

Inorganic Contaminants from Past Mining Activity: Bioaccumulation in Fish and Aquatic Macro- Invertebrates, Santa Cruz Watershed, Arizona



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Introduction

- In Arizona alone, there are > 60,000 abandoned and/or inactive mines
- ~ 320 km of contaminated surface water.
- Traditional methods for remediation = capping, solidification, bioremediation or removal.



Environmental Remediation a Daunting and Expensive task

Techniques are needed that can identify:

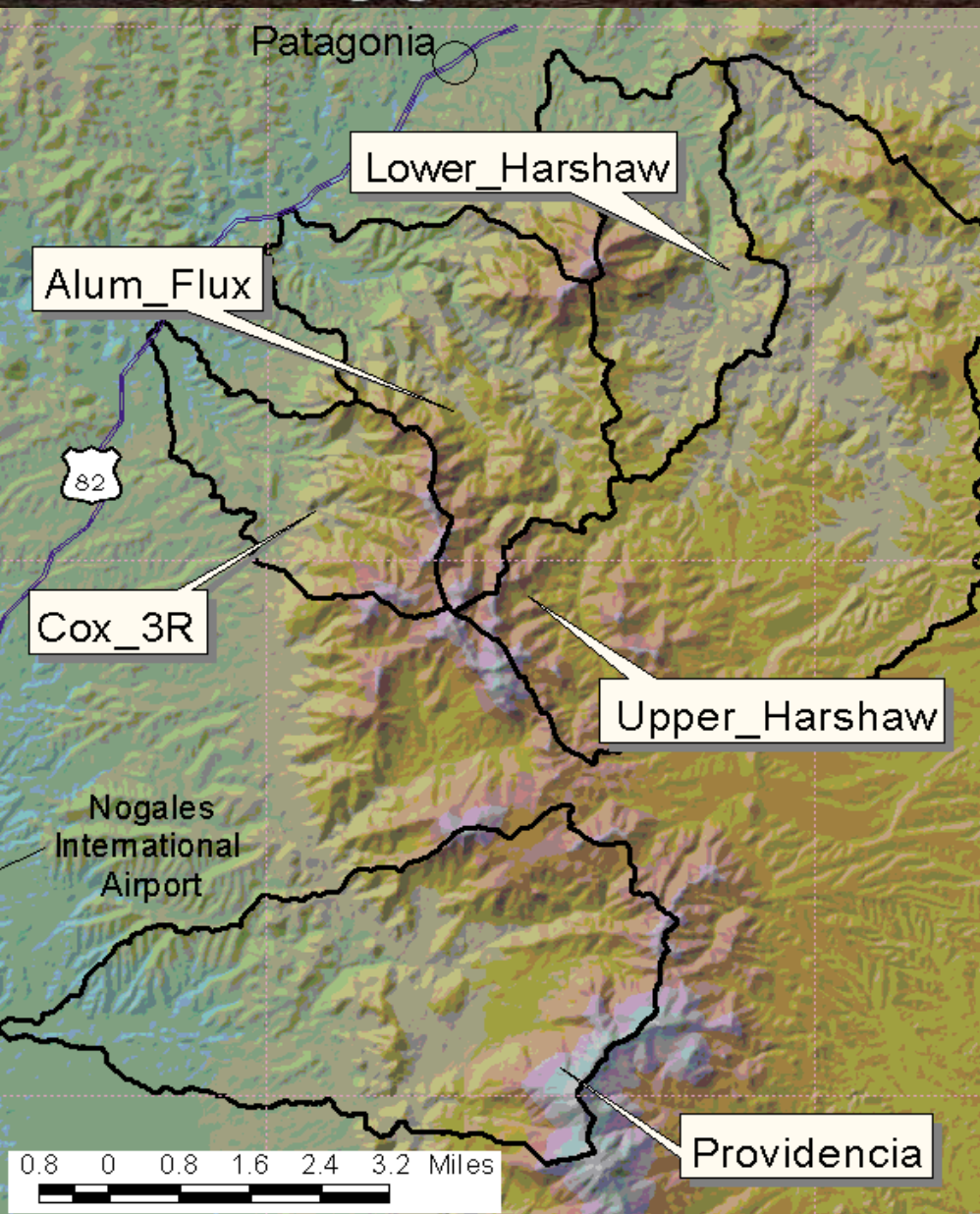
- (i) Important sources of contamination,
- (ii) Off-site transport mechanisms
- (iii) Pathways of bioaccumulation and biomagnification
- (iv) Efficacy of alternative remediation strategies.





Processes Involved in the Release, Transport, and Deposition Of Metals in Watersheds Within the Patagonia Mountains, S.E. Arizona





Project Goals

- Watershed approach
- Observe/monitor water quality
- Examine bioaccumulation of contaminants in biota in the Santa Cruz watershed near Patagonia Lake

