

# MERCURY IN THE NORTH PACIFIC OCEAN: IMPLICATIONS FOR FISHERIES

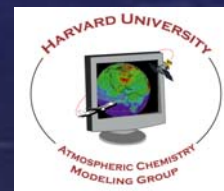
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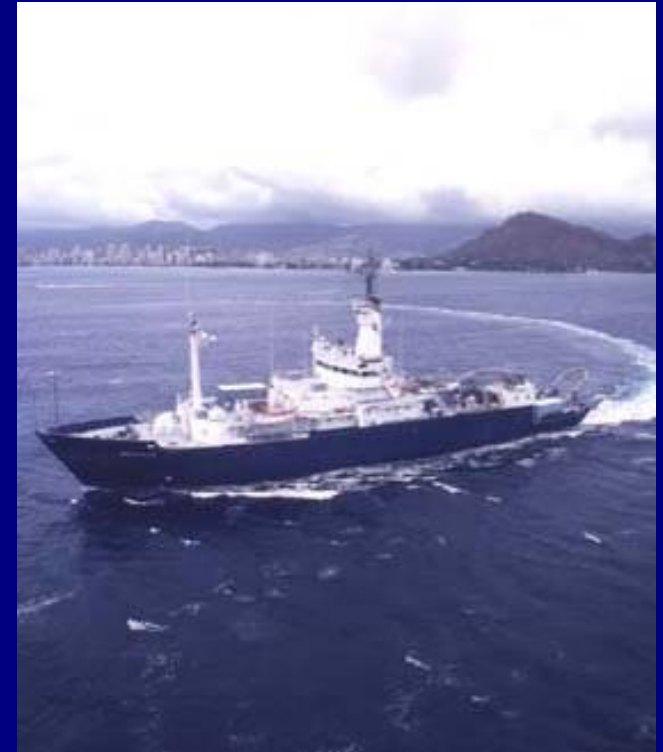
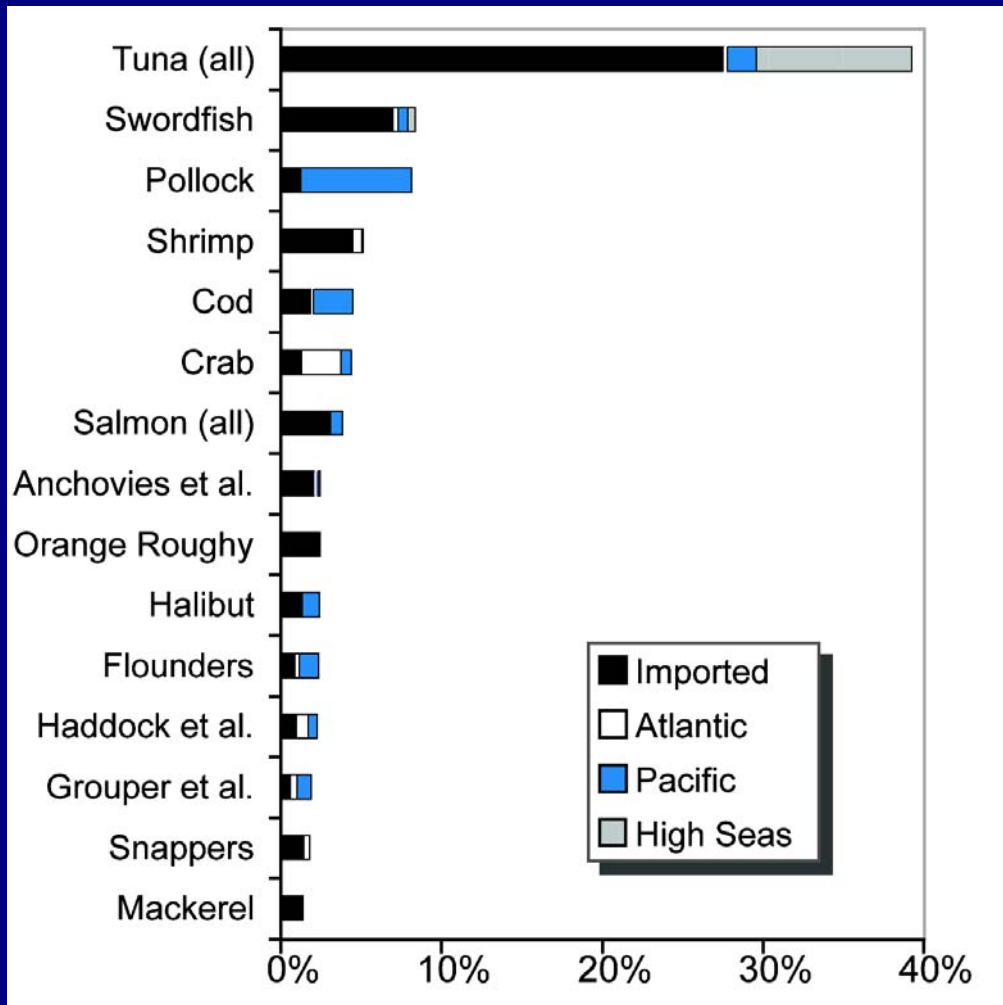
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Oceanic Hg sources and cycling remains poorly defined yet >90% of population-wide Hg exposure in the US is from consumption of estuarine & marine fish (Sunderland, 2007)

