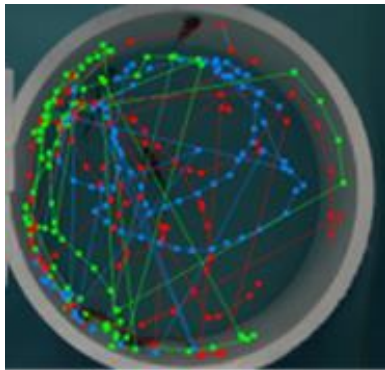


Behavioral Methods in Aquatic Toxicology



HOLLY PUGLIS

U.S. GEOLOGICAL SURVEY

COLUMBIA ENVIRONMENTAL RESEARCH CENTER

JUNE 13, 2018

Talk Outline

- 1) What is behavioral toxicosis and why do we care about it
- 2) A tour of aquatic behavioral toxicology methodologies
- 3) Other capabilities at CERC
- 4) Behavior in the regulatory arena and restoration

Behavior

A series of overt, observable, whole-body activities that operate through the central nervous system and enable an animal to **survive, grow, and reproduce**

Behavioral Toxicosis

Occurs when a chemical stressor elicits an abnormal or maladaptive behavioral change

Behavioral Measures of Toxicity

Respiration

Coloration

Equilibrium

Rhythmicity

Thermotaxis

Rheotaxis

Phototaxis

Chemotaxis

Shelter seeking

Swimming

Migration

Feeding

Predation

Shoaling

Competition

Aggression

Reproduction

Learning

Reflexive



Complex

Essential Functions of Ecological Relevance

Habitat Selection

Competition

Predator Avoidance

Feeding

Reproduction



Population
Level Effects

Behavioral Test Criteria

Sensitive to a range of chemical substances

Applicable to a variety of species

Understand variables affecting response

Ecologically relevant

Practical to conduct

Toxicity Test Endpoints

STANDARD ENDPOINTS

(STEPHAN ET AL 1985)

Survival

Growth

Reproduction

Loss of Equilibrium

Immobility

BEHAVIORAL ENDPOINTS

Swimming Activity

Endurance

Avoidance

Predator/Prey Interactions

Feeding Response

Swimming Behavior (LOE/IM)



- **Loss of equilibrium (LOE)**
- **Immobilization**
- Lethargy/Hyperactivity
- Position in the water column
- Increase/Decrease in respiration
- Changes in body color
- Swimming patterns (circles)
- Tremors, body spasms, coughing

Swimming Behavior (LOE/IM)



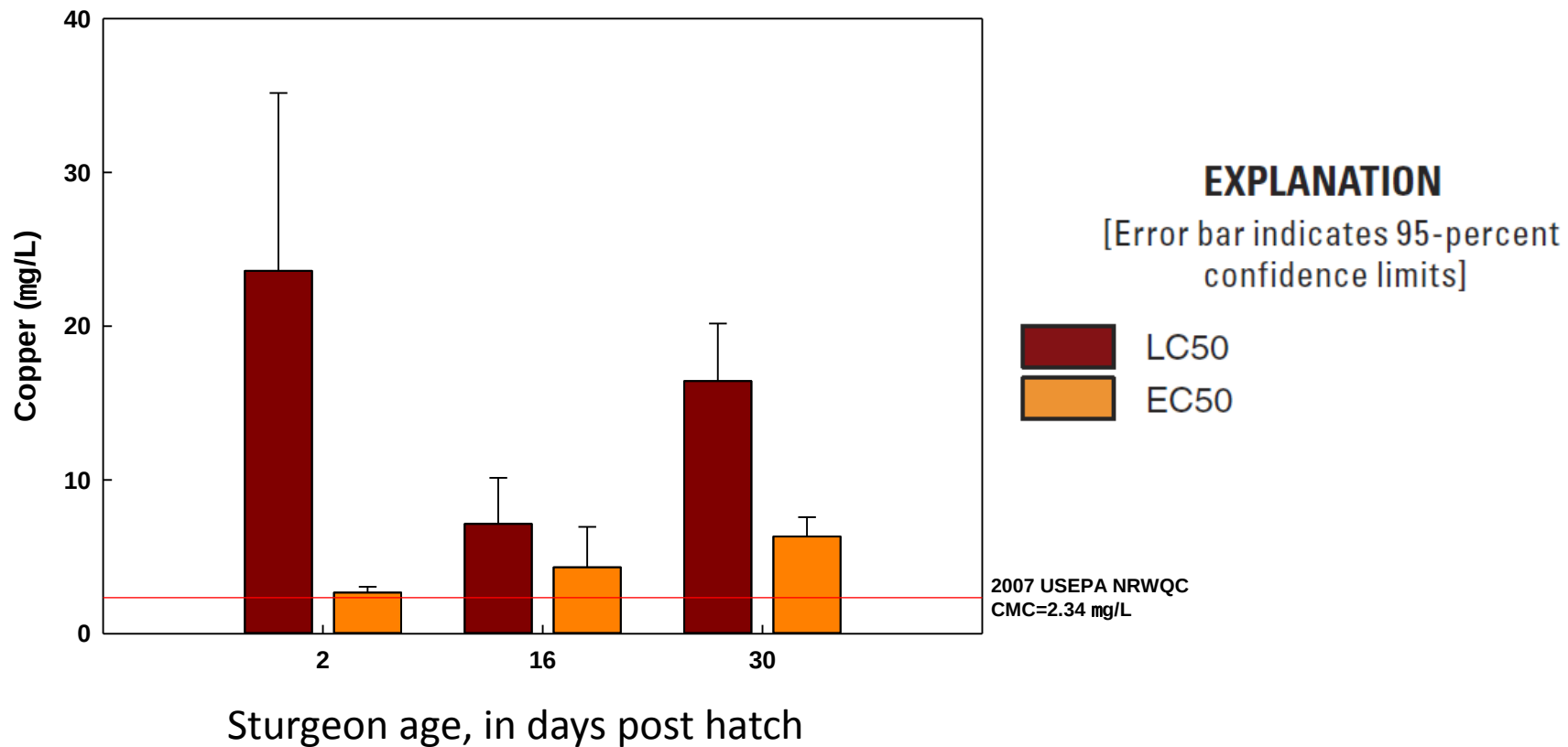
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Behavior More Sensitive Endpoint