Current Study Location

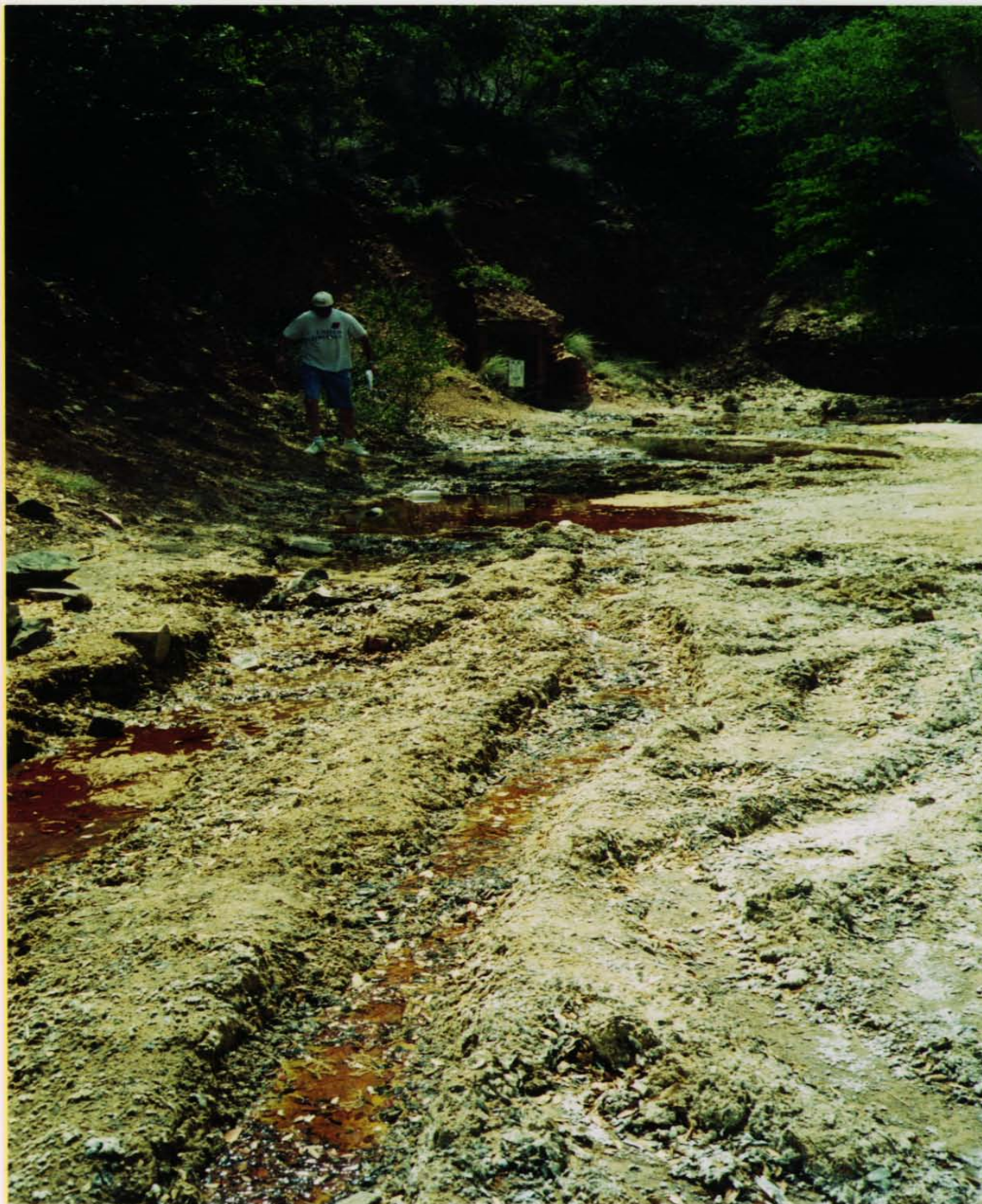


World's Fair Mine Site, Looking north at rocky, bare slopes



LOW-WATER ENVIRONMENTS

Discharge from
portal at World's Fair
Mine site



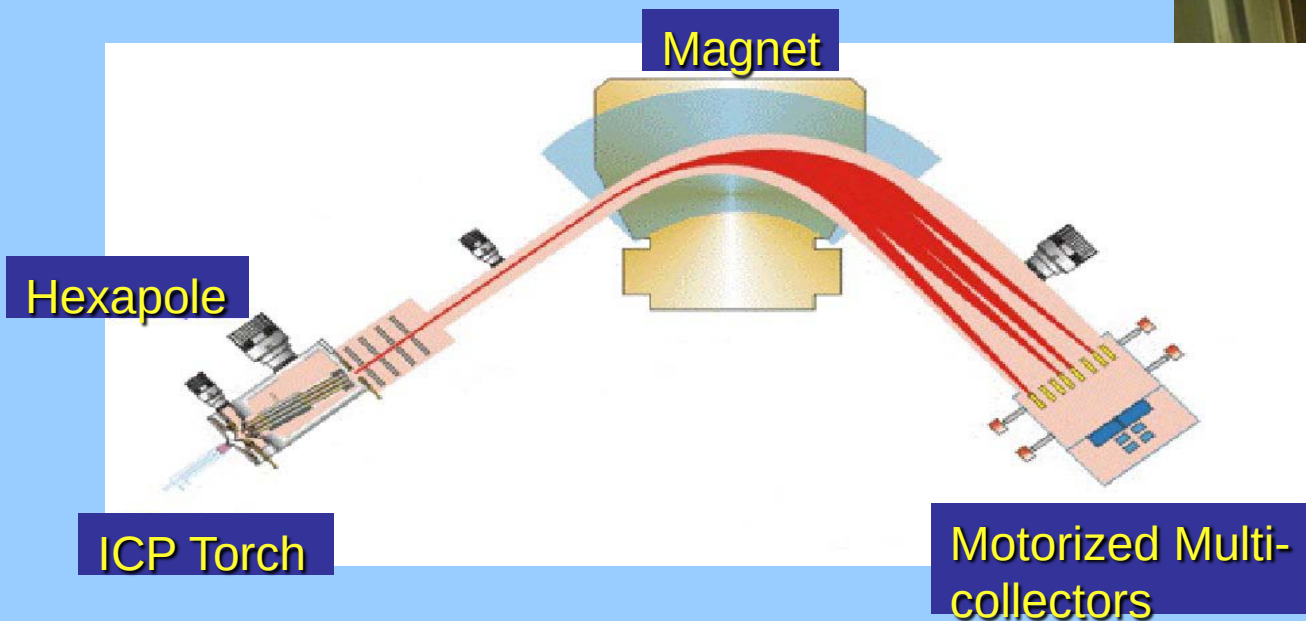
Methods

- Water, fish, aquatic macroinvertebrates
- Lakes and streams in the Santa Cruz basin
 - Patagonia Mountains
 - Alum Gulch – Above and Below World's Fair Mine
 - Harshaw Creek
 - Humboldt Creek
 - Patagonia Lake
 - Pena Blanca Lake



Contaminant Levels

- High Resolution Inductive Coupled Plasma Mass Spectrometry (HR-ICP-MS)
- 59 inorganic contaminants
 - Lead (Pb) and Mercury (Hg)



Sources of Lead = largely anthropogenic activities

Average lead concentration in adults & kids is 100 times greater than natural encumbrance.

Existing rates of Pb absorption = 30X level in pre-industrial society.

Potentially causing mental retardation, palsy, partial paralysis, hearing loss, anemia, reproductive failure and DEATH.

WHERE? - Food, water, direct ingestion of dust account for most of lead intake by humans

- Pb-containing paints.
- Leaded gasoline - Tetraethyl lead
- Mining and mine waste.

Lead exposure

About 310,000 U.S. children ages 1 to 5 have elevated blood lead levels, which can accumulate over months and years and cause serious health problems.

Effects on children

- Kids absorb up to 70 percent of lead, adults about 20 percent
- Often undetected; no obvious symptoms
- Can lead to learning disabilities, behavioral problems, malformed bones, slow growth
- Very high levels can cause seizures, coma, death

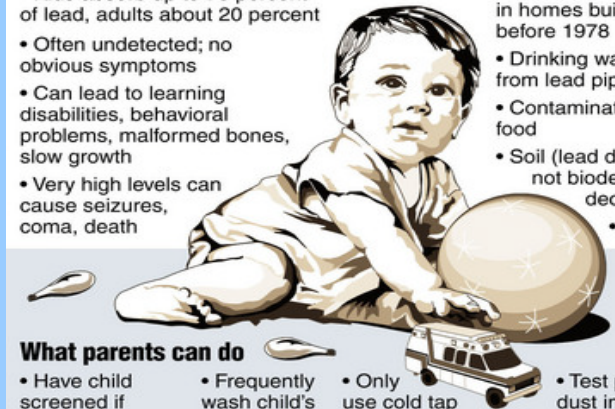
Sources

- Lead-based paint, contaminated dust in homes built before 1978
- Drinking water from lead pipes
- Contaminated food
- Soil (lead does not biodegrade, decay)
- Toys*

What parents can do

- Have child screened if there is concern of lead exposure
- Frequently wash child's hands, toys, pacifiers
- Only use cold tap water for drinking, cooking
- Test paint, dust in home if it was built before 1978

*Old toys with lead paint a known risk, but new toys from China now have come under scrutiny
Source: U.S. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services
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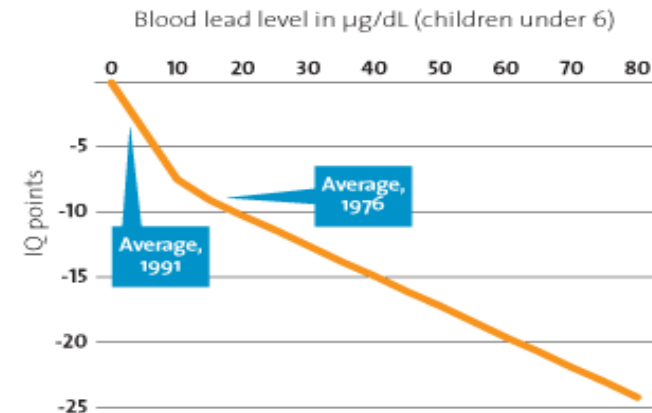
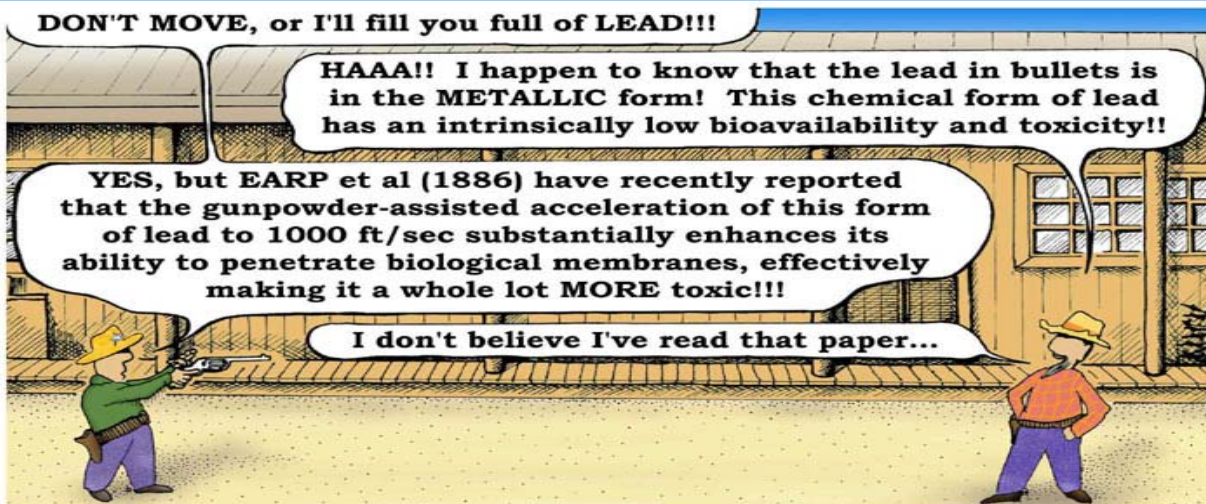


DON'T MOVE, or I'll fill you full of LEAD!!!

HAAA!! I happen to know that the lead in bullets is in the METALLIC form! This chemical form of lead has an intrinsically low bioavailability and toxicity!!

YES, but EARP et al (1886) have recently reported that the gunpowder-assisted acceleration of this form of lead to 1000 ft/sec substantially enhances its ability to penetrate biological membranes, effectively making it a whole lot MORE toxic!!!

I don't believe I've read that paper...



