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Some States' Strategies to Address Mercury Emissions from Coal-Fired Power Plants: Hot Spots, Rationale Against Hg Emissions Trading, Available and Affordable Control Technologies/Strategies

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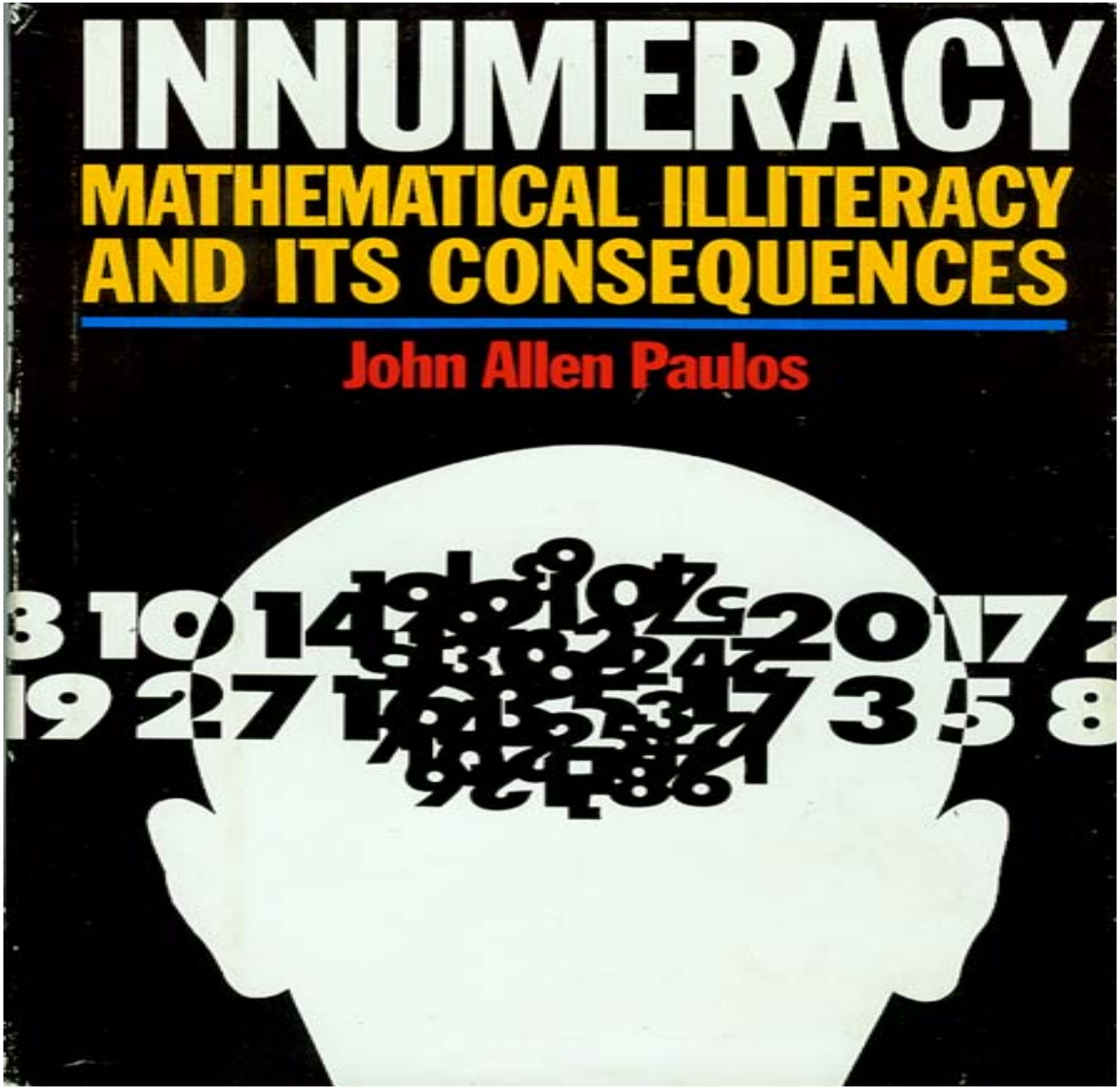
INNUMERACY
MATHEMATICAL ILLITERACY
AND ITS CONSEQUENCES
John Allen Paulos

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Overview

- **What does NESCAUM do?**
- **Performance-based MACT approaches are more certain and more protective than EPA's Hg-trading-based approach that is based on weak and distant-future caps (20%/2010; 70%/2025(?))**
- **What exactly are hot spots?**
- **State legislation/regulations/policies on performance-based approaches with no Hg trading (80 to 95% control by 2008-2012)**
- **Technologies are here/have been here for quite some time**

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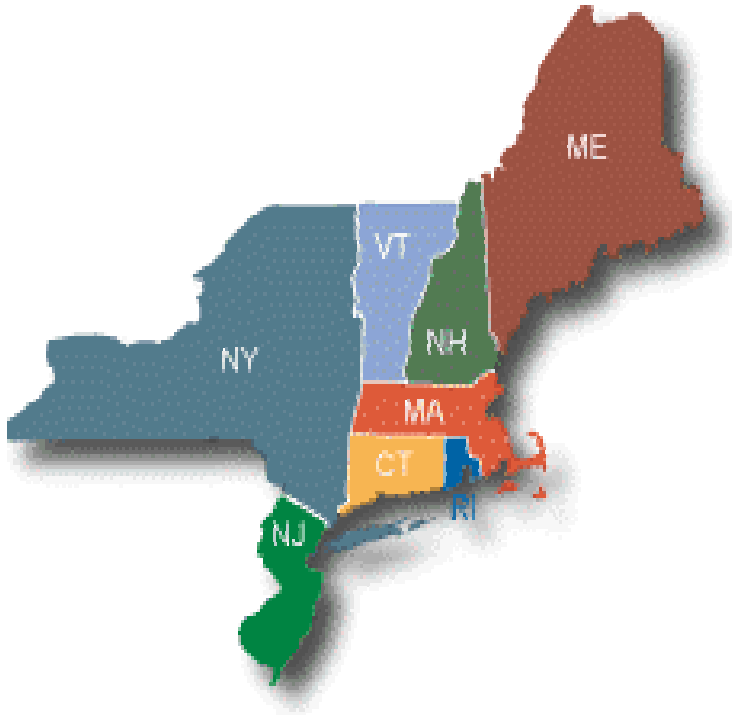
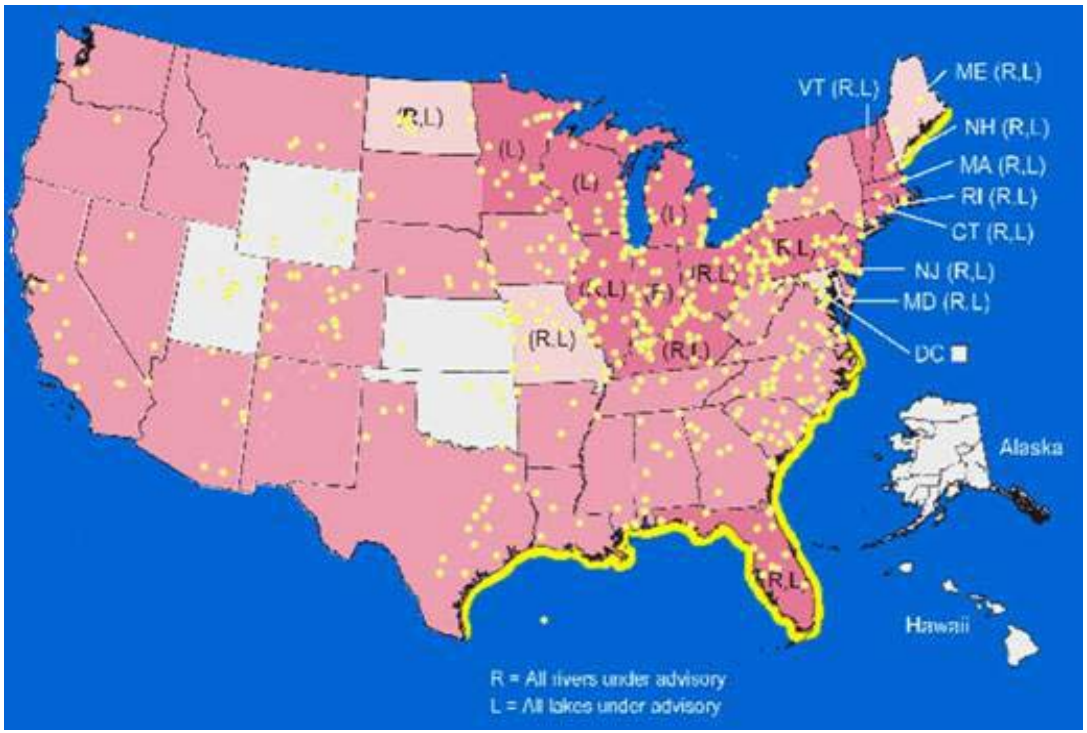
Who we are

