Effects of Copper on Aquatic Species: A review of the literature

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Photo North American Benthological Society

Scope of Literature Review

- Review "more current" documents on effects of Cu on fish, periphyton and invertebrates
- Emphasis on research after 1990
- Review focused on:
  - acute toxicity
  - chronic toxicity
  - factors affecting Cu toxicity

Which Forms of Cu are toxic?

- Toxicity depends on bioavailability
- Free Cu^{2+} ions are most toxic, but may not be common
- Most dissolved Cu is complexed with other ligands – may or may not be bioavailable

Copper: The good

- Cu is a micronutrient for plants and animals
- Cu in invertebrate hemocyanin is similar to iron in hemoglobin, both carry oxygen

Copper: the bad

- In higher concentrations, Cu can be toxic to plants and animals
- Cu, usually as $CuSO_4$
  - control algae in ponds and lakes,
  - as a fungicide and
  - as an insecticide

Factors that Reduce Cu toxicity

- Hardness
- Alkalinity
- Naturally occurring organic and inorganic ligands
- pH
- Temperature

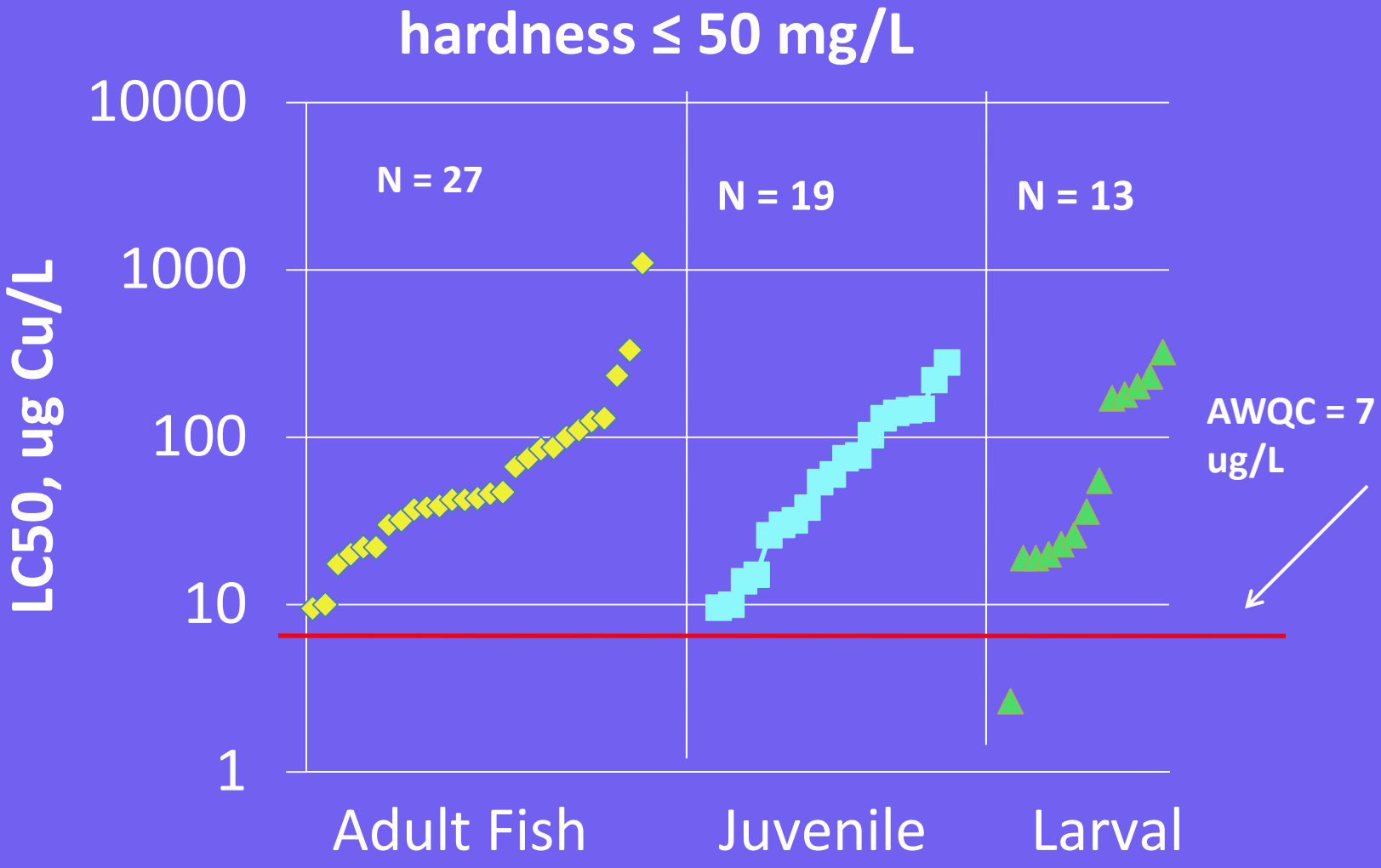
Cu Effects on Aquatic Species

- Acute toxicity
- Chronic, or long-term toxicity
  - Decreased growth
  - Changes in olfactory responses
  - Avoidance
  - Reduced swimming speed
  - Organ or cellular damage

Acute Toxicity to Fish

- 78 different tests were found in literature
- 1 test result was lower than the hardness-adjusted AWQ acute criteria
- The maximum toxicity value was 1100 µg/L
- The minimum toxicity value was 2.58 µg/L for Arctic grayling alevins (hardness not given)

AWQ Acute criterion is lower than 58 reported toxic effects



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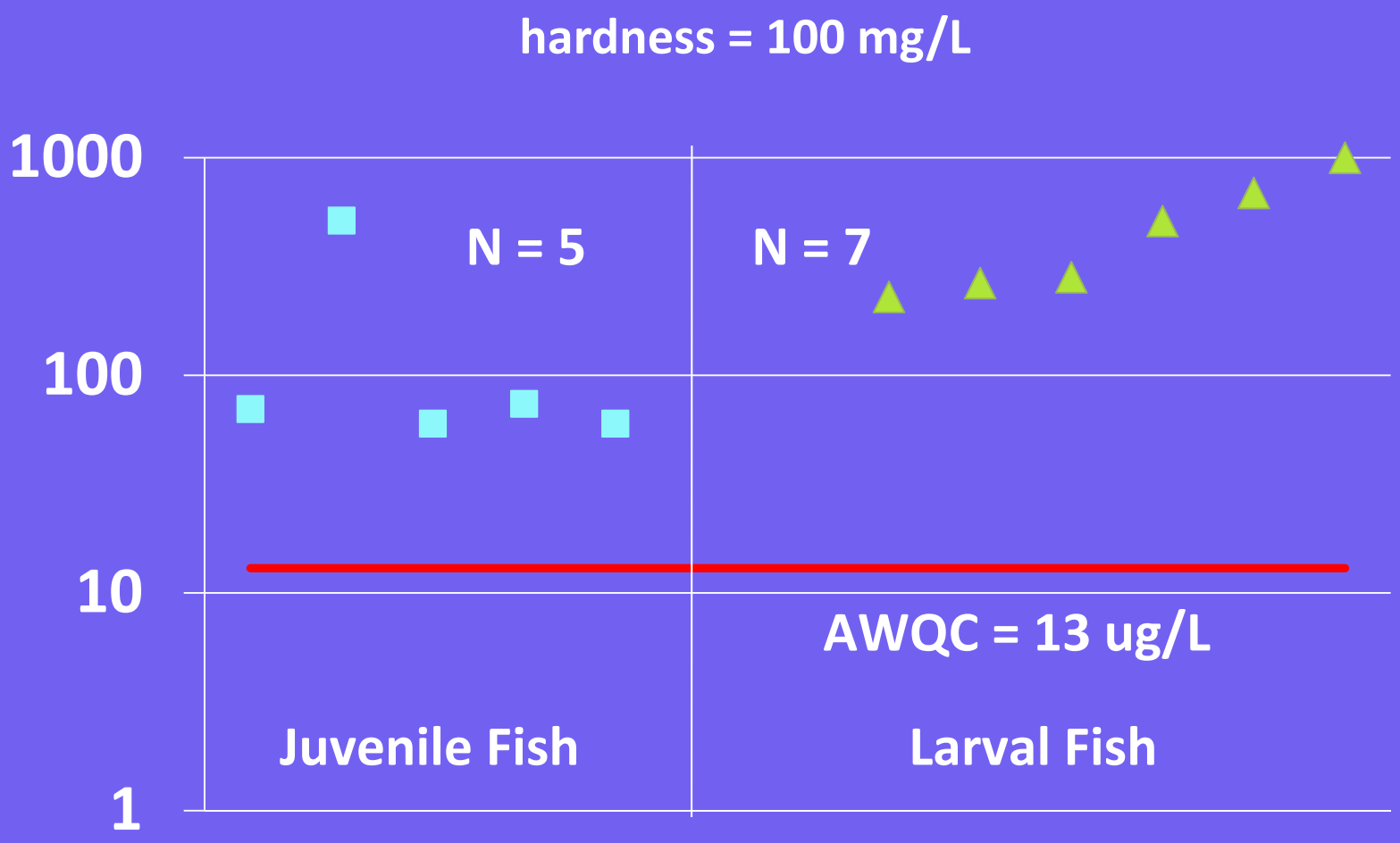

