Preliminary summary of results from USGS laboratory toxicity testing of major ions with select freshwater fish and invertebrates

Chris Ingersoll and Ning Wang
US Geological Survey
Columbia Environmental Research Center
Columbia, Missouri 65201
cingersoll@usgs.gov, nwang@usgs.gov

Water Quality Standards Stakeholder Meeting
Missouri Department of Natural Resources
Jefferson City, Missouri, October 17 2014

Department of the Interior
U. S. Geological Survey

Overview

- Major ions can be toxic to aquatic organisms (e.g., chloride, sulfate, bicarbonate, sodium, potassium, calcium, magnesium)
- Examples of toxicity thresholds for some major ions:
  - Chloride: USEPA (1986) Water Quality Criteria (WQC)
  - Chloride: Iowa (2009) Water Quality Standard (WQS)
  - Chloride: British Columbia (2003) Water Quality Guideline (WQG)
  - Sulfate: Illinois (2008) Acute WQS
  - Sulfate: British Columbia (2013) Chronic WQG
  - Conductivity: USEPA (2011) Water Quality Benchmark for Central Appalachia
- Toxicity of major ions depends on base water quality within a region or within a site within a region (e.g., hardness [Ca, Mg], other ions)

Overview (cont.)

- Data identified by USEPA needed to refine or develop WQC or WQS for major ions:
  - Influence of water quality on major ion toxicity (Lead: USEPA Duluth)
  - Toxicity of major ion mixtures (Lead: USEPA Duluth)
  - Chronic toxicity of major ions (Leads: Illinois Natural History Survey and USGS)
  - Toxicity of major ions to under-represented species
    - Mussels (Lead: USGS)
    - Mayflies (Lead: INHS)
- Objective of today's presentation is to provide a preliminary summary of findings from the USGS studies
- USGS data are being provided to USEPA for consideration in revisions or development of WQC or WQS for major ions

Chronic ammonia toxicity data (USEPA 2013 WQC for ammonia)

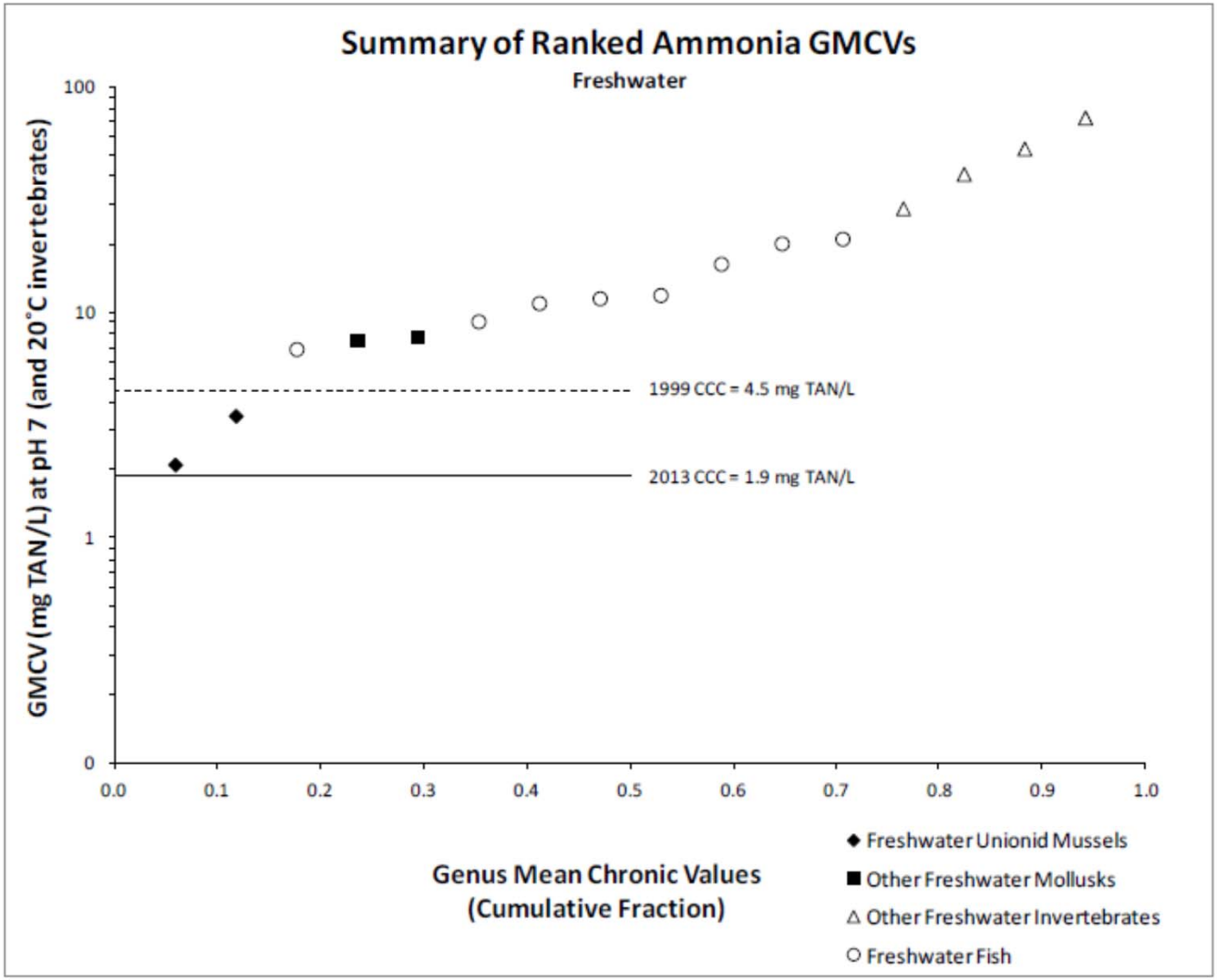
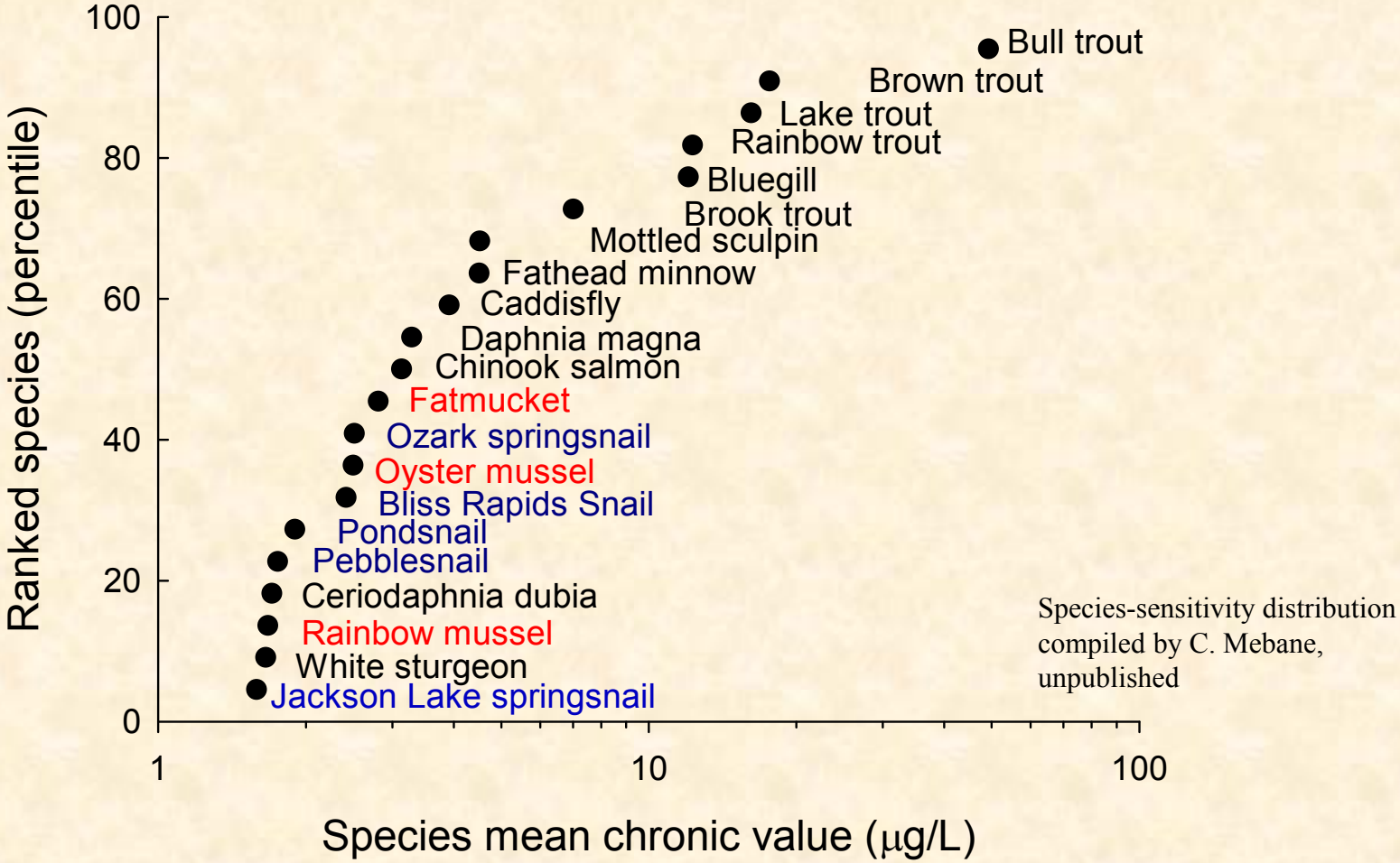


