Selenium in the KUCC Wetlands

Harry Ohlendorf
CH2M HILL
Sacramento, CA

Key Questions

- How can recent findings be explained?
- Should other variables be measured?
- What actions are appropriate as a result of findings?

Approach

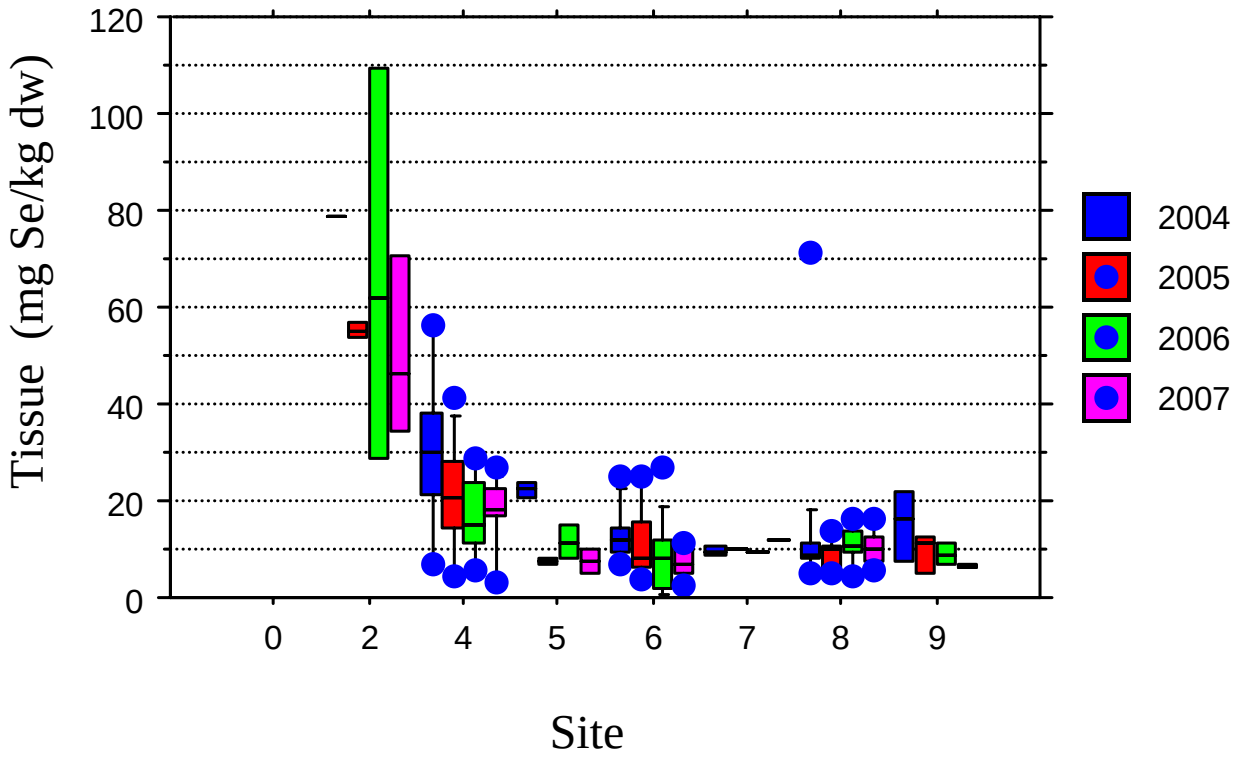
- Reviewed available information
  - Monitoring data 2003-2007
  - Construction/remediation and operational history
- Visited the site
- Provide conclusions and recommendations (here and in technical memorandum)

Approach (cont'd)

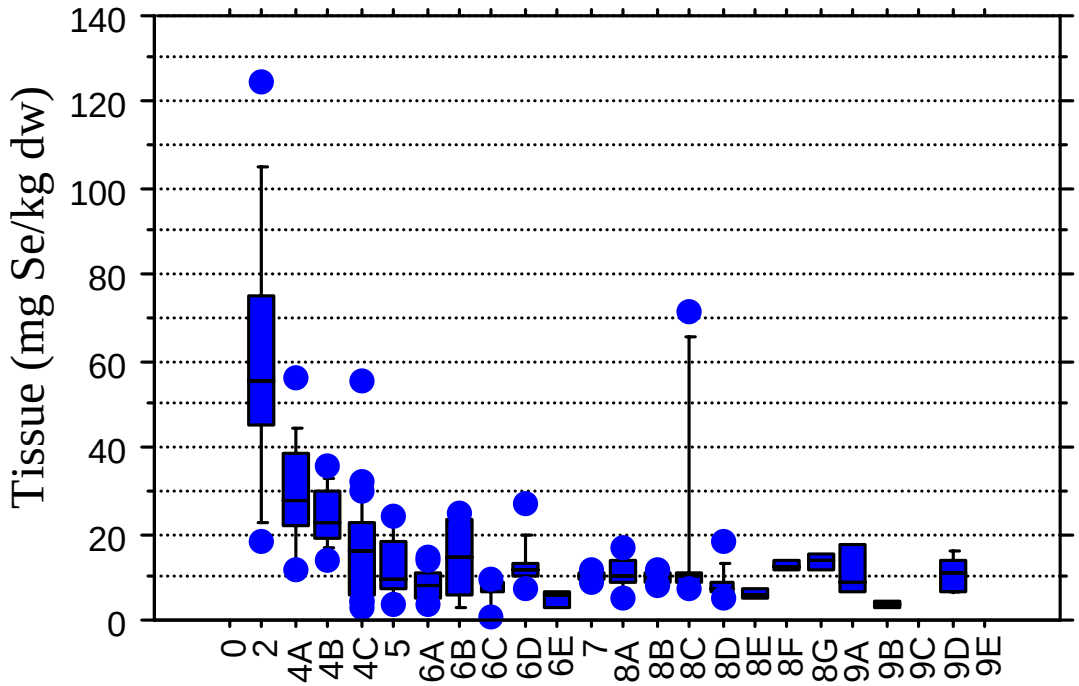
- Reviewed biota data for
  - Temporal patterns
  - Spatial patterns by pond/subarea within ponds
  - Associations between abiotic media and tissue for factors potentially affecting bioaccumulation
  - Tissue concentrations and BAFs/BSAFs for different trophic levels of invertebrates
- Considered possible further sampling and potential treatment/remediation

