

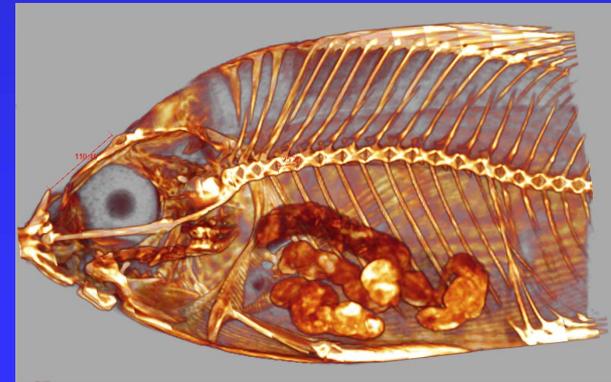
Assessment of Fish Population Health in the Vicinity of the Kingston Fly Ash Release

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Mark Greeley - ORNL



Presentation Outline

- Research objectives
- Study Design
- Results and major findings
 - *individual responses*
 - *integrated (holistic) responses*
 - *causal relationships*
- Relevance and application

Objectives of Fish Health Studies

Determine if fly ash exposure is causing short and/or long-term health effects on representative (sentinel) fish populations

Evaluate potential causal relationships between bioaccumulation of metals in fish tissue and various indicators of fish health

Study Design

Sample Frequency

spring and fall each year since spring 2009

Fish Species Sampled

Spring - bluegill, largemouth bass, redear sunfish,
and white crappie

Fall - bluegill, largemouth bass, and channel catfish

Sample Sites

- 6-7 sample sites along downstream gradient of Emory and Clinch Rivers
- includes 2 instream reference sites

Health Indicators Measured

- *condition indices*
- *bioenergetic indices*
- *histopathology*
- *organ dysfunction*
- *carbohydrate-protein metabolism*
- *electrolyte homeostasis*
- *feeding and nutrition*

Fly Ash Spill

Exposure of Fish to Metals

Focus on sentinel species
(different trophic levels and home ranges)

- sunfish
- bass
- catfish
- crappie

Bioaccumulation
25 metals + Hg

Assess Effects and Causality

Analysis of Fish Health

Whole fish

Muscle

Liver

Ovary

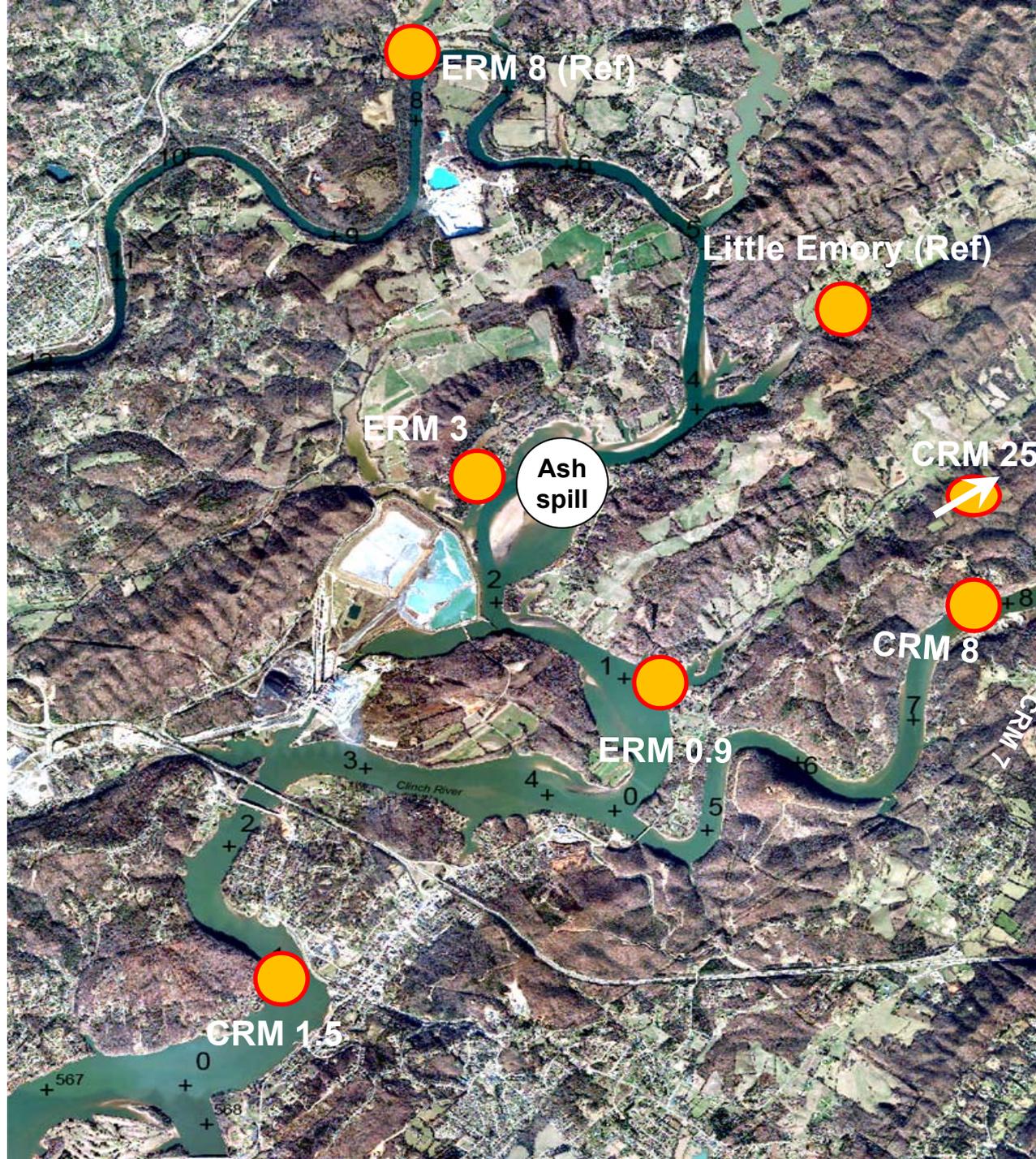
Physiological

Reproductive

Histopath

Bio-energetic

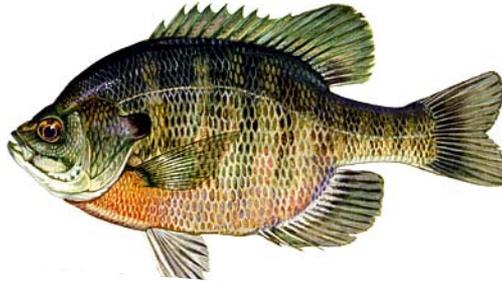
Sample Sites



Sentinel species for bioaccumulation and fish health studies

Bluegill

- mid trophic level/omnivore
- restricted home range

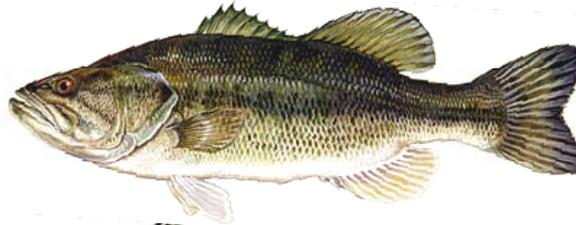


Types of Studies

Bioaccumulation, fish health, and reconstruction analysis

Largemouth bass

- upper trophic level/predator
- intermediate home range



Bioaccumulation, fish health, and reconstruction analysis

Channel catfish

- bottom feeder/omnivore
- large home range



Bioaccumulation and fish health

Redear Sunfish

- exclusive molluscavore
- high site fidelity



Bioaccumulation, fish health, & trophic analysis (stable isotopes)

