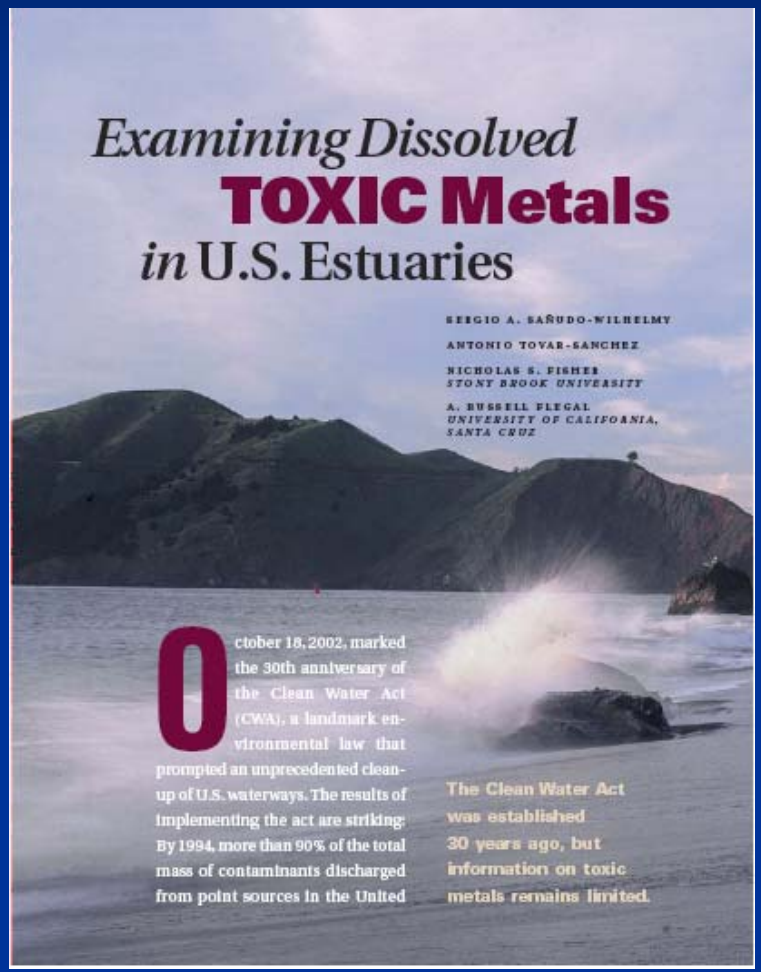
Monitoring Metals in San Francisco Bay: Quantification of Temporal Variations from Hours to Decades



Examining Dissolved
TOXIC Metals
in U.S. Estuaries

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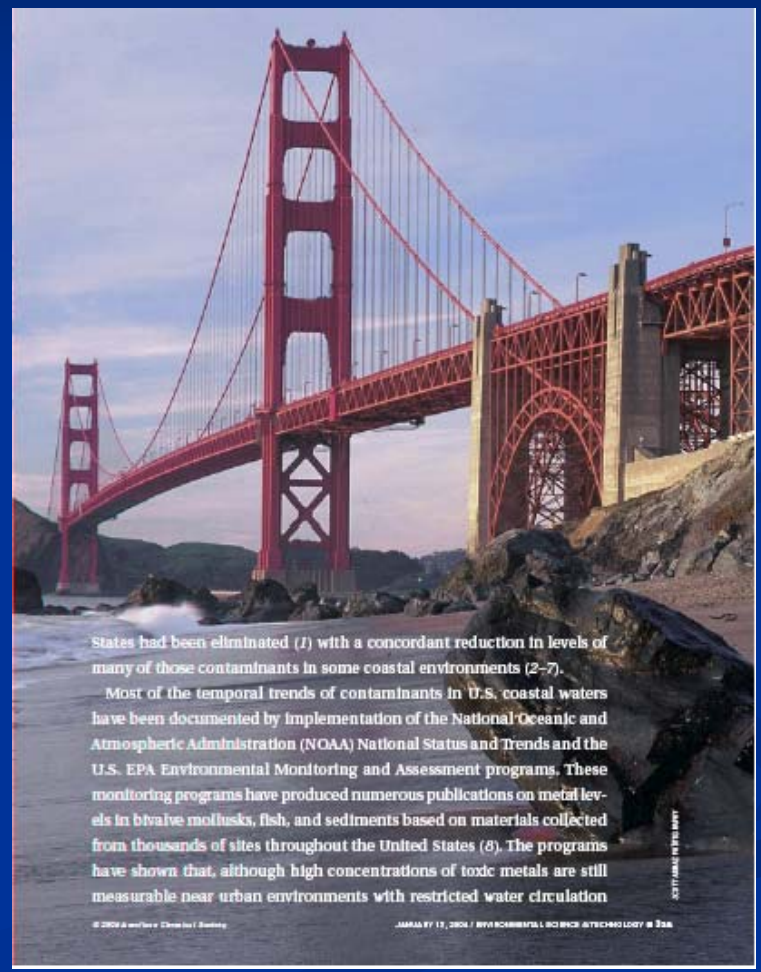
October 18, 2002, marked the 30th anniversary of the Clean Water Act (CWA), a landmark environmental law that prompted an unprecedented clean-up of U.S. waterways. The results of implementing the act are striking: By 1994, more than 90% of the total mass of contaminants discharged from point sources in the United

The Clean Water Act was established 30 years ago, but information on toxic metals remains limited.