Temporal and Spatial Patterns

- Results for 2004-2007 most useful, so focused on those
- Sites 10-12 substantially different than Sites 2-9, so considered them separately
- Site 13 sampled only in 2004



Tissue concentrations by site and year



Sites 2 – 9. All years, all tissue data, individual sites

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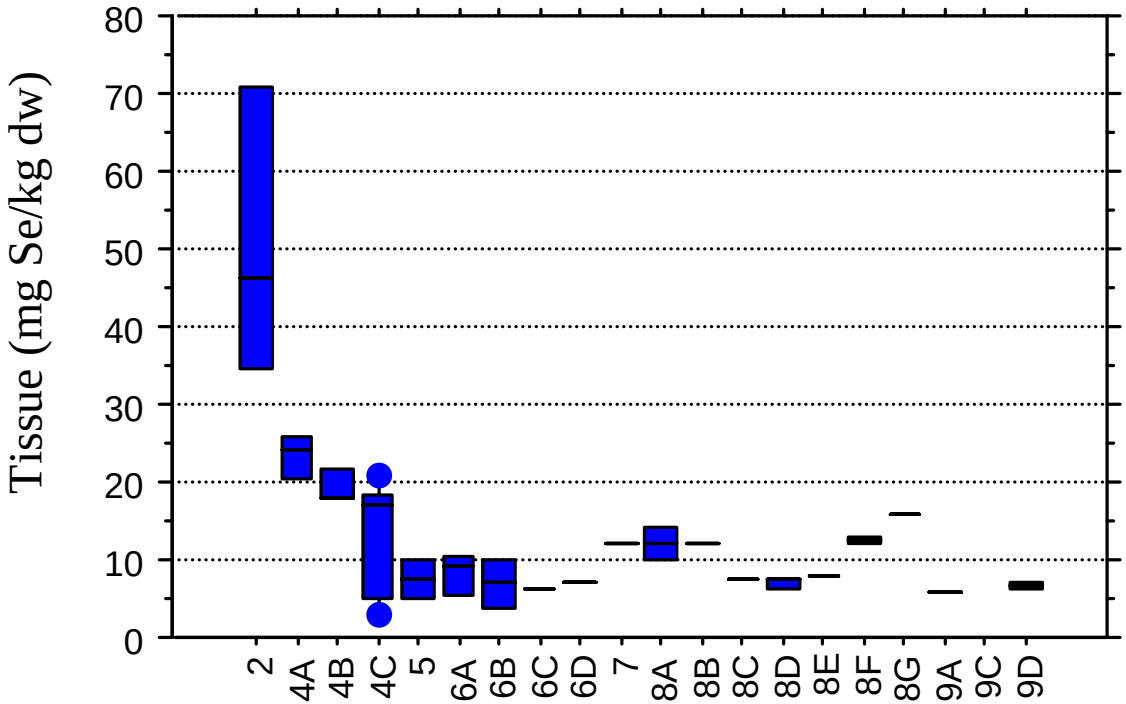

