

# Incorporation of Field or Meso/Microcosm Data to Validate Criteria in Watersheds Supporting Federally Listed Species

Why are the data needed?

How can data be incorporated?

# T&E Aquatic Species Nationwide



46 snails + 43 in review  
25 crustaceans + 81 in review  
6 aquatic invertebrates + 29 in review



35 amphibians +  
43 in review



163 fishes +  
43 in review



88 mussels +  
35 in review

WQC based on  
laboratory  
testing

303d listings  
based on  
biological  
community

T&E listings  
based on  
population  
declines

Discharges may meet WQS  
Yet

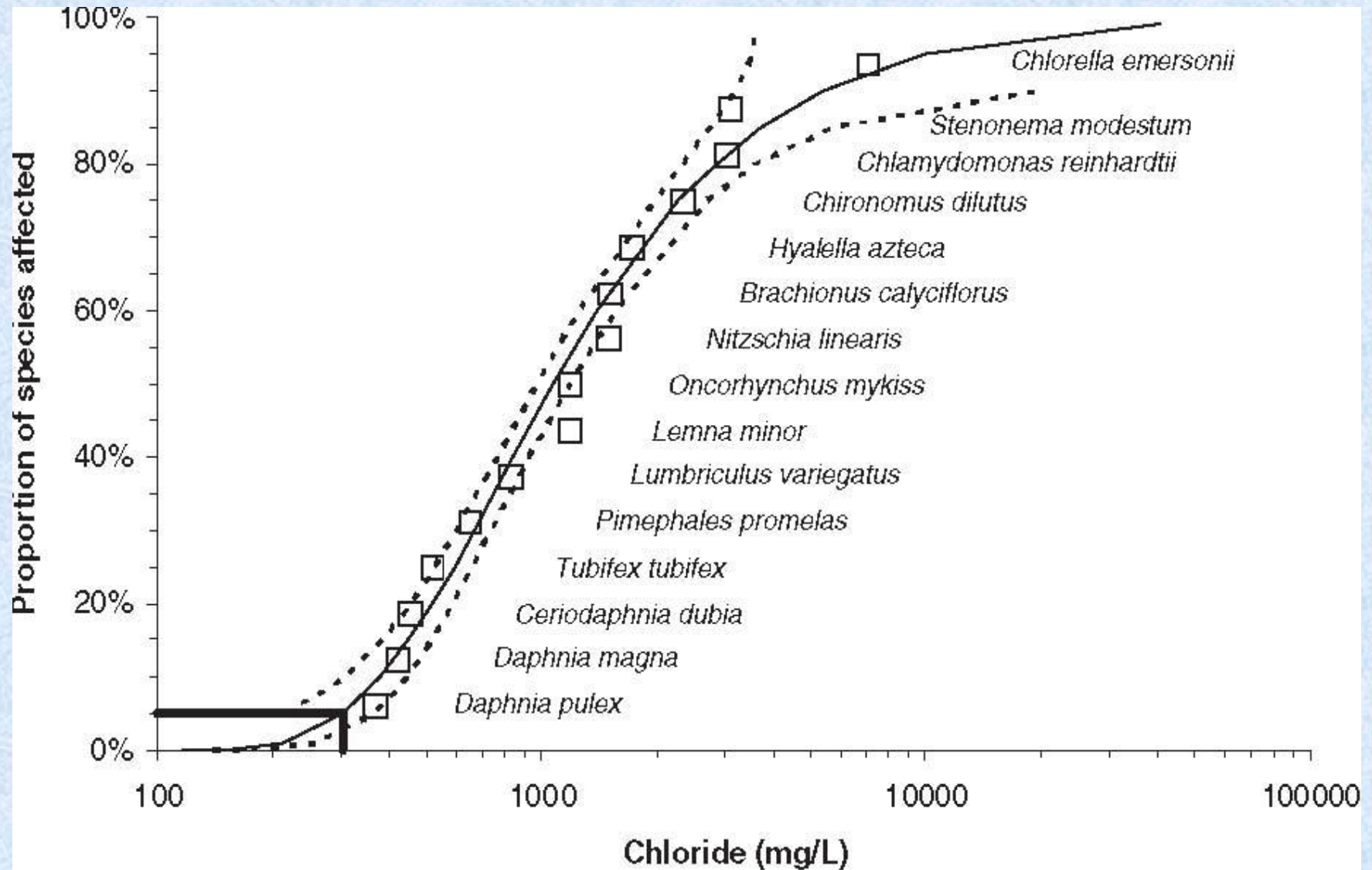
Stream listed as 303d and/or species at risk declining