States had been eliminated (*1*) with a concordant reduction in levels of many of those contaminants in some coastal environments (*2*–*7*).

Most of the temporal trends of contaminants in U.S. coastal waters have been documented by implementation of the National Oceanic and Atmospheric Administration (NOAA) National Status and Trends and the U.S. EPA Environmental Monitoring and Assessment programs. These monitoring programs have produced numerous publications on metal levels in bivalve mollusks, fish, and sediments based on materials collected from thousands of sites throughout the United States (*8*). The programs have shown that, although high concentrations of toxic metals are still measurable near urban environments with restricted water circulation

THE PROBLEM:
Insufficient long-term data
– that is accurate & available & peer-reviewed

Literature Survey

metals in US estuaries

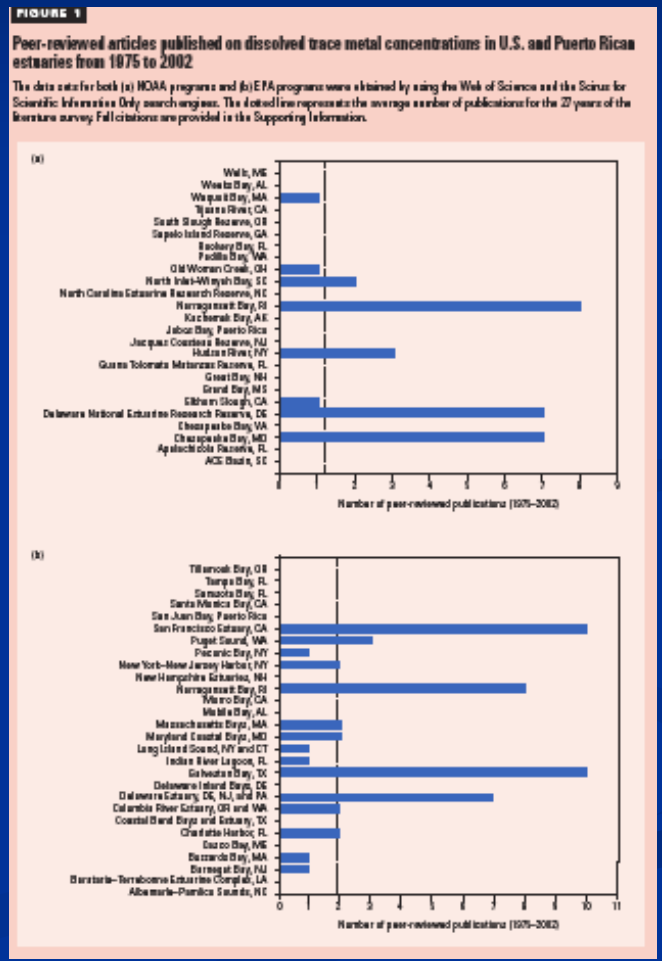
1975-2002

Results

only 83 articles

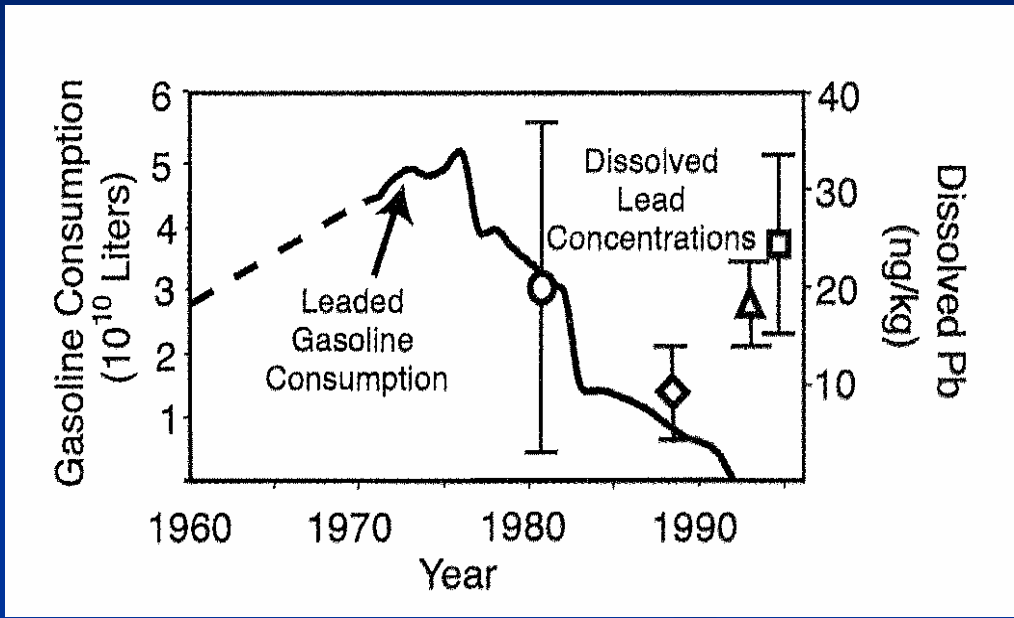
no data ~ 1/2 estuaries

only long term -SF Bay



(Sañudo-Wilhelmy et al., 2004)

Billions have been spent to remove billionths of pollutants in US waters



But it is difficult, if not impossible, to quantify any benefits from reductions in metal contaminants in most US waters because there are insufficient accurate measurements of that contamination.