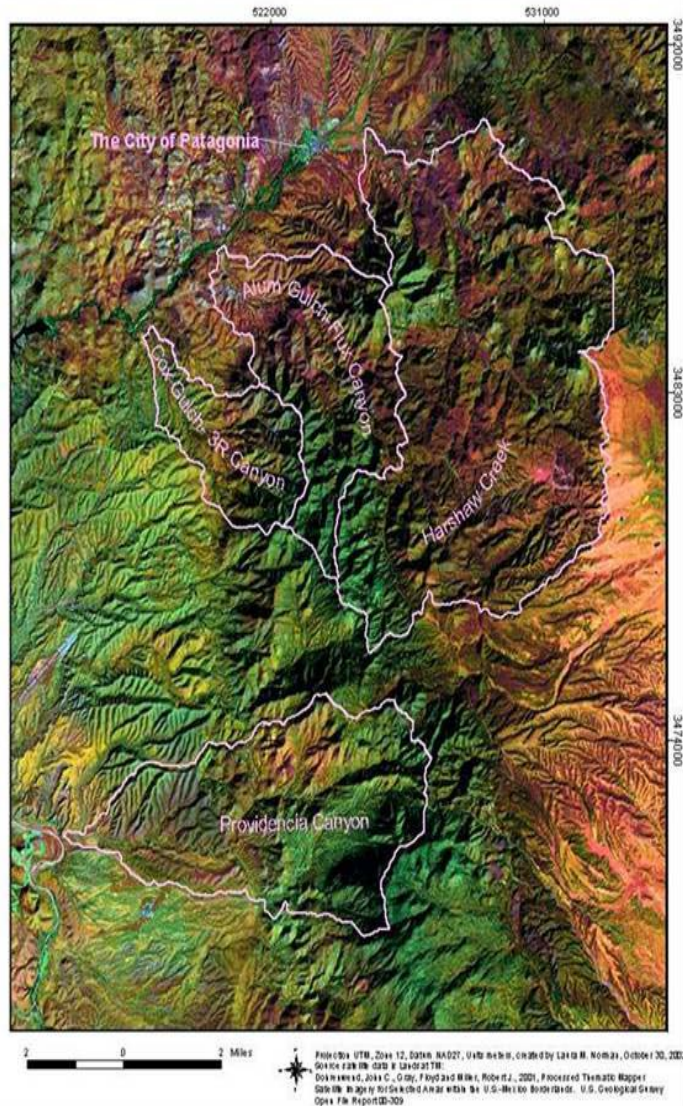
Sources: Rick Nevin, CDC

ENVIRONMENTAL SCIENTISTS IN THE WILD WEST

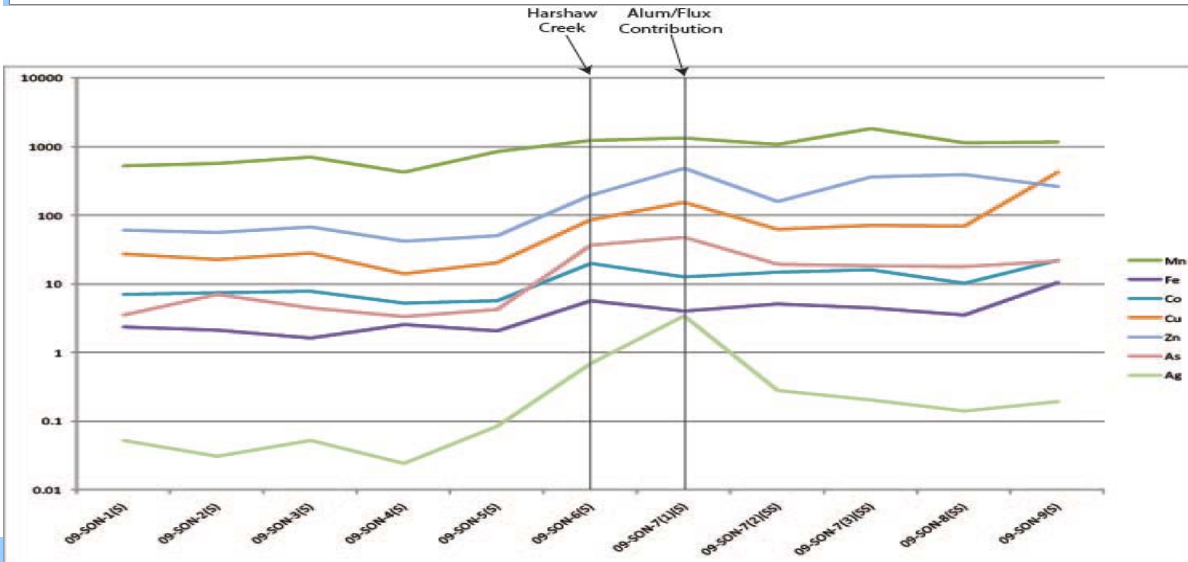
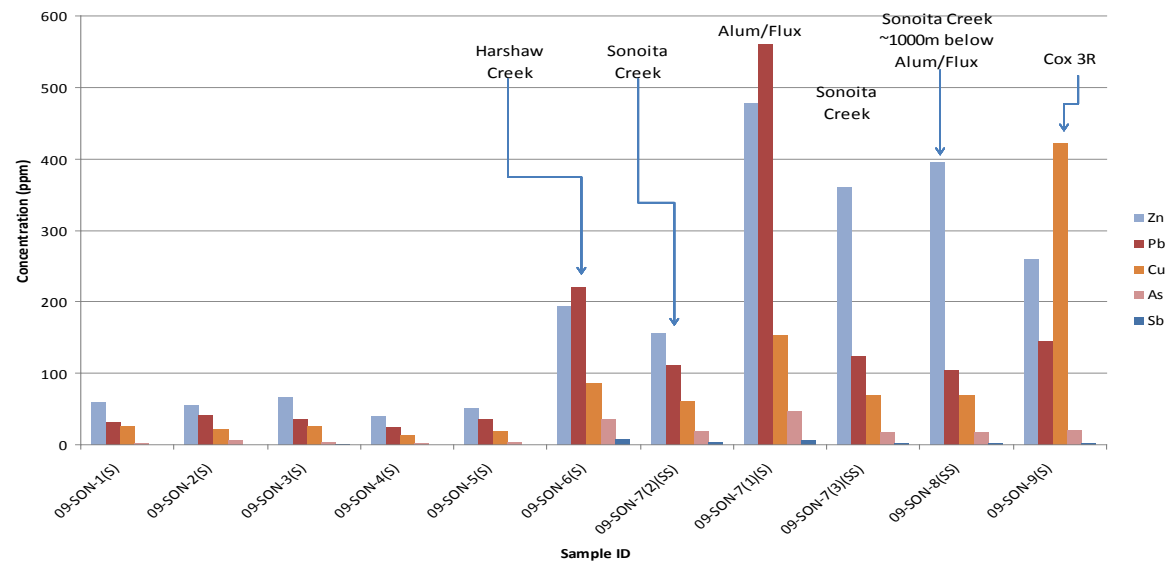
Mother Jones

Soil Approach to Lake Patagonia

Patagonia Watersheds depicted by Landsat TM Imagery



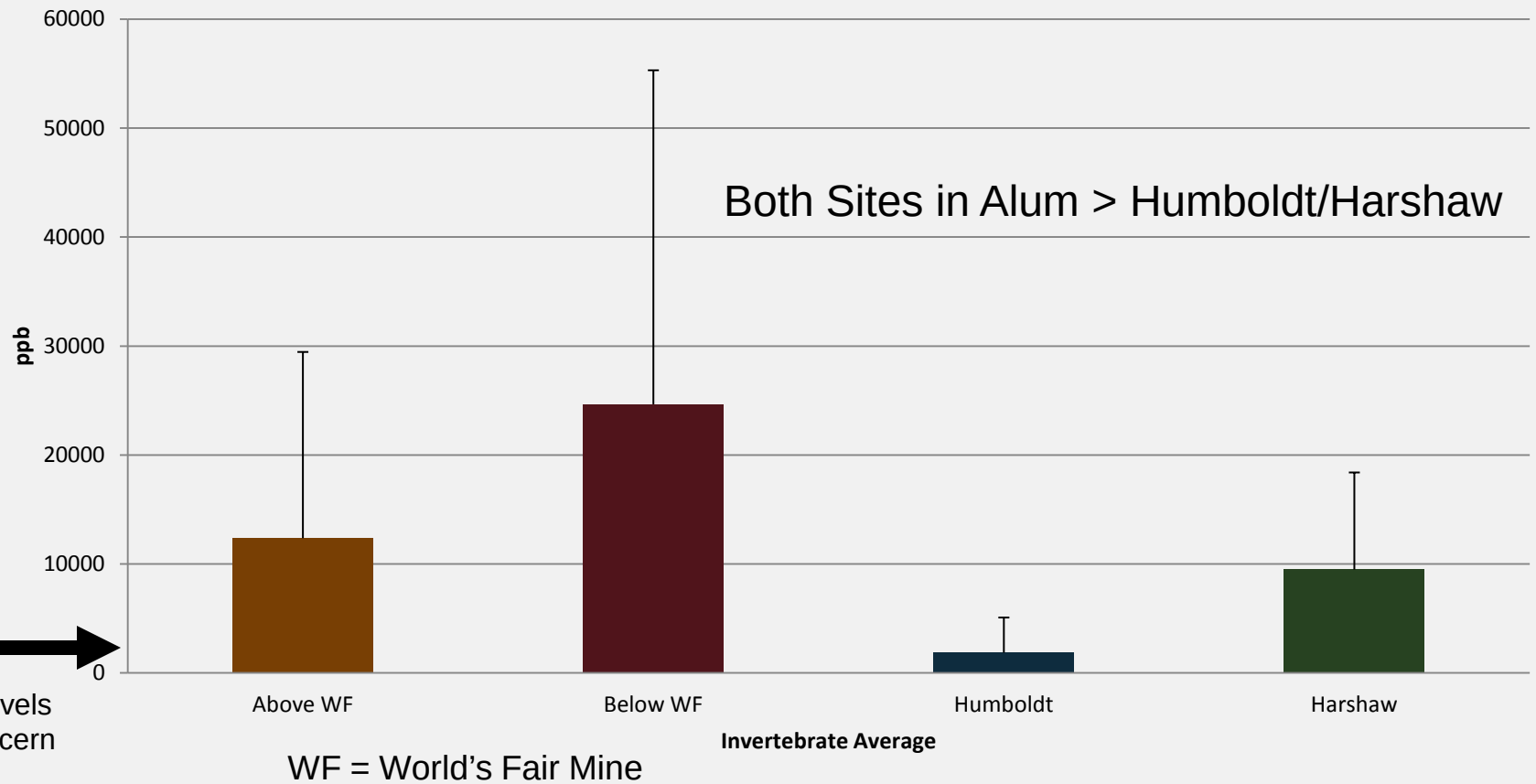
Soil Metal Concentrations in the Sonita/Patagonia Region



Lead Levels in Alum Invertebrates

WHO max water lead content = 10 ppb

Lead (Pb)

