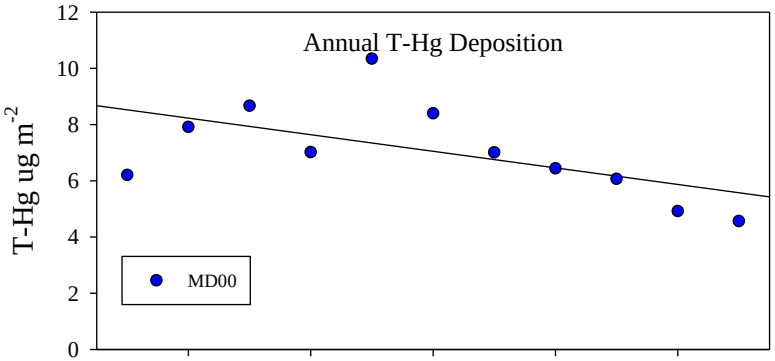


Mercury Concentration

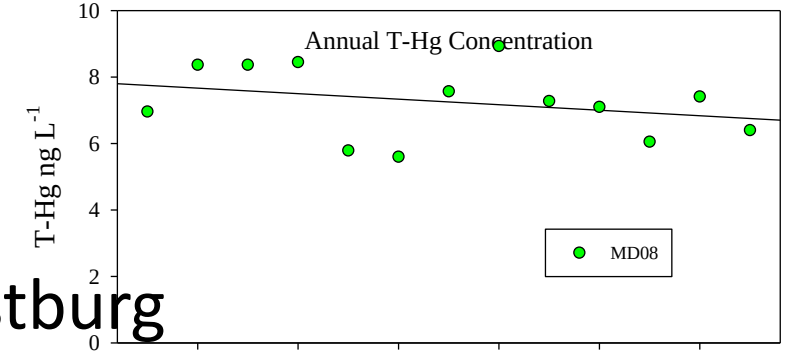
Mercury Deposition

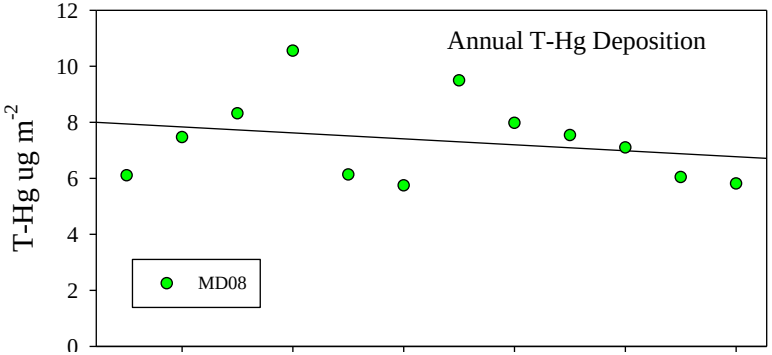
SERC



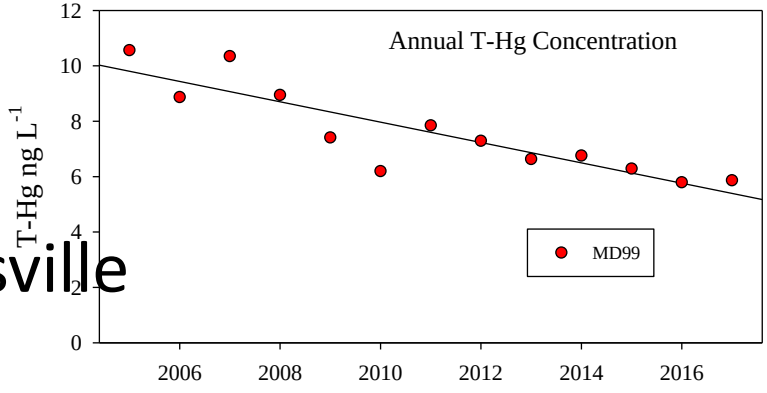


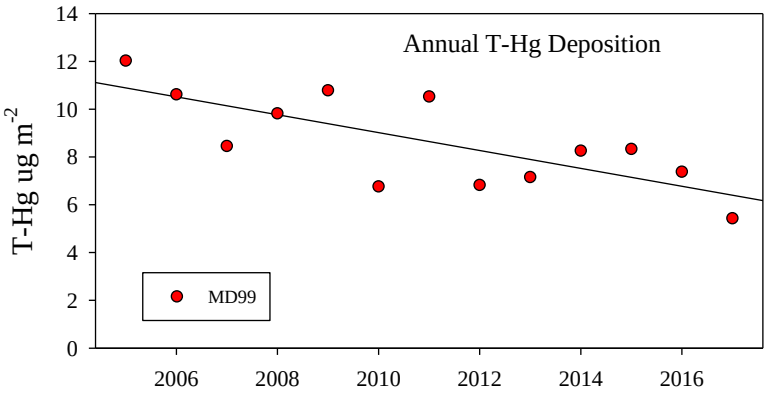