## Fraction of Population-Wide Hg Intake (%)



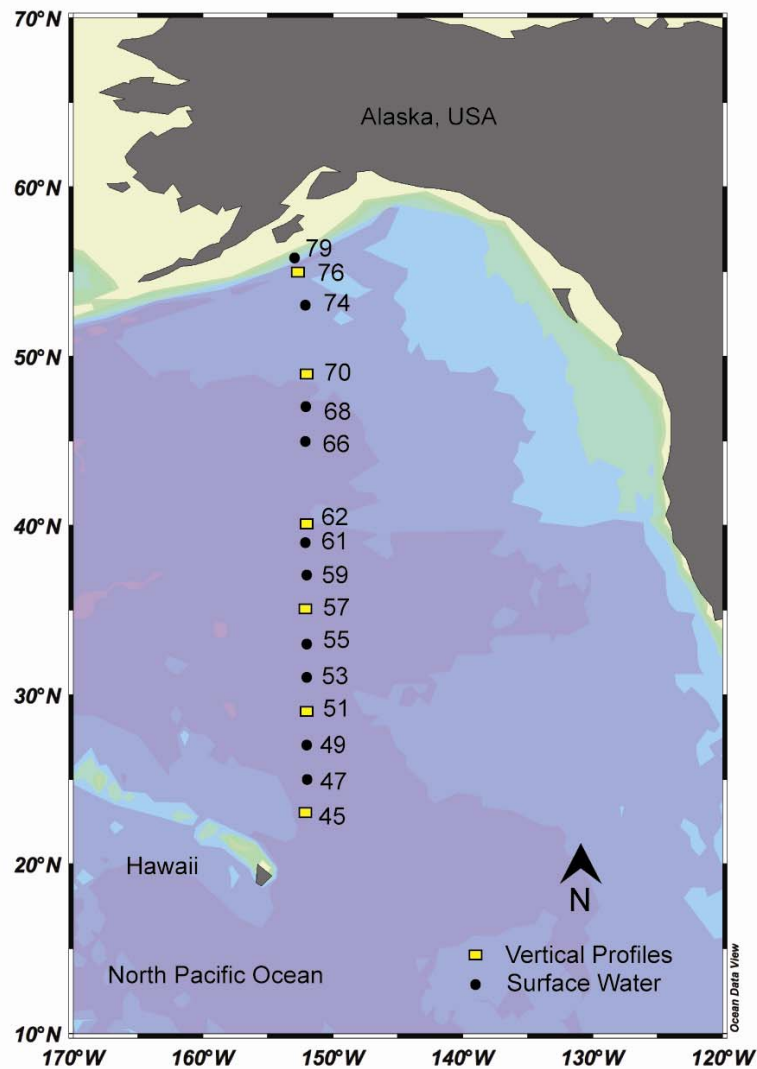
# U.S. Population-Wide Hg Intake

~200 kg MeHg per year consumed in fish and shellfish

	% MeHg Intake
Fresh & Farmed	14.9%
Nearshore Marine	7.9%
North Atlantic >55N	6.5%
Atlantic	14.7%
North Pacific >30N	29.5%
Pacific/Indian <30N	25.4%
Mediterranean	1.0%
Antarctic	0.1%
Total	100.0%



# P16N Cruise Track (March 10-30, 2006)



**R/V Thomas G. Thompson AGOR 23**



# Research Questions

- Are mercury concentrations in ocean waters tracking trends in atmospheric mercury deposition?
- How long will it take for the North Pacific to respond to changing atmospheric Hg emissions?
- What are the likely effects of future changes in anthropogenic emissions and climate on Hg accumulation and bioavailability?
- What are the likely trends in marine fish MeHg levels?



# Modeling Tools Applied

## GEOS-Chem Global Atmospheric Chemistry Model (Selin et al., 2007, *JGR-Atm.*)

- Including a Surface Ocean Slab Model (Strode et al., 2007, *GBC*)
- Tagged tracer results (Strode et al., 2008, *JGR-Atm.*)

