



Invasive Mussel  
Collaborative

# Unraveling the nuances of dreissenid mussel control tool efficacy

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Toolbox



**HELP  
STOP  
AQUATIC  
HITCHHIKERS!**

**Management  
Actions**

Minnesota Department of Natural Resources



**USGS**  
science for a changing world

**LATEST  
RESEARCH**

**Invasive  
Species  
Alert**

**Applications  
And  
Implications**

**CAUTION**



**FUTURE**

**SLOW - NO WAKE**

**OBSERVATIONS**

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

# Available Tools

## Search Terms

Pests: "ZEBRA MUSSEL" & "ZEBRA MUSSEL (DREISSENA)"

Use Sites: "LAKES (WATER TREATMENT)"

Status: "ACTIVE"

## Lakes (water treatment)

Registered Name	Active Ingredient
Drexel Defol 40%	Sodium chlorate (40%)
Natrix	Copper ethanolamine complex (9.1% Cu)
MBI-401 SDP	<i>P.f.</i> CL145a (~50%)

## Others Used

Registered Name	Active Ingredient
EarthTec (+5 syn.)	Copper sulfate pentahydrate (5% Cu)
Citrine Ultra	Natrix syn.
Potassium chloride*	



National Pesticide Information Center  
424,451 Products  
([npic.orst.edu/NPRO](http://npic.orst.edu/NPRO))



PC: Barbour

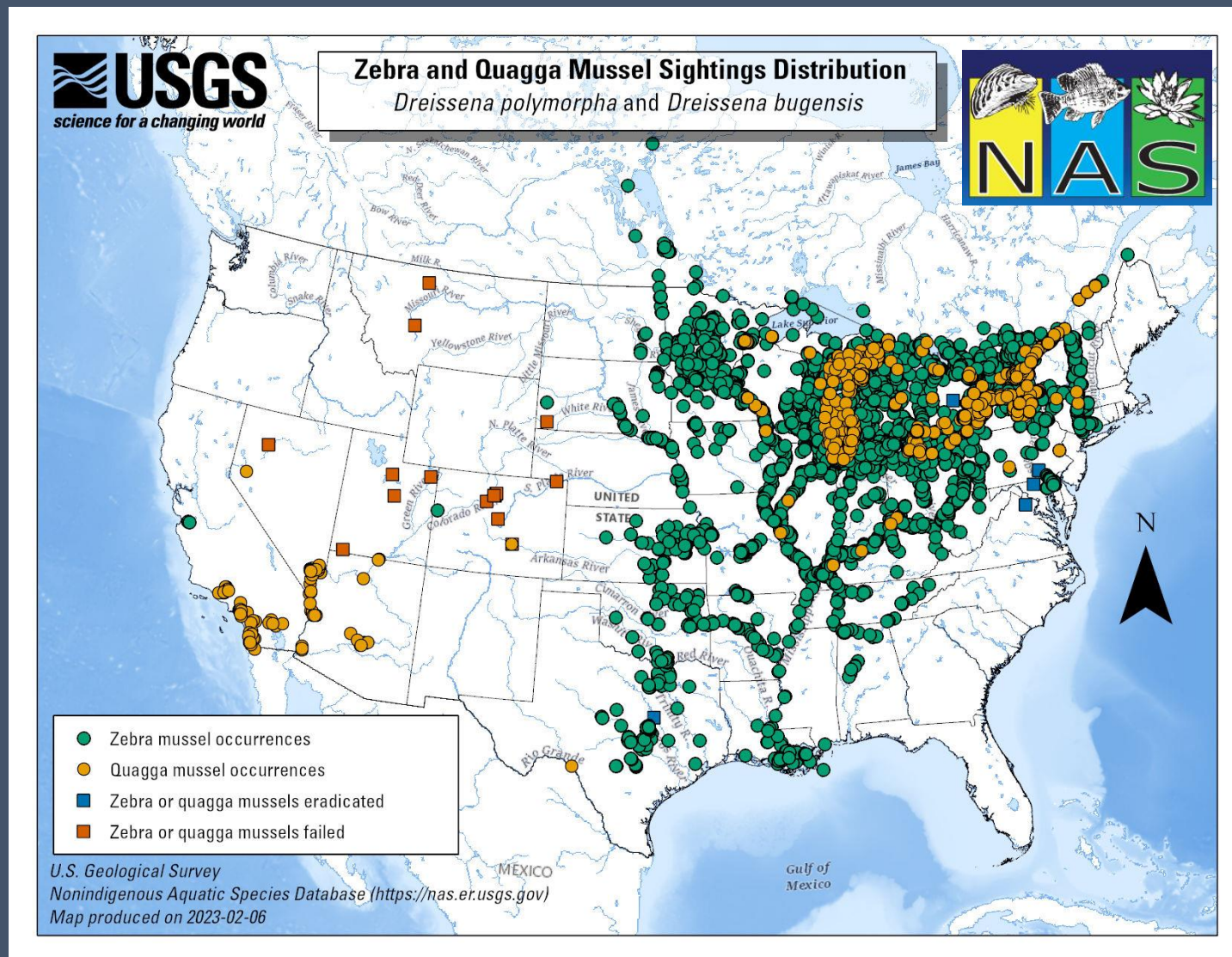


# Control Efforts

## Traditional Approach

- Prevention
- EDRR Treatment
- Contain
- Biofouling Mitigation

Established population?  
“ERADICATE!”