- Our Members include:
  - Connecticut
  - Massachusetts
  - Maine
  - New Hampshire
  - New Jersey
  - New York
  - Rhode Island
  - Vermont



Coal-Fired Power Plants



- There are about 530 power plants with 305 GW of capacity (56% of GWhr). The capacity consists of about 1,300 units, 1,150 of which are >25 megawatt. They burn 1 billion TPY of coal; 40% is PRB coal
- Coal plants generate the vast majority of power sector emissions:
  - 100% of Hg
  - 95% of SO2
  - 90% of NOX

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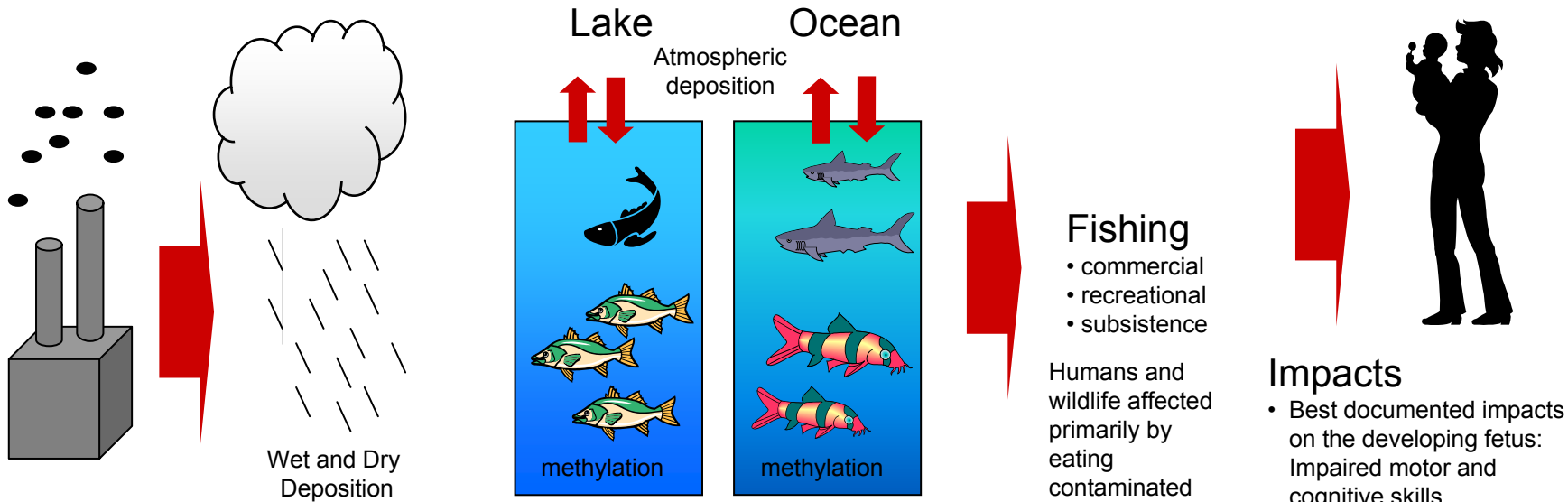
Mercury Emissions Contribute to Exposure to Mercury



Emissions and Speciation → **Atmospheric Transport and Deposition** → **Ecosystem Transport, Methylation, and Bioaccumulation** → **Consumption Patterns** → **Human Exposure**

- **The primary pathway of human exposure to mercury in the U.S. is through eating contaminated fish.**
- **Power plants emit approximately 48 tons of mercury and are the largest source of mercury emissions in the U.S. (approximately 41%).**

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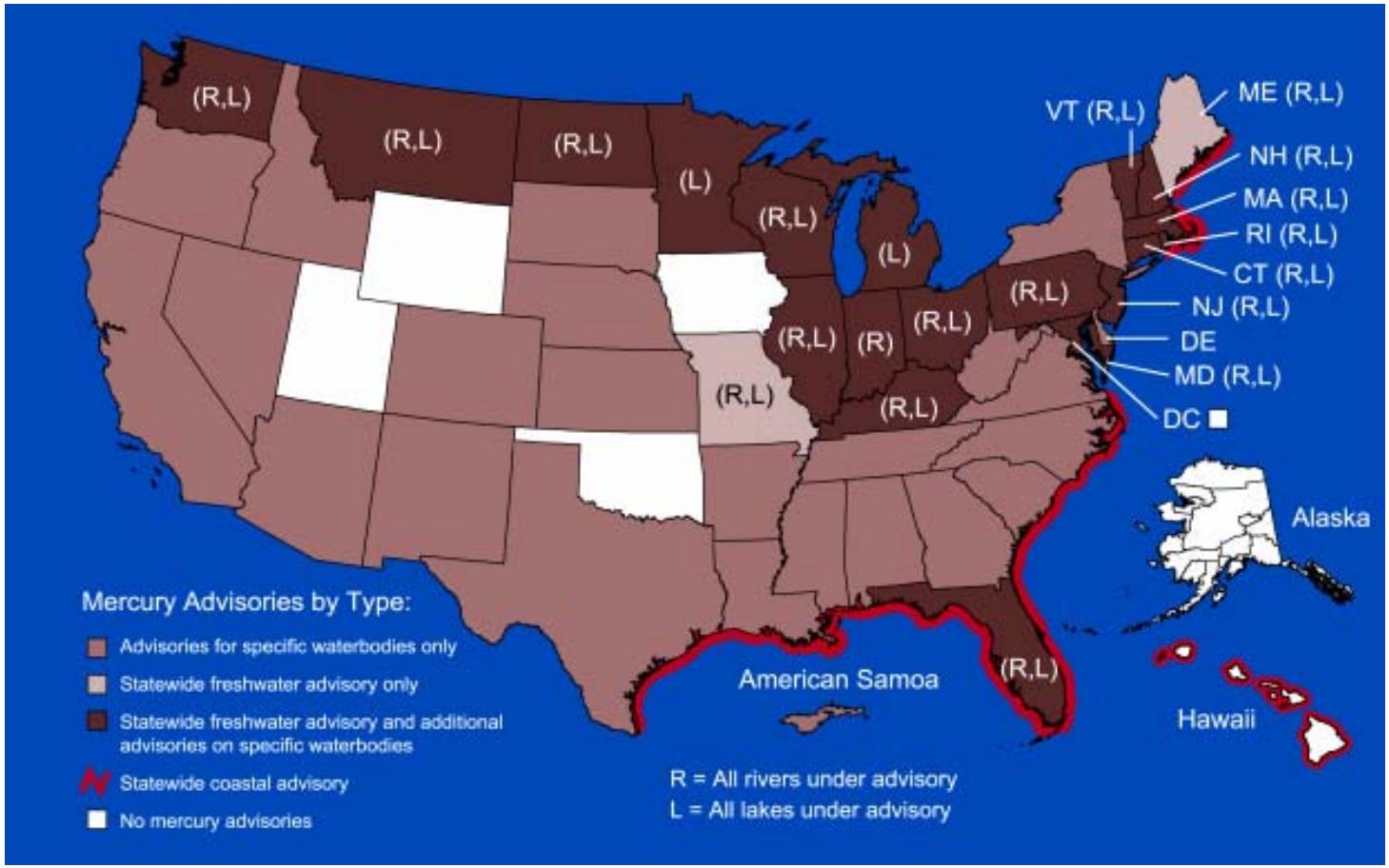
States with Mercury Fish Consumption Advisories (2002)



NOTE: This map depicts the presence and type of fish advisories issued by the states for mercury as of December 2002. Because only selected waterbodies are monitored, this map does not reflect the full extent of chemical contamination of fish tissues in each state or province.

