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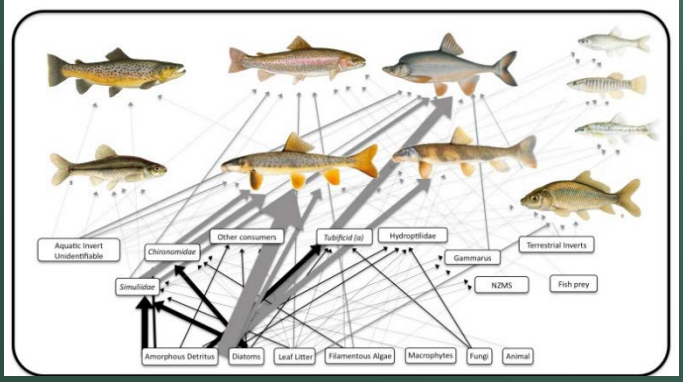
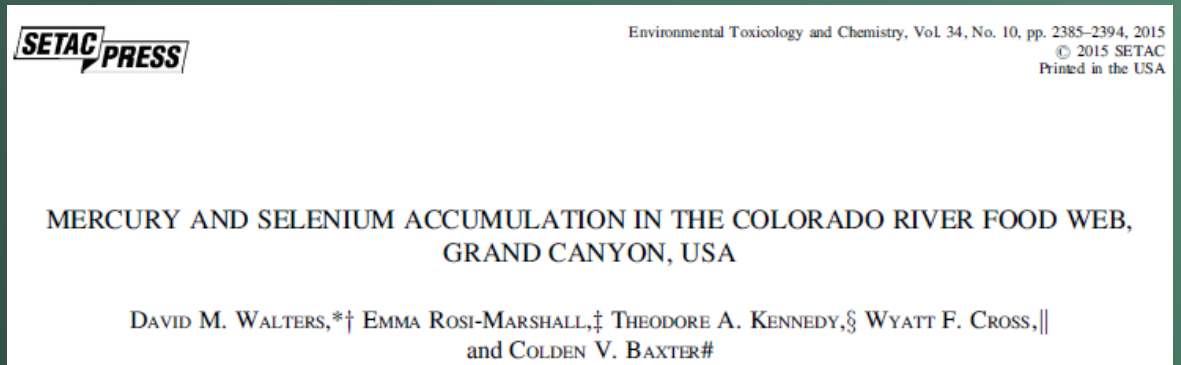
Mercury and Selenium in the Colorado River Food Web, Grand Canyon

D.M. Walters, E. Rosi-Marshall, T.A. Kennedy, W.F. Cross, and C.V. Baxter



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.



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MERCURY AND SELENIUM ACCUMULATION IN THE COLORADO RIVER FOOD WEB, GRAND CANYON, USA