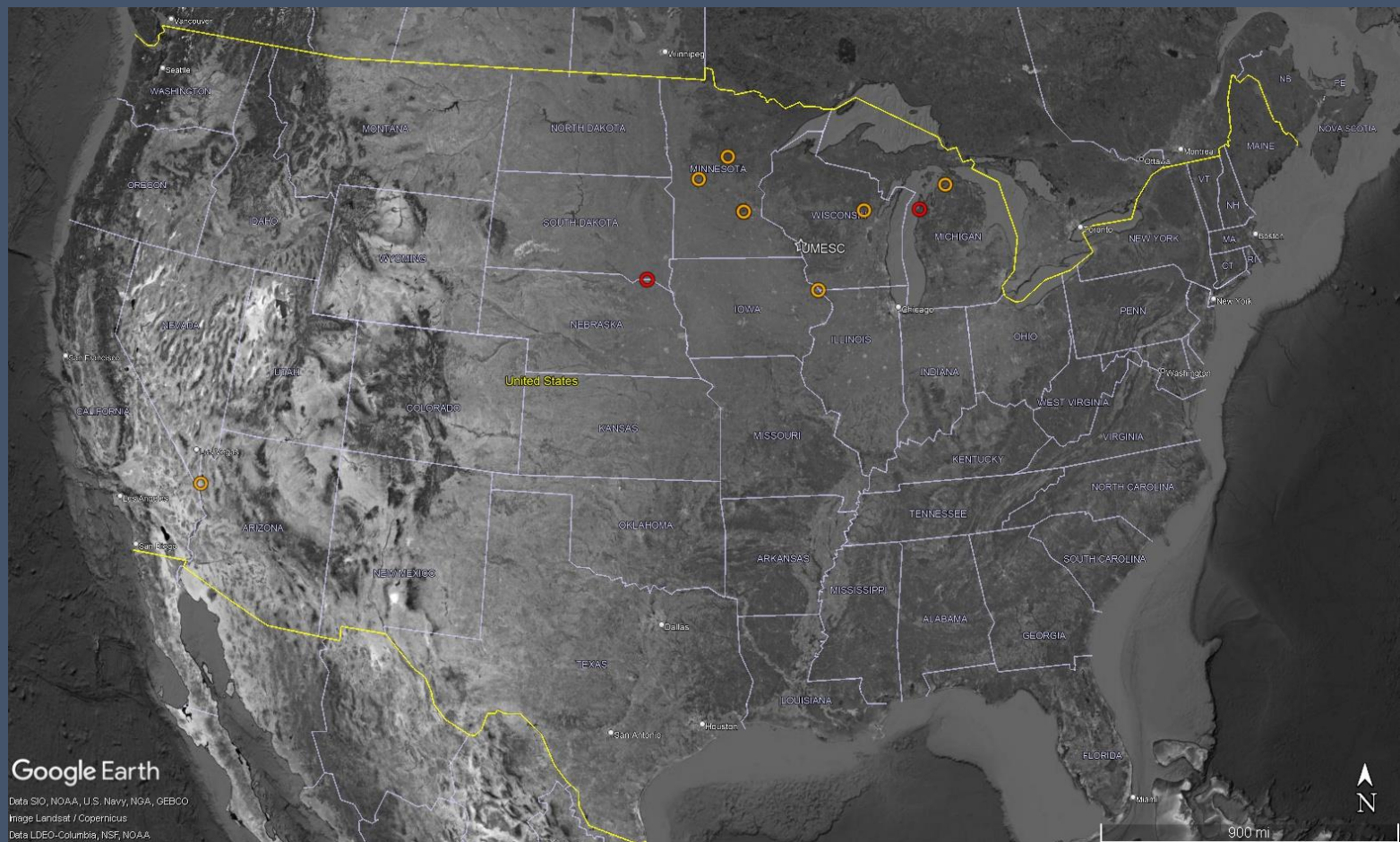


# Control Efforts

## Our Research

- Population control
- Functional eradication
- Target habitats
- Biofouling

Established population?  
“Mitigate”



# Our Observations

## Copper Treatments

>30% (up to > 50%) mortality of adults during 80 µg/L copper treatment targeting veligers.