Figure 4. Ranked Freshwater Genus Mean Chronic Values (GMCVs) with Criterion Continuous Concentrations (CCCs).

USGS

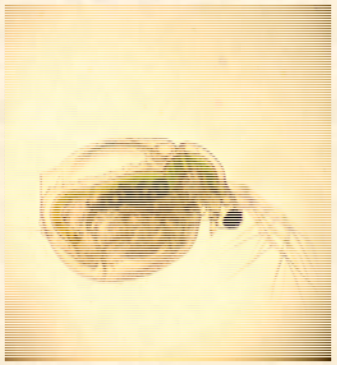
Chronic toxicity data with addition of snails and mussels - Copper



Chronic copper values, BLM-normalized to ASTM mod-hard water

USGS

Sensitivity of other mussels species or sensitivity of mussels to other chemicals relative to commonly tested surrogates



Cladoceran
(Ceriodaphnia dubia)

Amphipod
(Hyalella azteca)

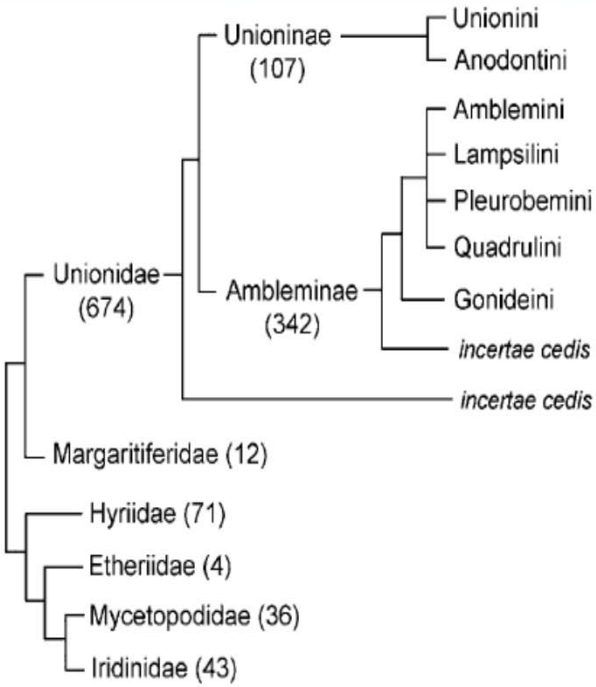
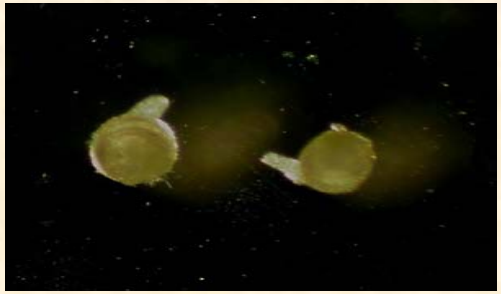


FIG. 1. Phylogenetic classification of Unionoida, adapted from Graf and Cummings (2007). Estimated numbers of species in families and subfamilies are indicated. Classification of North American species referred to in our paper follows Campbell et al. (2005): Margaritiferidae.—*Margaritifera, Cumberlandia*; Anodontini.—*Alasmidonta, Anodonta, Anodontoides, Lasmigona, Pegias, Pyganodon, Strophitus, Simpsonaias, Utterbackia*; Gonideini.—*Gonidea*; Quadrulini.—*Cyclonaias, Megalonaias, Quadrula, Quincuncina infucata, Tritogonia*; Pleurobemini.—*Elliptio, Elliptoideus, Fusconaia, Plethobasus, Pleurobema*; Amblemini.—*Amblema, Popenaias, Fusconaia ebena*; Lampsilini.—*Actinonaias, Cyprogenia, Cyrtonaias, Dromus, Epioblasma, Ellipsaria, Glebula, Hamiota, Lampsilis, Leptodea, Ligumia, Medionidus, Obliquaria, Obovaria, Plectomerus, Potamilus, Ptychobranchus, Toxolasma, Truncilla, Venustaconcha, Villosa*.