## Intermediate & Deep Ocean Model

- *Sunderland & Mason (2007, GBC)*

## Comparison to other N. Pac. cruise data

- NPAC 1980
- VERTEX 1987
- IOC 2002

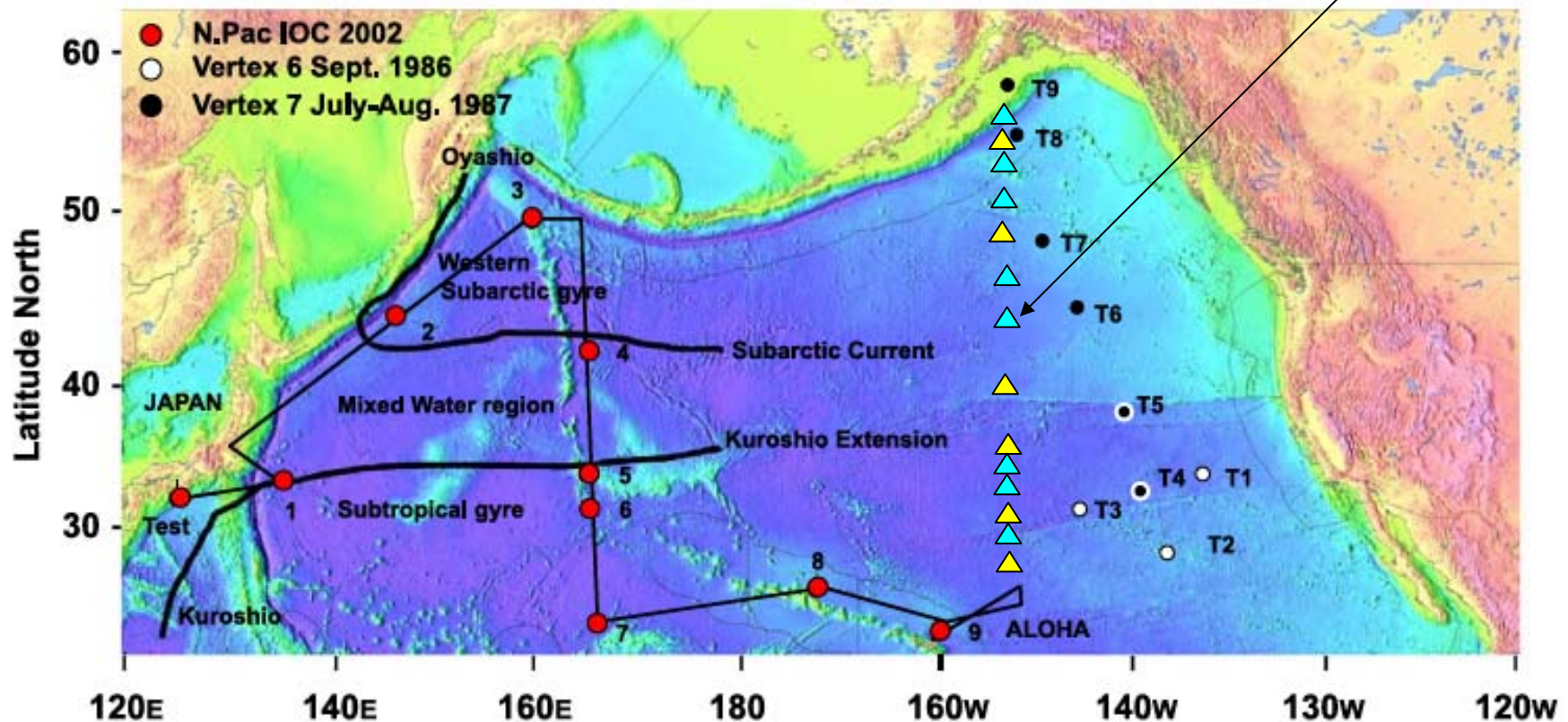




# All Sampling Stations (Incl. Previous Cruises)

- ▲ Surface Water samples
- ▲ Profiles 0-1000 m

March 2006

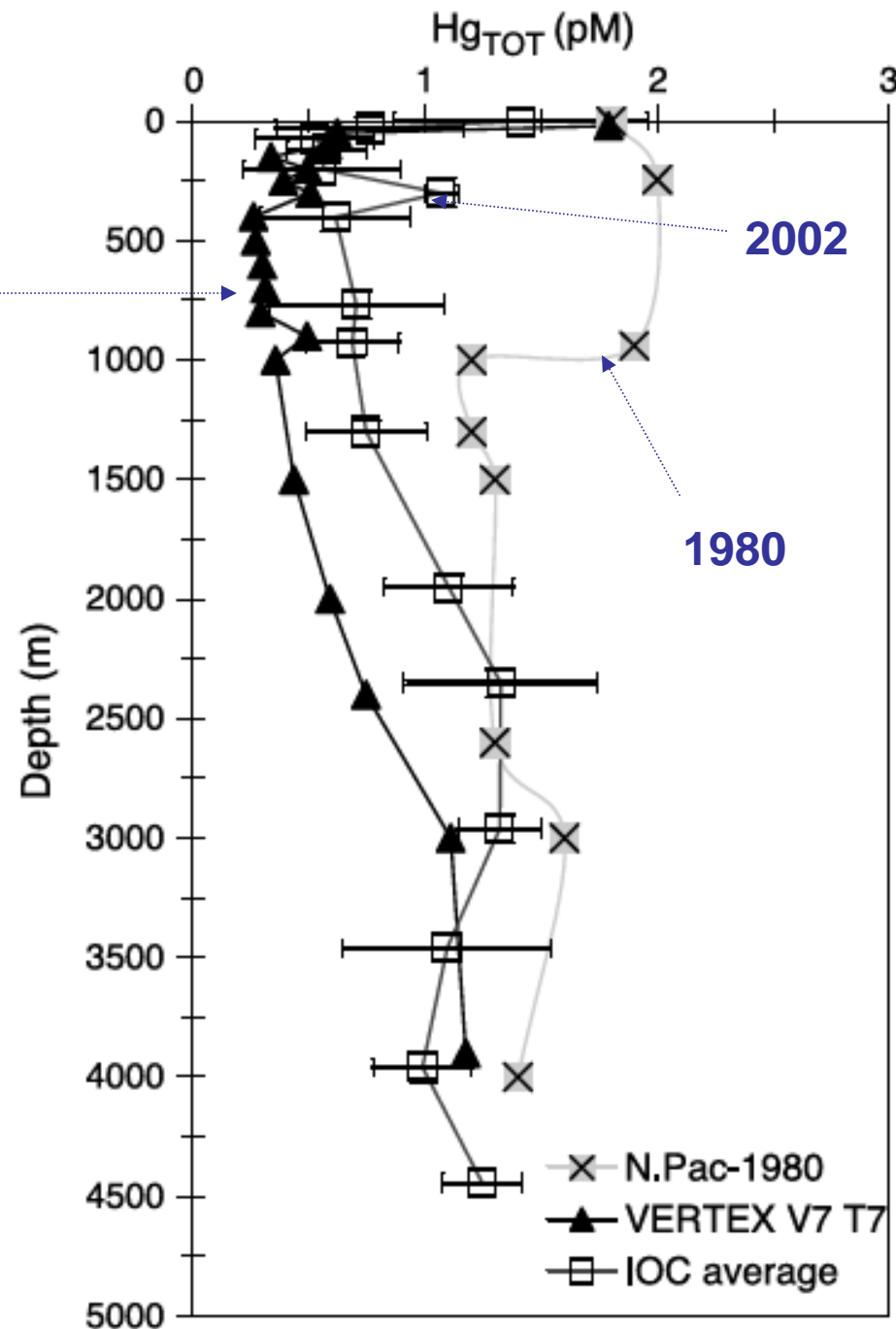


# Prior Research

No change in  
seawater Hg  
concentrations in  
the North Pacific  
over the past 20  
years?

