An evaluation of the *Ceriodaphnia dubia* chronic toxicity test as an indicator of instream effects from mountaintop coal mining

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Jones Branch
Middle Fork Watershed
Martin Co., KY

Background

- Alkaline coal mining effluent
- Elevated Total Dissolved Solids (dominated by Ca^{2+}, Mg^{2+}, HCO_3^- and SO_4^{2-}), Fe, Mn, Ni, Zn, Se and NO_3^-
- Mined streams have increased base flow
- Adverse effects to water quality and benthic macroinvertebrates

Background

- NPDES permit limits require pH, Fe and TSS
- Some WQBELs for Mn, Al, Se
- No limits for TDS/conductivity/ions
- Whole Effluent Toxicity (WET) testing has been proposed for NPDES permits
- Would WET protect native biota?

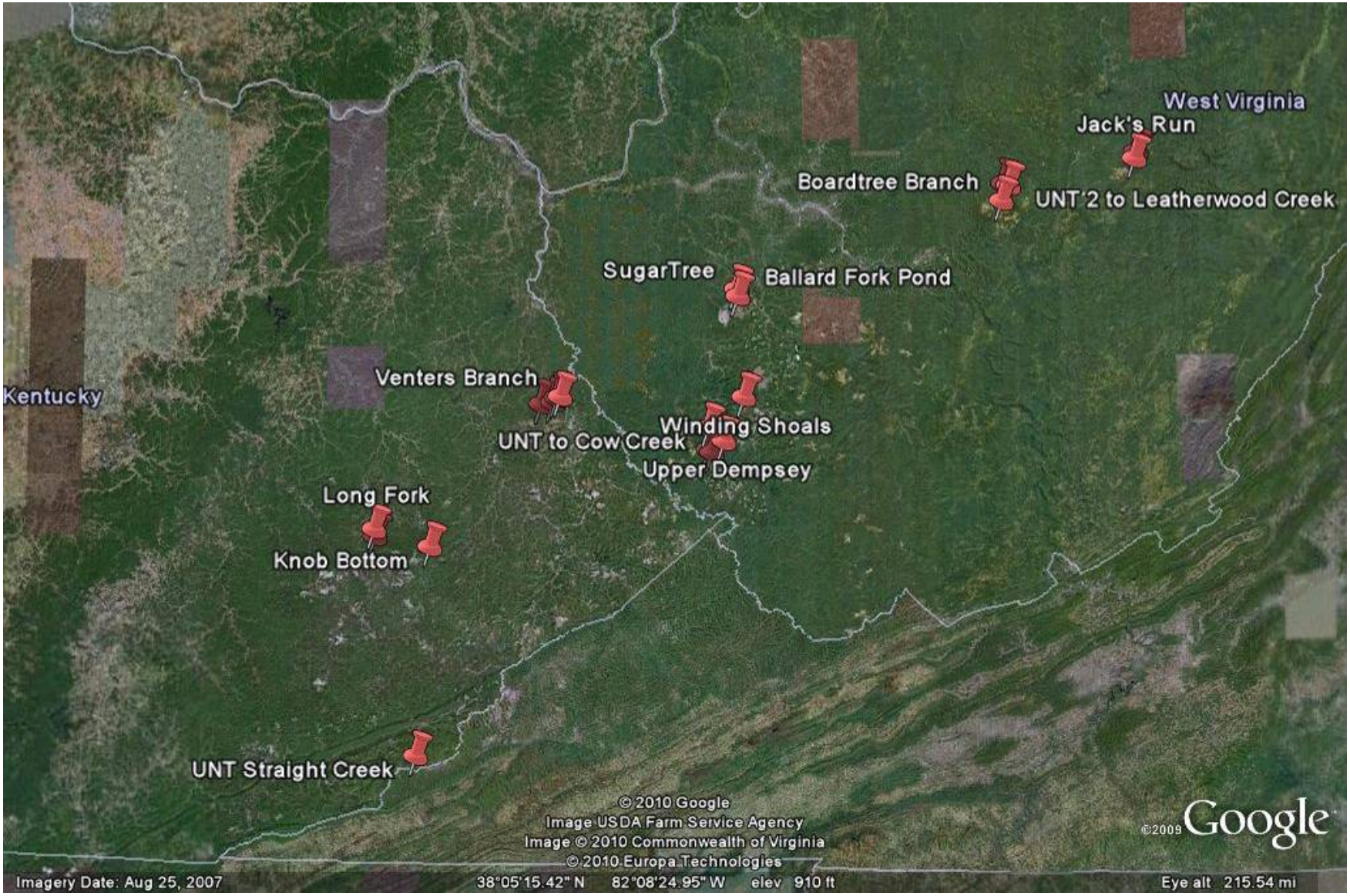
Objectives

- What level of water quality degradation is associated with lethal or sublethal effects to *C. dubia*?
- What's causing the observed toxicity?
- How do WET results compare to macroinvertebrate results?
- Can *C. dubia* chronic tests indicate instream aquatic life condition?

Site Criteria

- Central Appalachians
- Headwater streams downstream valley fills
- pH circum neutral or alkaline
- Cond > 1000 uS/cm