(Sanudo-Wilhelmy et al., 2004)

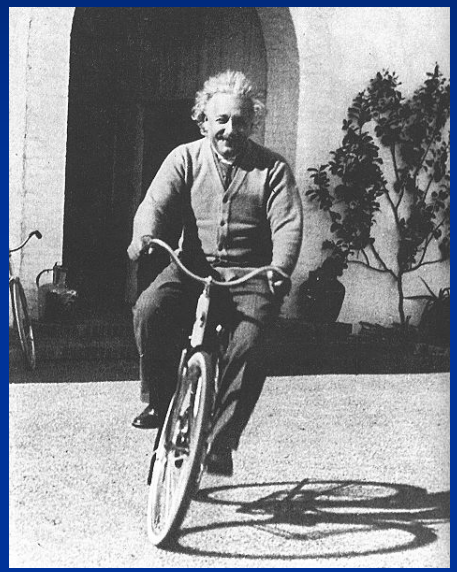
"More than half of US streams polluted: EPA"

"In its first-ever study of shallow or "wadeable" streams, the agency found 42 percent were in poor condition, and another 25 percent were considered fair. Only 28 percent were in good condition, EPA said. Another 5 percent were not analyzed because of sampling problems in New England."

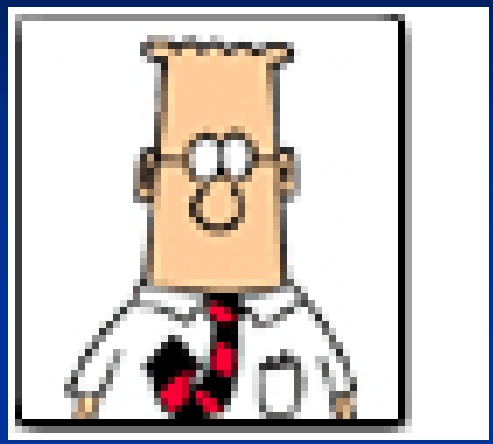
Reuters, May 5, 2006

→ IT'S NOT JUST METALS IN ESTUARIES

Who Benefits from Long-Term Data Sets ?