Frostburg





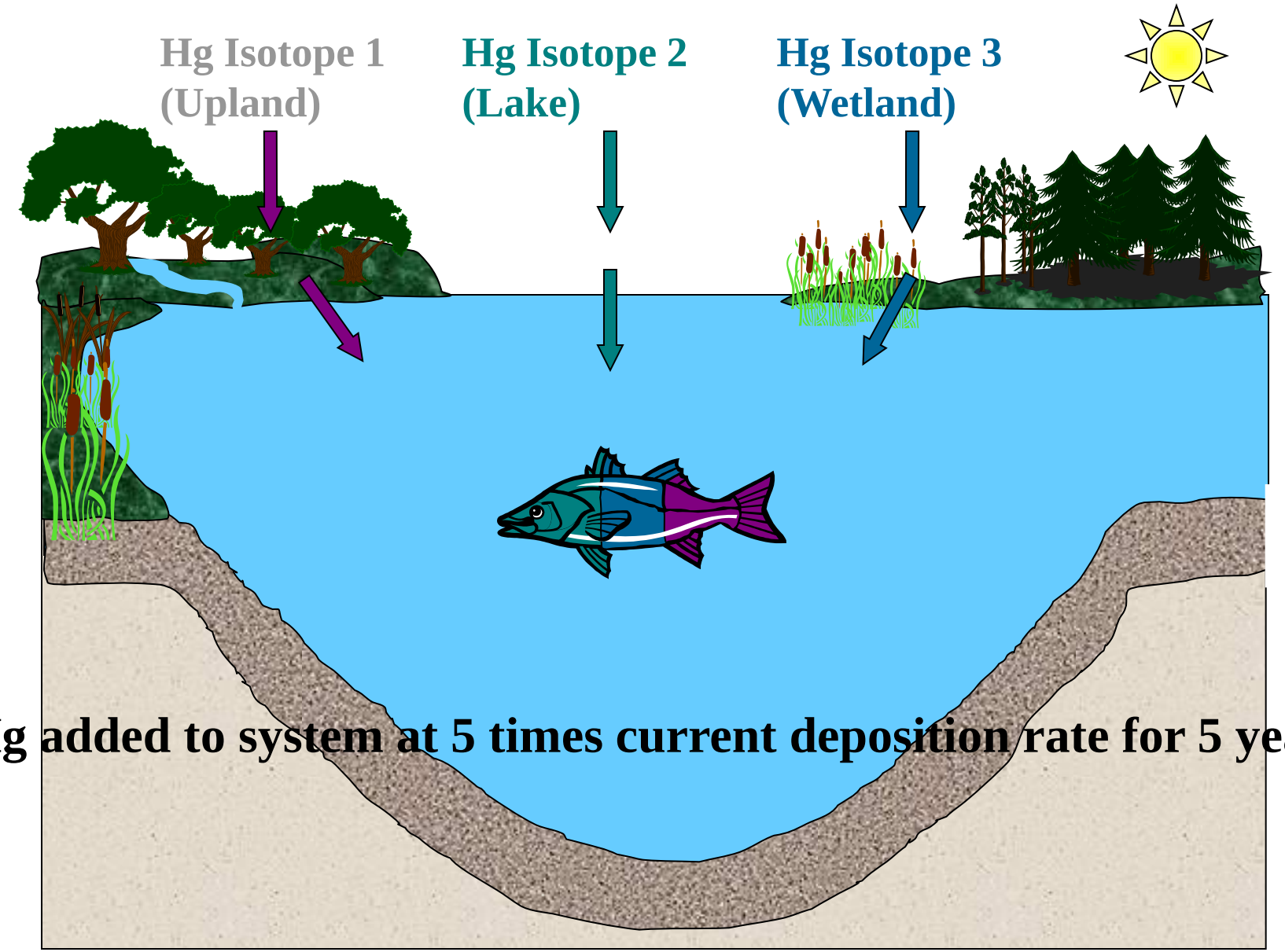
Beltsville





Mercury in Fish

Measure Different Source Contributions to Fish Hg



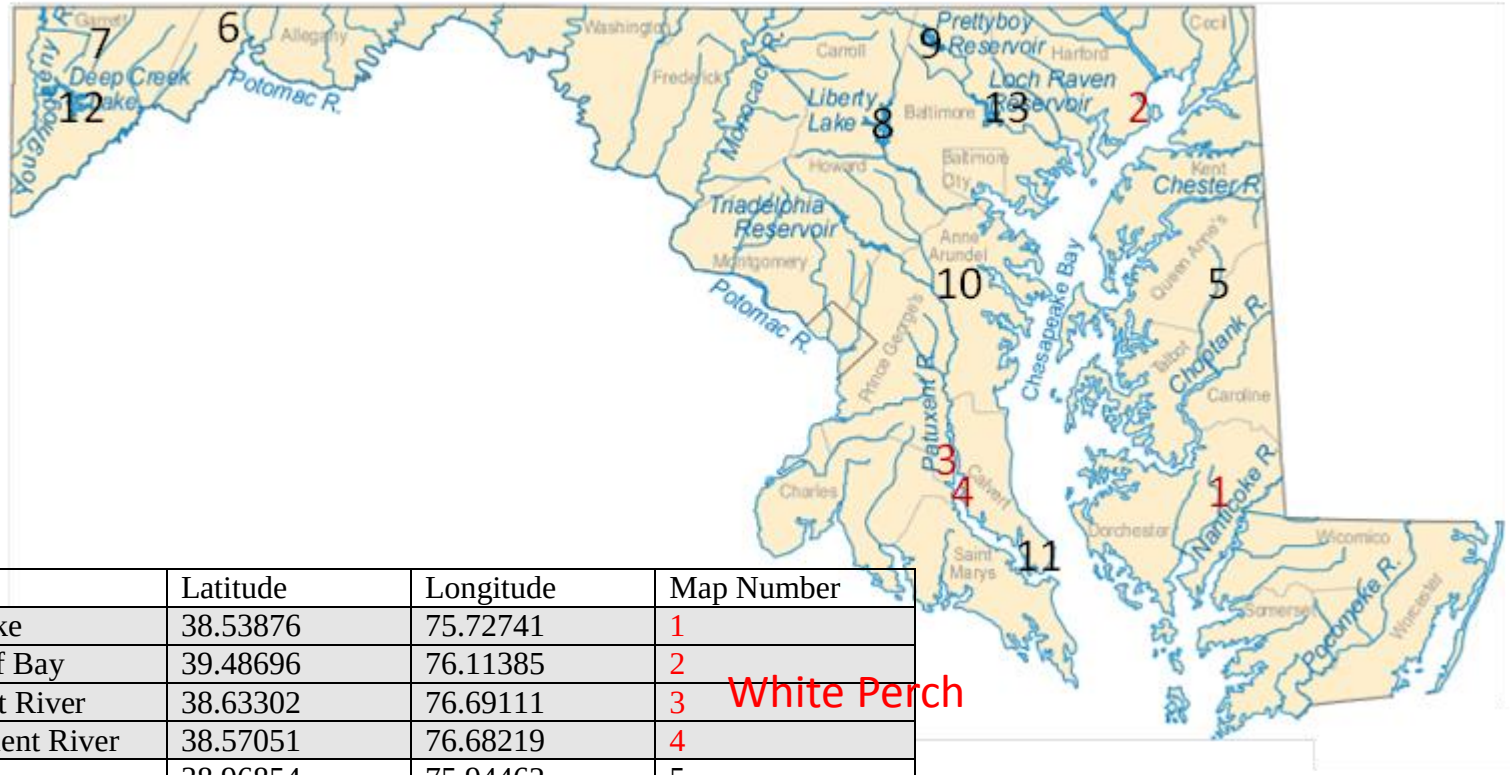
Hg added to system at 5 times current deposition rate for 5 years.

