Comparison of Fish Tissue, Deposition and Emission Trends

by Dennis Leonard
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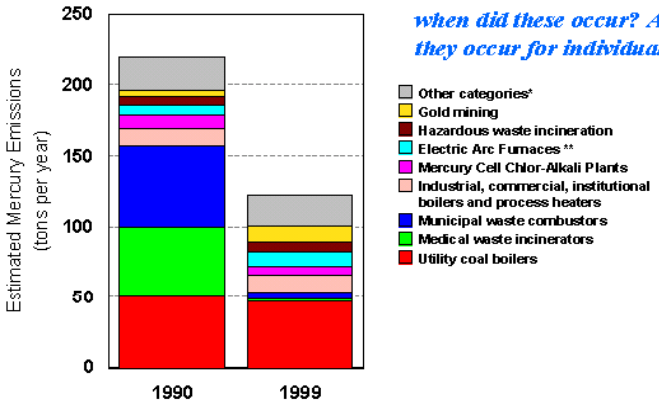
Importance of Looking Beyond Models to Actual Monitor Data

- Models May not be accurate
- Most emission reduction already occurred
- Understanding what has occurred, allows for informed discussion about benefits of future emission reductions

While there is general knowledge of large mercury emission reductions during the 1990's, there is less understanding of continued declines in emissions and importance of oxidized mercury emissions

U.S. Anthropogenic Emissions for 1990 and 1999 (USEPA)



There were big reported changes in emissions between 1990 and 1999, but when did these occur? And when did they occur for individual facilities?

* Data for Lime Manufacturing are not available for 1990.
** Data for Electric Arc Furnaces are not available for 1999. The 2002 estimate (10.5 tons) is shown here.

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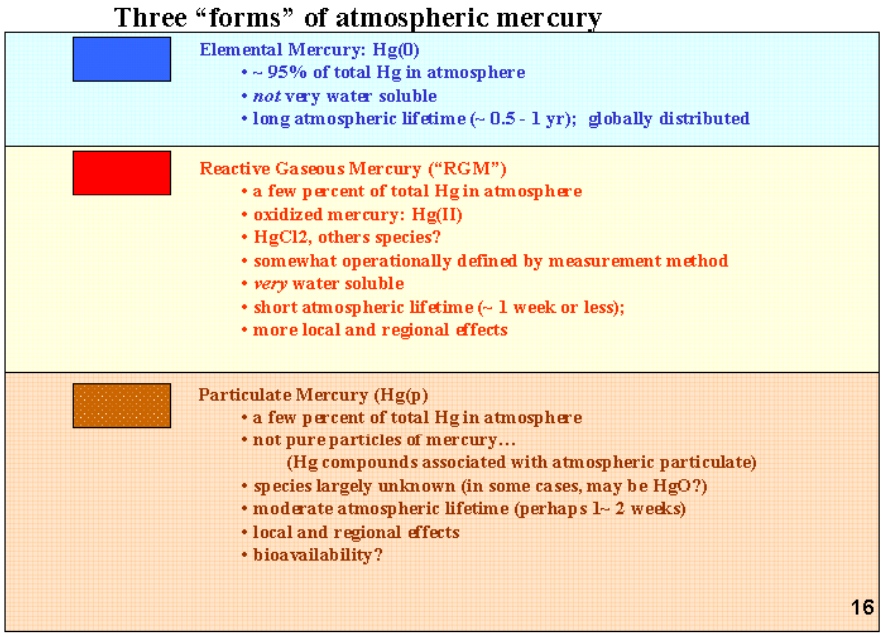
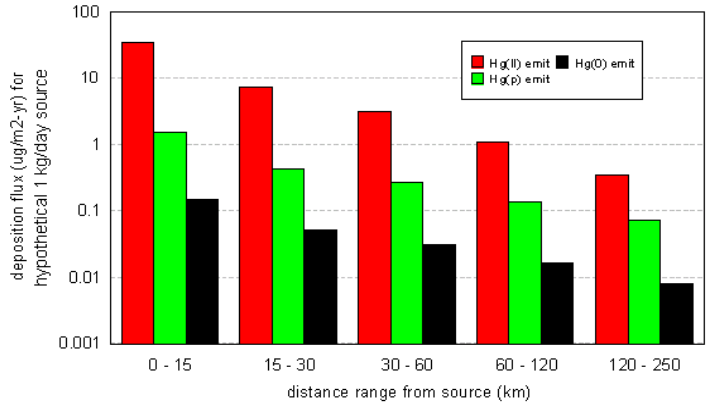
Importance of Oxidized Mercury

- Mercury is emitted in oxidized, particulate, and elemental forms.
- As the following slides from the National Oceanic and Atmospheric Administration demonstrate, only the oxidized and particulate forms of mercury deposit in the U.S. to any significant extent.



Why is emissions speciation information critical?



Logarithmic

NOTE: distance results averaged over all directions – Some directions will have higher fluxes, some will have lower

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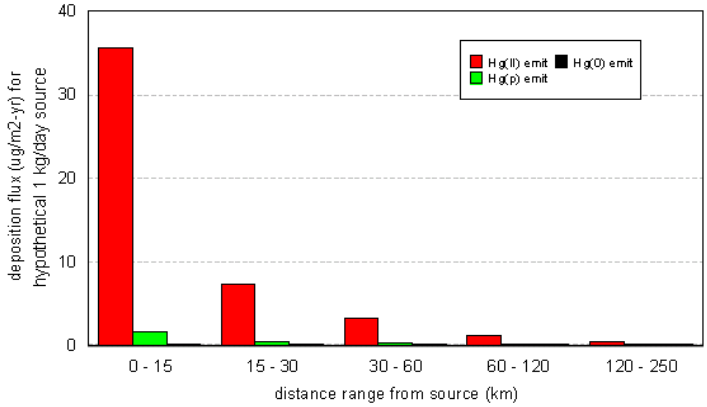
Why is emissions speciation information critical?