# Potential Factors

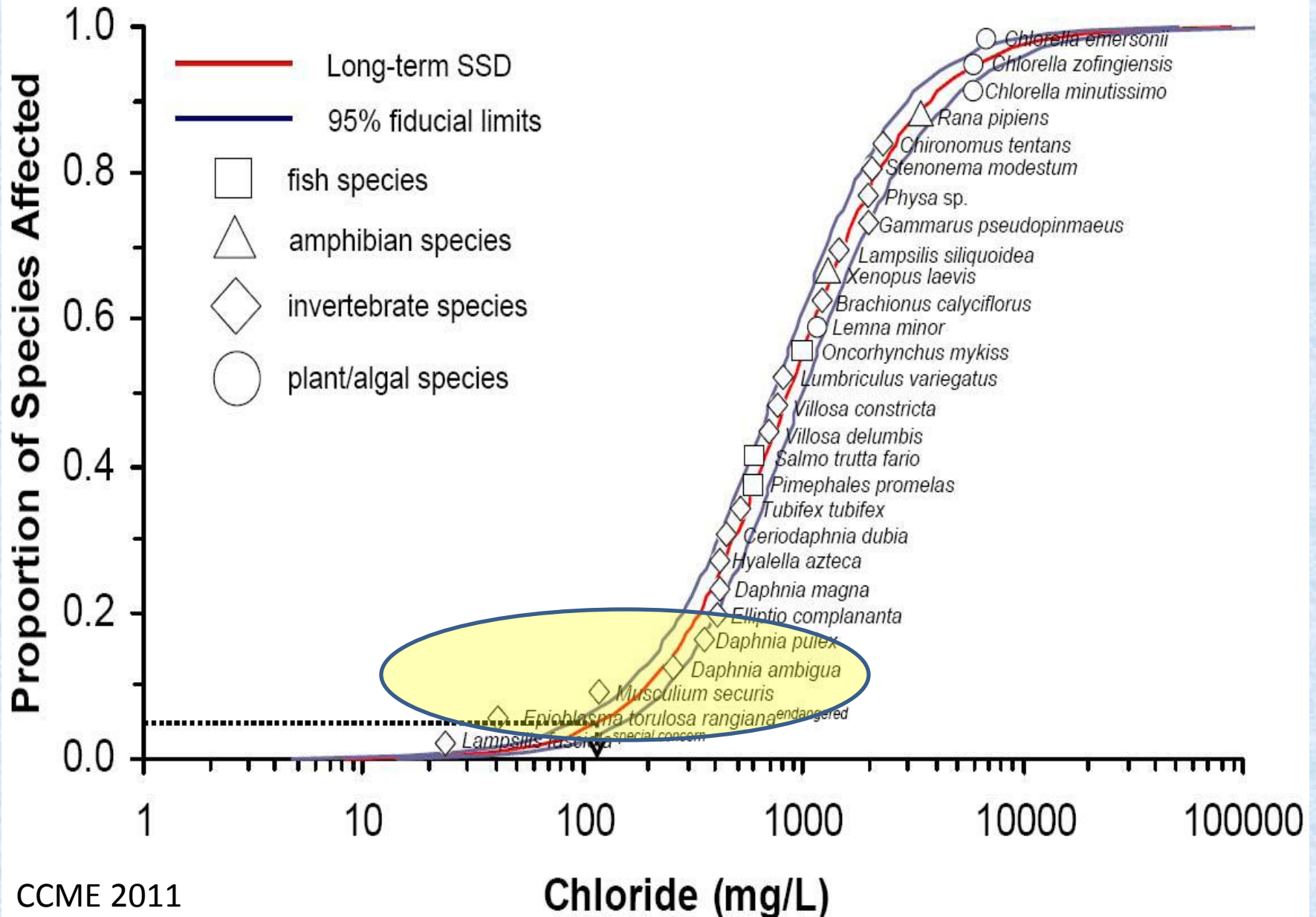
- **Differences between tested and rare species in species sensitivity distribution (SSD)**
- **Listed species may be in the 5% not protected by a WQC**
- **Additional stressors in water bodies**
- **Contaminant-induced maladaptive behaviors**
- **Indirect effects on food webs**
- **Exposure duration (acute vs life long)**
- **Absence of behavioral endpoints**