Swimming Activity Affected at Low Cu



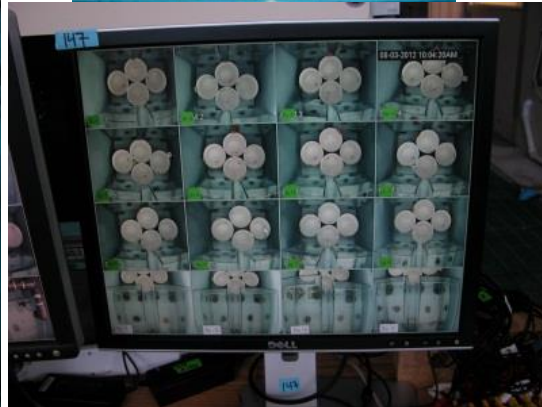
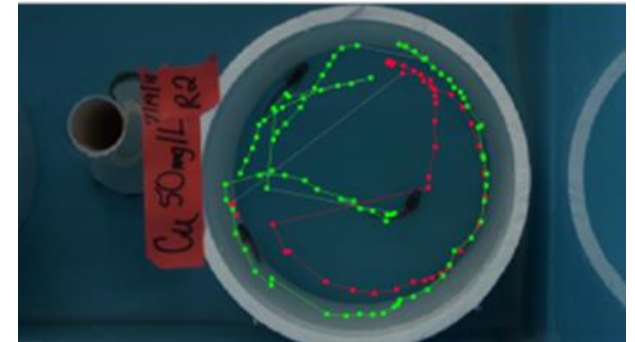
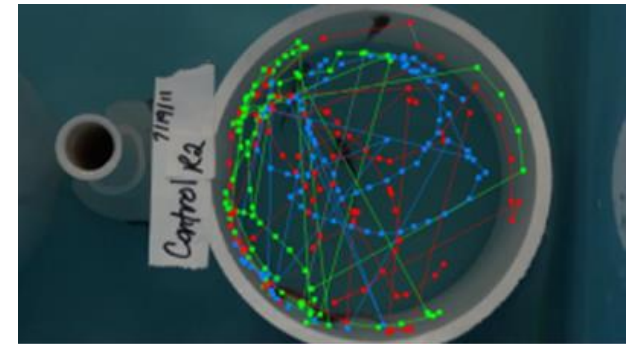
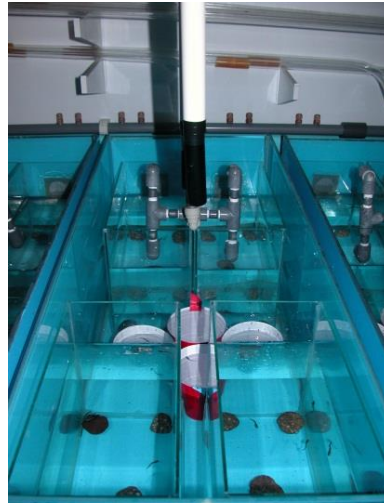
2 dph Cu Control