Linear

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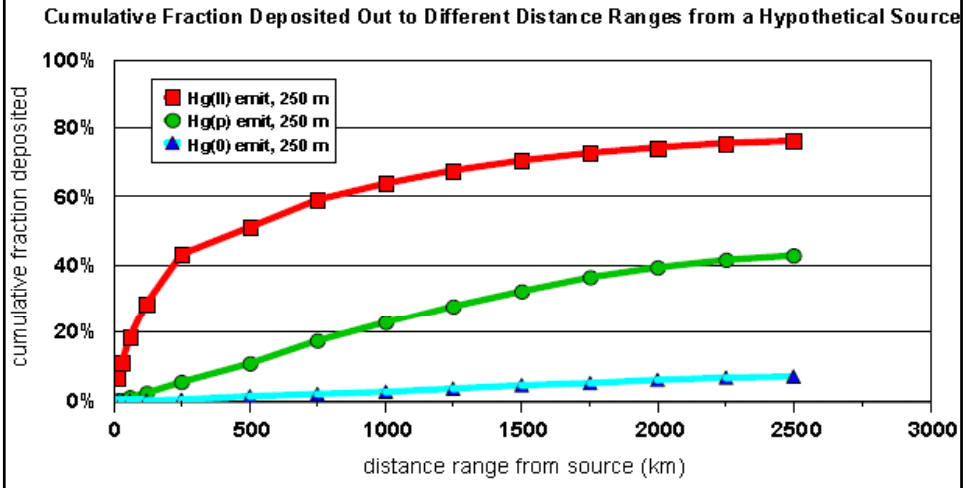
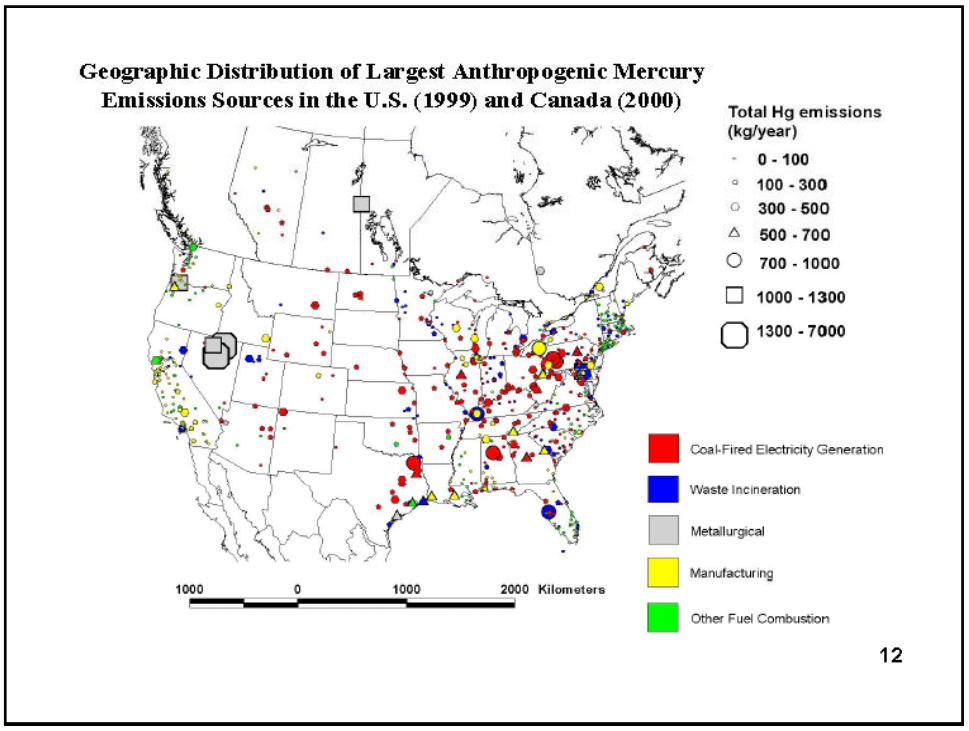
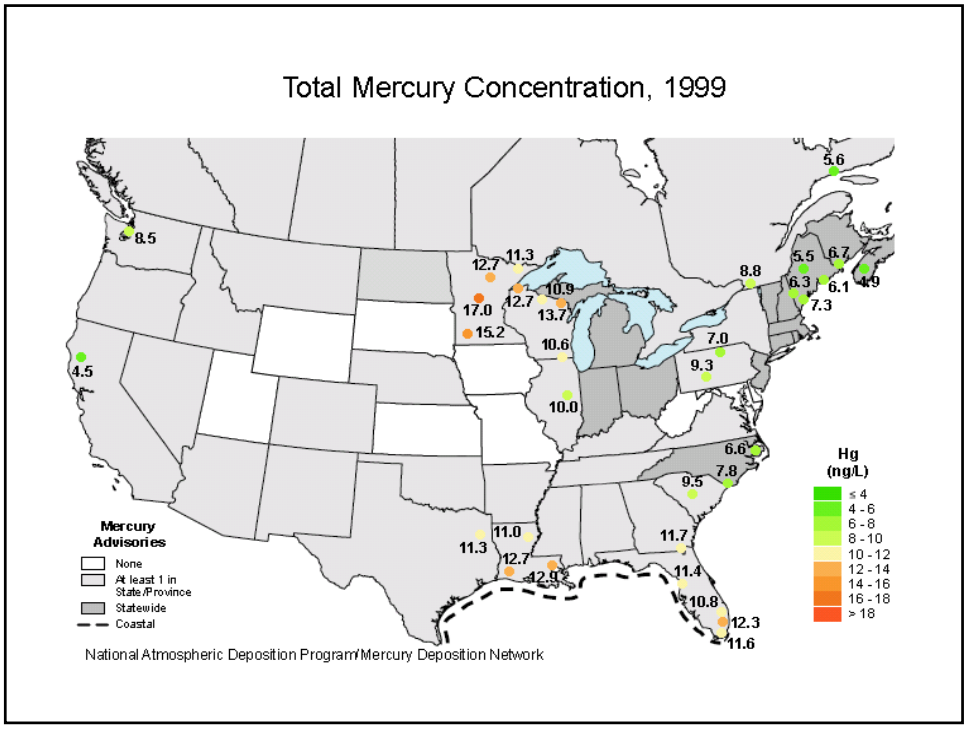
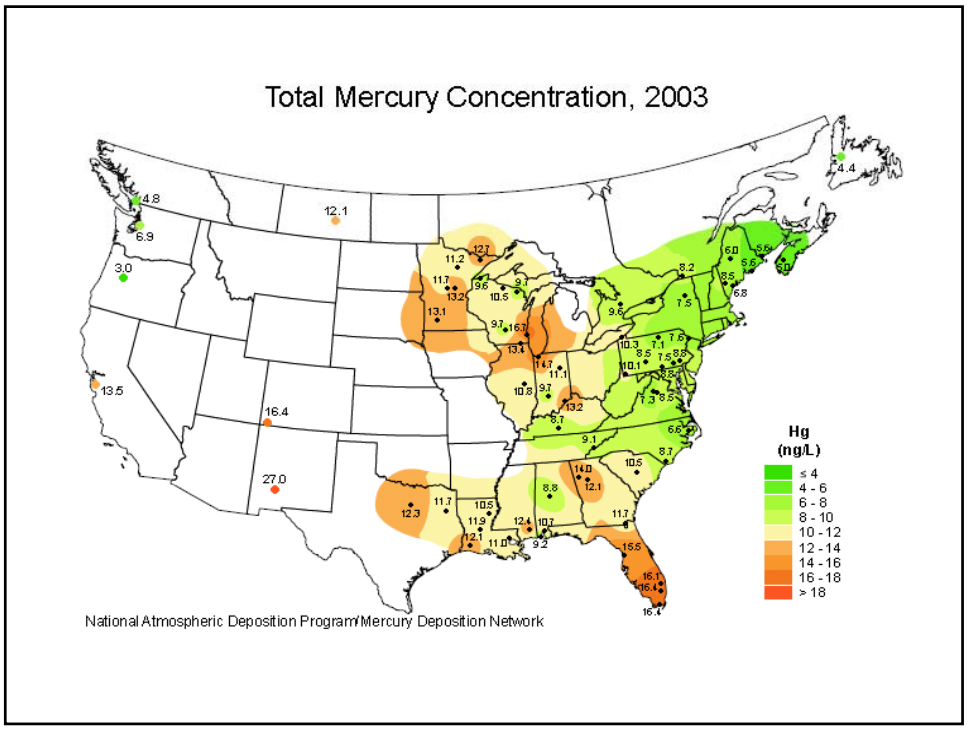
The fraction deposited and the deposition flux are both important, but they have very different meanings…
The fraction deposited nearby can be relatively "small",
But the area is also small, and the relative deposition flux can be very large…