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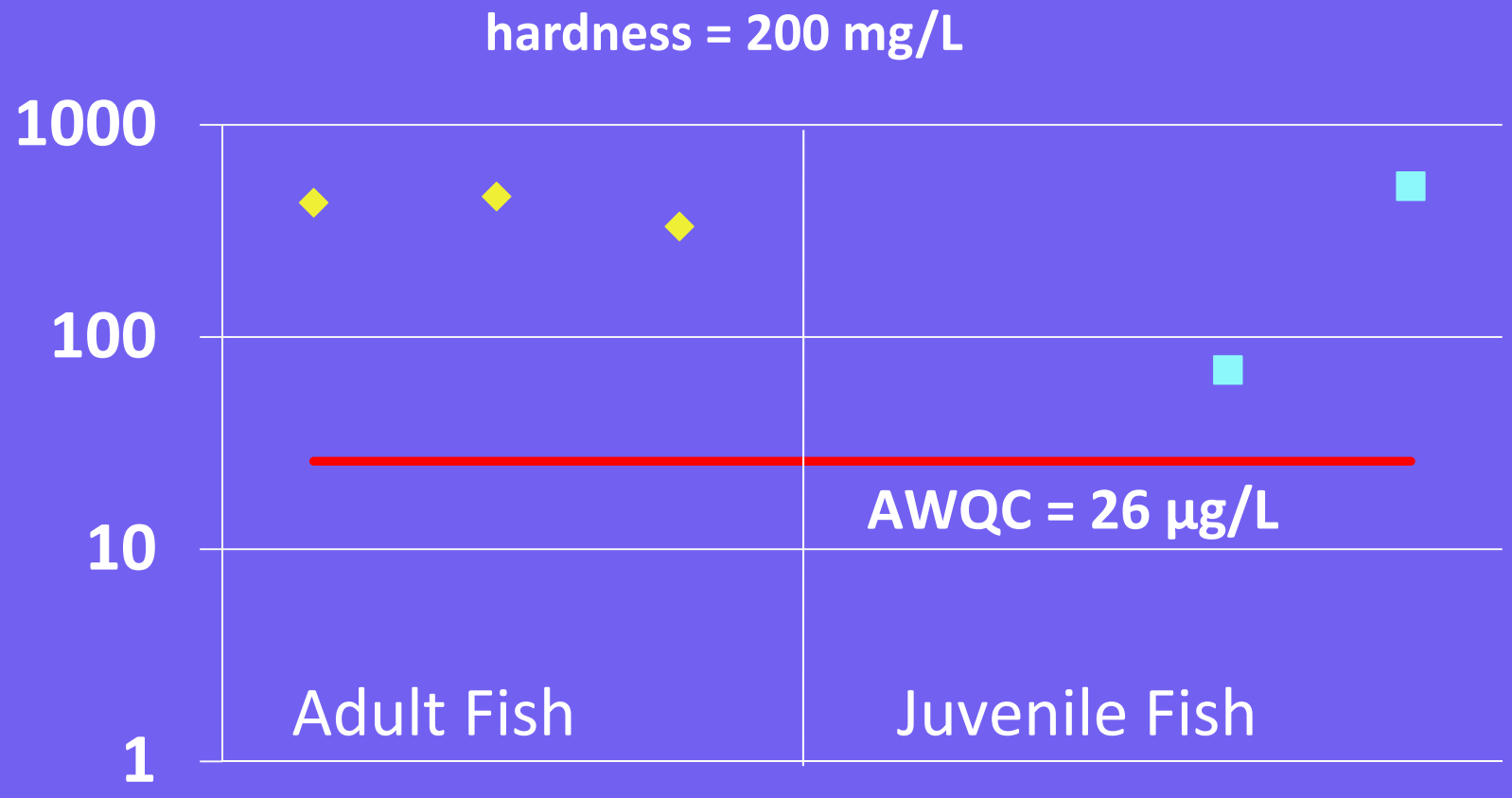

