

Why

It Is Important To Monitor
For Atmospheric Mercury

Why Monitor Atmospheric Mercury Deposition?

Atmospheric Deposition is the key input of Mercury in water bodies

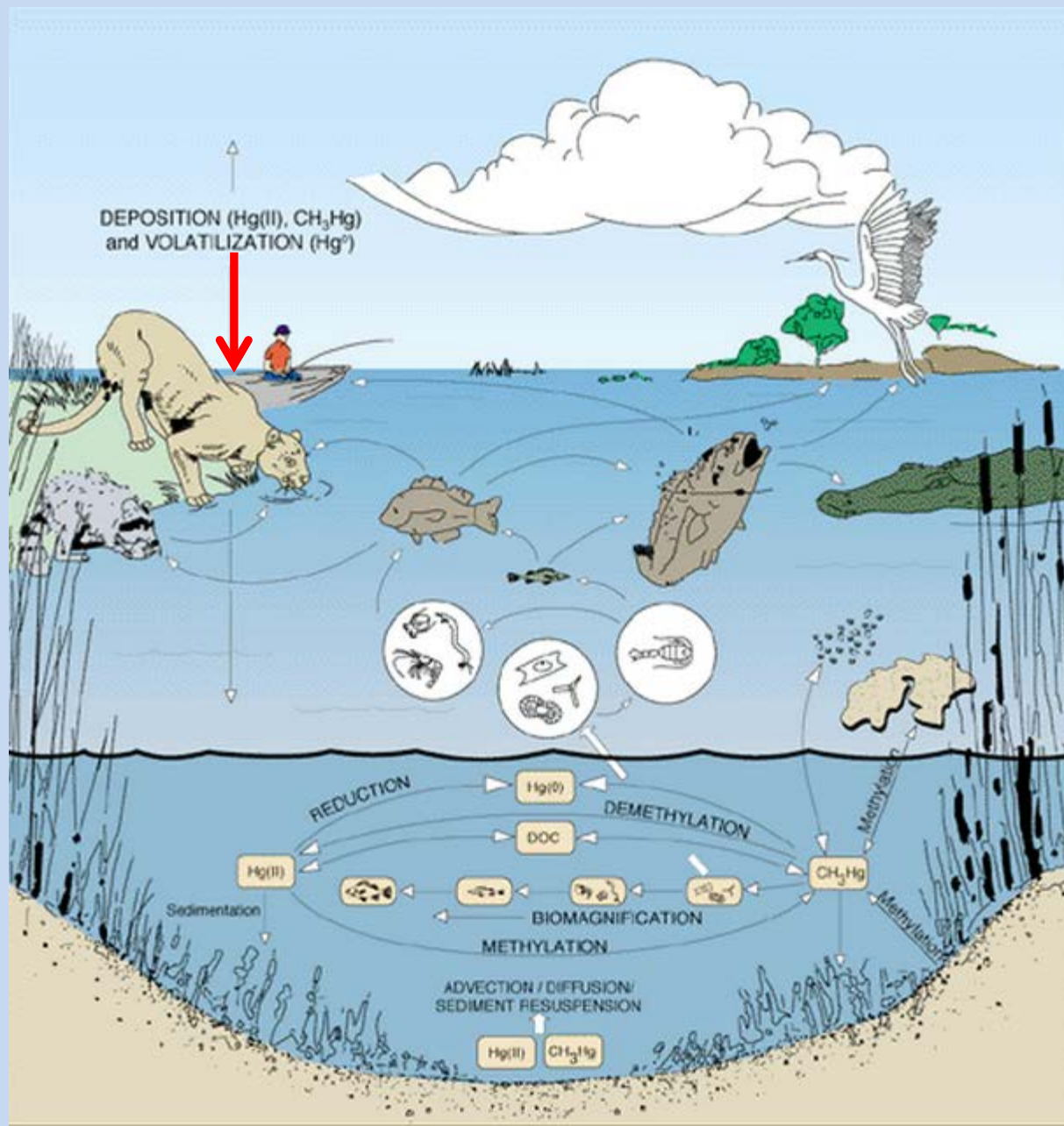
Environ. Sci. Technol. 2006, 40, 6261–6268

Mercury in Soils, Lakes, and Fish in Voyageurs National Park (Minnesota): Importance of Atmospheric Deposition and Ecosystem Factors

J. G. WIENER,^{*,†} B. C. KNIGHTS,[‡]
M. B. SANDHEINRICH,[†]
J. D. JEREMIASON,[§] M. E. BRIGHAM,^{||}
D. R. ENGSTROM,[⊥] L. G. WOODRUFF,^{||}
W. F. CANNON,[#] AND S. J. BALOGH[△]

- Hg source to water bodies is *overwhelmingly atmospheric deposition and anthropogenic*

*“We conclude that **nearly all of the mercury in fish in this seemingly pristine landscape was derived from atmospheric deposition**, that most of this bioaccumulated mercury was from anthropogenic sources, and that both watershed and lacustrine factors exert important controls on the bioaccumulation of methylmercury.”*



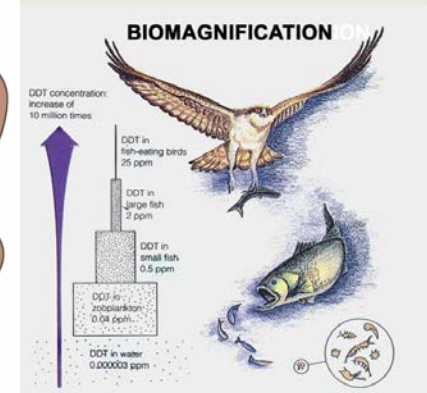
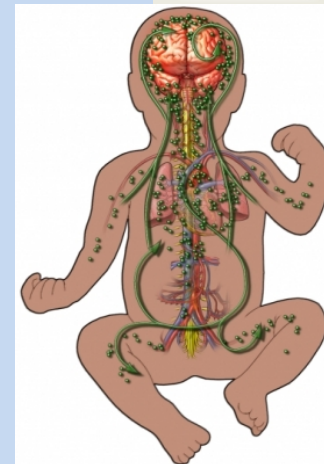
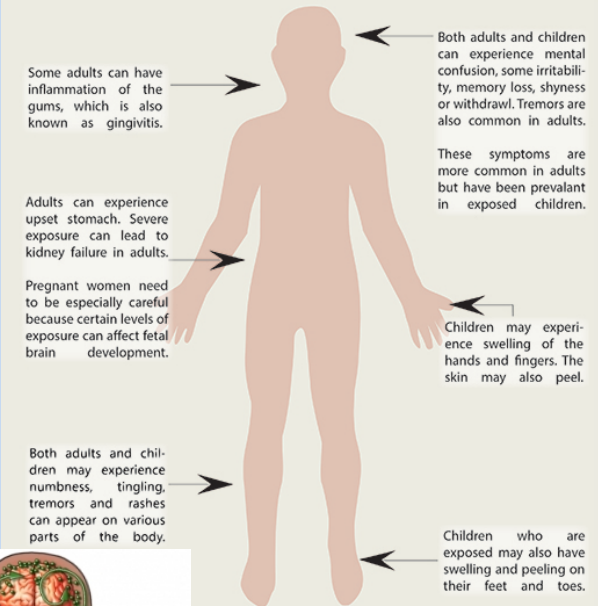
**Mercury is a health concern,
particularly to children and
developing fetuses**

A Human Health Concern

- Neurological Disorders
 - Persistent bioaccumulative neurotoxin
 - Large problem in children up to about 7-12 years
 - » Birth defects
 - » learning disabilities
 - Problem in adults under certain conditions

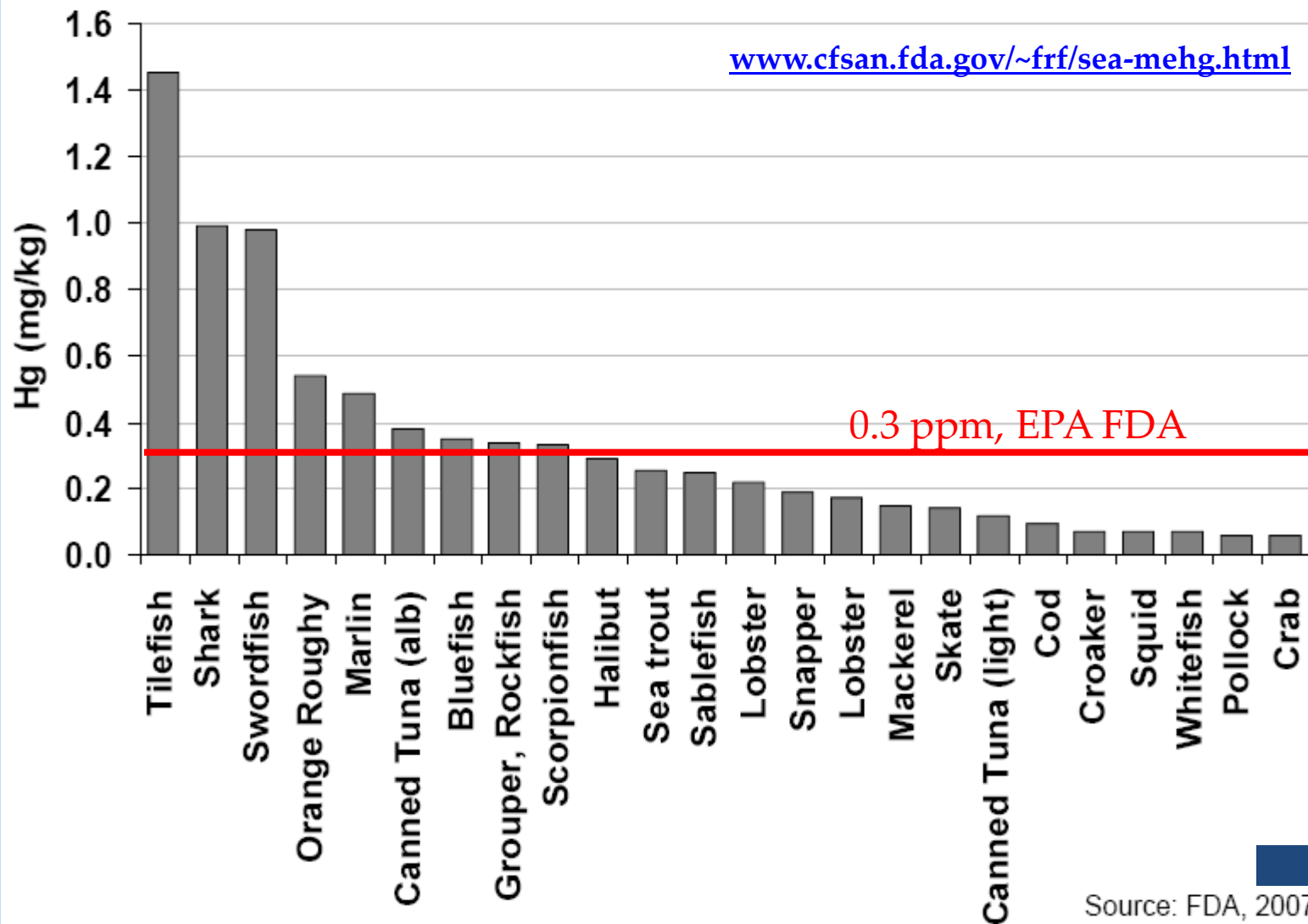
Environmental mercury: What does it do?

Mercury is more common than you would think. It can be found in thermometers, fluorescent light bulbs, batteries and other household items. Below are some of the side effects mercury can have on the human body.

