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The Long-Term Impact of Metal Smelting Operations on Arsenic Availability in Urban Lakes of the South-Central Puget Sound Region

Sponsored by: University of Washington Superfund Research Program

Delivered: June 26, 2013, 2:00 PM - 4:00 PM, EDT (18:00-20:00 GMT)

Instructor:

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Moderator:

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Seminar Homepage

The screenshot shows the EPA website for a seminar titled "Site Characterization for Munitions Contaminants" presented by the EPA Federal Facilities Forum in 2002. The page includes a navigation sidebar with "Go to Seminar", "Links", and "Feedback" buttons. The main content area features a "Presentation Overview" section with detailed text about the seminar's purpose, including the involvement of the Federal Facilities Forum and the U.S. Army Corps of Engineers. It also lists the seminar's objectives and provides a "Go to Seminar" button. A "Download Slides" button is located on the right side of the page, and a "Feedback" button is at the bottom right. The page footer contains the EPA logo and contact information for the Technology Innovation and Field Services Division.

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- Entire broadcast offered live via Adobe Connect
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- Audio is streamed online through by default
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- Q&A – use the Q&A pod to privately submit comments, questions and report technical problems
- This event is being recorded and shared via email shortly after live delivery
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Although I'm sure that some of you have these rules memorized from previous CLU-IN events, let's run through them quickly for our new participants.

Please mute your phone lines during the seminar to minimize disruption and background noise. If you do not have a mute button, press *6 to mute #6 to unmute your lines at anytime. Also, please do NOT put this call on hold as this may bring delightful, but unwanted background music over the lines and interrupt the seminar.

You should note that throughout the seminar, we will ask for your feedback. You do not need to wait for Q&A breaks to ask questions or provide comments. To submit comments/questions and report technical problems, please use the ? Icon at the top of your screen. You can move forward/backward in the slides by using the single arrow buttons (left moves back 1 slide, right moves advances 1 slide). The double arrowed buttons will take you to 1st and last slides respectively. You may also advance to any slide using the numbered links that appear on the left side of your screen. The button with a house icon will take you back to main seminar page which displays our agenda, speaker information, links to the slides and additional resources. Lastly, the button with a computer disc can be used to download and save today's presentation materials.

With that, please move to slide 3.

New online broadcast screenshot

The screenshot shows an Adobe Connect seminar window titled "CLUIN Default Seminar Template - Adobe Connect". The main content area displays a slide with the text "View presentation live online here" and fields for "Instructor(s):" and "Moderator(s):". At the bottom of the slide, it says "Visit the Clean Up Information Network online at www.cluin.org" and "1 of Total # of slides".

Callouts and controls include:

- Control online audio:** A callout box pointing to a speaker icon in the bottom left corner.
- Enlarge presentation:** A callout box pointing to a "Full Screen" button in the top right corner.
- Information about Sponsors & Speakers:** A callout box pointing to a "CLU-IN" logo in the top right corner.
- Submit private questions, comments or report technical problems:** A callout box pointing to a text input field with a downward arrow in the bottom right corner.

**The Long-Term Impact of
Metal Smelting Operations on
Arsenic Availability in Urban Lakes of the
South-Central Puget Sound Region**

Jim Gawel, Ph.D.
University of Washington Tacoma
Environmental Science and Studies

Research Team

- UWT Undergraduates: Lindsay Tuttle, Sarah Burdick, Michelle Miller, Jessica Asplund, Shawna Peterson, Kara Ziegler and Alexandra Ehle
- Bellarmine High School: Amanda Tollefson and Brian Rurik
- UW Seattle Faculty: Becca Neumann

Importance of Urban Lakes

- Human population concentrated in urban areas; already 50% or greater worldwide
- Urban poor rely on local, inexpensive recreational water resources
- Some rely on water sources for cultural ties and diet augmentation
- Urban waters serve as critical habitat for multiple species

Urbanization & Arsenic Pollution

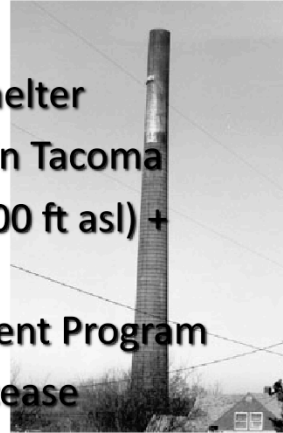
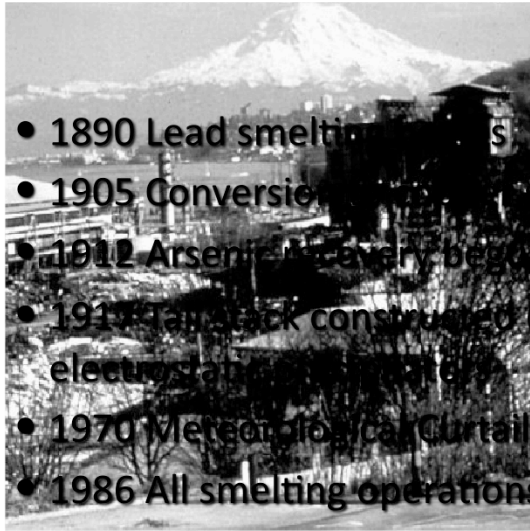
- Lake sediments act as As reservoirs after external source removal
- If remobilized periodically As may migrate to surface sediments
- Cultural eutrophication can exacerbate As release from sediments
- Other anthropogenic inputs may affect As mobility (e.g. road salt, nitrate and phosphate)