$R^2 \approx 0.60$  for  $LC_{90} * \text{Temp}$

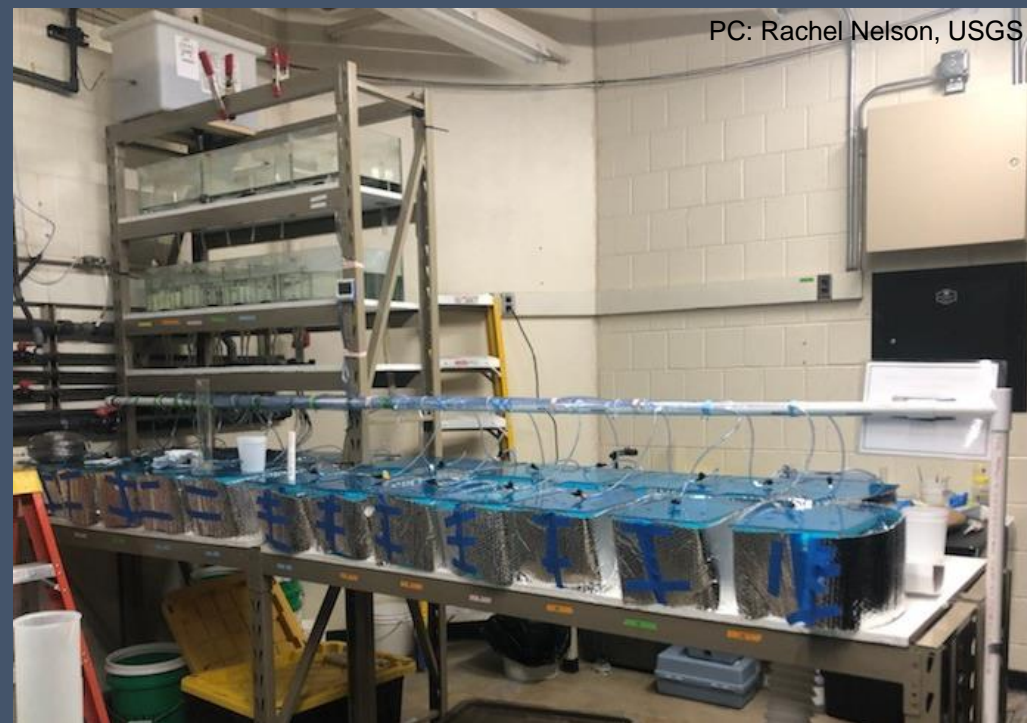
## CO<sub>2</sub> Toxicity Trials

Zebra mussels far more susceptible to CO<sub>2</sub> than unionids tested.

What are potential drivers?  
How does water chemistry matter?

# Carbon Dioxide

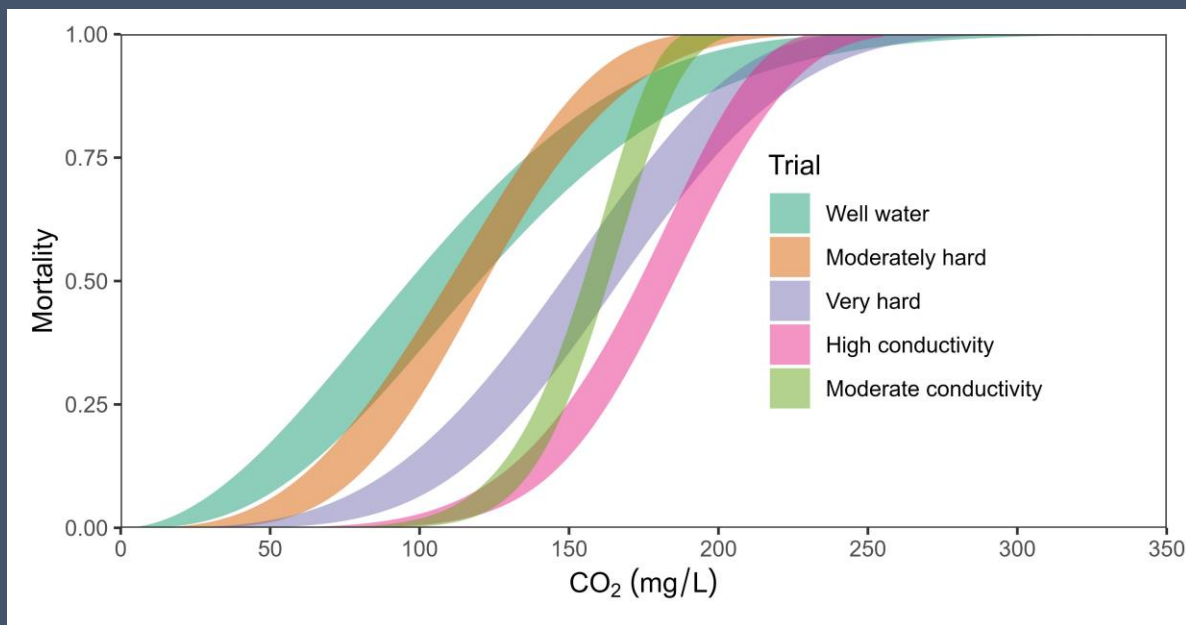
- Reconstituted water
- Acclimated mussels to chemistry
- Exposed in flow-through diluter
- 96-h exposure; 96-h recovery
- Measured:
  - Alkalinity
  - Hardness
  - Major cations
  - Specific conductance
  - Dissolved O<sub>2</sub>
  - Temperature
  - pH



Trial	Total hardness (mg/L CaCO <sub>3</sub> )	Alkalinity (mg/L CaCO <sub>3</sub> )	Specific conductance (μS/cm at 25 °C)	Cations (mmol/L)			
				Na <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	K <sup>+</sup>
Well water	186	145	409	0.62 <sup>a</sup>	1.19 <sup>a</sup>	0.66 <sup>a</sup>	0.038 <sup>a</sup>
Very hard	306	195	967	4.26	1.00	1.77	0.108
Moderately hard	105	74	324	1.23	0.47	0.52	0.065
High conductivity	189	148	819	4.81	1.46	0.72	0.050
Moderate conductivity	184	136	615	2.71	1.36	0.67	0.065