- Sampling reach upstream of residences
- Impaired aquatic life
- Physical habitat "sufficient"
- 18 headwater streams, 1 pond, 1 ditch
- 1 VA, 7 KY, 12 WV

Site Locations



Methods

- WVDEP macroinvertebrates
  - WVSCI, genus level metrics
  - All sites impaired for macroinvertebrates
- RPB habitat
- C. dubia 7-day chronic testing
  - IC25: dilution that resulted in a 25% decrease in reproduction compared to control
  - IC25 > 100%, no toxicity; as IC25 decreases, more toxicity
- Field and lab chems
- Ion Toxicity Model (Mount et al 1997): Acute 48-hr mortality, relative measure of ion toxicity

$$K^+ > HCO_3^- = Mg^{2+} > Cl^- > SO_4^{2-}$$

Habitat not a confounding factor:

UNT to Cow Creek
Island Creek watershed
Logan Co., WV
RBP 165
Optimal

Habitat a slight confounding factor:

Upper Dempsey Branch
Pigeon Creek Watershed
Logan Co., WV
RBP 146
Marginal to suboptimal

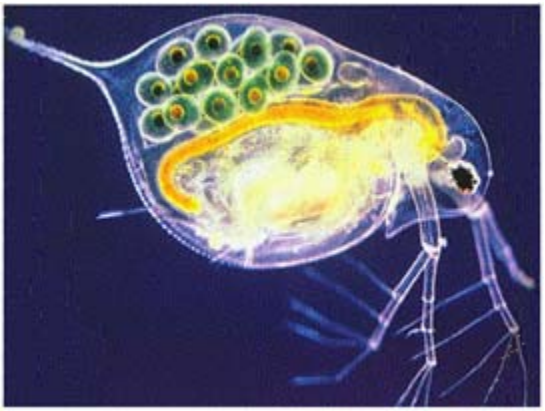
Habitat a severe confounding Factor? Severe mineral precipitation caused by poor water quality.

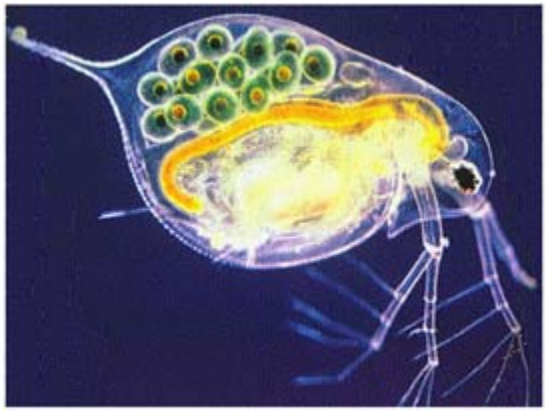
UNT Leatherwood Creek
Leatherwood Creek
Clay Co., WV
RBP 111
Marginal - poor


Mineral precipitation on substrates
UNT Leatherwood Creek
WV
A single *Hydropsyche* was collected.