**Field, Mesocosm  
and  
Microcosm Examples**

# Tested vs Resident Species



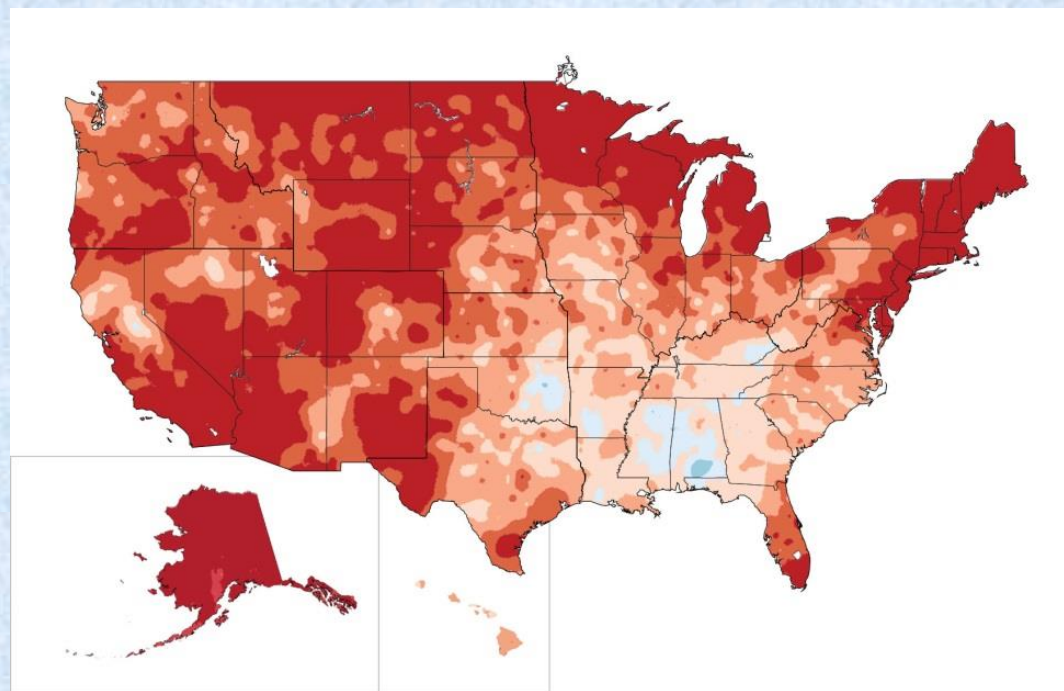
# Effect of Including Data for Two Rare Species