2007 Only. Sites 2 – 9, individual sites

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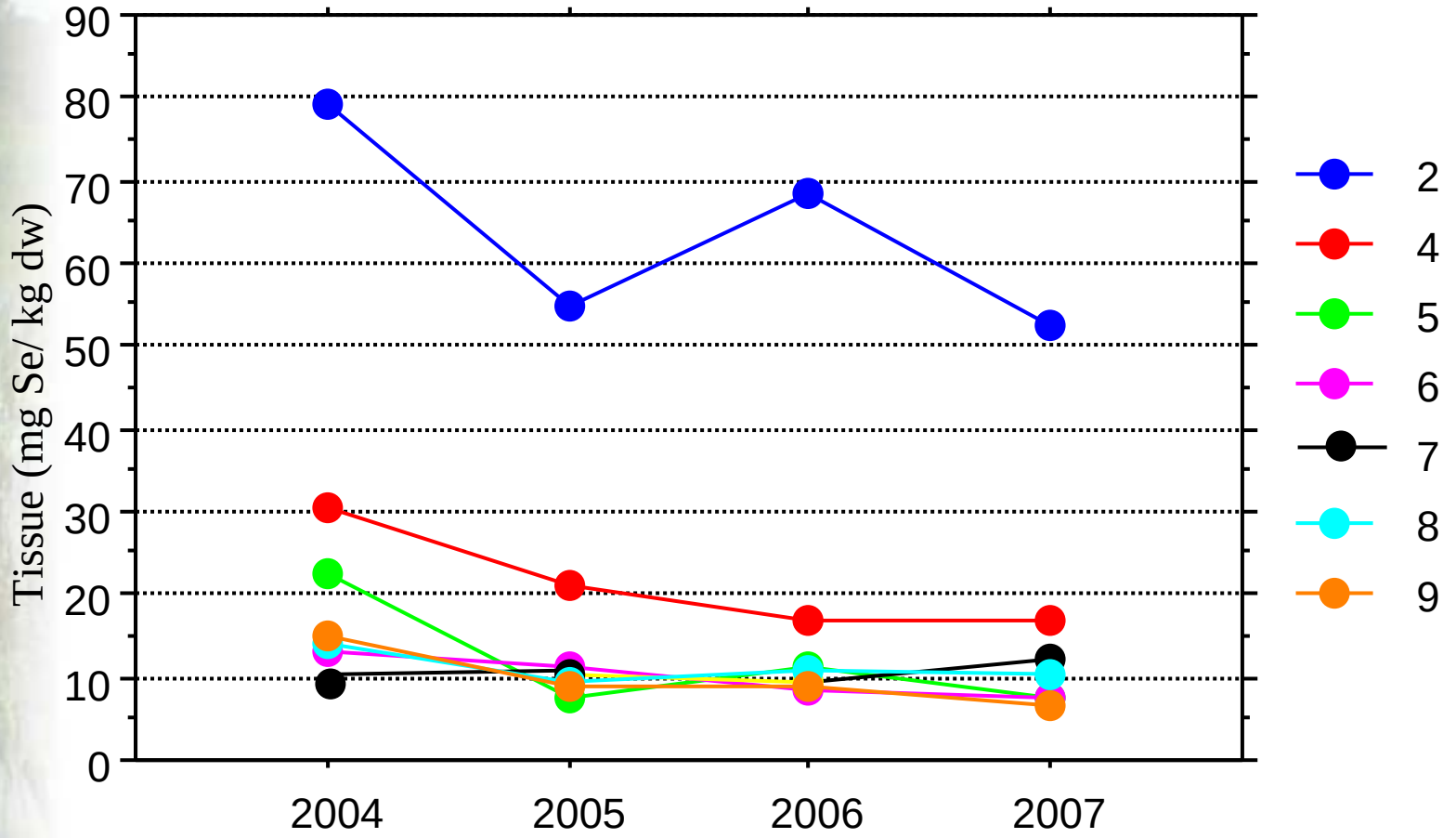
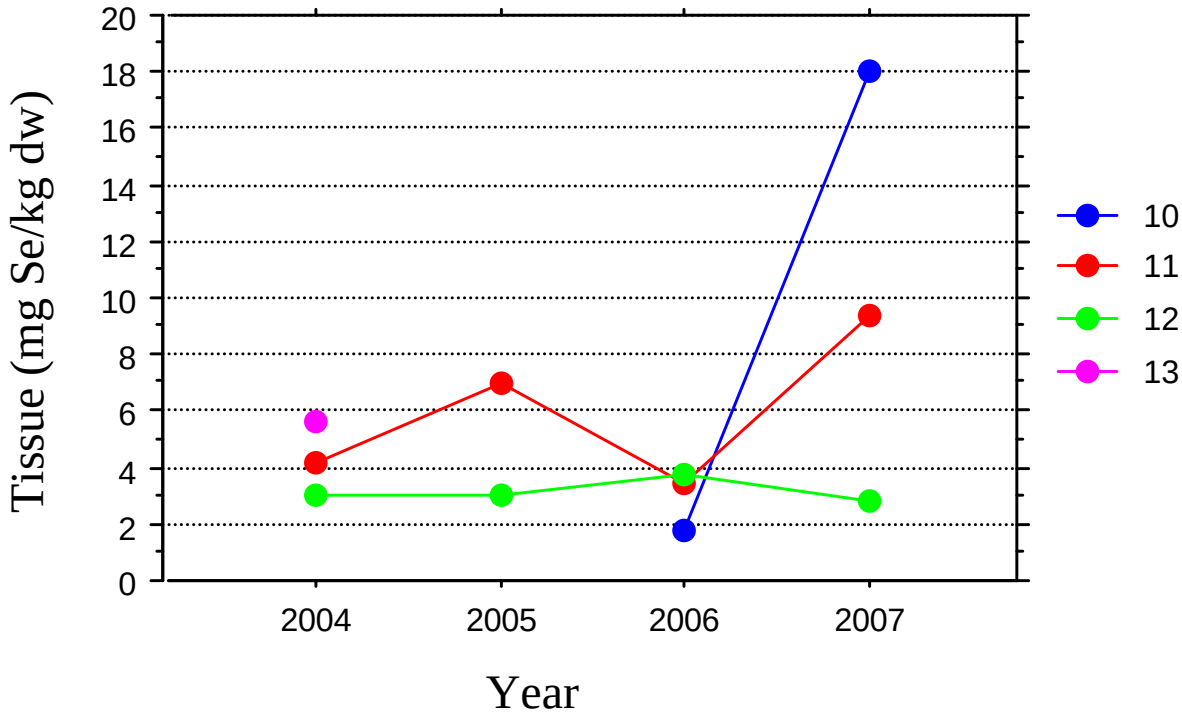


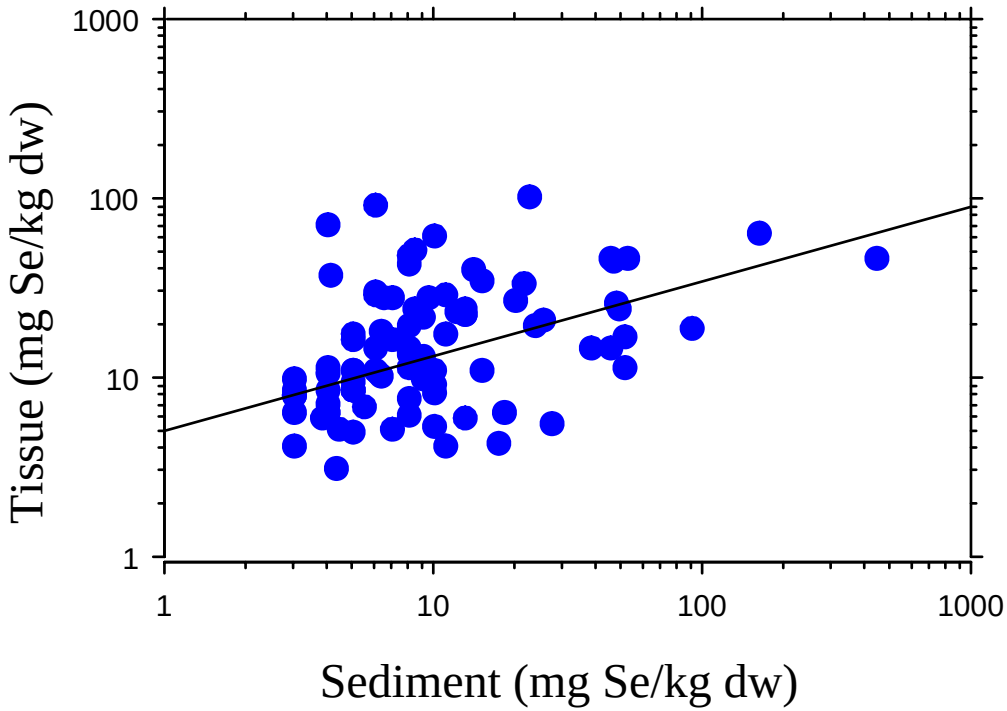
Sites 2 – 9. Average tissue concentrations by site by year