Major Sources of Arsenic in Lakes

- Herbicide applications in lakes
- Fruit orchard insecticides
[Paris Green - $3\text{Cu}(\text{AsO}_2)_2 \cdot \text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2$]
- Chemical manufacture
- Timber treatment [CCA]
- Mine tailings and drainage
- *Smelting*
 - *Air emissions*
 - *Slag disposal*

ASARCO

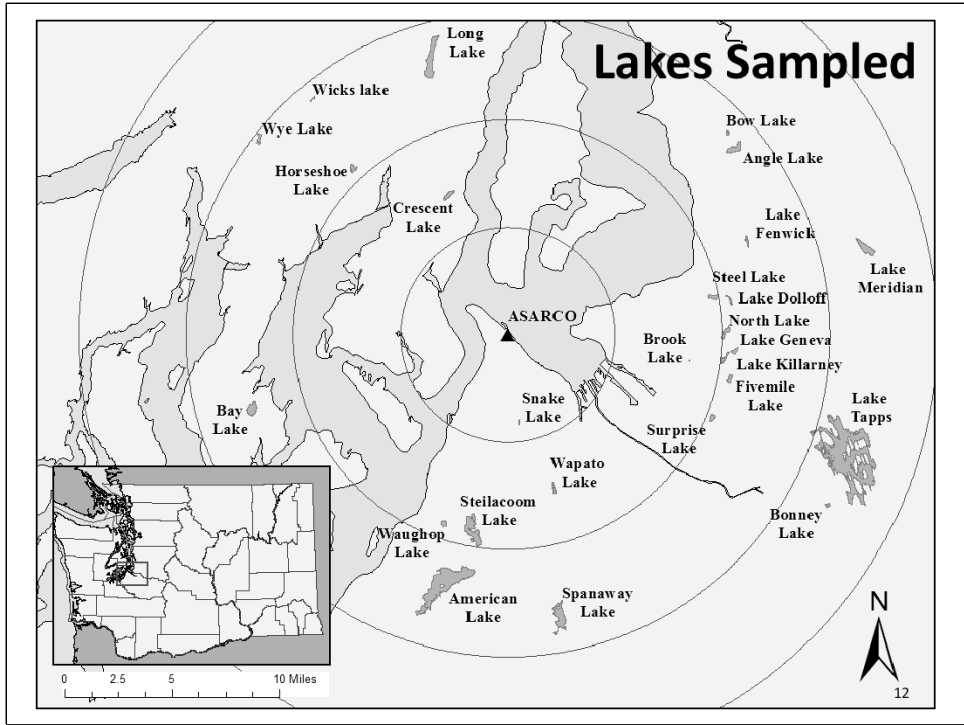
- 1890 Lead smelting begins
- 1905 Conversion to zinc smelter
- 1912 Arsenic recovery begun in Tacoma
- 1917 Tall stack constructed (700 ft asl) +
electrostatic precipitator
- 1970 Meteorological Curtailment Program
- 1986 All smelting operations cease