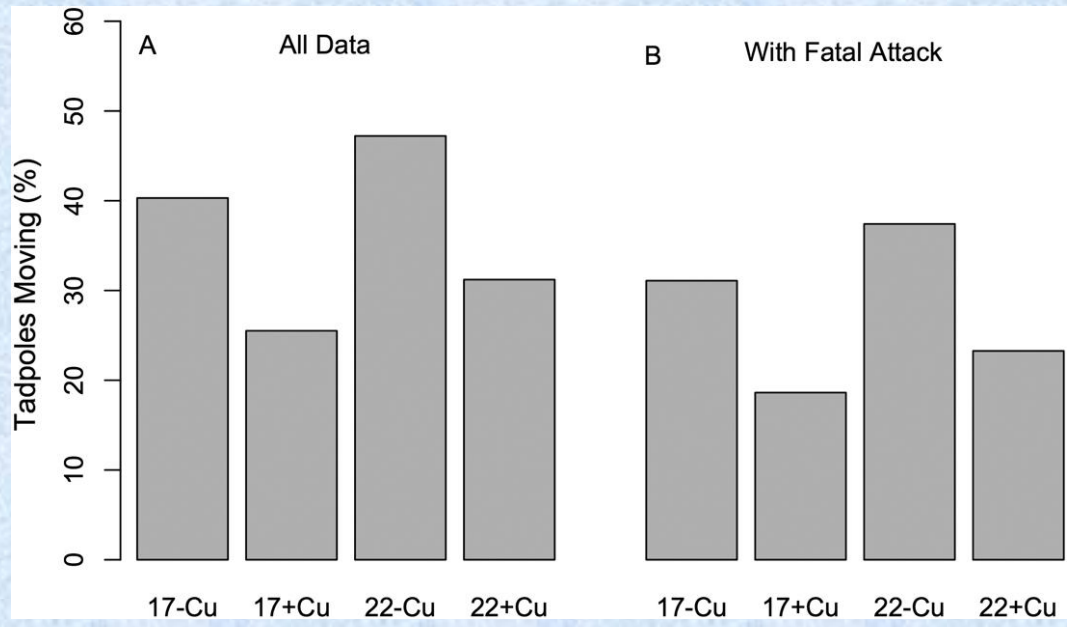
# Additional stressors

## Maladaptive behaviors

- Amphibians –  
worldwide decline  
sensitive to metals
- Copper –  
point and non-point  
sources
- Climate change -  
warmer waters