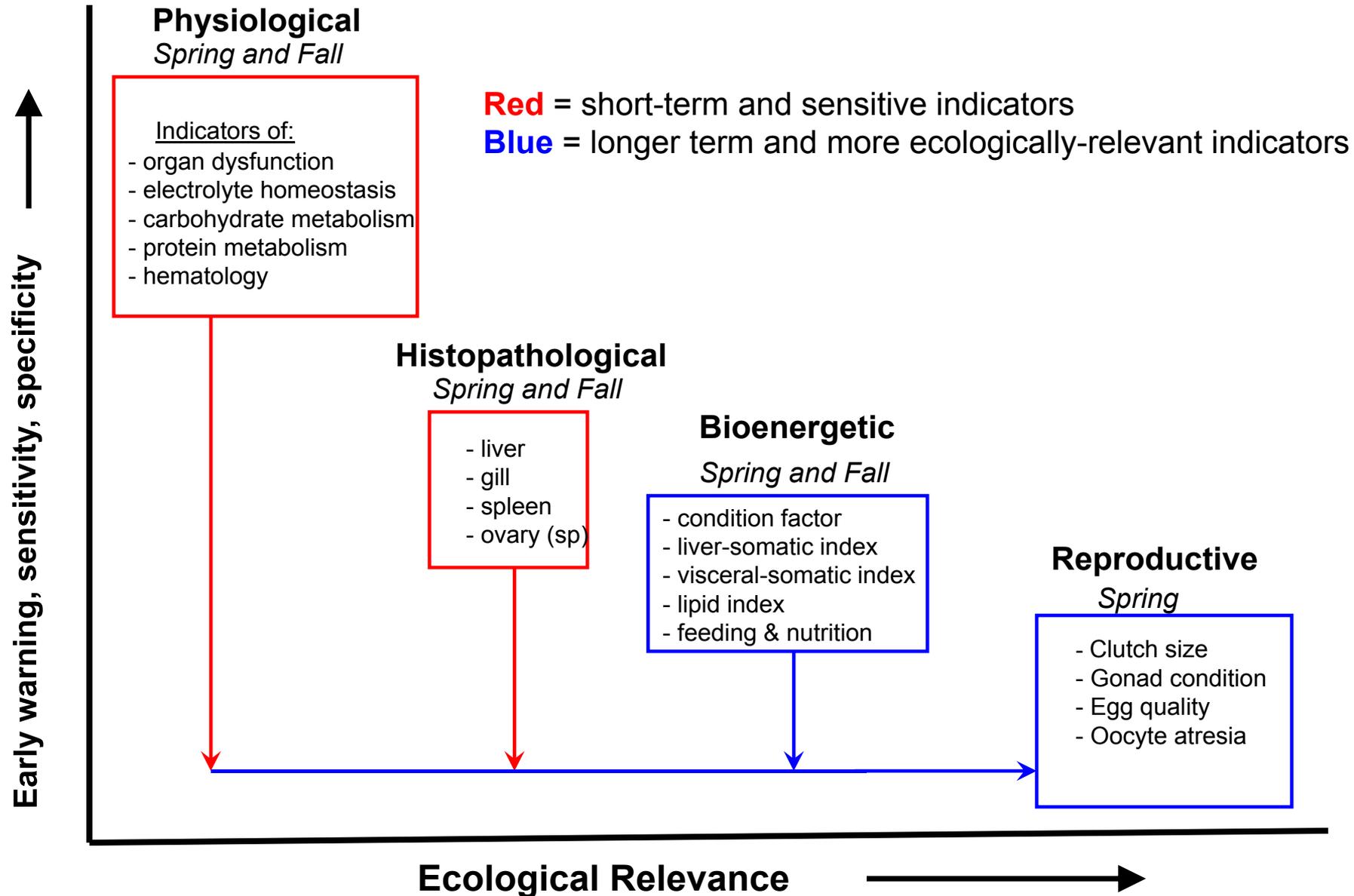
Gizzard Shad

- feeds on detritus & periphyton
- large home range

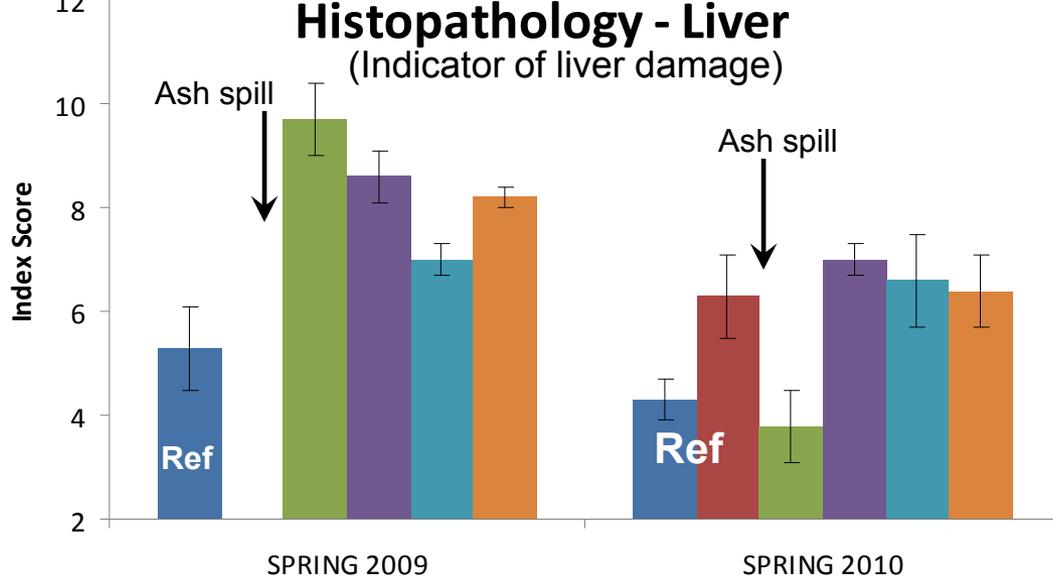


Bioaccumulation and role in food chain transfer of metals

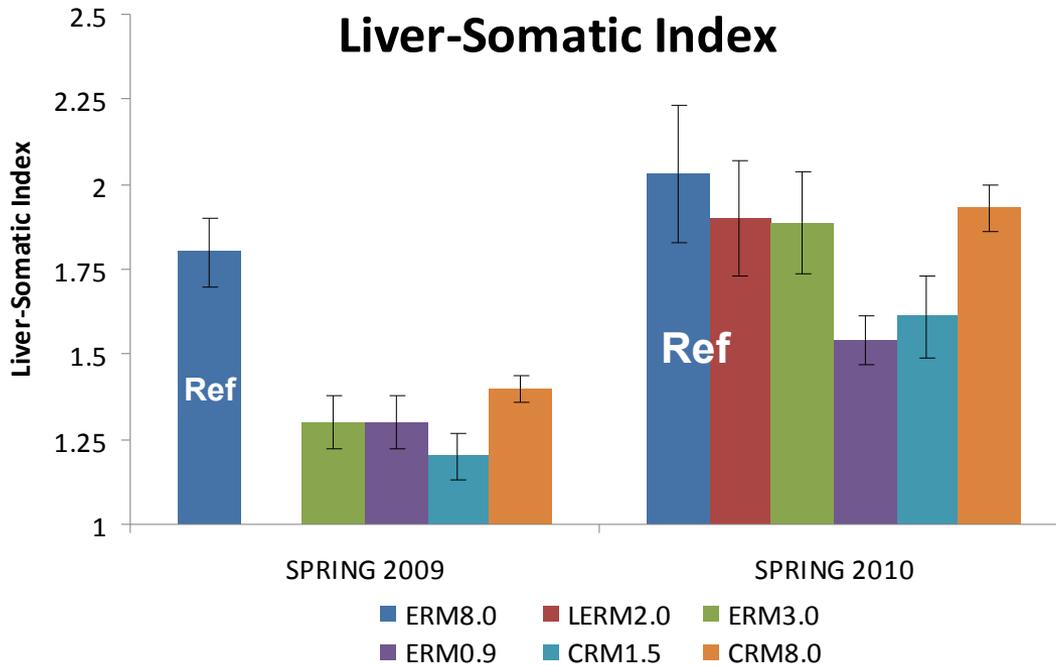
Measures of Fish Health



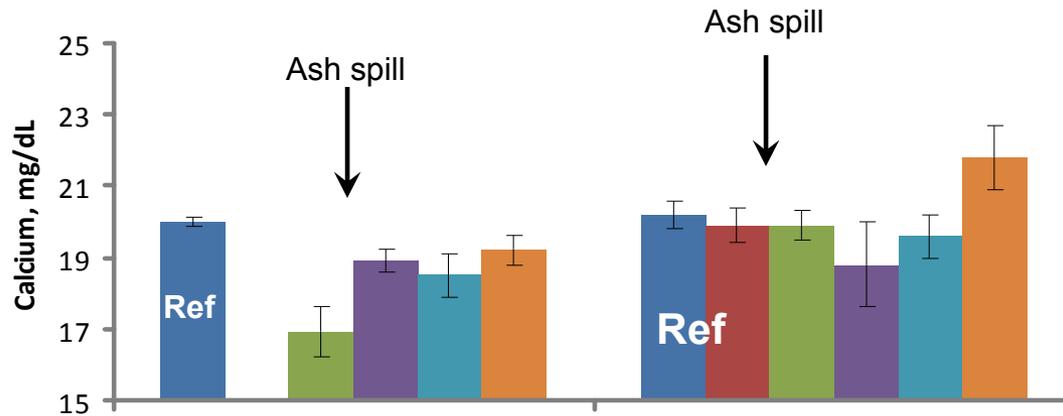
Individual and Integrated Health Responses