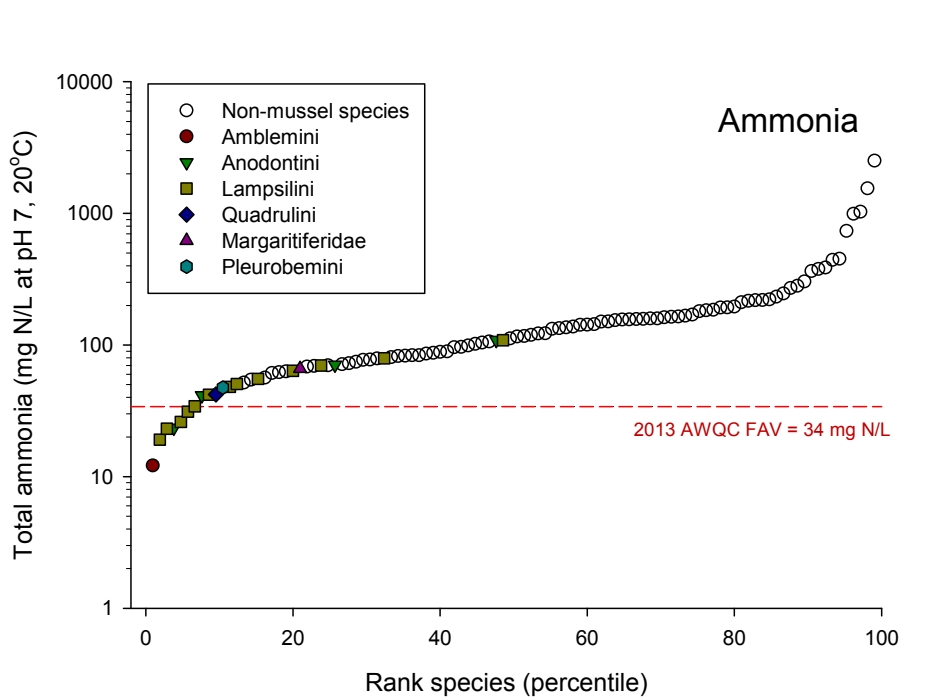


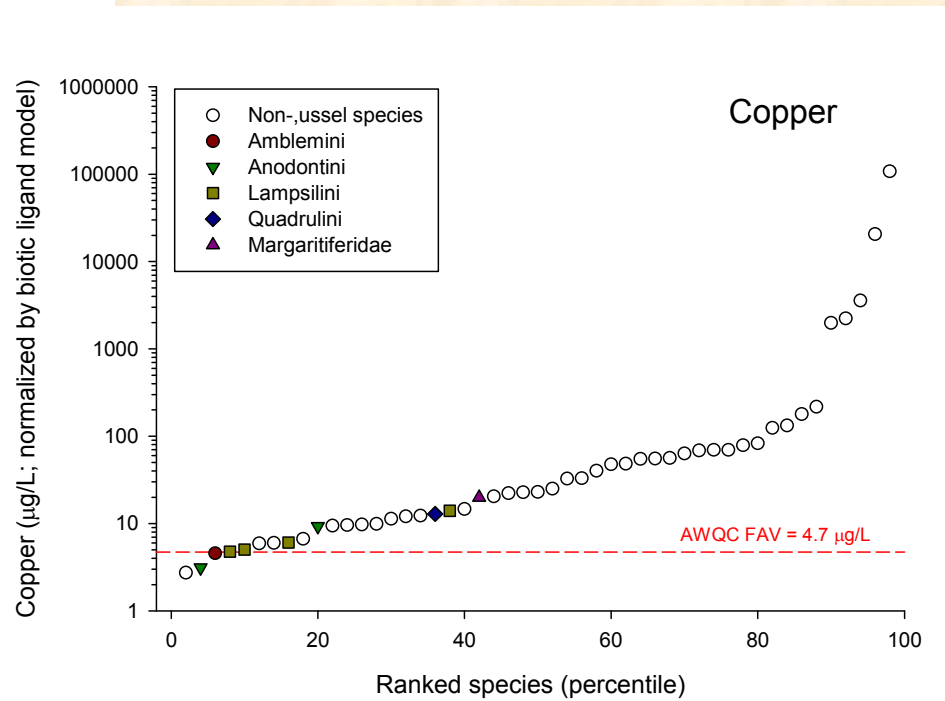
Fatmucket
(*Lampsilis siliquoidea*)

Great pond snail *(Lymnaea stagnalis*)

USGS

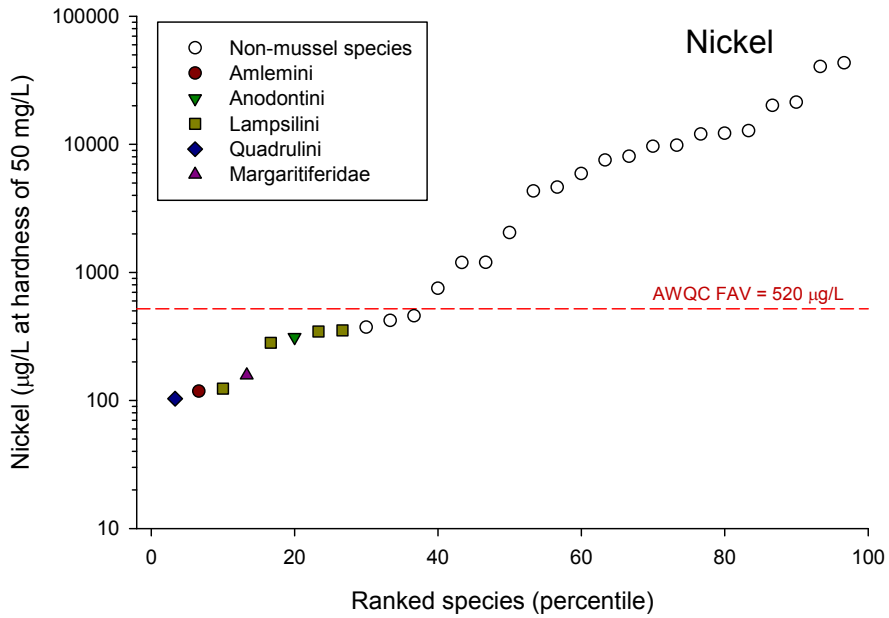
Acute toxicity data with addition of mussels of different tribes and families