- *Laurier et al. 2004*

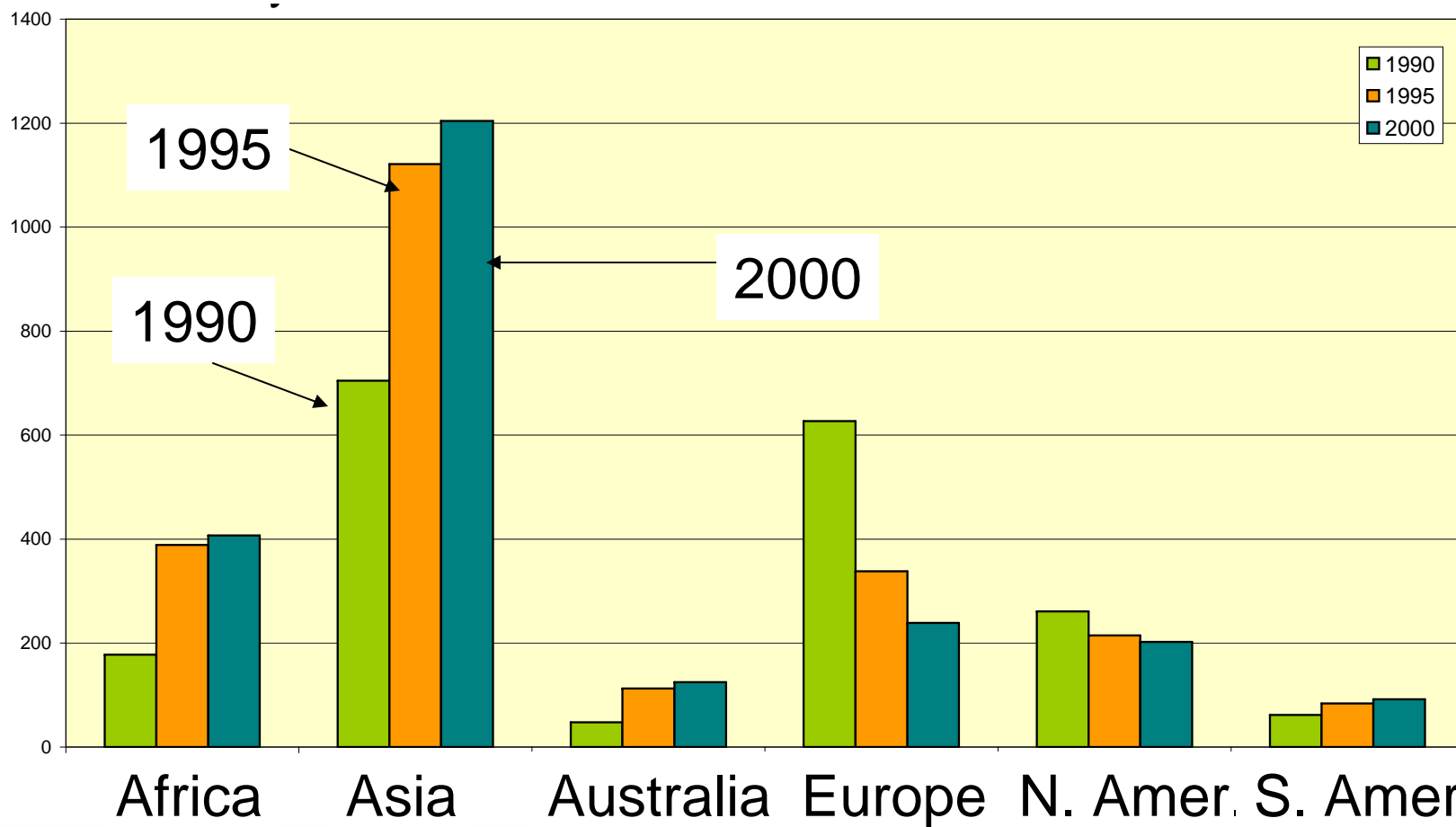
1987





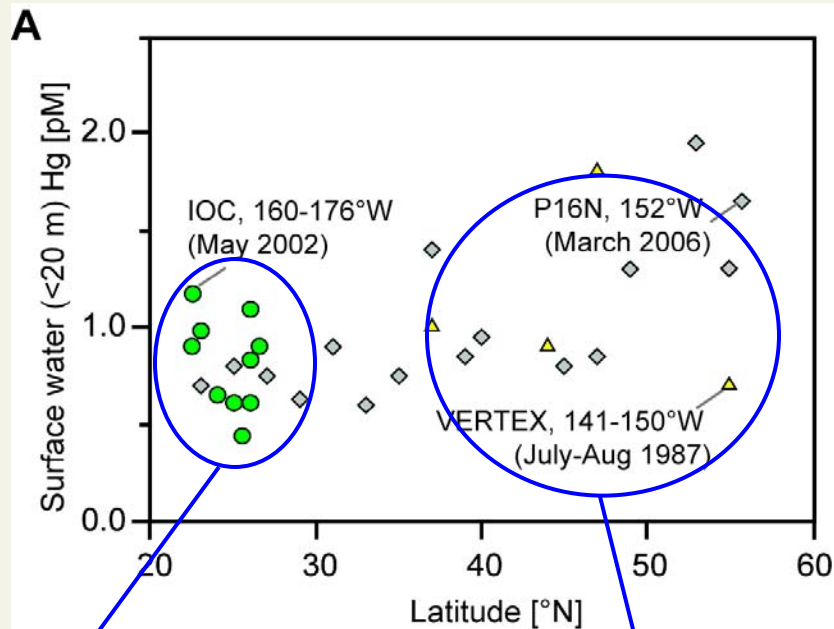
# Hg Emissions and Deposition from Asia

Global anthropogenic Hg emissions 1990-2000  
(tonnes per year)



# Relationship between Atmospheric Deposition & Surface Water Hg Concentrations

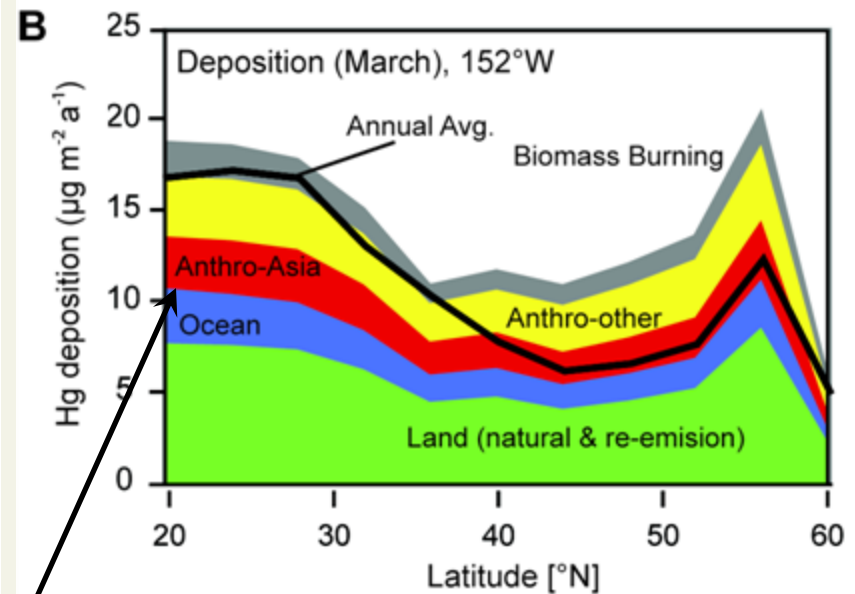
Total Hg Concentrations in  
Surface Waters (<20 m)  
Eastern North Pacific Ocean



**2002**

**1987**

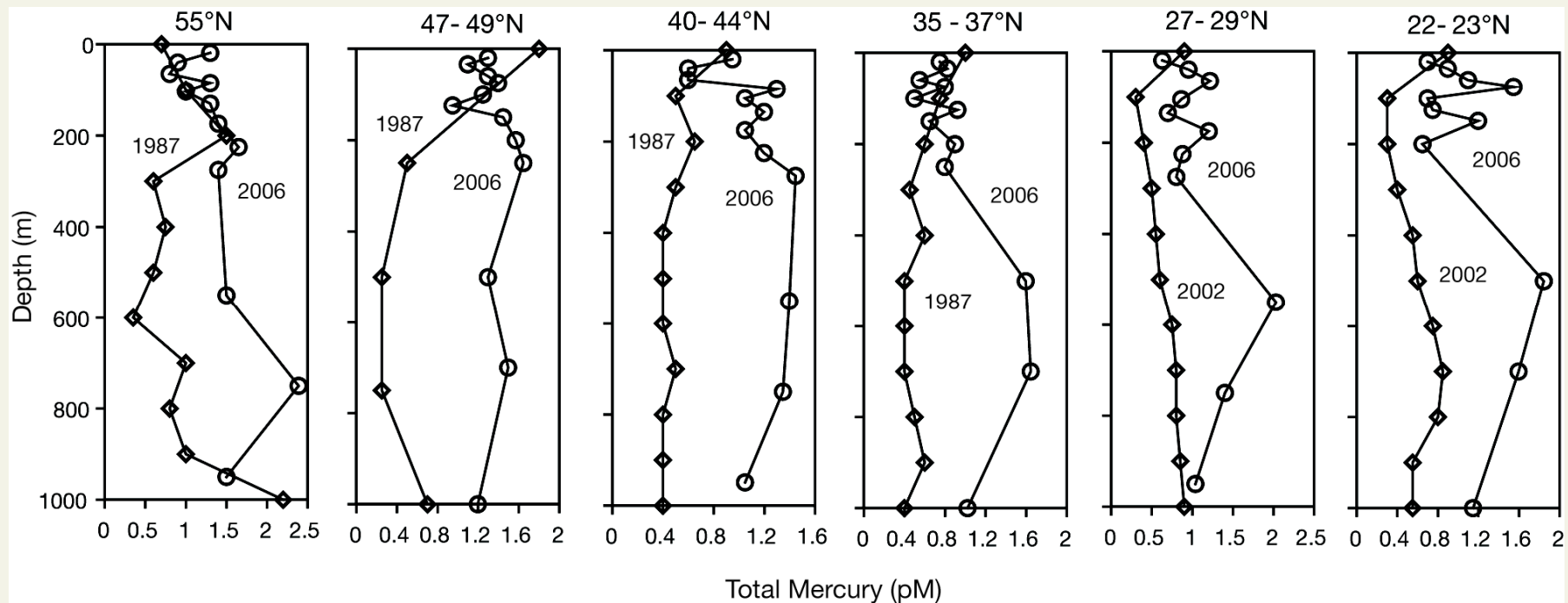
Atmospheric Deposition Source  
Attribution along Cruise Track



contribution to deposition from  
Asian anthropogenic sources (<20%)