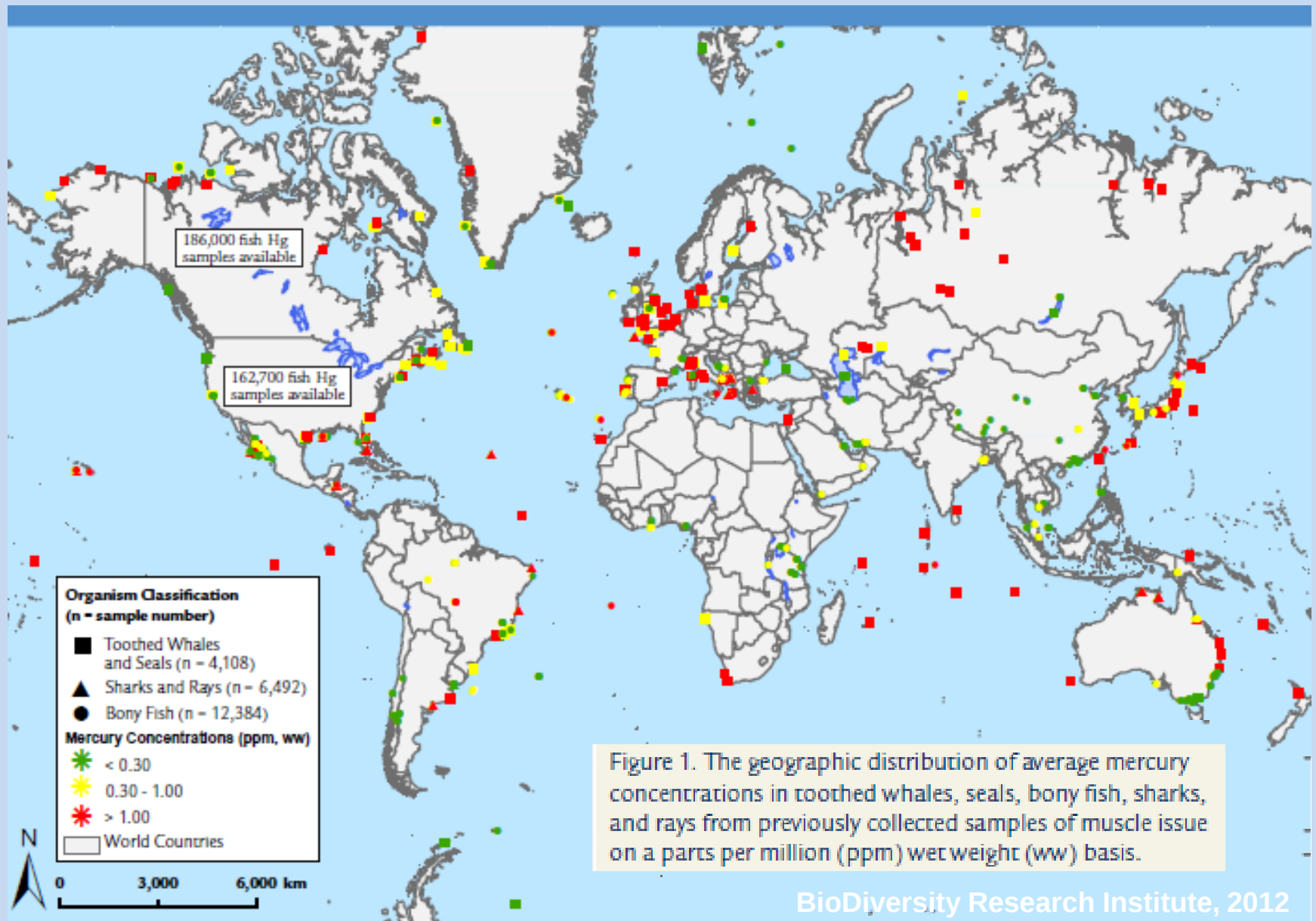


**Mercury exposure to humans is
primarily through the
consumption of fish**

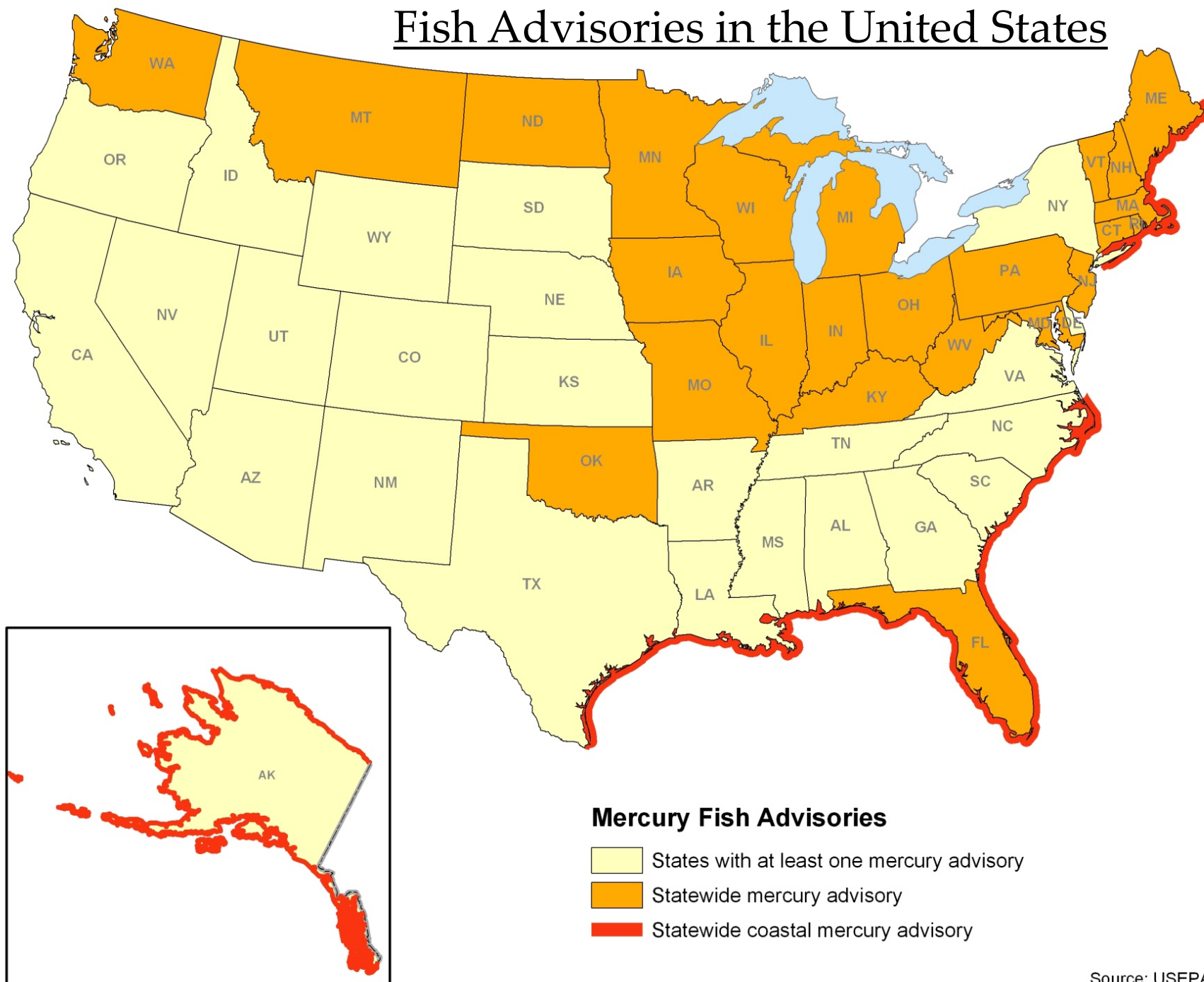
FDA Reported National Hg Values



Mercury in fish and marine mammals



Fish Advisories in the United States



**Mercury is damaging to wildlife
exposed to mercury**

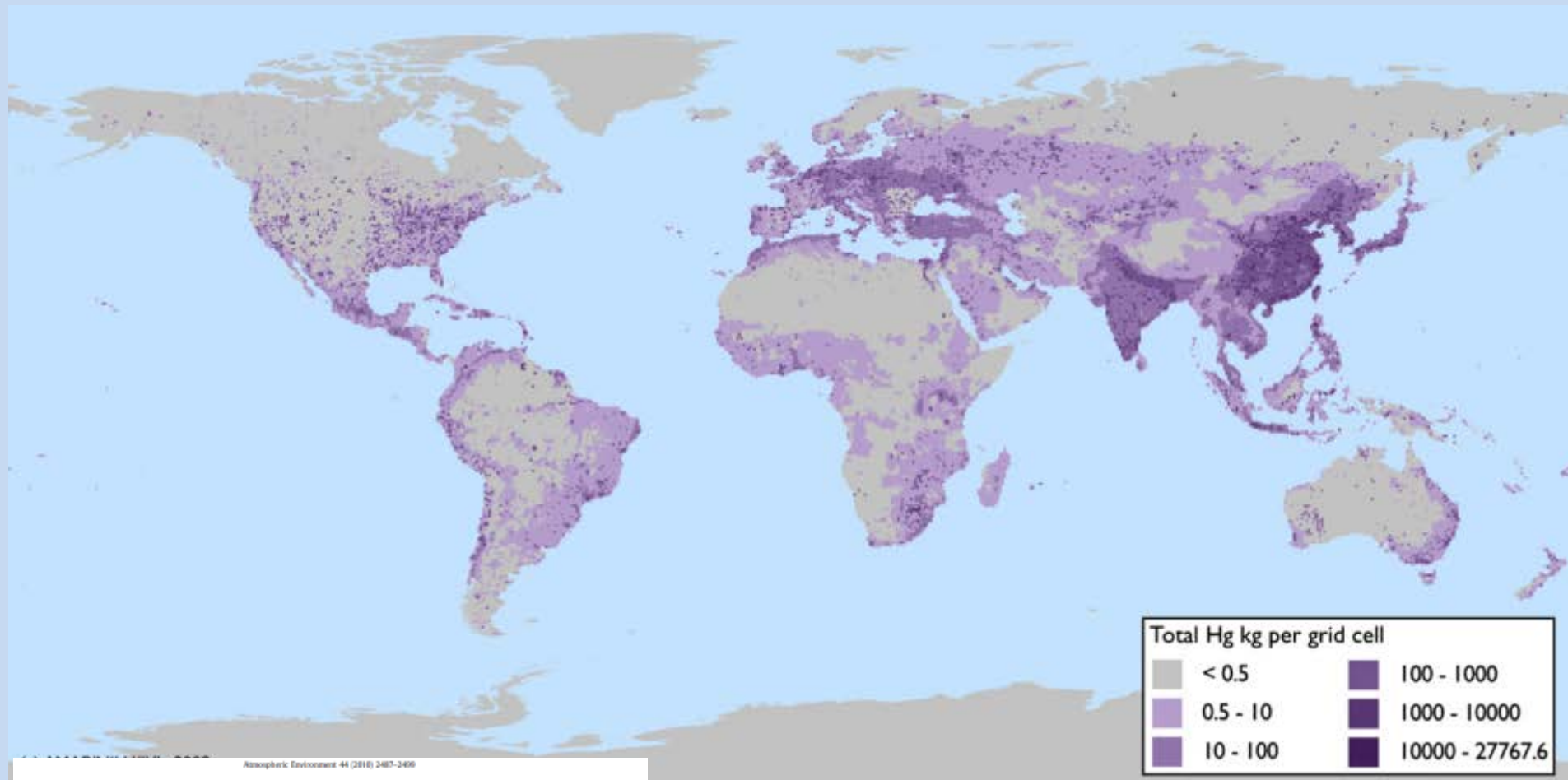
(eating within the same food chain)

But it isn't just humans....



**Mercury pollution is distributed
globally**

Global Emissions of Mercury to the Atmosphere



Atmospheric Environment 44 (2010) 2487–2498

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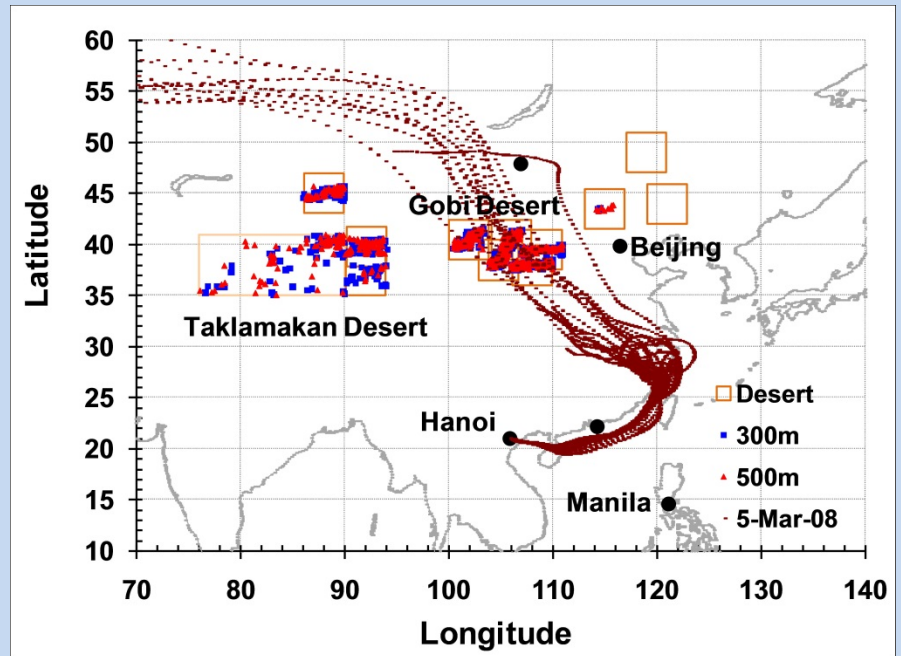
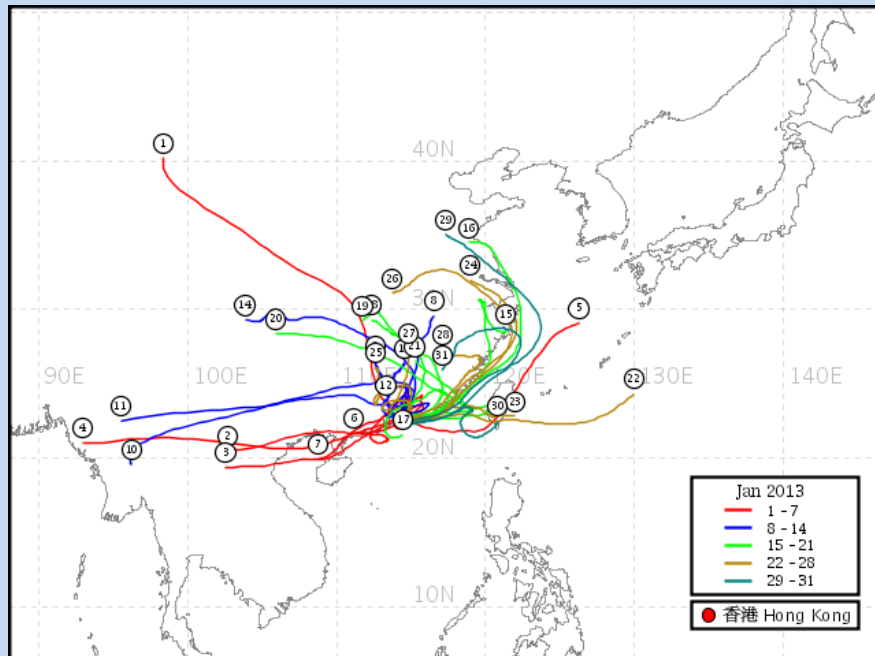