Barbour et al., 2024

# CO<sub>2</sub> Results



Weibull 2-parameter

Agg. = 784

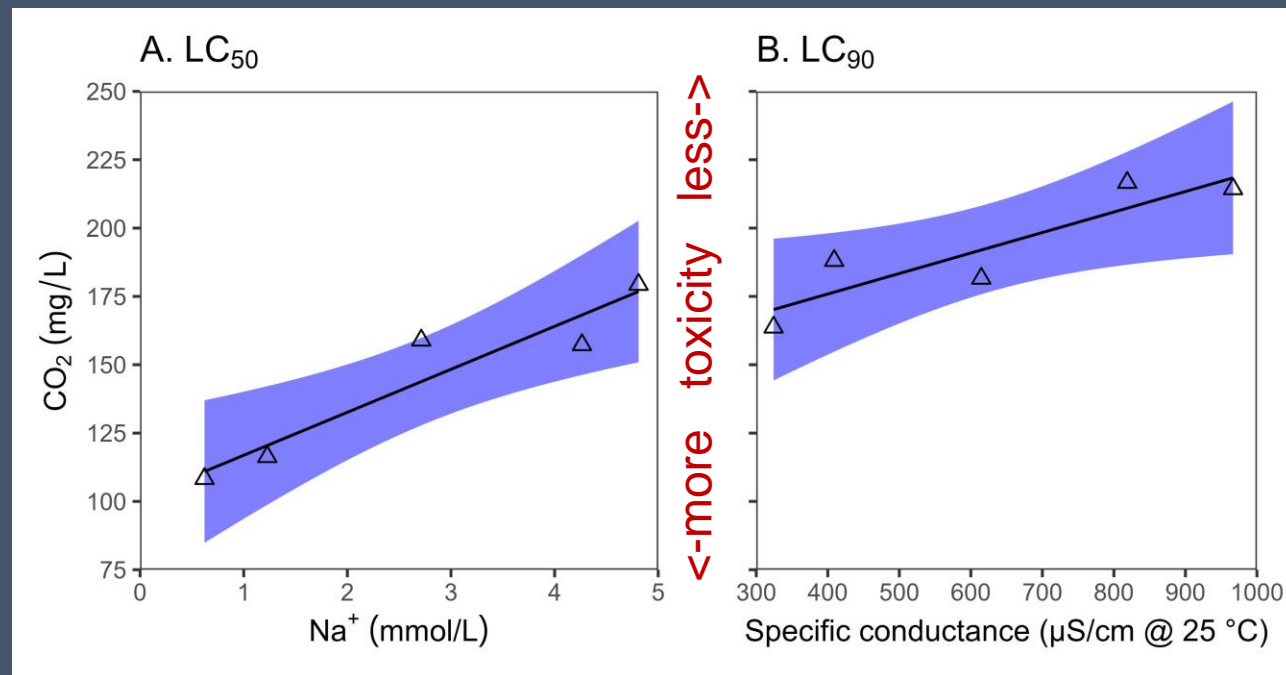
Ind. = 447

$$R^2 = 0.8974$$

$$p = 0.0144$$

$$R^2 = 0.8089$$

$$p = 0.0377$$