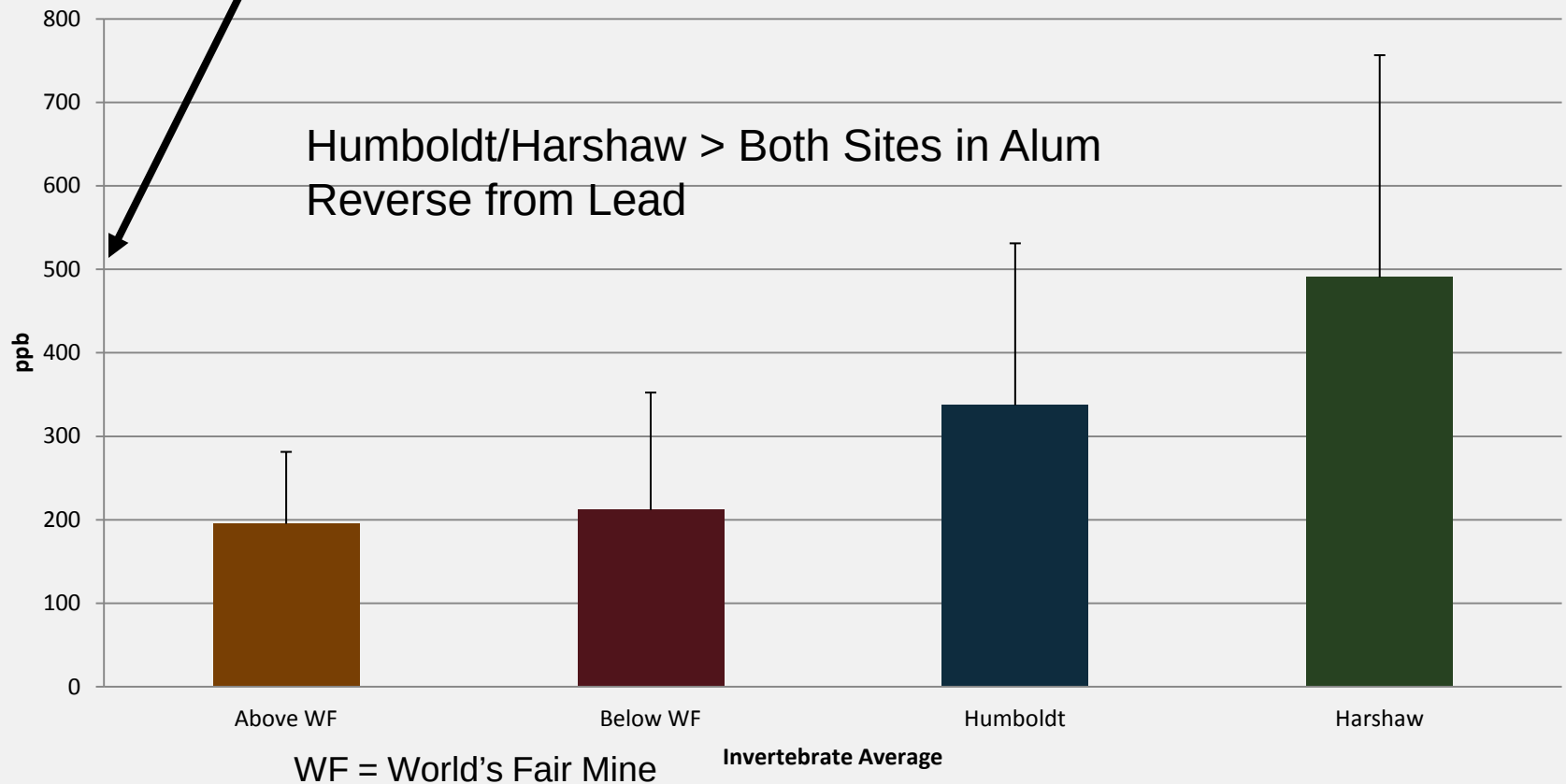


Mercury Levels in Alum Invertebrates

FDA Action Level (fish tissue) = 1 ppm

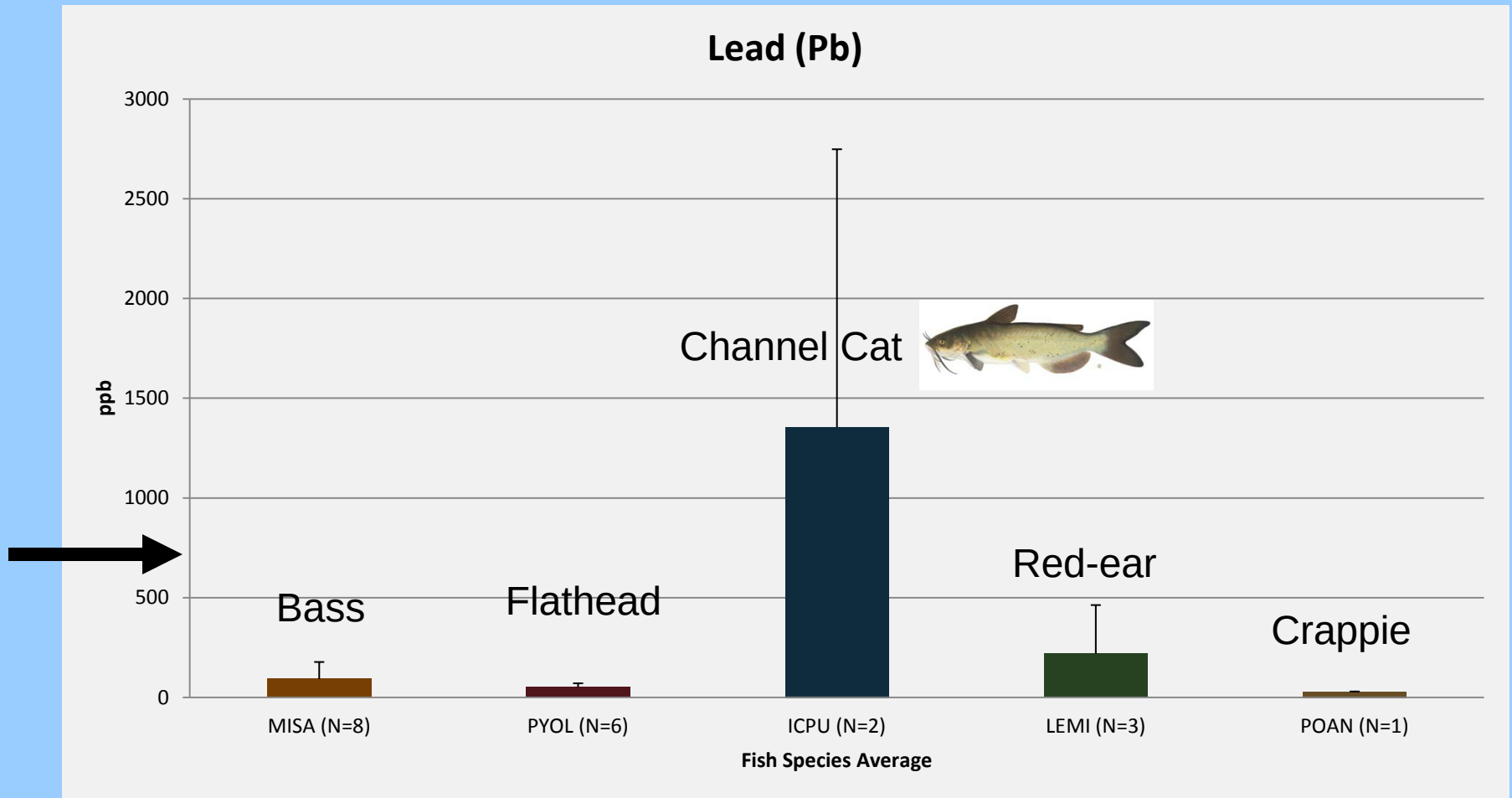
Canadian Limit (fish tissue) = 0.5 ppm

Mercury (Hg)