Bluegill

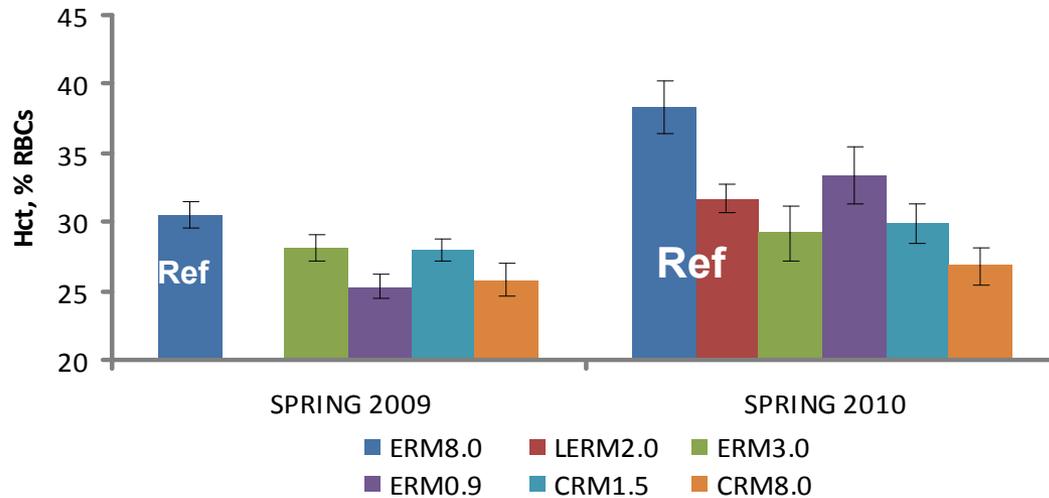


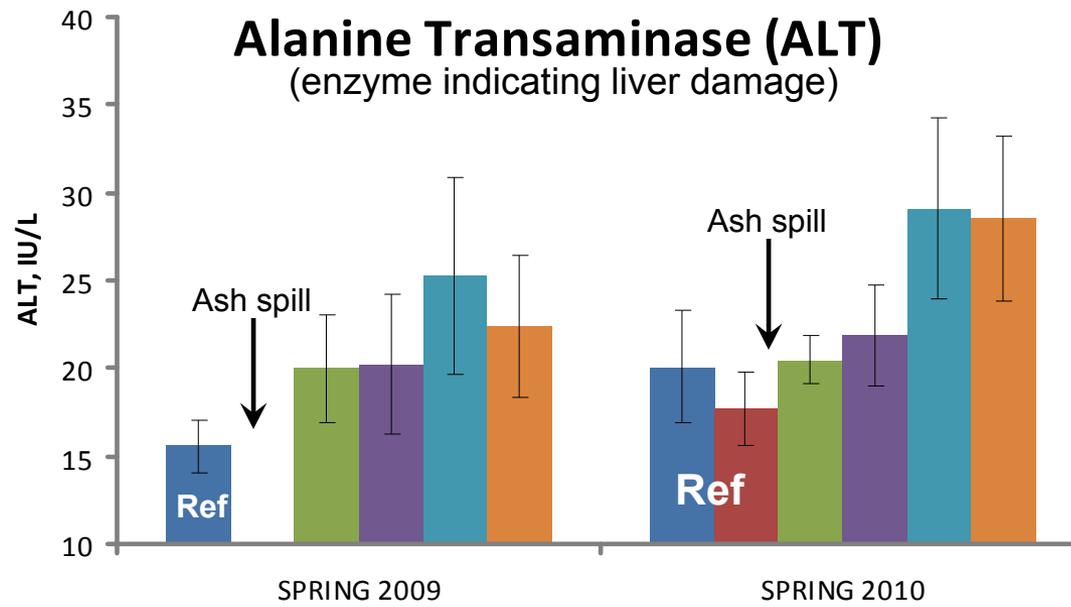
Calcium (blood)



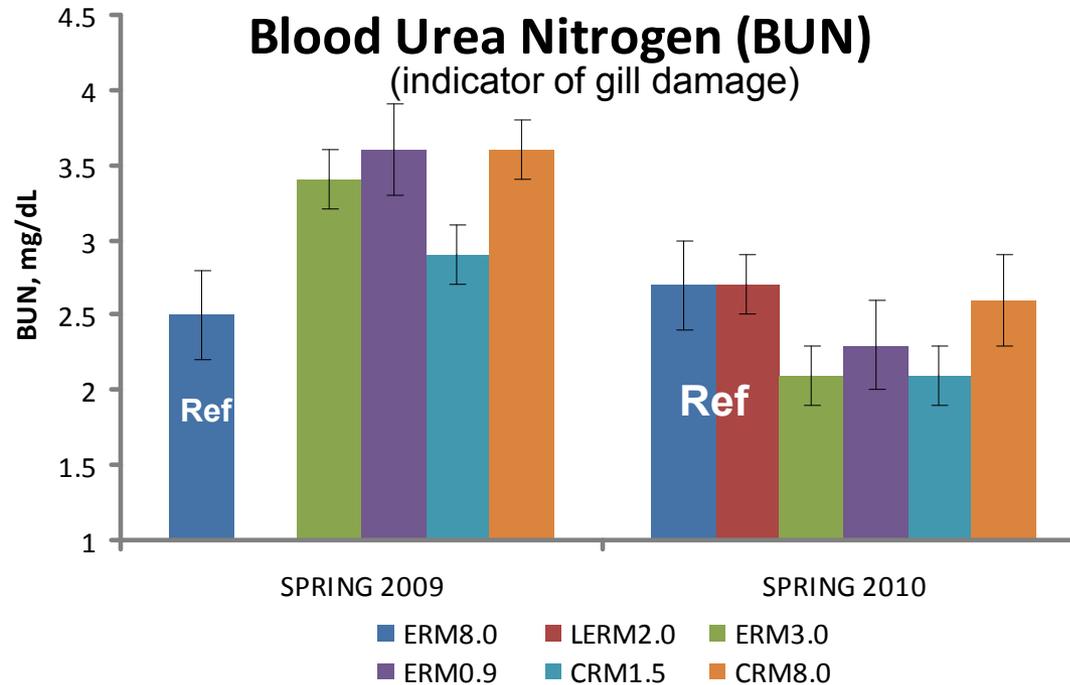
Bluegill

Hematocrit





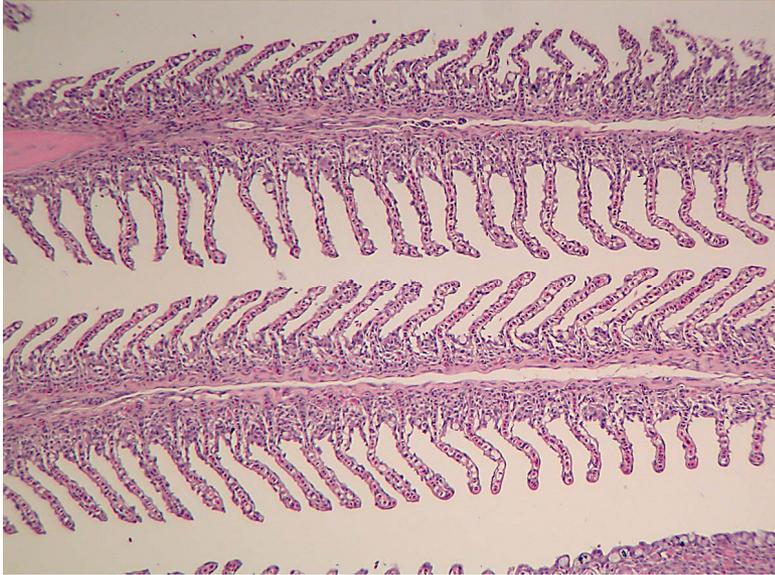
Bluegill



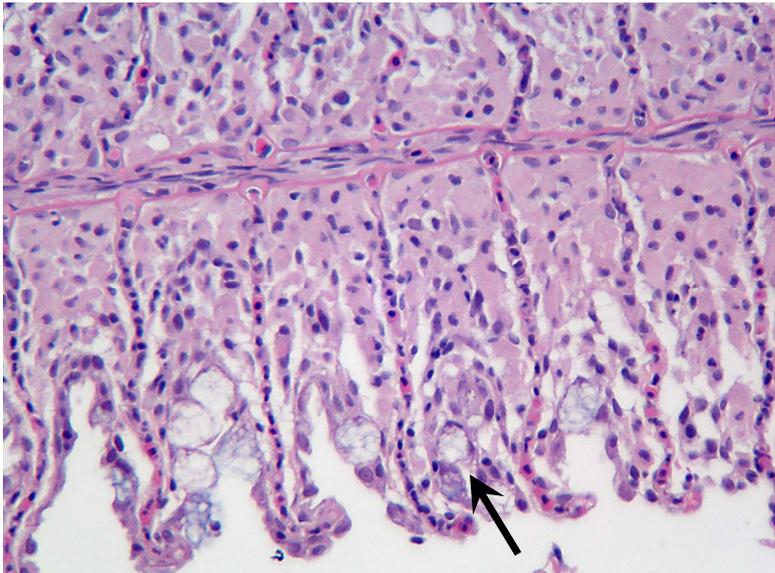
■ ERM8.0 ■ LERM2.0 ■ ERM3.0
■ ERM0.9 ■ CRM1.5 ■ CRM8.0