2 dph Cu 2.66 $\mu\text{g/L}$

2 dph EC50 = 1.51 $\mu\text{g/L}$

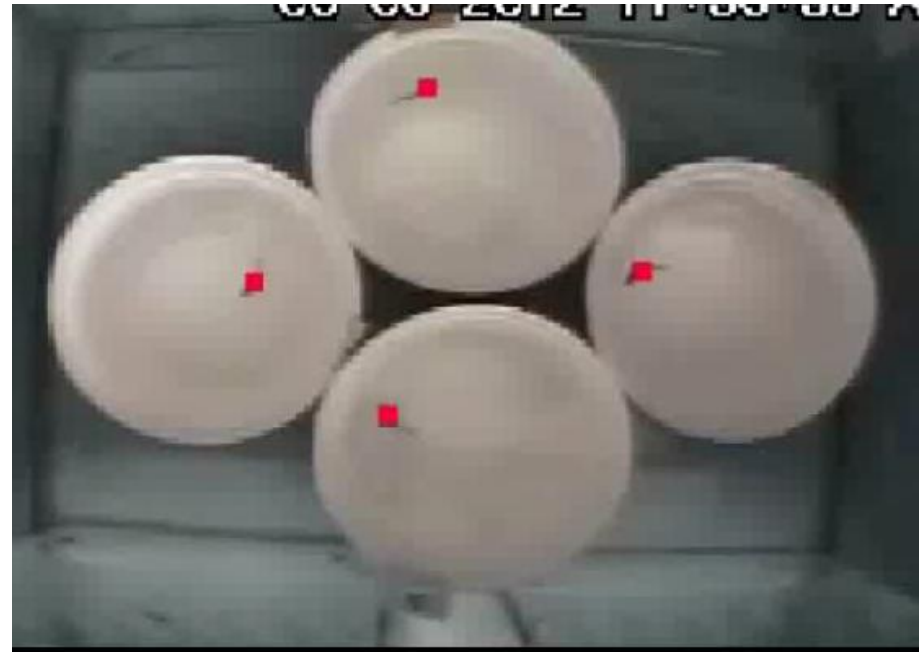
Swimming Activity



Example of Digital Swimming Paths of Sturgeon

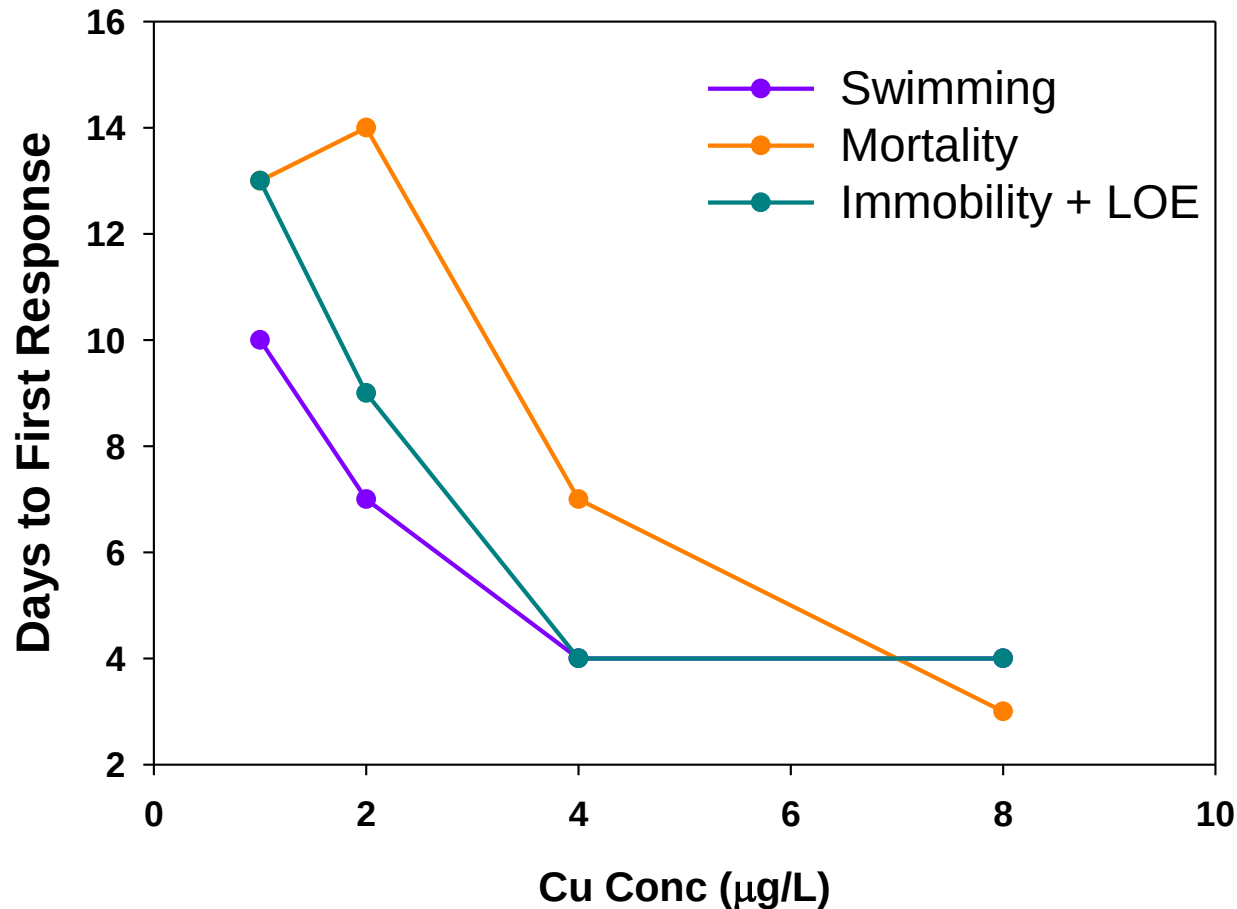


Control

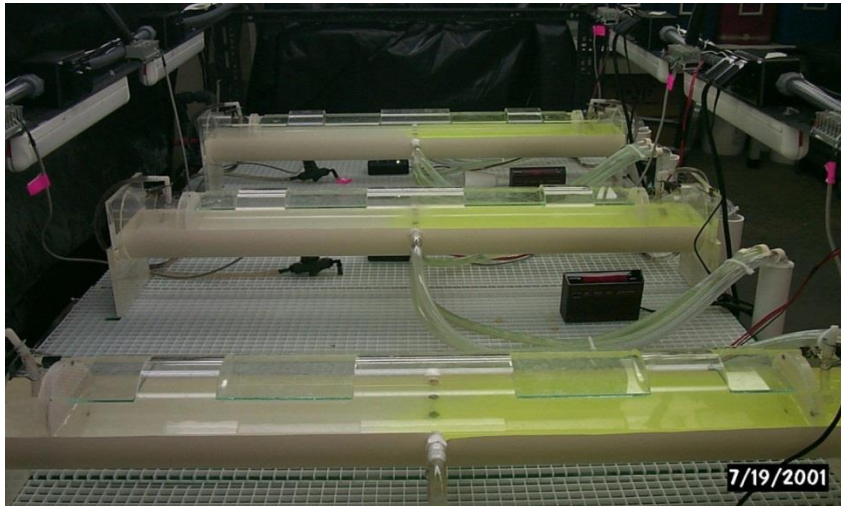
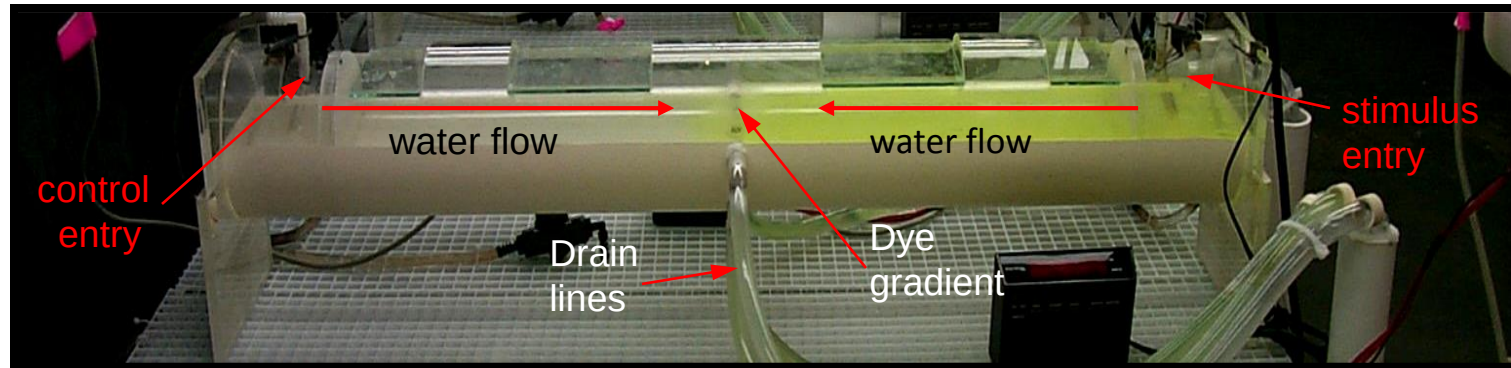


2 $\mu\text{g/L}$ Copper

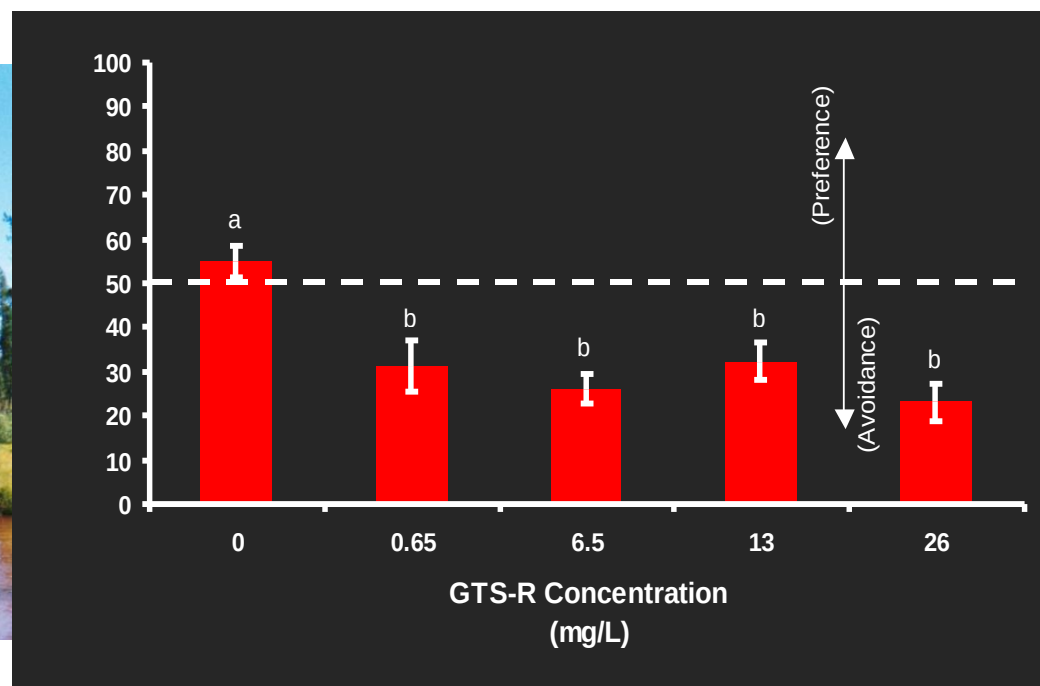
Changes in Swimming Activity Detected Earlier than LOE/IM