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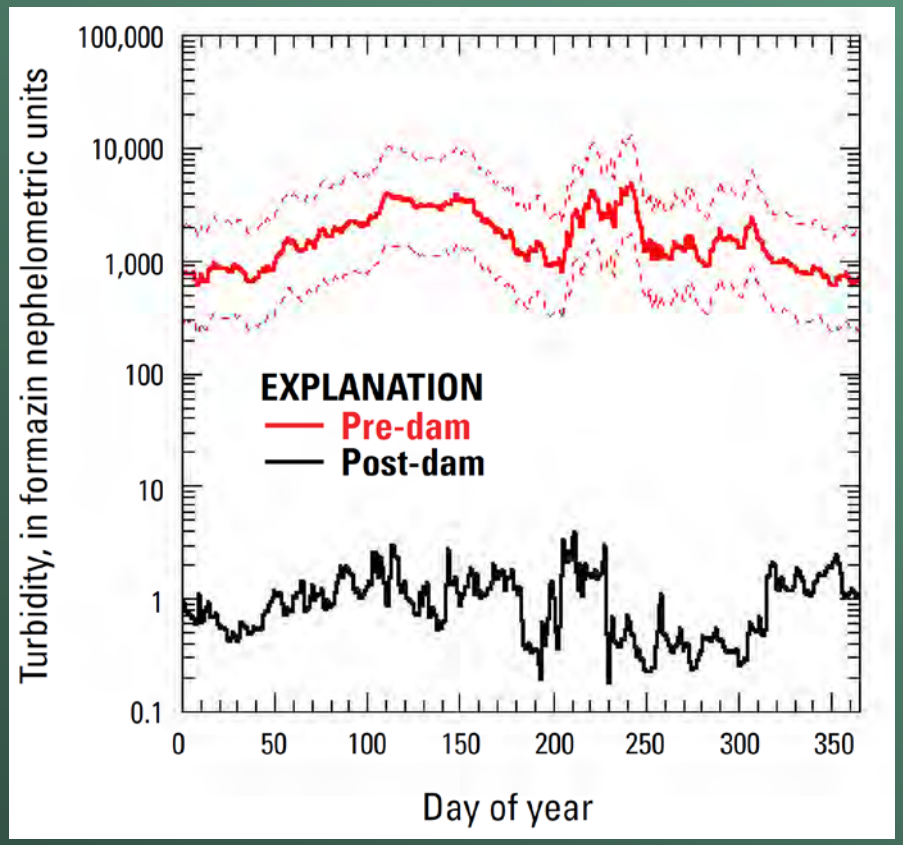
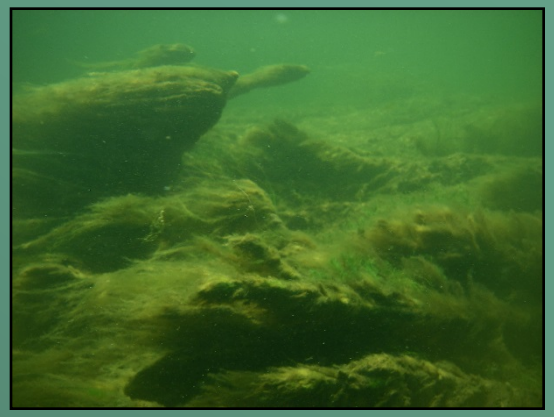
The Colorado River in Grand Canyon is an incredibly remote, but heavily altered ecosystem.