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"Scientific" Scales of Air Pollution

- **Air Pollution is a "Mixture" of Scales**
  - **Local** (CO, ozone, SO2, PM, **mercury**); hot spots
  - **Regional** (ozone, PM, NOx, **mercury**, acid deposition, regional haze); warm to hot spots
  - **Global** (CFC's, CO_2, **mercury**, methane, "background" ozone), "not so hot" cool spots

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"Scientific" Scales of Air Pollution

- **Key is to design Hg control strategies that take into account relative contributions from various transport scales (local, regional, global)**
- **And, avoid "political" scales of transport: mercury(s) is/are NOT just a global pollutant!**

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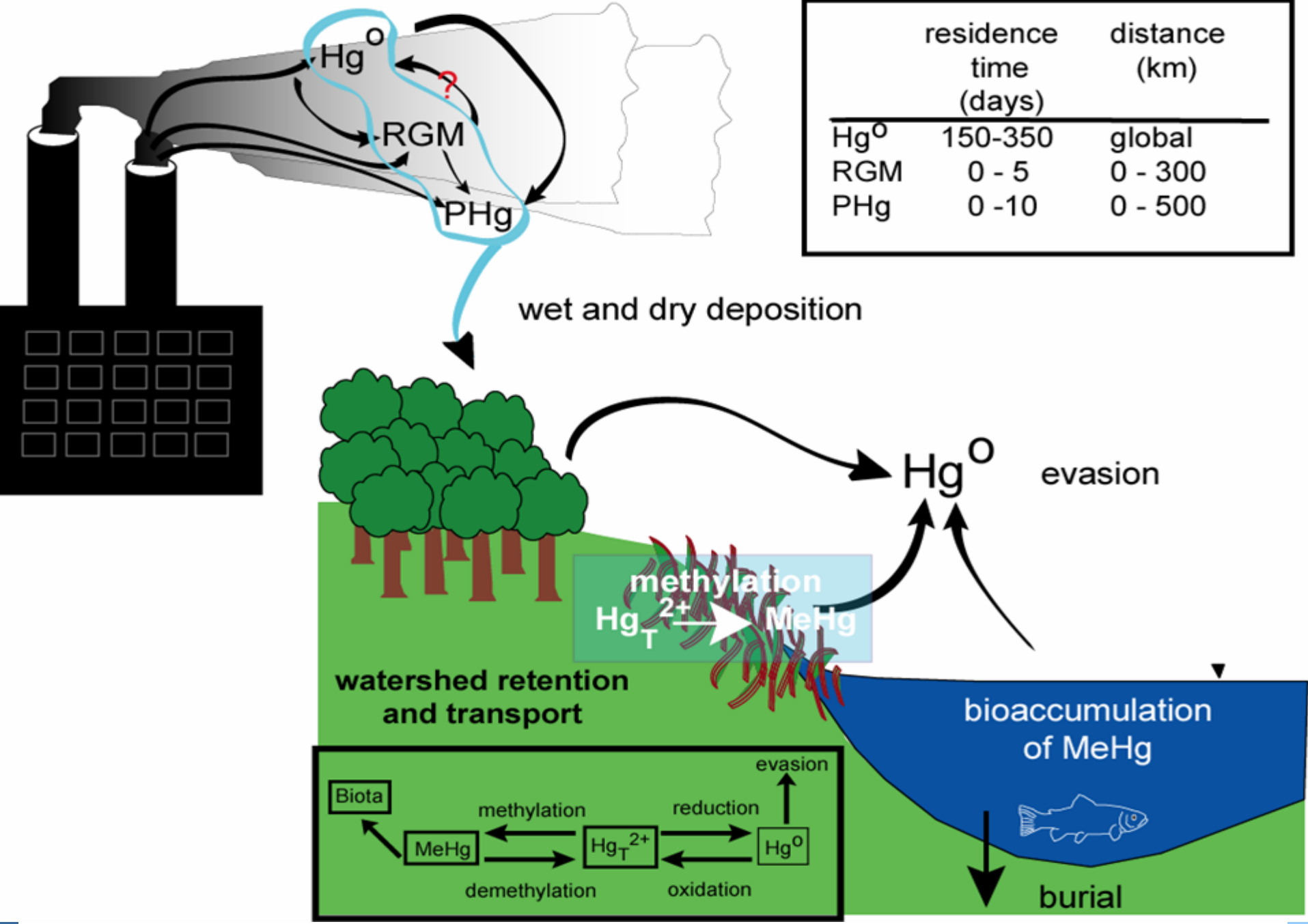
Atmospheric Transport and Deposition of Mercury

- Hg^0 is not very soluble and has a low dry deposition velocity (<0.1 cm/s)
- Hg^{II} is very soluble and adsorbs readily on surfaces: it is rapidly removed by wet and dry deposition
- Hg_p is mostly in the fine particle range and will remain in the atmosphere for several days in the absence of precipitation



	residence time (days)	distance (km)
Hg^0	150-350	global
RGM	0 - 5	0 - 300
PHg	0 -10	0 - 500

Source: Charles Driscoll, Syracuse University

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To Trade or Not to Trade?

- **Balance between public risk management and private cost savings (cap and trade approach; performance-based approach)**
- **Mercury is not about the averages ("average" fish, "average" exposed person, 36-km grid "averaged" deposition); hot spots exist and could get worse**
- **Properly-designed cap-and-trade approaches are useful when spatial and temporal scales of emissions, transport, *and* effects allow for mostly "harmless" and cost-saving trades (OTC NOx, 110 SIP call, Title IV SO2)**
- **Performance-based approaches are NOT "command and control" Approaches**

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More on Mercury Trading

- **Effect of other (CAIR) trading programs on mercury (NOx control without SO2 control; could create brand new hot spots of oxidized Hg!)**
- **Too much intellectual capital spent on developing trading rules and protocols; not enough on what the cap needs to be for environmental and people- protection (Title IV, OTC/SIP Call ozone-season control)**

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Mercury Hot Spots

- **Cap and Trade Approach does not say how emissions are geographically distributed under a cap**
- **Performance-based approaches provide geographic certainty of reductions**
- **Many types of hot spots**
  - **There are many types, regardless of what caused them (UAHS: utility-attributable hot spots)**