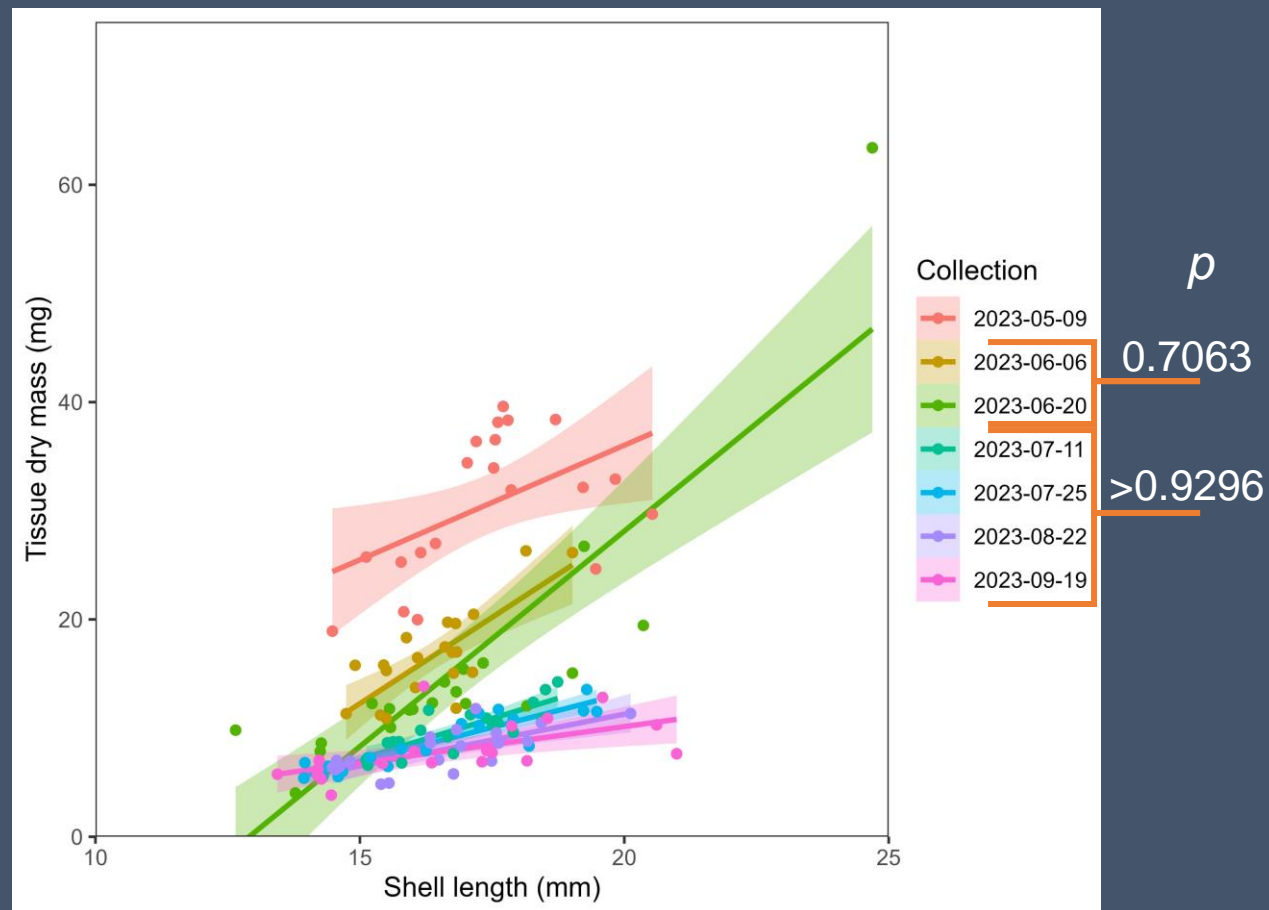
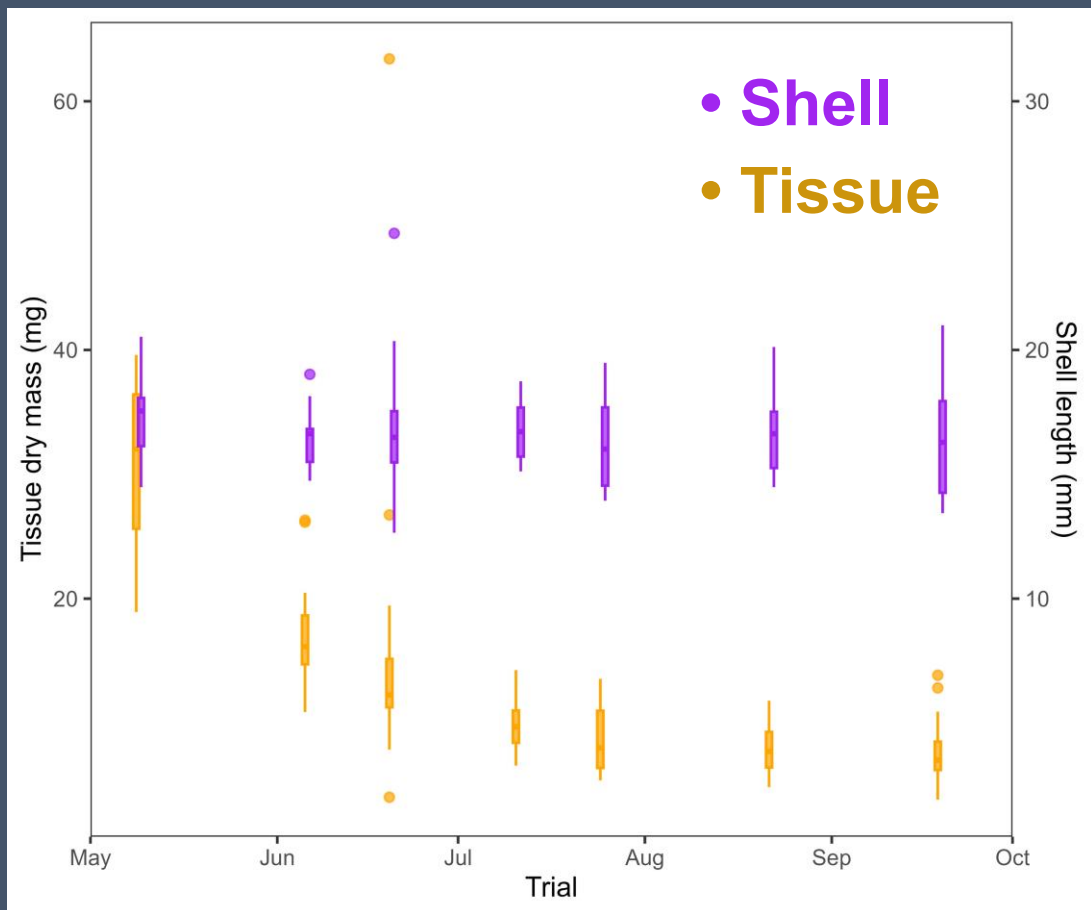
# Copper

- Through reproductive season
- Exposure temperatures matched lake
- Condition factors
- 96-h exposure; 96-h recovery