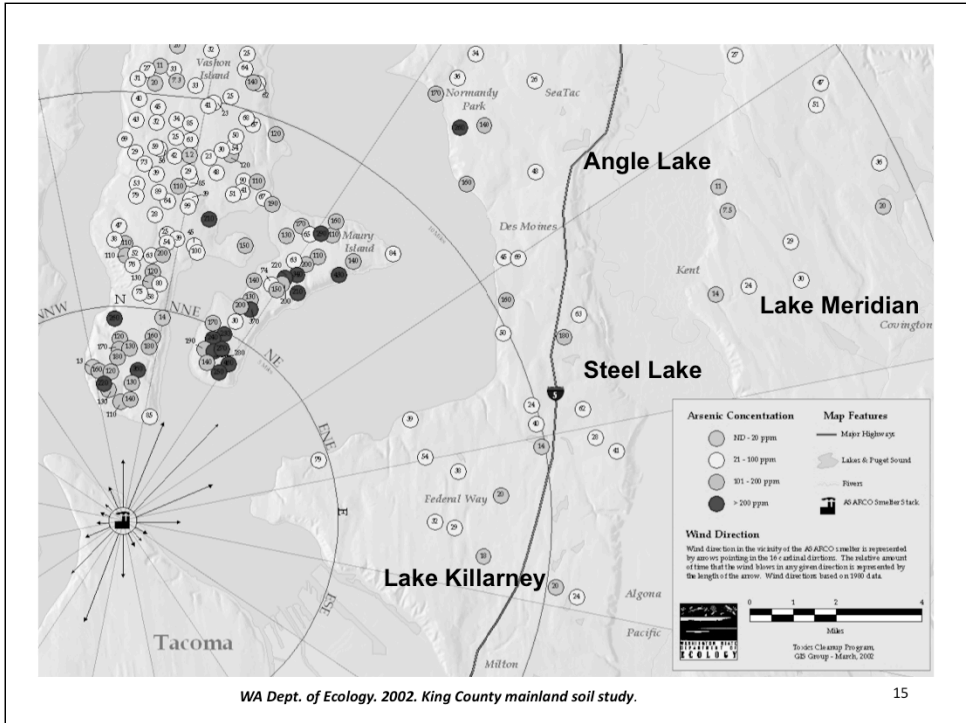


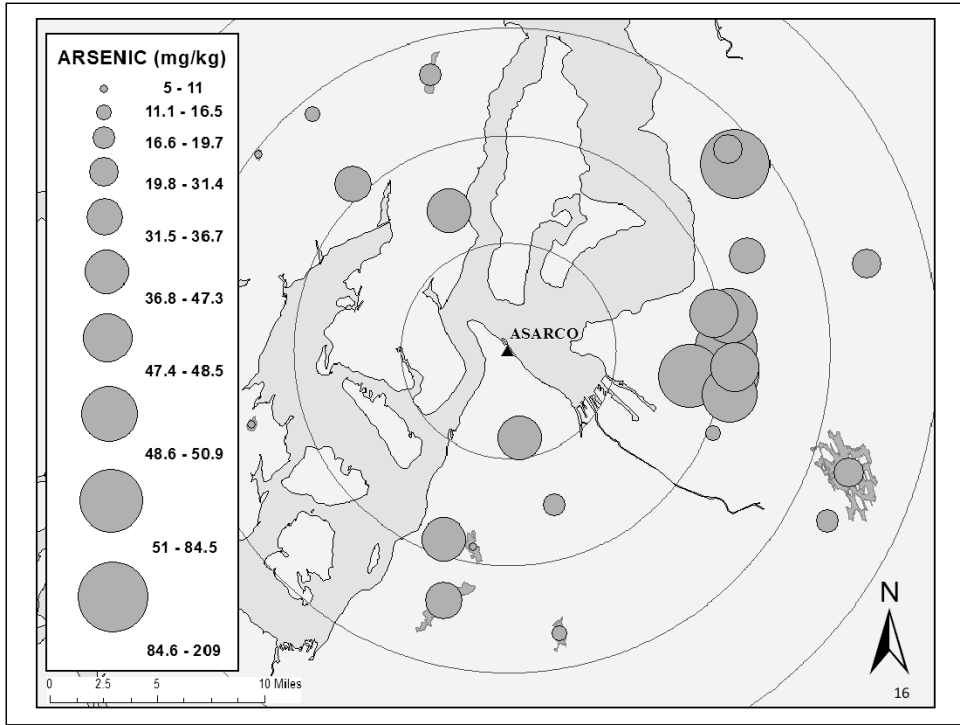
Ongoing Study Breakdown

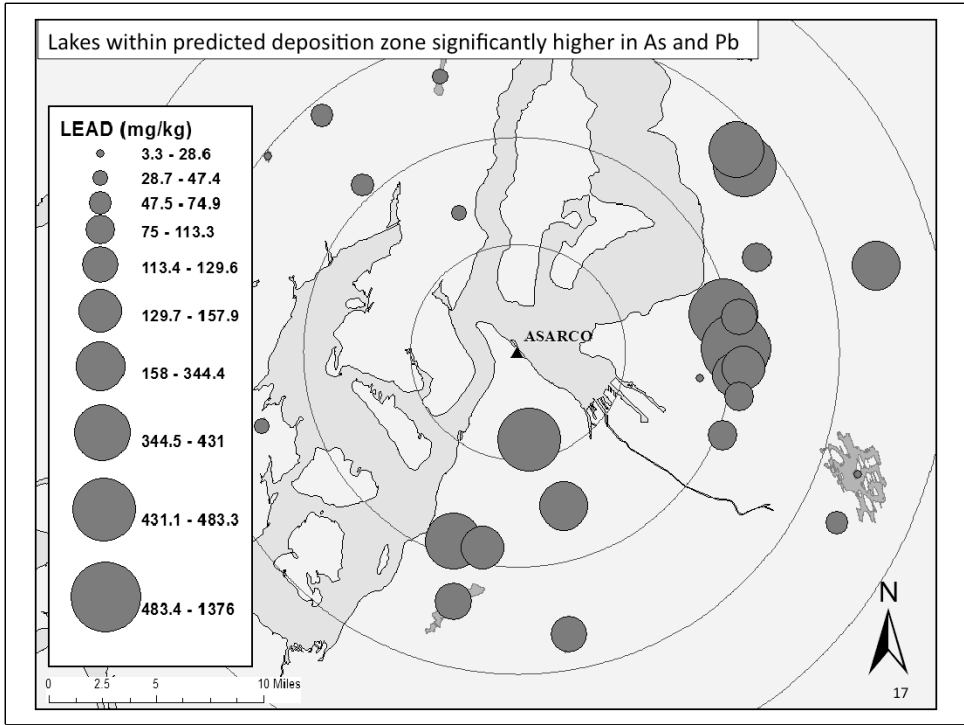
- Spatial distribution of As and Pb in lake sediments
- Temporal distribution in sediments
- Arsenic mobility and release to water column
- *Chemical, biological, and physical controls on As mobility, bioavailability and toxicity*