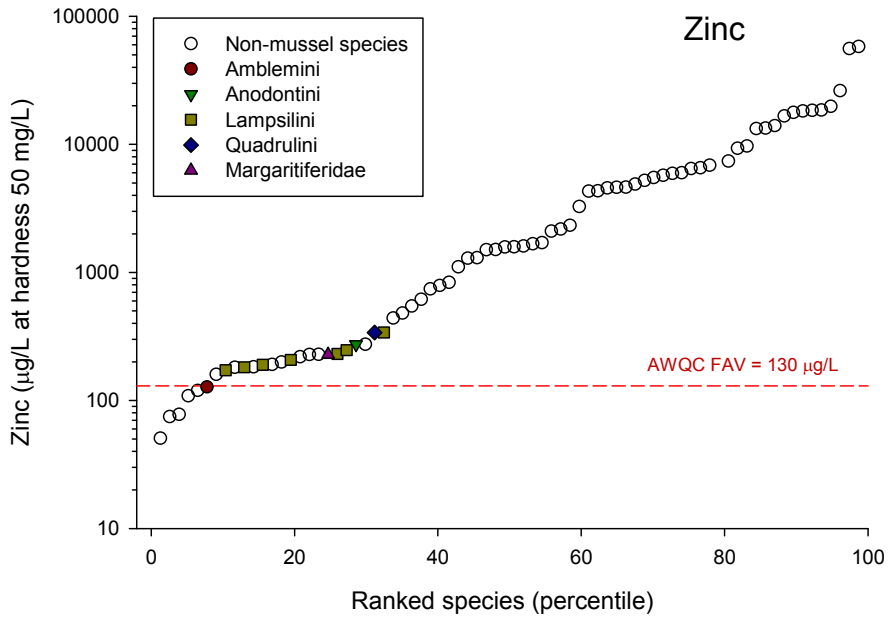




Wang et al. 2013

Acute toxicity data with addition of mussels of different tribes and families

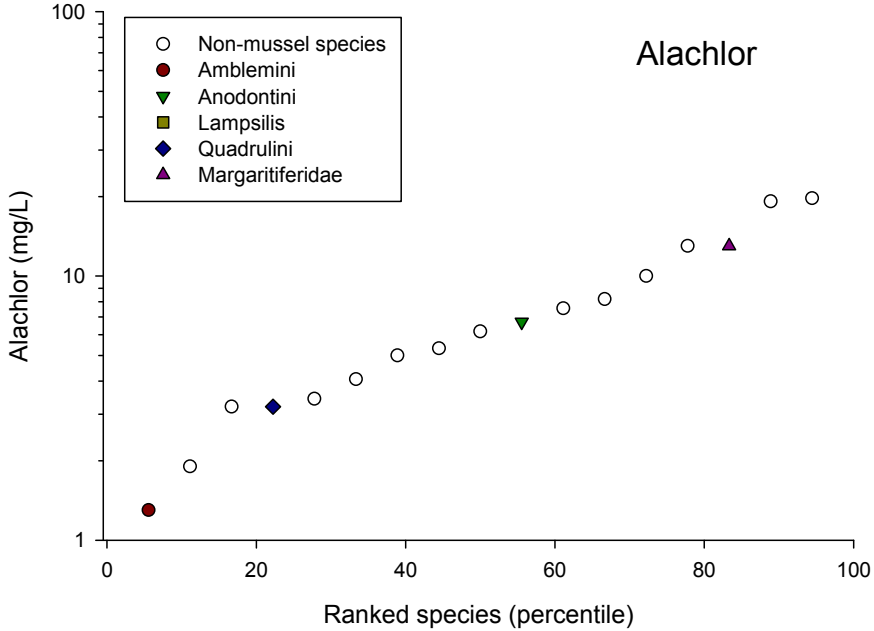


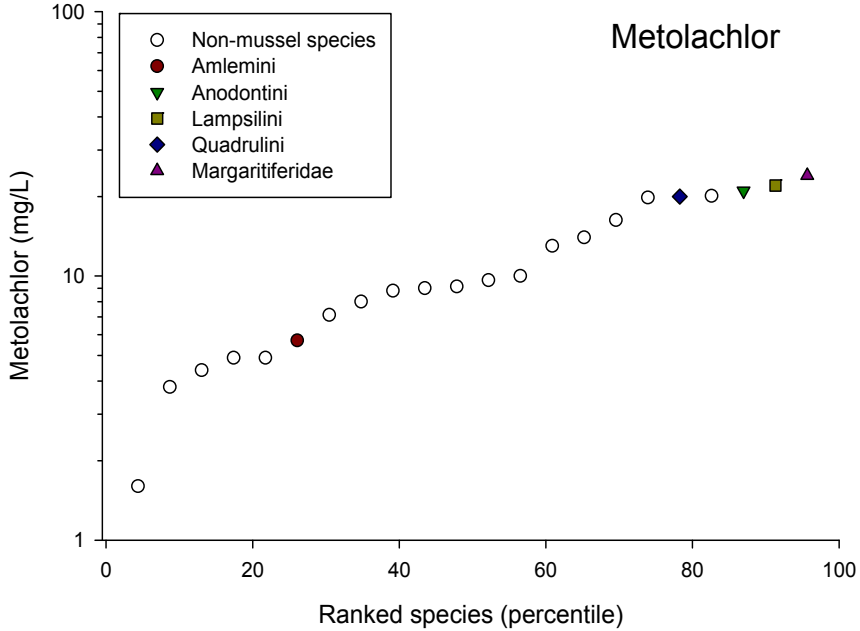


USGS

Wang et al. 2013