Example of Gill Histopathology

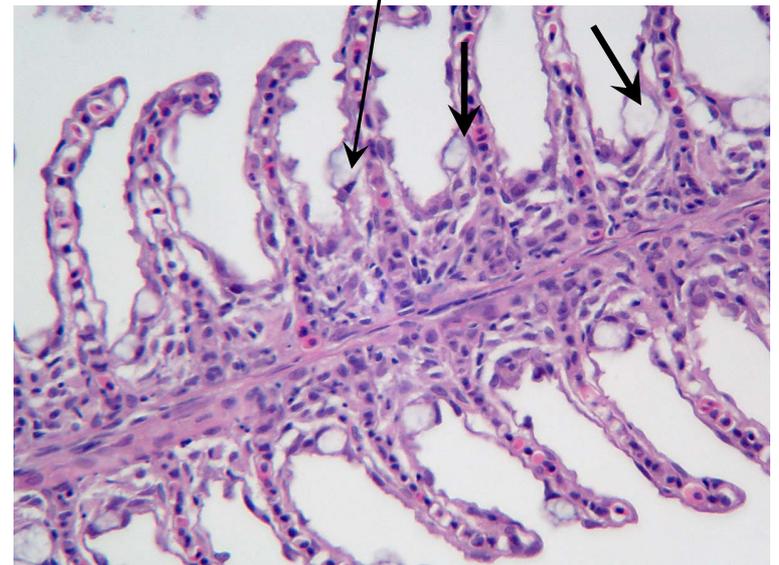
Normal gill showing secondary lamellae



Mucus cell hyperplasia in gill



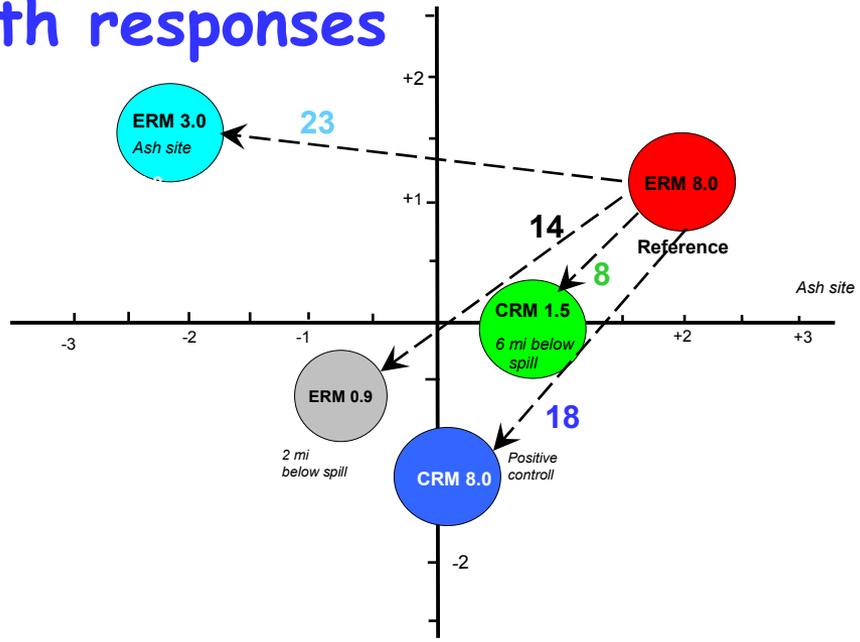
Severe mucus cell hyperplasia



Mild mucus cell hyperplasia

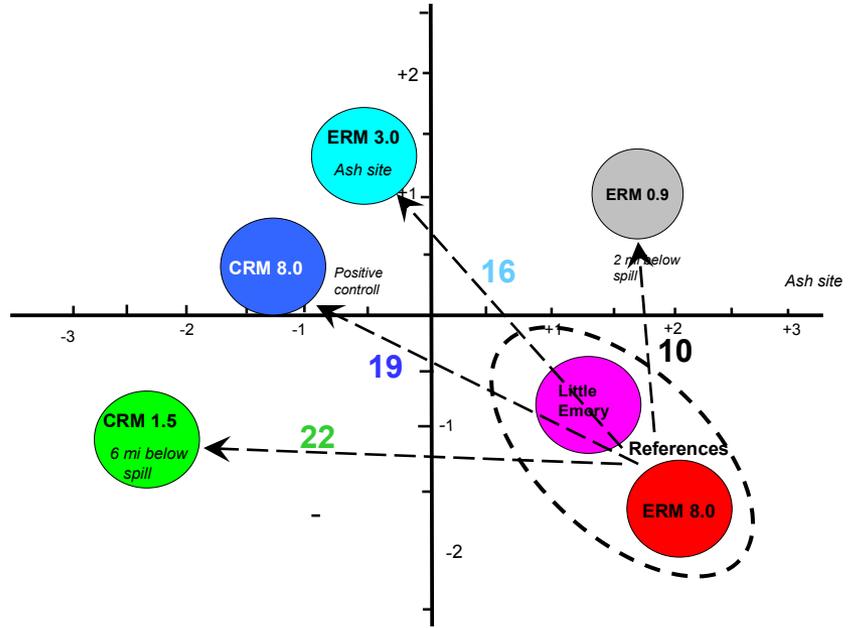
Integrated health responses

Bluegill
Spring 2009



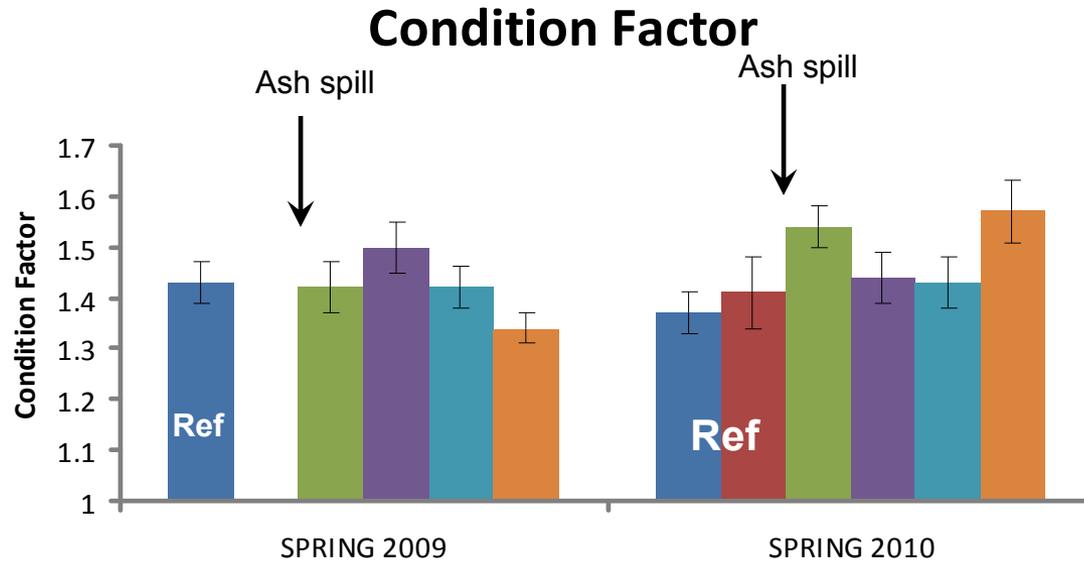
- Variables used**
In analysis
- Condition factor
 - Liver-somatic index
 - Visceral-somatic index
 - Feeding index
 - Hematocrit
 - Glucose
 - Total protein
 - Globulin
 - Blood urea nitrogen
 - Creatinine
 - Liver enzyme
 - Potassium
 - Calcium
 - Liver histopath
 - Ovary histopath

Bluegill
Spring 2010



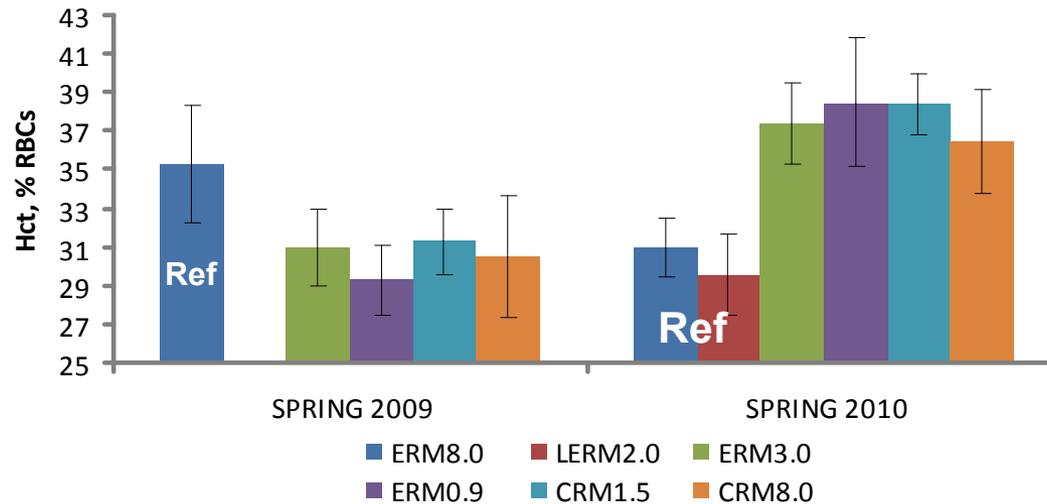
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Individual Responses