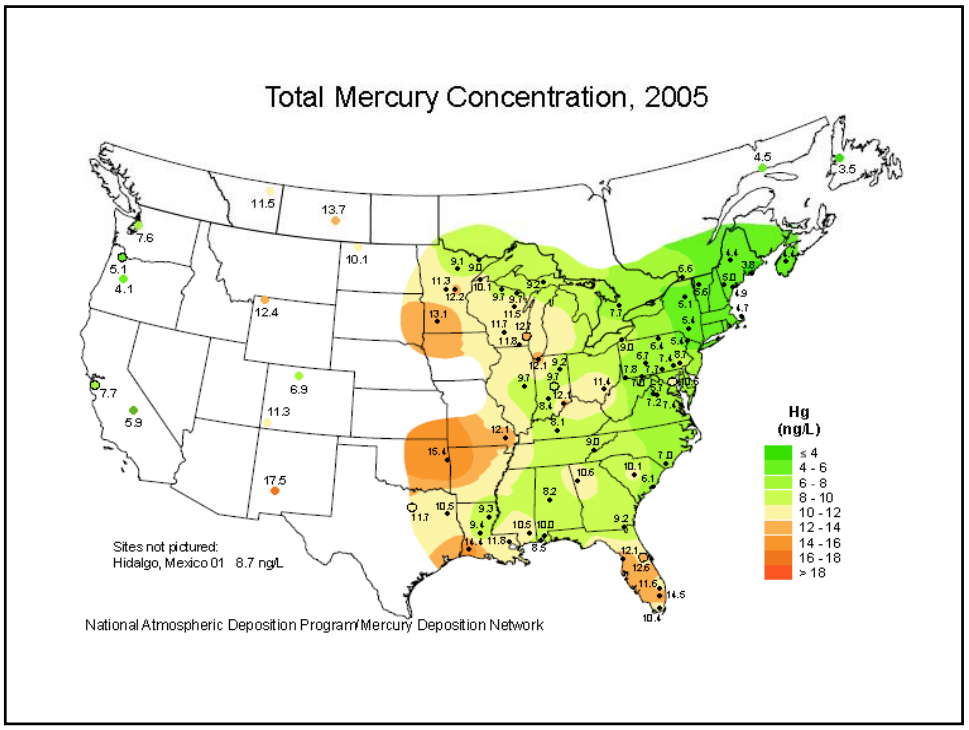


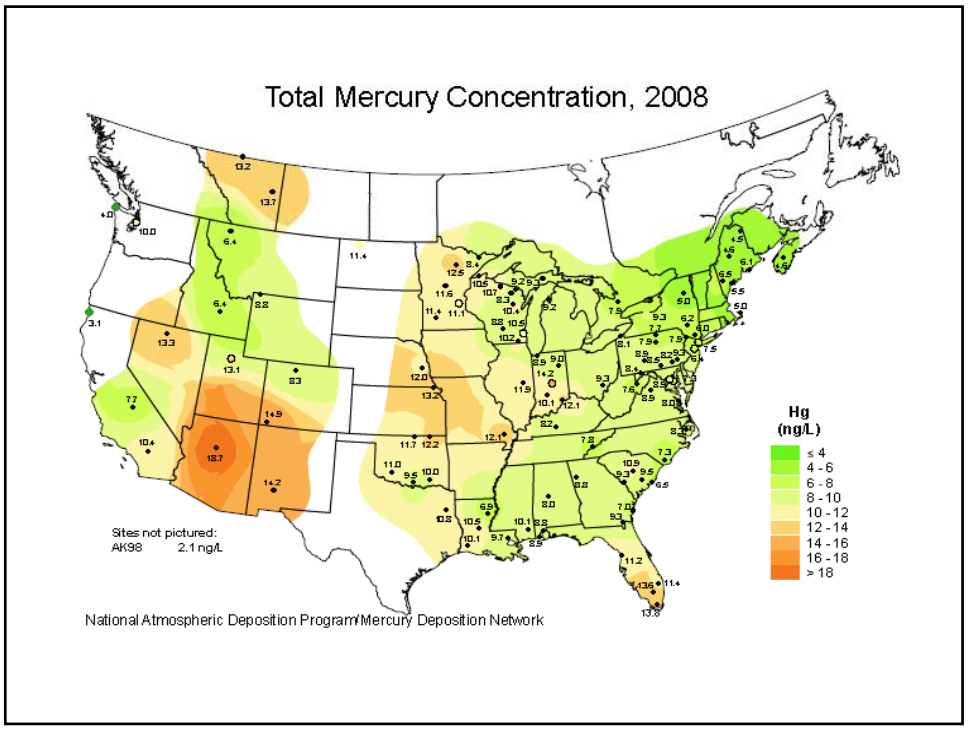
Background Information on Historical Spatial Distribution of Mercury Emissions and Typical Data from Mercury Deposition Network


Geographic Distribution of Largest Anthropogenic Mercury Emissions Sources in the U.S. (1999) and Canada (2000)
Total Hg emissions (kg/year)
0 - 100
100 - 300
300 - 500
500 - 700
700 - 1000
1000 - 1300
1300 - 7000
Coal-Fired Electricity Generation
Waste Incineration
Metallurgical
Manufacturing
Other Fuel Combustion
1000 0 1000 2000 Kilometers
12


Total Mercury Concentration, 1999
Mercury Advisories
None
At least 1 in State/Province
Statewide
Coastal
Hg (ng/L)
≤ 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16 - 18
> 18
National Atmospheric Deposition Program/Mercury Deposition Network


Total Mercury Concentration, 2003
Hg (ng/L)
≤ 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16 - 18
> 18
National Atmospheric Deposition Program/Mercury Deposition Network


Total Mercury Concentration, 2005
Hg (ng/L)
≤ 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16 - 18
> 18
Sites not pictured:
Hidalgo, Mexico 01 8.7 ng/L
National Atmospheric Deposition Program/Mercury Deposition Network



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ENVIRONM
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egional precipitation mercury trends in the eastern USA 1998 2005: Declines in the Northeast and Midwest, no trend in the Southeast

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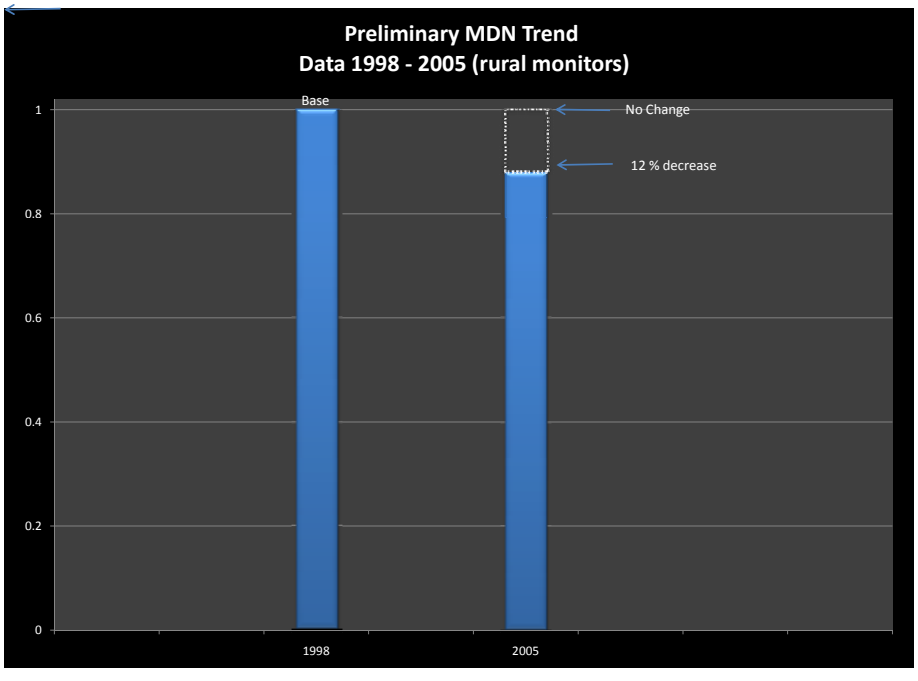
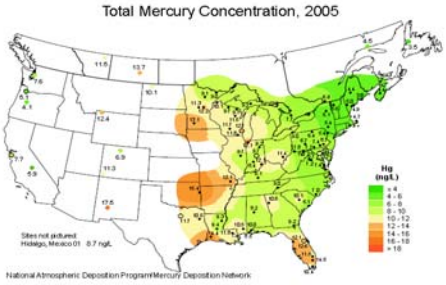
Received 3 May 2007; received in revised form 30 October 2007; accepted 30 October 2007