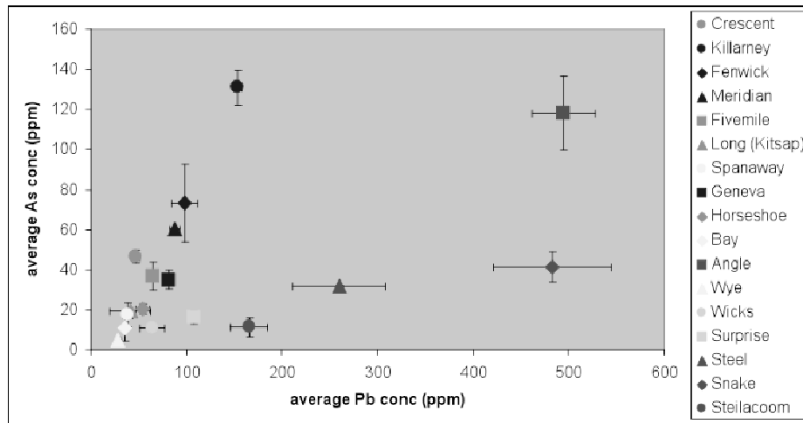




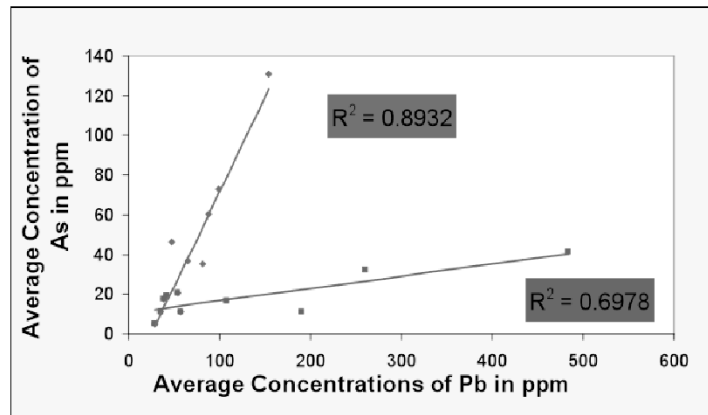




As vs. Pb in Surface Sediments



Two Different Sources?

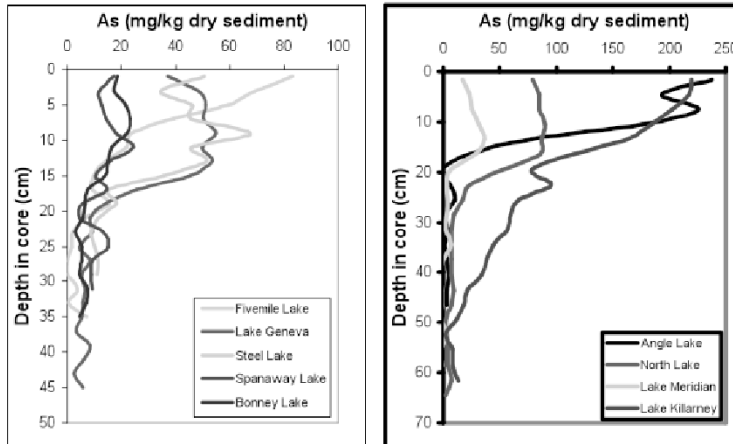


•1:1 As:Pb ratio may be fingerprint of ASARCO slag/emissions (Mariner et al. 1997)

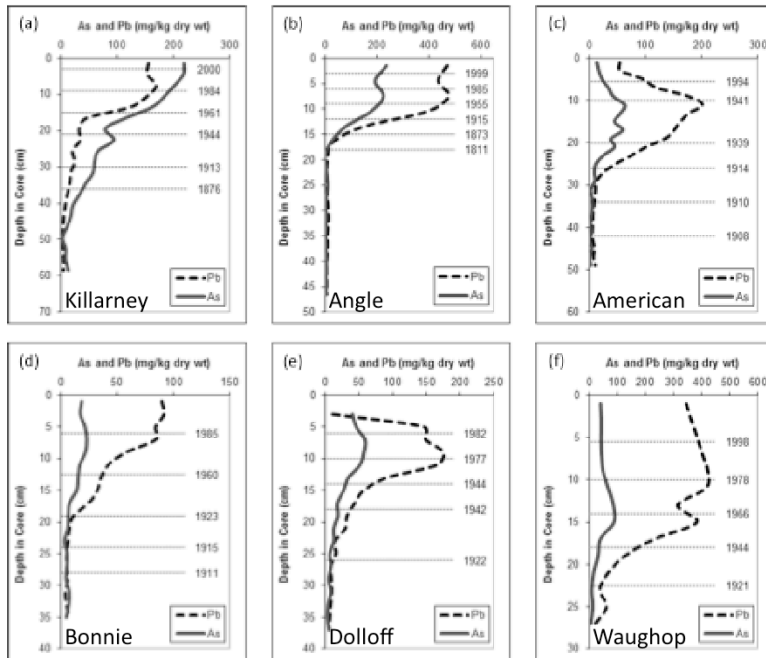
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Slag deposition or atmospheric transport or road runoff influences?

As in Sediment Cores



•Significant correlation between As and Pb in all cores except Brook and Spanaway