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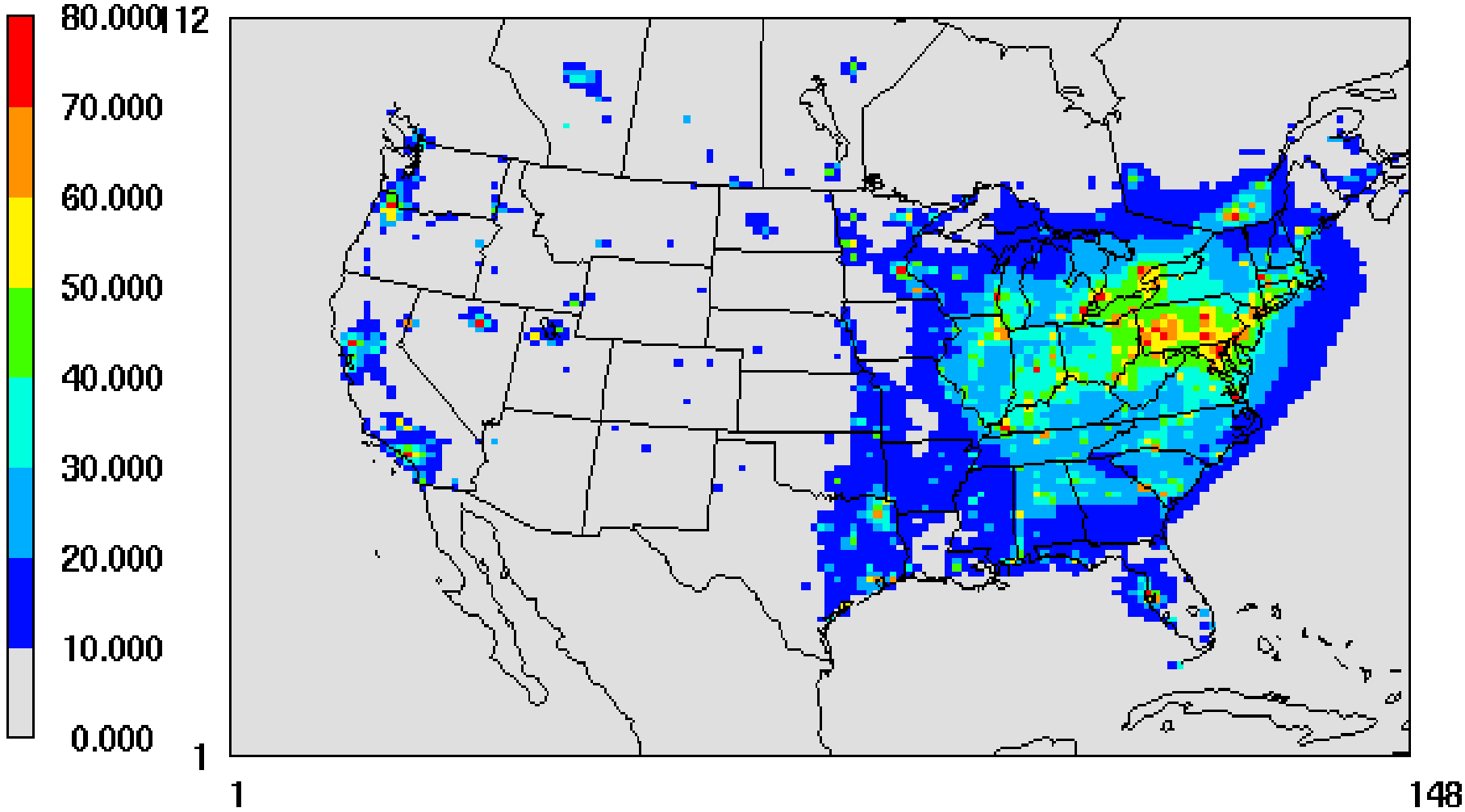
Mercury Hot Spots

- **Emission hot spots**
- **Deposition hot spots**
- **Biological hot spots**
- **Exposure hot spots (environmental justice issues)**
- **Existing hot spots and creating new ones**
  - **Which approach addresses existing hot spots more effectively ?**
- **CMAQ (alone and as applied) and IPM are not able to spatially resolve hot spots (grid resolution; less confidence down the chain of hot spots)**

Percent of Total Mercury Deposition Attributable to US & Canadian Sources: 2001



Source: U.S. EPA

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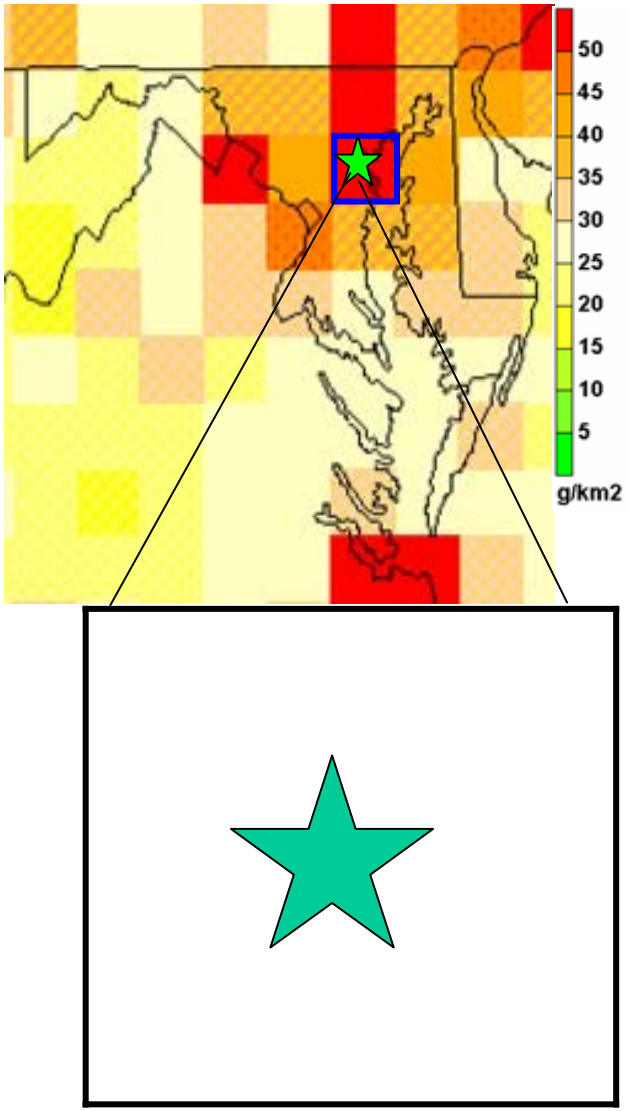
Finer Modeling Resolution Better Highlights Local "Hot Spots" Impacts; Issue of Measured Hot Spots