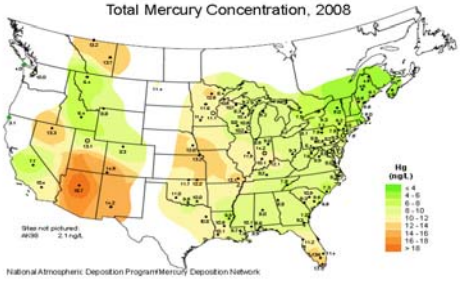
Need to Confirm 12% Deposition Decline with more MDN years

- Linear Regression Model showed no decline but
- Random Coefficient model showed 12% in N.E.

& Midwest (but not in Winter) & no decline in South





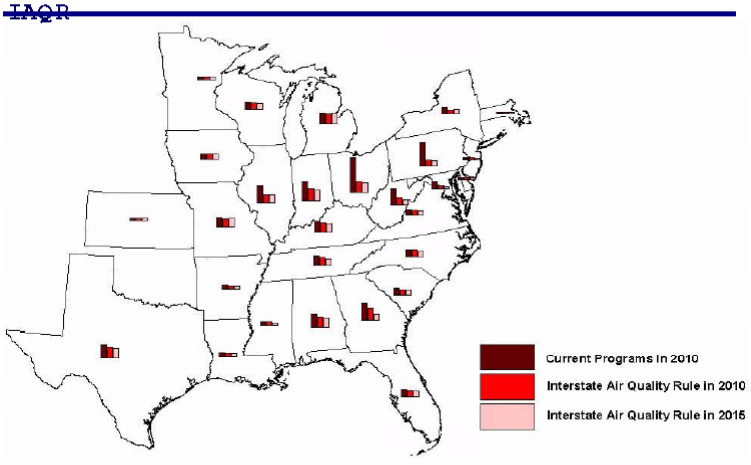


Background Data on Past Emissions of Oxidized Mercury and 2010 and 2018 Projections

Basis for 2010 and 2018 Oxidized Mercury Projections

CAIR will result in the deepest cuts in sulfur dioxide and nitrogen oxide emissions in more than a decade. …..These technologies, once implemented, not only reduce sulfur dioxide and nitrogen oxide, they provide important reductions of mercury emissions from coal-fired power plants. (source EPA)