Glen Canyon Dam fundamentally changed the river's physical template



Voichick and Topping 2014



Filamentous algae

Water is 1000X clearer

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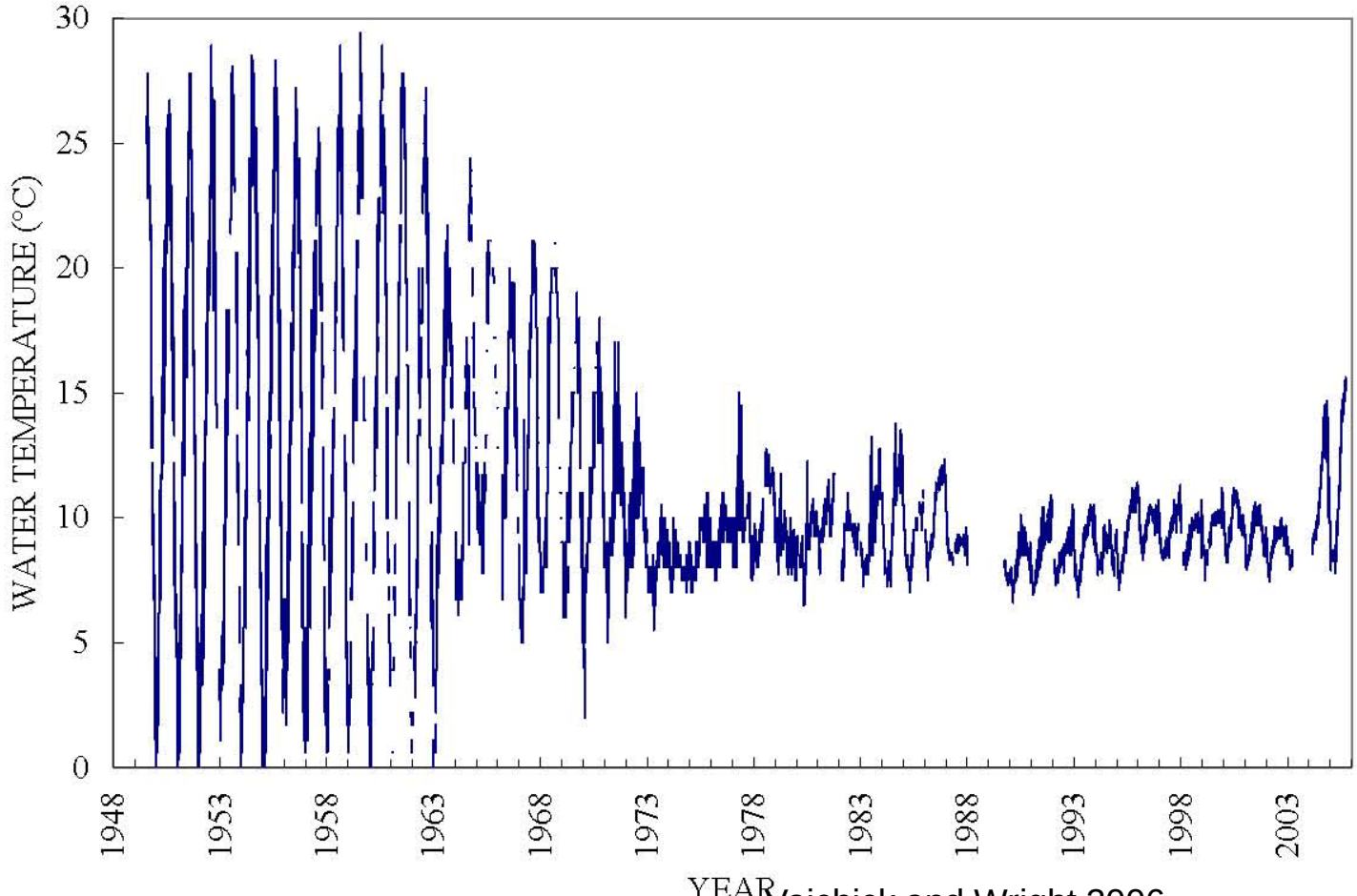
Glen Canyon Dam fundamentally changed the river's physical template



Voichick and Wright 2006

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Cold and constant water temperatures

Altered Foodbase

Black flies

Scuds

New Zealand mudsnails

The dominant aquatic invertebrates in Glen and Grand Canyon are non-native.

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Our new friends

Rainbow Trout

Brown Trout

Common Carp

Fathead Minnow

Plains Killifish

Many invasive fish species.

Remaining Native Fishes

Humpback Chub

Flannelmouth Sucker

Bluehead Sucker

Speckled Dace

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Available online at www.sciencedirect.com
ScienceDirect
Science of the Total Environment 378 (2007) 376–402
Science of the Total Environment
www.elsevier.com/locate/scitotenv

Chemical contaminants, health indicators, and reproductive biomarker responses in fish from the Colorado River and its tributaries

Jo Ellen Hinck [a,*], Vicki S. Blazer [b], Nancy D. Denslow [c], Kathy R. Echols [a], Timothy S. Gross [d], Tom W. May [a], Patrick J. Anderson [e], James J. Coyle [c], Donald E. Tillitt [a]

On top of all this, chemical alteration?