METAALICUS unpublished
Under review
Please do not cite or display
See published paper for earlier plot

Harris, R.C., Rudd., J.W.M., Amyot, M., Babiarz, C.L., Beaty, K.G., Blanchfield, P.J., Bodaly, R.A., Branfireun, B.A., Gilmour, C.C. Graydon, J.A., Heyes, A. Hintelmann, H., Hurley, J.P., Kelly, C.A., Krabbenhoft, D.P., Lindberg, S.E., Mason, R.P. Paterson, M.J. Podemski,C.L., Robinson, A., Sandilands, K.A., Southworth, G.R., St. Louis, V.L., Tate, M.T. 2007.
Whole ecosystem study shows rapid fish mercury response to changes in mercury deposition.
Proc. Nat. Acad. Sci. 104:16586-16591. 10.1073/pnas.0704186104.

We can see this clearly because we used enriched isotope

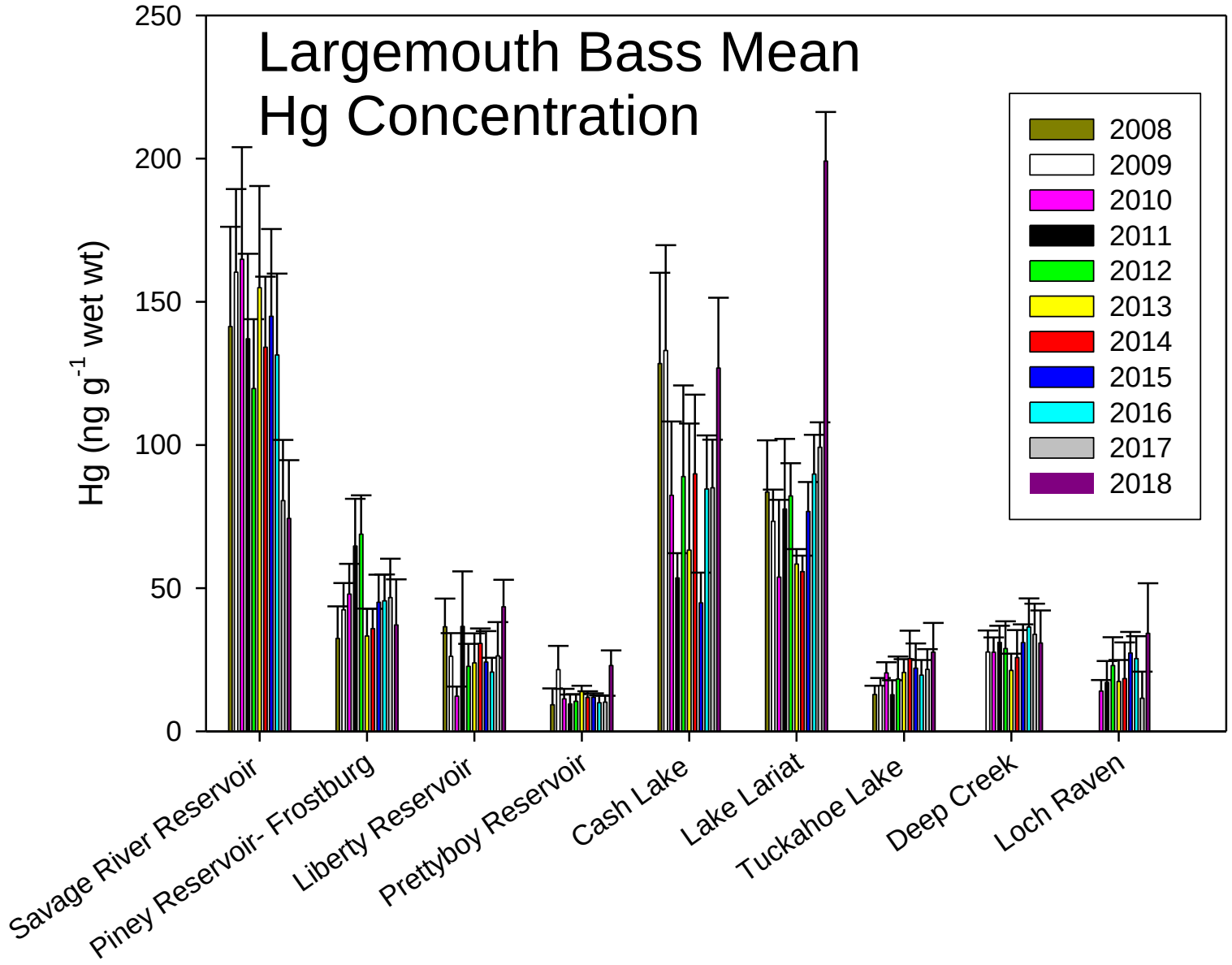
Young of the Fish Year Study



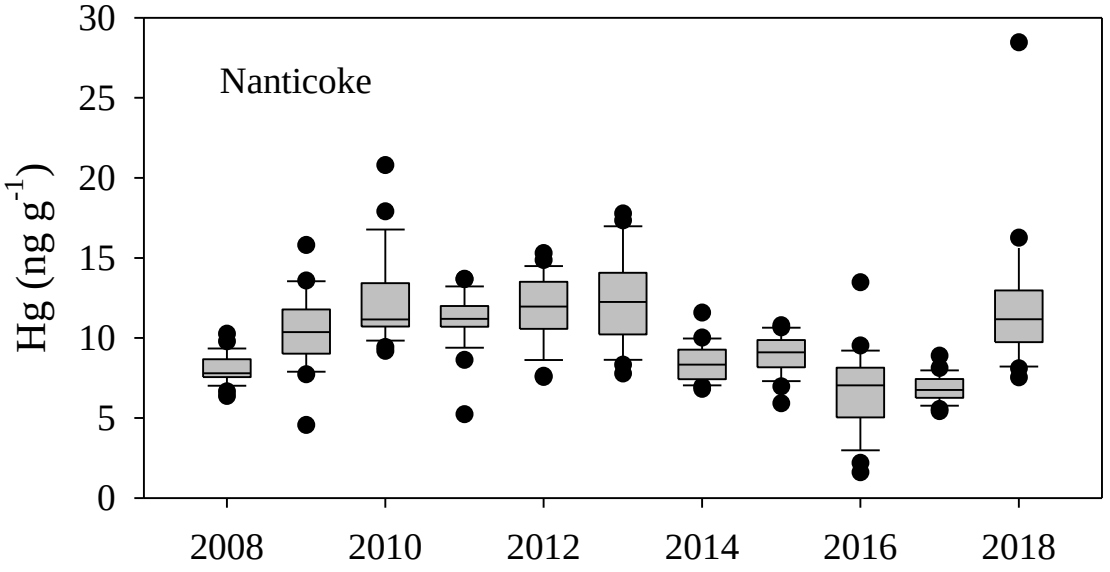
Site	Latitude	Longitude	Map Number
Sharptown-nanticoke	38.53876	75.72741	1
Plum-Point Head of Bay	39.48696	76.11385	2
Mill Town Patuxent River	38.63302	76.69111	3
Eagle Harbor Patuxent River	38.57051	76.68219	4
Tuckahoe Lake	38.96854	75.94462	5
Piney Reservoir	39.70842	79.0018	6
Savage River Reservoir	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