Sites 10 – 13. Average tissue concentrations over time

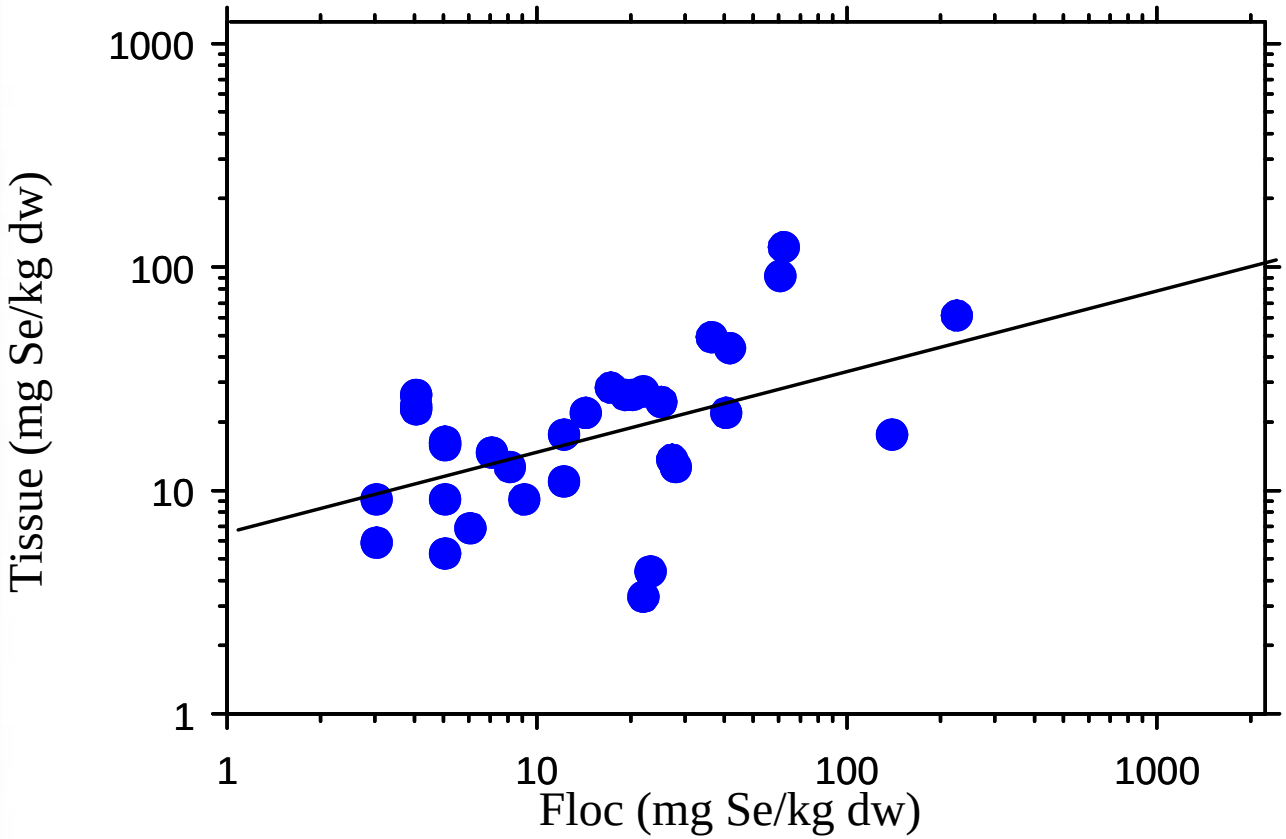
Associations between Abiotic Media and Bioaccumulation

- Factors considered (i.e., data available)
  - Sediment and floc
    - *Selenium*
    - *TOC*
  - Water
    - *Selenium*
    - *Sulfate*
    - *TDS*
    - *pH*



Sediment vs. tissue; all sites, all years

Tissue = 10^((0.414*Log sediment Se) + 0.787),
$r^2 = 0.227$, $P < 0.001$



All tissue samples vs. floc, 2006-2007

Tissue Se = 10^((0.392*Log floc Se)+0.801),
r^2 = 0.273, P = 0.0021

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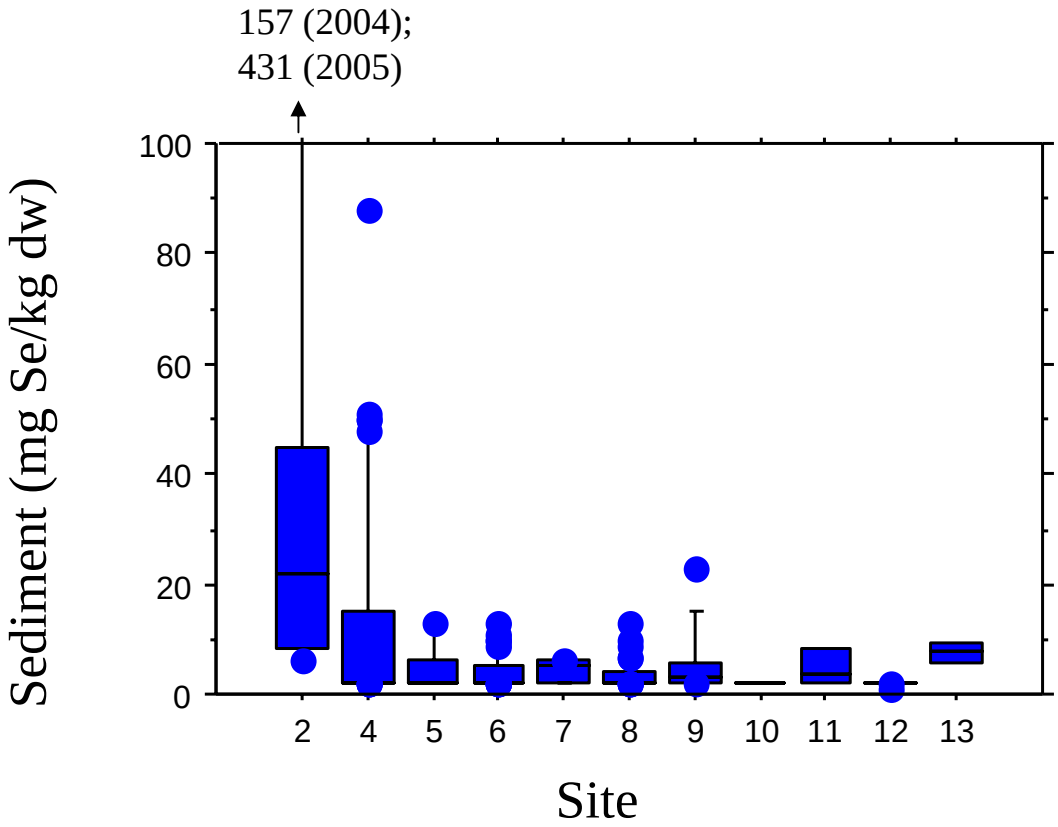
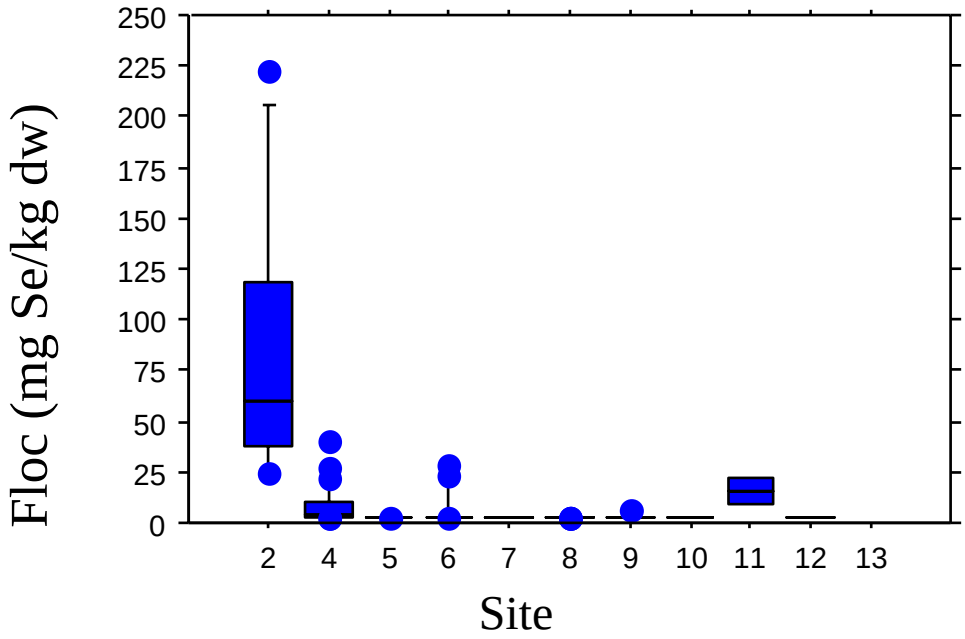