Lead Levels in Patagonia Fish

WHO max water lead content = 10 ppb

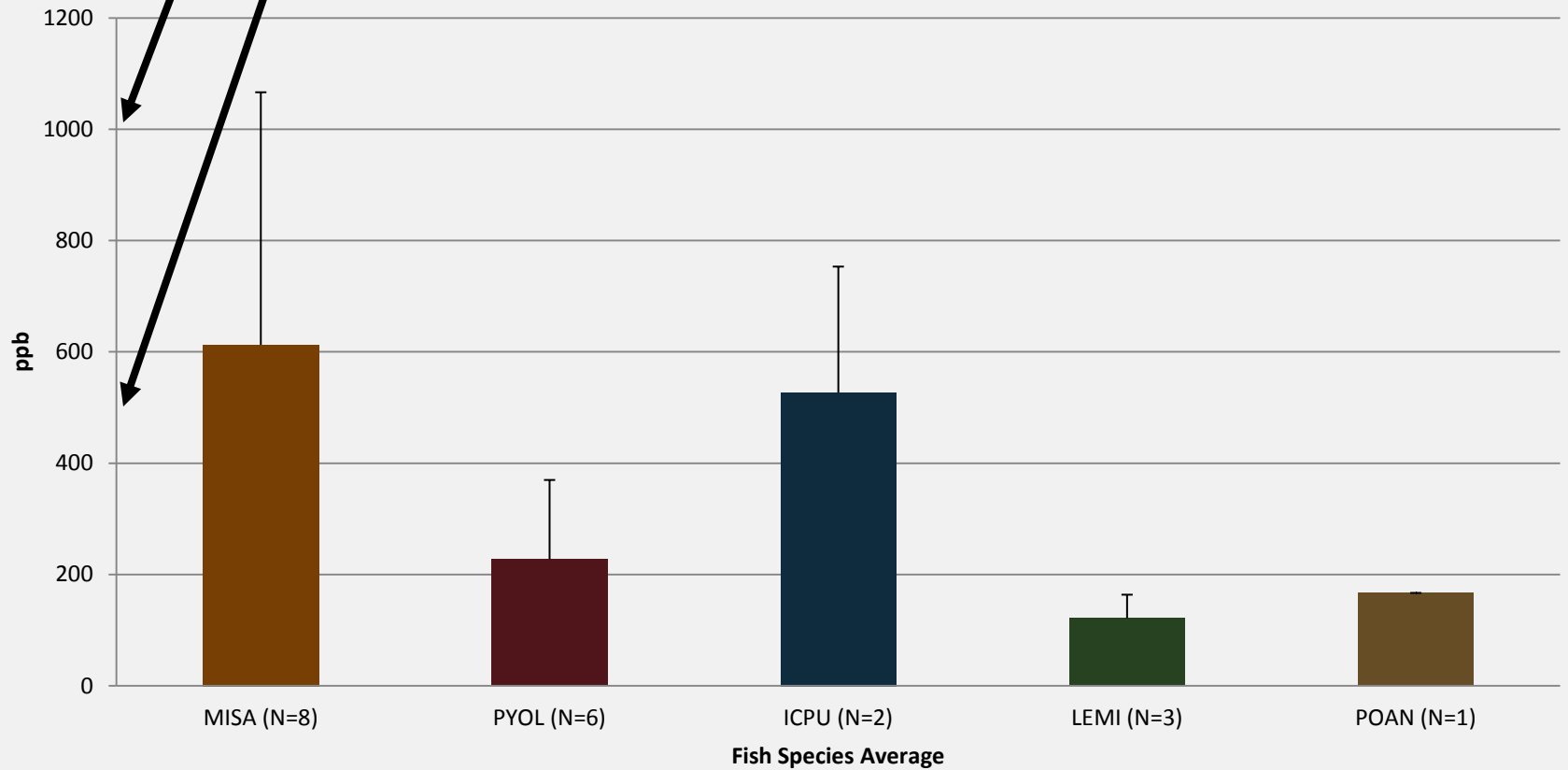


Mercury Levels in Patagonia Fish

FDA Action Level (fish tissue) = 1 ppm

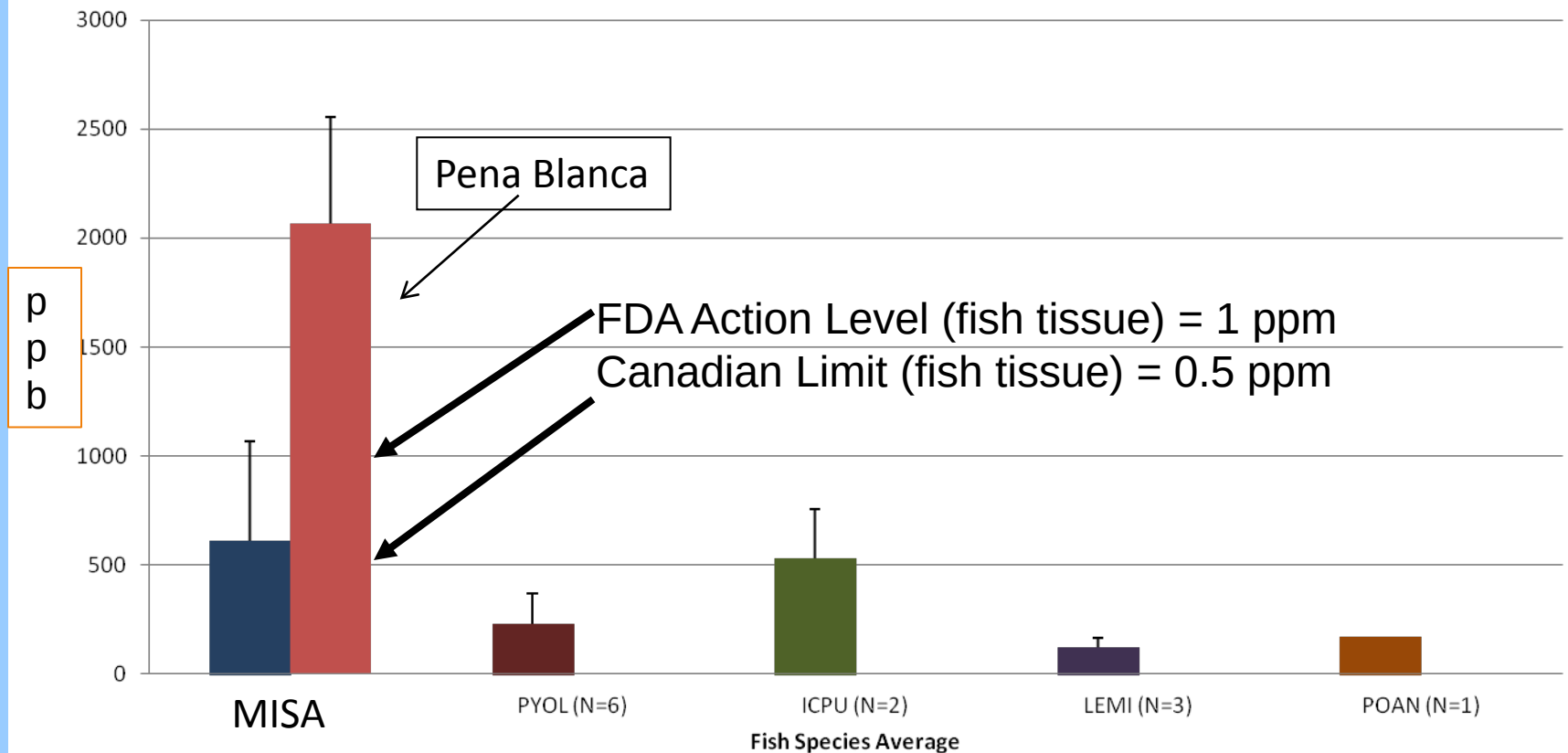
Canadian Limit (fish tissue) = 0.5 ppm

Mercury (Hg)



Mercury Levels in Fish (Patagonia vs Pena Blanca Lake)

Mercury (Hg)



Lead Point Source

- High Resolution Inductive Coupled Plasma Mass Spectrometry (HR-ICP-MS)
- Soil, water, and aquatic biota

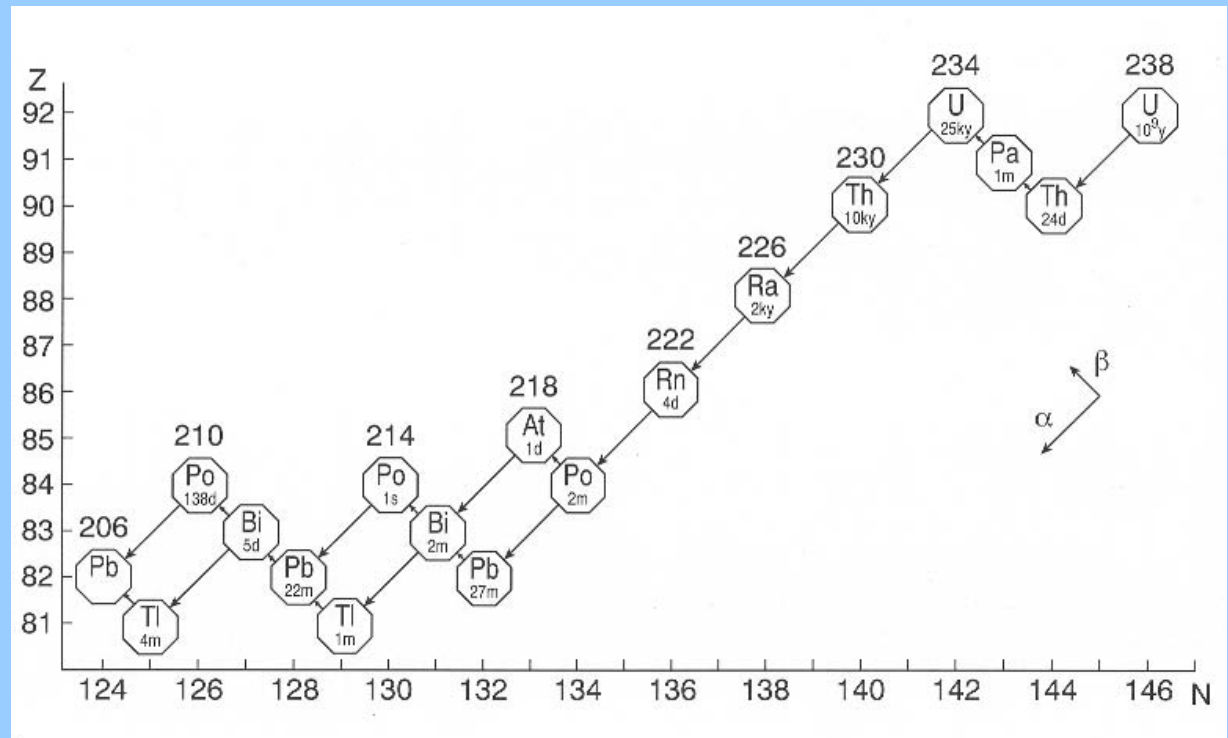


Why do Pb Isotopes Vary?

Half-Life

$^{238}\text{U} \rightarrow ^{206}\text{Pb} + 8^4\text{He} + 6\text{B}^- + \text{Q}$ ~4.468 billion yrs
 $^{235}\text{U} \rightarrow ^{207}\text{Pb} + 7^4\text{He} + 6\text{B}^- + \text{Q}$ ~0.738 billion yrs
 $^{232}\text{Th} \rightarrow ^{208}\text{Pb} + 6^4\text{He} + 4\text{B}^- + \text{Q}$ ~14.010 billion yrs
 ^{204}Pb ; primordial