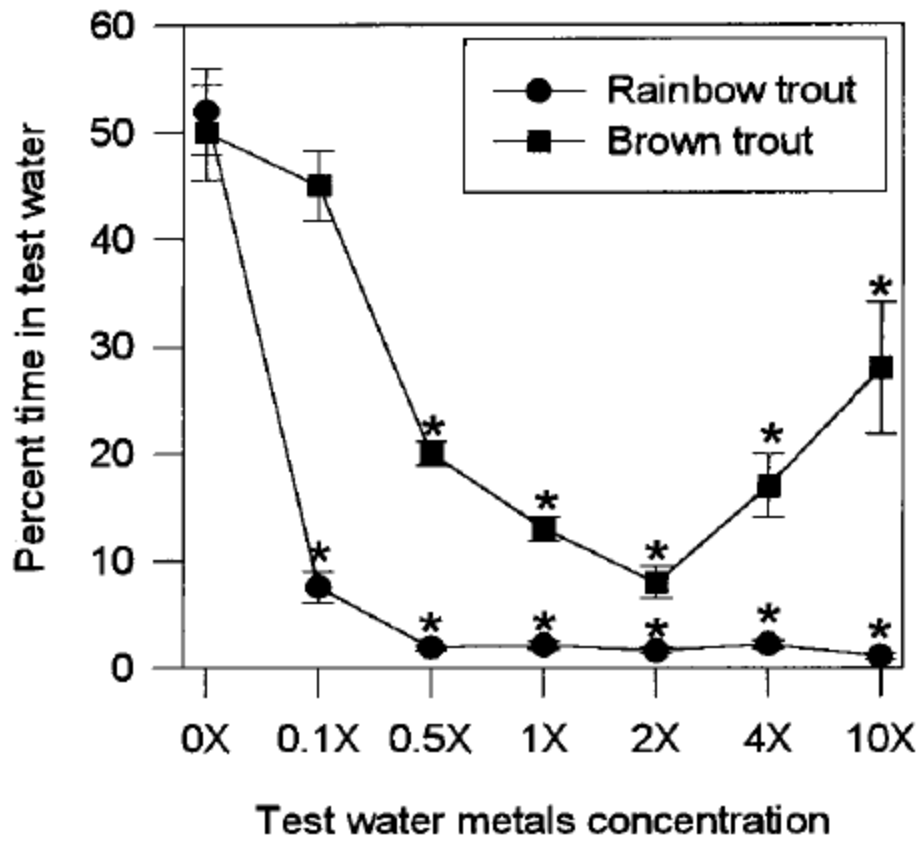
Avoidance/Attractance



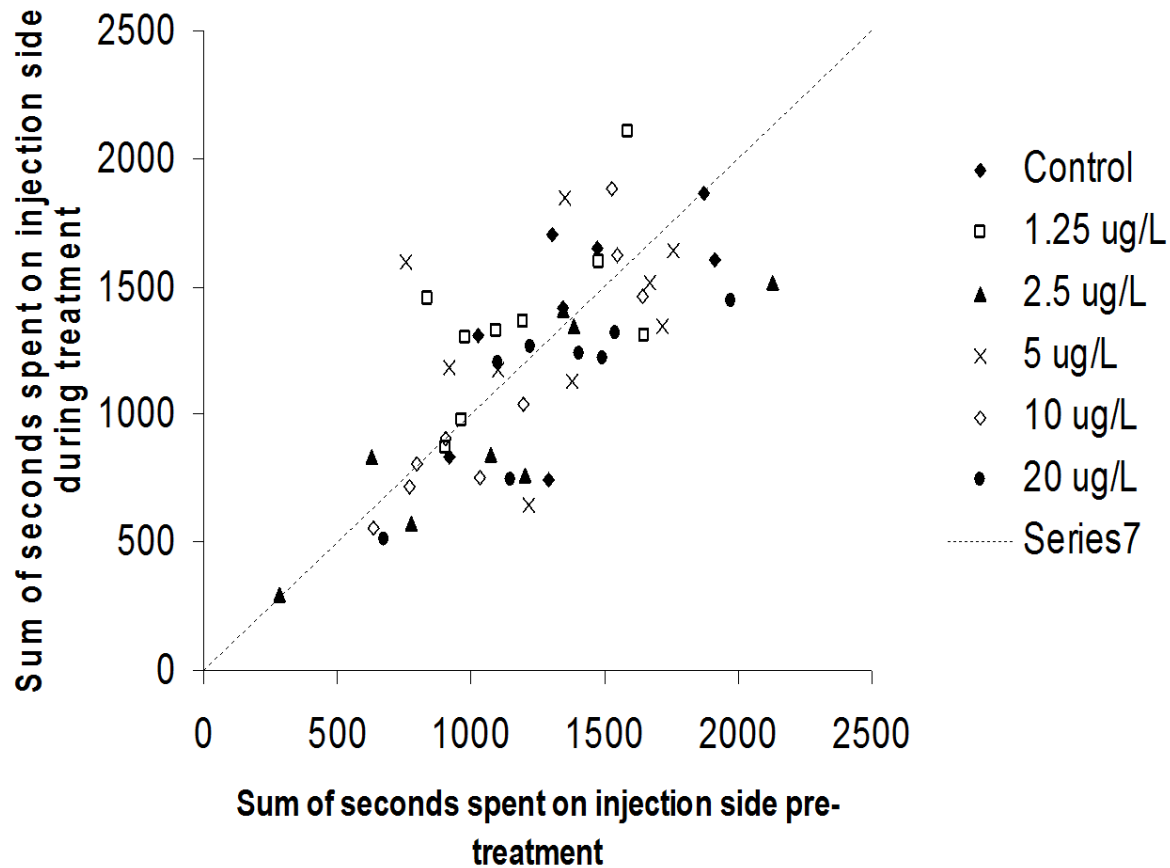
Rainbow Trout Avoid Fire Retardant



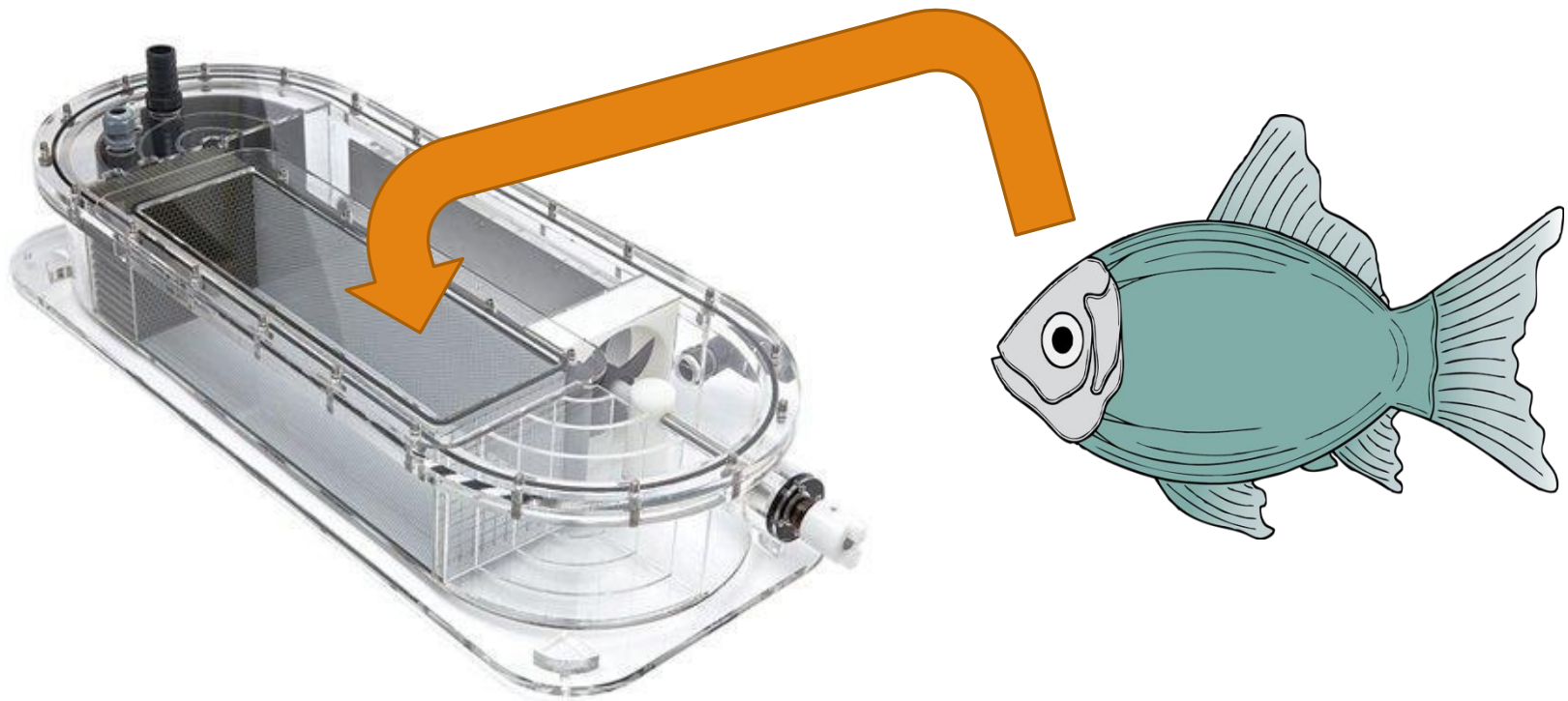