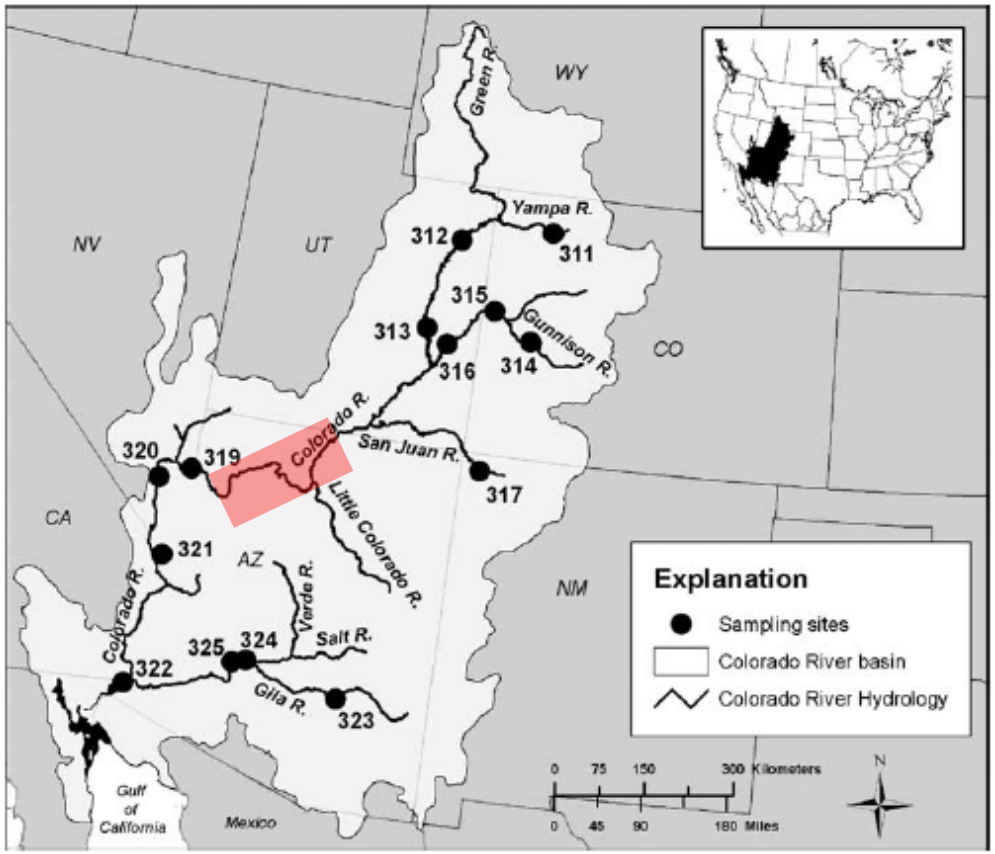
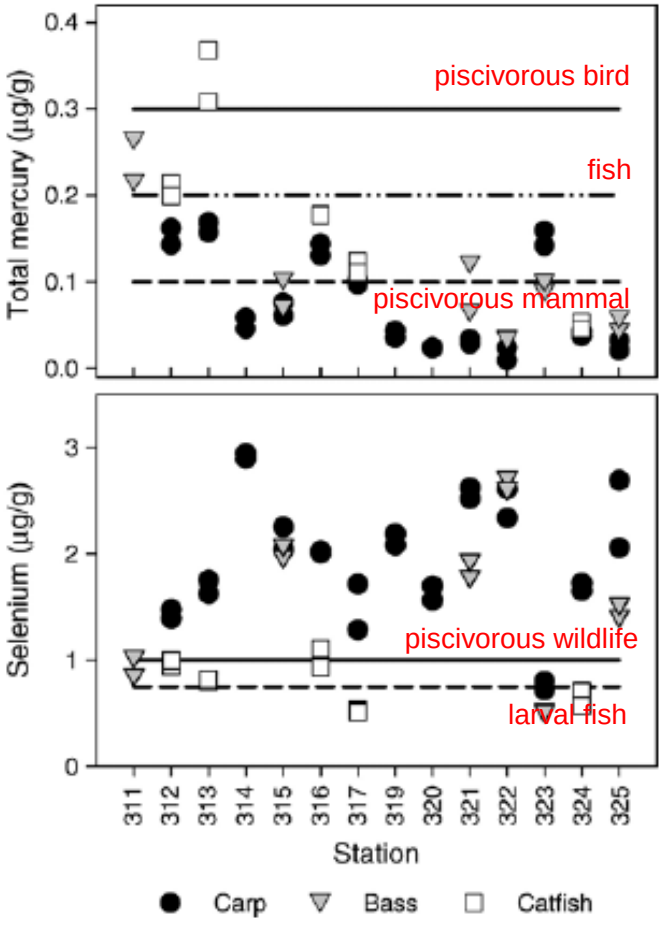


Fig. 1. Map of the Colorado River Basin illustrating waterways, state and international boundaries, and locations sampled.