Projected Annual SO_2 Emissions for EGUs Under the ~~IAQR~~



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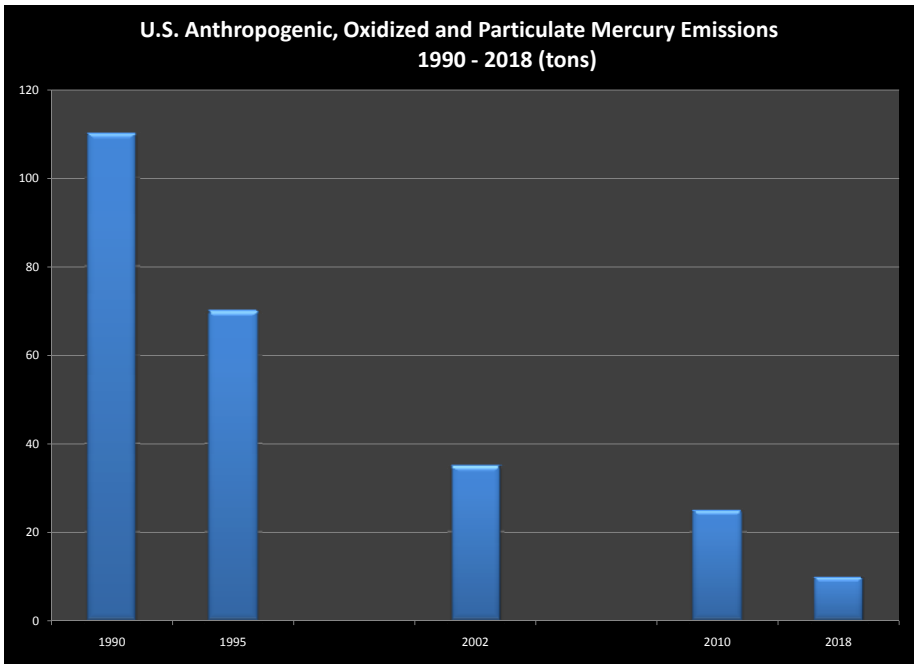