**Copper decreased tadpole activity**

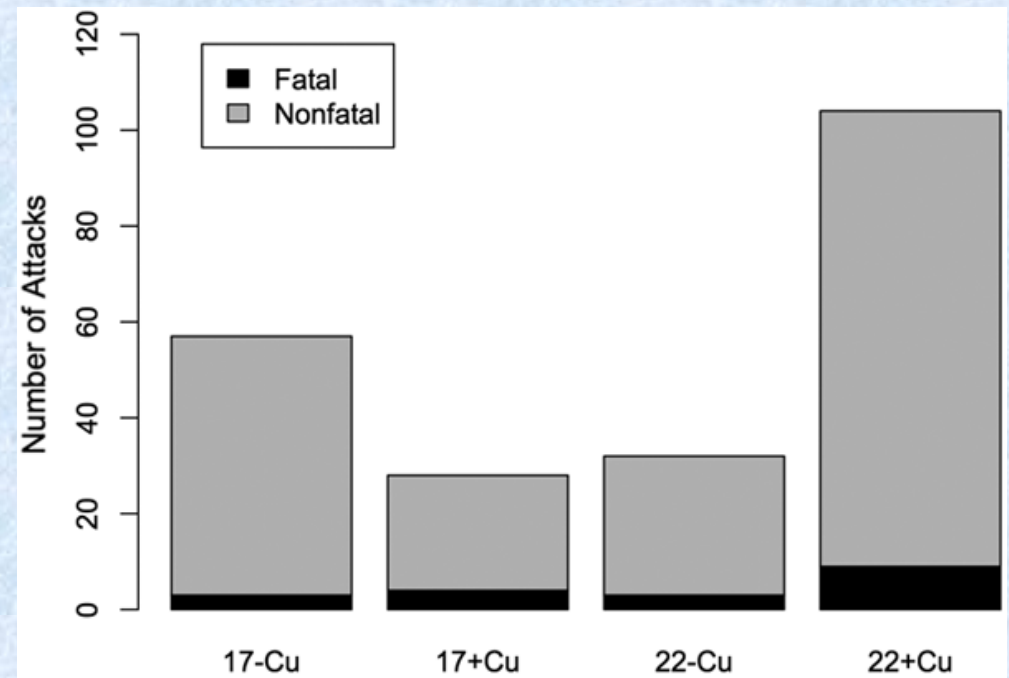


**Increased susceptibility to predation**

**Temperature increased dragonfly activity**



**Increased tadpole predation**



# Additional stressors

## Maladaptive behaviors

- **Amphibians**
  - 35 listed
  - 43 species in review
  - Sensitive to pesticides
- **Carbaryl**
  - agricultural/residential
  - widely used
- **Salinity**
  - sea level rise
  - deicer use
  - irrigation
  - mining/O&G



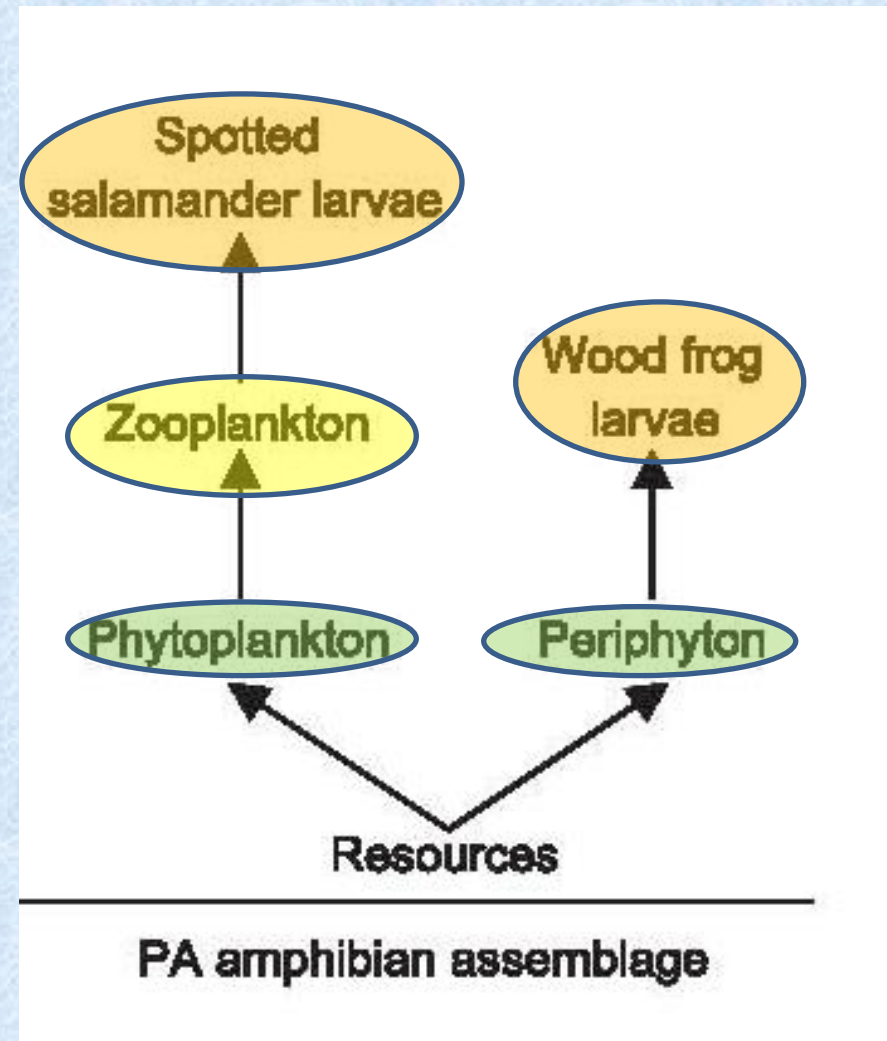
# Decreased feeding resulting in slower growth/development