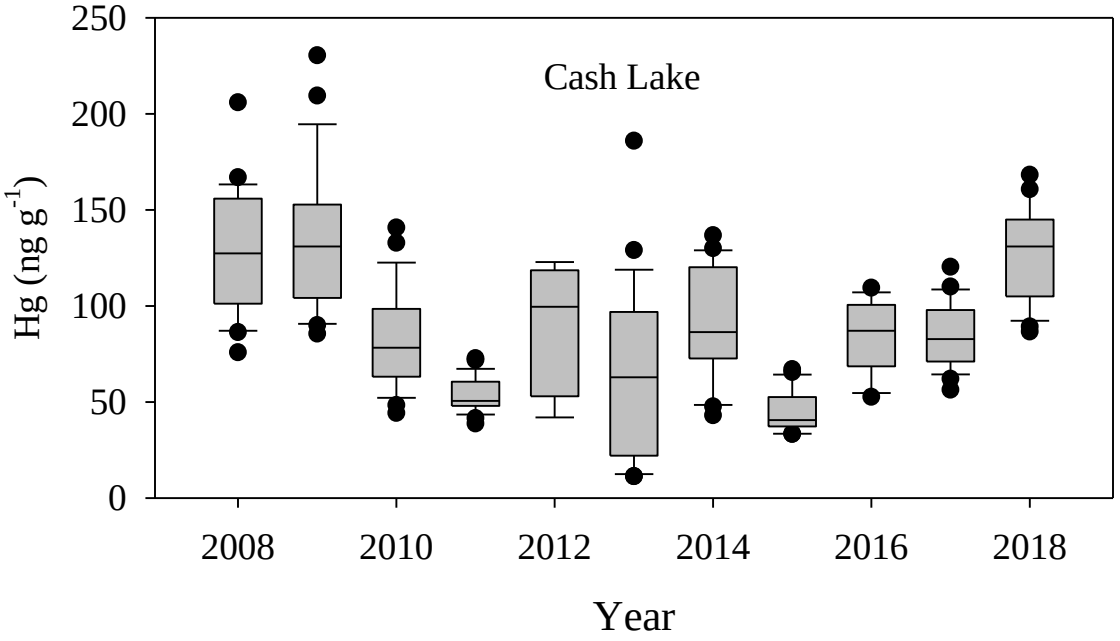
Bass


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
2018
Savage River Reservoir
Piney Reservoir- Frostburg
Liberty Reservoir
Prettyboy Reservoir
Cash Lake
Lake Lariat
Tuckahoe Lake
Deep Creek
Loch Raven