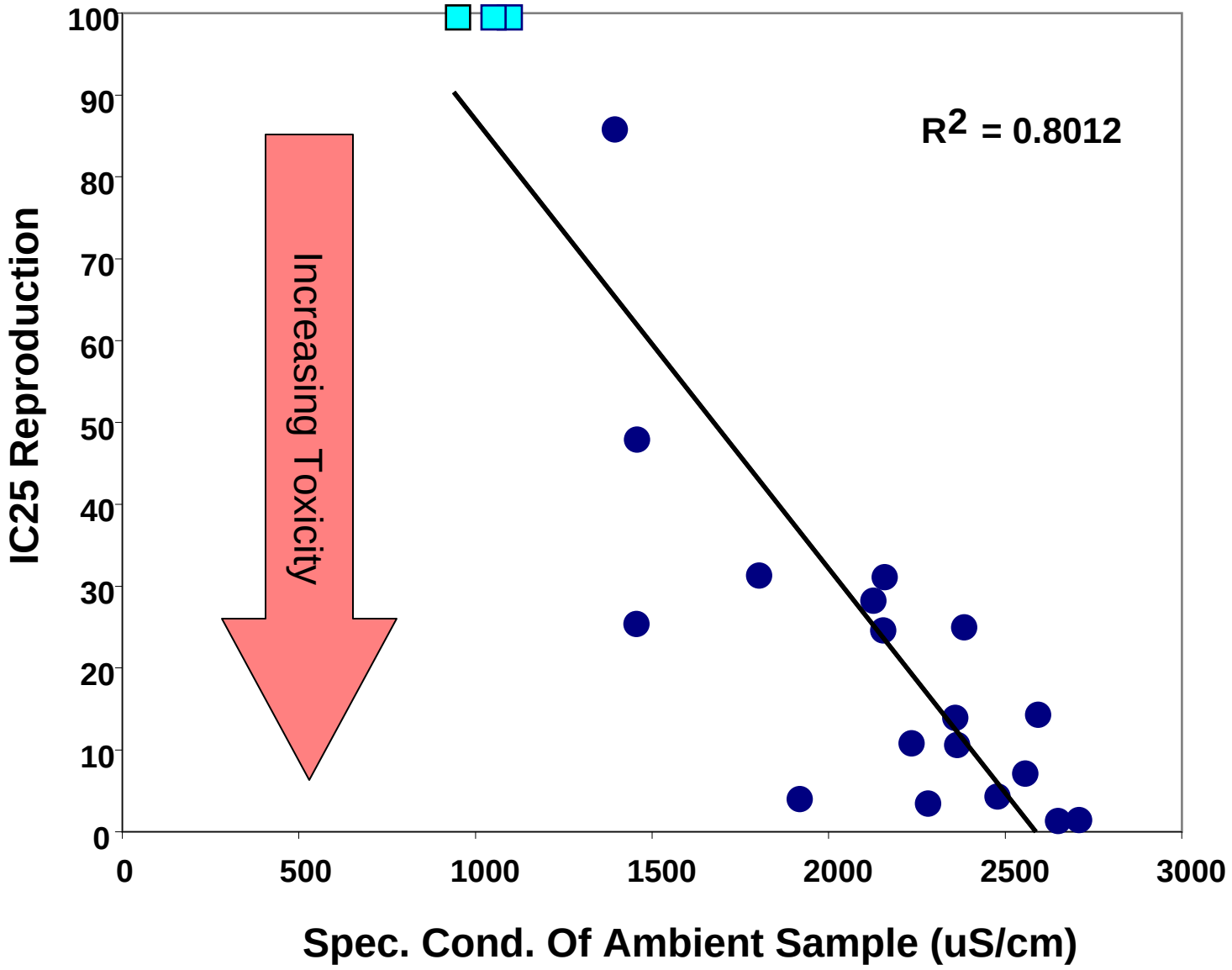
C. dubia Results

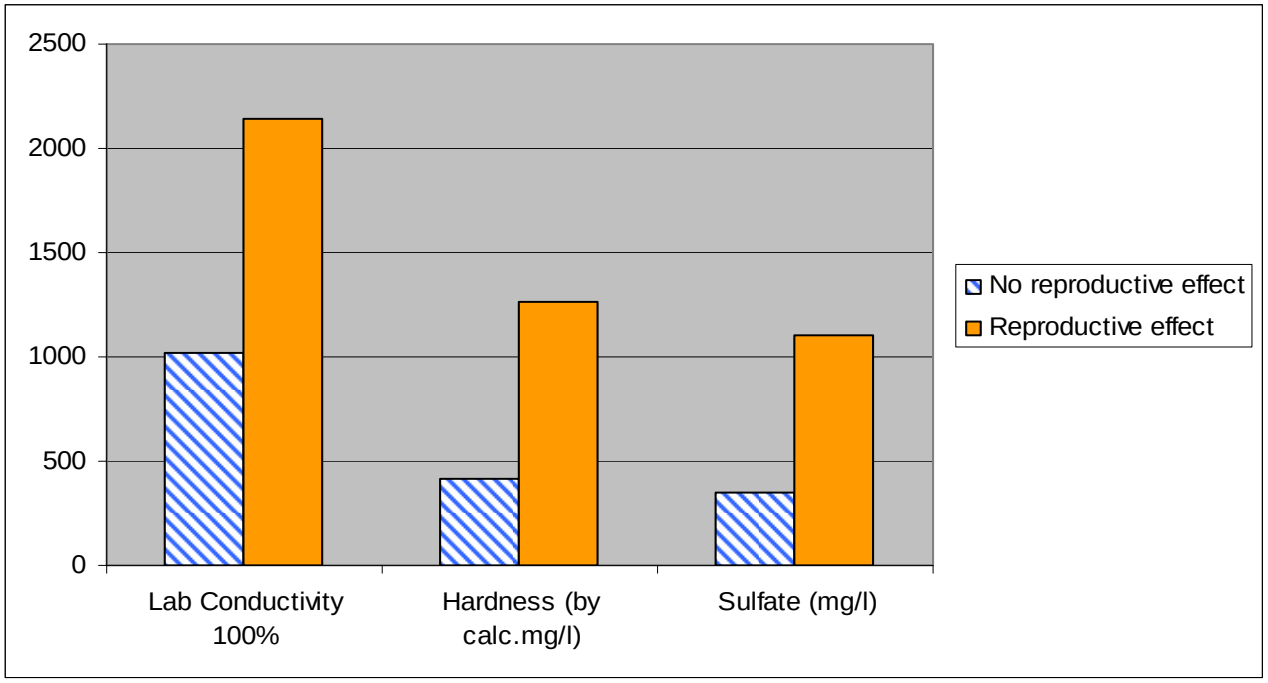
- Lethal and sublethal toxicity at 2 sites
- Sublethal toxicity at 15 sites
- No toxicity at 3 sites (IC25 > 100%)
- Mean IC25 of toxic samples was 21%
- Conductivity of ambient sample was a good predictor of toxicity