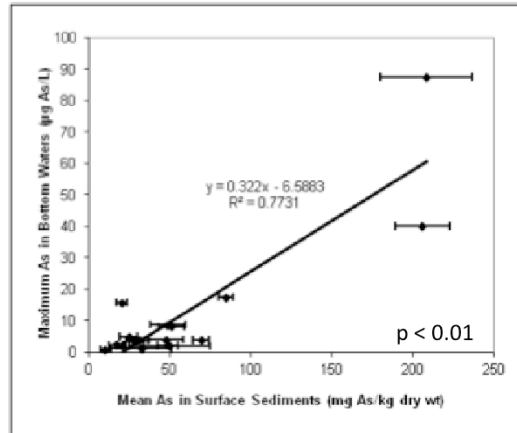


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Sediment Summary

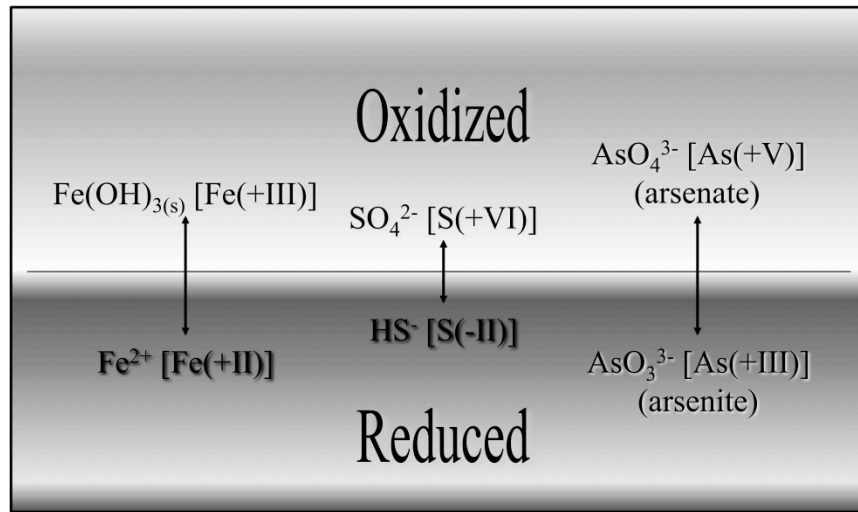
- Surface sediments in 10 of 12 lakes in deposition zone exceed *probable effects concentration* of 33 ppm As and 128 ppm Pb
 - PEC = “above which harmful effects are likely to be observed” (MacDonald et al. 2000)
- Lake Killarney and Angle Lake show highest sediment concentrations at sediment surface
 - Ongoing inputs?
 - Vertical migration?

Sediment/Water Transfer

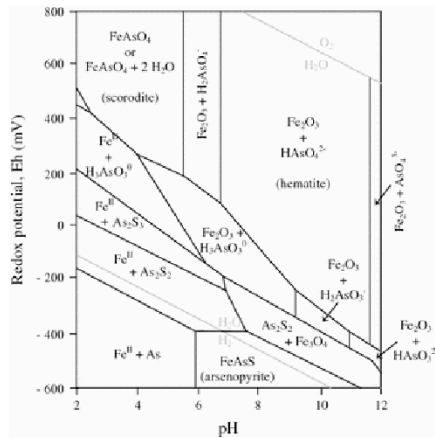


- Similar ratio seen in Lake Washington by Peterson and Carpenter (1986)
- Similar ratio in suite of lakes in Massachusetts by Lattanzi et al. (2007)