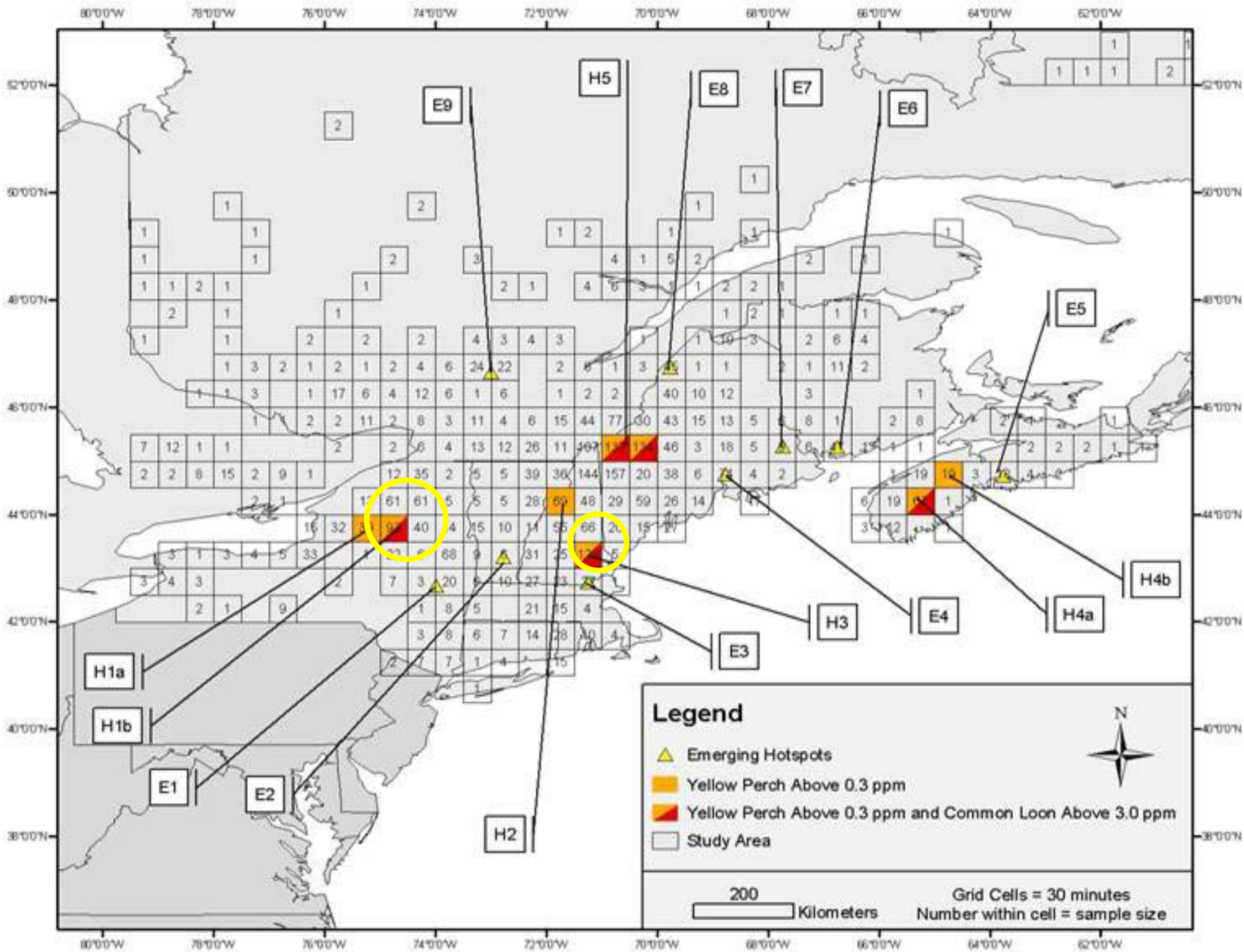


36km Resolution
Avg. = 98 g/sq.km

72	516	71
44	127	43
33	49	36

12km Resolution
Avg. = 110 g/sq.km

Source: U.S. EPA



Source: Charles Driscoll, Syracuse University

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Ecosystem Sensitivity for Mercury Methylation

- Deposition is only one factor affecting the levels of mercury in fish.
- Water bodies vary substantially in the extent to which deposited mercury is methylated.
- Factors that can affect methylation include:
  Dissolved organic carbon
  pH
  Sulfate concentration
  Acid neutralizing capacity
  Wetlands or other hydric soils

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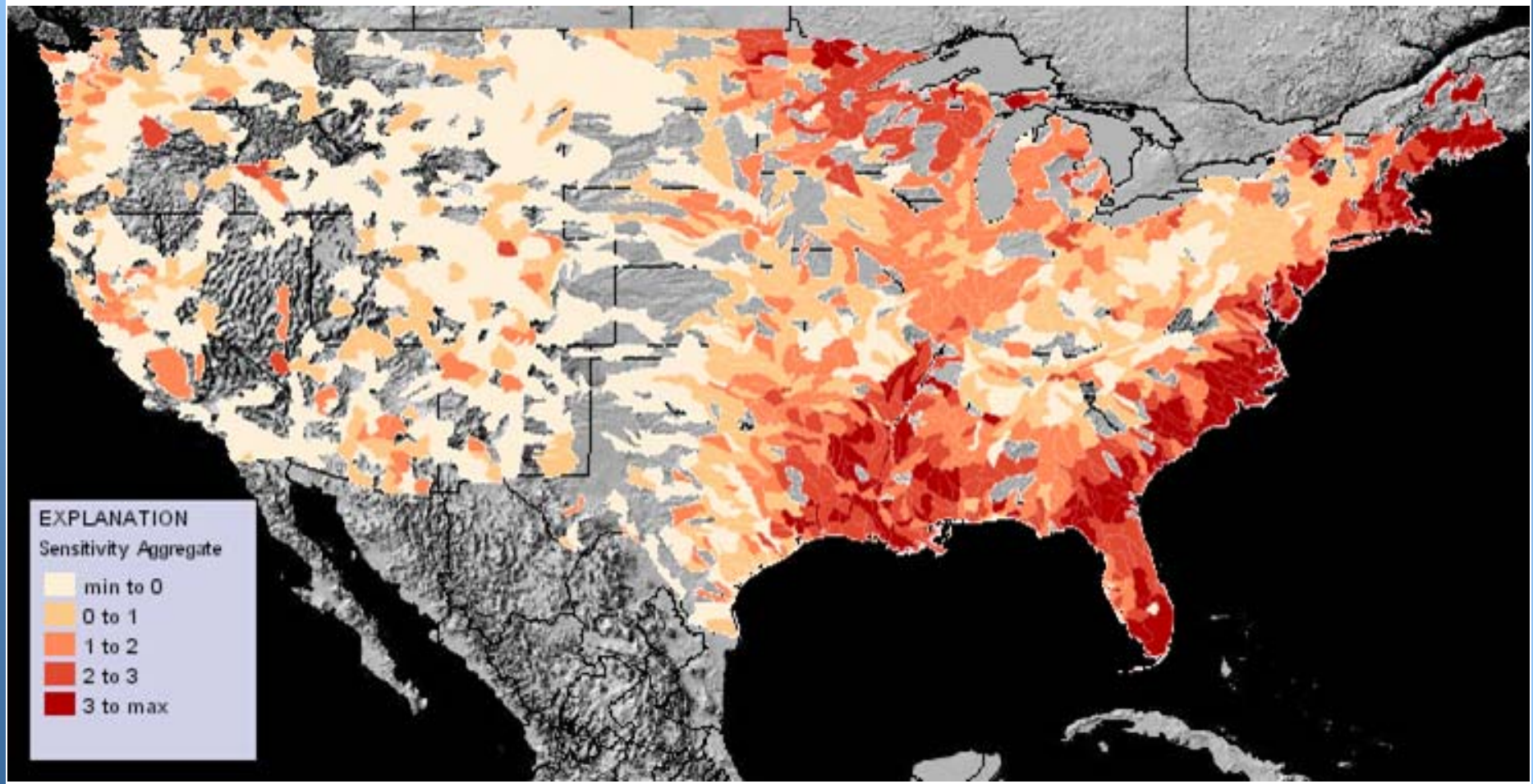
USGS Mercury Methylation Sensitivity Map for Aquatic Ecosystems (Preliminary)



Based on USGS data for TOC, pH, aquatic sulfate concentration, and hydric soils. Areas not colored are missing data for one or more of these indicators.

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States Justification For More Stringent, Timely Controls with No Trading

- Substantial Human health benefits (in billions, not in millions); recall innumeracy!
- Ready availability of control options/technologies/strategies
- Extremely cost-effective controls
- Existing hot spots can be cooled down (Massachusetts, Florida) : quick response

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Economic Valuation of Human Health Benefits of Controlling Mercury Emissions from U.S. Coal-Fired Power Plants

February 2005

A NESCAUM Report (Praveen Amar) with Harvard Center for Risk Analysis (Glenn Rice, ScD Candidate, and Dr. James Hammitt, Director)

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Overview

- The report covered diverse areas of policy-relevant research including:
  - Mercury emissions (including changes from coal plants), atmospheric transport and fate, modeling of Hg deposition
  - Relationship between Hg deposition and methylmercury levels in fish, current and future exposures in humans to mercury in fish
  - Dose response functions, and finally, monetization of benefits

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What did the NESCAUM-Harvard Report Monetize?