Trout Avoid Metals in Clark Fork



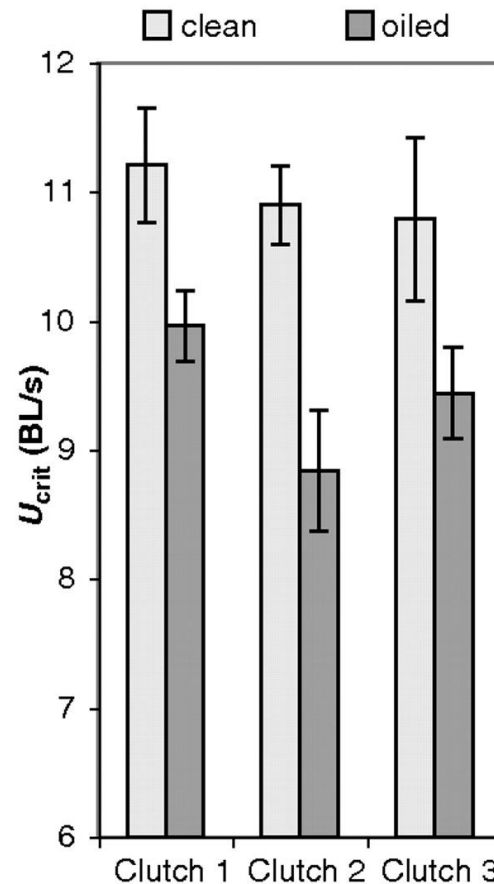
Sturgeon Fail to Avoid Cu



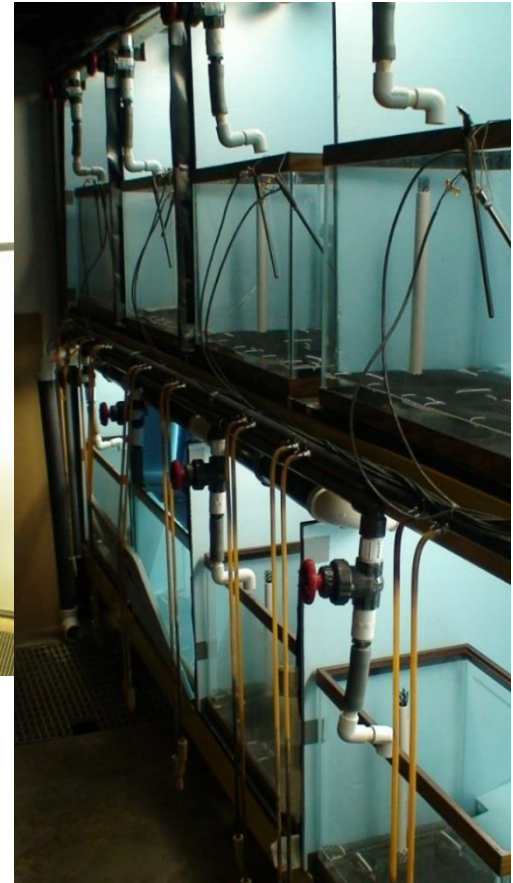
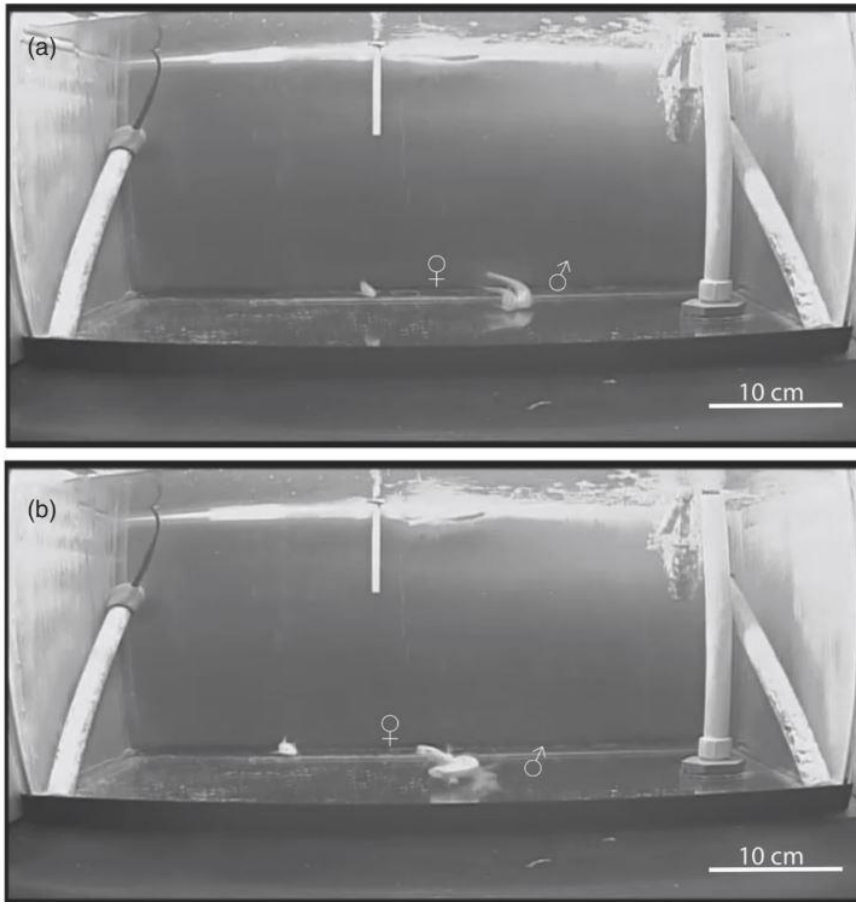
Endurance