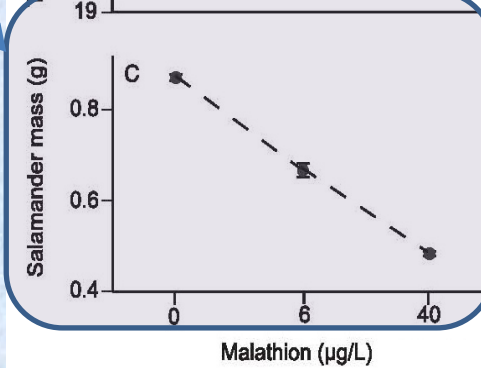
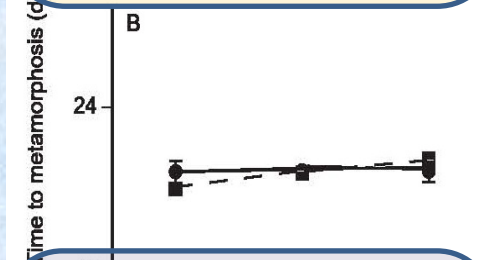
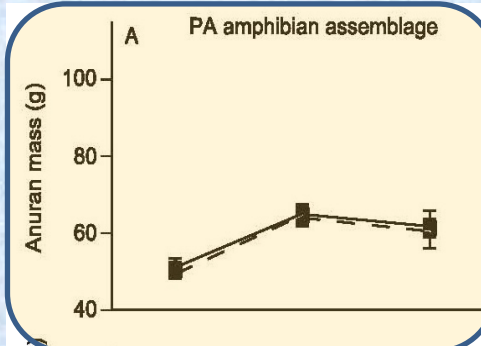
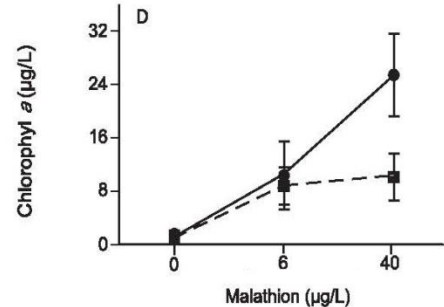
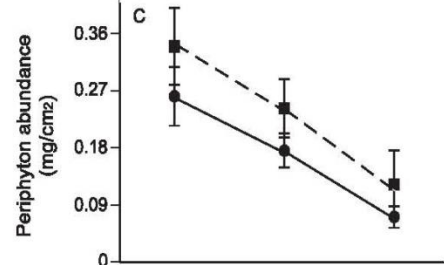
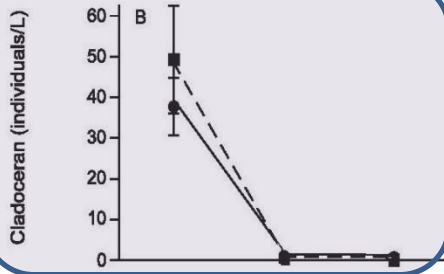
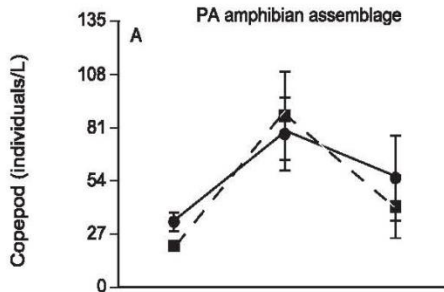
## Decreased movement affects predator avoidance and survival

Response variable	Performance relative to freshwater control							<b>KEY</b>
	Freshwater			Brackish water				
	<i>Atra-zine</i>	<i>Glyph-osate</i>	<i>Carb-aryl</i>	<i>None</i>	<i>Atra-zine</i>	<i>Glyph-osate</i>	<i>Carb-aryl</i>	
Survival			*					10 to 20%
Tadpole mass	*		***	***			**	5 to 10%
Time to metamorphosis			***	***				-5 to 5%
Mass at metamorphosis				***				-5 to -10%
Activity ( <i>day 10</i> )				***				-10 to -20%
Feeding ( <i>day 10</i> )				***		†	***	-20 to -30%
Activity ( <i>day 21</i> )			***	*			†	-30 to -40%
Feeding ( <i>day 21</i> )			***				**	-40 to -50%
Average speed			†	*			***	-50 to -60%
Maximum velocity			***	***			***	-60 to -70%