Global emission of mercury to the atmosphere from anthropogenic sources in 2005 and projections to 2020

E.G. Pacyna^a, J.M. Pacyna^{a,b,c}, K. Sundseth^d, J. Munthe^e, K. Kindbom^e, S. Wilson^d,
F. Steenhuisen^g, P. Maxson^f

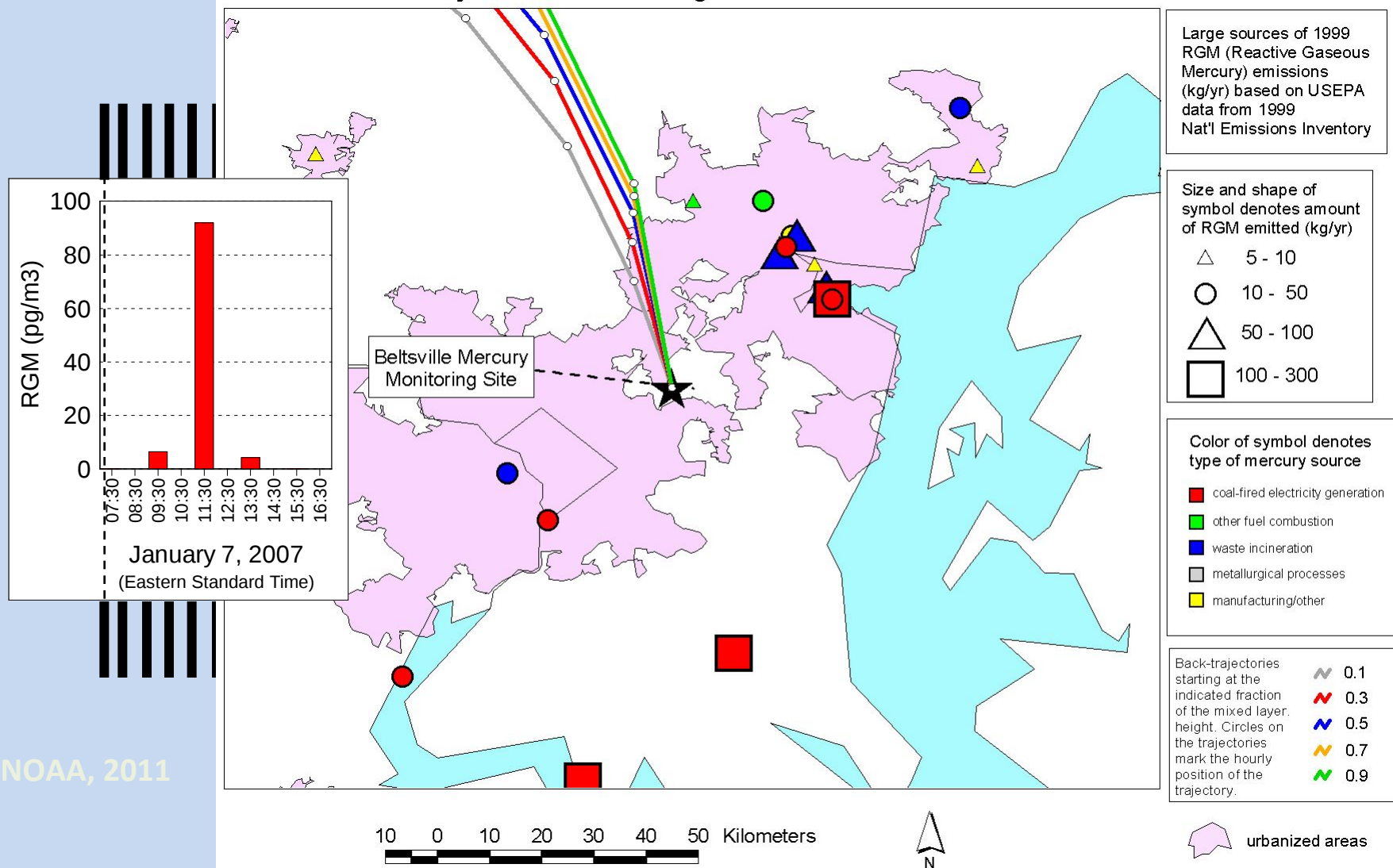
Given Measurements, you can determine where the Hg comes from...

Local regional or global



Impacts of mercury emitting sources

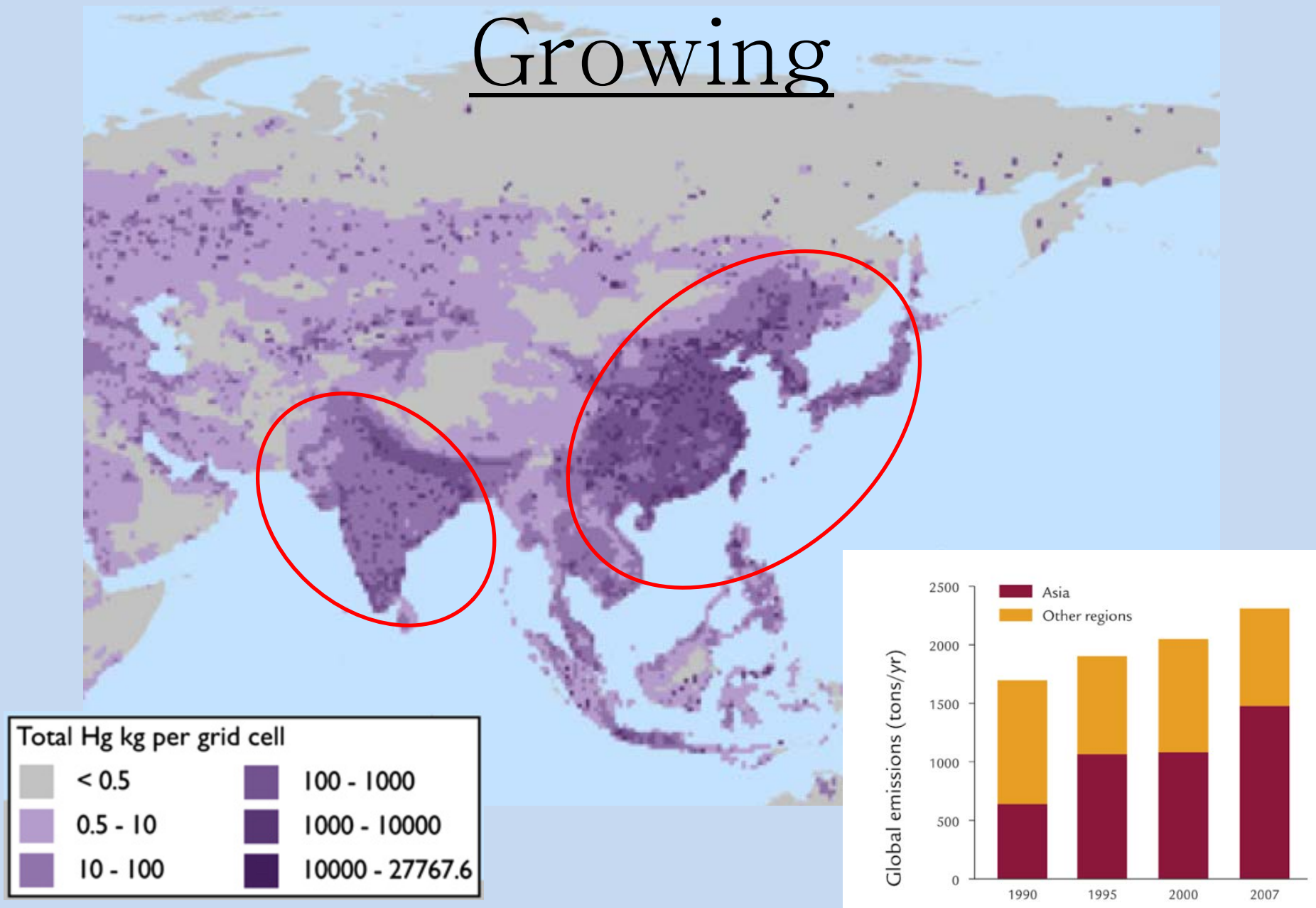
Back Trajectories Arriving at 1/07/2007 07:00 EST



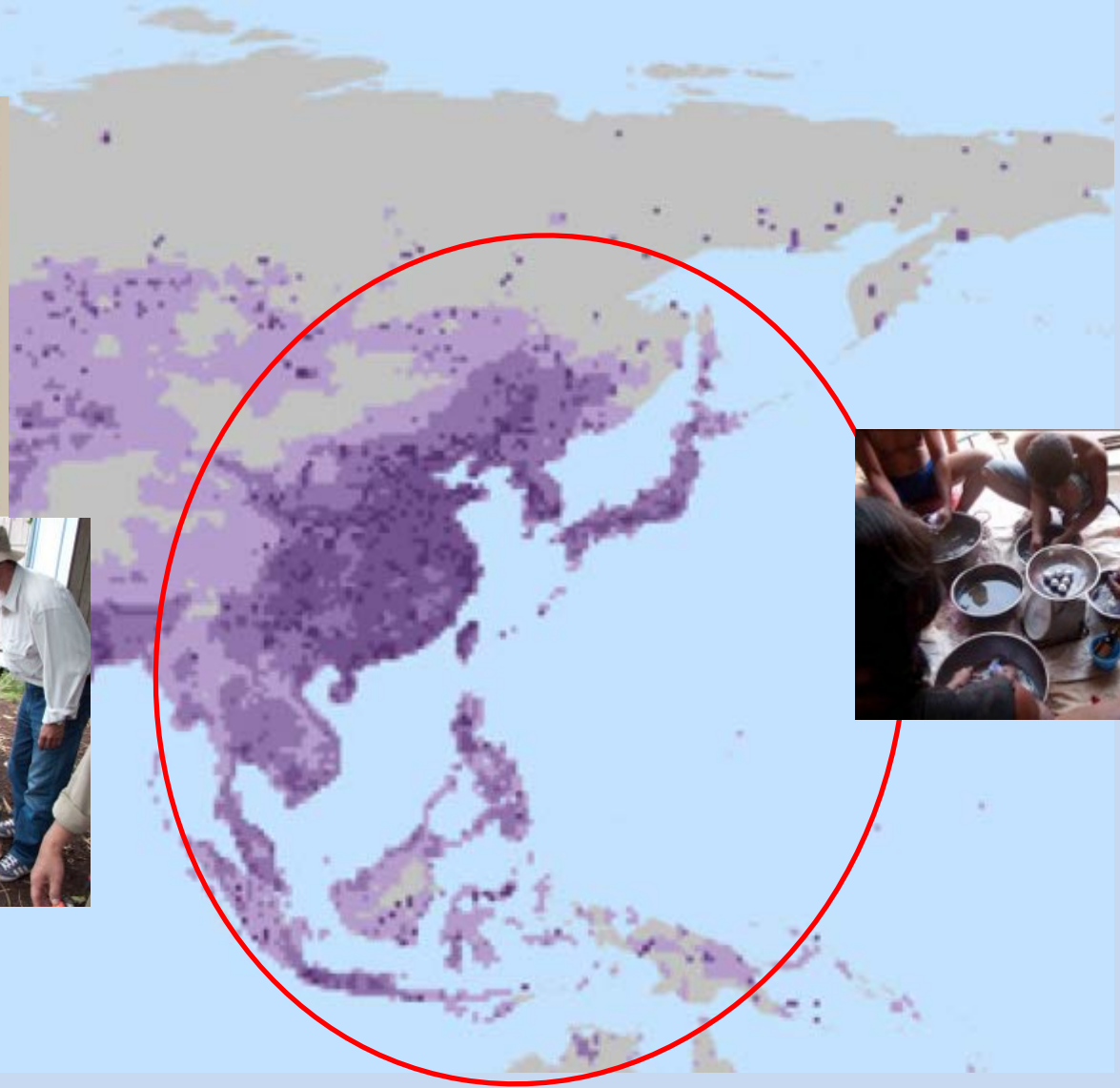
Sometimes, we see evidence of local and regional “plume” impacts

**Asia is the world's largest mercury
source region**

Largest Emissions and Growing



Small Scale Artisanal Gold Mining?