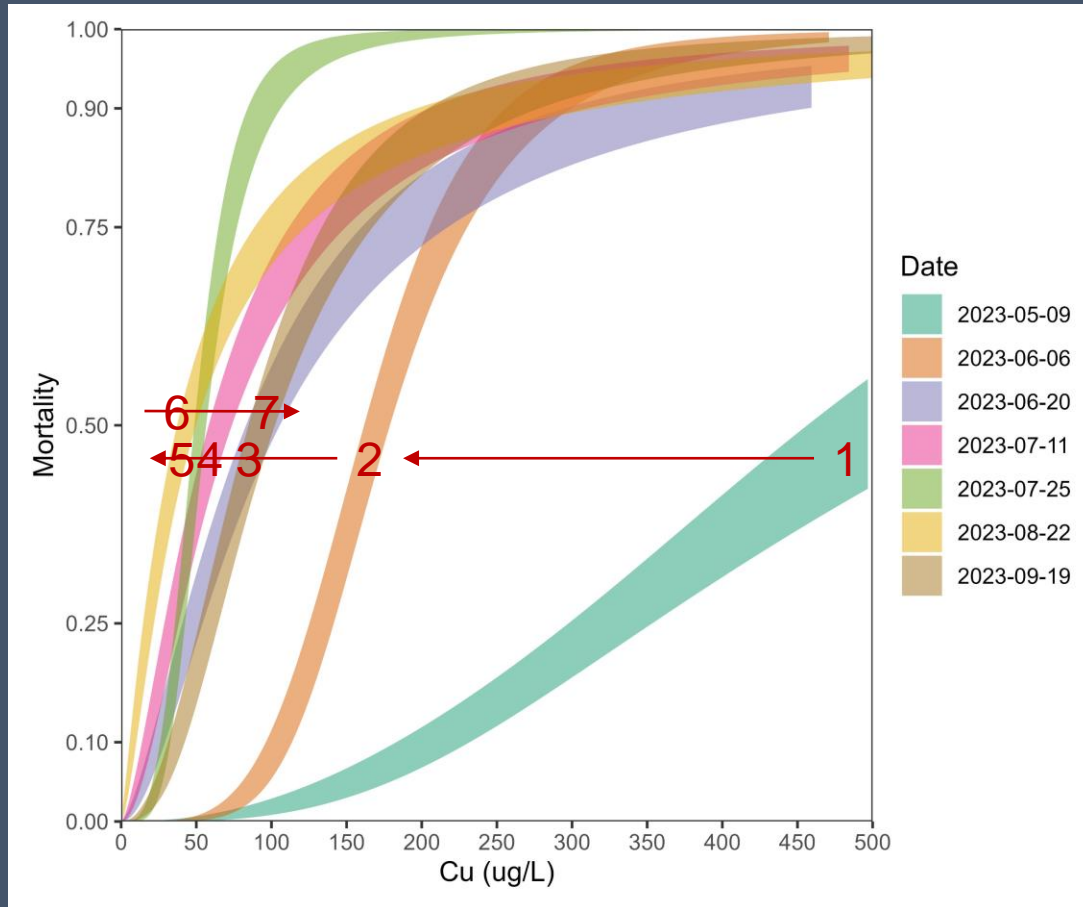


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# Copper Results



# Copper Results



2-parameter, log-logistic models

Agg. = 4679

Ind. = 1985

All dose-response statistically dissimilar