Decay Chain for ^{238}U



Data Presentation

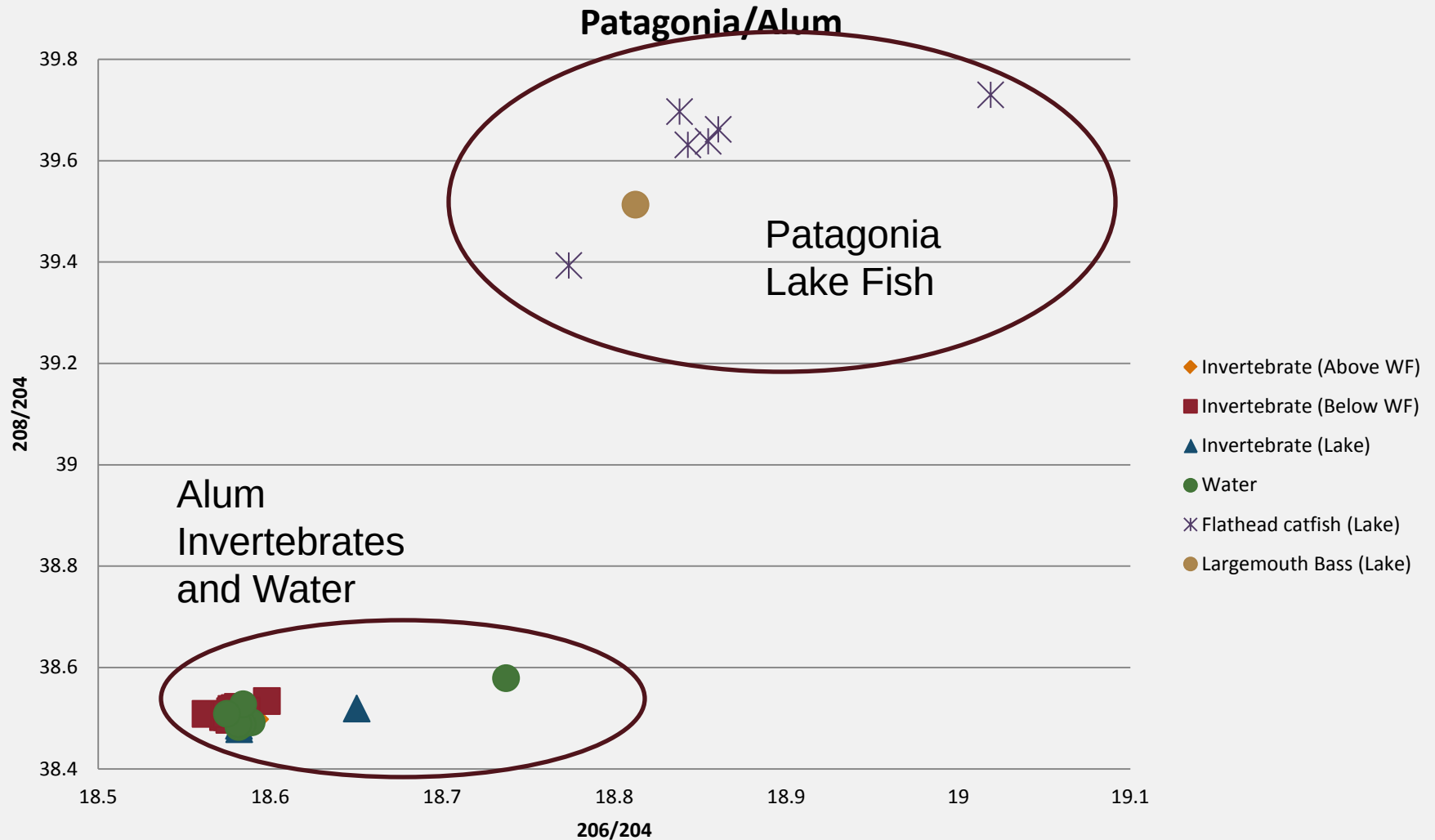


^{204}Pb non-radiogenic, least abundant isotope

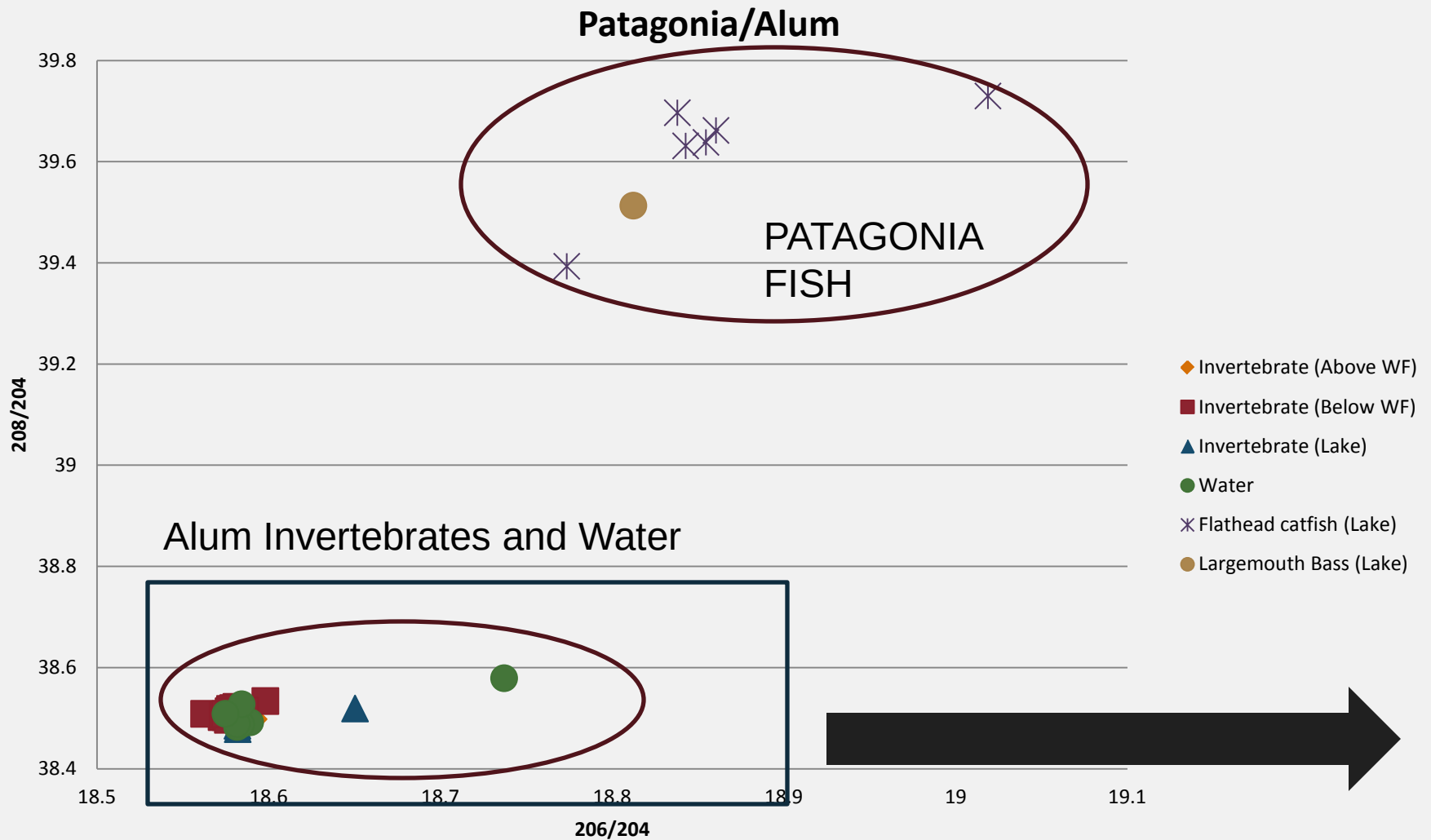
Ratios of ^{206}Pb , ^{207}Pb and ^{208}Pb to ^{204}Pb vary
due to age and geochemistry of Pb deposit or geology.

Strontium Isotopes - $^{87}\text{Sr}/^{86}\text{Sr}$

Lead Isotopes (Patagonia vs Alum)