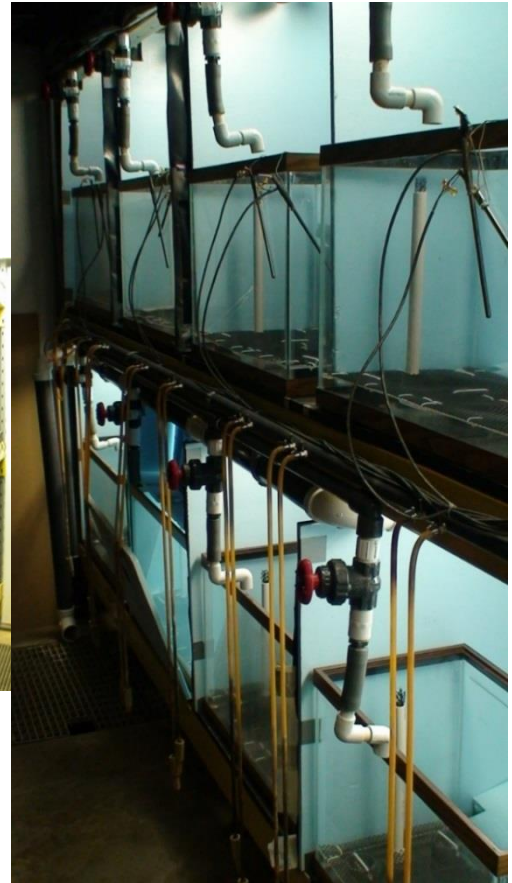
Reduced Endurance After Exposure to Oil



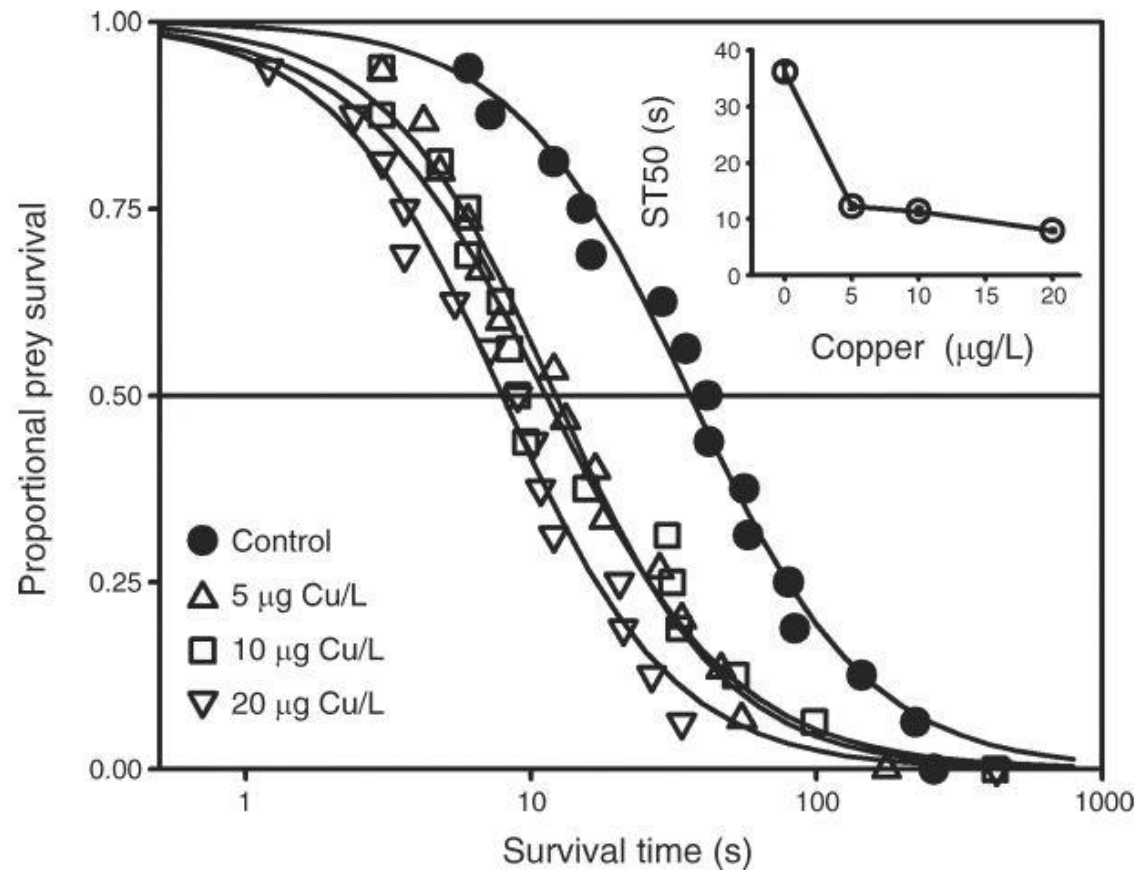
Reproductive Behavior



Predator/Prey Interactions



Copper Affects Survival With Predators

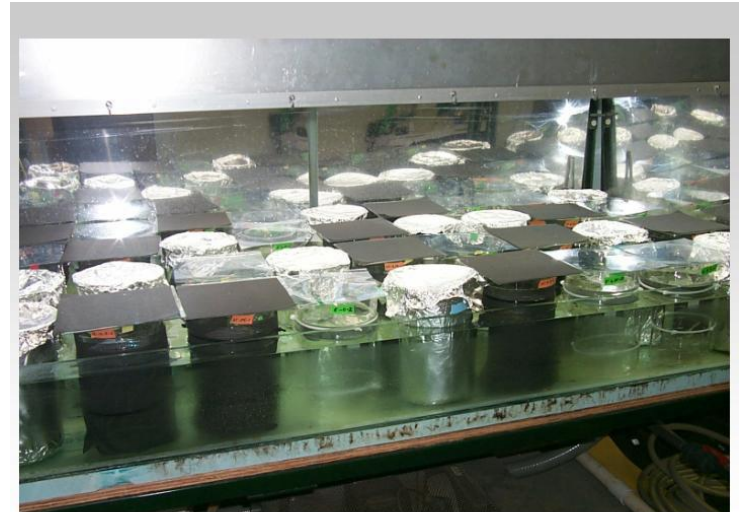


Over 1500 ft² of dedicated behavioral research space



Other Capabilities

- Solar simulator/
Photoenhanced toxicity
of contaminants
- Outside experimental
streams
- Experimental ponds
- Physiological responses
 - Olfactory cues/EOG

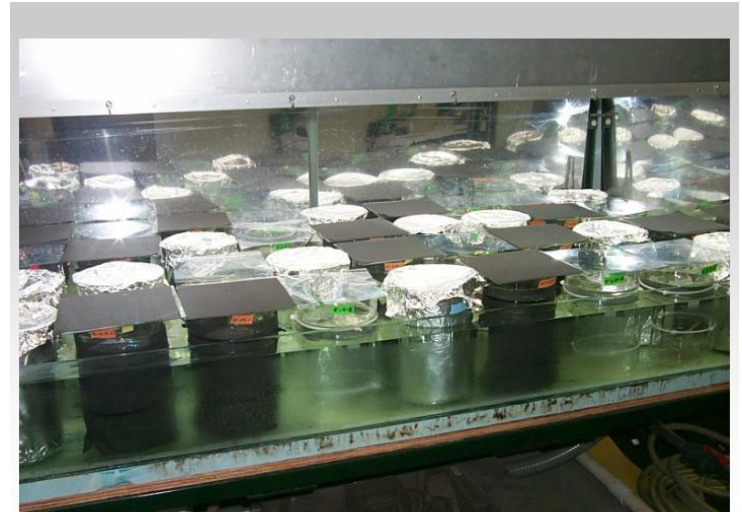


Other Capabilities

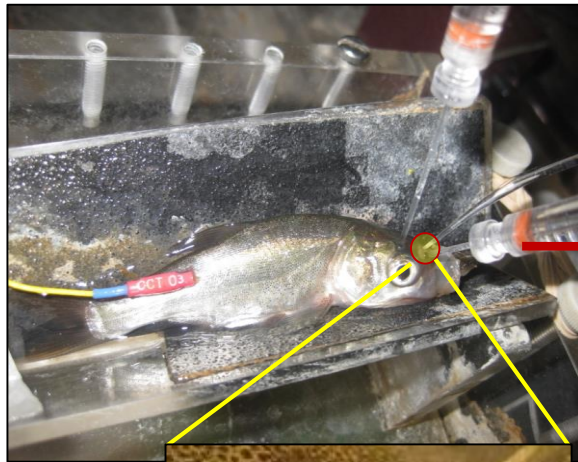


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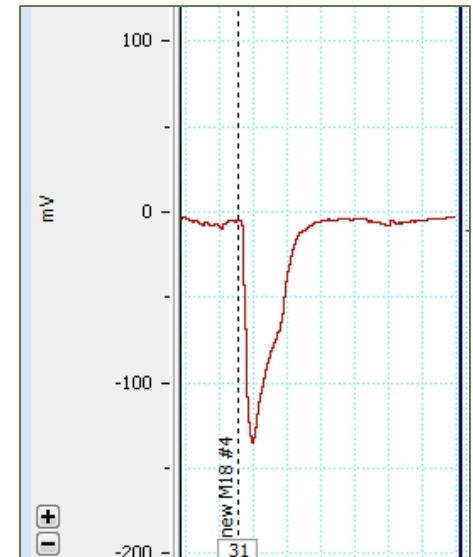
How is Olfaction Measured?