# Indirect Effects via Food Webs

- Amphibians –  
under represented in lab  
suited to mesocosms
- Low dose pesticide exposure  
relevant to environment
- Simple Food Web –  
different sensitivities  
evident interactions





**Selective toxicity in prey  
Perturbs food web balance**



**Selective indirect effects in  
predators without direct  
toxicity**



**Annual exposures could  
eliminate entire populations**

# Exposure Duration and Endpoints

- Freshwater mussels
  - under represented in lab
  - Uniquely sensitive to some chemicals
  - Sessile; complex life history; long lived
- Metal mixtures –
  - typical environmental exposure
- Sediments & Pore Water
  - relevant to filter feeders that burrow
- Lab Testing & Field Surveys-
- -combination warranted to understand toxicity



# Correspondence of laboratory testing and field survey

	Field impact	Field no impact
Lab toxic	33%	0%
Lab nontoxic	27%	40%

**Potential Factors for Discrepancy:**  
**Lifetime exposure of mussels**  
**Effects on reproduction not assessed**



**Critical population reductions for rare species**

# Why are the data needed?

- **Water quality critical to T&E aquatic species**
- **274 aquatic species under review for T&E**
- **Difficult logistics for lab testing T&E species**
- **Lifetime and full life cycle exposure effects**
- **Indirect toxicity via food web perturbations**
- **Ubiquity of environmental stressors including climate changes**



# How can data be incorporated?

- Incorporate laboratory toxicity data for T&E species or closely related surrogates into SSDs
- Include mesocosm/*in situ* studies with T&E species in SSDs
- prioritize chronic studies and sublethal endpoints in setting WQC
- Consider field monitoring data encompassing T&E distributions in assessing the need for WQC revisions

# T&E Toxicity Data in SSD

- derive unique WQC for watersheds with sensitive taxa (e.g., ammonia)
- select surrogates for testing in consultation with T&E species experts (e.g., FWS, NOAA, academics)
- add weight to quality studies with T&E species in deriving WQC

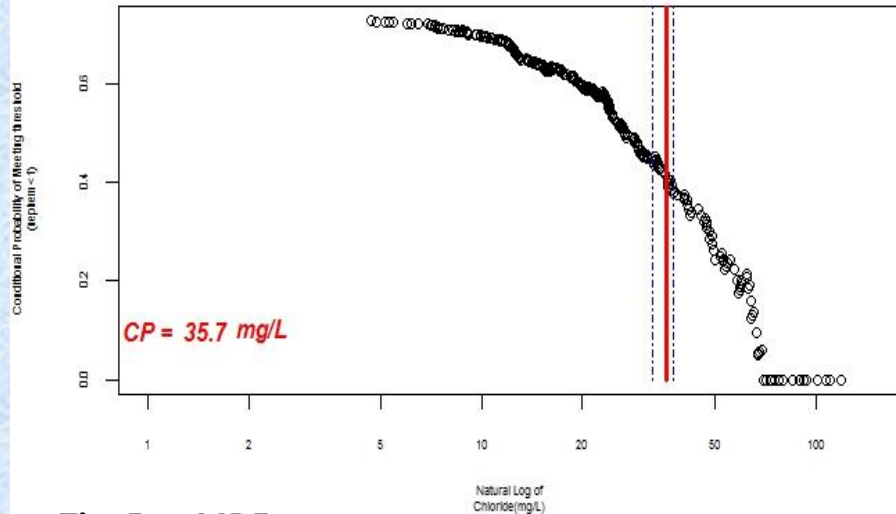
# T&E Mesocosm/*In Situ* Studies

- Enables testing species difficult to sustain in lab
- Allows for extended exposures
- Enables testing of mixtures/other stressors
- Incorporates behavioral responses
- Facilitates assessment of indirect effects
- Used for EPA pesticide approvals
- Evaluation guidance available from other countries