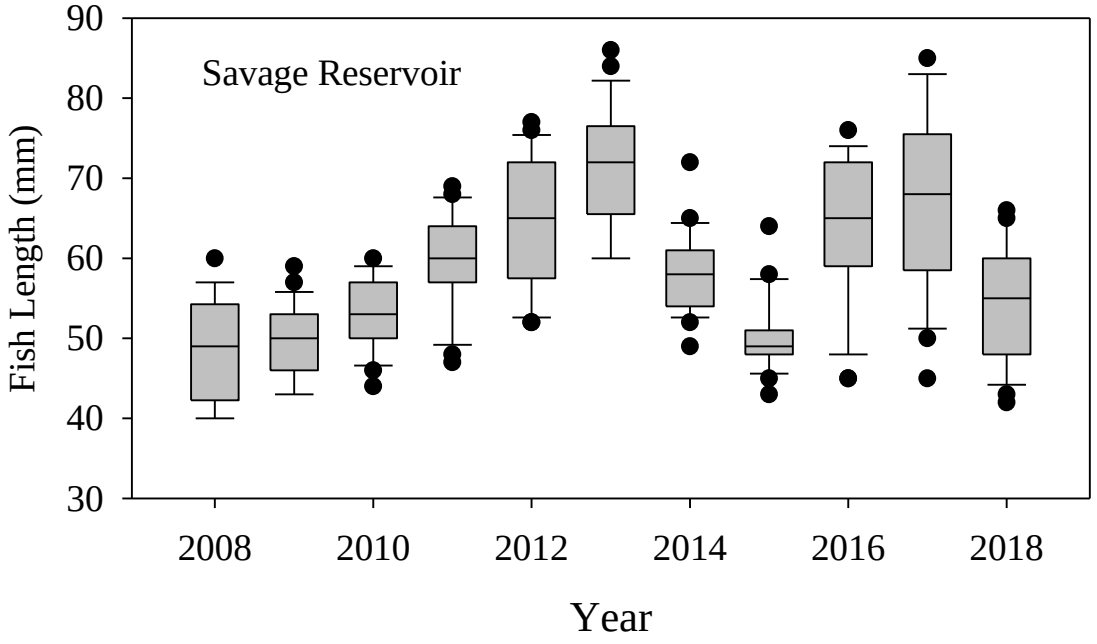
White Perch



Largemouth Bass

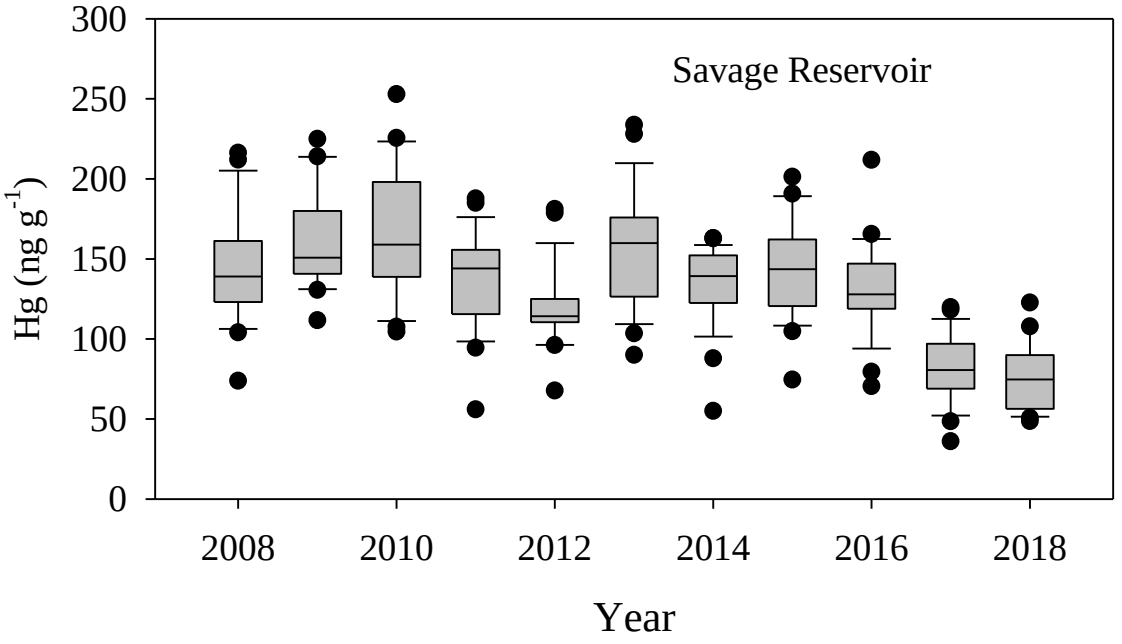


Fish Size



Largemouth Bass

Fish Hg



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- benthic vs. pelagic
- Fish growth rate

Water chemistry – DOC, Cl

Lake stratification

Transport of MeHg from sites of methylation

Controls on net methylation:

"Age" and complexation of Hg

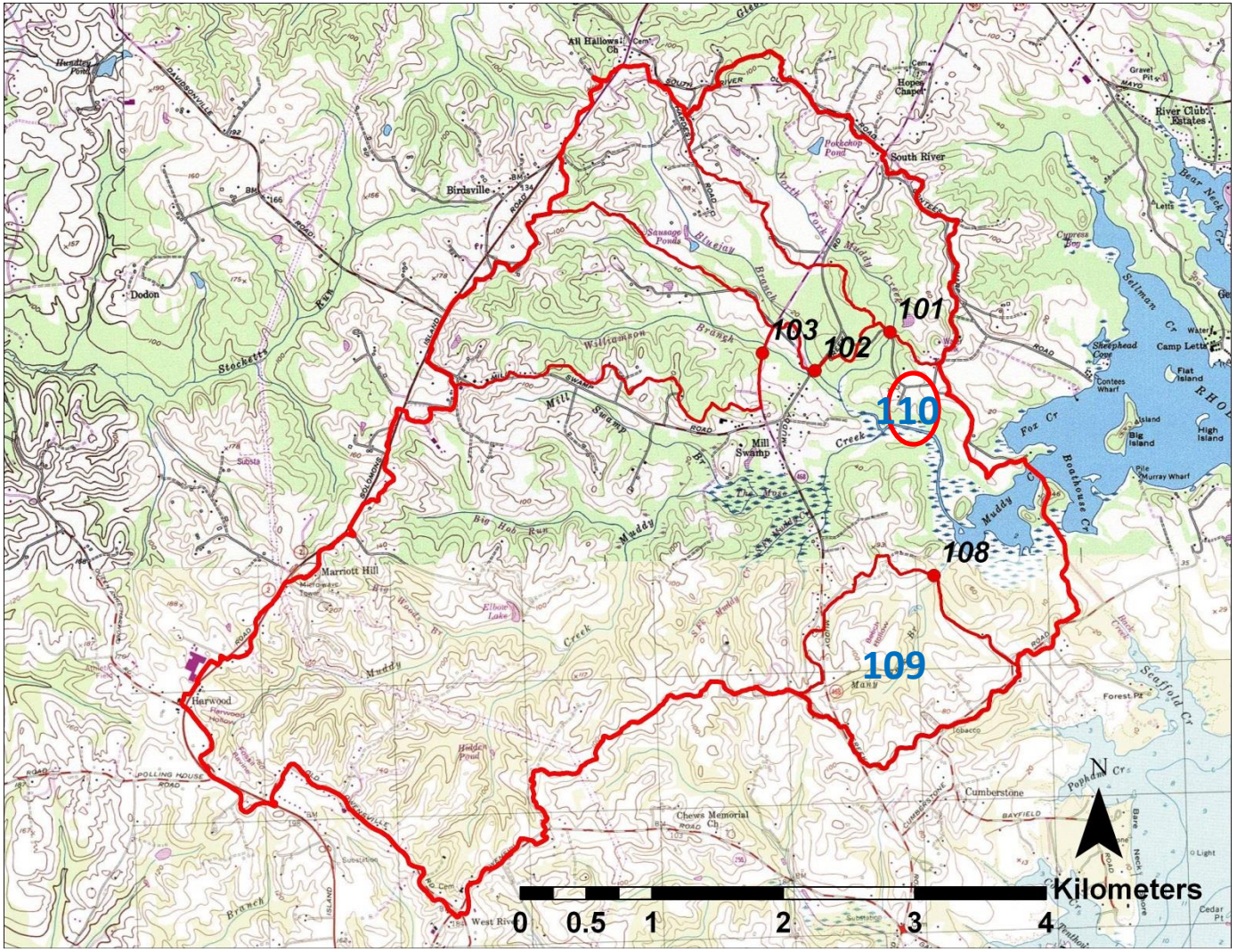
Basin morphometry -
- extent of shallow sediments and wetlands
- surface to volume ratio