Sediment selenium concentrations by site, 2004 – 2007



Floc selenium concentrations by site, 2006-2007

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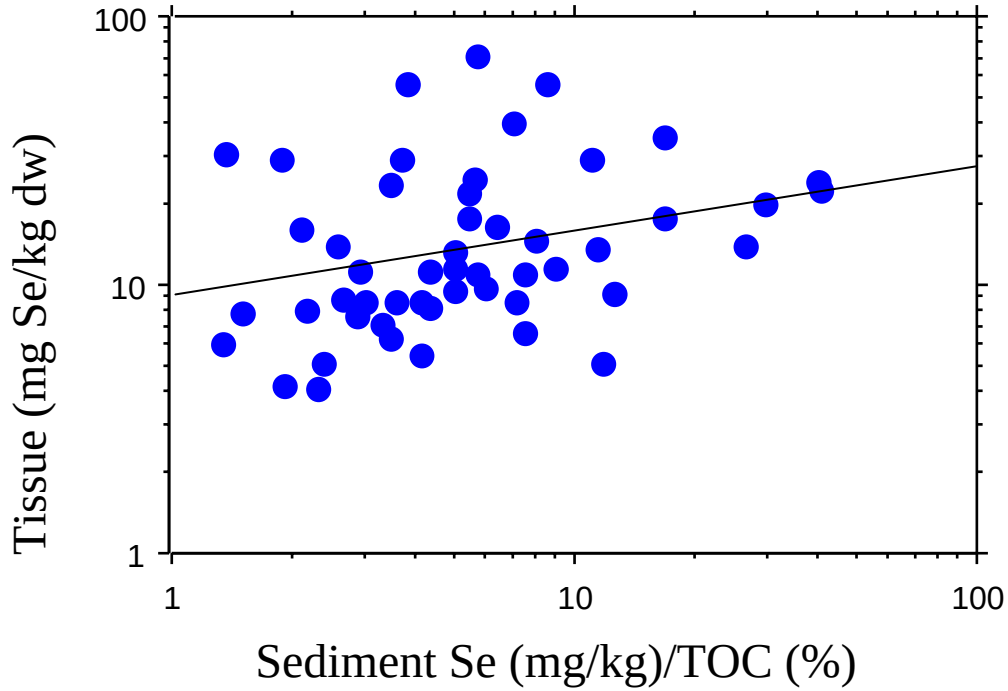