- Monetized two end points:
  - IQ of children born to mothers with high blood-Hg levels
  - Cardiovascular effects (myocardial infarction and premature mortality among adults)

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NESCAUM's Benefit Assessment Different Than EPA's

- EPA's benefit assessment considered only the loss of IQ points related to fetal exposure

- EPA's assessment did not consider cardiovascular effects, immune system and reproductive effects, delayed neurotoxicity, and other neurotoxic effects

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Spectrum of Health Effects Certainty and Benefits

	Persistent IQ deficits from fetal exposures above MeHg RfD	Persistent IQ deficits in all children from fetal MeHg exposures	Cardiovascular effects and premature mortality in male consumers of non -fatty freshwater fish with high MeHg levels	Cardiovascular effects and premature mortality in male fish consumers	Cardiovascular effects and premature mortality in all fish consumers
Scenario 1 (26 TPY)	$75M	$194M	$48M	$1.5B	$3.3B
Scenario 2 (18 TPY)	$119M	$288M	$86M	$2.3B	$4.9B

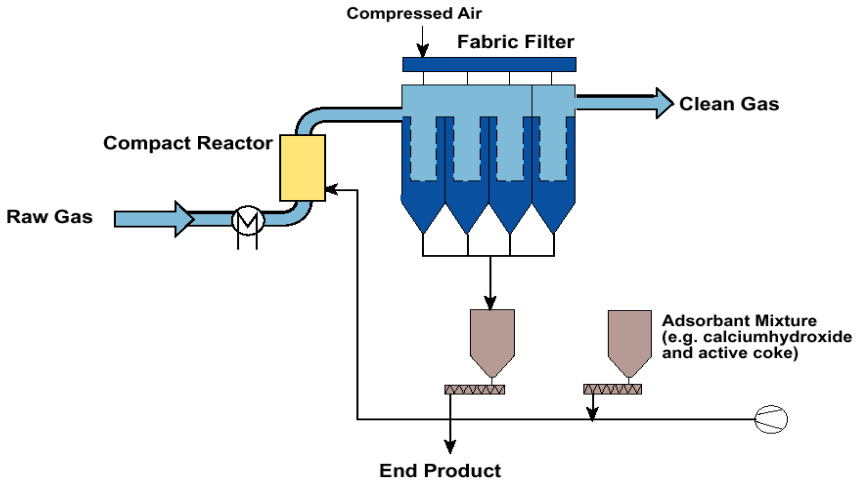
Decreasing Certainty

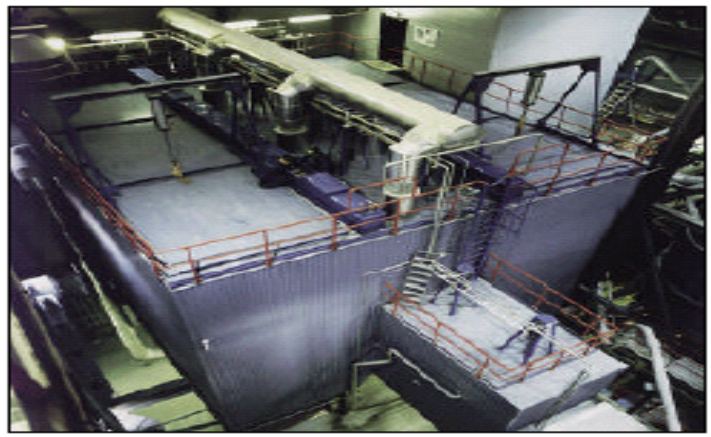
Increasing Benefit

Spectrum of Certainty of Causal Association of Health Effect with Mercury Exposure with Estimated Benefit Overlay in Millions ($M) and Billions ($B) of Dollars (2000$)

ACI Technology Has Been Used for Mercury Control in the Waste Industry for Over 10 Years

- **Commercialized mercury removal technology for the European WtE industry**
- **Sorbent injection upstream of dedicated FF**
  - Systems installed during early 1990s in Europe and the US
    - Utilize activated carbon/coke
    - ALL have operated reliably for more than 10 years
    - ALL achieve between 80 - 90% (some at 98%) mercury removal
    - ALL capture both elemental and oxidized mercury





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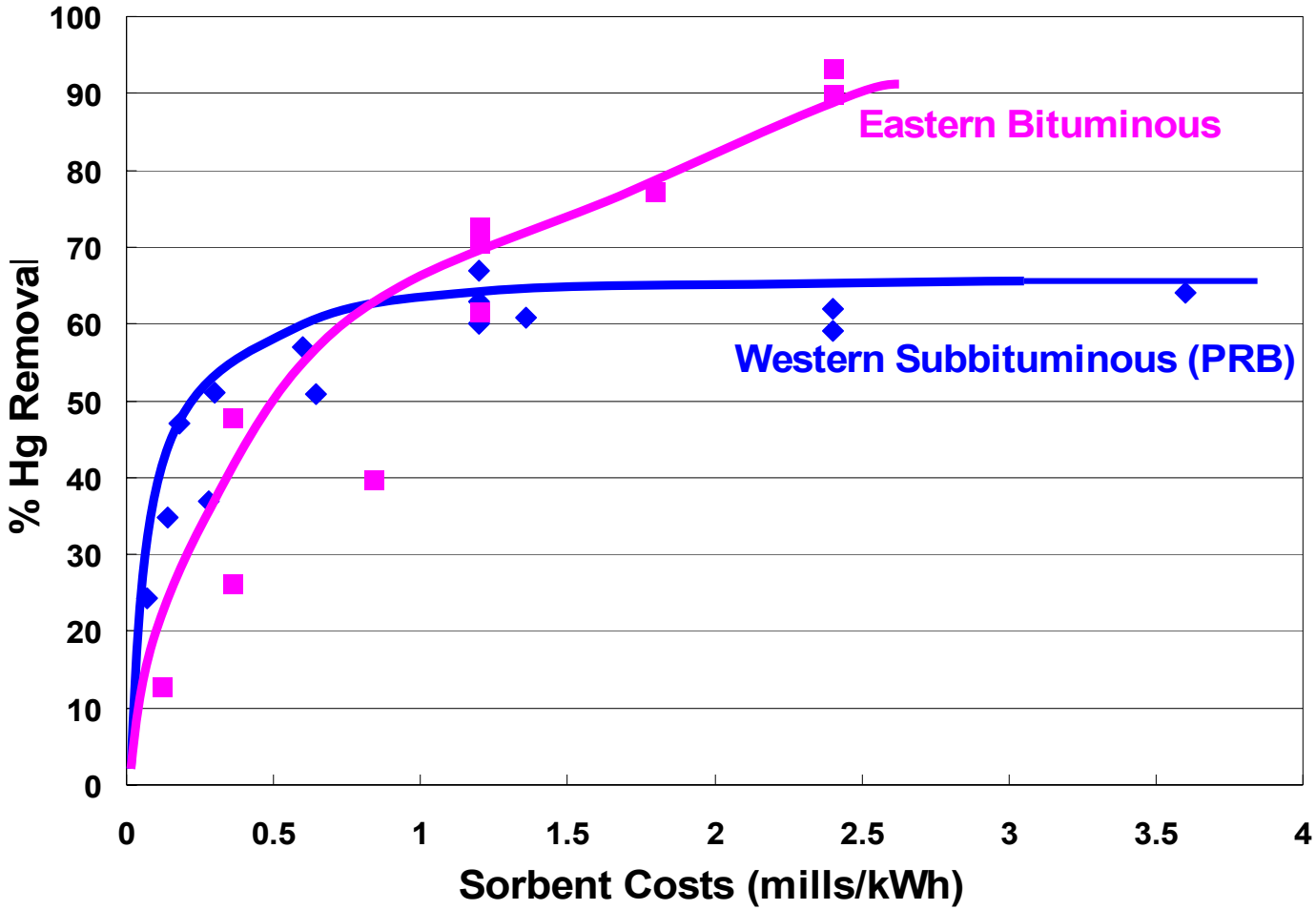
Cost and Performance: 2004