Basic Red/Ox Chemistry



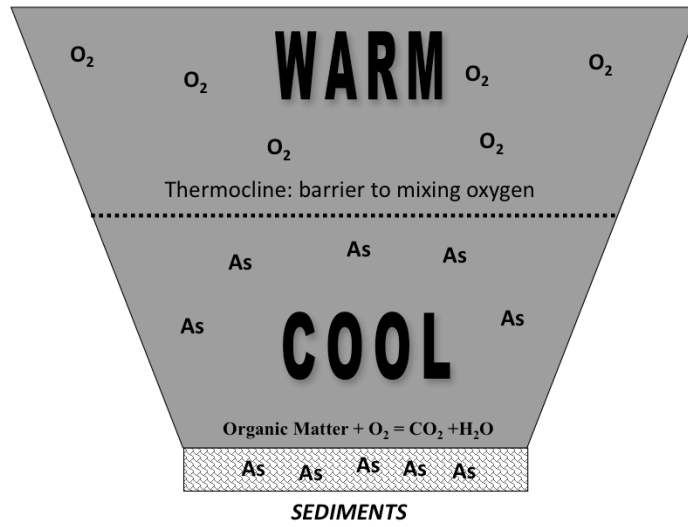
Effect of Eh and pH on As/Fe/S

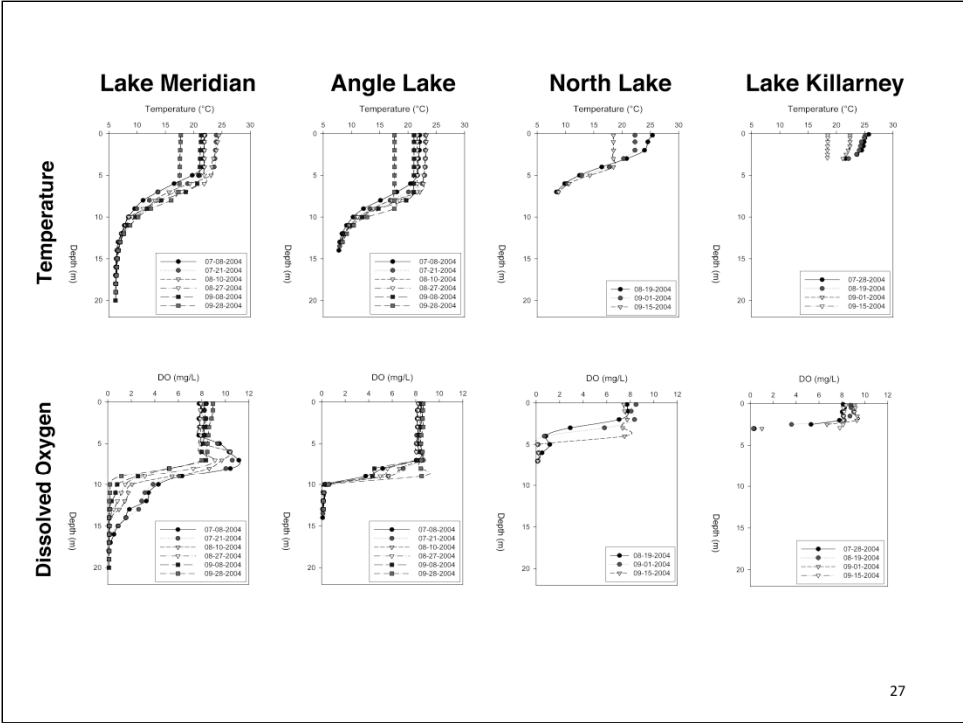


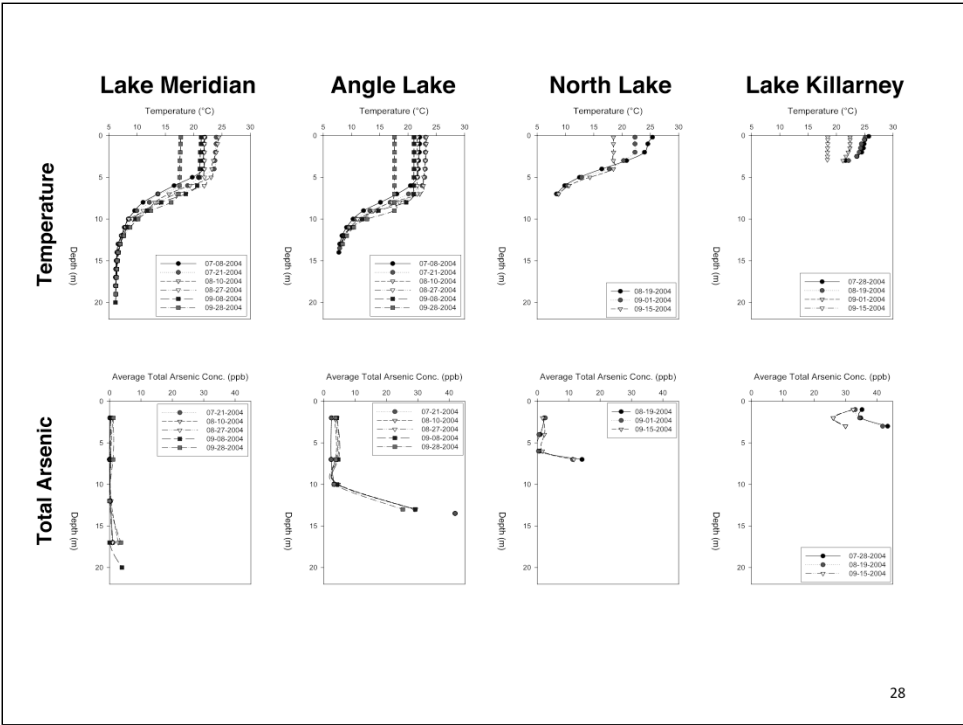
Daus et al. (2002), $\Sigma\text{As}=\Sigma\text{S}=\Sigma\text{Fe}=10^{-6}$ M

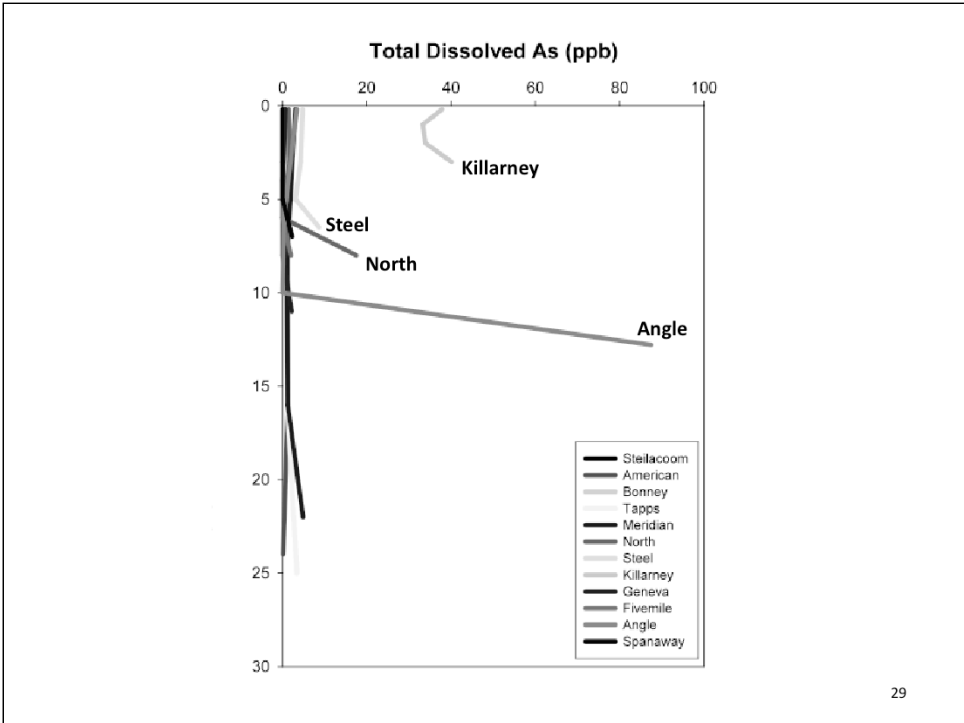
- Primary inorganic forms:
 - arsenate [As(V): H_2AsO_4^-]
 - arsenite [As(III): H_3AsO_3]
- As(V) binds readily to Fe(III)-oxides and may precipitate
- As(III) is more soluble and toxic
- As(III) may bind to S(-II) and Fe(II) and precipitate