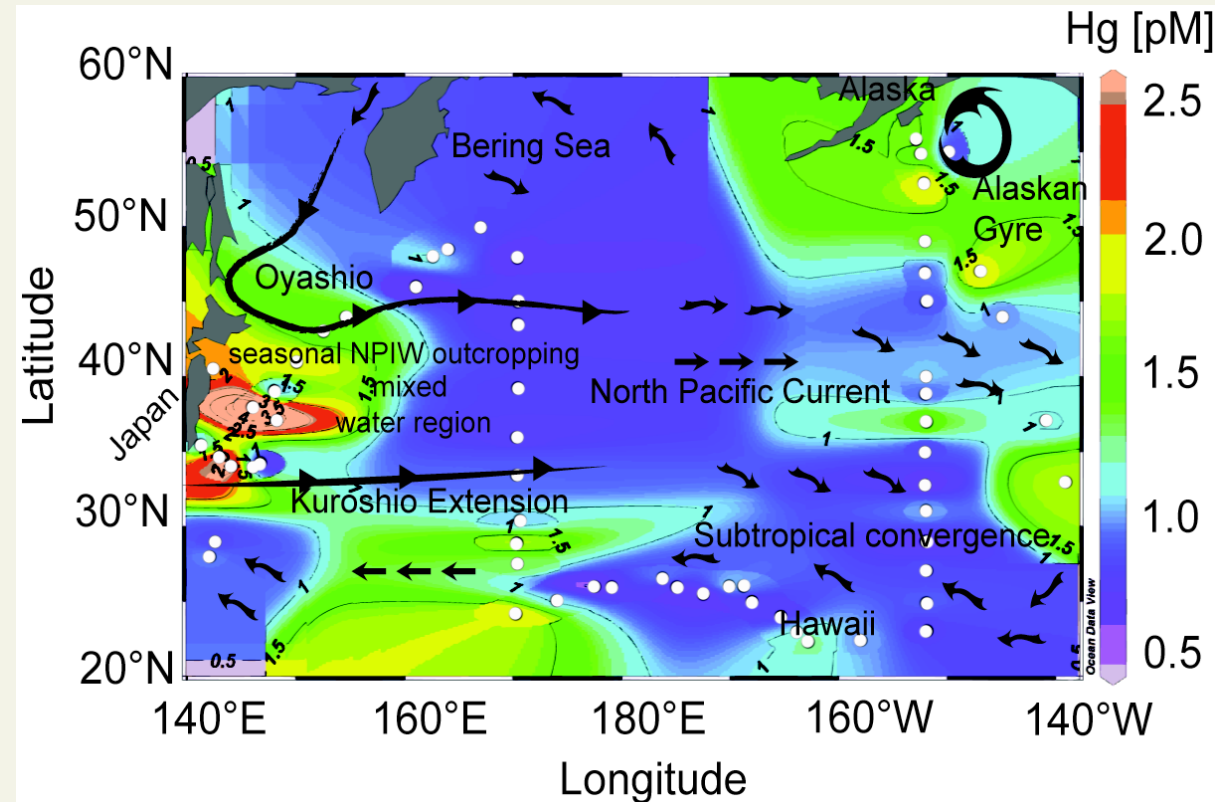
# Subsurface Hg Enrichment

Total Hg in subsurface waters are enriched at all 2006 North Pacific sampling locations relative to 2002 and 1987 cruise data

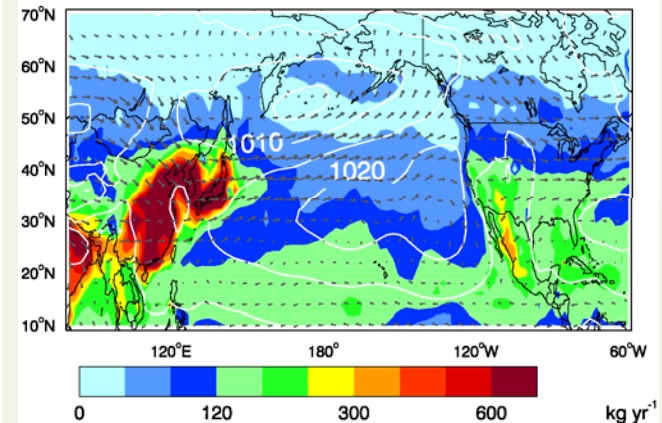




# Spatial Patterns in North Pacific Surface Waters (<20 m depth)



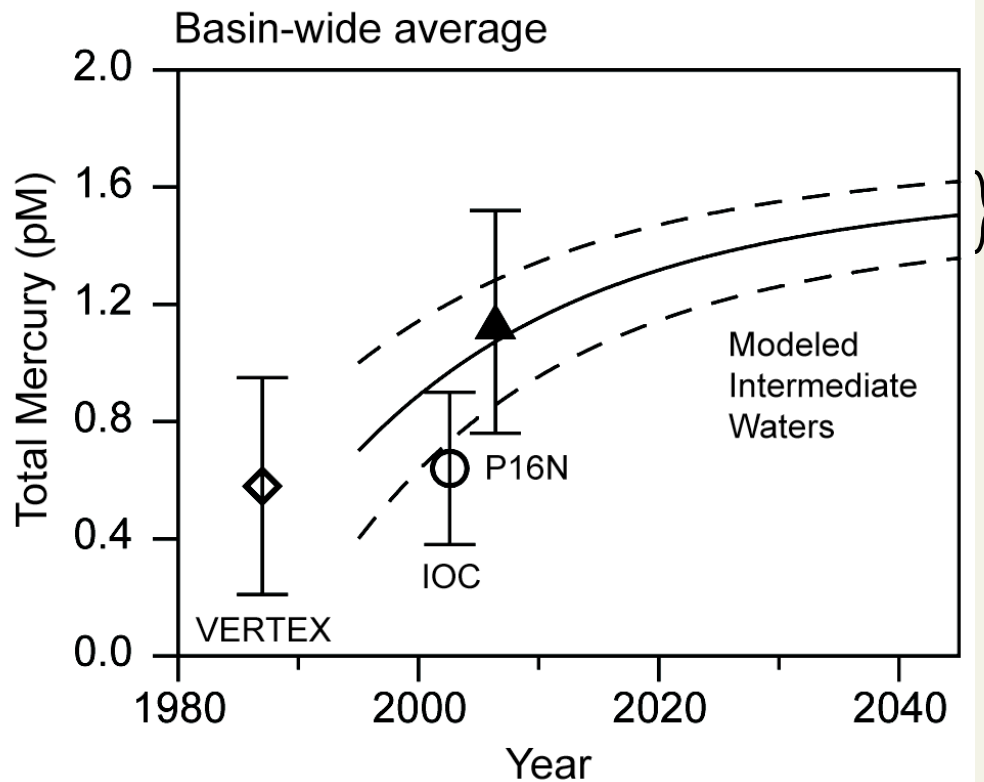
## Atmospheric Deposition Asian Sources



Strode et al., 2008

Enriched Hg concentrations off coast of Japan, sink and are transported east in subsurface waters (North Pacific Intermediate Waters)