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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

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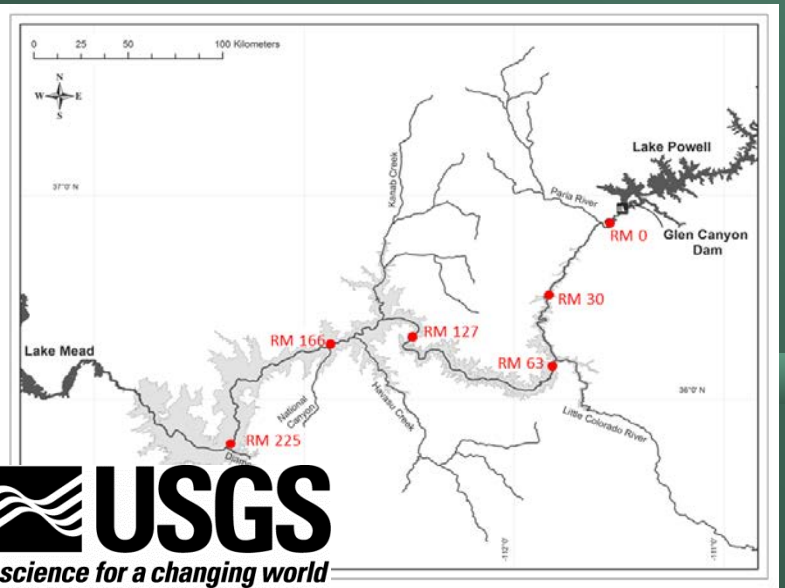
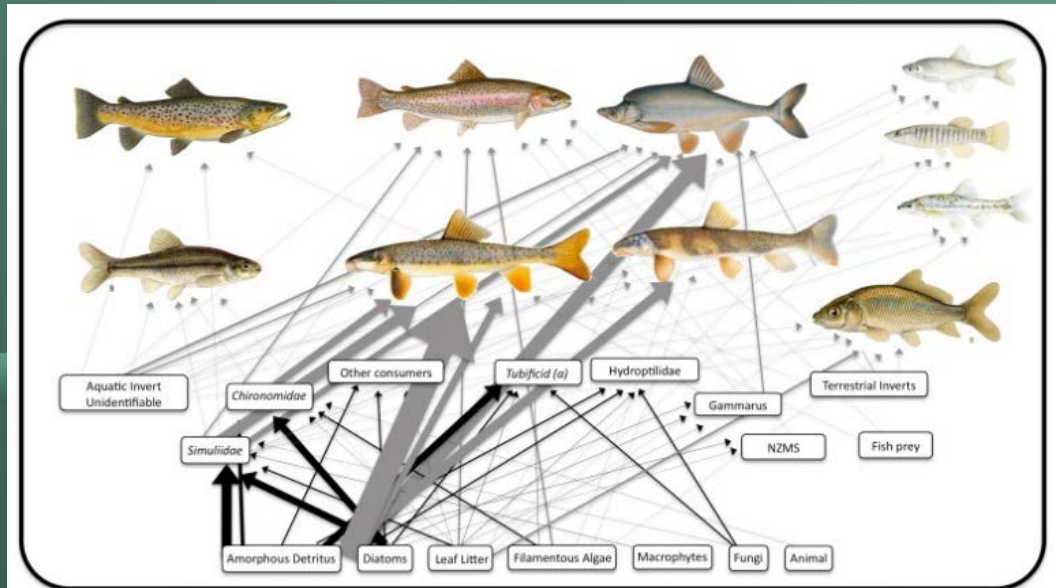
Objectives

- 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





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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