Arsenic Remobilization

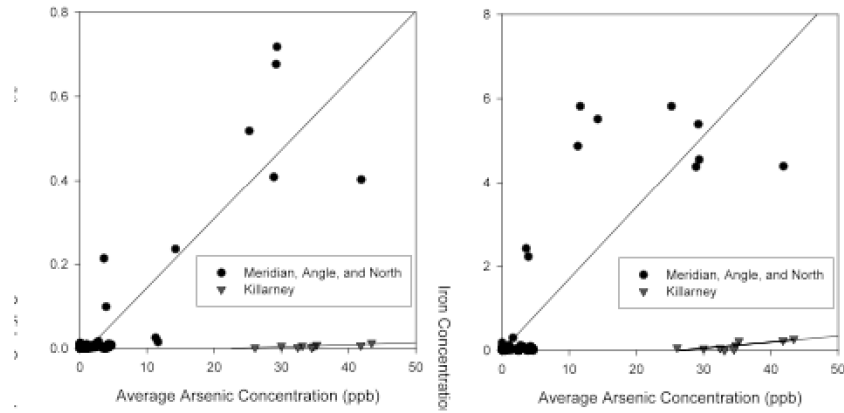






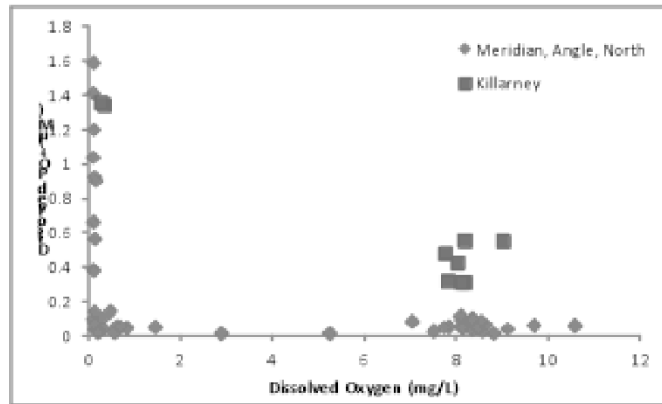


As:Fe:S in Select Lakes



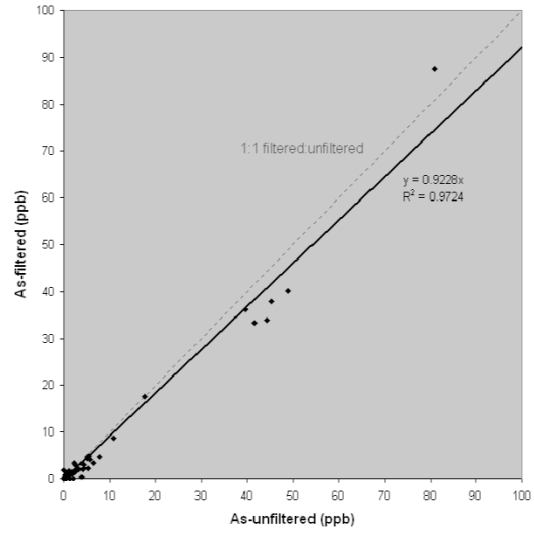
- Generally dissolved As, Fe, and S increase proportionately under reducing conditions
- Killarney does not match that pattern, why?

DO vs PO₄ in Select Lakes

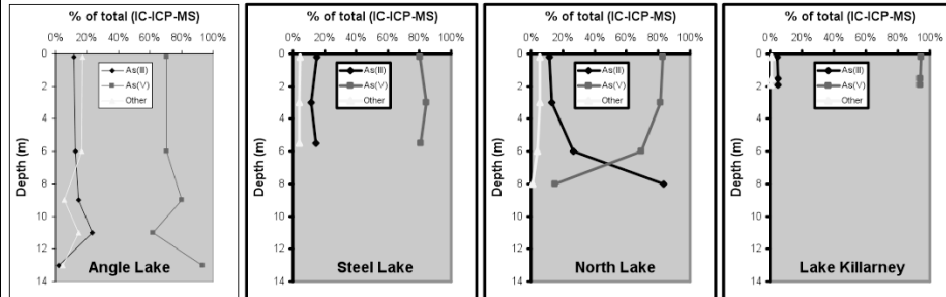


- PO₄ still elevated in Killarney in the presence of high DO
- Highest PO₄ when near bottom water goes anoxic (calm, warm weather)

Filtered vs. Unfiltered



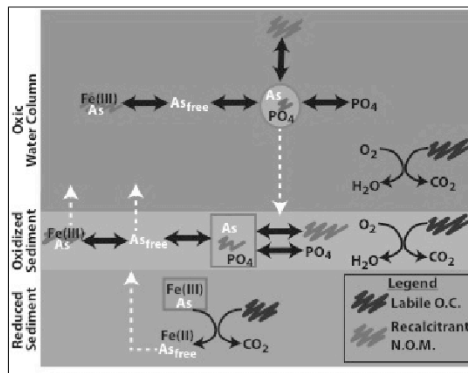
Dissolved Arsenic Speciation



•Analysis by Applied Speciation Inc.

