Mercury and Selenium in the Colorado River Food Web, Grand Canyon

Key Findings

- Mercury (Hg) and selenium (Se) concentrations are relatively high in the Colorado River food web throughout Grand Canyon.
- Hg and Se in organic matter, algae, invertebrates, and fish exceed protective thresholds for fish, wildlife, and humans.
- Hg concentrations were low in rainbow trout in Glen Canyon, so human health risks associated with this popular sport fishery are low.
- However, Hg in trout was higher downstream. Some of these areas are targeted for trout removal, which are provided for human consumption.
- Managing exposure risks in Grand Canyon will be challenging, because sources of Hg and Se are beyond Park boundaries.
The Colorado River in Grand Canyon is an incredibly remote, but heavily altered ecosystem.
Glen Canyon Dam fundamentally changed the river’s physical template.

Water is 1000X clearer.

Filamentous algae

Voichick and Topping 2014
Glen Canyon Dam fundamentally changed the river’s physical template.

Cold and constant water temperatures

Voichick and Wright 2006
The dominant aquatic invertebrates in Glen and Grand Canyon are non-native.
Our new friends

- Rainbow Trout
- Brown Trout
- Common Carp
- Fathead Minnow
- Plains Killifish

Remaining Native Fishes

- Humpback Chub
- Flannelmouth Sucker
- Bluehead Sucker
- Speckled Dace

Many invasive fish species.
On top of all this, chemical alteration?

Hg and Se data missing from Grand Canyon
Why should we care about Hg and Se?

- **Effects of Hg**
  - Neurotoxin (cognition and behavior)
  - Lower reproductive success, growth, and survival

- **Effects of Se**
  - Deformities of embryo/larvae
  - Lower reproductive success, growth, and survival
  - Hg – protective thresholds thoroughly vetted
  - Se – protective thresholds are preliminary
Objectives

- Sample Hg and Se along upstream-downstream gradient and throughout entire food web
- Compare Hg and Se concentrations to protective threshold to determine risk to humans and wildlife
- Examine potential sources
Approach

- Six sites (river mile 0, 30, 63, 125, 165, 225)
- Hg and Se concentrations – 1 season (Summer 2008)
- ~4 replicate samples of dominant types of organic matter, macroinvertebrates, and fish per site
  - Endangered humpback chub not sampled
Hg and Se concentrations are relatively high throughout Grand Canyon, with no clear downstream patterns.

Walters et al. 2015
Hg concentrations among sites

Hg concentrations commonly exceed protective thresholds

Walters et al. 2015
Se concentrations commonly exceed protective thresholds

Dietary and maternal risk thresholds

Walters et al. 2015
Where does Hg come from?

Humans have greatly increased atmospheric Hg, contaminating remote & protected areas.

“…human activities have increased atmospheric Hg concentrations 3- to 5-fold during the past 150 years.”

“…[human activities] have resulted in some of the most remote and protected areas of the world becoming contaminated with Hg…”

Humans have greatly increased atmospheric Hg, contaminating remote & protected areas.
Where does Hg in Grand Canyon come from?

Atmospheric sources of Hg to Grand Canyon are likely a mixture of distant and nearby sources.

Emissions from Navajo Generating Station are deposited in Grand Canyon and Lake Powell.
Where does Se come from?

• Se is high where:
  - marine sedimentary geology
  - high evaporation index
  - irrigation

Seiler et al. 1999
How much Se enters Glen Canyon?

- **Lake Powell**: 100 kg d⁻¹
  - **Glen Canyon**: 83 kg d⁻¹
    - **irrigation**: 71%
    - **natural weathering**: 21%
    - **point source**: 8%

Se data 1985-94: Engberg, 1999
Hg and Se Transport Model

Lake Powell likely plays a key role in Hg and Se cycling and transport.

Hg/Se cycling

- inorganic Se & Hg
- anaerobic conditions
- microbial activity
- organic Se & Hg (bioavailable and toxic)
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