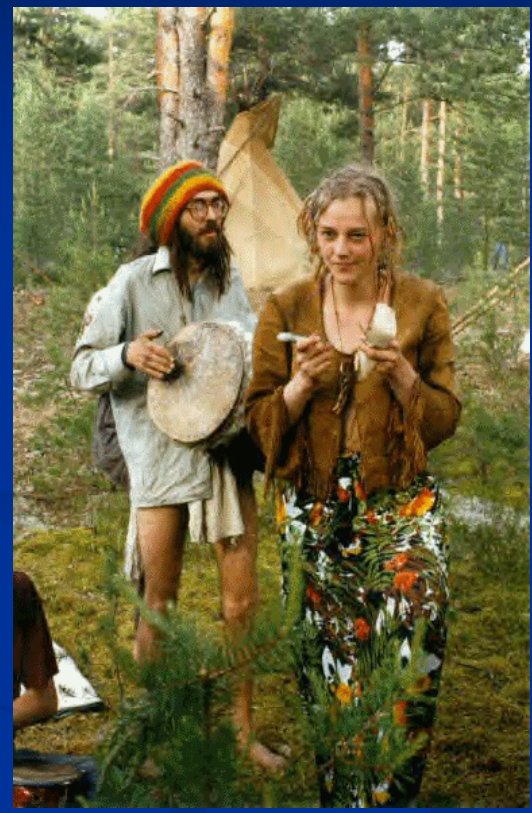


Scientists & Engineers



Bureaucrats & Regulators

Government & Industrialists



Environmentalists & Everyone Else

SF Bay Regional Monitoring Program: Metals

Collections 1989-present

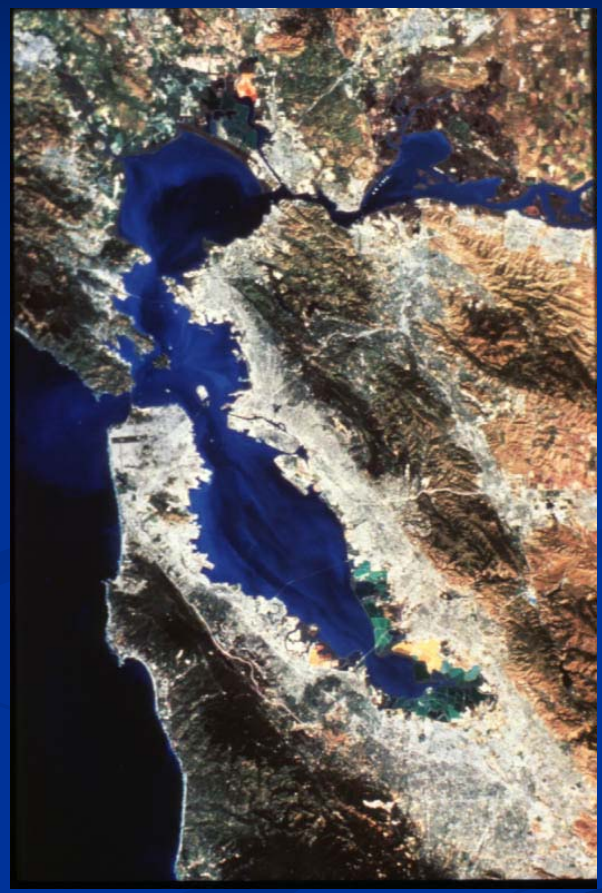
26 locations

Seasonal samplings

Trace metal clean protocols

Rigorous QA/QC

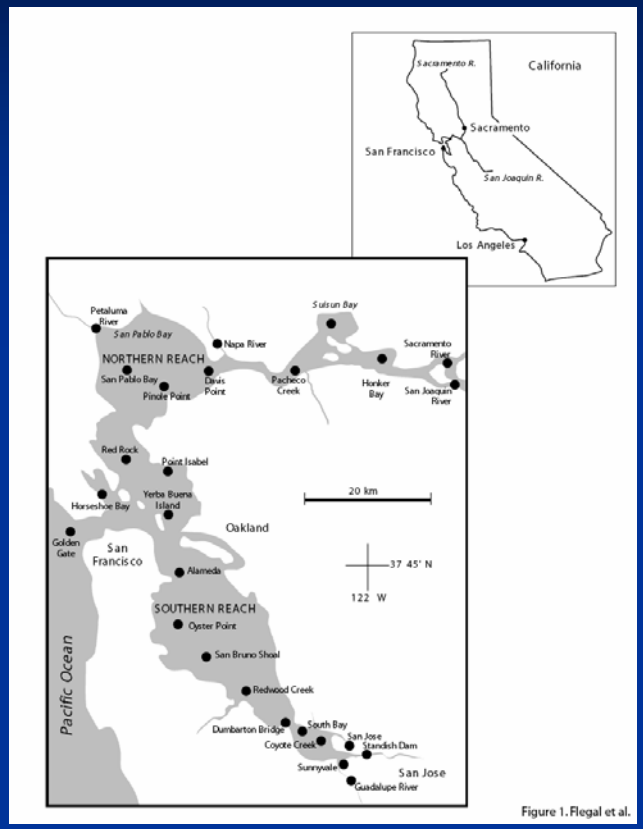
Analytical precision ≤10%



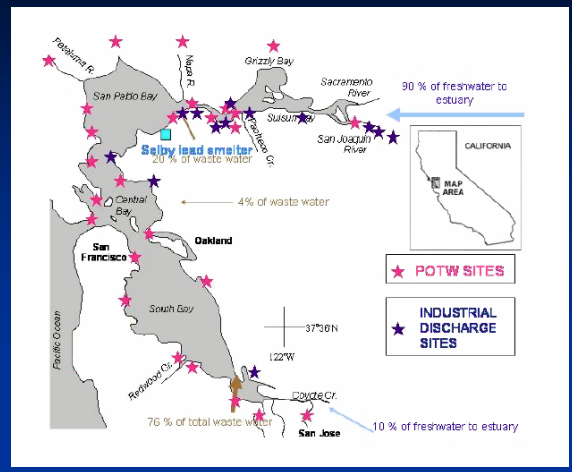
(SpaceShots)