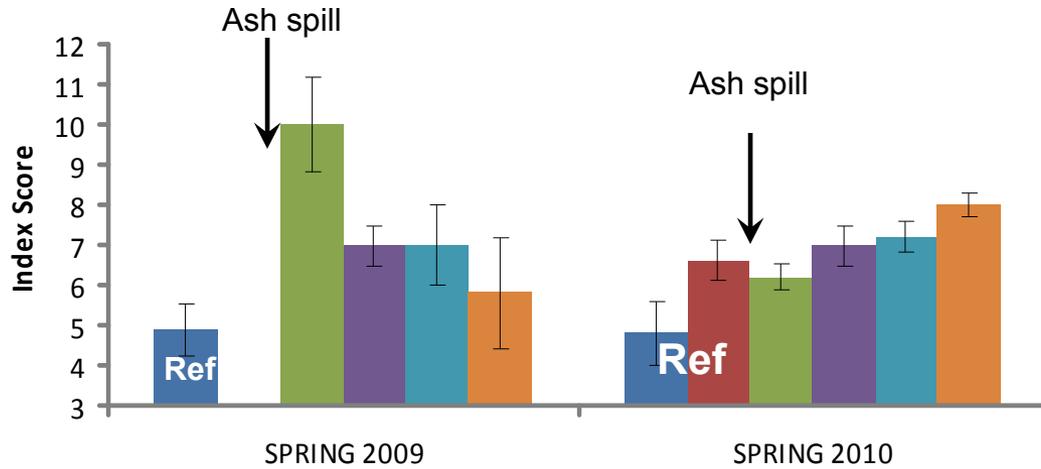


Largemouth Bass

Hematocrit

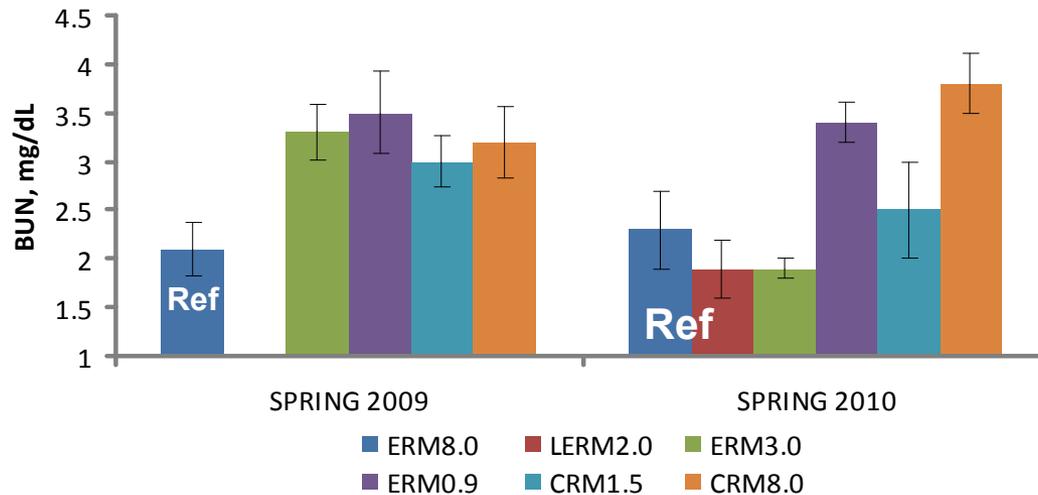


Histopathology - Liver

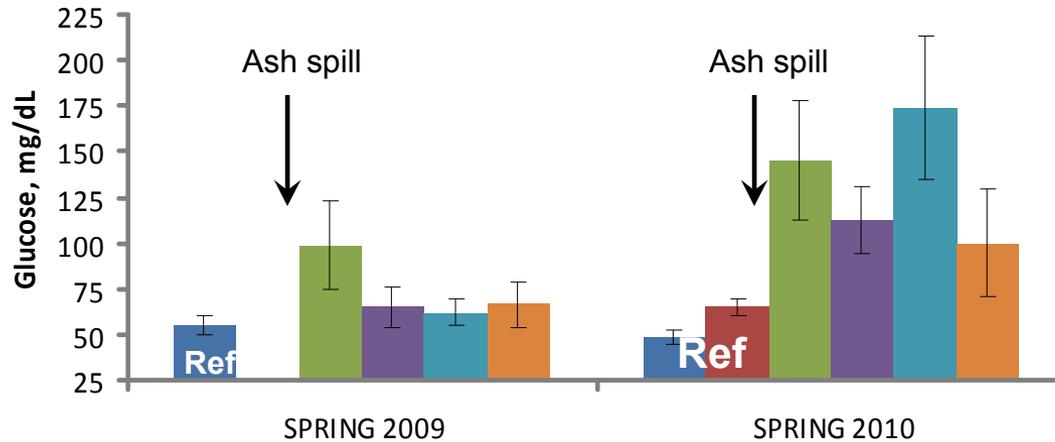


Largemouth Bass

Blood Urea Nitrogen (BUN) (indicator of gill damage)

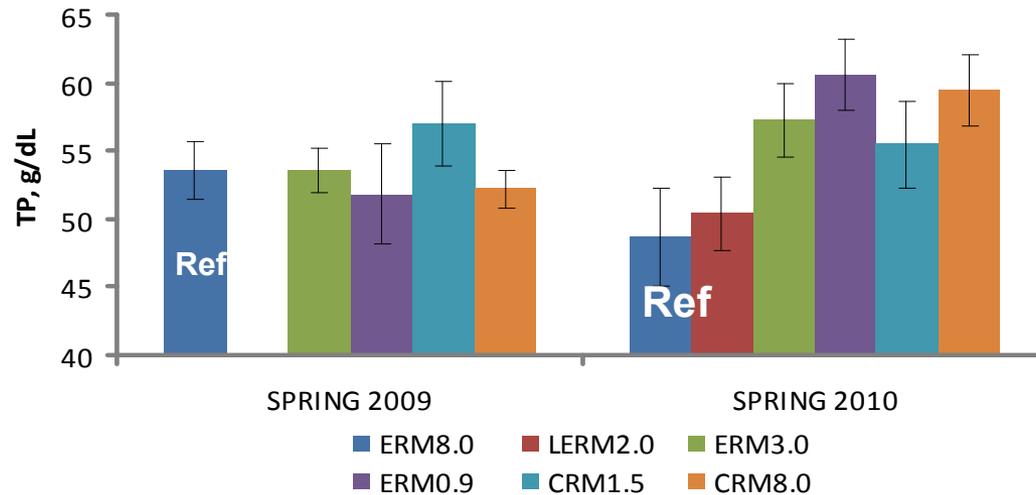


Glucose (blood) (general stress indicator)



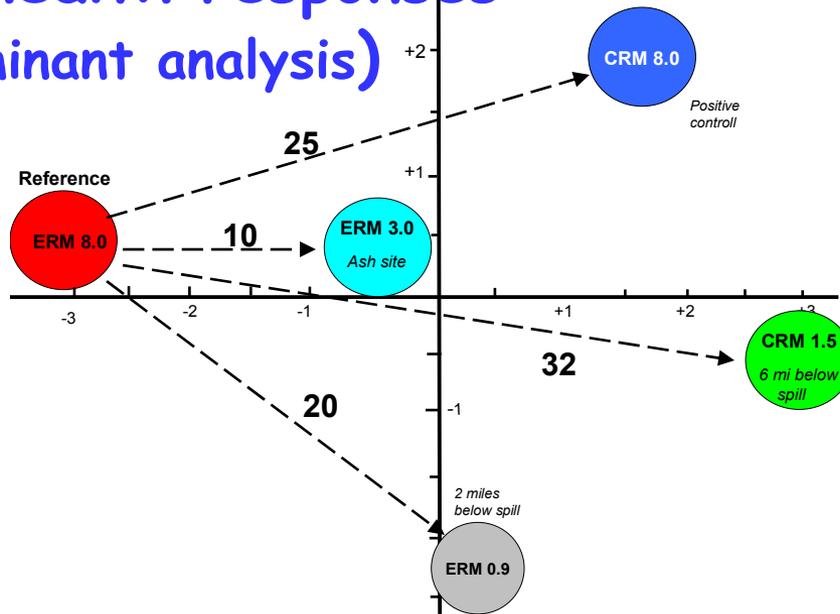
Largemouth bass

Total Blood Protein (indicator of protein metabolism)



Integrated health responses (conical discriminant analysis)

Largemouth bass
Spring 2009

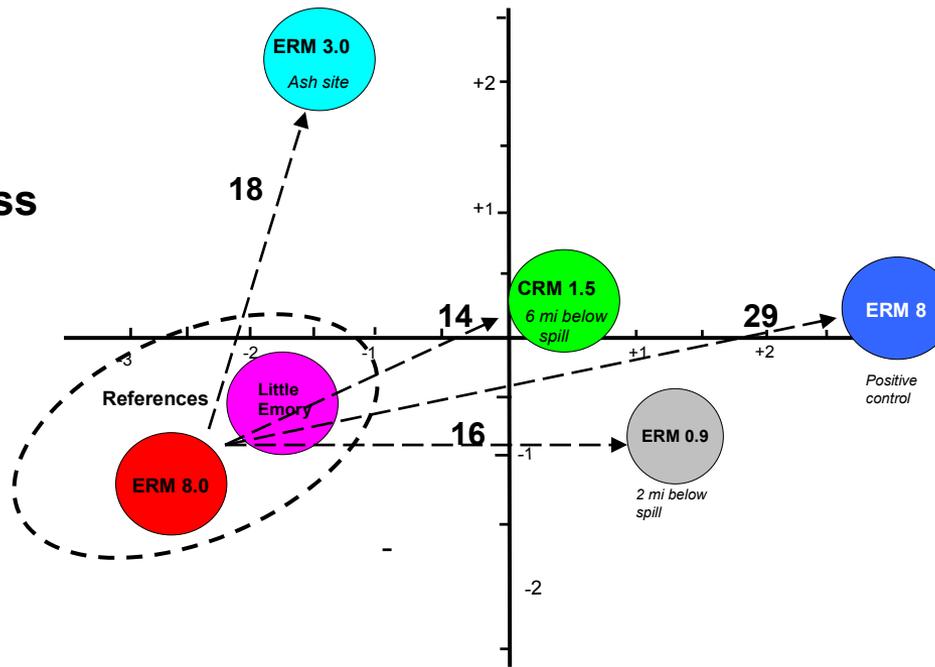


Variables use

In analysis

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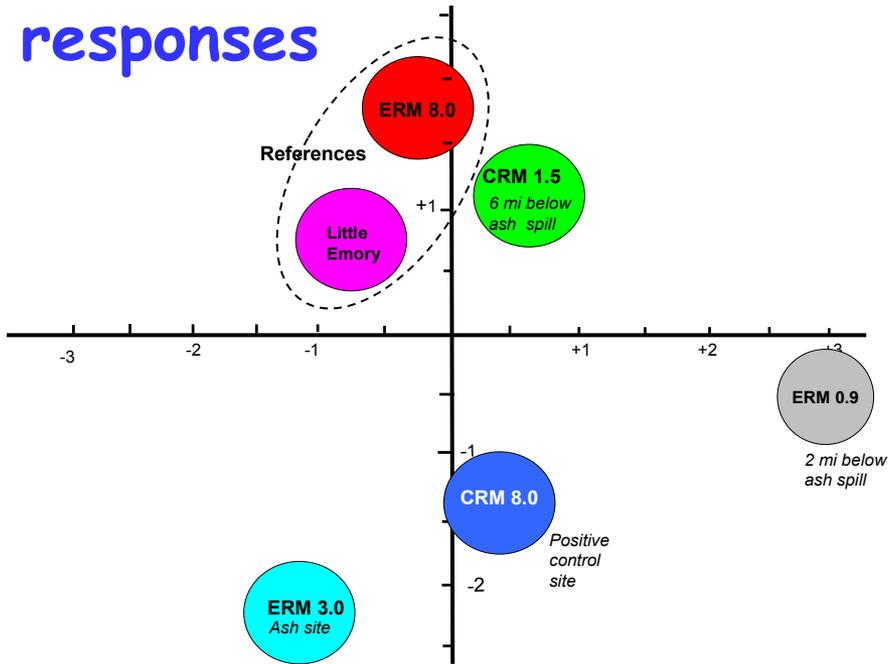
Largemouth bass
Spring 2010