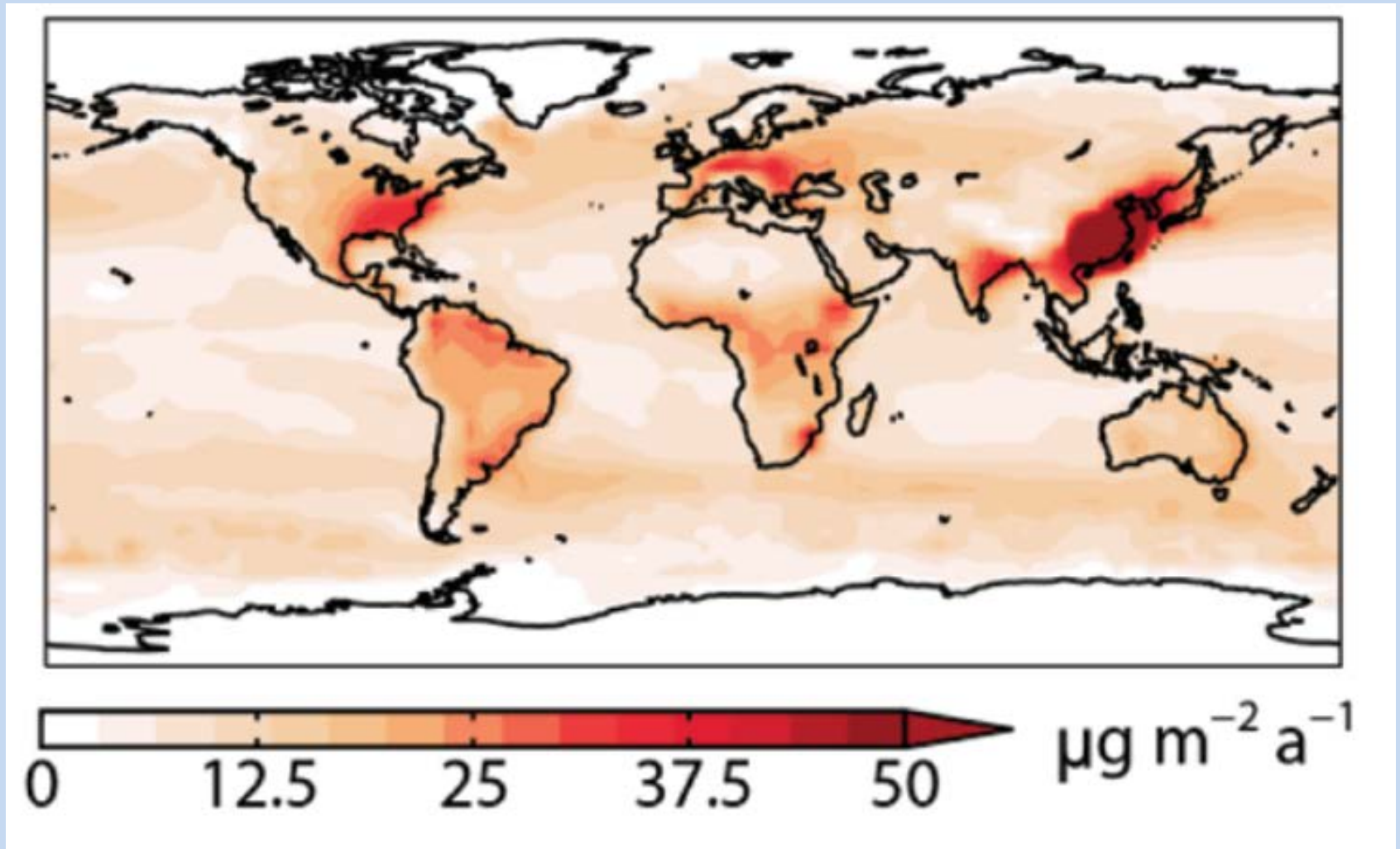


Much of Asia Deposition

**is not currently being recorded or
measured consistently**

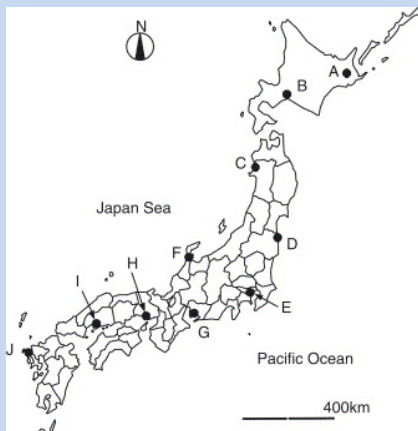
Estimated Global Wet Deposition of Mercury

Modelled Net Mercury Deposition, Corbitt et al, EST 2011



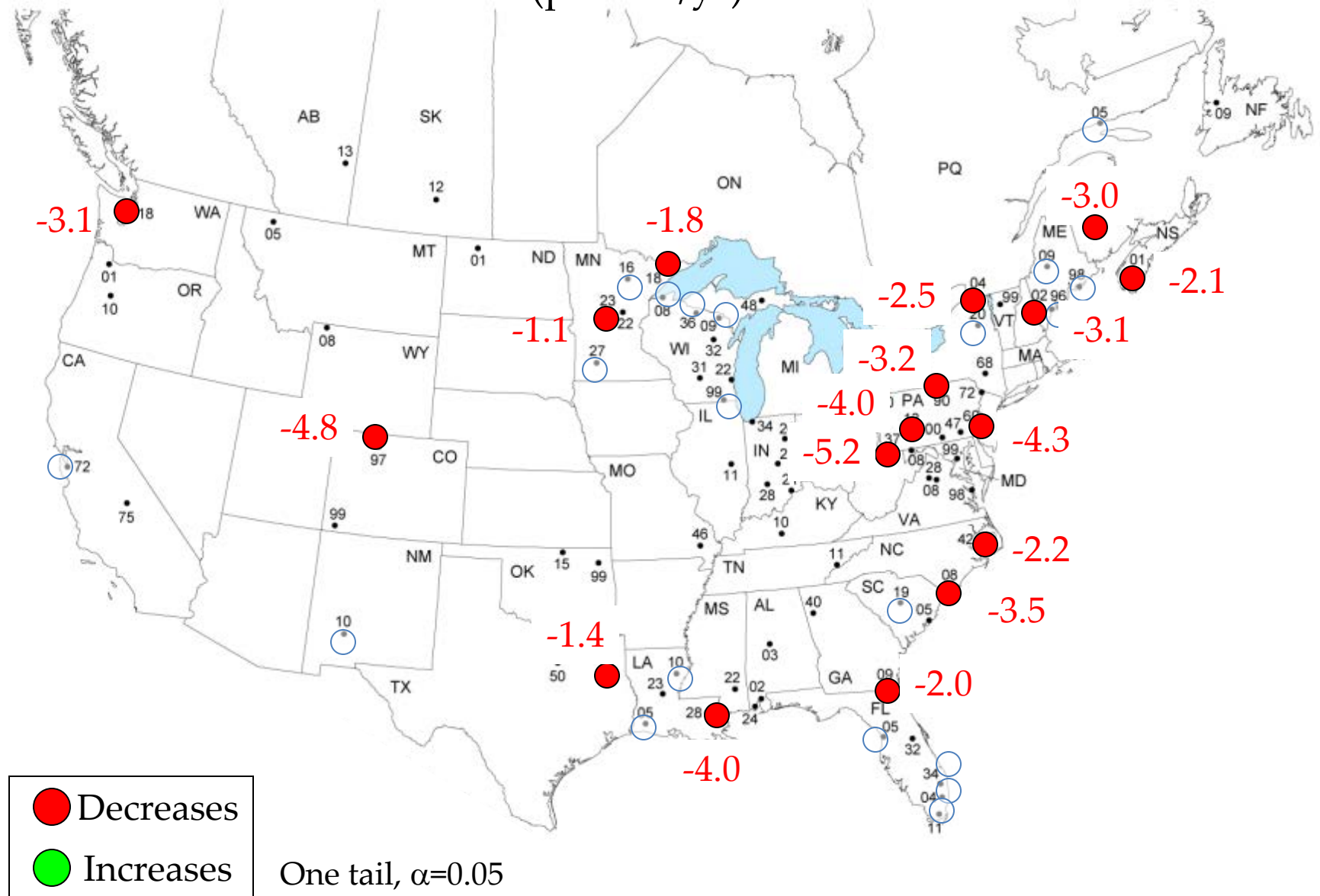
East Asia Hg Monitoring Networks are Operating and/or Developing

- **Korea** – National Institute of Environmental Research (NIER)
- **Japan** – Dr. Maramoto, Dr. M. Sakata, et al., wet deposition
- **Taiwan** – Mt. Lulin and other stations – see work by Guey-Rong Sheu
- **China** - see work by Xinbin Feng, others

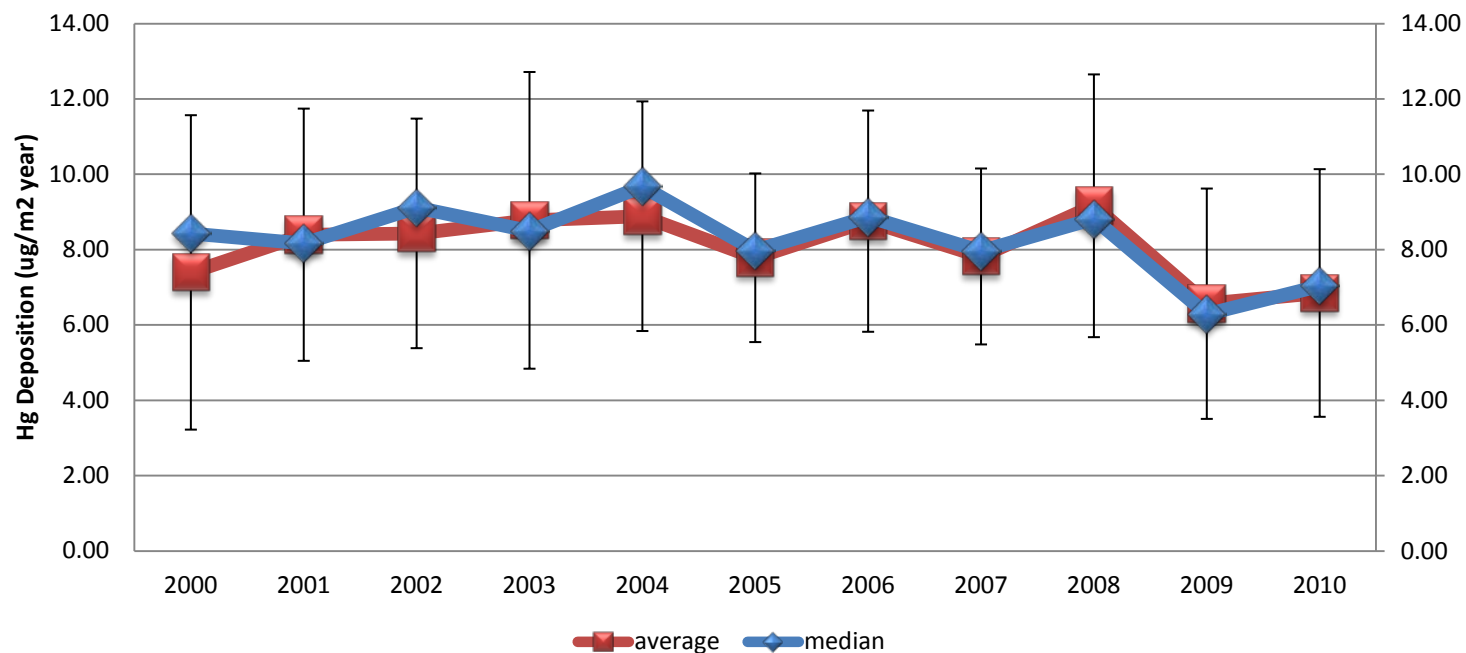
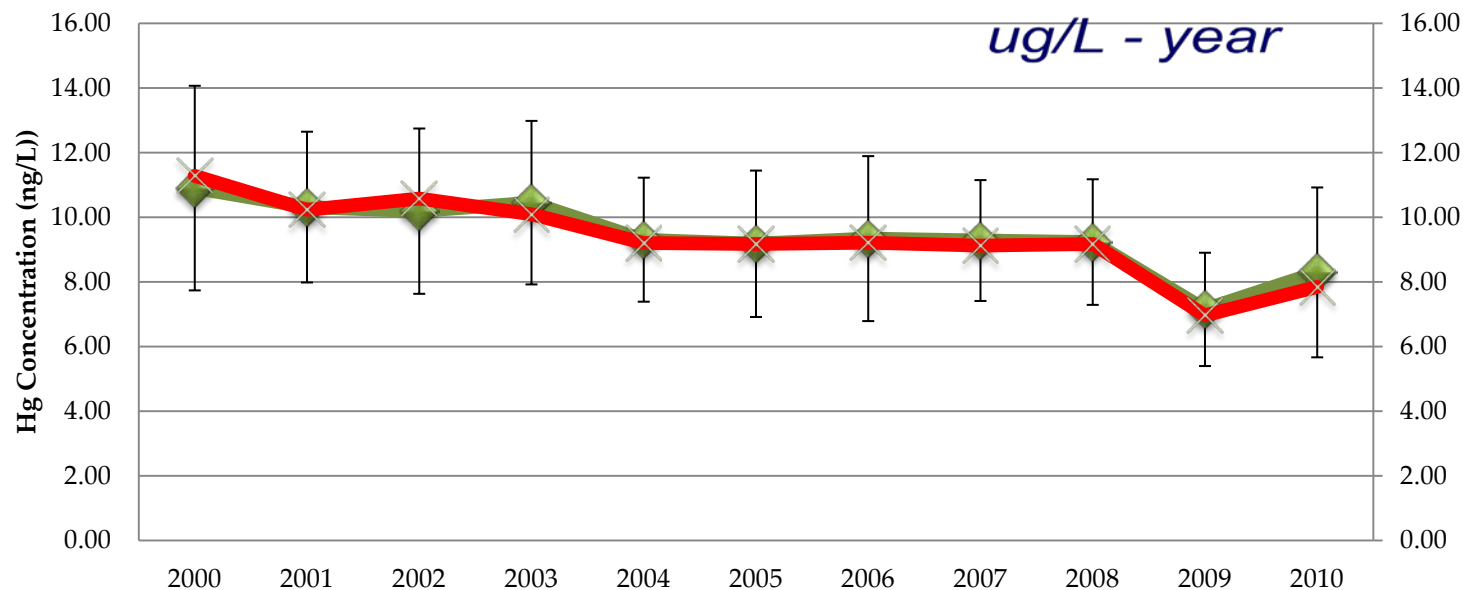