Acute toxicity data with addition of mussels of different tribes and families

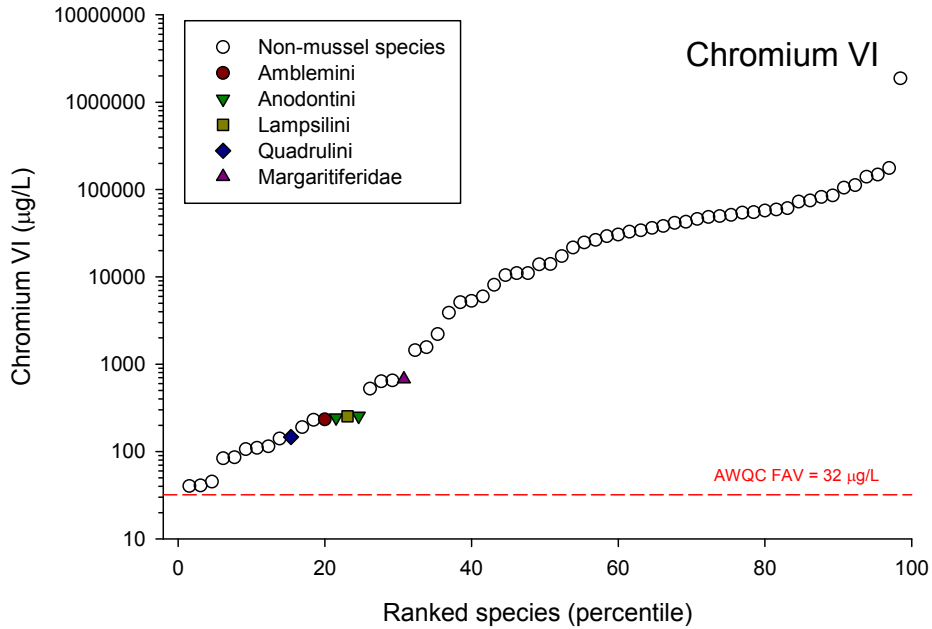


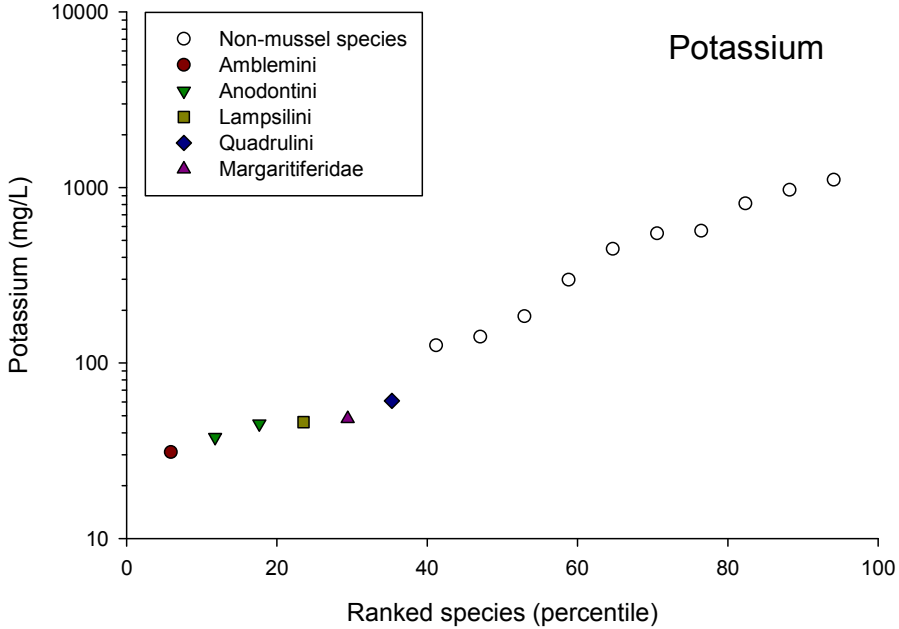


USGS

Wang et al. 2013

Acute toxicity data with addition of mussels of different tribes and families