→ Time series analyses are possible for SF Bay

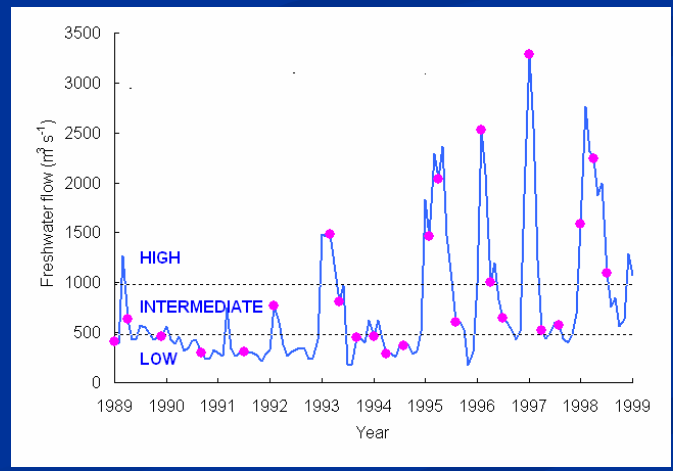
BUT: Time Series Analyses Aren't Easy



Limited Sampling Sites



Multiple Sources: Natural & Industrial



Limited Collections & Hydrological Variability

CASE STUDY: Mercury in SF Bay

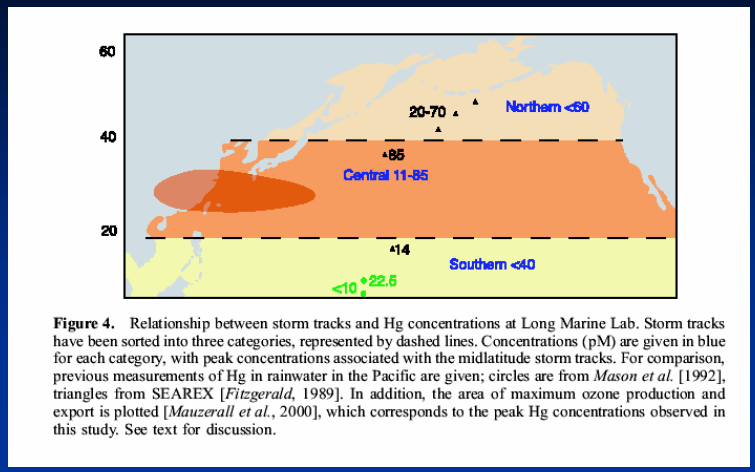
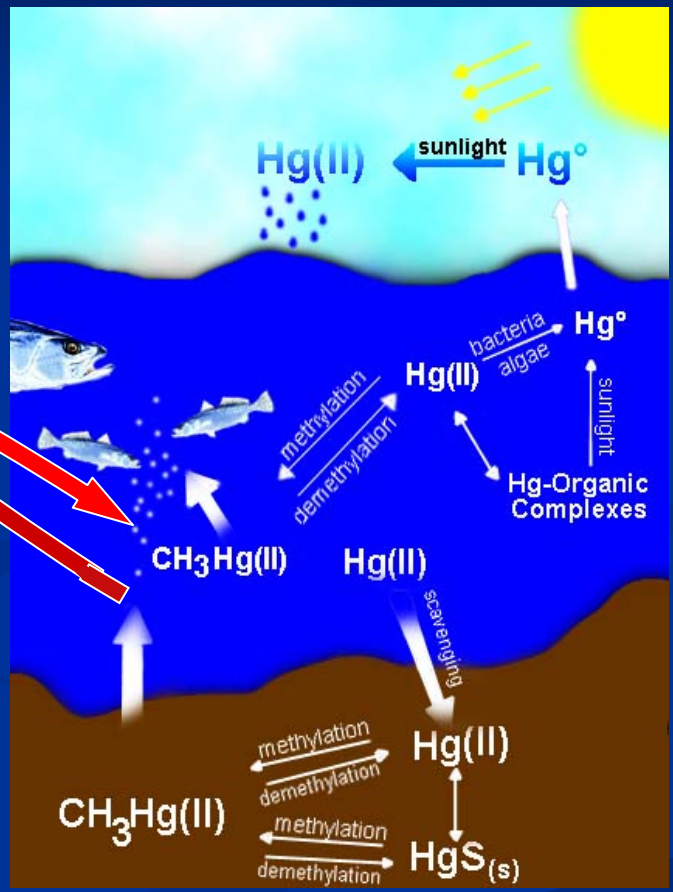


Figure 4. Relationship between storm tracks and Hg concentrations at Long Marine Lab. Storm tracks have been sorted into three categories, represented by dashed lines. Concentrations (pM) are given in blue for each category, with peak concentrations associated with the midlatitude storm tracks. For comparison, previous measurements of Hg in rainwater in the Pacific are given; circles are from *Mason et al.* [1992], triangles from SEAREX [*Fitzgerald*, 1989]. In addition, the area of maximum ozone production and export is plotted [*Mauzerall et al.*, 2000], which corresponds to the peak Hg concentrations observed in this study. See text for discussion.

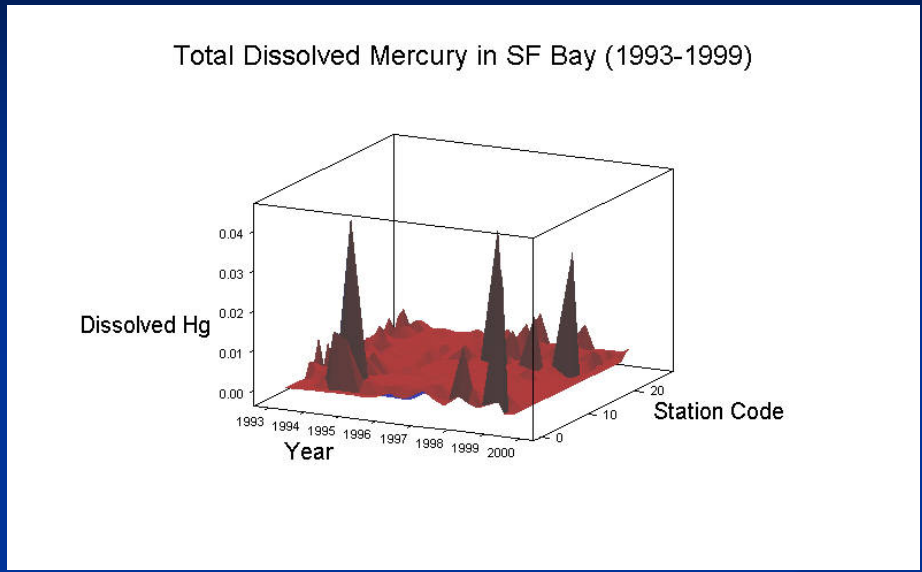
Present: Asian industrial aerosols (~ 50%)