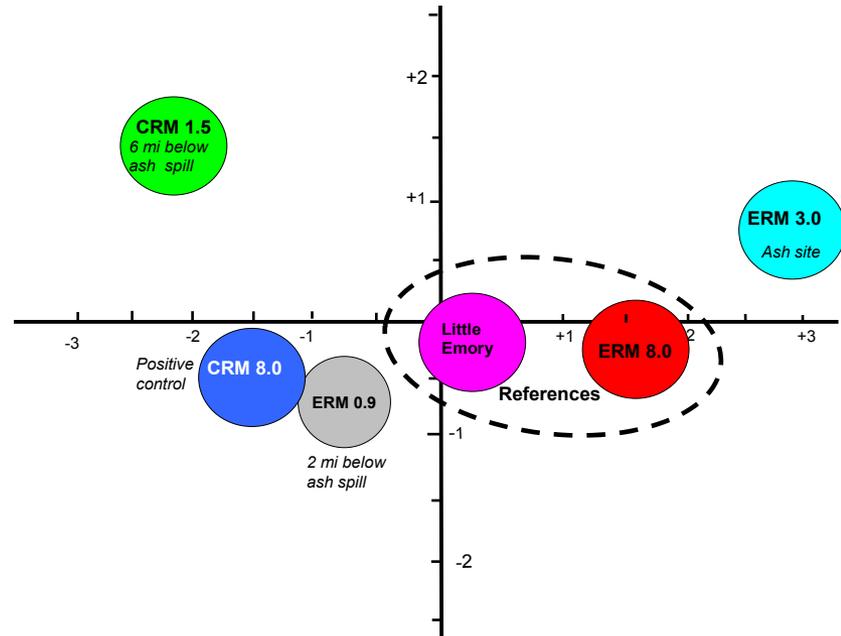
- Condition factor
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- Creatinine
- Liver enzyme
- Sodium
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Integrated health responses