Source: ADA-ES

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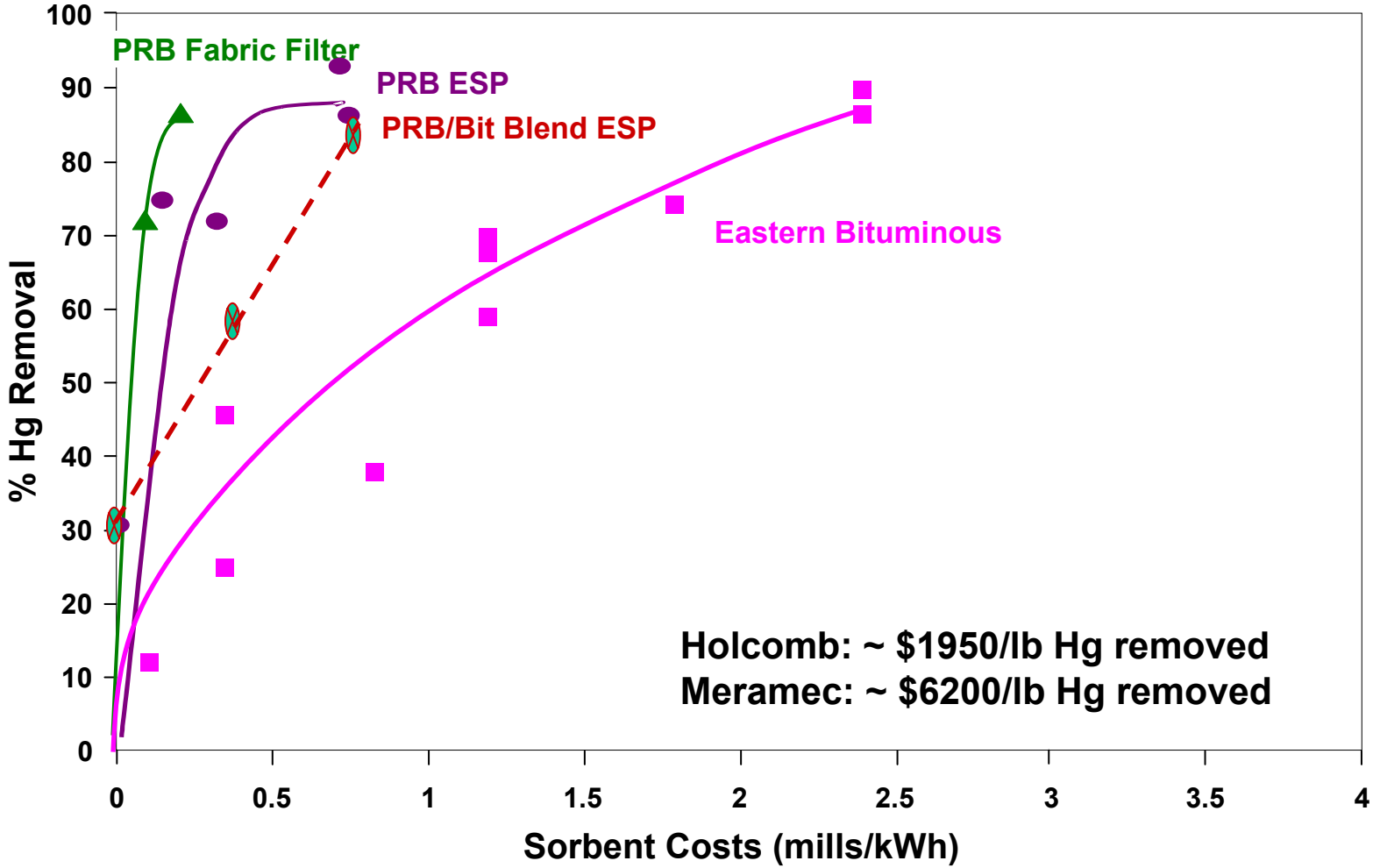
Improvement in Cost and Performance: 2005



Source: ADA-ES

PAC Installations on Various Coal-Burning Power Plants

Eastern Bituminous

ND Lignite

PRB

PRB

Eastern Bituminous

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A Comparative Estimate of Hg Control Costs with ACI (mills/kWh): "Remember The Innumeracy"

Control Type	Annual Levelized Cost
Activated Carbon Injection for Hg	0.2 to 0.8 mills/kwh (capital cost : $2-4/kw)
FGD for SO2	3 to 5 mills/kwh(capital cost: $150-250/kw)
SCR for NOx control	1 to 2 mills/kwh (capital cost :$50-125/kw)

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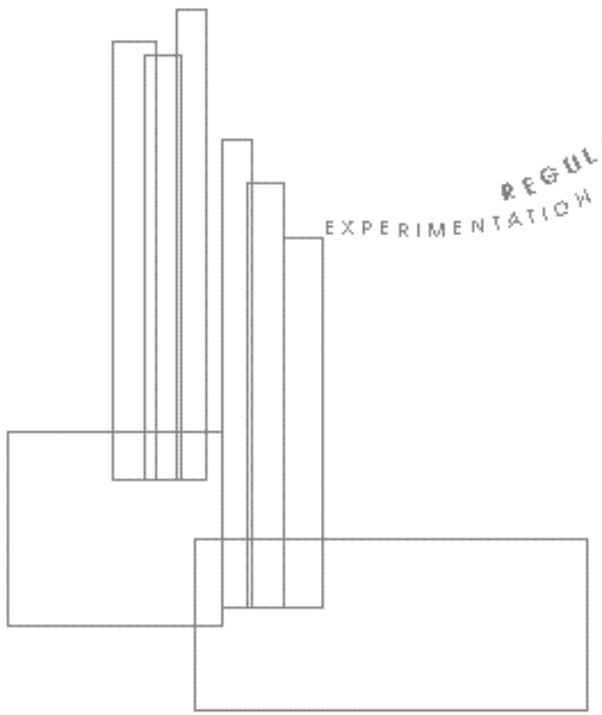
Federal and States' Regulatory Drivers

- EPA's Clean Air Interstate Rule (CAIR), Clean Air Mercury Rule (CAMR): Weak drivers for mercury
  - 2010 Phase I cap of 38 TPY (about 20 percent reduction)
  - 2018 Phase II cap of 15 TPY (70% reduction; not achieved till 2025 and beyond because of trading)
  - States have leeway to adopt EPA's CAMR or propose a more-stringent approach
- State Rules/Legislation (strong drivers, in place and pending)
  - More than a dozen states
- Consent Decrees: We Energies, Xcel, PSNM, Dynegy
- New Power Plants (about 20 to 80)

Environmental Regulation and Technology Innovation:

Controlling Mercury Emissions from Coal-Fired Boilers

September 2000



REGULATION
INNOVATION
IMPLEMENTATION
EXPERIMENTATION

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Northeast States
for Coordinated
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Commercial Mercury Control Contracts as of July 2006

Plant Size MWs	Prime OEM Contractor	Coal	APC Configuration	Hg Control	New Plant or Retrofit	Regulatory Driver
270	WAPC/ NORIT	PRB	TOXECON	ACI	Retrofit	Consent Decree
250	WAPC	Bituminous	SDA/FF	ACI	Retrofit	State Regulatory
250	WAPC	Bituminous	SDA/FF	ACI	Retrofit	State Regulatory
650	WAPC	Bituminous	ESP	ACI	Retrofit	State Regulatory
740	B&W	PRB	SDA/FF	Br-ACI	New Plant	Construction Permit
550	B&W	PRB	SDA/FF	Br-ACI	New Plant	Construction Permit
350	B&W	PRB	SDA/FF	Br-ACI	Retrofit	Consent Decree
350	B&W	PRB	SDA/FF	Br-ACI	Retrofit	Consent Decree
800	B&W	PRB	SDA/FF	Br-ACI	New Plant	Construction Permit
350	ADA-ES	Bituminous	ESP	ACI	Retrofit	Consent Decree
350	ADA-ES	Bituminous	ESP	ACI	Retrofit	Consent Decree
204	Dustex	PRB	TOXECON	ACI	Retrofit	Consent Decree
375	WAPC	Bituminous		ACI	Retrofit	Concent Decree
650	Alstom	PRB	SDA/FF	Br-ACI	New Plant	Construction Permit
215	Powerspan	Bituminous	Multipollutant	ECO	Retrofit	
	Mobotec	PRB	ESP	CDEM	Retrofit	