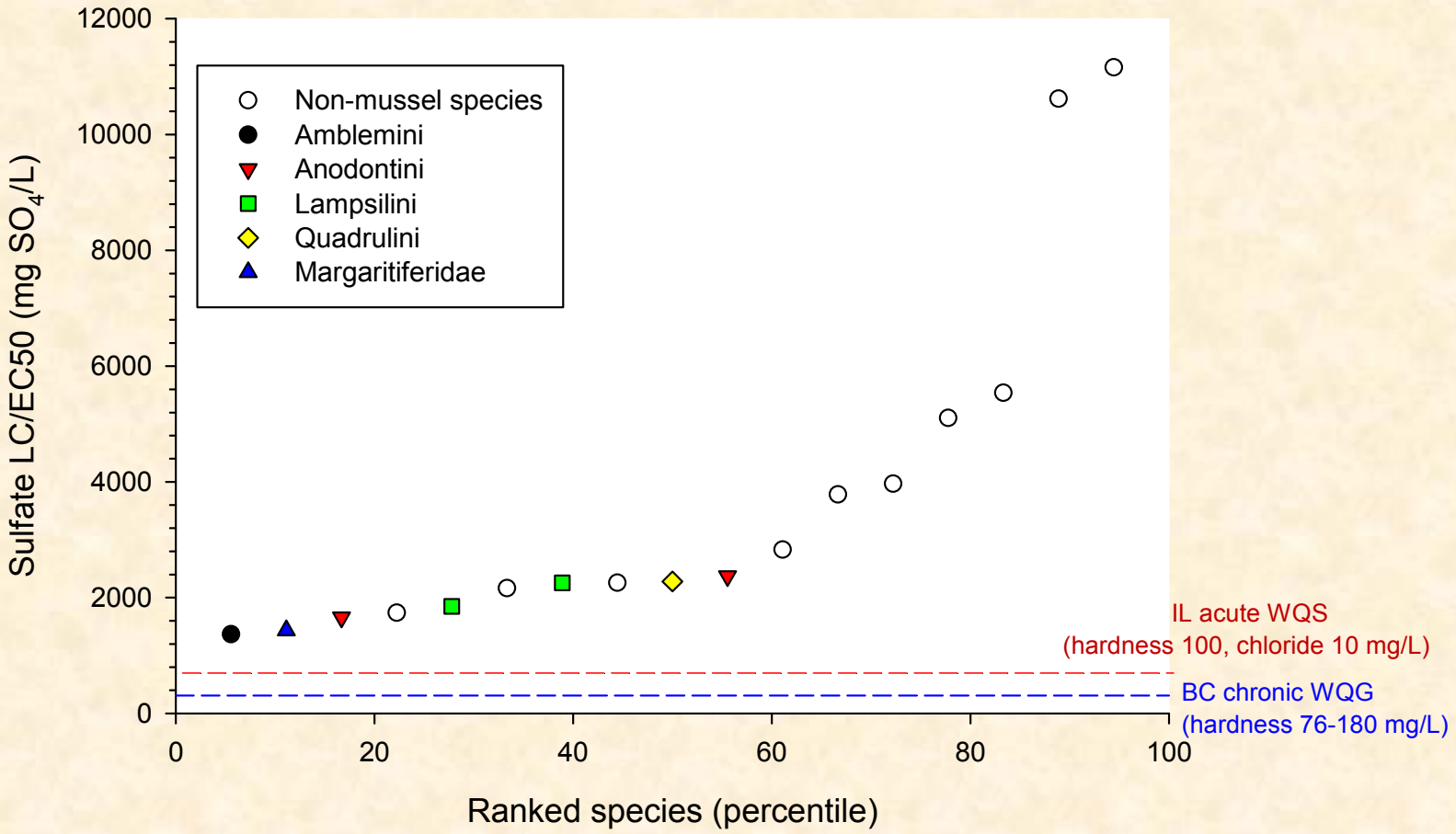




USGS

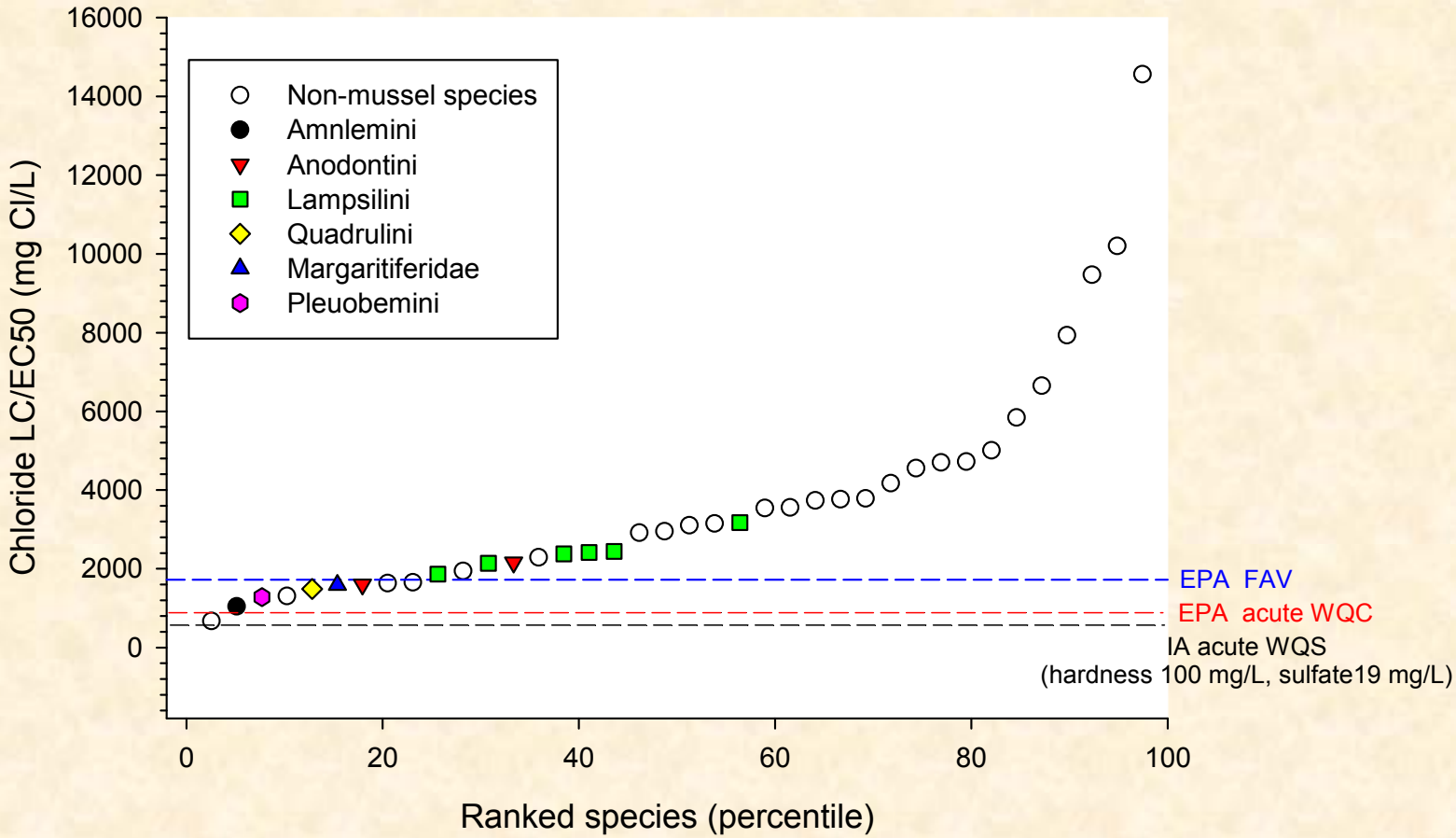
Wang et al. 2013

Ranked freshwater species mean acute values in a compiled database for sulfate generated from test waters at hardness of 80 to 120 mg/L and chloride <25 mg/L