Bluegill-fall 2009

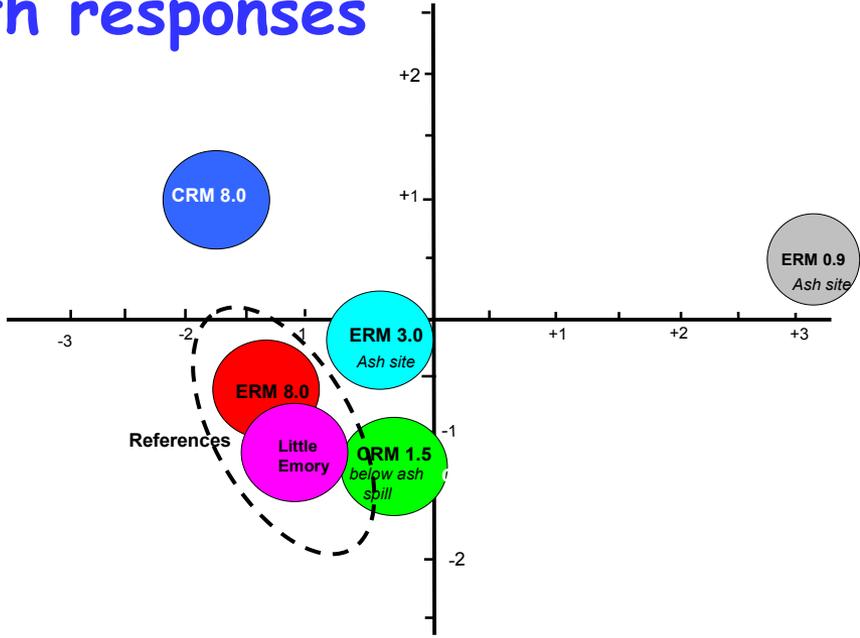


Bluegill-fall 2010

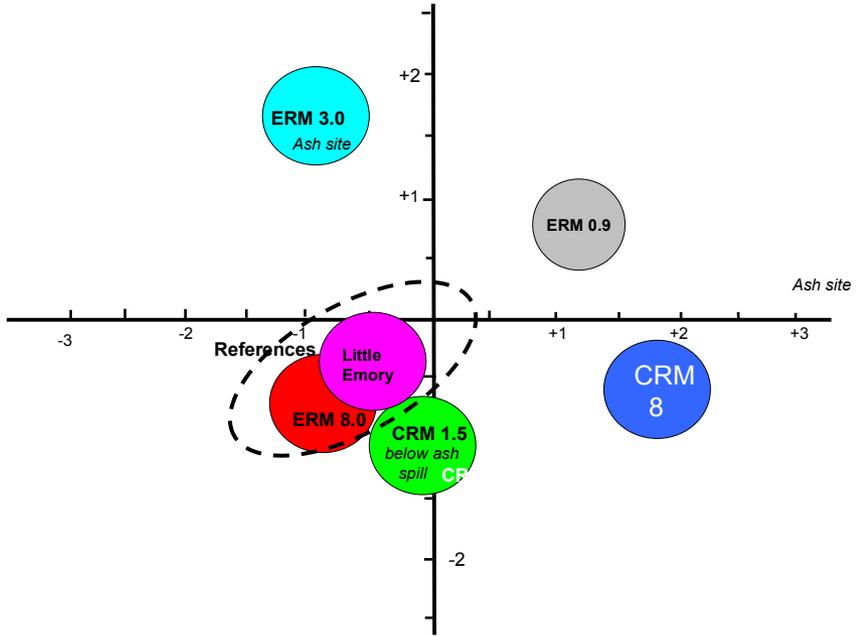


Integrated health responses

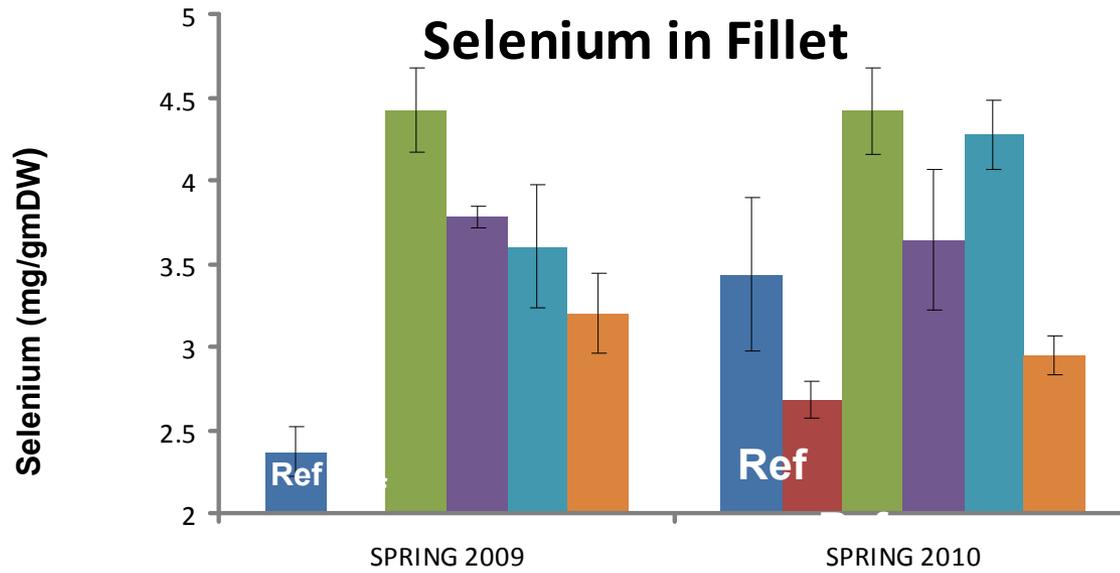
Largemouth bass
Fall 2009



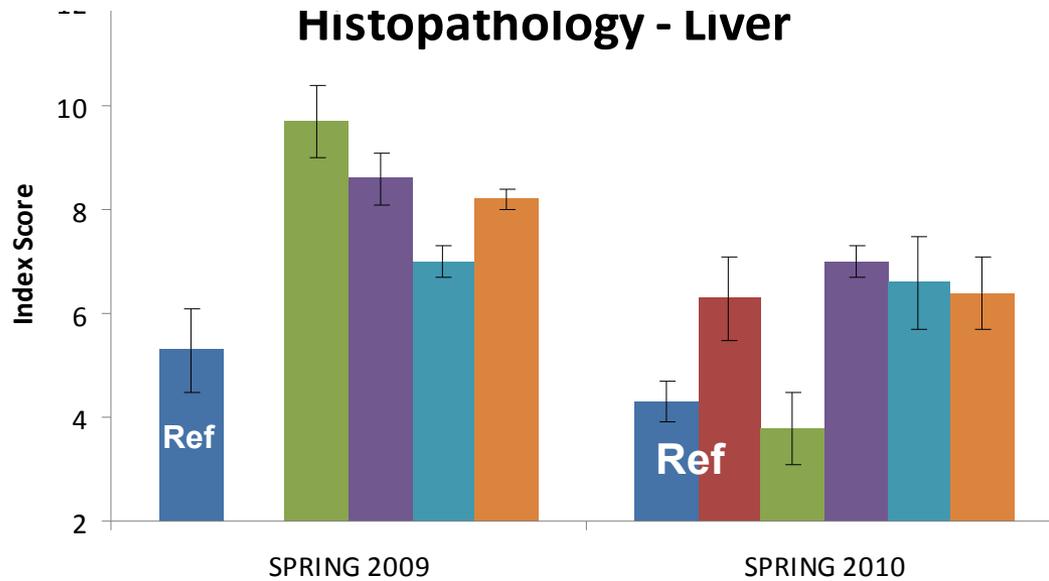
Largemouth bass
Fall 2010



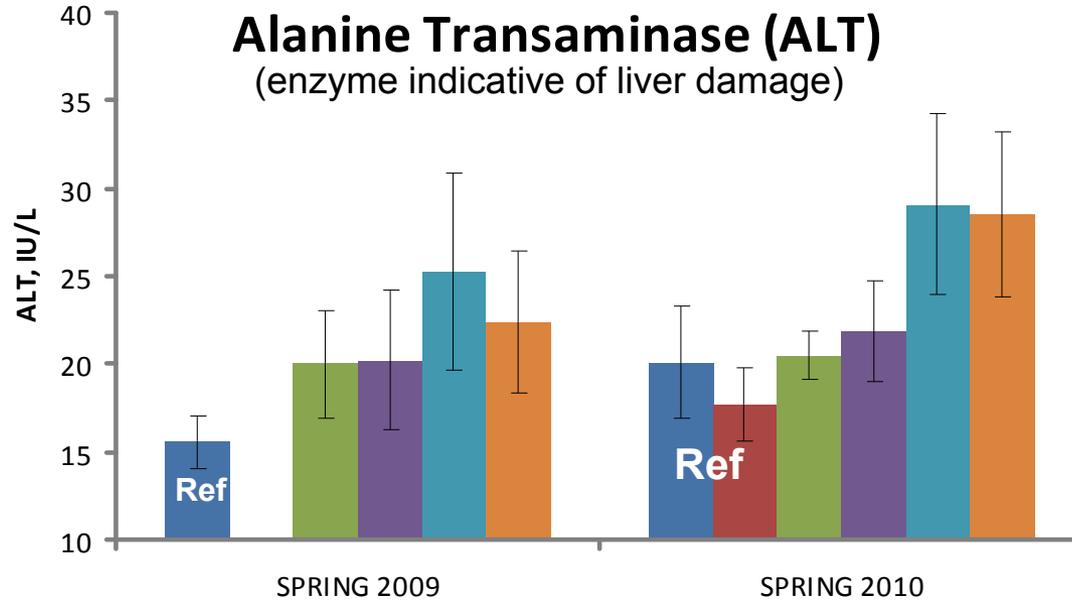
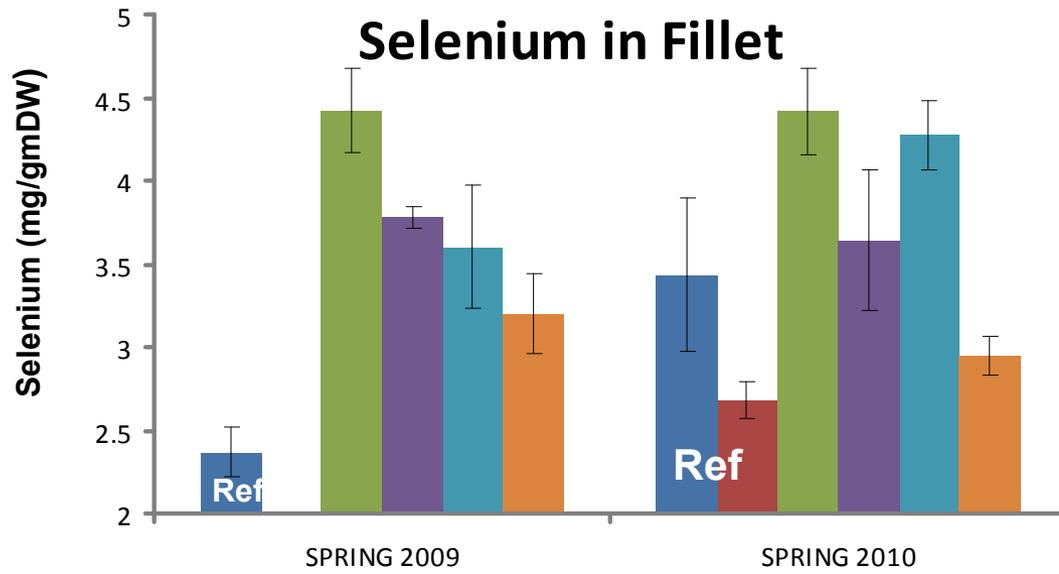
**Causal relationships
between metal exposure and fish health**