# Basin-wide Temporal Trends in Hg

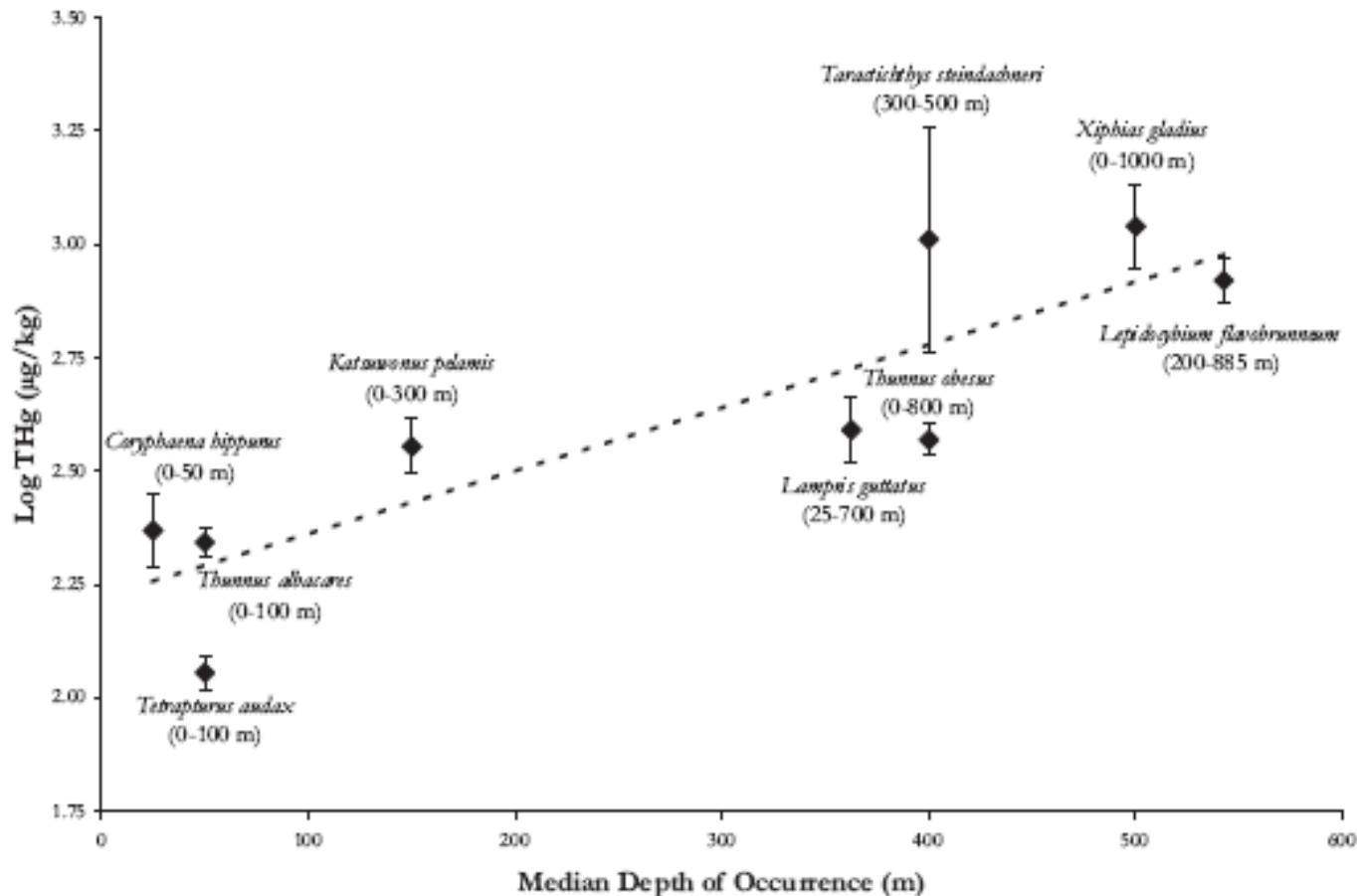


95% Confidence Interval for model results based on empirically constrained fluxes

At present atmospheric Hg deposition rates, North Pacific seawater Hg may double relative to ca. 1995 by 2050

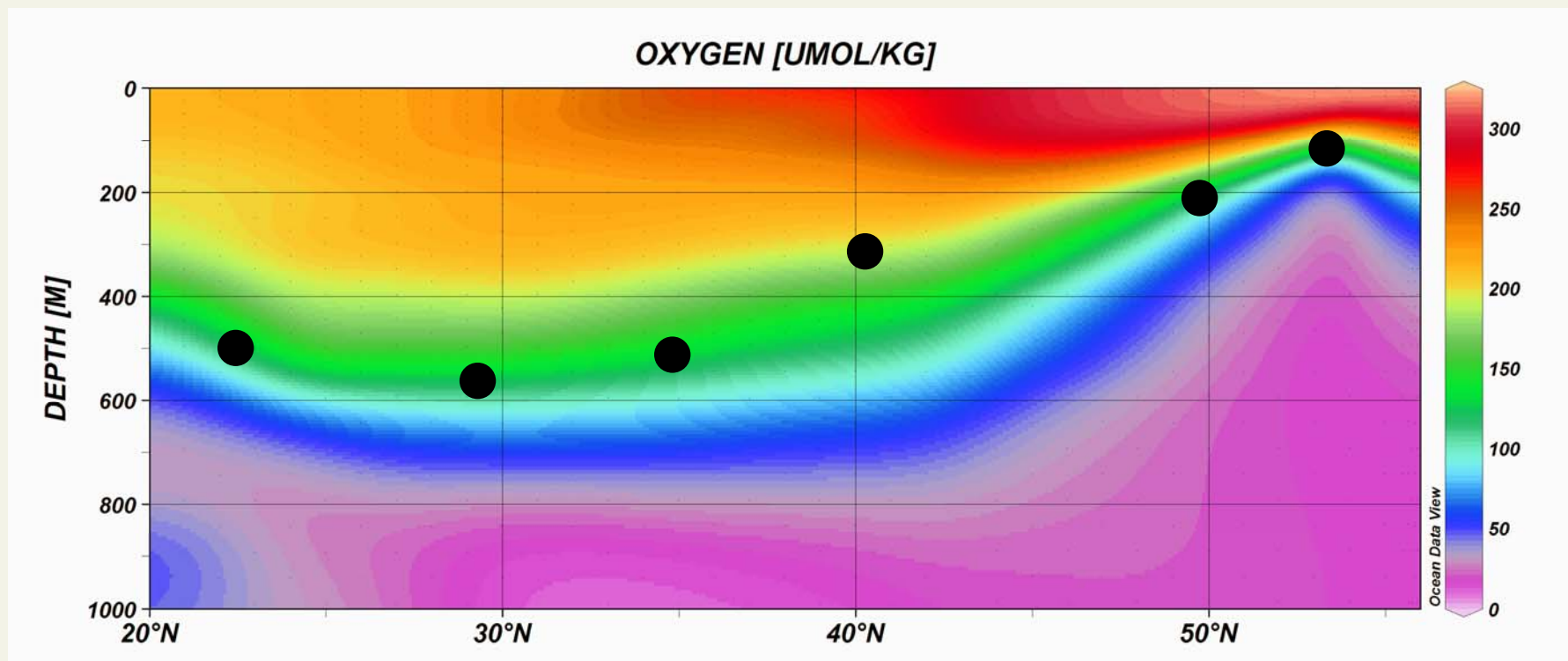
Modeling scenarios based on GEOS-Chem atmospheric deposition (*Selin et al.*, 2008) and *Sunderland and Mason* (2007) model for surface-1500 m depth