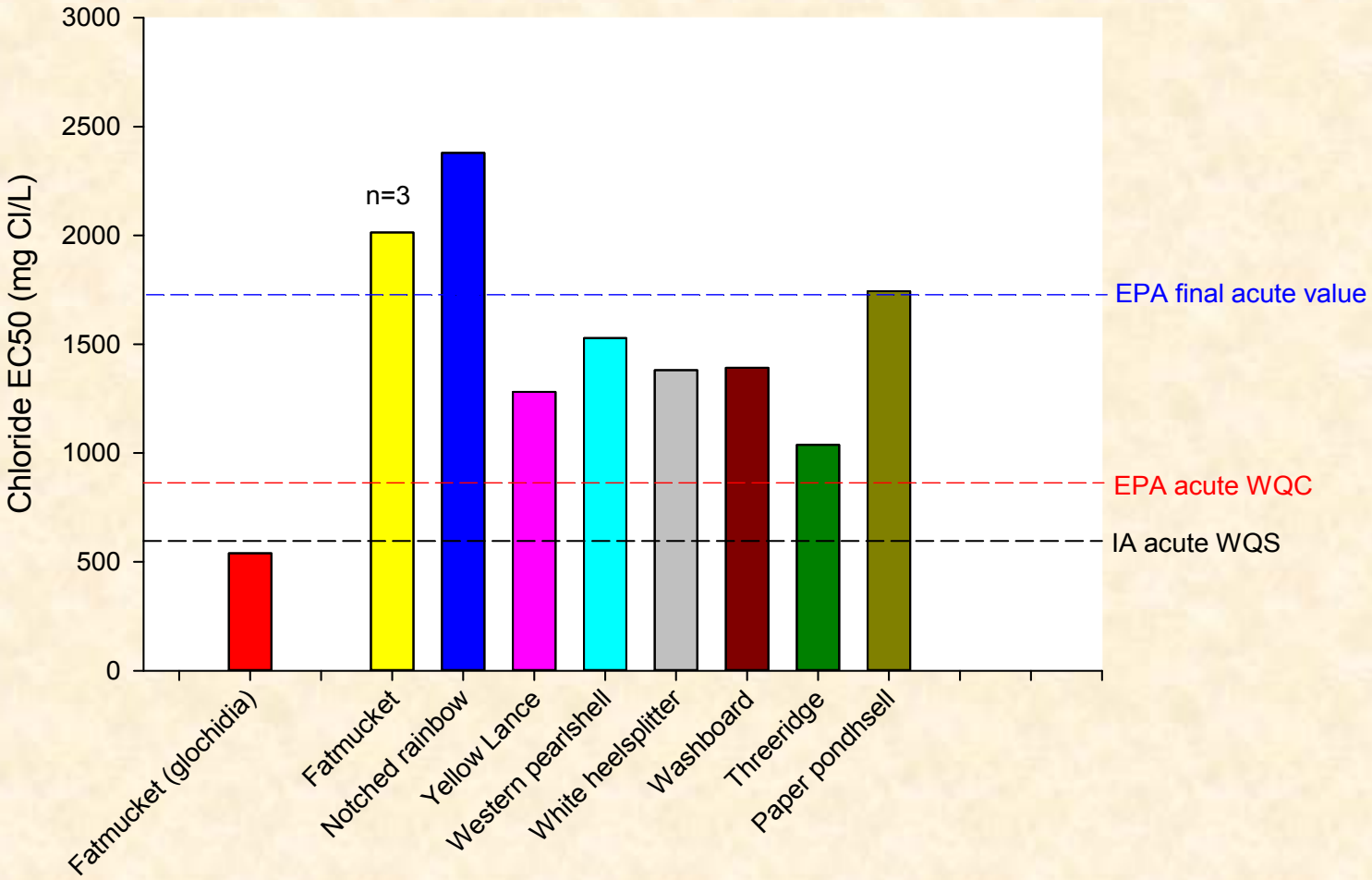
Wang et al. 2013

Ranked freshwater species mean acute values in a compiled database for chloride generated from test waters at hardness of 80 to 180 mg/L and sulfate <200 mg/L



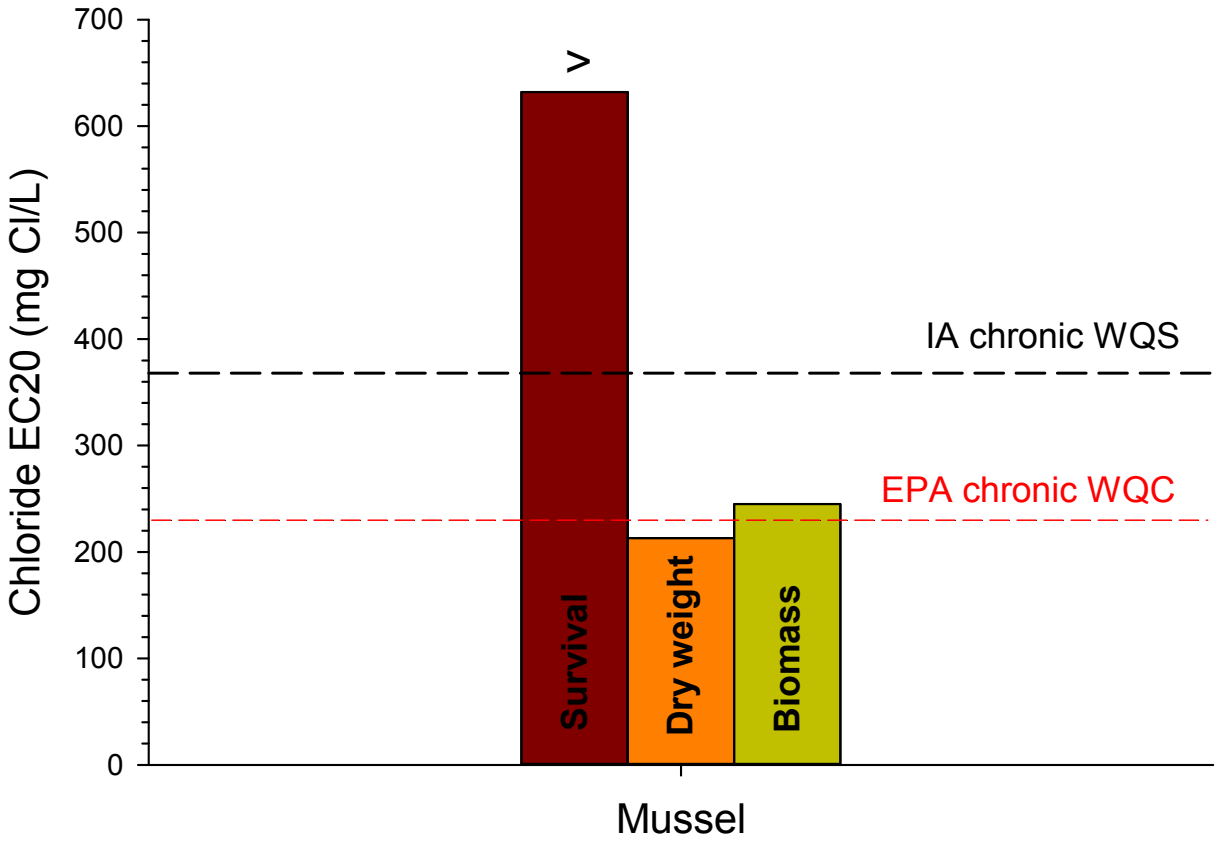
Wang et al. 2013

Acute EC50s for chloride with larval or juvenile mussels at hardness 100 to 170 mg/L