Trends Determination of Changes in Mercury Deposition

Mercury Concentration Trend Slopes (percent/yr)



Great Lakes Mercury Wet Concentration and Deposition



If Mercury Emissions Regulations are Implemented..

- Measurements are needed..
 - to determine if deposition is being reduced
 - How fast deposition is being reduced
 - If deposition is going down in all areas
 - If fish concentrations are also being reduced
 - If human exposure is decreasing
- Mercury reduction is proceeding in some countries, and the Minamata Convention should continue this trend.

Minamata Convention

Many Countries have signed on....

- Mercury emission reductions should follow
- *Now* is the time to be measuring
 - To determine if changes can be shown in scientifically defensible data.
- The Convention depends upon monitoring of the mercury cycle
 - Driven by atmospheric deposition.

Global Mercury Monitoring

- All Scientists need sound measurements from everywhere, particularly in Asia
 - To understand the global problem...
 - To run global models...
 - To track results of the Minamata Convention

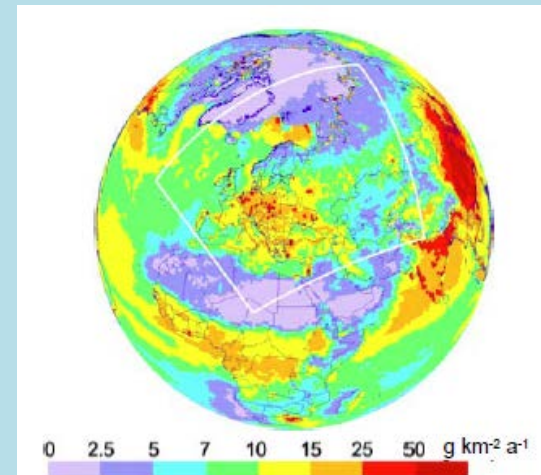
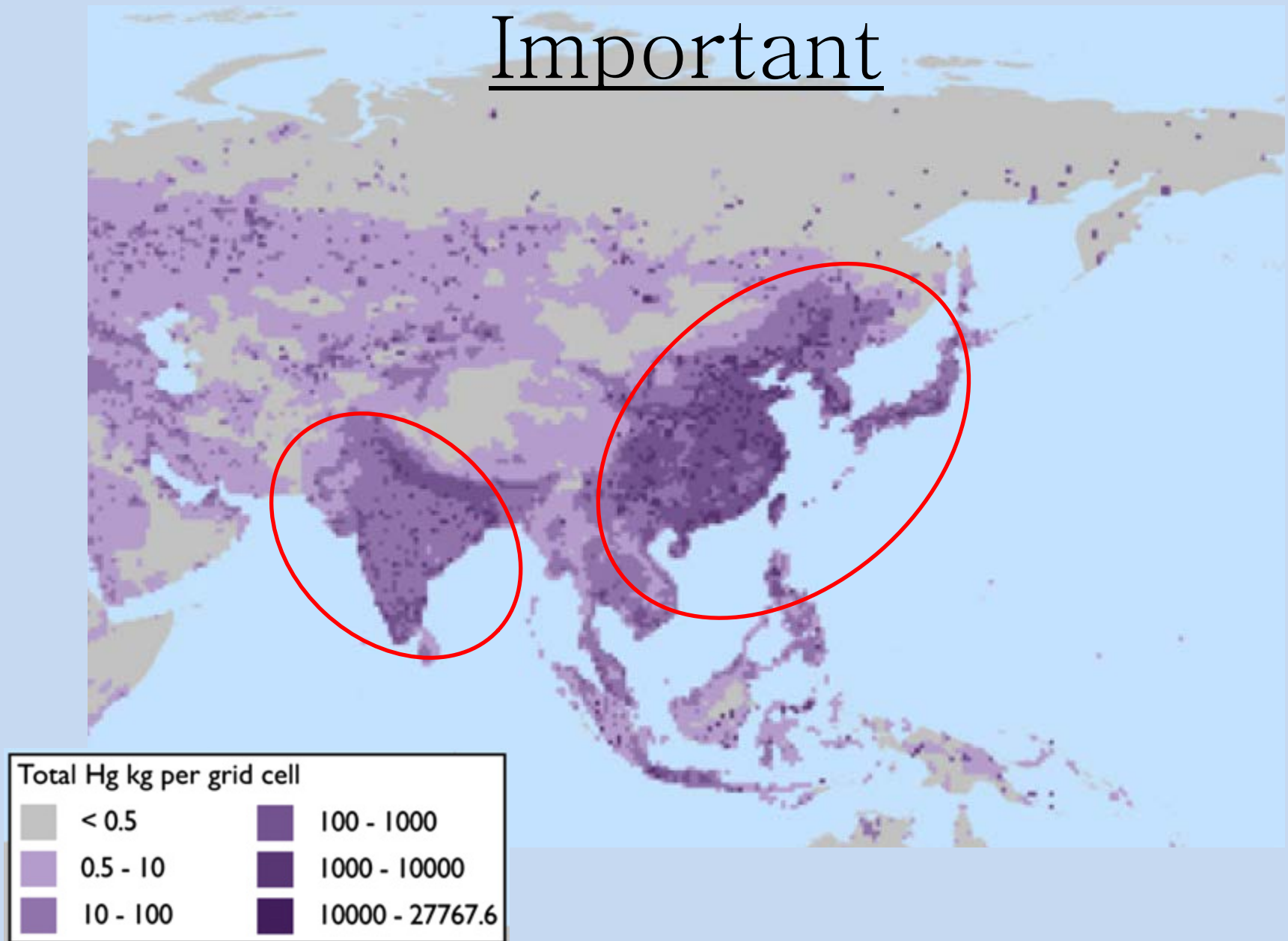


Fig. 3.13. Spatial distribution of mercury deposition flux on a global scale in 2010. White rectangle shows location of the EMEP domain.

Global Monitoring Effort



Asian Monitoring is Very Important



Again, Mercury is a global pollutant, so...

- We all need global organization
- We need harmonize methods and sampling times
- We need global reporting of measurements

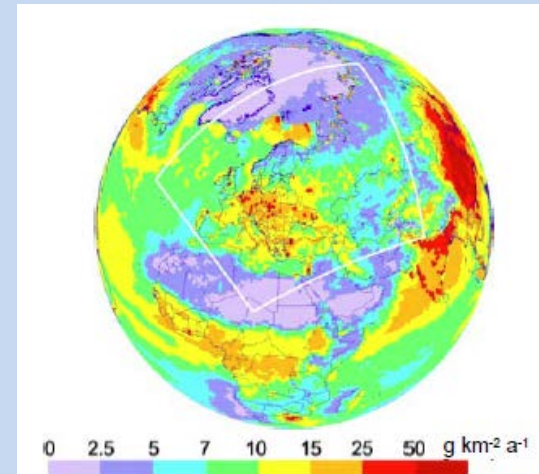
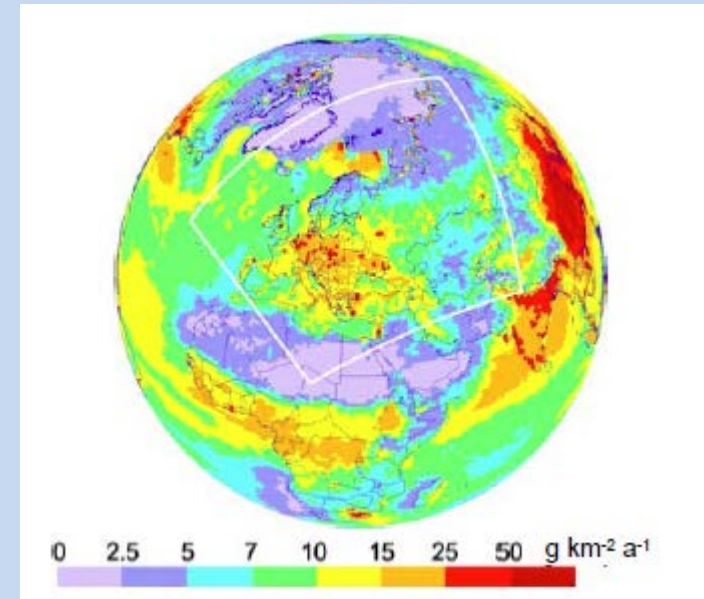


Fig. 3.13. Spatial distribution of mercury deposition flux on a global scale in 2010. White rectangle shows location of the EMEP domain.