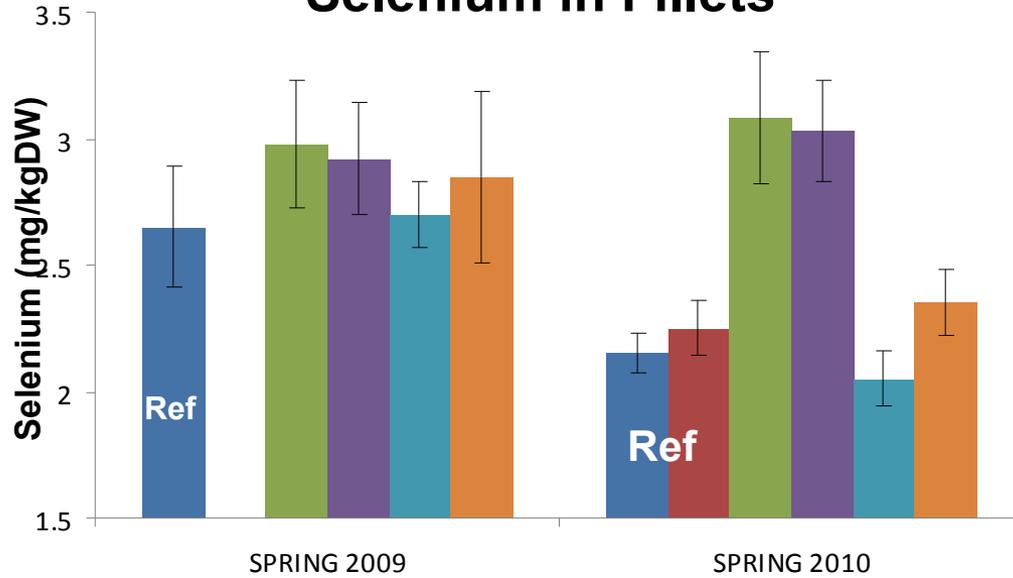
Bluegill



Bluegill

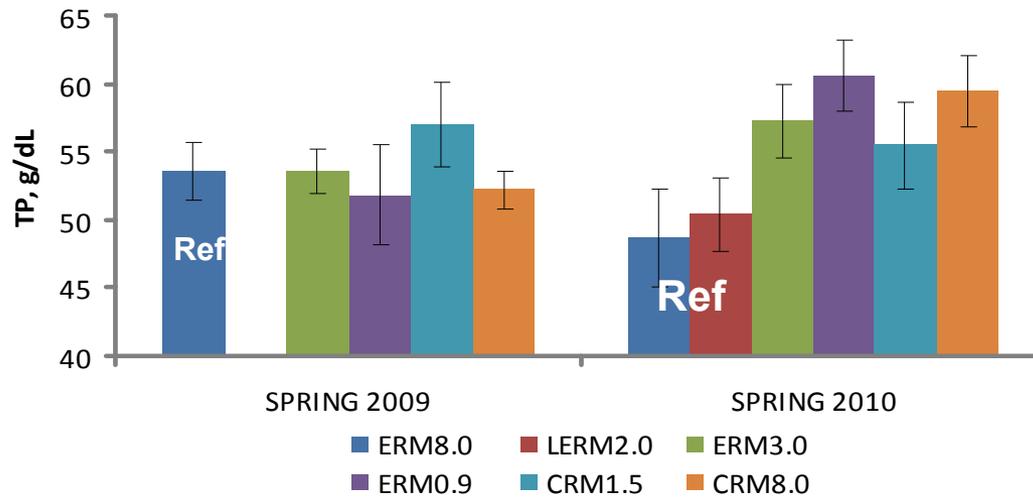


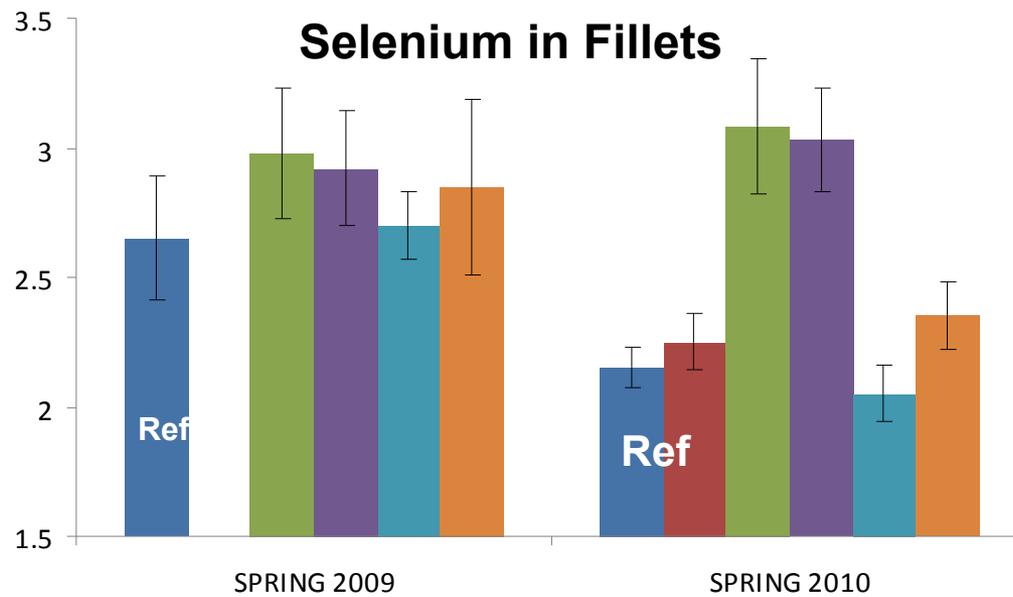
Selenium in Fillets



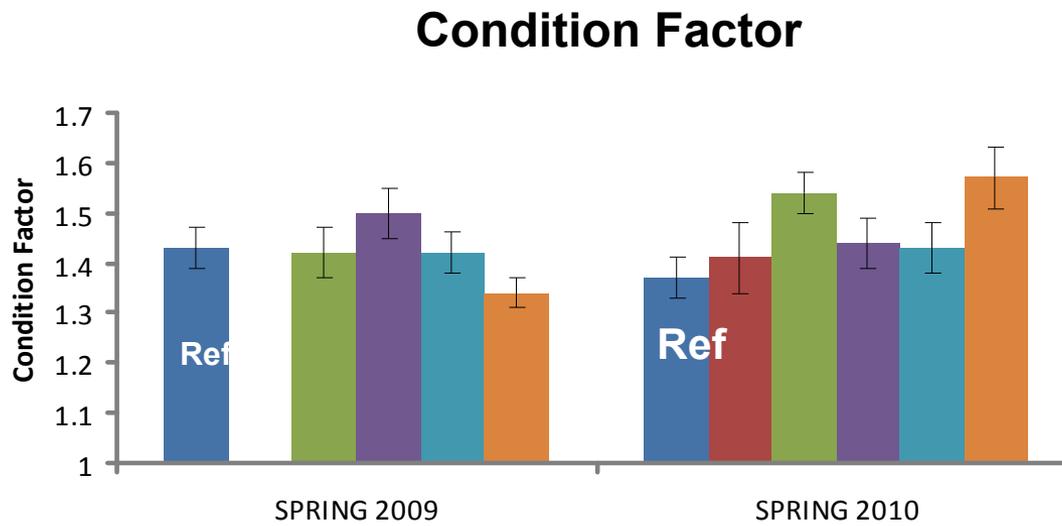
Largemouth Bass

Total Blood Protein



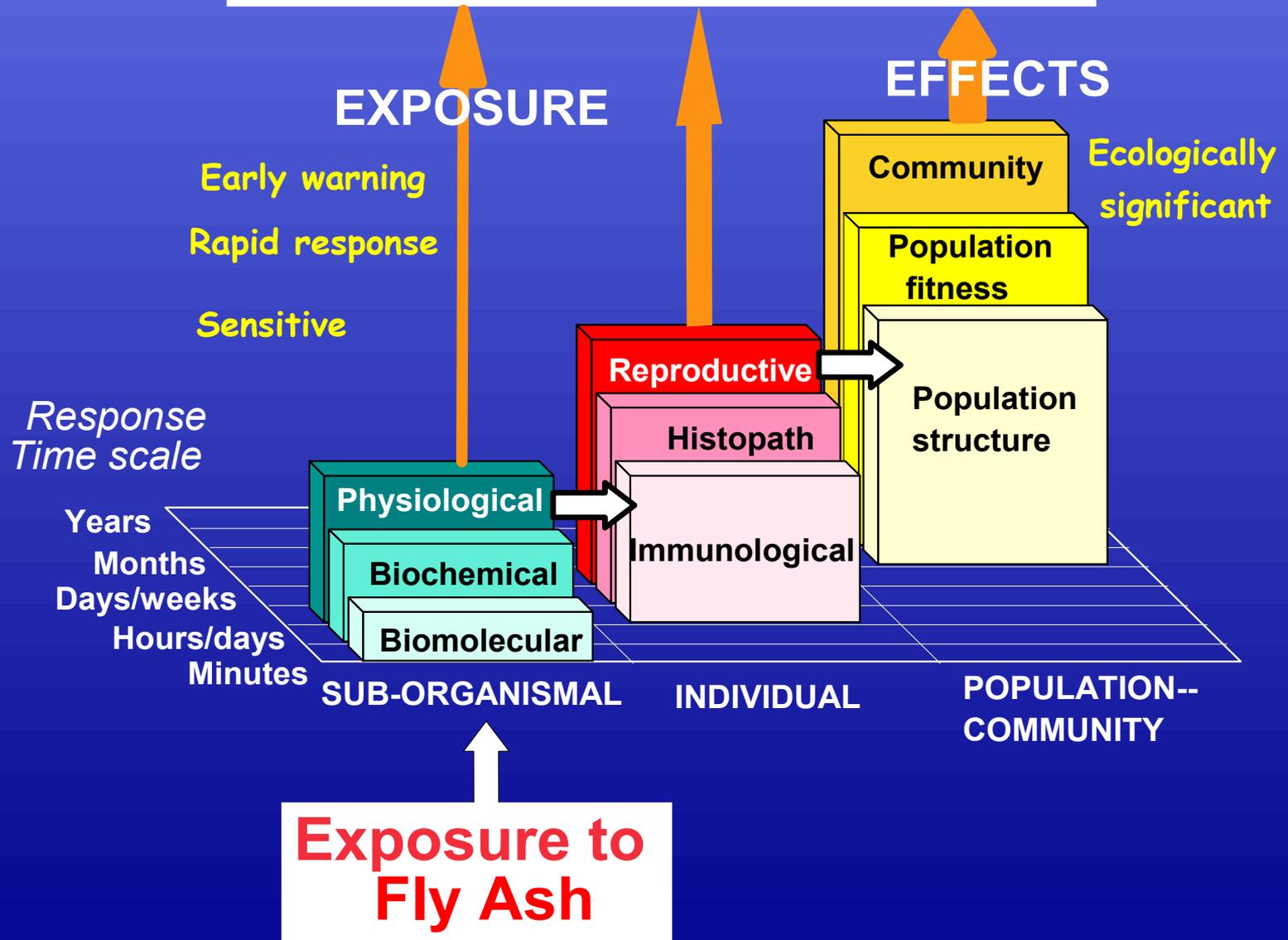


Largemouth Bass

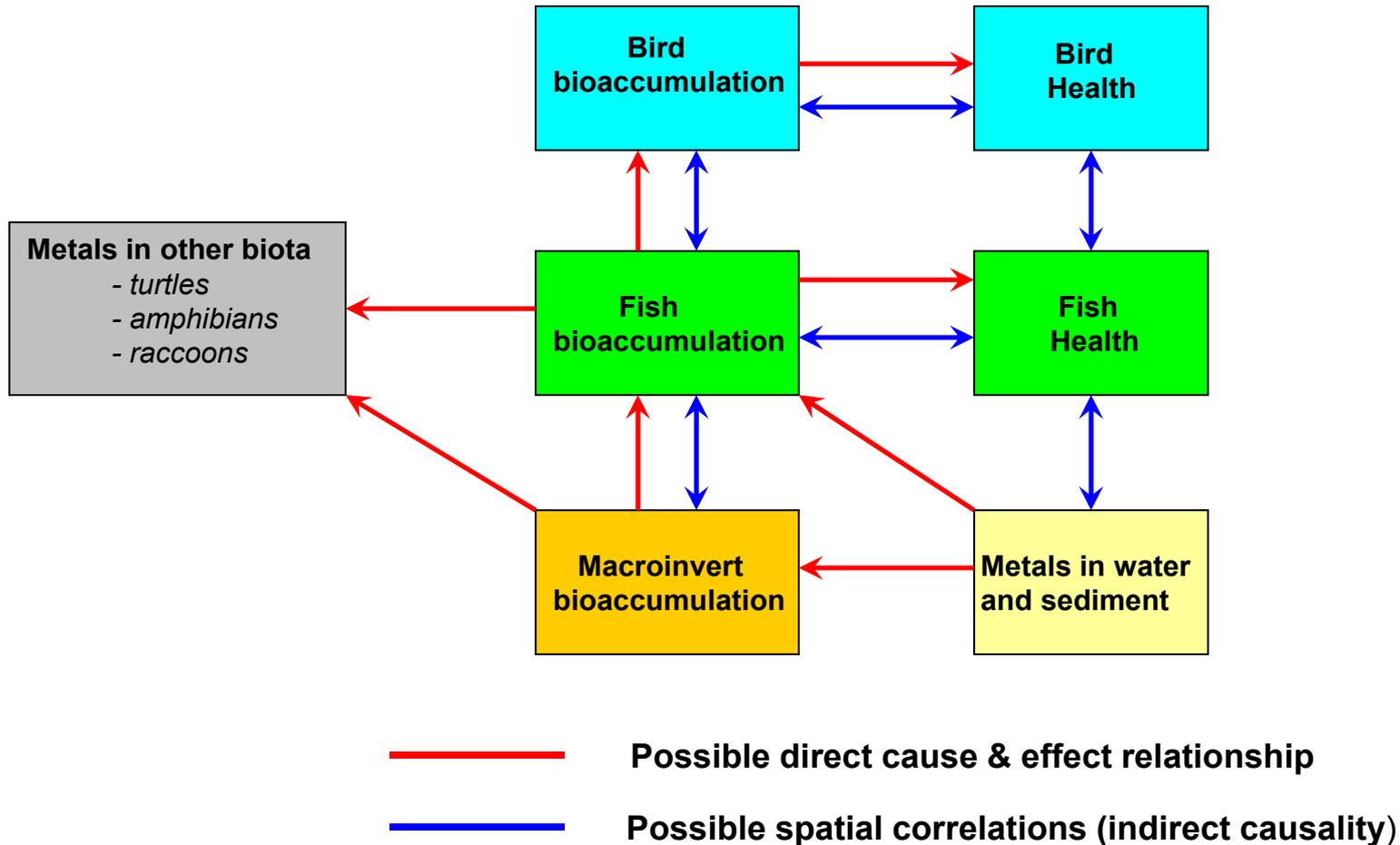


Relevance and application of fish health studies

**Ecological Risk Assessment
Assessment of Fish Health
Natural Resource Damage Assess.**



Establishing causal relationships among environmental variables



Summary

- As demonstrated by individual bioindicators and the discriminant analysis procedure, the health of fish is generally poorer downstream of the fly ash spill than at reference areas
- Even though the health of fish immediately below the ash spill appears to be compromised to some degree, effects appears to be localized to a small area and to resident species
- From 2009 -2010, improvement in health status (recovery) seen in bluegill and bass at 2 of the 3 sites downstream of the ash spill
- No significant health effects (i.e., damage or injury) have been observed in fish suggesting that: 1) metal exposure is not of sufficient magnitude or duration to elicit changes in biological responses, and/or 2) the rate of biological repair exceeds the rate of damage
- Food chain studies in combination with the use of multiple bioindicators provide a weight-of-evidence approach for evaluating possible causal relationships between exposure to fly ash metals and biological responses