Sediment selenium normalized to percent TOC vs. tissue selenium, 2004

Tissue = 10^((0.265*Log sediment Se) + 0.934),
r2 = 0.1, P = 0.024

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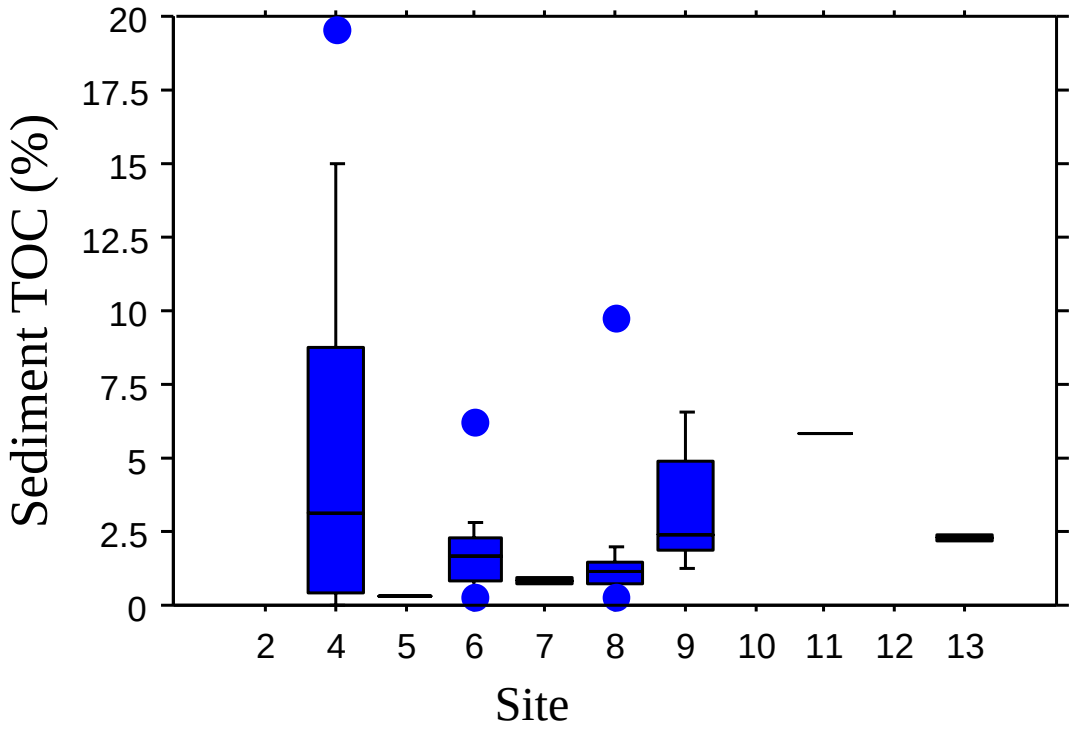
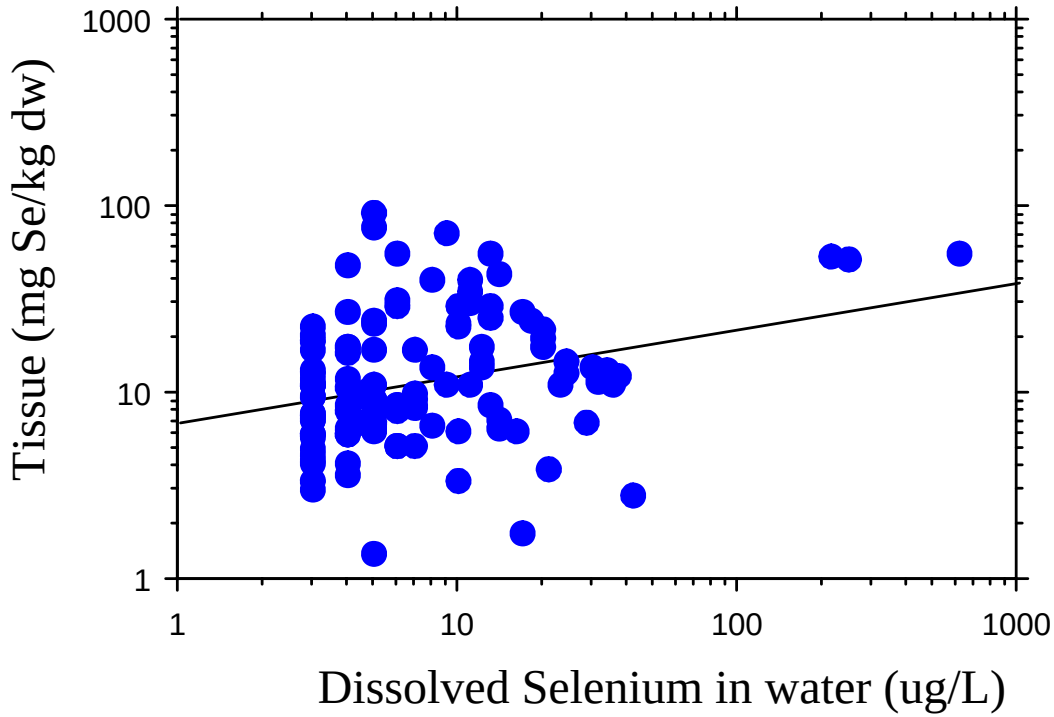


Sediment percent Total Organic Carbon (TOC) by site, 2004



Invertebrate tissue selenium as predicted from waterborne selenium; all sites, all years