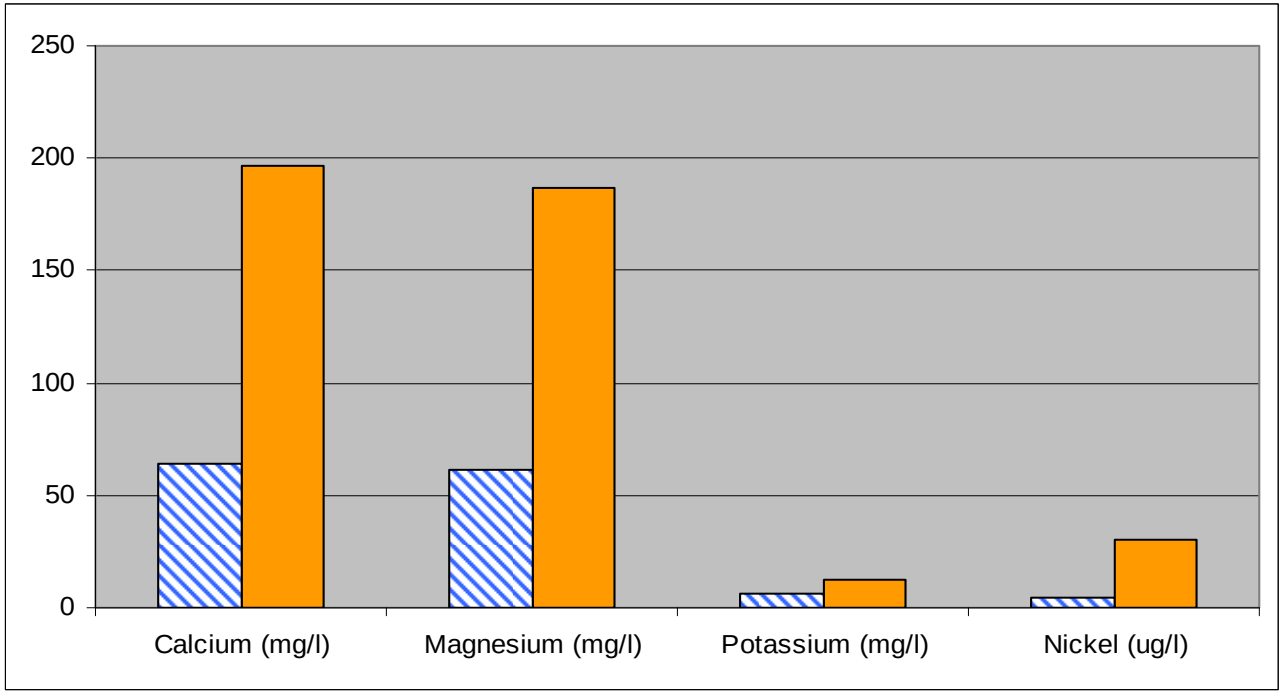




Conductivity and IC 25







Conductivity, hardness, calcium, magnesium, potassium, nickel and sulfate were significantly higher in sites that exhibited reproductive effects (n=17) compared to those that did not (n=3).