1850-1970: Hg & Au Mining (10,000 tons)



Diagenetic remobilization

Dissolved Mercury Concentrations in SF Bay



Hg_T : Pronounced spatial & temporal variability

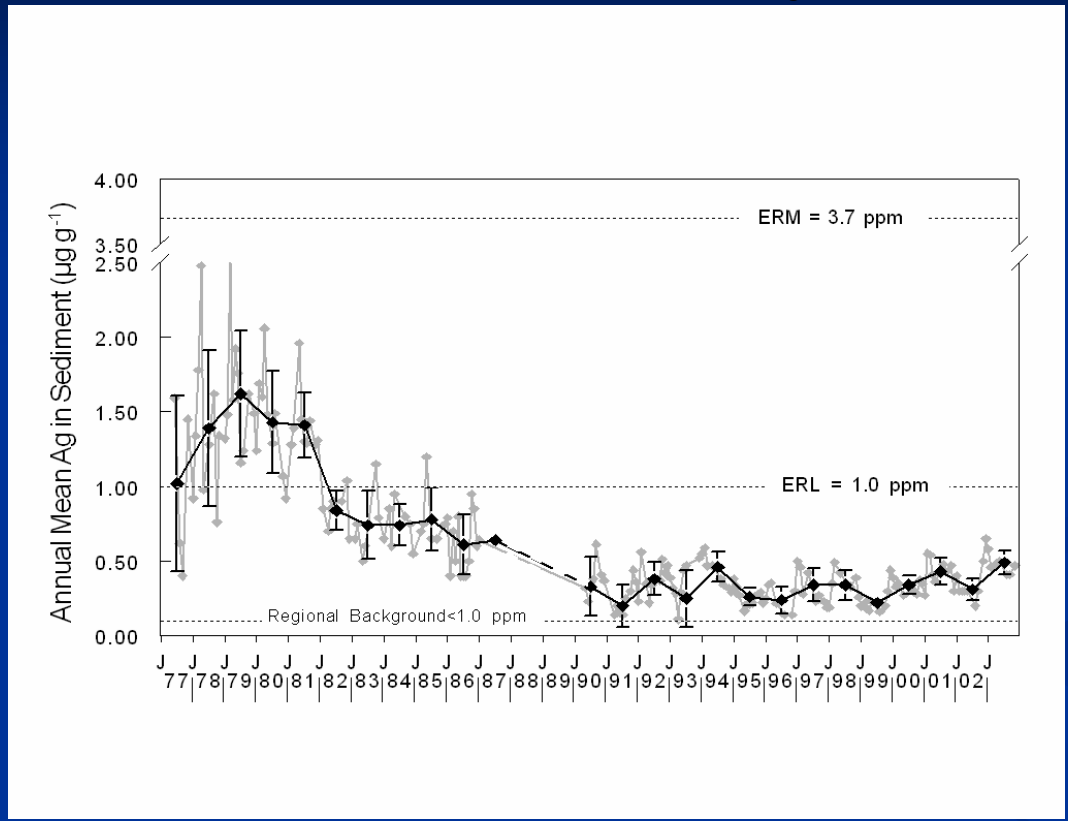
~ corresponds with spatial sediment variability

MeHg: Much more pronounced spatial & temporal variability

restored wetland production ?

diurnal component in photodegradation/production ?

Silver is Simpler in SF Bay: "The Silver Estuary"



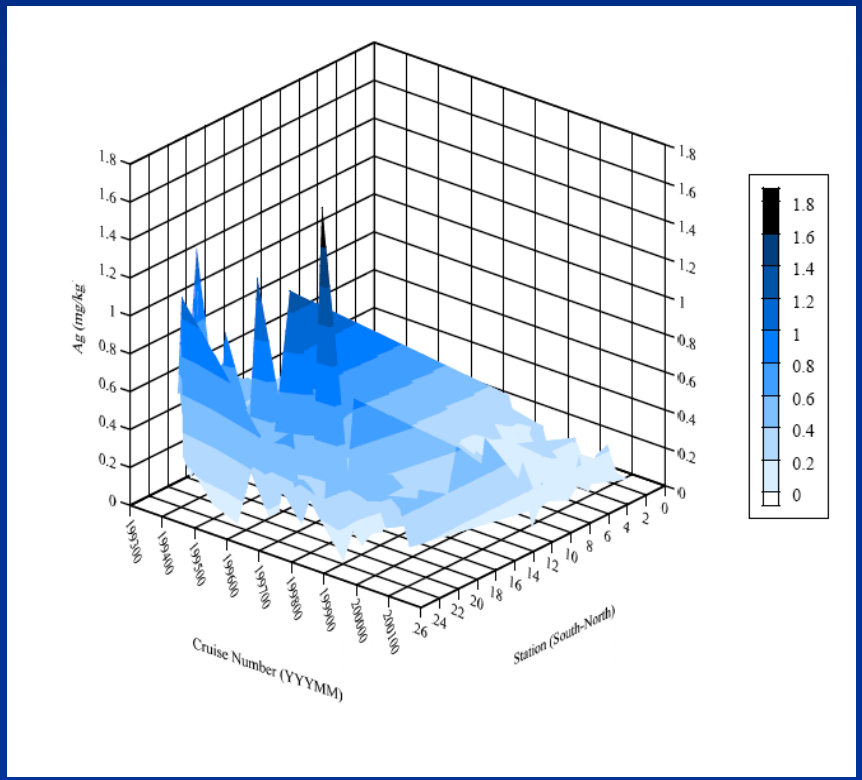
~ Simple biogeochemical cycle

Contamination ~ with previous (< 1976) POTW discharge

USGS long-term (~30 yr) study of metals in a SF Bay mudflat

(Moon et al., 2005)