Tissue Se = 10^ ((0.247*Log diss. water Se)+0.849)
r2 = 0.078, P = 0.0021

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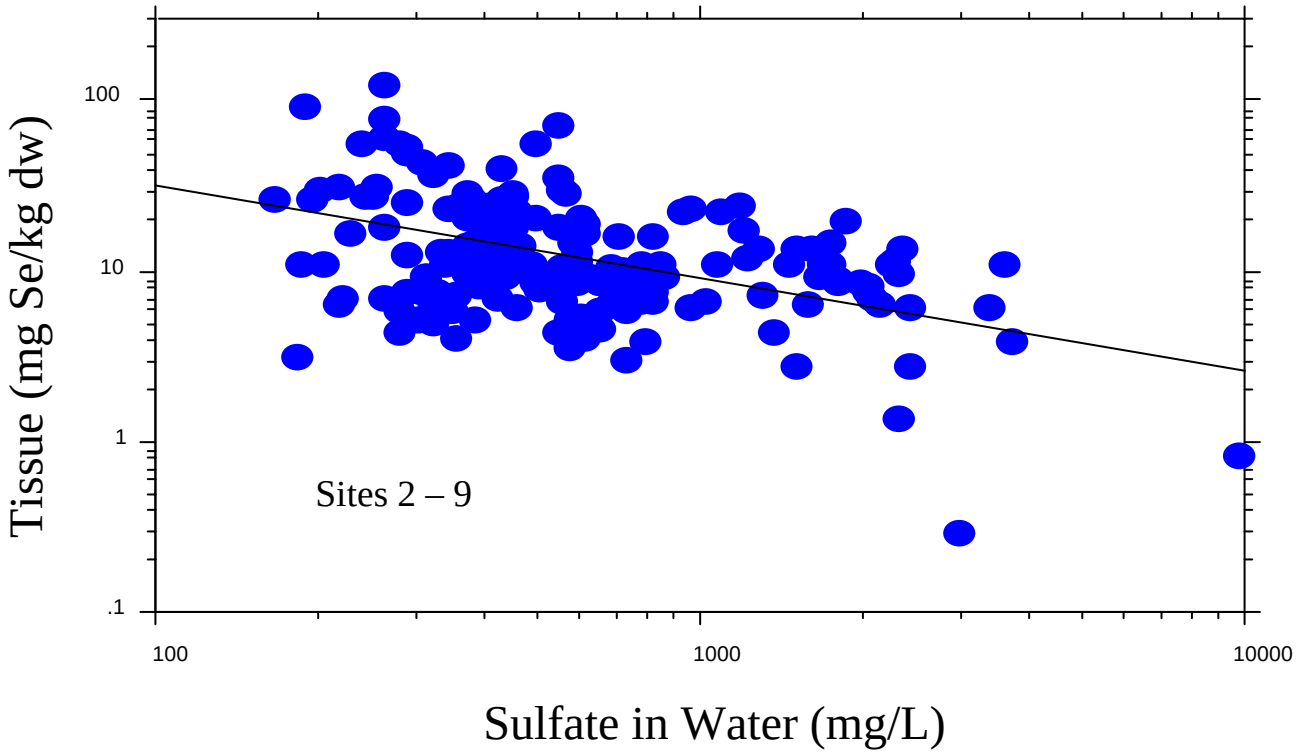
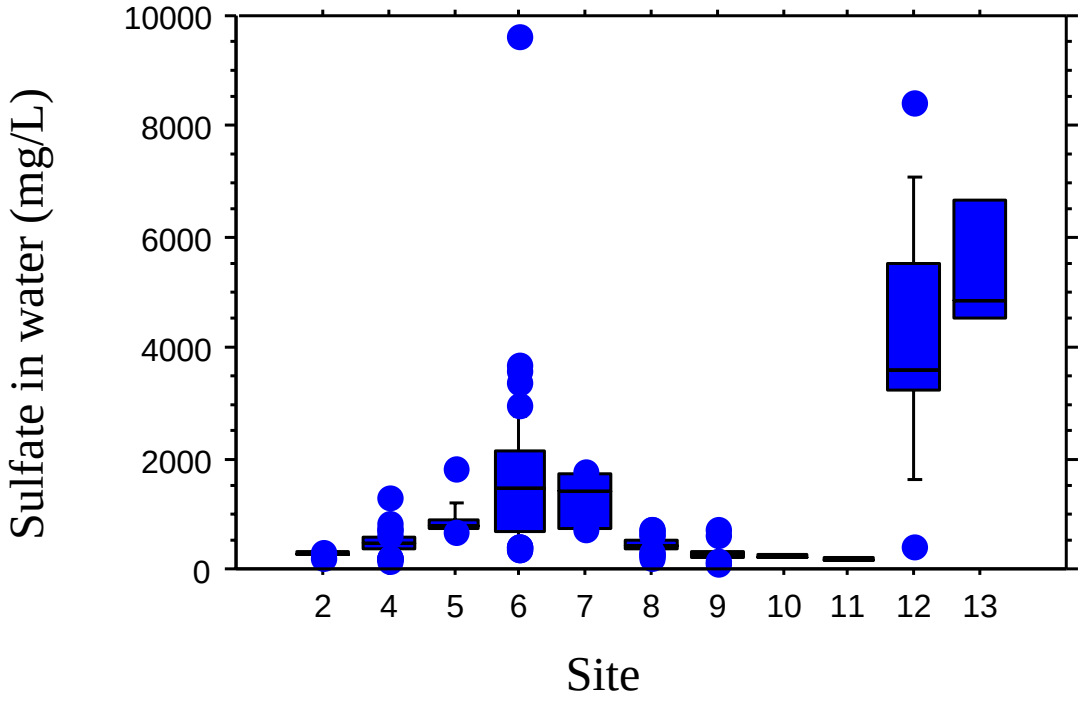


Tissue Se = 10^(2.461 – (0.499 * Log sulfate));
$r^2 = 0.197$, $P < 0.001$



Sulfate concentrations by site, 2004 – 2007

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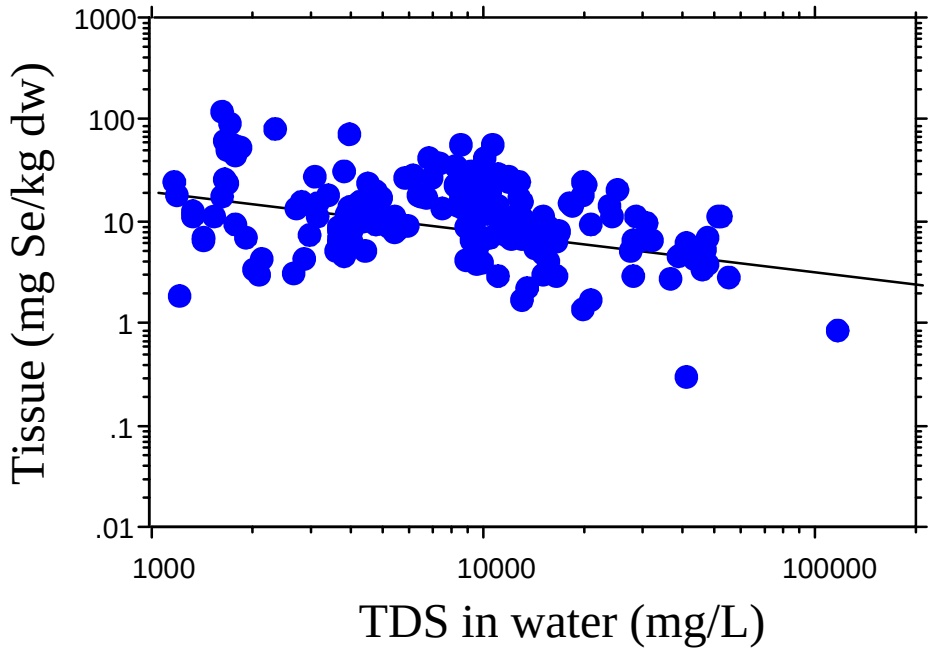

Invertebrate tissue selenium as predicted from waterborne Total Dissolved Solids (TDS); all sites, all years