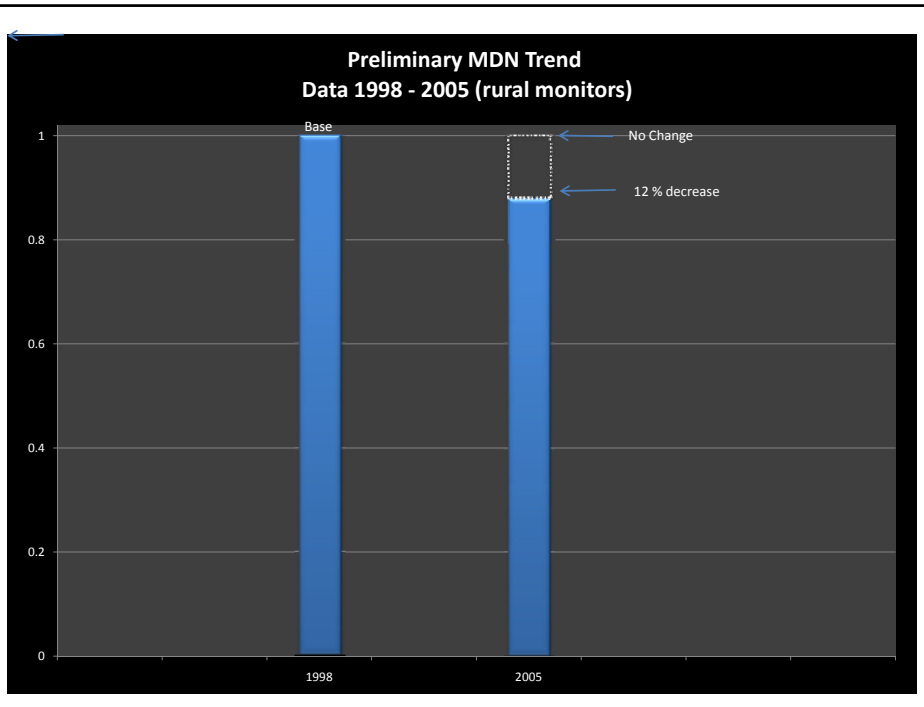
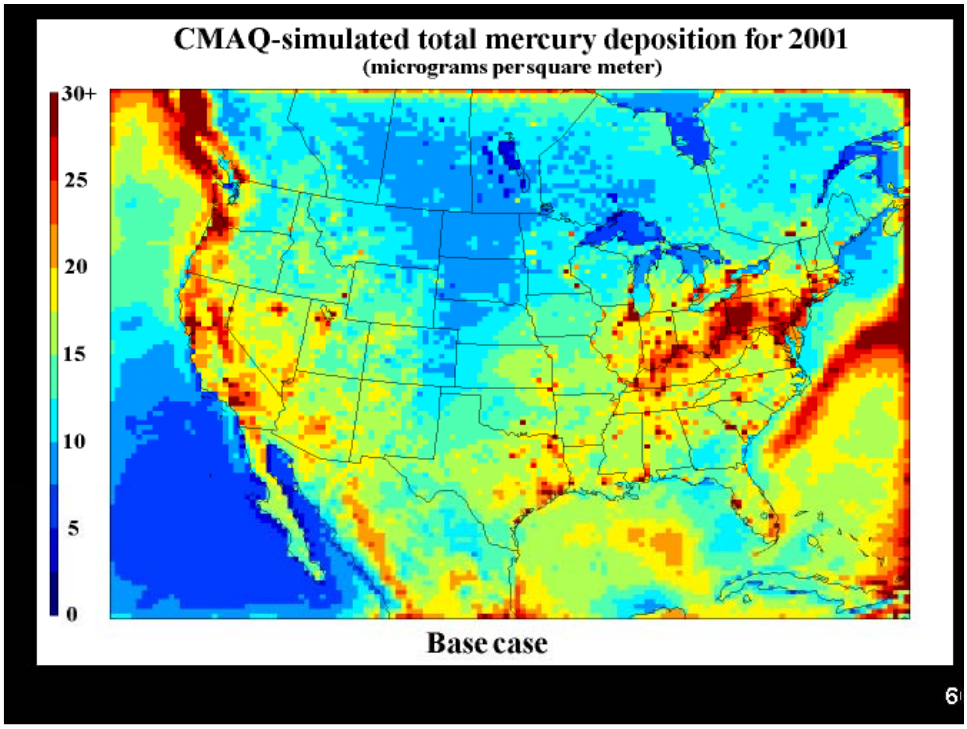
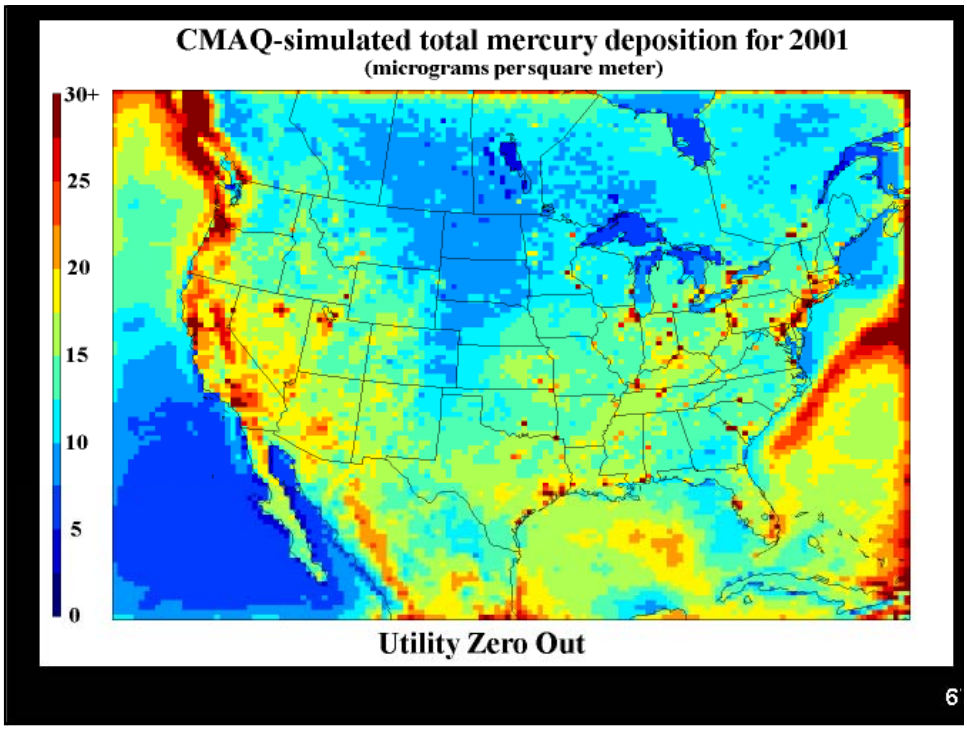
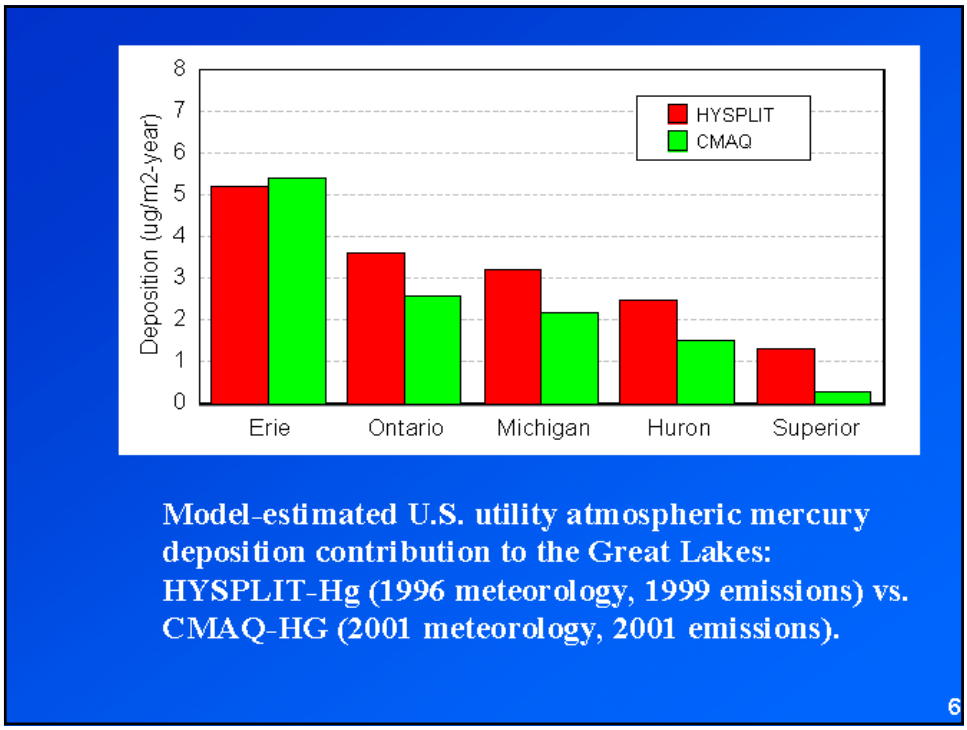