Water and sediment chemistry –
- sulfate, DOC, nutrients

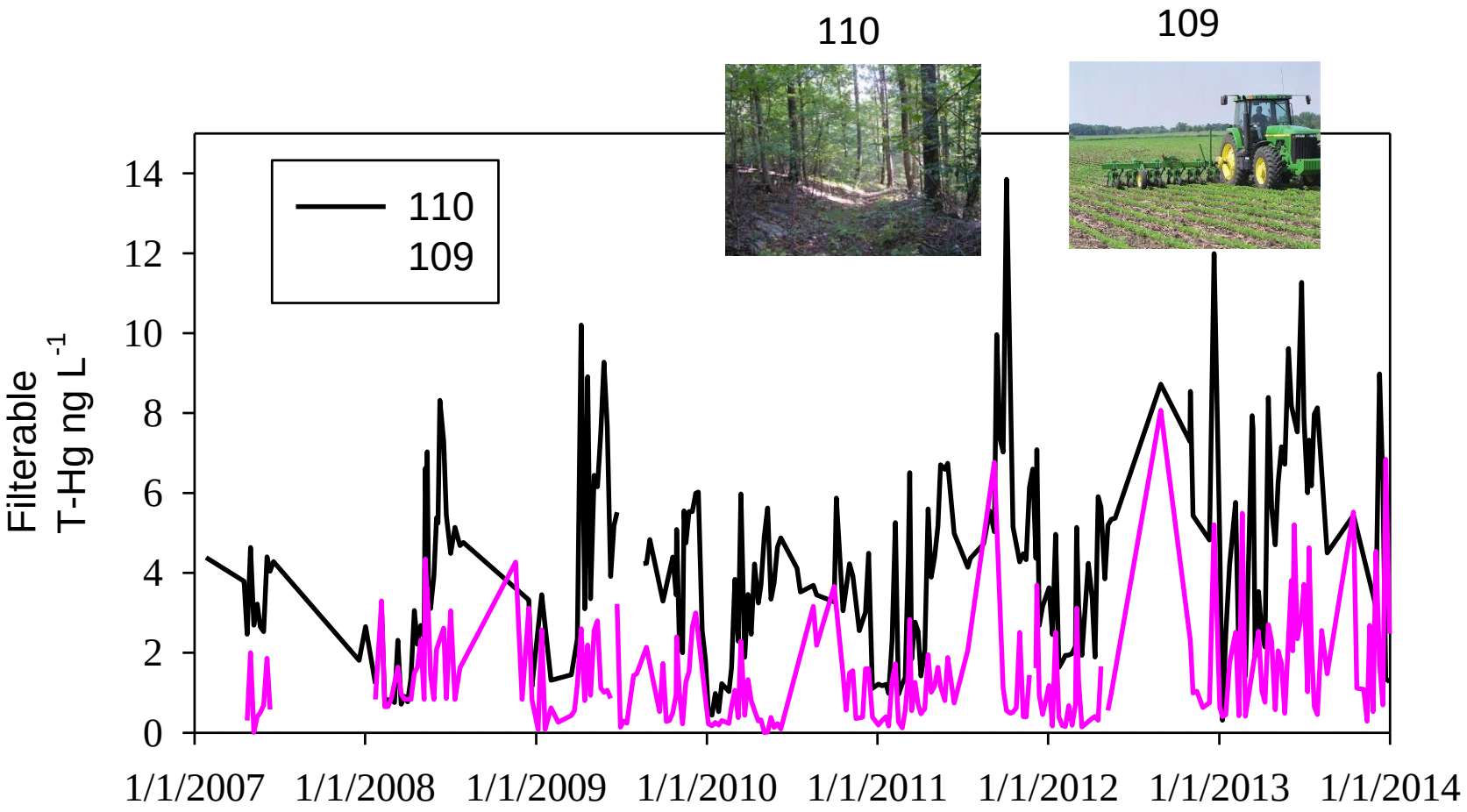
Temperature

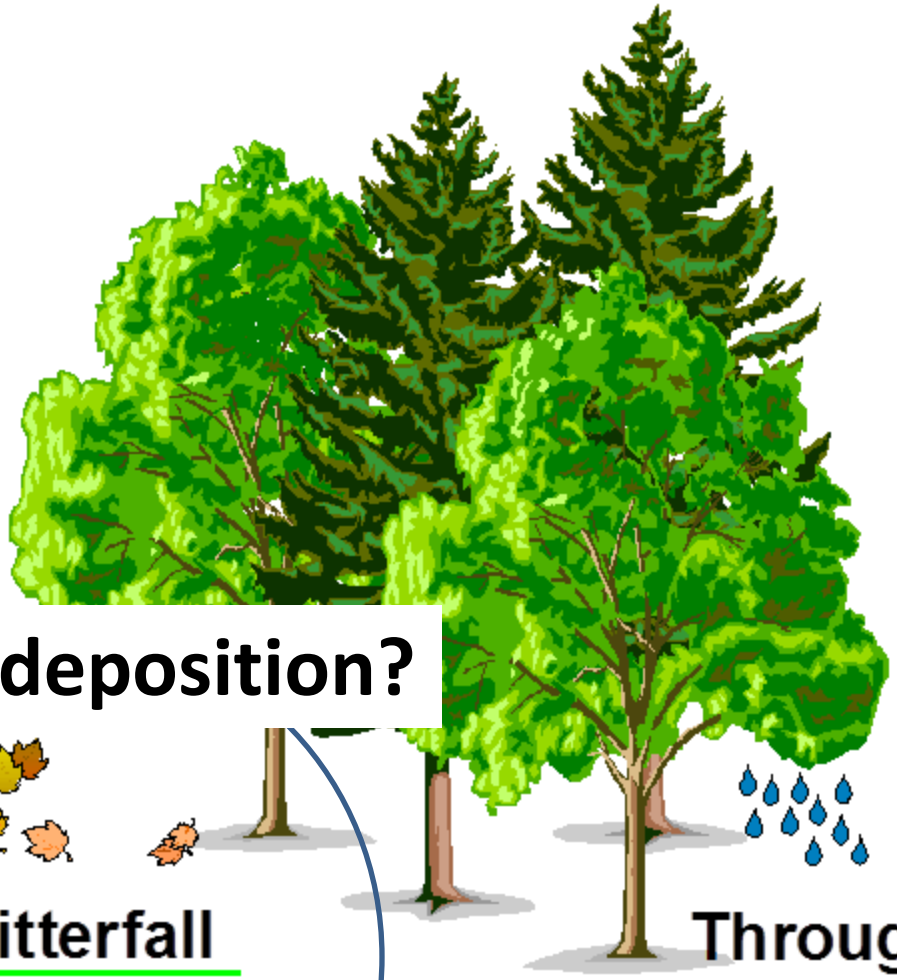
Drying and rewetting of soils/sediments

Impact of Land-use



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





Direct deposition

MeHg	IHg
0.9	70

2X wet deposition?