Temporal Decline of Ag in SF Bay Sediments:



(Flegal et al., in press)

Bay-wide decline

corroboration of local data

USGS ~ RMP

30 yrs ~ 10 yrs

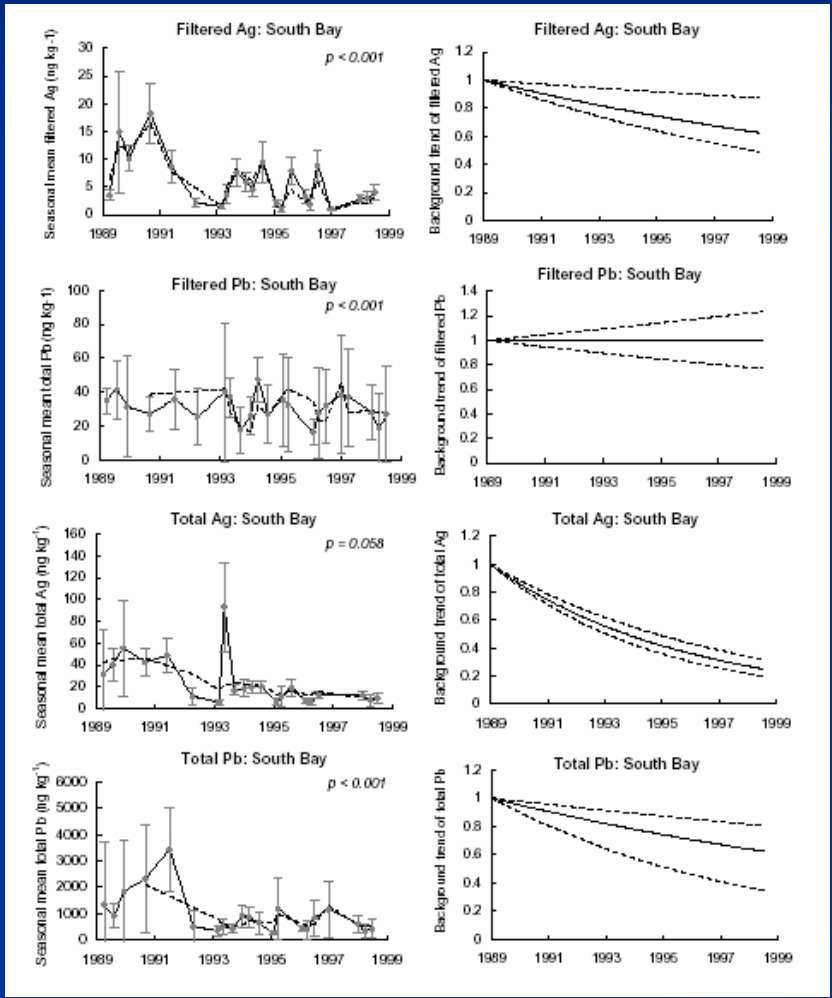
Temporal decrease

dilution

dispersion

→ Quantifiable benefits of regulation

Ag Declines in Water ~ Declines in Sediments (Lead doesn't show a similar decline)



South SF Bay (1989-2000)

Dissolved Ag:

~ 40% decline

Dissolved Pb:

no decline

Total Ag:

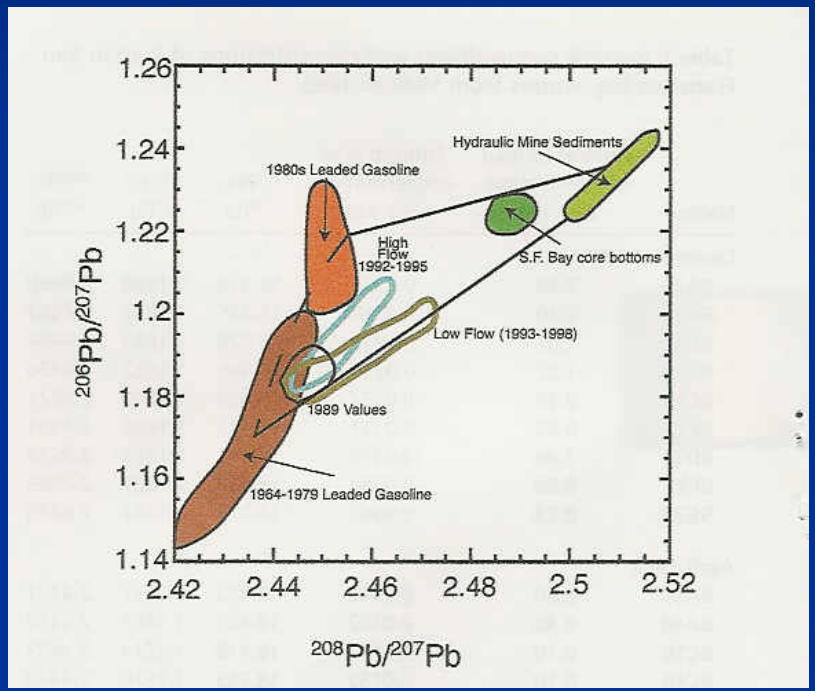
~ 70% decline

Total Pb:

~ 40% decline

(Squire et al., 2002)

Stable Lead Isotope Analyses: Corroborate Time Series Analyses

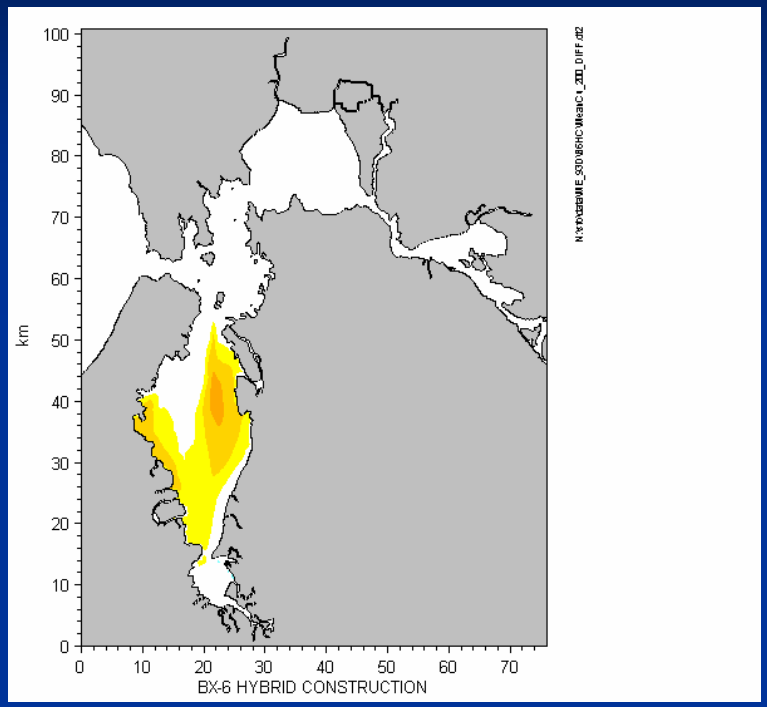


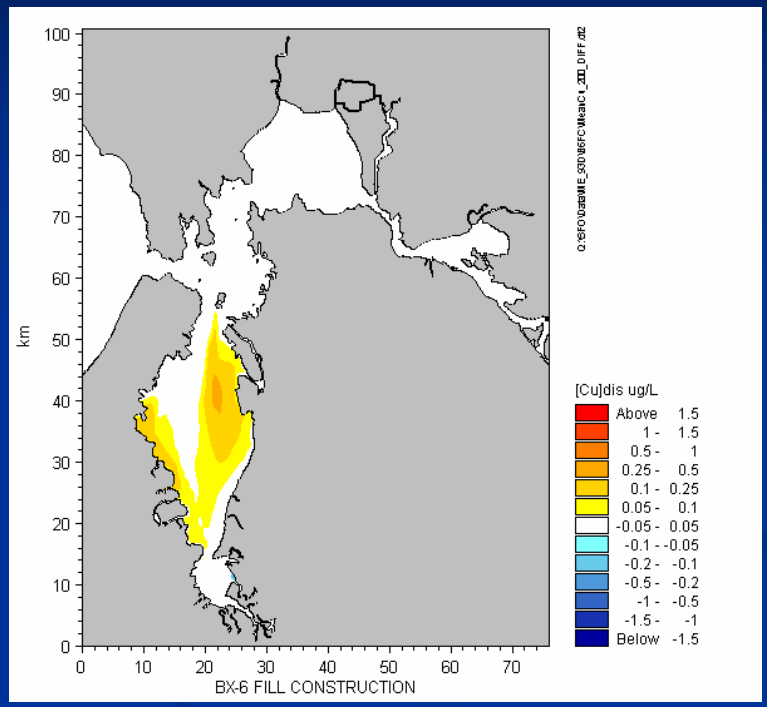
(Steding et al., 2000)

isotopic composition analyses corroborate ongoing input and recycling of historic industrial lead emissions (1850s-1980s) to SF Bay

> > decade to observe declines in conservative, particle reactive contaminants

Extrapolation of RMP Data: SF Airport Expansion





Model of difference in dissolved copper concentration during proposed SF airport expansion construction

→ Models enabled by RMP long-term data set

(Cooke et al., unpublished data)

CONCLUSIONS

(Reuters May 5, 2006)

Long-term data are needed to quantify the health of US waters

Interdisciplinary studies are needed to assess those data

Rigorous statistical analyses are required for time-series analyses