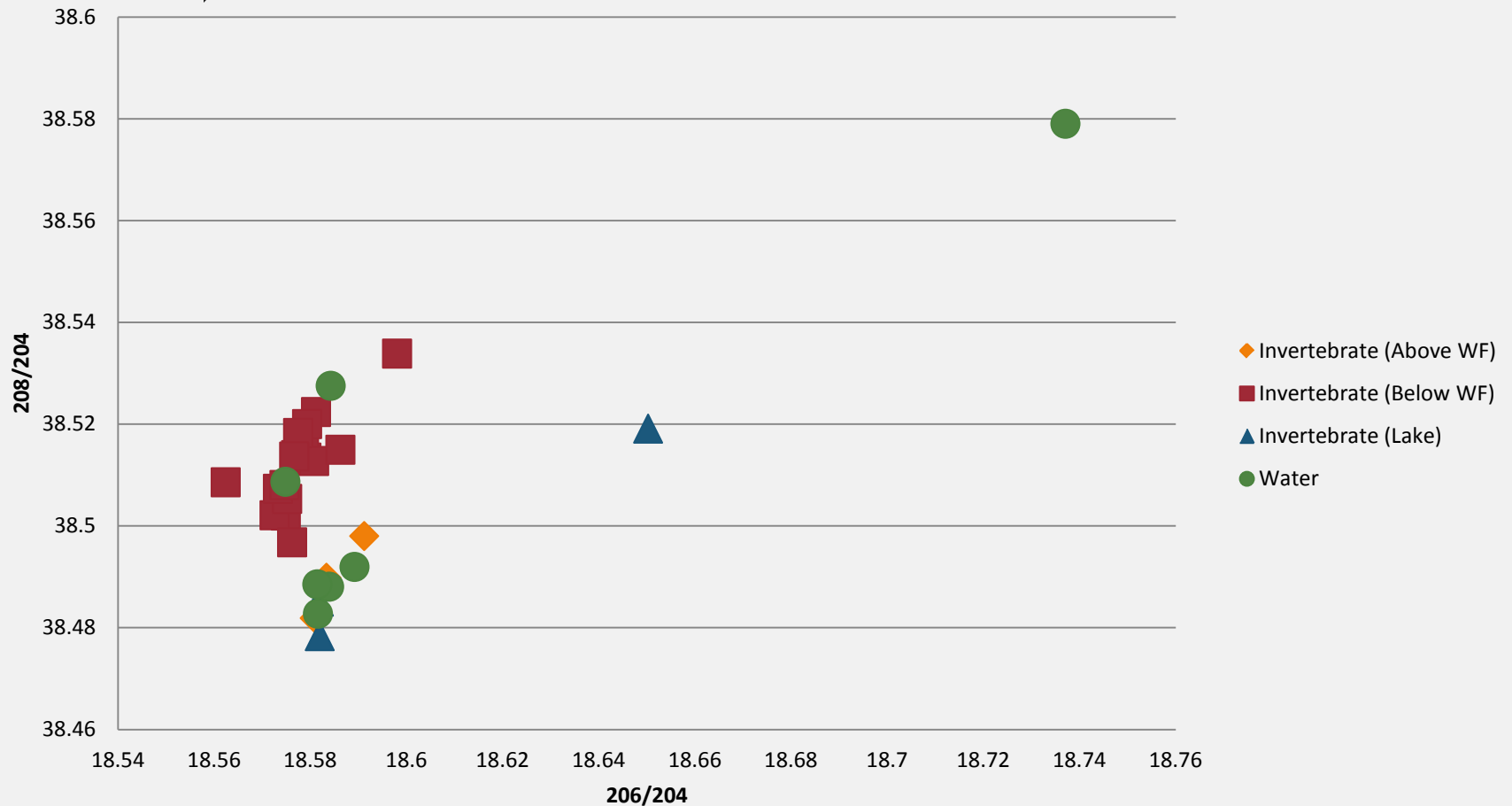


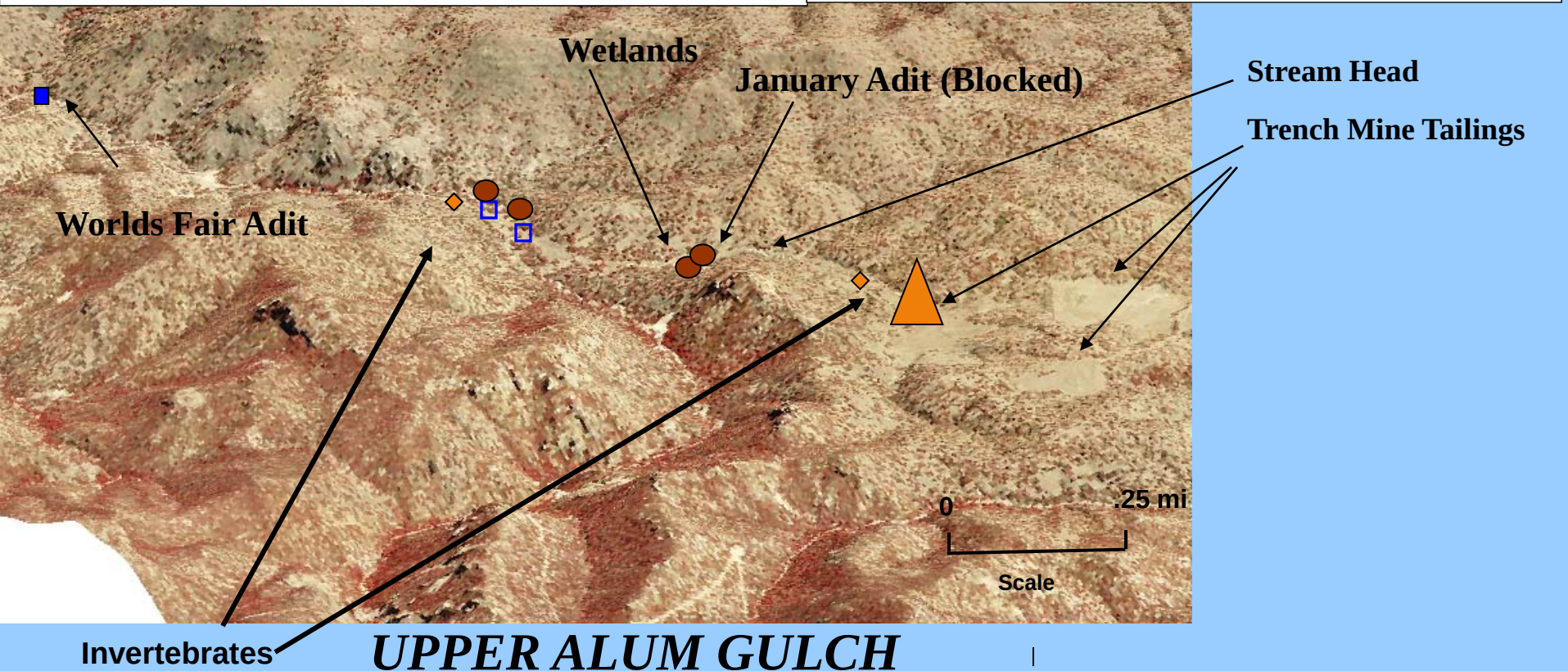
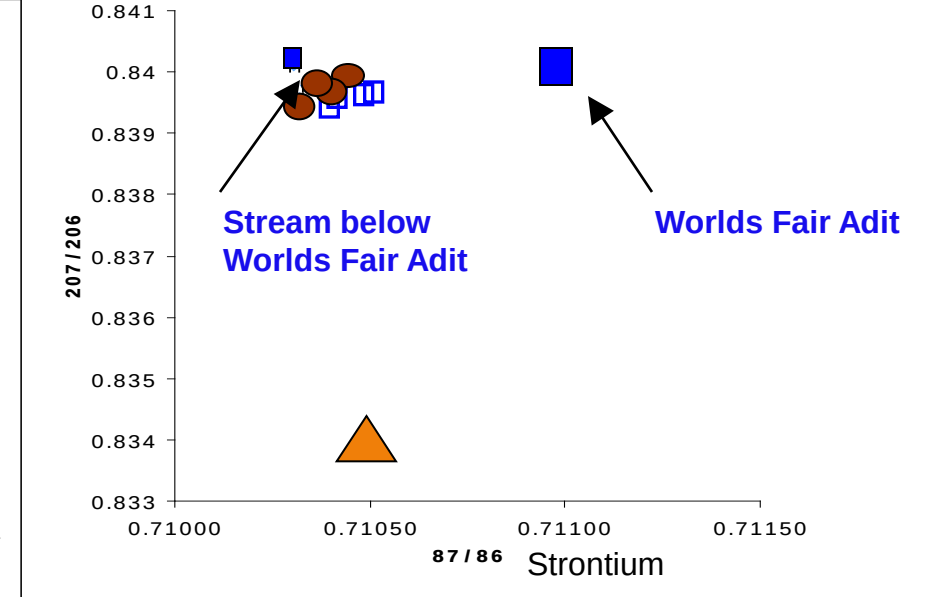
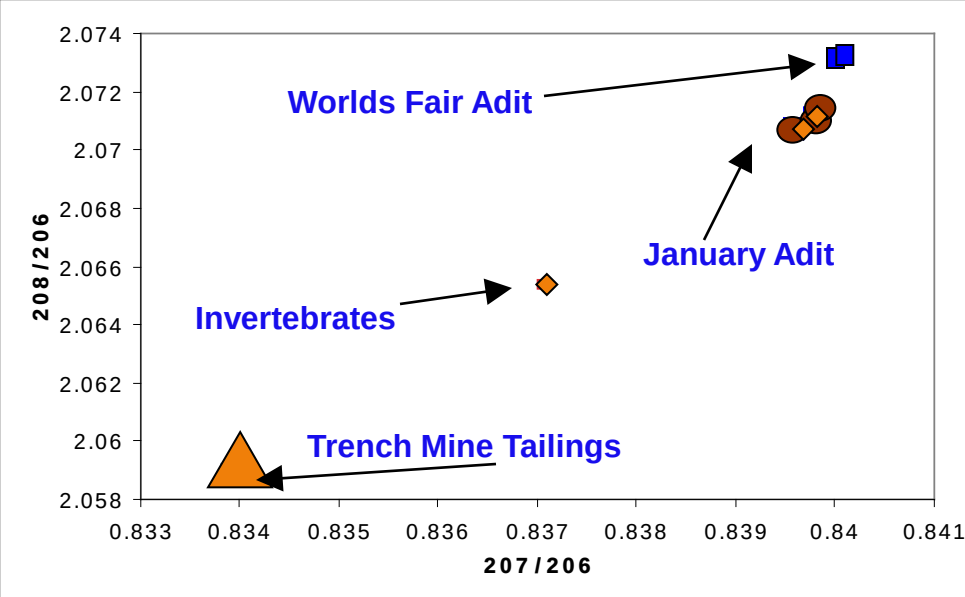
Lead Isotopes (Patagonia vs Alum)