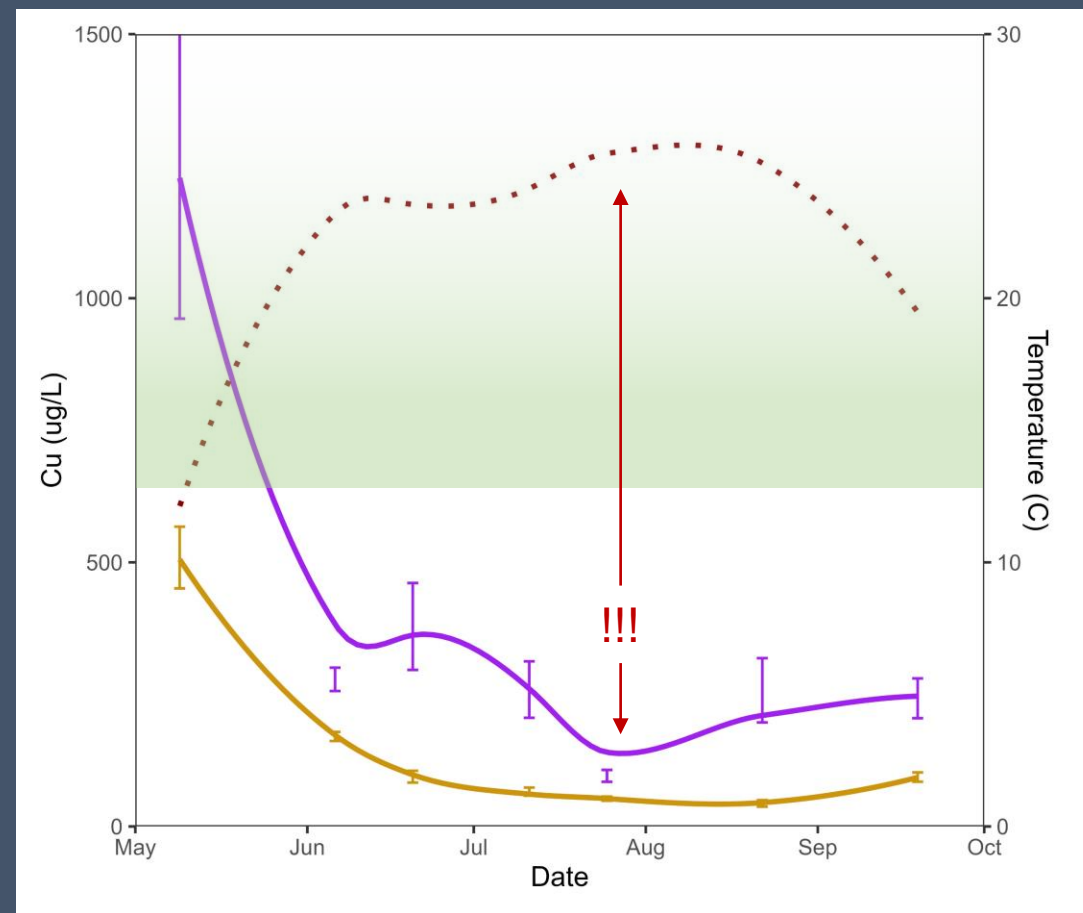
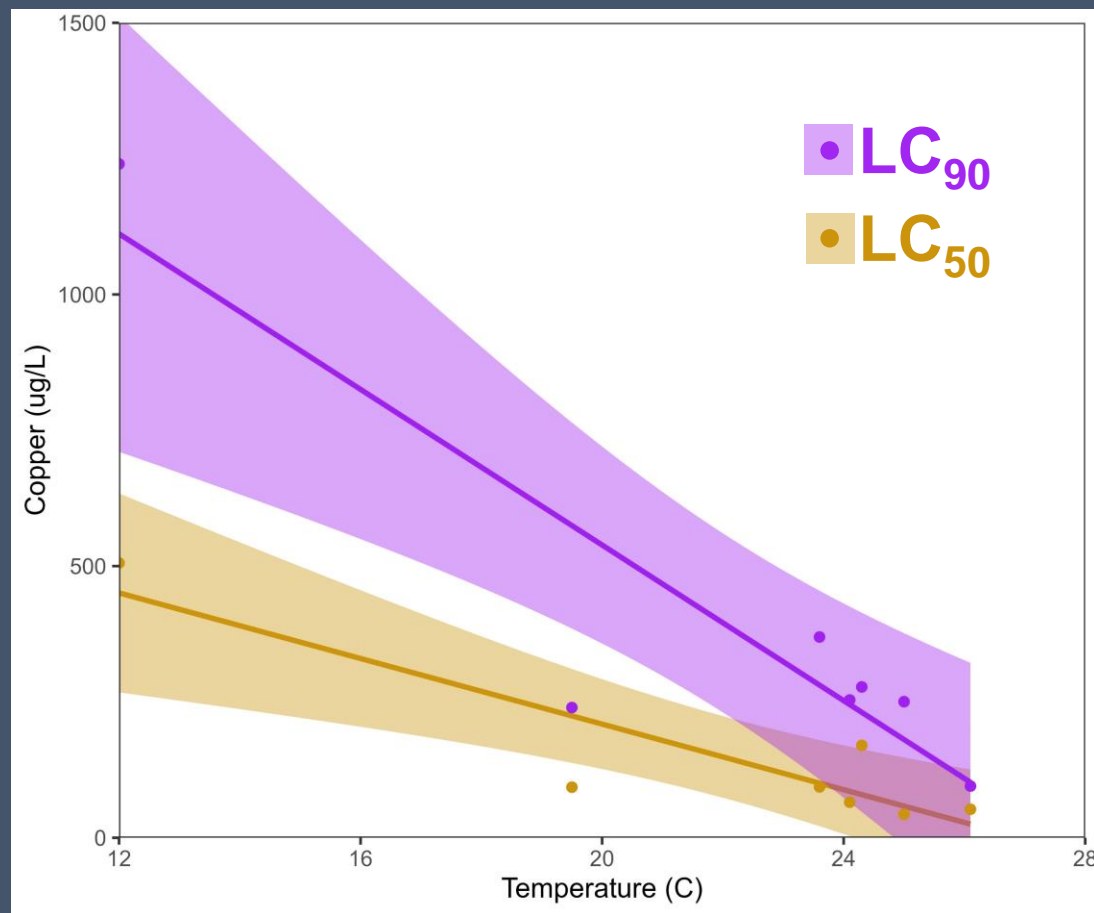
Temporal trend?

100  $\mu\text{g/L}$  in early May vs late July...

<10% mortality vs >90% mortality!

100  $\mu\text{g/L}$  is 10% product label restrictions!!!