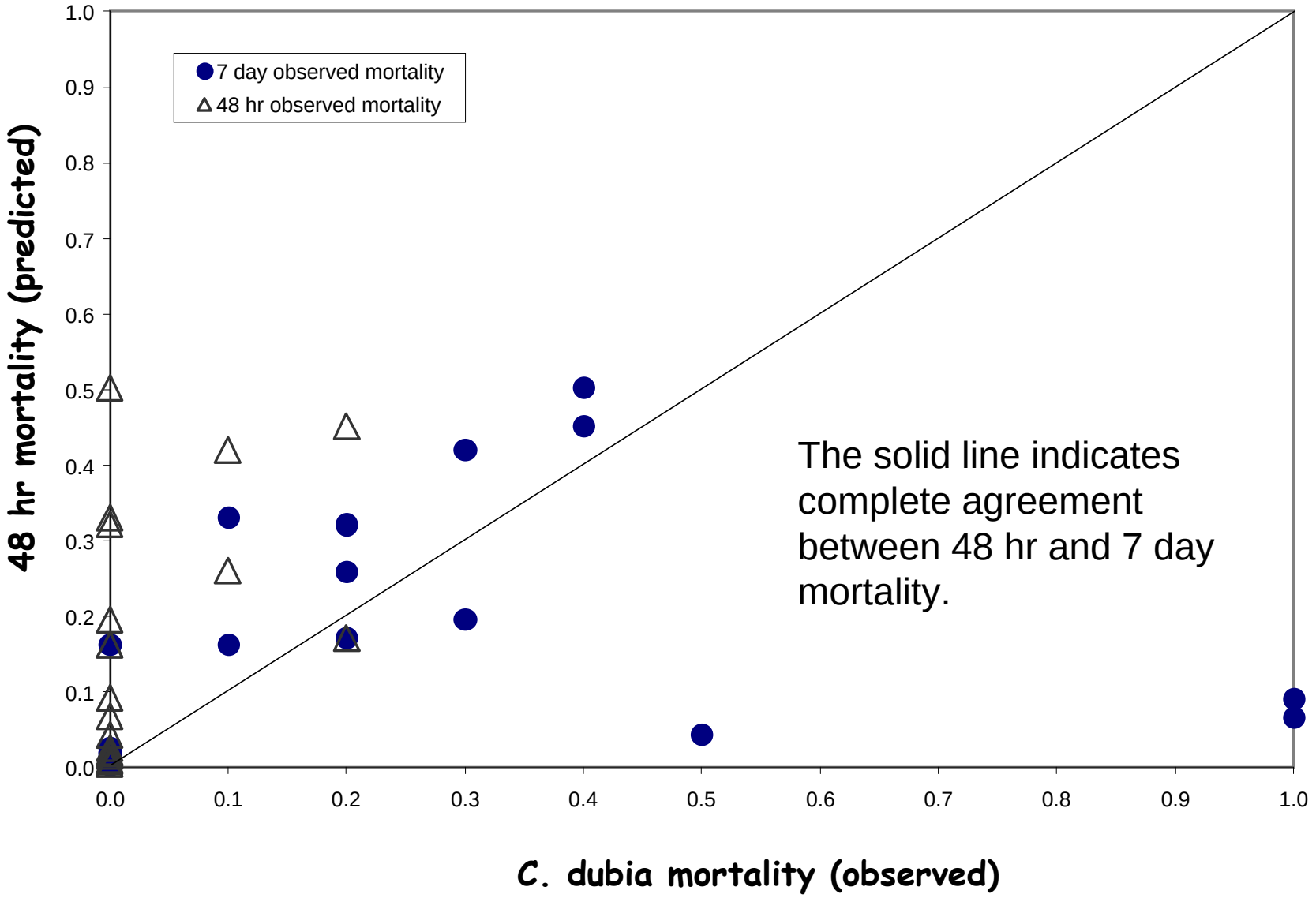
All [Metals] < chronic Criteria.