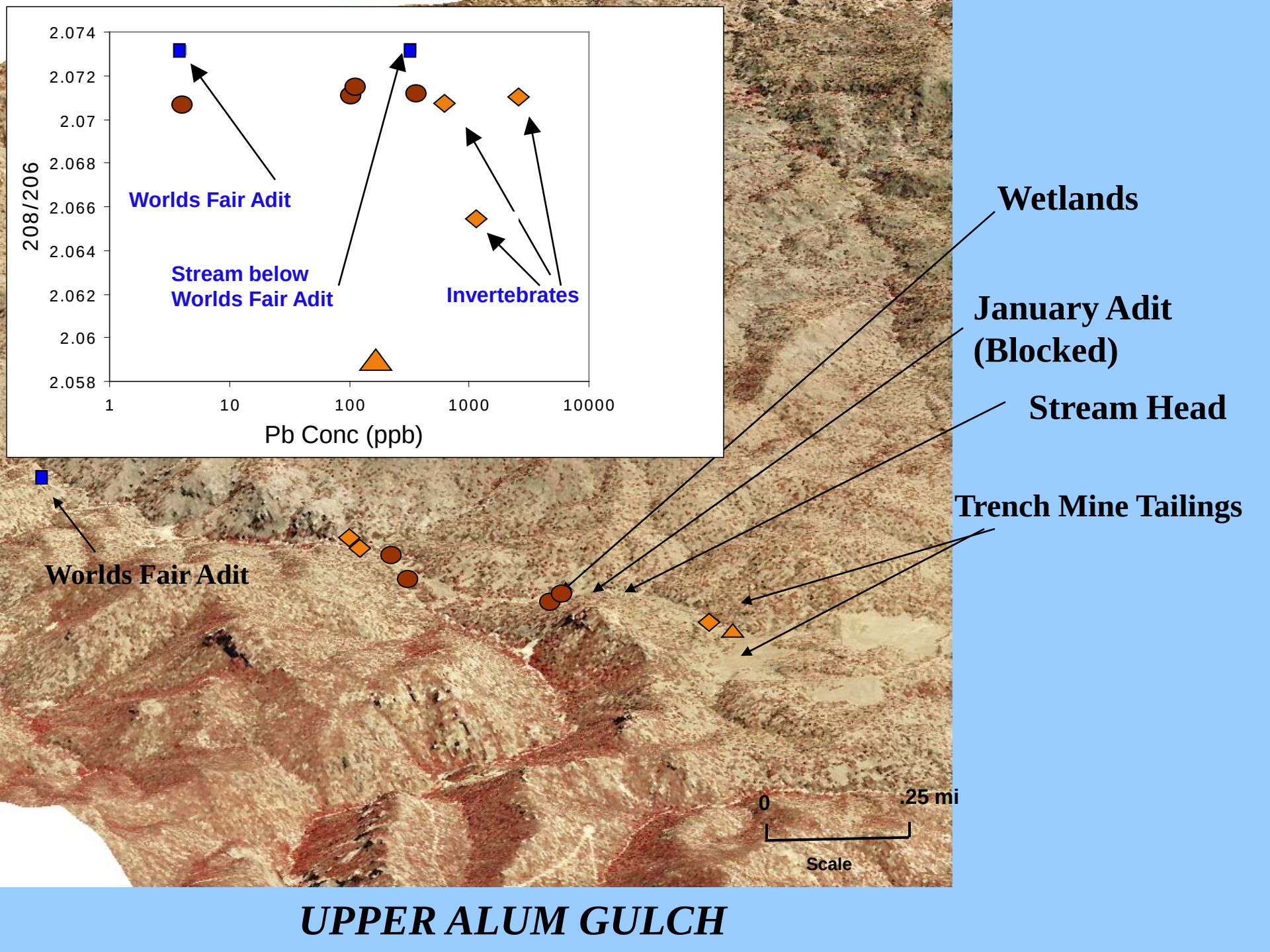
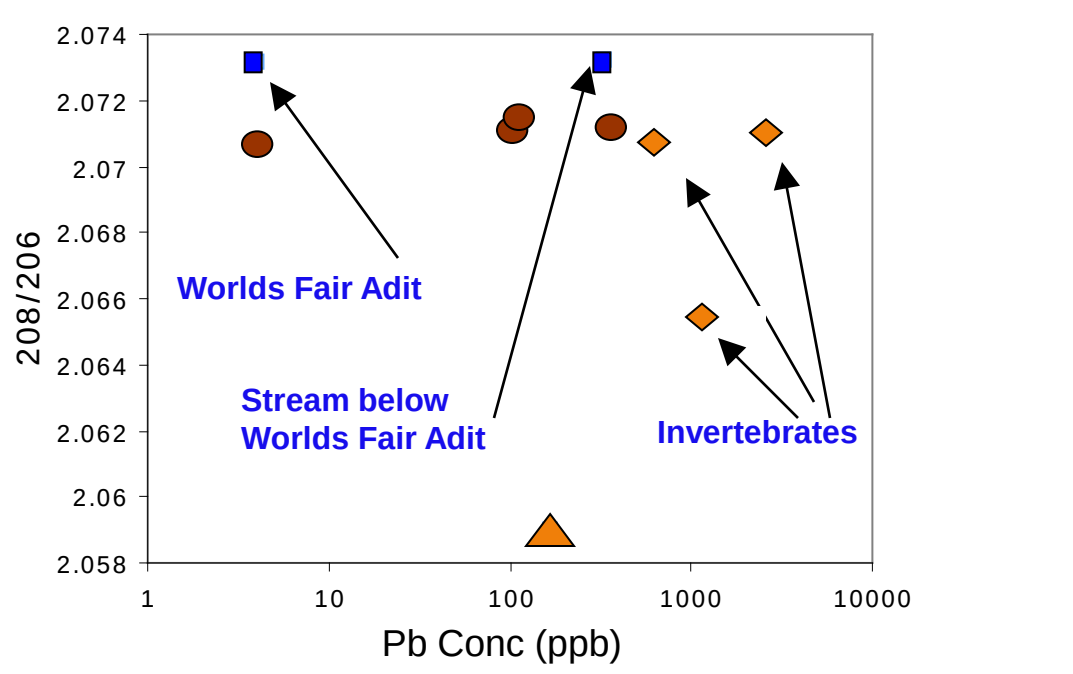


Lead Isotopes (with Alum)

Alum



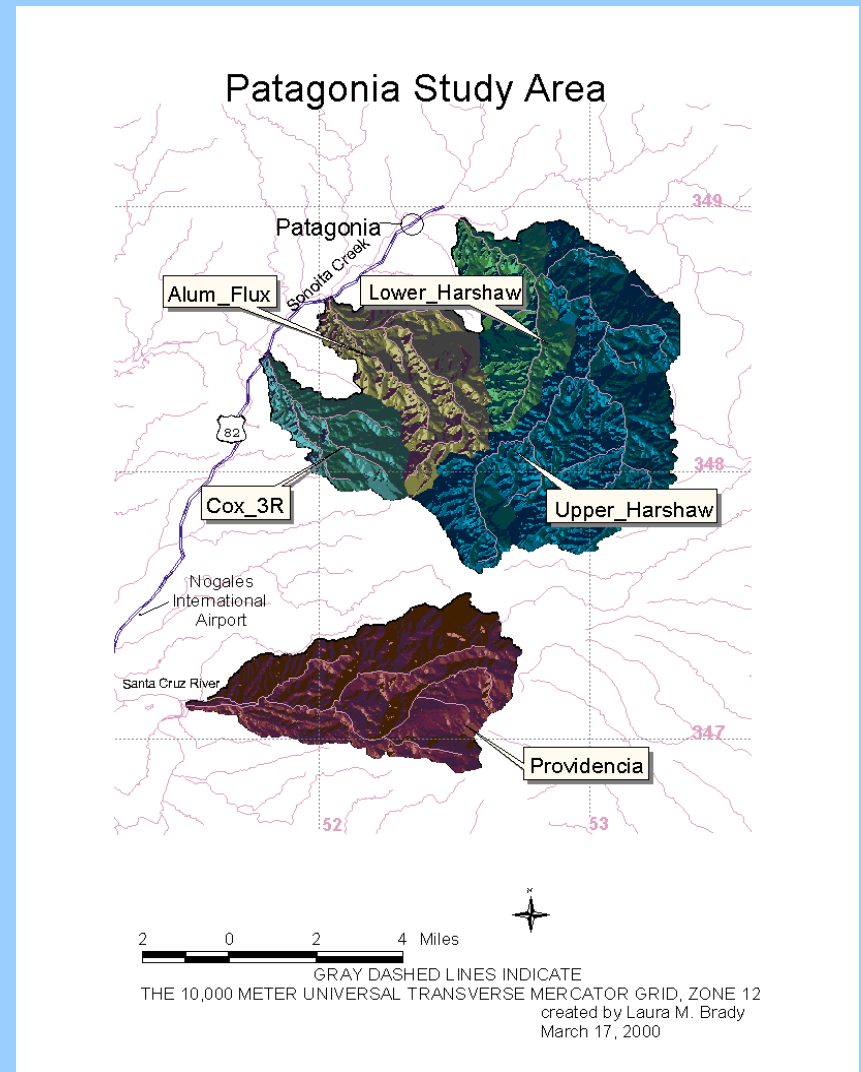




UPPER ALUM GULCH

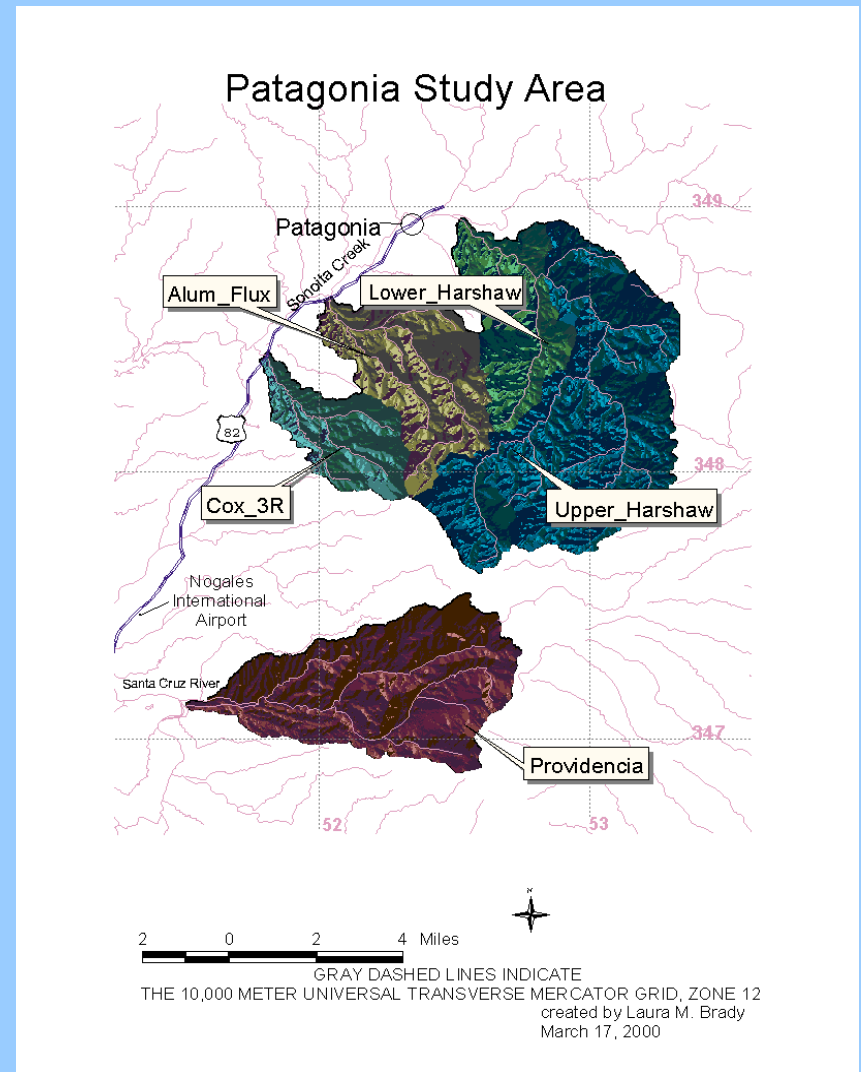
Conclusions

- Metal contaminants concern in aquatic systems
- Dust is major concern
- Alum/Patagonia different sources
- Do not eat Pena Blanca fish
- Need to develop tools and extend analyses



Future Direction

- Expansion of study site – need to look at entire watershed – including other watersheds (Providencia) and entire Santa Cruz
- Investigation into other isotopic systems used in geology/geochemistry:
 - $^{87}\text{Sr}/^{86}\text{Sr}$
 - $^{57}\text{Fe}/^{54}\text{Fe}$
 - $^{63}\text{Cu}/^{65}\text{Cu}$
 - $^{196}\text{Hg}/^{202}\text{Hg}$
 - $^{143}\text{Nd}/^{144}\text{Nd}$
 - $^{116}\text{Sn}/^{118}\text{Sn}/^{120}\text{Sn}$



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