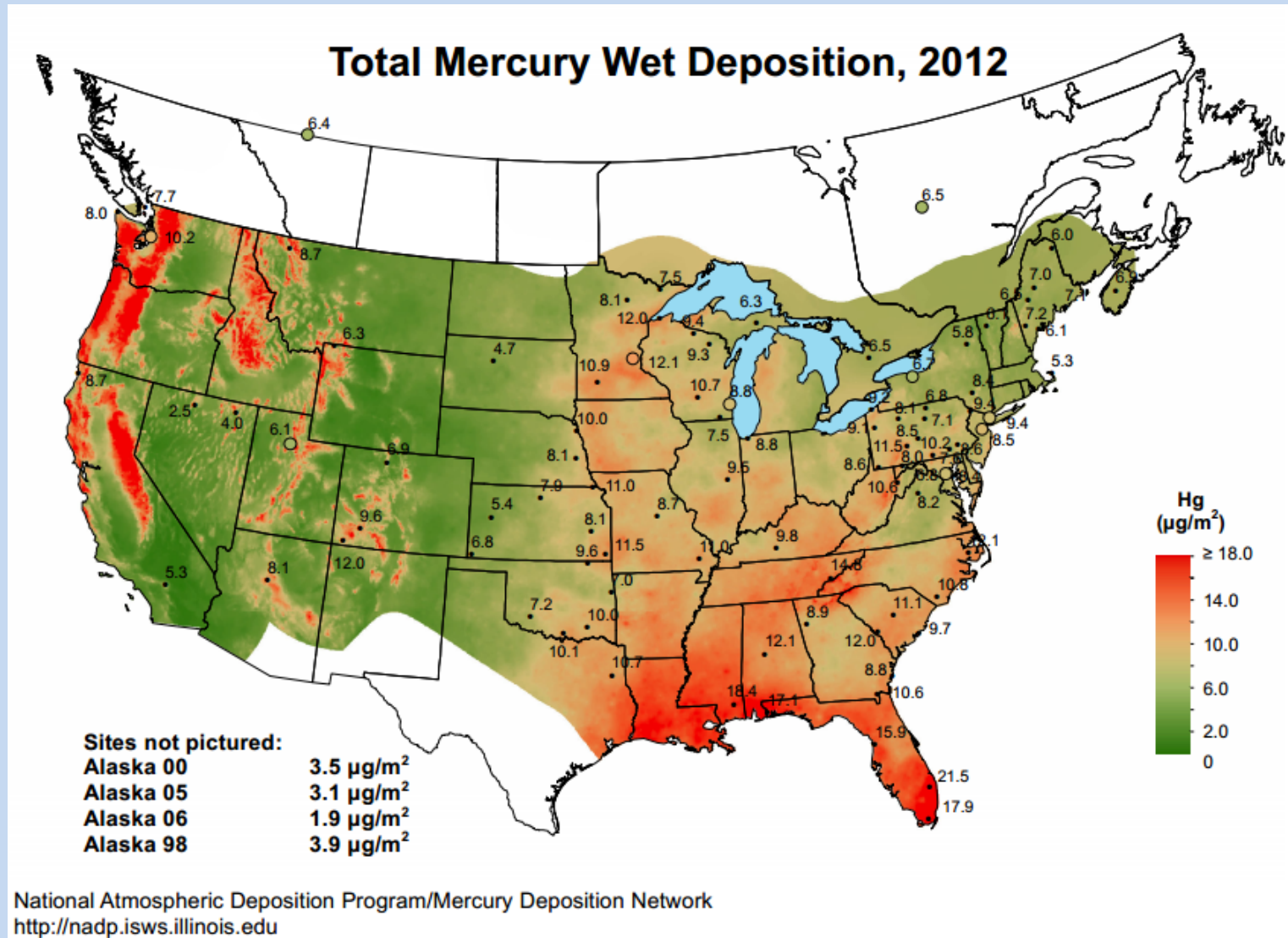
Strength in Network Design

The Value of Monitoring

- Using same methods!!!
 - “apples to apples”
 - on a global basis
 - Harmonization of measurements
- Long term monitoring is required to see small changes.
- Sharing Data
 - We need global data to understand a global pollutant
 - Working together is the *best way forward*
- Understand the problem through science
- Is Policy Working?
 - Put legislation in place
 - But is it working
 - Is the problem improving



But More Monitoring and COOPERATION is Needed For This..



The Asia-Pacific Mercury Monitoring
Network could provide these
measurements!



Where is the Asia-Pacific Mercury
Monitoring Network Now?

Summer, 2013 Meeting in Washington DC

- Vietnam, Korea, Japan, Taiwan, Thailand, Indonesia
 - Decided to begin a pilot mercury wet deposition network
 - Investigate atmospheric mercury emissions capabilities
 - Hold further meetings
- Pilot Network developed
 - Vietnam, Thailand, Indonesia
 - Common laboratory in Taiwan
- Plan to begin monitoring
 - in September, 2014
 - Equipment in place
 - Laboratory ready





Japan, Korea, Taiwan

- Agreed to support the APMMN
- Opportunity to network their mercury measurement
 - Atmospheric measurements
 - Wet deposition measures
- Taiwan supporting measurements at the three pilot wet deposition sites.
- Are considering other supporting roles

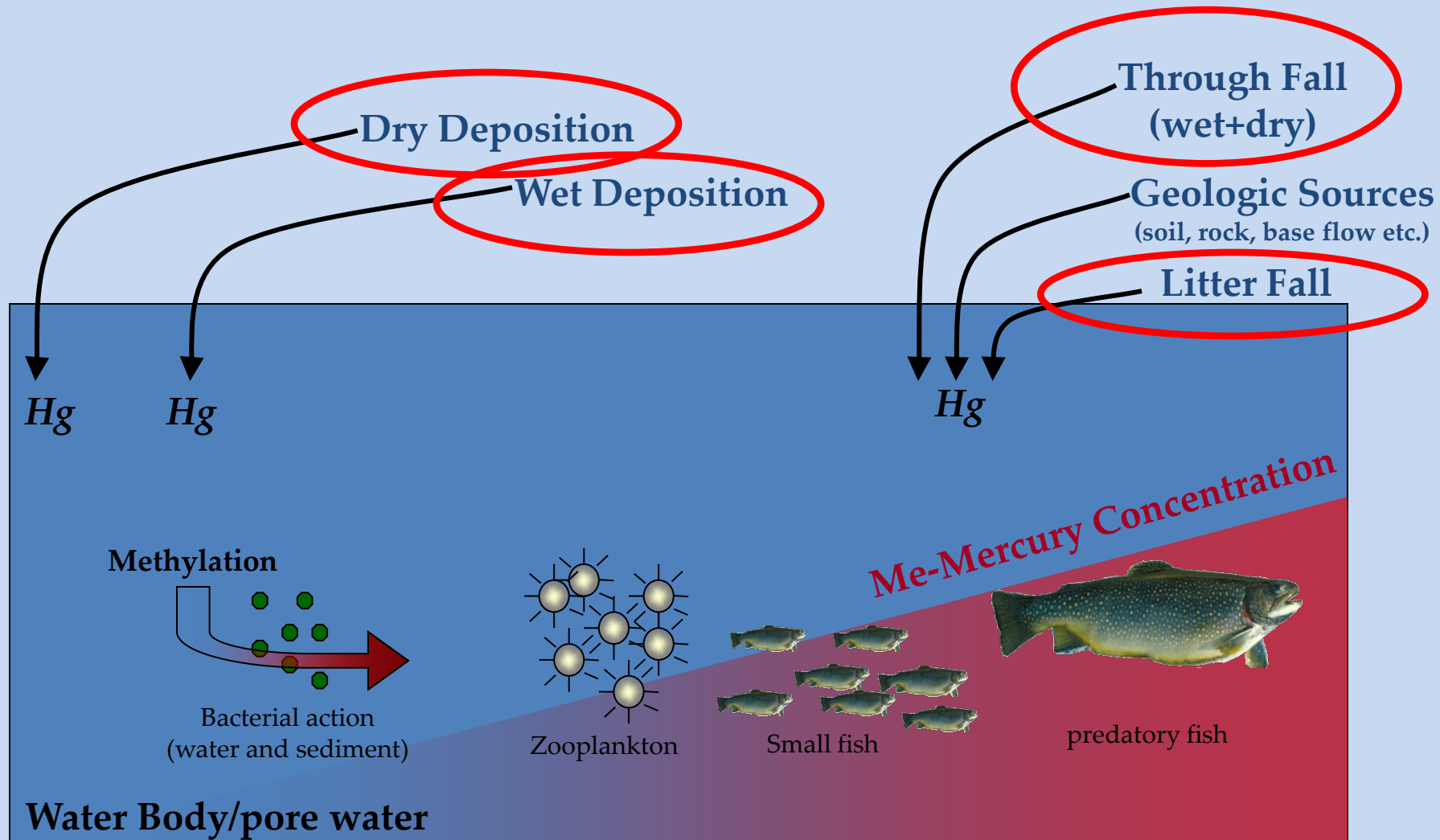
Opportunities for Growth



The Mercury Problem.....



Bioaccumulation of Methyl Mercury

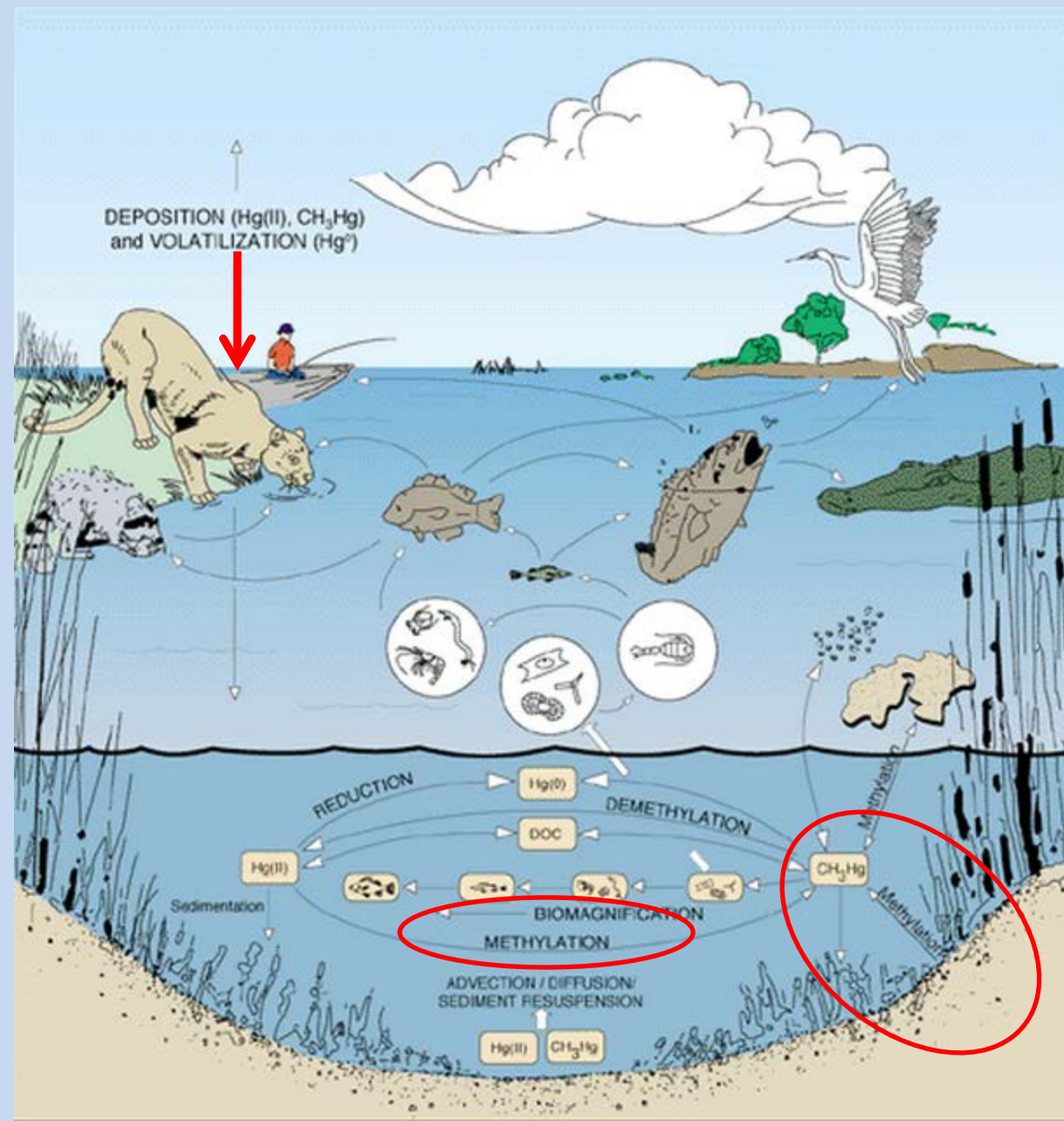


The Mercury Cycle and Methylation



Promotion of Methyl formation

- wetlands & anoxic waters/sediments
- *Geobacter sulfurreducens*
Several sulfate-and iron-reducing bacteria species
- Sulfite present & active sulfate reduction
- Low light penetration
- High DOC
- Low oxygen (reduction)
- Bioavailable inorganic Hg