Litterfall

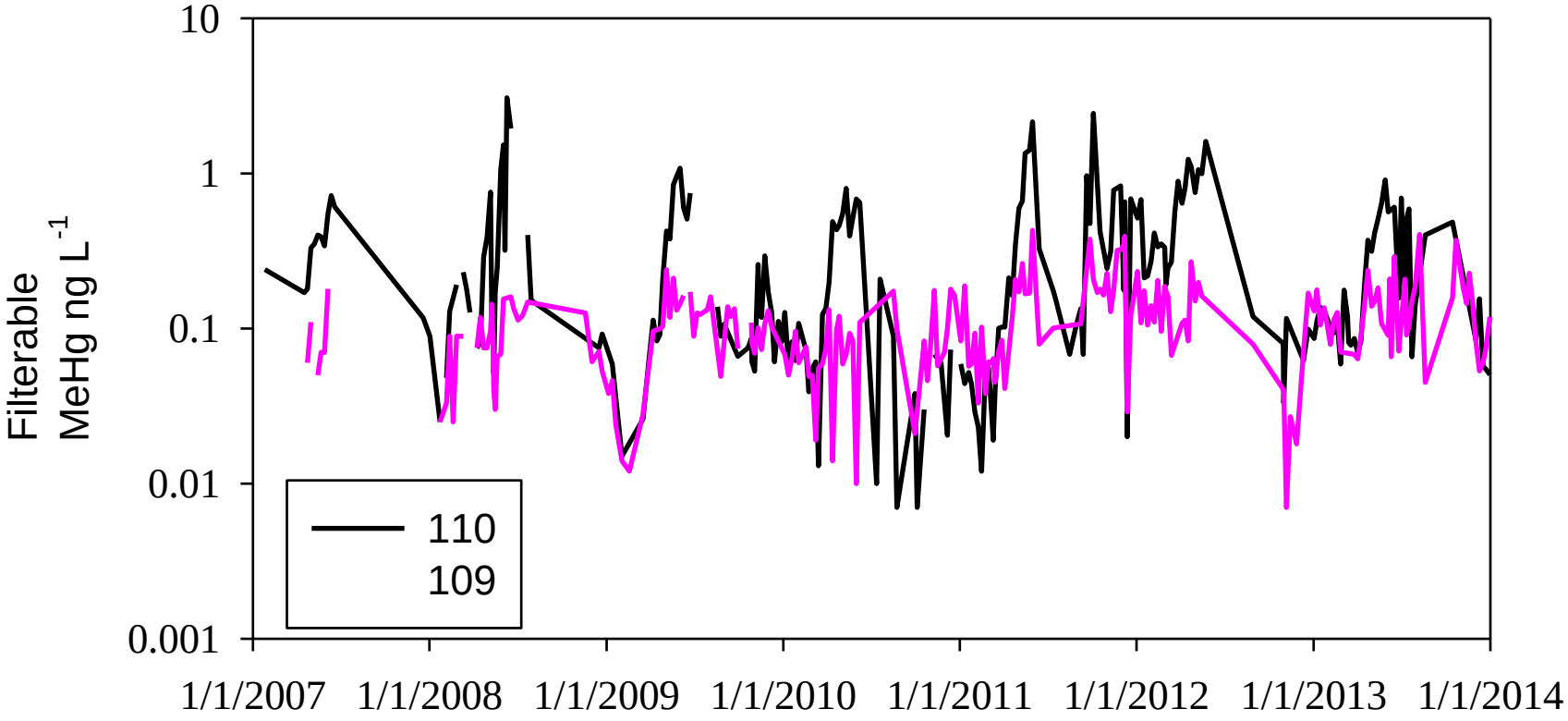
MeHg	IHg
0.8	113

Throughfall

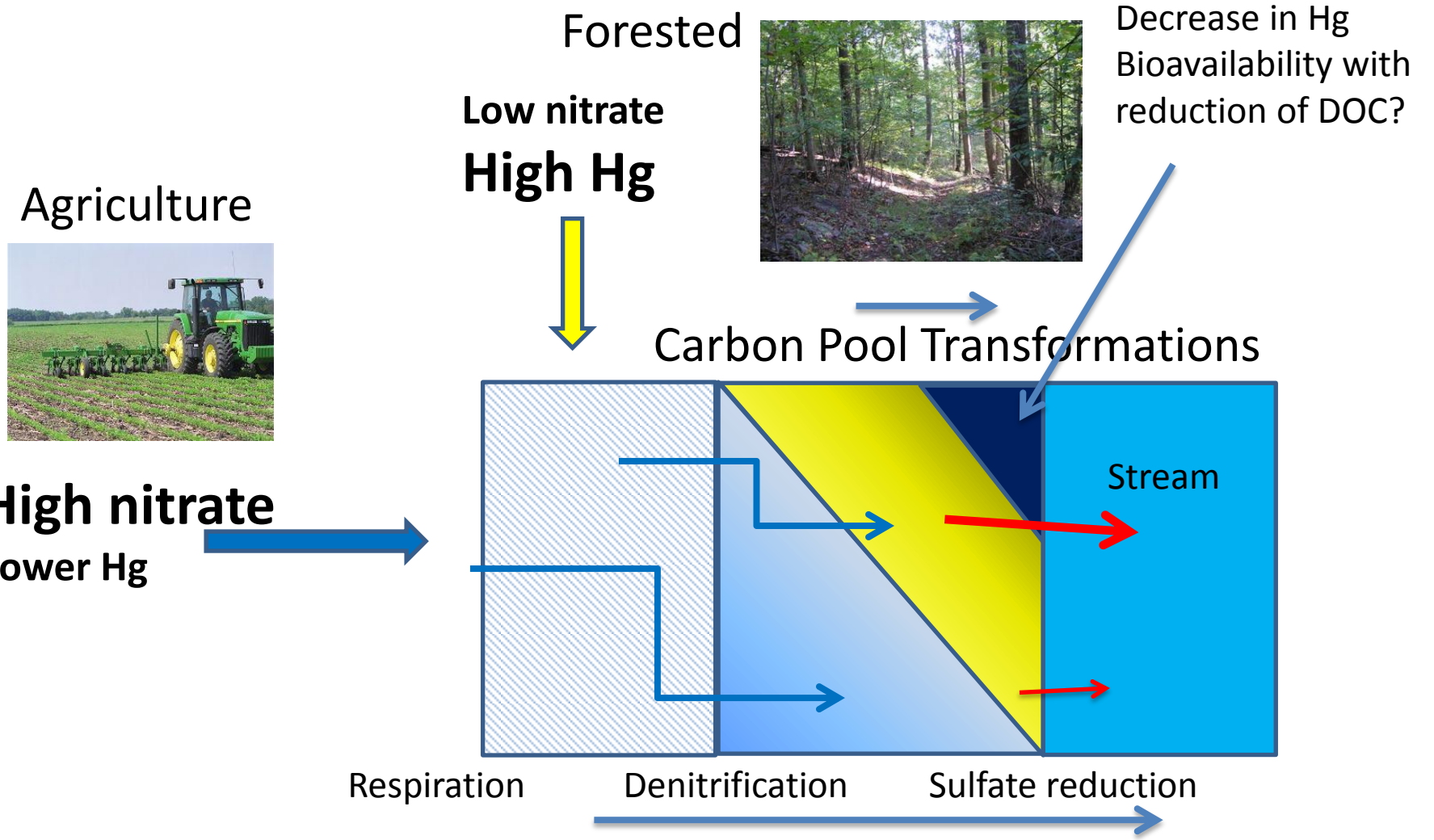
MeHg	IHg
0.9	80

Fluxes in mg/ha/yr

Filterable MeHg Concentrations in Stream water 2007-2013

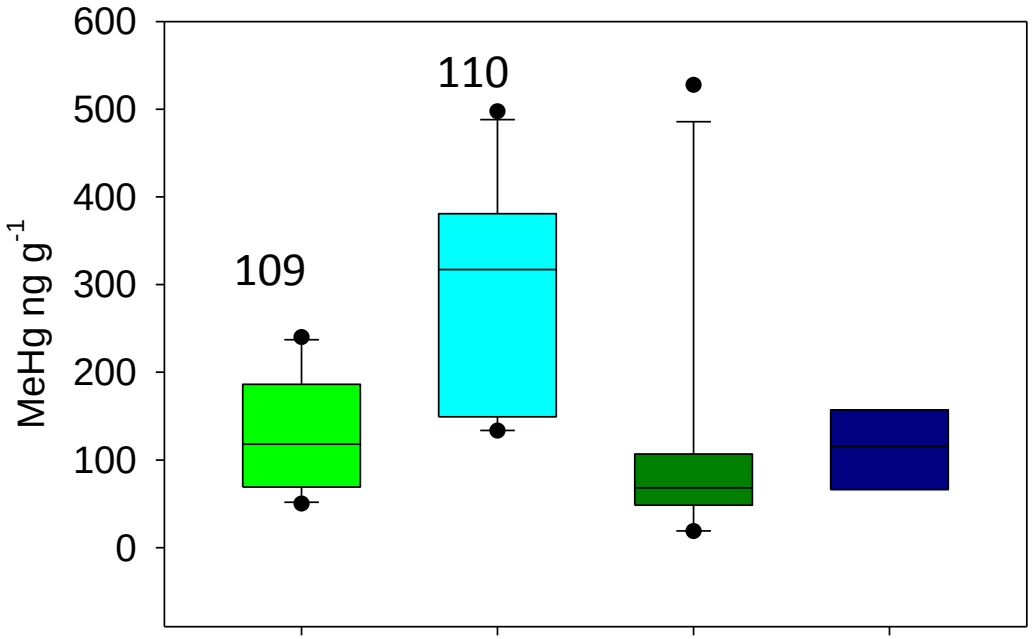


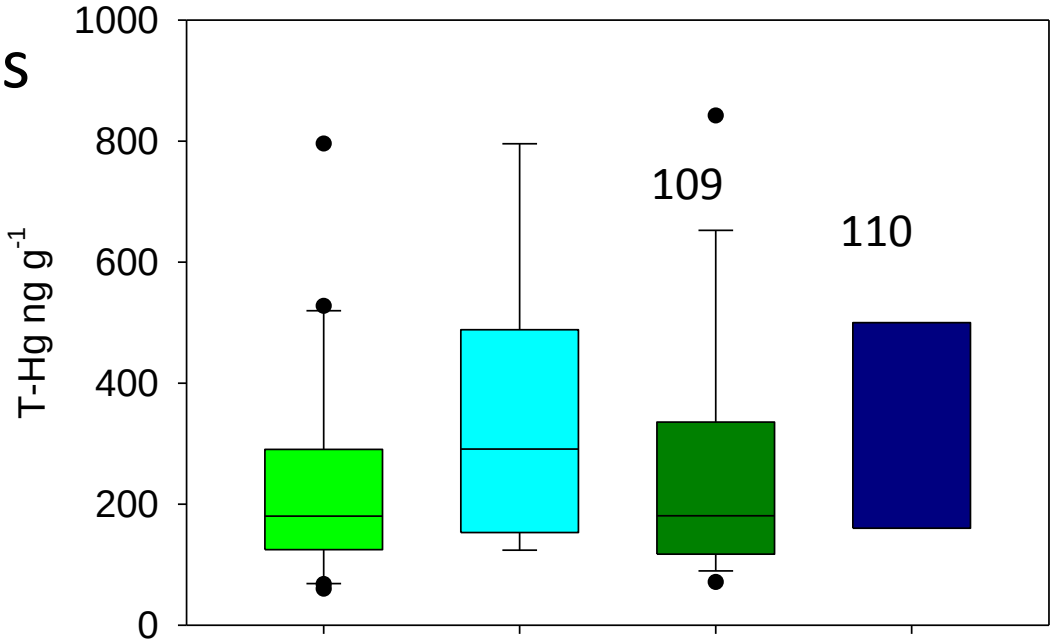
Schematic Model of Biogeochemical Processes in Riparian Zone – Hg Methylation



Timing of processes are different between the two watersheds

SERC Stream Invertebrates 2016





Concentration and deposition decreasing slowly

Watershed variables have an impact

There is a couple between Hg load and Hg in biota

Need to investigate dry deposition and
role of forest and transit time of Hg with watersheds

To my knowledge there are no studies like these being conducted elsewhere in the world!

Questions?