Tissue Se = 10^ ((-0.32*Log TDS)+2.274)
r2 = 0.118, P < 0.001

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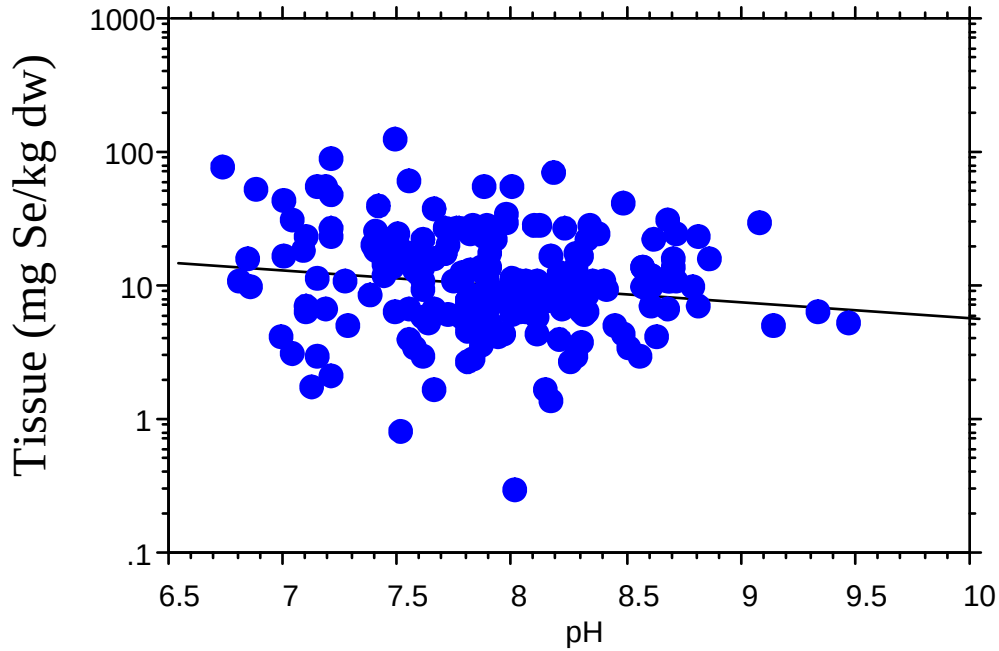

Invertebrate tissue selenium as predicted from waterborne pH; all sites, all years

Tissue Se = 10^ ((-0.114*pH)+1.943)
r2 = 0.024, P = 0.0084

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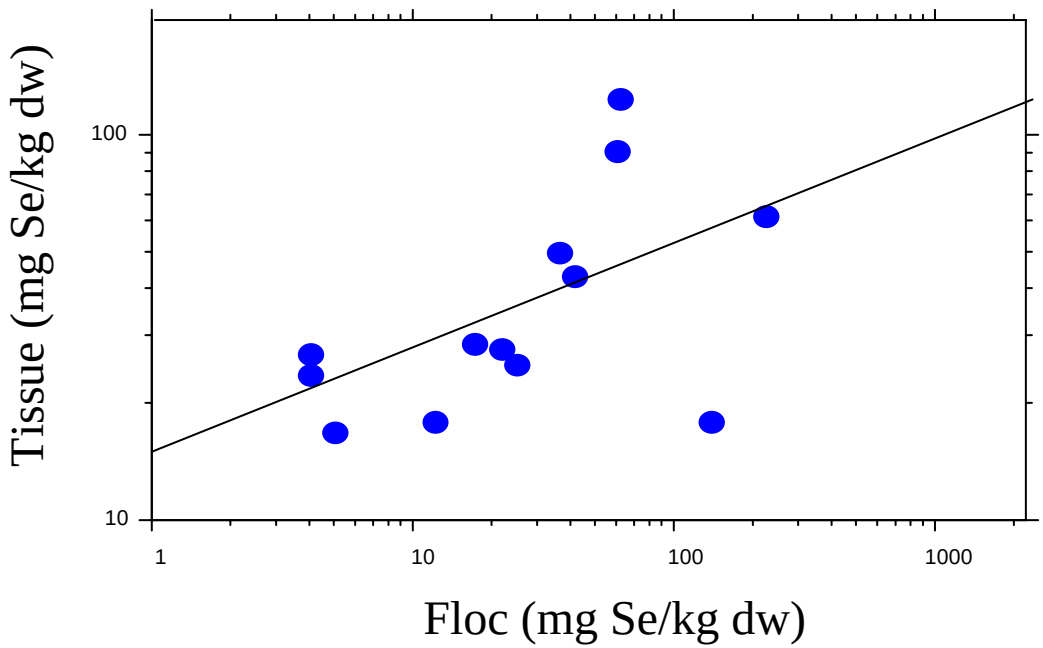
Tissue Concentrations and Trophic Levels of Invertebrates

- No significant association between floc Se and tissue of predators (odonates, beetles, bugs)
- Variable but positive association between floc Se and tissue of herbivores and detritivores (fly larvae, midges)



Dipteran larvae tissue Se vs. floc Se

Tissue Se = 10^(1.166 + (0.269*log floc Se))
r^2 = 0.293, P = 0.056

Conclusions

- Some “lows” in Se concentrations are based on very small samples (6A3 and 10 in 2006)
- Waterborne Se is generally so low that speciation would be difficult
- There is clear association of higher levels of invertebrate tissue Se with higher Se in floc and sediments
- Lower level of bioaccumulation occurs in ponds with higher levels of waterborne sulfate
- Tendency toward less bioaccumulation with higher TDS and pH of pond water

Conclusions (cont'd)

- Tendency toward highest levels of Se bioaccumulation in midges and other fly larvae rather than predators like dragonflies (although differences may be pond-specific)
- In general, Ponds 2 - 9 show these associations more clearly than do Sites 10 - 12
- Overall, results indicate that problematic levels of Se bioaccumulation are reached through a benthic food web of sediment-associated invertebrates (dipteran larvae) linked to organic-enriched floc or sediments

Uncertainties/Questions

- Is there a shallow groundwater influence?
- How do the highest bioaccumulation areas compare in terms of porewater or near-bottom Se, sulfate, TDS, and pH?
- How do the highest bioaccumulation areas compare in terms of redox potential (Eh) at the sediment-water interface?
- Is it possible to collect sufficient invertebrate biomass so they could be separated by taxa?

Uncertainties/Questions (cont'd)

- Are there fish to sample in some of the ponds?
- How much bird use is there of the higher-Se areas, and do their eggs reflect elevated dietary exposure?

Recommendations

- Fill in Pond 2 ditch
- Measure Se, sulfate, TDS, and pH in porewater and near-bottom water
- Measure redox potential (Eh) at the sediment-water interface to assess conditions affecting bioavailability of Se
- Do not separate floc and sediment; continue to measure TOC in surficial sediment (top 3 inches)
- Consider additional approaches for collecting sufficient invertebrate biomass so they could be separated by taxa

Recommendations

- Where possible, sample fish in addition to invertebrates
- Assess level of bird use of the higher-Se areas, and collect eggs to determine if they reflect elevated dietary exposure