Protectiveness of Aquatic Life Criteria for Copper Against Olfactory and Behavioral Effects in Freshwater and Saltwater Fish

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Protectiveness of Aquatic Life Criteria for Copper Against Olfactory and Behavioral Effects in Freshwater and Saltwater Fish

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Copper Sources

- Surface runoff
  - Brake pad abrasion
  - Leaching from roofing materials and residential plumbing components
  - Pesticides; lawn and agricultural fertilizers
- Anti-fouling paints (direct release or runoff)
- *Puget Sound Toxics Report* (Ecology 2011)
  - Copper a Priority 1 level of concern in fresh water and nearshore marine areas
  - Recommended as priority for near-term actions (along with PAHs, DEHP, and petroleum)
Copper Bioavailability

Copper and Olfactory Impairment/Behavioral Effects

- Copper can impair olfactory function (sense of smell) in fish, including salmon.
- DOC shown to mitigate against copper-induced olfactory impairment in juvenile coho, but hardness has negligible influence (McIntyre et al., 2008, *ES&T*, 42:1352-1358).
- DOC also shown to mitigate against behavioral responses to copper in juvenile Chinook (Kennedy et al., 2012, *ET&C*, 31:2281-2288).
Copper Water Quality Criteria (WQC)

- Existing Washington State WQC:
  - Freshwater: hardness-based
  - Saltwater: fixed (not adjusted for water chemistry)

- USEPA-recommended WQC:
  - Freshwater: biotic ligand model (BLM)-based
  - Saltwater: currently fixed (draft BLM-based saltwater criteria pending)
Freshwater
Freshwater Copper WQC

Salvelinus

Oncorhynchus

Invertebrates

Percentile

Acute Value, µg/L
Freshwater Copper WQC

Acute Value, µg/L

Percentile

1
4.7
10
31.4
100

Oncorhynchus
• BLM-based copper criteria protective against olfactory impairment and olfactory-mediated behaviors
  • Hardness-based copper criteria not always protective
• Parameterized existing BLM to predict IC20 values for olfactory impairment
Ratios of Diss. Cu Conc.’s to Criteria & Olfactory IC20s
(Ecology 2011 – Phase 3 data)

Driven by very low pH samples

Diss. Cu > Criterion or IC20
Saltwater
Saltwater Copper WQC

Normalized Copper EC50 values (µg/L)

- GMAV 5th percentile: 14.14 (µg/L)
- Mytilus edulis SMAV: 8.545 (µg/L)

- Mytilus (mussel)
- Paralichthys (summer flounder)
- Strongylocentrotus (sea urchin)
- Coho salmon, Oncorhynchus kisutch

Percentile

0.1  1   10   20   50   80   90   99   99.9
Saltwater Copper WQC

No-effect concentration for olfactory impairment in seawater phase Chinook salmon (Baldwin 2012)
Ratios of Various Sub-lethal Effects Thresholds to Draft BLM-based Saltwater Cu Criteria
Saltwater Example - Marinas

M. galoprovincialis
NOEC > 100%

- dissolved Cu (µg/L)
- saltwater BLM 'criteria'
- WA chronic WQC
Summary and Conclusions

• Water chemistry matters
  • Bioavailability-adjusted copper criteria appear to be protective against olfactory impairment and olfactory-mediated behaviors
  • Bioavailability should be considered in site-specific and regional assessments
  • Measurement of key parameters that influence metal bioavailability should become routine

• Many stressors in Salish Sea ecosystem
  • Use of BLM-based criteria helps identify locations and exposure scenarios where Cu is truly a concern