U.S. Anthropogenic, Oxidized and Particulate Mercury Emissions
1990 - 2018 (tons)
120
100
80
60
40
20
0
1990
1995
2002
2010
2018


Preliminary MDN Trend
Data 1998 - 2005 (rural monitors)
Base
No Change
12 % decrease
1
0.8
0.6
0.4
0.2
0
1998
2005

Some models predict large sections of the U.S. have/had large percentages of deposition associated with U.S. Emissions

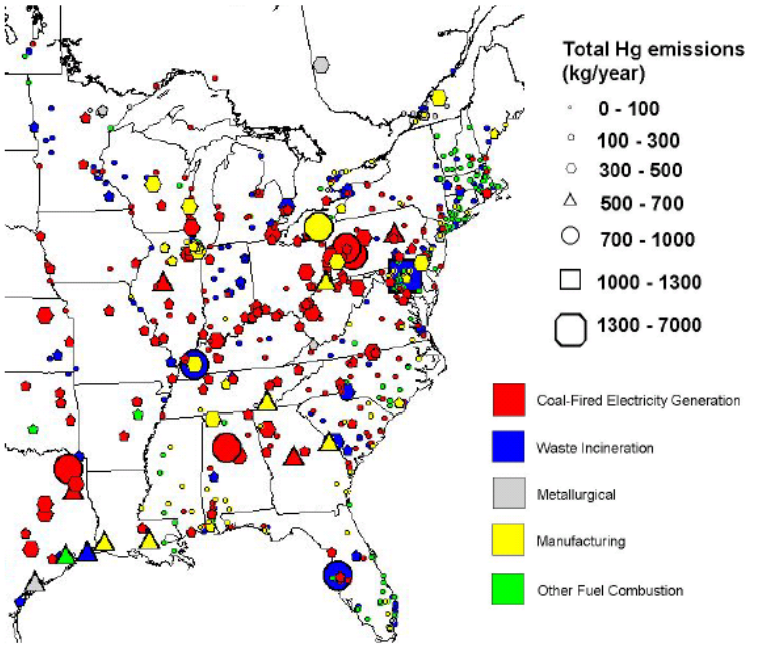



CMAQ-simulated total mercury deposition for 2001
(micrograms per square meter)
30+
25
20
15
10
5
0
Utility Zero Out


Deposition (ug/m2-year)
8
7
6
5
4
3
2
1
0
HYSPLIT
CMAQ
Erie
Ontario
Michigan
Huron
Superior
Model-estimated U.S. utility atmospheric mercury deposition contribution to the Great Lakes: HYSPLIT-Hg (1996 meteorology, 1999 emissions) vs. CMAQ-HG (2001 meteorology, 2001 emissions).