# T&E in Field Monitoring Data

Conditional Probability of Meeting 'Number of Ephemeroptera' Metric (Coastal Plain)



Tim Fox MDE

**Captures effects of:**  
**long term exposures**  
**multiple life stages**  
**multiple stressors**  
**Indirect effects**

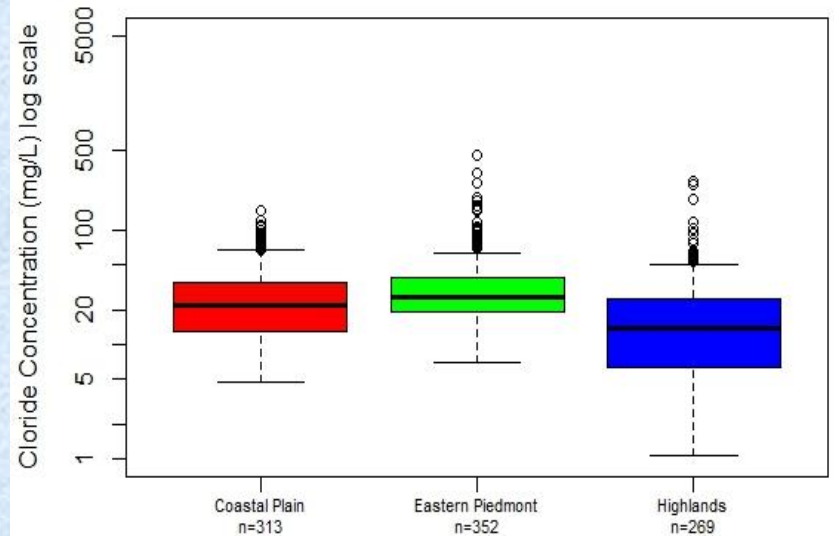
Demonstrated to be effective for:

- conductivity (e.g., Appalachians)
- chloride (e.g., Maryland)

Signals failure of WQC to protect sensitive species

Useful for documenting effectiveness of revisions to WQC or state standards

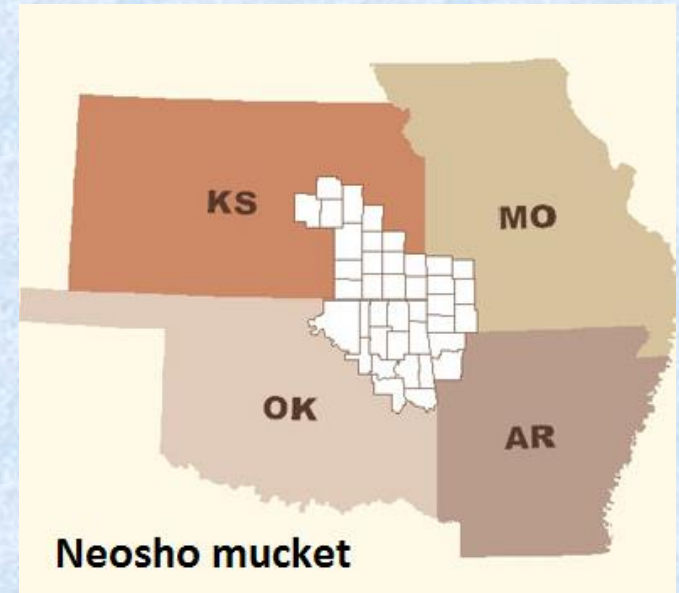
Box Plot of Chloride Concentrations (Filtered Data Set)



Tim Fox MDE

# Federal Strategy

- T&E species ranges cross state boundaries
- States provide inconsistent protection
- Inefficient and ineffective protection at the permit-specific level
- Federal review of toxicity data for laboratory and field studies needed to ensure standardization



# Acknowledgements

- Mari Reeves – USFWS AK
- Dave Mosby and Andy Roberts – USFWS MO
- Tim Fox – Maryland Department of the Environment
- Monica Nowierski – Ontario Ministry of the Environment and Climate Change