Estimated Chemical Means @ IC 25

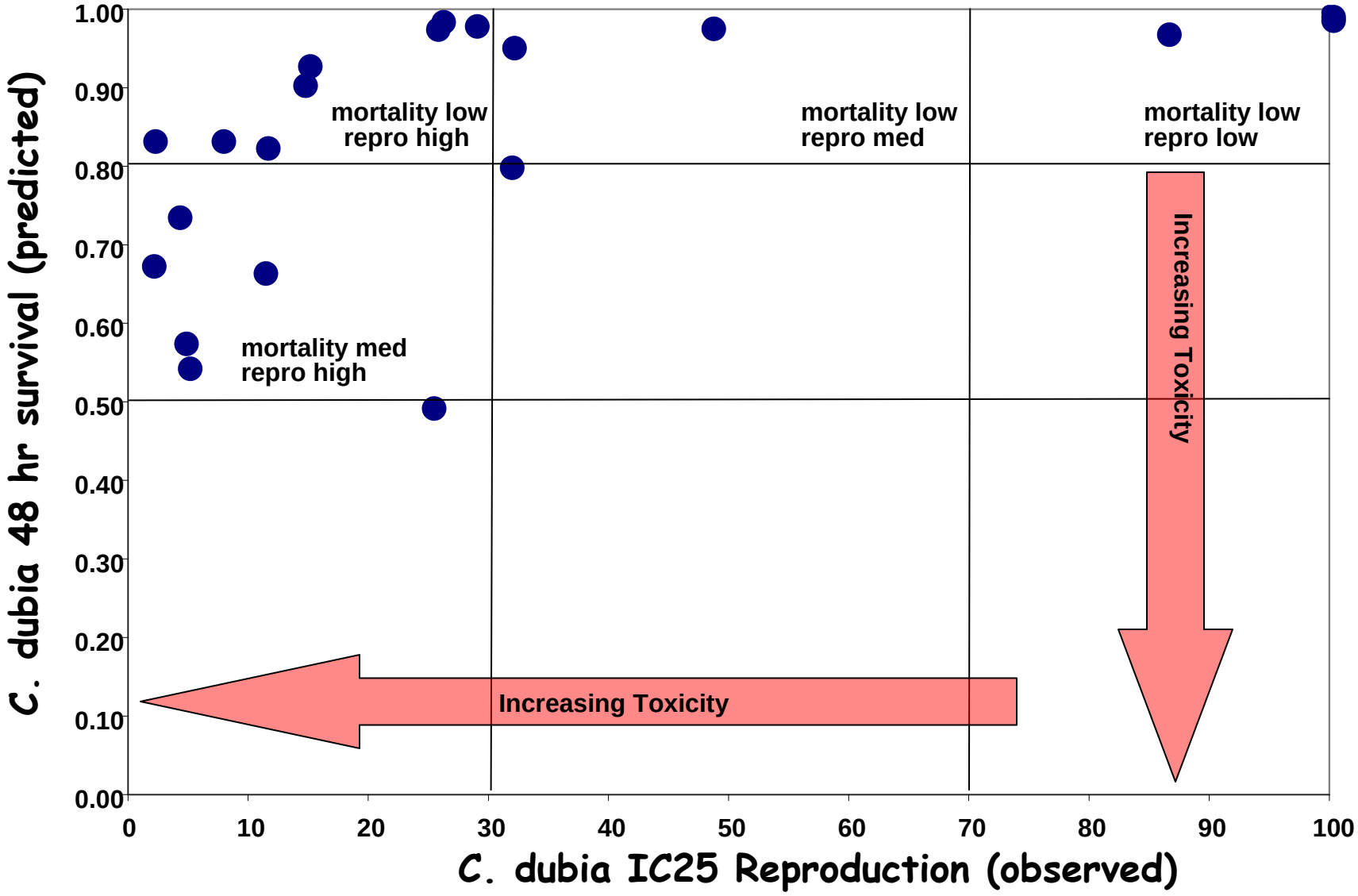
- Potential Toxicants
  - 546 µS/cm conductivity
  - 203 mg/l sulfate
  - 108 mg/l HCO_3^- alkalinity
  - 35 mg/l magnesium
  - 3 mg/l potassium
  - 5.0 µg/l nickel

- Potential Ameliorating Factors
  - 291 mg/l hardness
  - 59 mg/l calcium

Observed and Predicted Mortality



Observed IC25 and Predicted Survival



Conclusions

- 17 of 20 sites toxic
- Effect is chronic and sublethal
- Ions are causing some toxicity
- Metals < chronic criteria
- Additional toxicants present at some sites?
- Conductivity correlated well to toxicity

Conclusions

- *C. dubia* more tolerant than natives
- Habitat confounding at some sites
- WET will not fully protect aquatic life, but
- WET tests and TIEs still a good idea
- Instream biomonitoring also needed to:
  - fully protect aquatic life
  - evaluate success of permits