# Copper Results

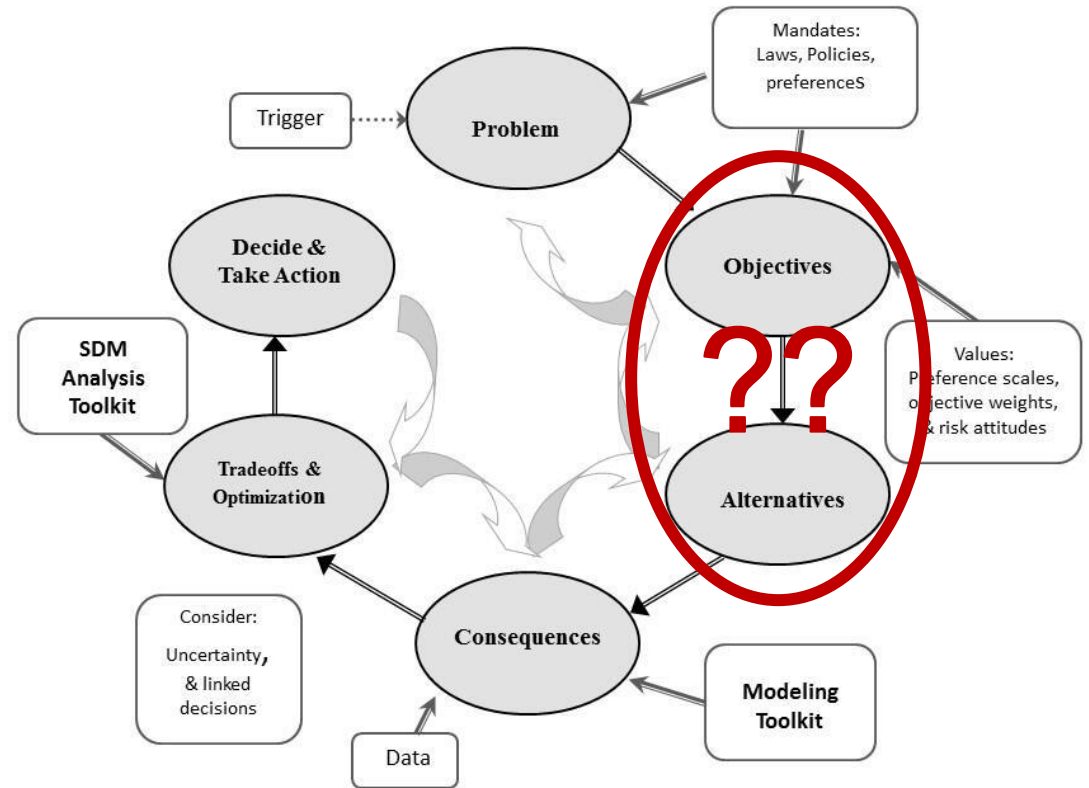
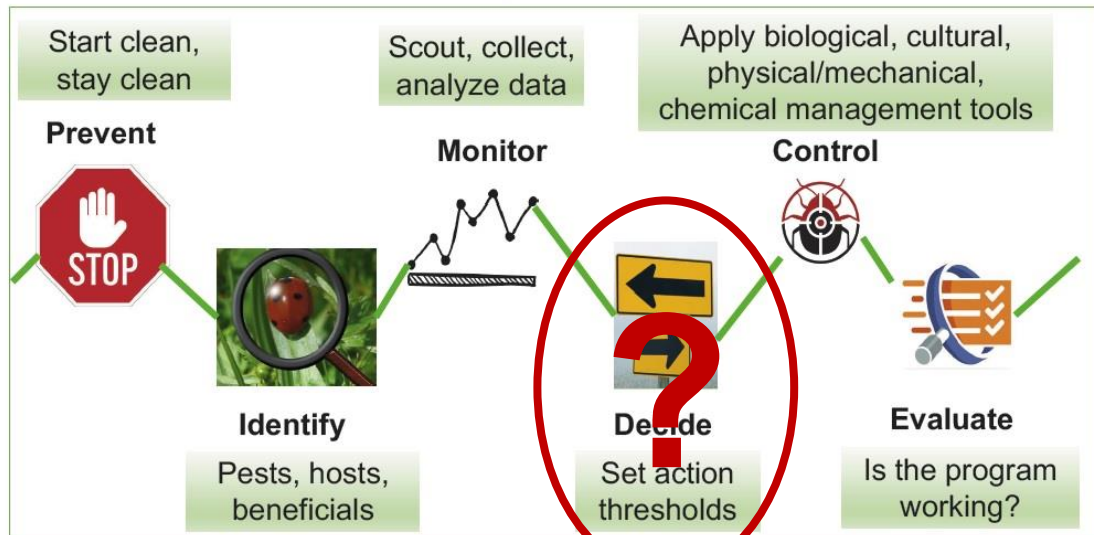


Temperature or temporal? Can we separate them???

# Applying Results

- Structured Decision-Making
- Integrated Pest Management

## Principles of IPM



Source: Jean Fitts Cochrane

# Implications for Management

What are the capabilities and limitations of the tools on hand?

CO<sub>2</sub> work emphasizes tailoring treatments to water chemistry

Copper work emphasizes treatment timing and mussel biology



# Our Future

- Investigating lower copper doses for biofouling
  - Product comparisons (Natrix vs EarthTec)
  - Veliger toxicity
- Applications of CO<sub>2</sub> as alternative to benthic mats
- Strategies to prevent biofouling on native mussels
- Novel formulations, products, and techniques
  - Zequanox
  - Niclosamide



Our work has been possible thanks to many partners and collaborators.



And many, many more...



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