# Pelagic Fish Hg Levels Correlated with Feeding Depths



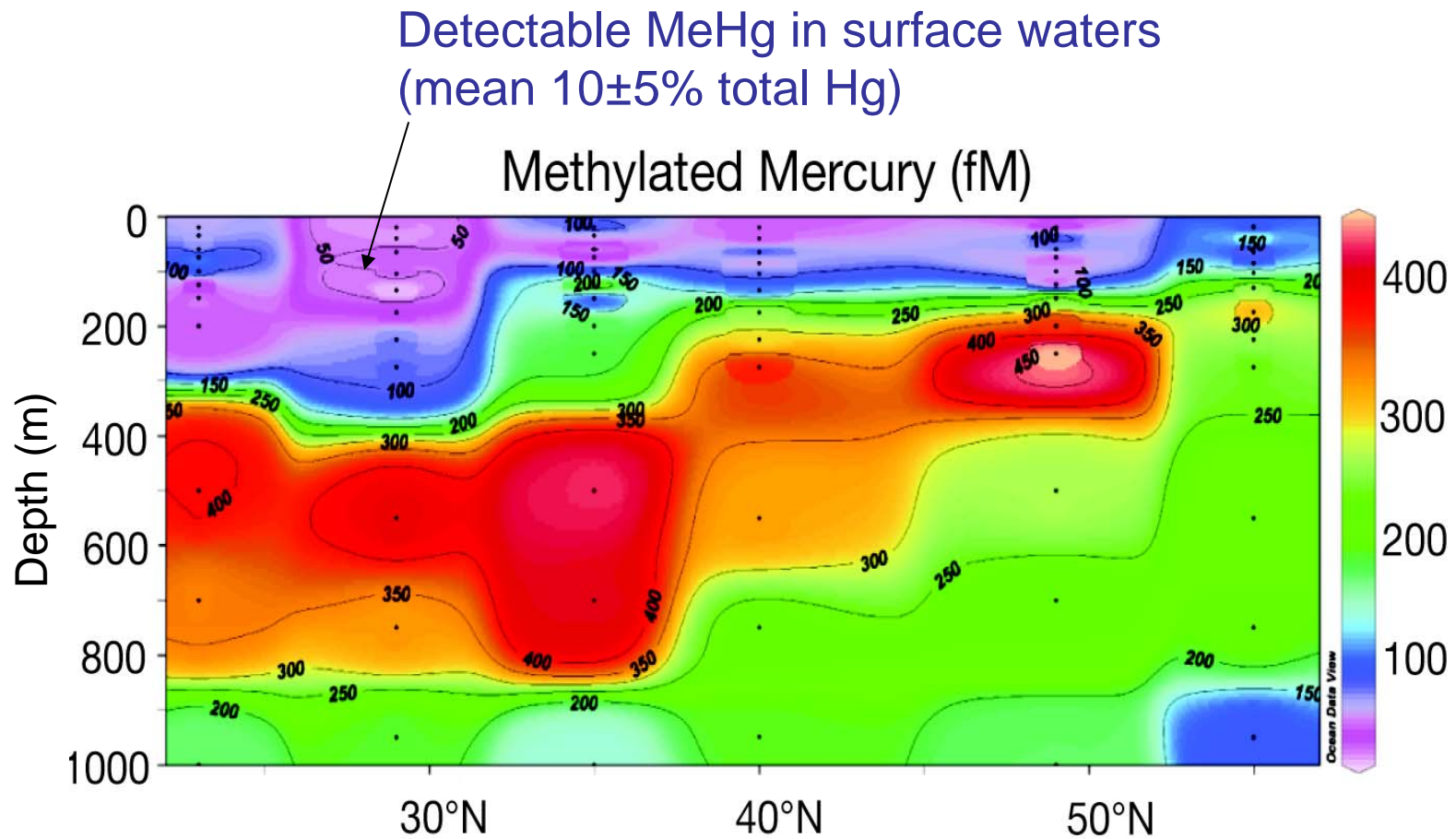


# Maximum Observed MeHg vs Oxycline Position



● Maximum Observed MeHg Concentration

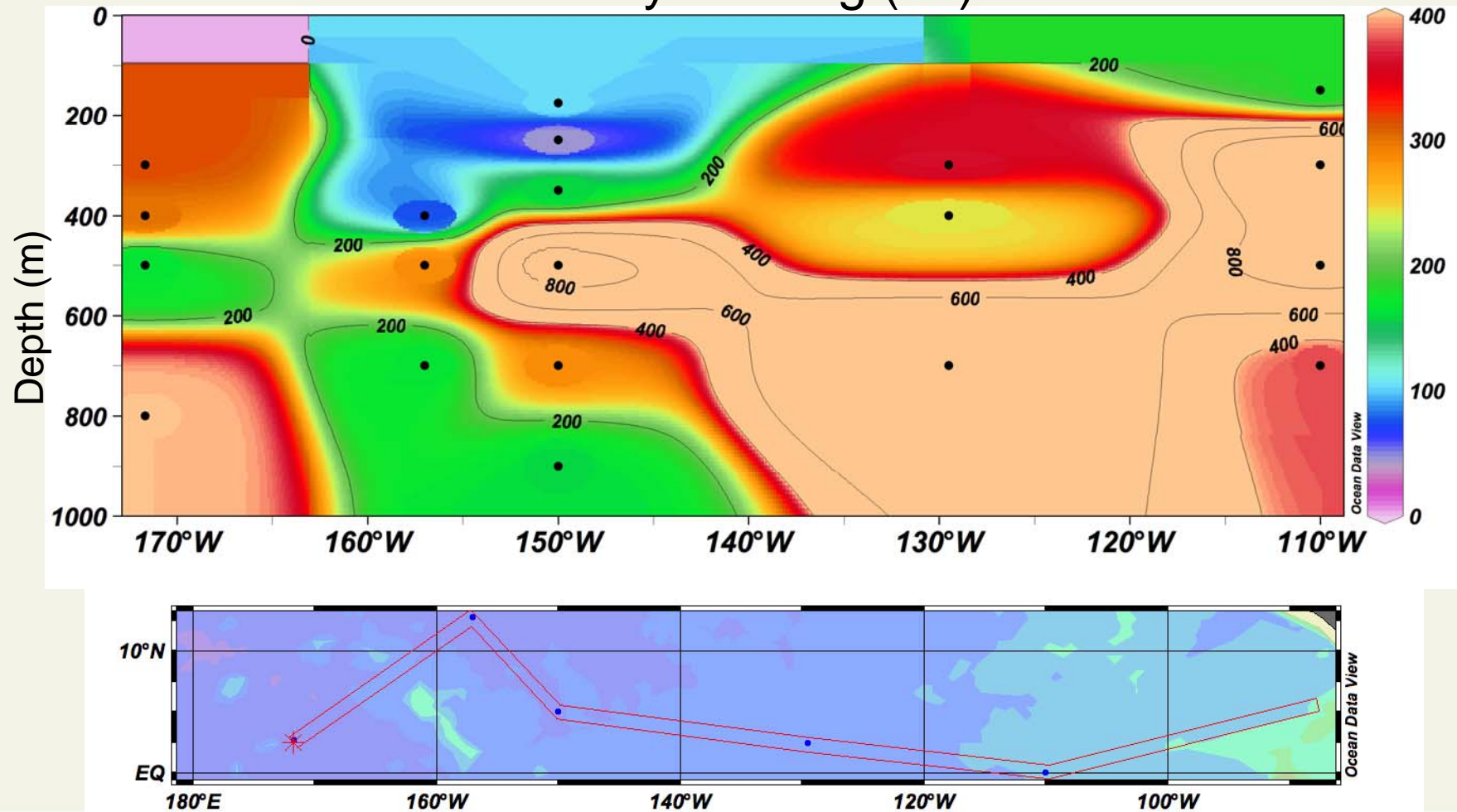
# North Pacific Seawater MeHg Levels



Subsurface peak in methylated Hg concentrations  
(mean  $19 \pm 6\%$  total Hg)

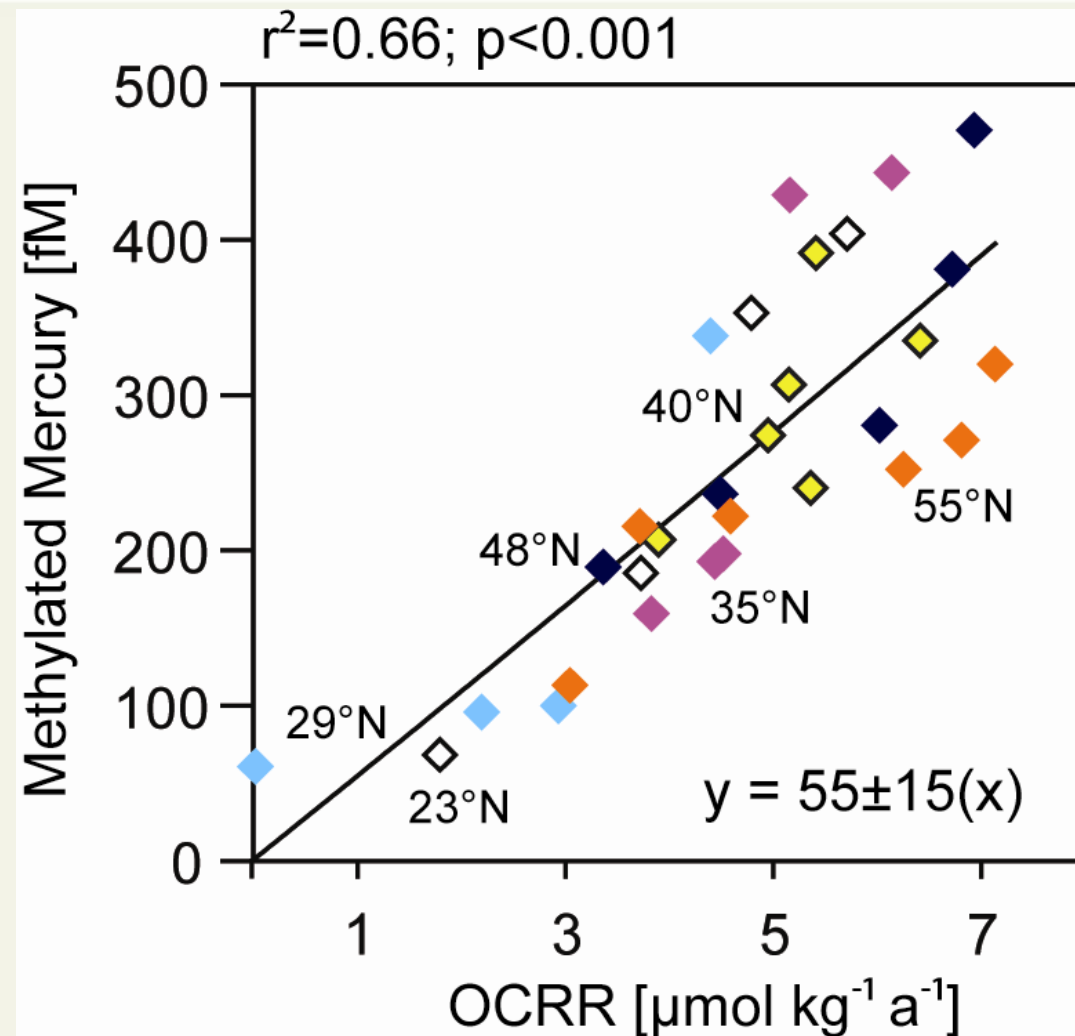
# Eq. Pacific Seawater MeHg Levels

Methylated Hg (fM)





# Distribution of Methylated Hg in Ocean Waters



OCRR = Organic Carbon Remineralization Rate, which reflects the ocean's biological pump

# Summary

- Total Hg concentrations in North Pacific subsurface waters elevated relative to previous cruises.
- Potential increase in integrated seawater profile concentrations are supported by results from intermediate/deep ocean model.
- Likely cause is enhanced Hg(II) deposition in Asian coastal waters and transport in intermediate water circulation (NPIW).
- Maximal methylated Hg concentrations in low oxygen subsurface waters with high levels of bacterial activity.
- Positive linear relationship between methylated Hg and organic carbon remineralization rates.

# Acknowledgements

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