Rosette of
a nose

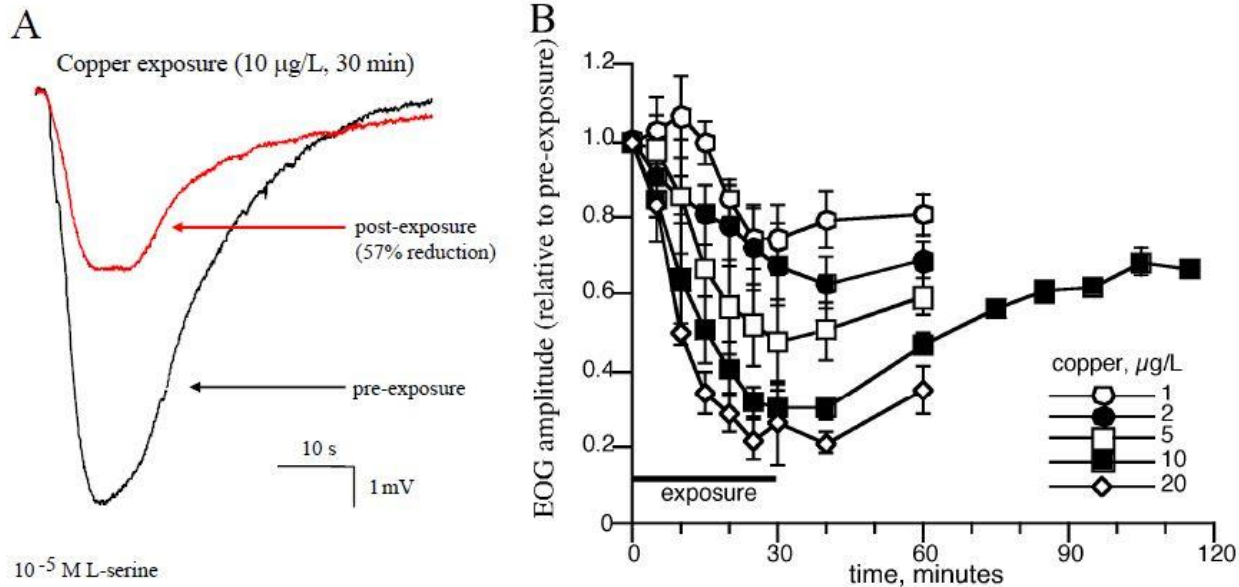


DC amplifier



Reduced EOG After Cu Exposure

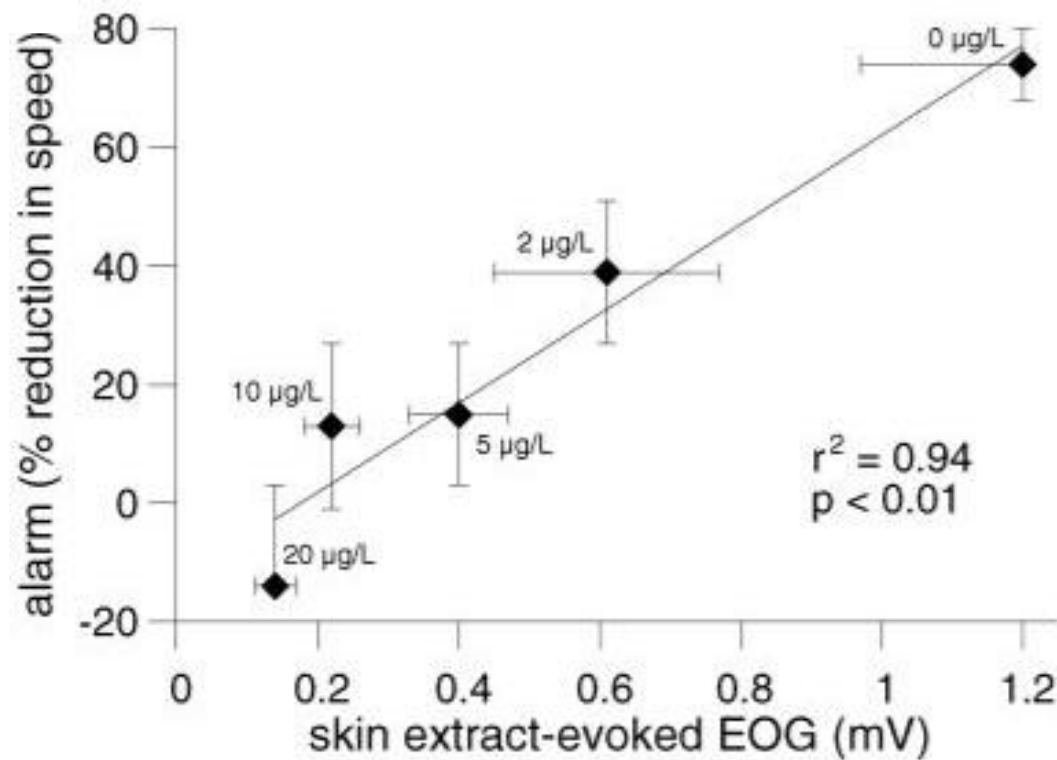
Sublethal copper neurotoxicity in juvenile coho (30 min exposures)



Baldwin, et al., 2003, *Environ. Toxicol. Chem.* 22:2266

Sandahl et al., 2004, *Can. J. Fish. Aquat. Sci.* 61:404

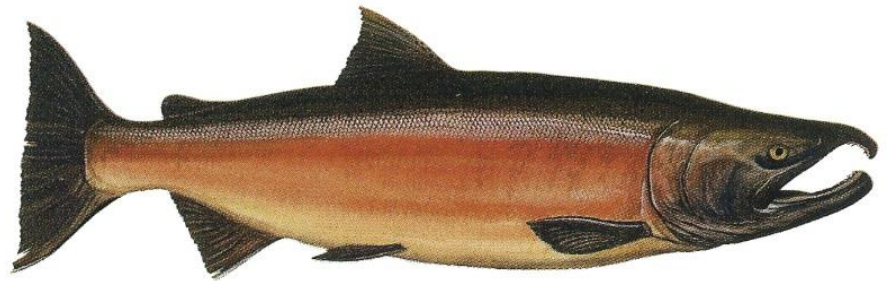
Reduced EOG and Altered Behavioral Response



Behavior Used to Change Law

Better Brake Laws on the books in California and Washington

- Large body of evidence of effects of copper on salmon
 - Olfaction - EOG
 - Alarm response
 - Predator/Prey Interactions
 - Homing