Wang et al. 2013

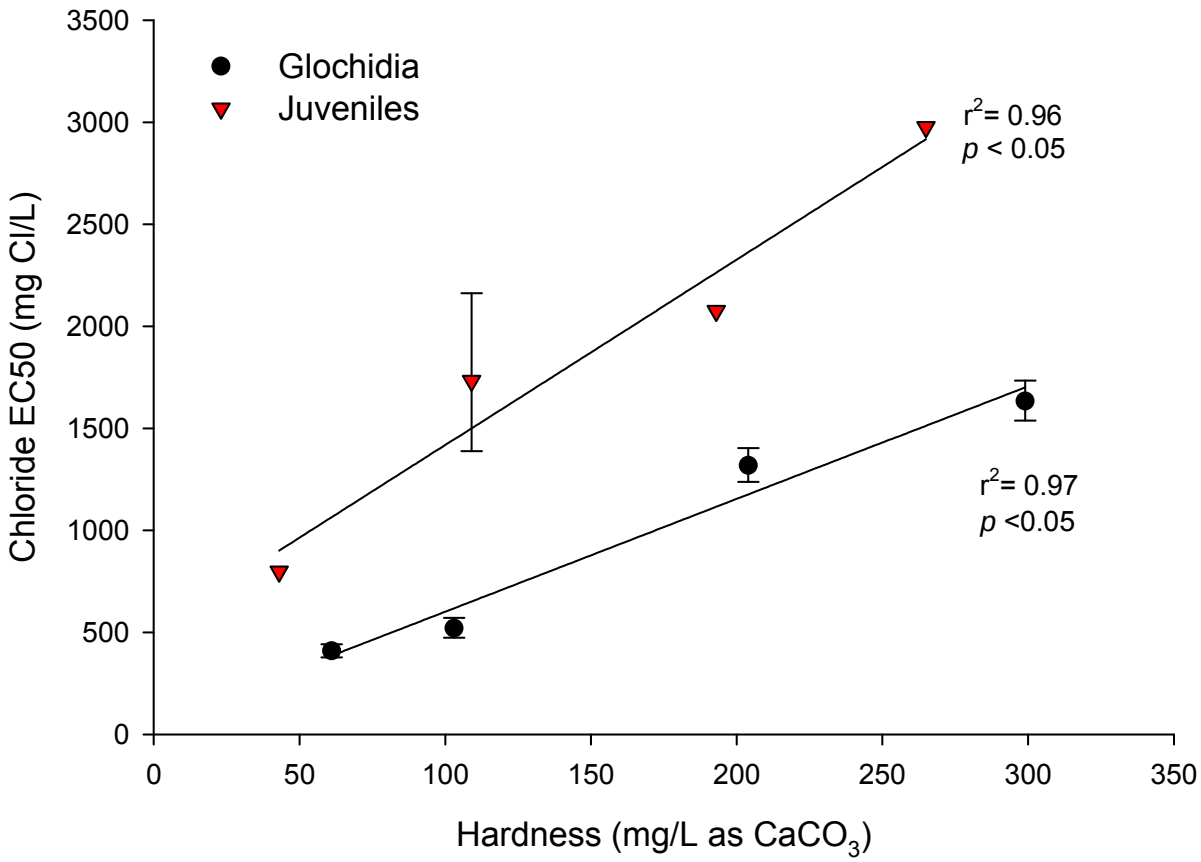
Chronic EC20s for chloride with a unionid mussel (fatmucket, *Lampsilis siliquoidea)* at water hardness 100 mg/L



Acute-chronic ratio **9.5**

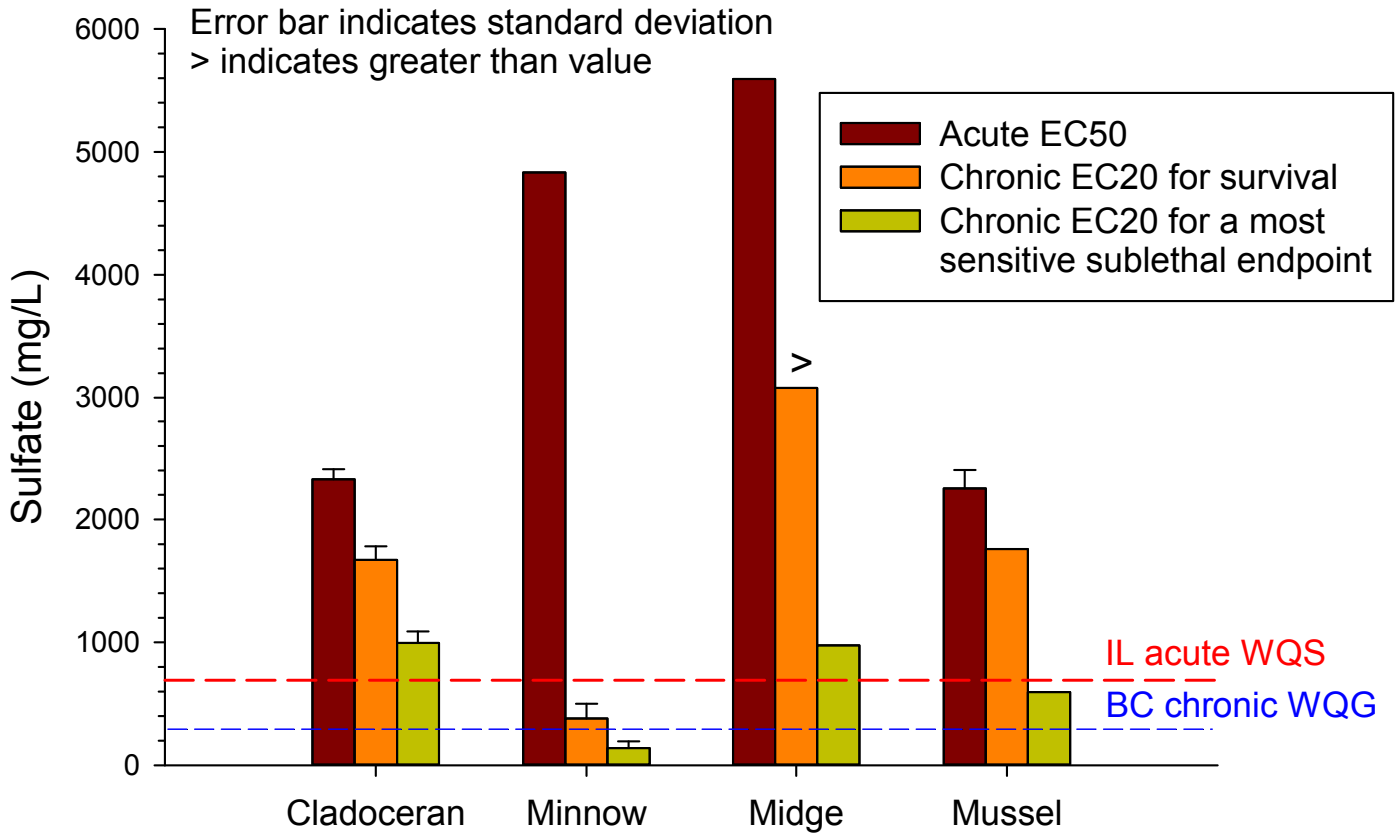
Ivey et al. 2013

Acute EC50s for chloride with larval and juvenile fatmucket (*Lampsilis siliquoidea*) at different hardness



Ivey et al. 2013

Acute EC50s and chronic EC20s for sulfate with a cladoceran (*Ceriodaphnia dubia*), a midge (*Chironomus dilutus)*, a unionid mussel (pink mucket, *Lampsilis abrupda*), and a fish (fathead minnow, *Pimephales promelas*) at water hardness 100 mg/L



Acute-chronic ratio	2.3	34	5.7	3.8

USGS

Wang et al. 2011

Summary

- Primary studies completed:
  - Chronic toxicity of major ions
  - Toxicity of major ions to under-represented species
- Primary studies ongoing:
  - Influence of water quality on major ion toxicity
  - Toxicity of major ion mixtures
- Status of data:
  - Preliminary data are being provided to USEPA for consideration in revisions or development of WQC or WQS for major ions
  - Manuscripts are being develop for submission to scientific journals
  - Release of final data after completion of QA/QC review