Chronic Effects of Cu to Fish

Observed Effect	Endpoint	Effects Conc. μg l^{-1}	No. of observations	No. of Values < AWQ chronic criterion
Avoidance	LOEC	1.6 to 72	16	4
Cellular damage	LOEC	20 to 25	2	0
Feeding	NOEC	173	1	0
Growth	IC10- IC50	10.8 to 54	3	0
Social interactions	LOEC	30	3	0
Swimming	LOEC	5	1	0

USEPA Study

- Bert Shephard, USEPA, conducted an extensive literature review
- He found 105 different test results; 102 tests showed chronic affects above AWQC
- Avoidance was the only chronic effect documented below AWQC

What about olfactory responses?

- Difficult to separate acclimation from effect
- Studies that investigate possible cellular damage to olfactory organs are more reliable
- 13 µg/L Cu reduced responsiveness of sensory epithelium, 2 µg/L resulted in altered alarm response

Cu Effects to Invertebrates

Acute Effects

Acute Toxicity to Invertebrates

	No. of Tests	No. < AWQC
Insects	7	1
Zooplankton	58	22
Freshwater Mussels	140	57

Aquatic Insect Results

- Few tests found in the literature
- Wide range of species occur in natural systems
- Some species are likely more sensitive than others

FW Zooplankton Results

- Many studies used lab water with added ions
  - Water may not contain DOC and ions of natural systems
- Zooplankton may be more sensitive than fish

Freshwater Mussel Sensitivity

- **Authors questioned their results:**
  - **Used reconstituted lab water**
  - **Water did not contain natural mix of organic carbon and ions**

However

- **Mussels may be more sensitive than fish**

Cu Effects to Invertebrates

Chronic Effects

Chronic Tests on Insects

- Cu concentrations in the range of 15 to 32 µg/L reduced both numbers of aquatic insect taxa and numbers of individuals

- These values are higher than the AWQ chronic criterion at the hardness of the test water

Chronic tests on FW Mussels

Endpoint	Effect	Effects Conc. $\mu g\ l^{-1}$	No. of tests	Values < AWQ
IC10	Growth	5.7 to 8	3	3
IC10	Survival	3.1 to 4.9	3	3
IC25	Growth	7.5 to 12	3	3
IC25	Survival	5.5 to 6.3	3	3

Summary

- Most studies show toxic responses above AWQC
- Studies need to be done in natural water containing DOC and ions
- Sensitivity to Cu appears to be species specific and highly dependent on other ions

Protecting Sensitive Species

- Conduct biomonitoring at site
- Site-specific toxicity tests
- Set site-specific criteria
- Manage for critical habitat conditions: overwintering or low water periods
- Consider managing for sensitive life stages: fertilization, incubation, etc.

Thanks

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http://www.habitat.adfg.alaska.gov/tech_reports/09_04.pdf