Models that have depicted large declines in Mercury Deposition are not consistent with monitoring data which is demonstrating little to no change in deposition

2009 and 2010 data from monitors near Steubenville Ohio will be especially important to analyze.



There have been a number of studies analyzing mercury trends in fish

- Canada
- Minnesota
- Florida
- Michigan
- Massachusetts

Some of these studies shows no trends, while others show trends but have a lot of variability in the data
(e.g. Minnesota and Massachusetts)

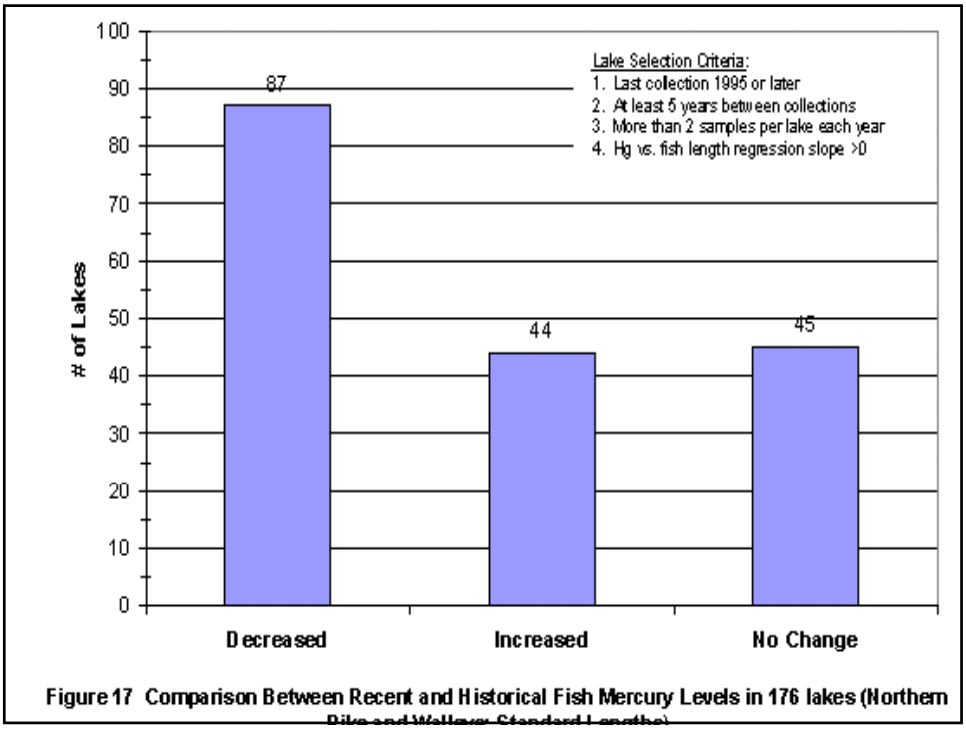


Figure 17 Comparison Between Recent and Historical Fish Mercury Levels in 176 lakes (Northern

Minnesota postulates that there may have been about a 1.1% annual decline in mercury in fish during the 1990's

This 1.1% decline compares to the earlier prediction that there was an 1.7% annual decline in deposition.

Massachusetts, based on 1994 and 2001 measurements, concluded that there was a 32% (yellow perch) to 25 % (large mouth bass) decline in mercury levels in lakes close to former incinerator emissions and a 15% (yp) to 19% (lmb) decline in other Mass. lakes

In state mercury emissions were estimated to have declined by 87% over this time

BUT…..

More recent Data from at least one lake in Massachusetts indicate increasing concentrations

Table B1. Summary (mean, min, max) of mercury concentrations (wet weight) in North Watuppa Pond fish tissue as reported by MassDEP (MassDEP 1997), the MassDEP ORS Mercury Research Project 1999 – 2004 (MassDEP 2006 and Rose 2008), and as calculated from 2005 and 2007 data (MassDEP 2008). *Note: these data are not normalized to size.*

Sampling Year	Species Code[1]	Mean Hg concentration (µg/g)	Min – Max Hg concentration (µg/g)	Sample size (n)
1994	YP	0.34	0.17 – 0.54	8
1994	LMB	0.72	0.32 – 1.0	9
2001	YP	0.57	0.17 – 0.98	42
2001	LMB	0.81	0.25 – 1.7	21
2002	YP	0.40	0.20 – 0.76	60
2004	YP	0.42	0.19 – 0.76	30
2004	LMB	0.93	0.33 – 1.2	12
2005	YP	0.45	0.20 – 0.81	30
2005	LMB	1.0	0.64 – 1.4	15
2007	YP	0.46	0.22 – 0.9	30
2007	LMB	0.92	0.55 – 1.4	15

[1] Species code: YP = yellow perch (*Perca flavescens*), LMB= largemouth bass (*Micropterus salmoides*)

Summary of Fish Trend Data

- In rural settings small decreases in fish tissue concentrations may have occurred as a result of small changes in deposition. On the other hand the alleged trend may be attributable to data variability.
- In close proximity to former, large sources of oxidized mercury, moderate decreases in fish tissue may have occurred as a result of very large decreases in oxidized mercury emissions, but sampling of current conditions is necessary to confirm trends that were based on only 2 points

Conclusions

- Over 90% of U.S. oxidized mercury emissions has or will occur as a result of current regulations. 1990 emissions were greater than 100 tons. 2018 emissions will be around 10 tons.
- Deposition in rural U.S. has changed little, (or not at all) as result of controlling most emissions.
- Controls on the approximate 10 tons of oxidized mercury emissions that will remain after 2018 will not measurably alter deposition or fish tissue.