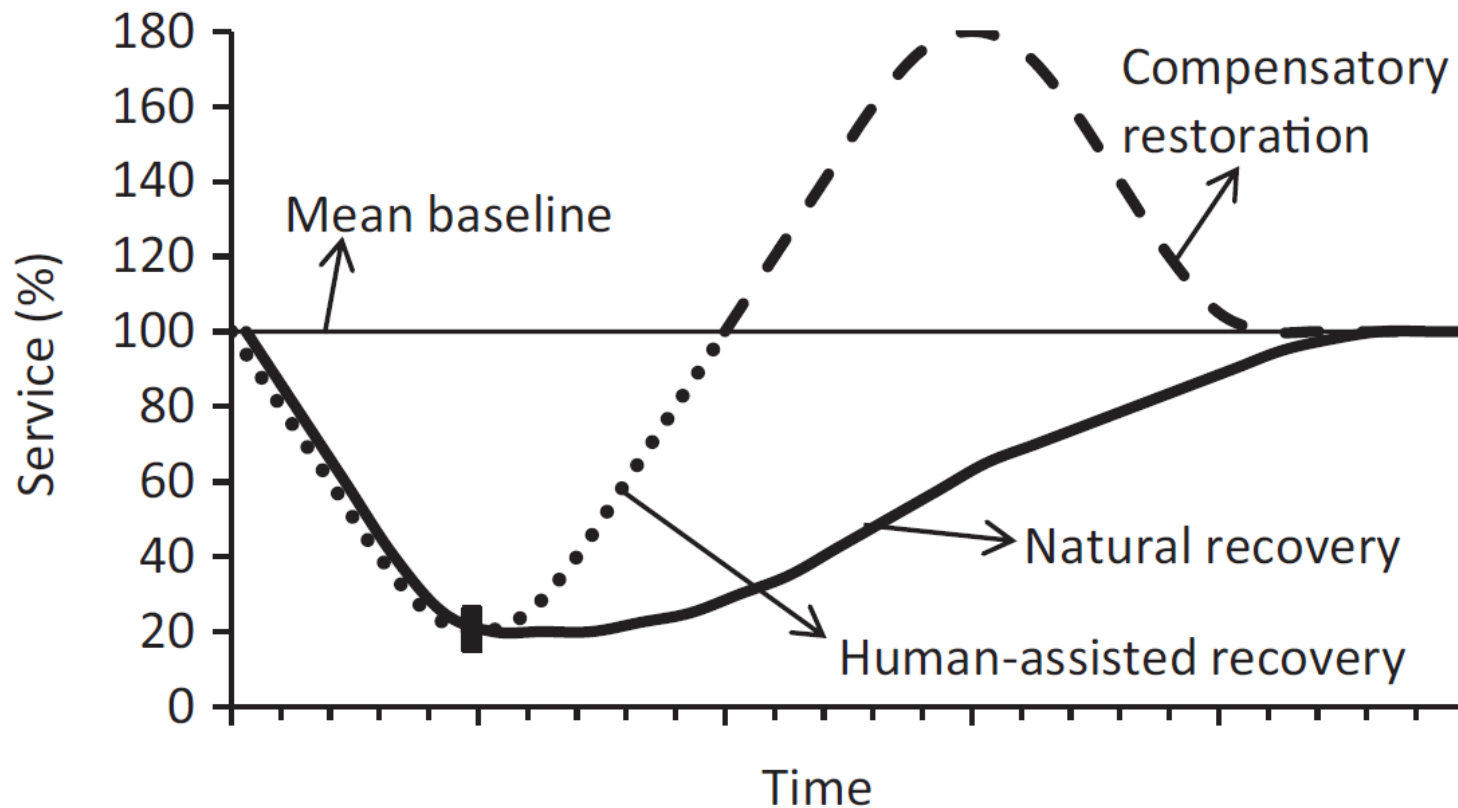


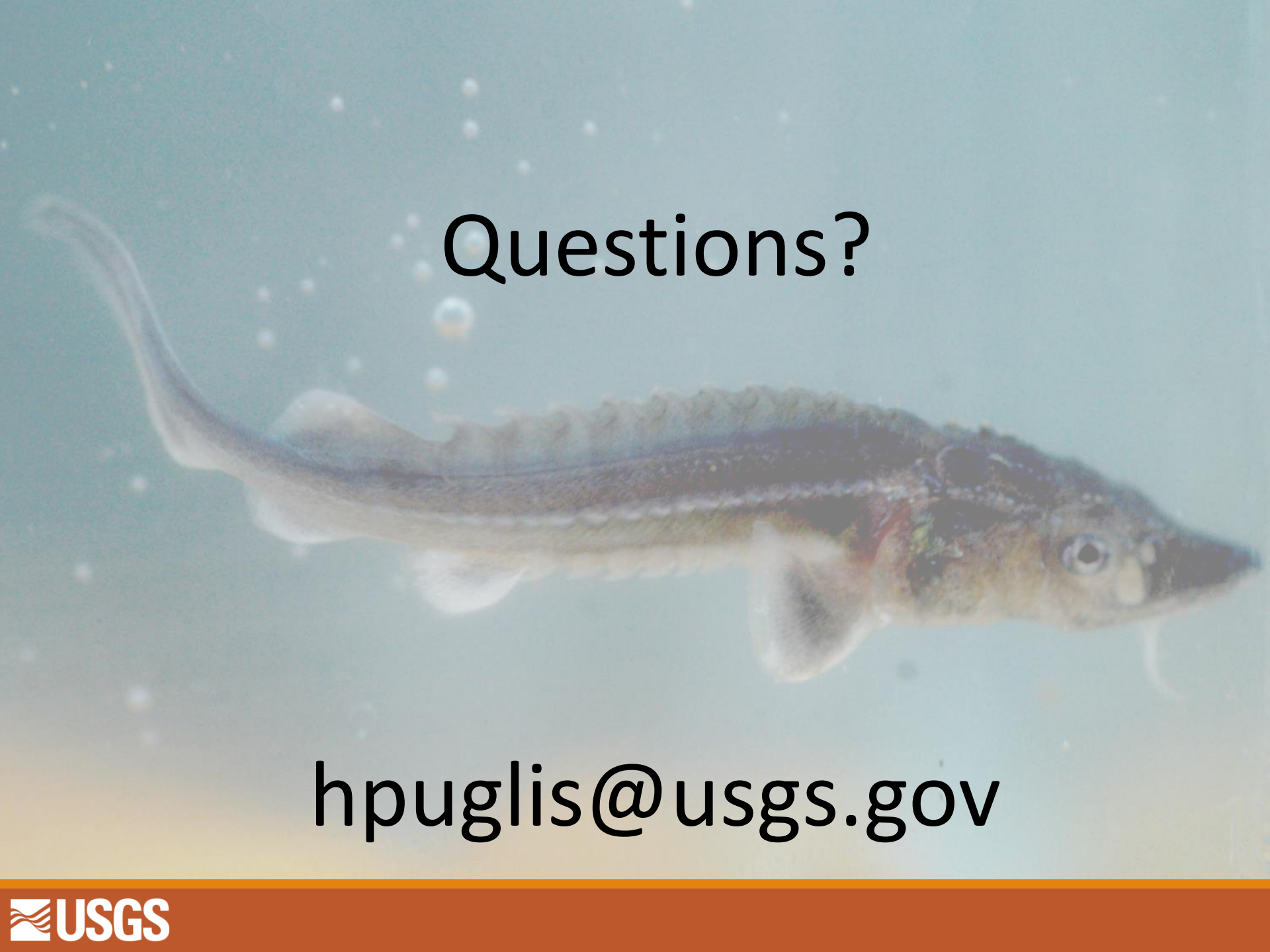
Behavior Used by Agency Partners

Behavioral data a factor in product selection and informs industry in formulation design



Behavior to Inform Restoration?



A longnose sturgeon is shown swimming horizontally in clear, light blue water. The fish has a long, pointed snout, a row of bony scutes along its back and sides, and a small eye. Bubbles are visible in the water around the fish.

Questions?

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