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State Rules Example: Massachusetts

- Adopted rule
- 85% capture or 0.0075 #/GWh by January 1, 2008
- 95% capture or 0.0025 #/GWh by October 1, 2012
- No interstate trading

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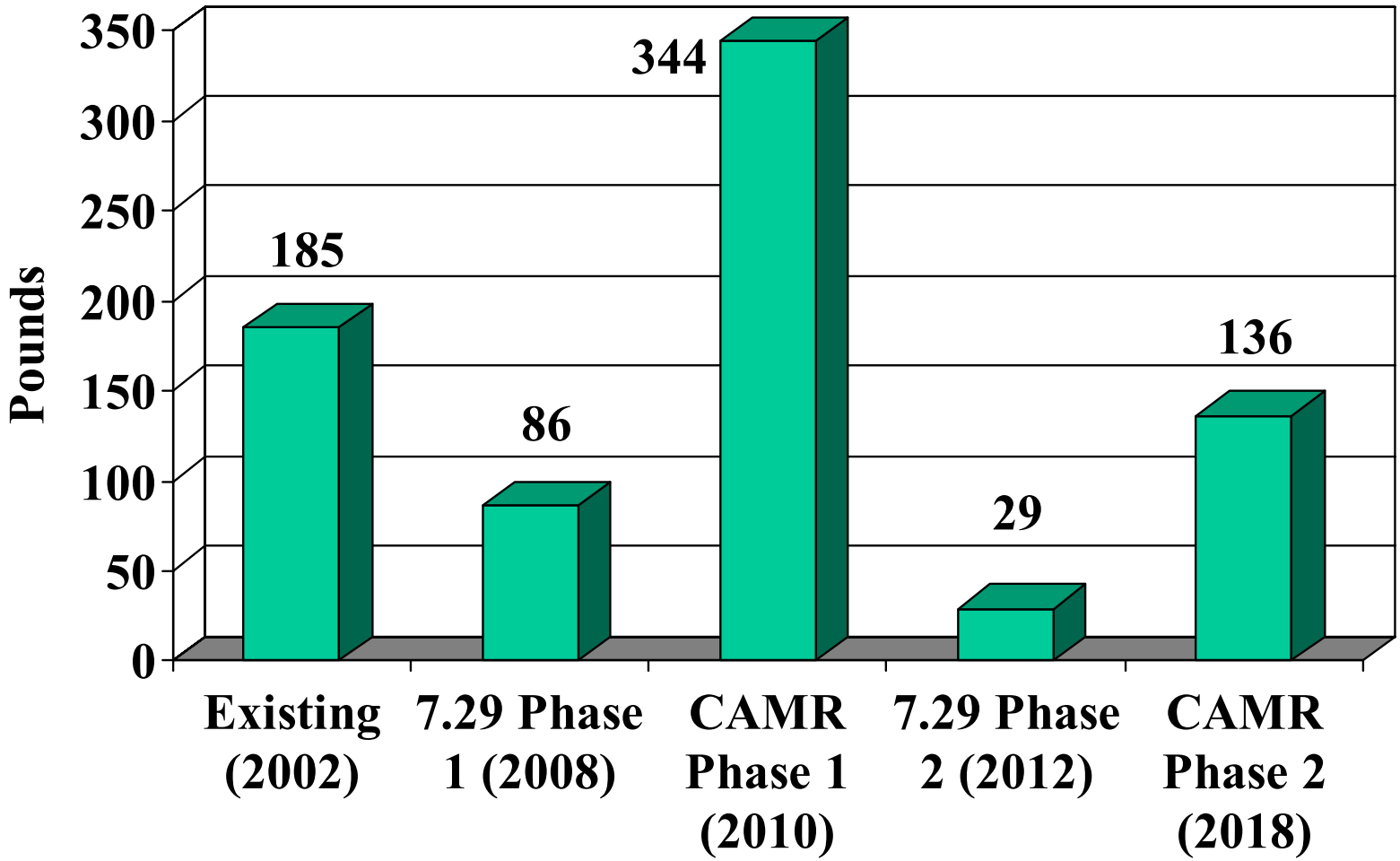
Massachusetts Coal-fired EGU Projected Mercury Emissions



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State Rules Example: New Jersey

- Adopted Rule
- 3.00 mg/MWh or 90% control across control device as of December 15, 2007 (one year extension possible)
- Multi-pollutant control option--December 15, 2012;
  - nitrogen oxides ≤ 0.100 lbs/MMBTU (dry bottom utility boilers); ≤ 0.130 lbs/MMBTU (wet bottom utility boilers) based on 30 days rolling avg.;
  - sulfur dioxide ≤ 0.150 lbs/MMBTU based on 30 days rolling avg; and
  - particulate matter ≤ 0.030 lbs/MMBTU based on USEPA Test Method 5;
  - 50% of MW controlled for mercury by 12/15/2007; 100% by 12/15/2012
  - If necessary, one additional year for optimization of control systems
- No interstate trading

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Goals of STAPPA/ALAPCO Model Rule

- **Policy Objectives:**
  - Protect public health and welfare (no trading)
  - Reduce Coal-Fired EGU emissions Hg to <7 tons/year (90 to 95 % reduction by 2012)
  - Provide flexibility to reduce cost
  - Spur rapid technological development

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States More Stringent Than CAMR Now or Proposed

- ❑ Connecticut
- ❑ Massachusetts
- ❑ New Hampshire
- ❑ New Jersey
- ❑ New York
- ❑ Delaware
- ❑ Maryland
- ❑ North Carolina

- ❑ Pennsylvania
- ❑ Georgia
- ❑ Illinois
- ❑ Michigan
- ❑ Minnesota
- ❑ Montana
- ❑ Washington
- ❑ Wisconsin (?)
- ❑ Virginia

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States Adopting CAMR

- ❑ West Virginia
- ❑ Alabama
- ❑ Mississippi
- ❑ South Carolina
- ❑ Tennessee
- ❑ Ohio
- ❑ Texas
- ❑ Iowa

- ❑ Kansas
- ❑ Missouri
- ❑ Nebraska
- ❑ North Dakota
- ❑ South Dakota
- ❑ Utah
- ❑ New Mexico
- ❑ Wyoming
- ❑ Louisiana

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The Future

- **November 18, 2006, deadline for state plans with fully adopted Rules and demonstration that state's Hg budget would be met**
- **What does the national trading system look like with 15-18 states not participating?**
- **Legal battles continue**
- **Greatest certainty may be in those states with stringent (90-95% control) MACT-like rules**

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Some Final Observations

- Many states in the U.S. are moving at a faster and a more certain pace than the federal CAMR, based on the assumption that environmental regulation drives technology innovation and implementation
- Hg Control technologies are now commercially available; new technologies are rapidly emerging; 90% and higher control is feasible; number of suppliers
- Cost effectiveness of Hg control is quite comparable to, and more attractive than, the cost effectiveness of SO2 and NOx controls from power plants (Hg:SO2:NOx: 0.2 to 0.8 mills/kwhr: 3-5 mills/kwhr: 1-2 mills/kwhr)
- Monetized benefits are much larger than monetized costs (benefits to cost ratio of 10)

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Some Final Observations

- Small cost savings (if any) of trading-based approaches are not worth the increased risk of hot spots (fish or human exposure)
- Mercury is not just about the averages – hot spots (emissions, deposition, biological (fish), and exposure (people) need to be considered