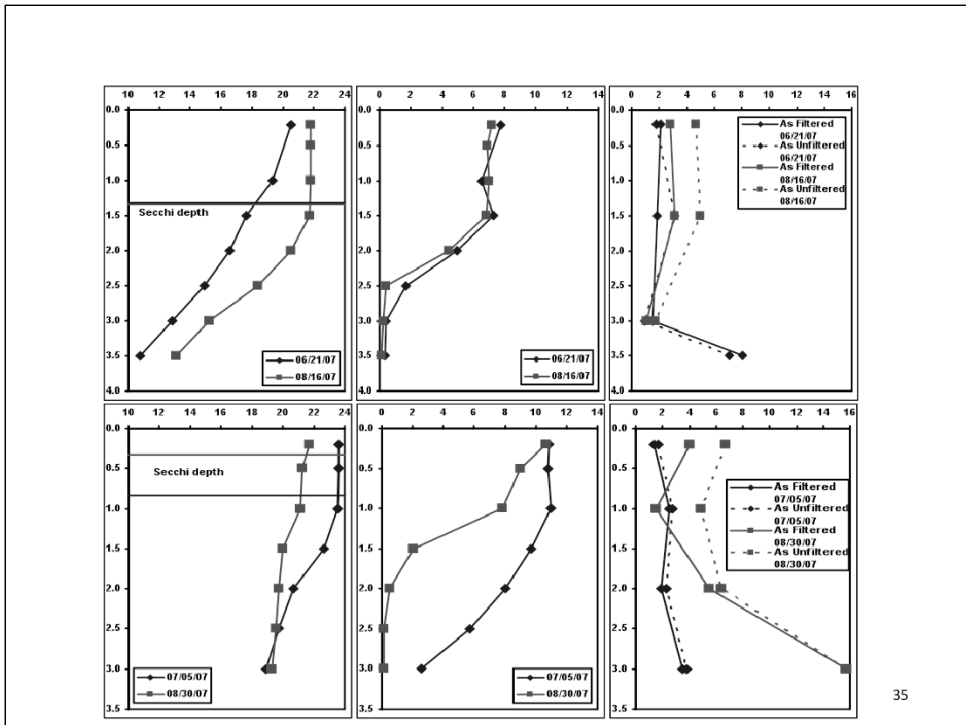
•Highly mobile As(V) in these lakes in general, with only North Lake having As(III)

Proposed Model for As Mobility in Presence of Oxygen

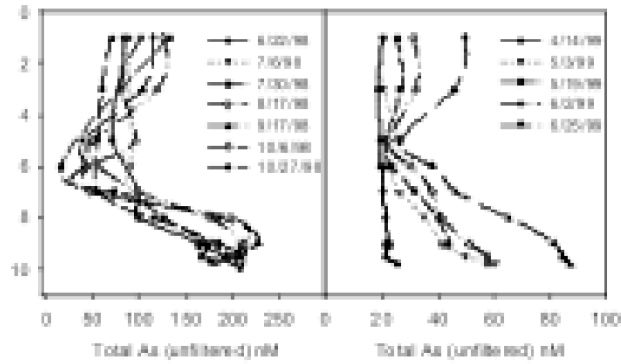


Current hypothesis:

- (1) Microbially available orgC for reductive dissolution of arsenic-bearing sediments
- (2) NOM and/or phosphate to keep arsenic from sorbing to settling particles
- (3) Shallow water column that resists stratification



Not Just in Washington

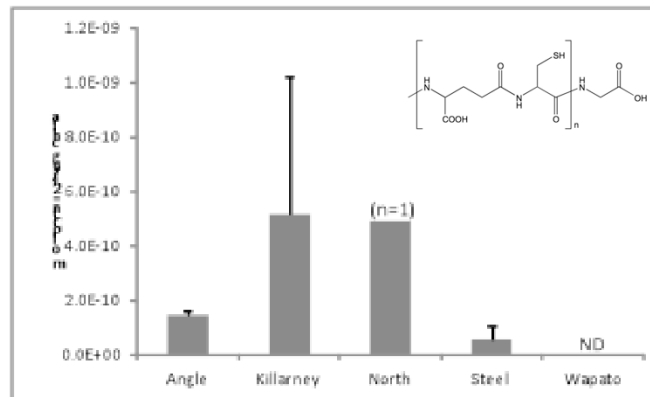


North Basin – Spy Pond, MA (Senn et al. 2007)

Questions to Address in Research

- What is the mix of water quality parameters to measure to predict As mobility in urban lakes?
- Does the presence of high levels of dissolved As in surface waters increase biotic uptake by phytoplankton, zooplankton, and fish?
- Would fish bioaccumulation become an issue under these conditions?
- How might this be important to freshwater sediment criteria development?

Bioindicators of Metal Toxicity



Acknowledgements

- Funded by:
 - UWT Environmental Sciences Program
 - UWT Founders Endowment
 - UWT Chancellor's Fund for Research
- As speciation provided by Applied Speciation, Inc., Tukwila, WA, at major discount



**To All My UW Tacoma
and Bellarmine
Researchers!**

Links page

- Dr. Jim Gawel (jimgawel@uw.edu)
- Environmental Sciences and Studies at University of Washington Tacoma:
<http://www.tacoma.uw.edu/interdisciplinary-arts-sciences/courses/environmental-studies>
- University of Washington Superfund Research Program:
<http://depts.washington.edu/sfund/>
- US EPA Region 10:
<http://www.epa.gov/aboutepa/region10.html>
- Dr. Bruce Duncan, Regional Science Liaison, US EPA Region 10
(duncan.bruce@epa.gov)
- Superfund Research Program- National Institute of Environmental Health Sciences(NIEHS)
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Thank you for your time!

Please click [here](#) to give the UW-SRP your feedback!

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- CLU-IN logo
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- U.S. EPA Technical Support Project Engineering Forum
- Green Remediation: Opening the Door to Field Use Session C (Green Remediation Tools and Examples)
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If you have additional questions or comments, please contact:

Katie Frevert, *University of Washington Superfund Research Program (UW-SRP)*
kfrevert@u.washington.edu
Tel (206)685-5379

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Thank you again for your attention and comments. I want to remind each of you that we are looking for your specific responses to many of the issues discussed today in our feedback form following this session. Also, there are several resources and related documents included in the links to more resources on this page.

If you have any additional questions or comments, please feel free to contact myself or fill out a comment form on CLUIN.

Thank you and have a great afternoon.