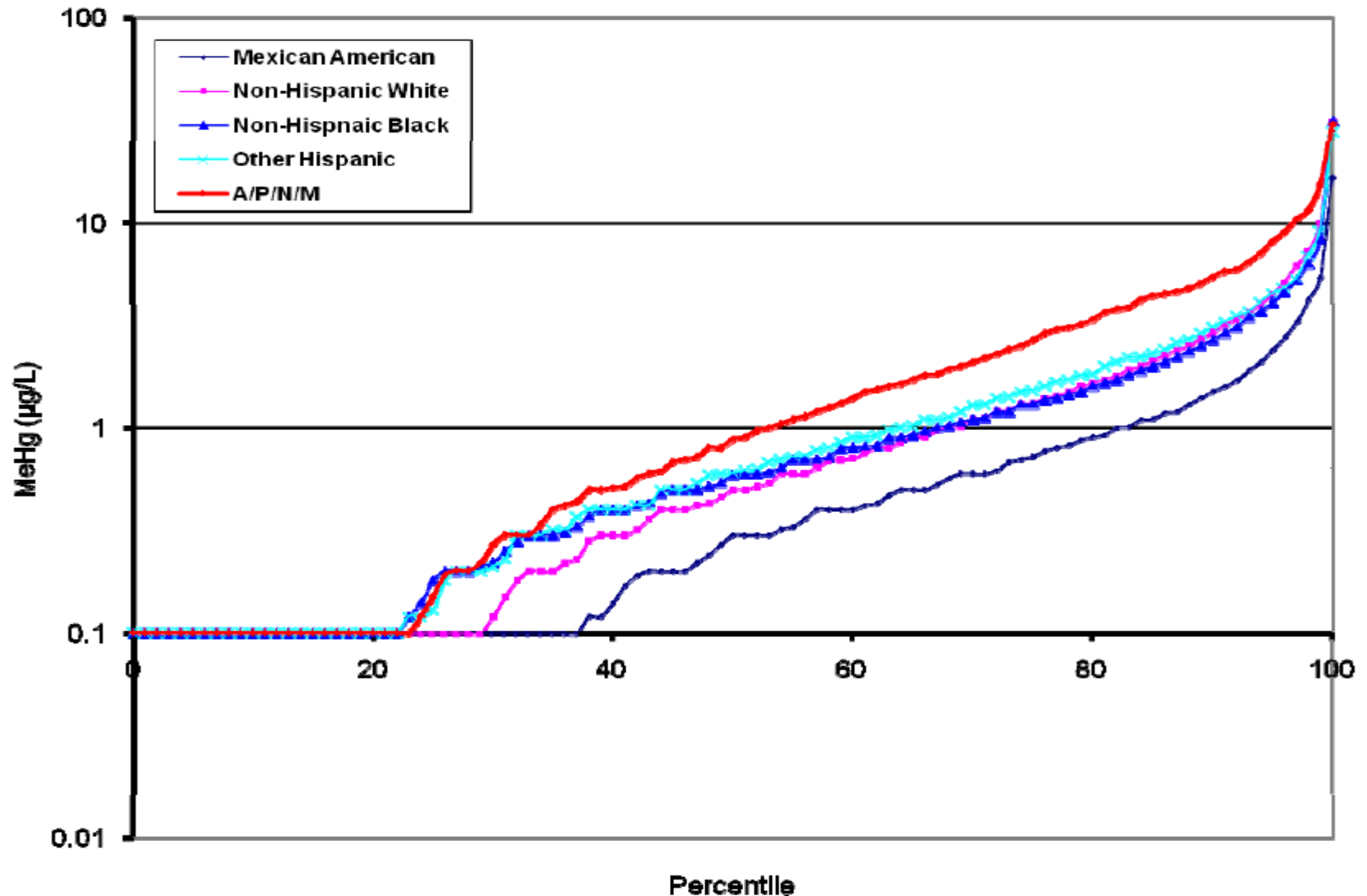


Atmospheric Mercury Measurement Determines.....

- The importance of the problem at a location
 - Other factors are at work, but this is one of the most important
- Trace the problem for trends in time
 - Is the source of mercury to my ecosystem increasing or decreasing?
 - Where is the input of mercury worst/best?
 - Etc.
- Ability to compare different locations
 - Spatial patterns

Differences in Ethnic Groups

Blood MeHg by ethnicity from 1999-2006 NHANES data



Asian Fish Consumption is High and Growing

TABLE 15
Per capita fish consumption (kg/person/year) in Asia and Europe

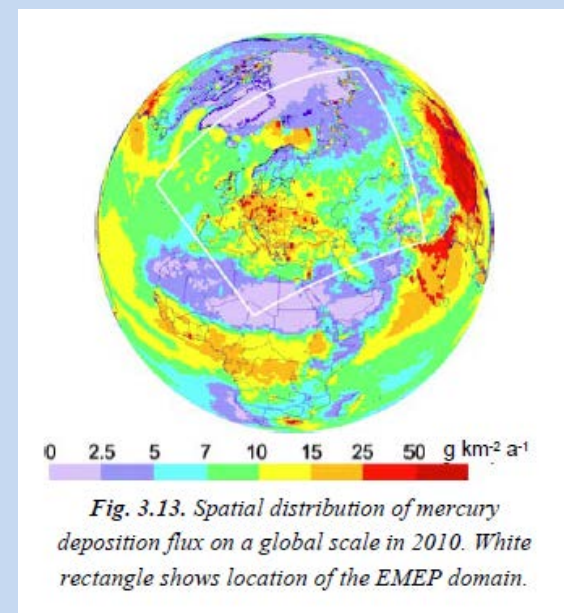
Country	1985	1990	1995	2000	2003	Average growth (%)
Bangladesh	7.0 (6.0)	7.0 (6.0)	8.0 (7.0)	11.0 (10.0)	11.0 (9.0)	57 (83)
China	7.0 (2.0)	11.0 (4.0)	20.0 (7.0)	25.0 (10.0)	25.0 (10.0)	257 (400)
India	3.0 (1.0)	3.0 (1.0)	4.0 (2.0)	4.0 (2.0)	4.0 (2.0)	33 (100)
Indonesia	13.0 (3.0)	14.0 (3.0)	17.0 (4.0)	20.0 (4.0)	20.0 (4.0)	54 (33)
Japan	69.0 (4.0)	71.0 (5.0)	71.0 (5.0)	67.0 (5.0)	66.0 (5.0)	-4 (25)
Myanmar	14.0 (1.0)	15.0 (1.0)	14.0 (2.0)	18.0 (2.0)	18.0 (3.0)	29 (200)
Philippines	33.0 (5.0)	36.0 (5.0)	32.0 (4.0)	29.0 (4.0)	28.0 (5.0)	-15 (0)
Thailand	20.0 (3.0)	20.0 (4.0)	33.0 (6.0)	30.0 (7.0)	30.0 (7.0)	50 (133)
Viet Nam	12.0 (3.0)	13.0 (3.0)	16.0 (5.0)	19.0 (7.0)	17.0 (6.0)	42 (100)
Asia	10.0 (2.0)	12.0 (3.0)	16.0 (4.0)	17.0 (6.0)	17.0 (6.0)	70 (200)
South Asia	3.0 (1.0)	4.0 (2.0)	4.0 (2.0)	5.0 (3.0)	5.0 (3.0)	67 (200)
East and Southeast Asia	21.0 (3.0)	22.0 (3.0)	24.0 (4.0)	25.0 (4.0)	25.0 (5.0)	19 (67)
Europe	18.0 (1.0)	20.0 (1.0)	19.0 (2.0)	19.0 (2.0)	20.0 (2.0)	11 (100)
Western Europe	21.0 (1.0)	24.0 (1.0)	25.0 (2.0)	25.0 (2.0)	26.0 (2.0)	24 (100)
Eastern Europe	8.0 (1.0)	6.0 (1.0)	6.0 (1.0)	7.0 (1.0)	8.0 (1.0)	0 (0)
World	12.0 (2.0)	13.0 (2.0)	15.0 (3.0)	16.0 (4.0)	16.0 (4.0)	33 (100)

The number in parenthesis within the table denote freshwater fish consumption.

Source: Adapted from Laurenti (2007).

Mercury is a *Global* Pollutant

- Gaseous Elemental Mercury
 - Atmospheric lifetime is **6 months to 2 years**
 - So all mercury emission is potentially important to every country
- Gaseous Oxidized Mercury/Particulate Bound Mercury
 - Atmospheric lifetime: minutes to 2 weeks
 - Evidence of movement from Asia to North America & from North America to Europe.
- Therefore it is not just local sources...

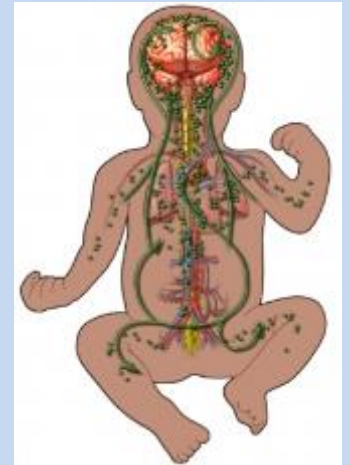


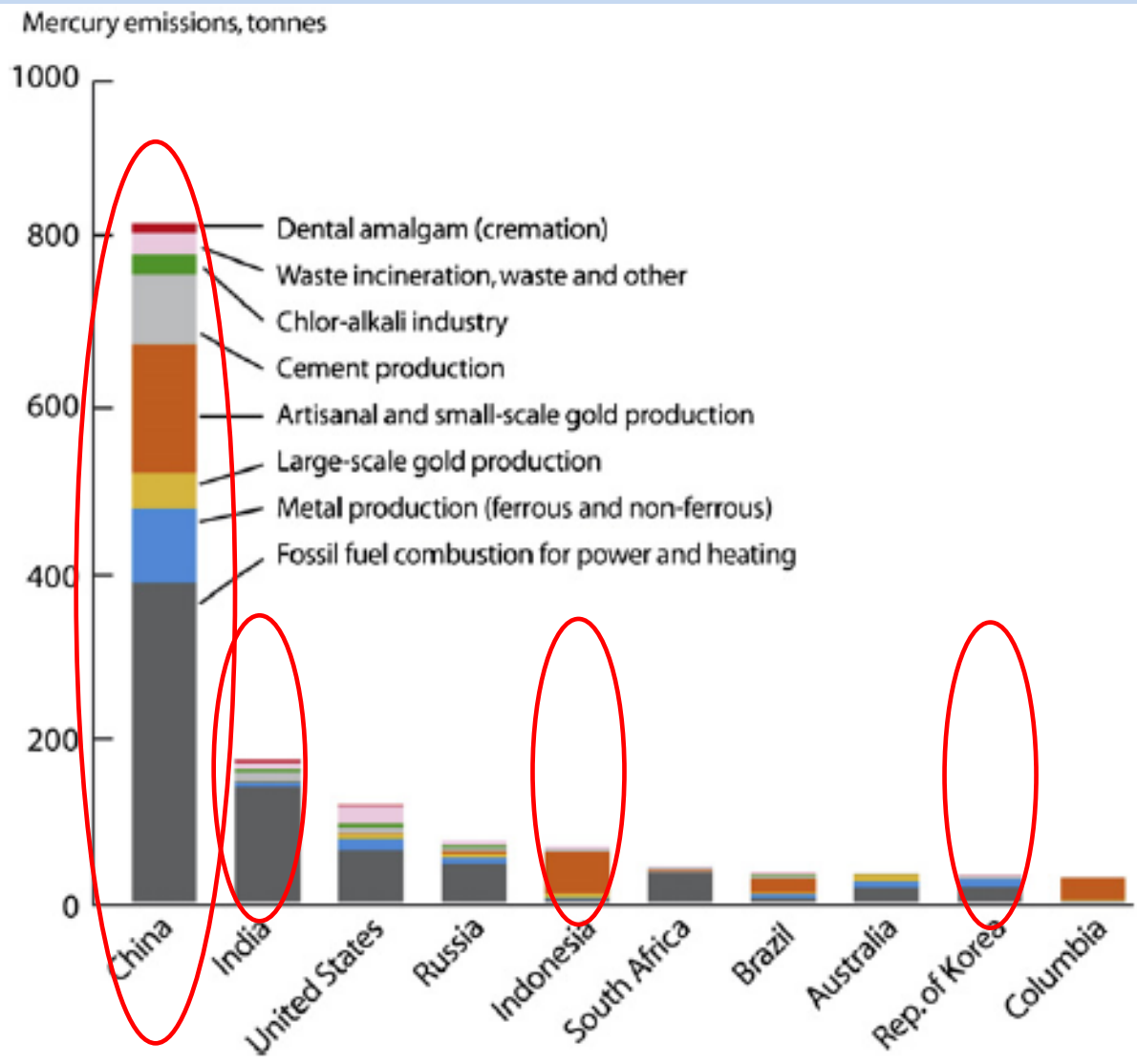
A Human Health Concern

- Children
- Women of child-bearing age (Hg passed on to fetus)

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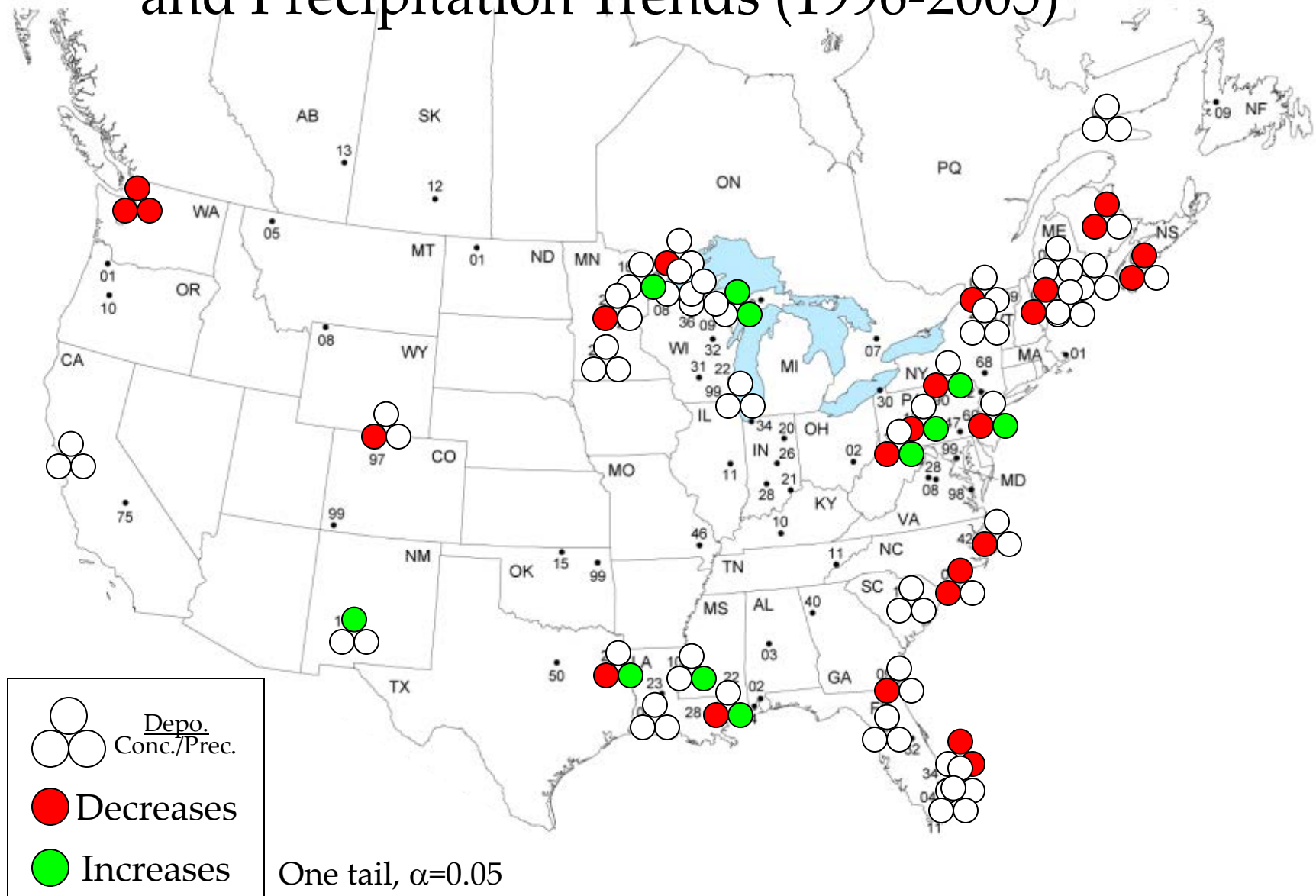
- Completely absorbed by the human gastrointestinal tract
- *in utero* damage:
  - readily transported across the placenta and absorbed by the developing fetus
  - have no blood-brain barrier to mercury
- Biologically persistent
  - half-life in human bloodstream is about 50 days
- Causes severe neurological damage in infants and children
- Incorporation in proteins results in abnormal molecular structure and affects cellular structure and function
- Also linked to increased risk of cardiovascular & kidney disease in adults
- Impairs brain function & cognitive development



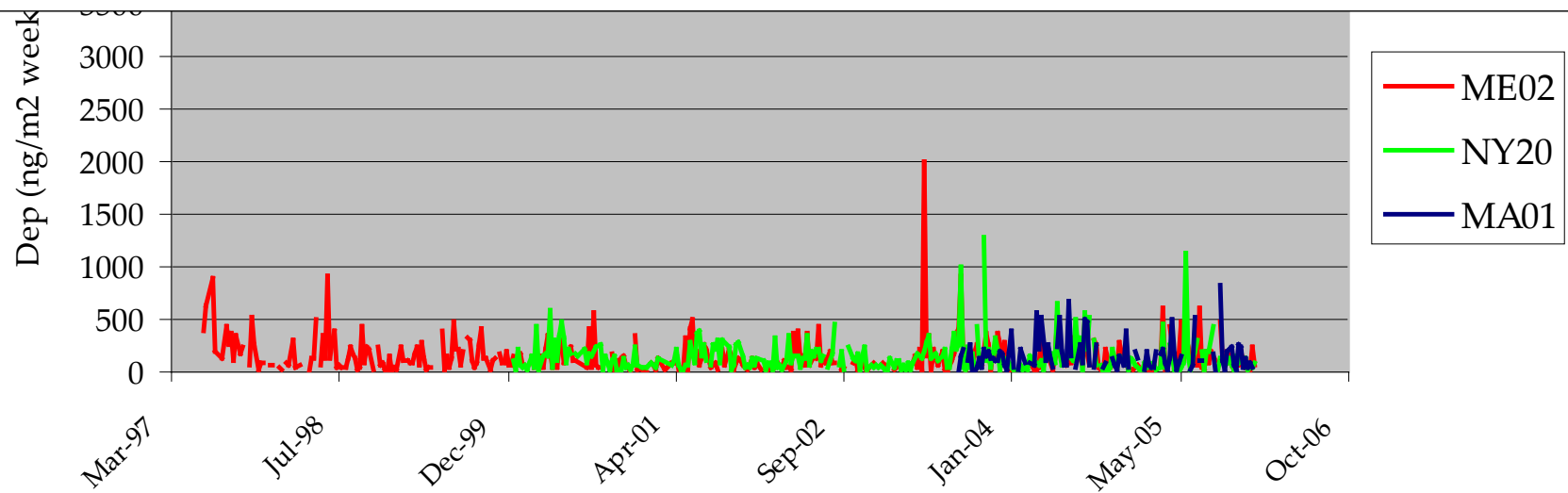
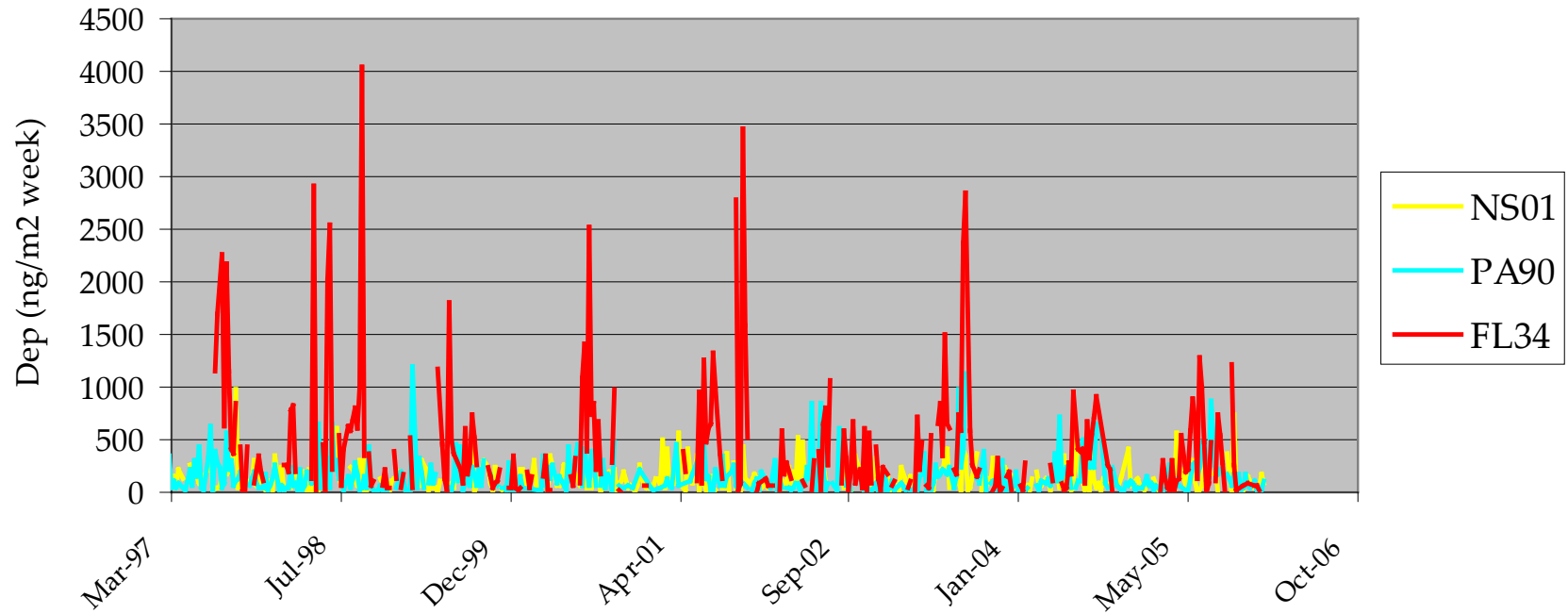


**Fig. 5.** Emissions of mercury to air in 2005 from various anthropogenic sectors in the ten largest emitting countries (AMAP/UNEP, 2008).

# All Seasons Mercury Concentration, Deposition, and Precipitation Trends (1996-2005)

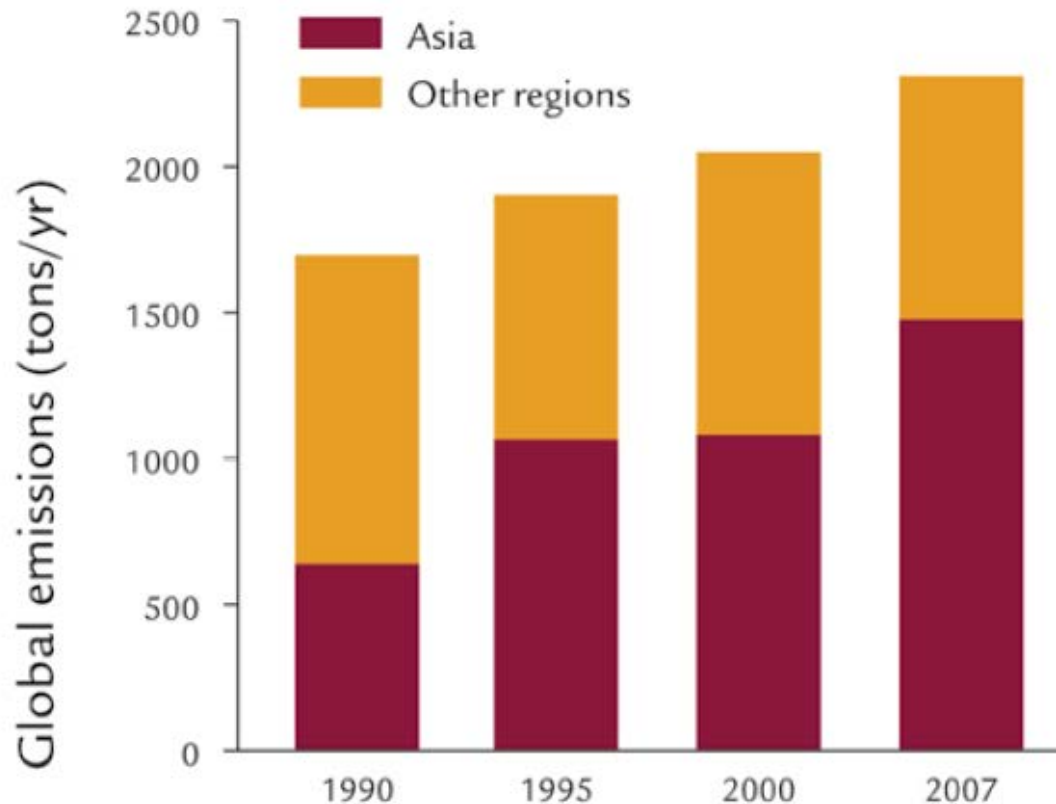


# Eastern North America Deposition Timelines

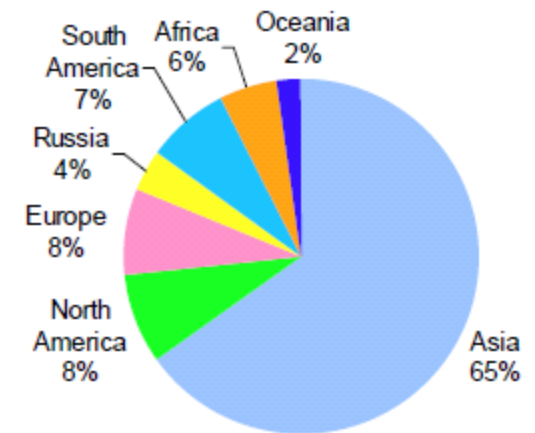


# Emissions Are Increasing

## Asian Growth



Evers, et al., 2012



*Fig. 1.14. Contribution of different continents and regions to the global anthropogenic emissions of Hg in 2005*

EMEP, 2012