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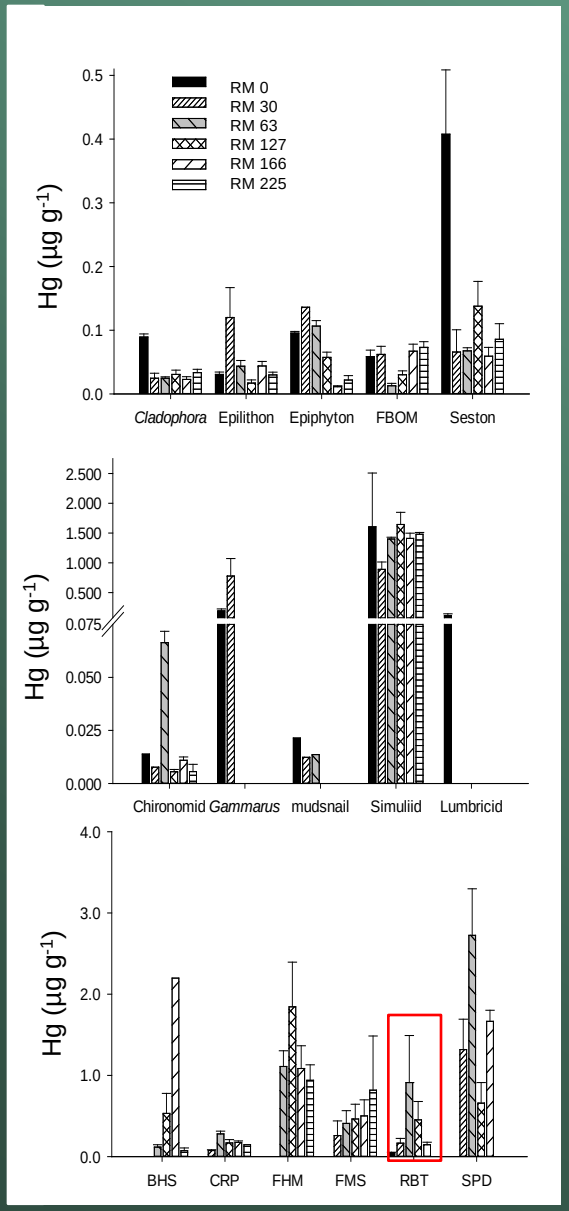
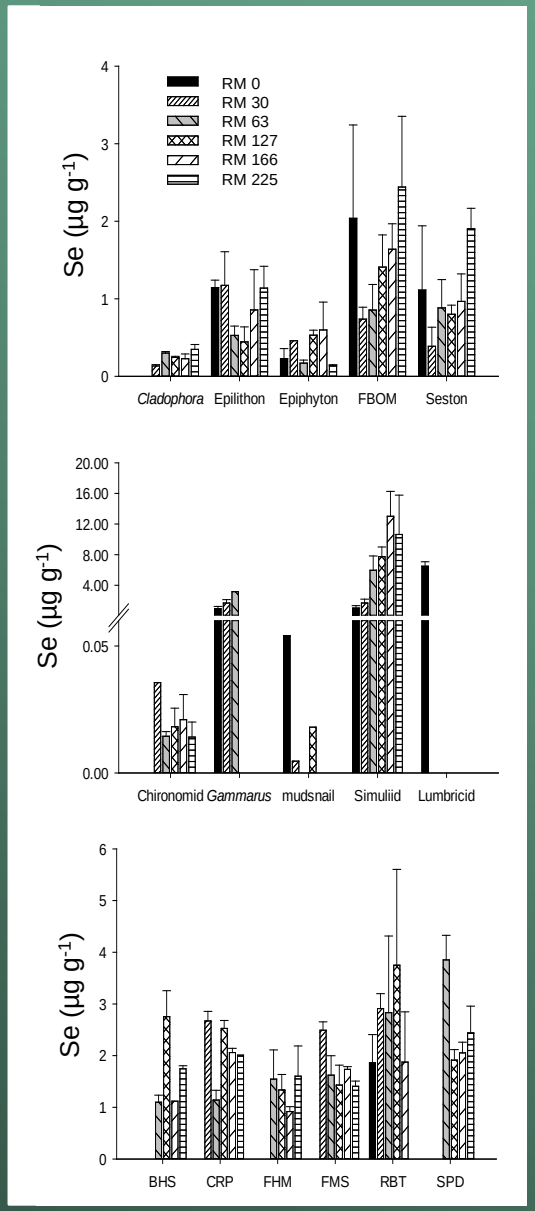
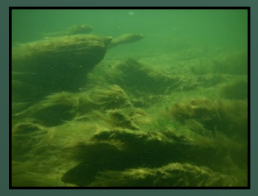


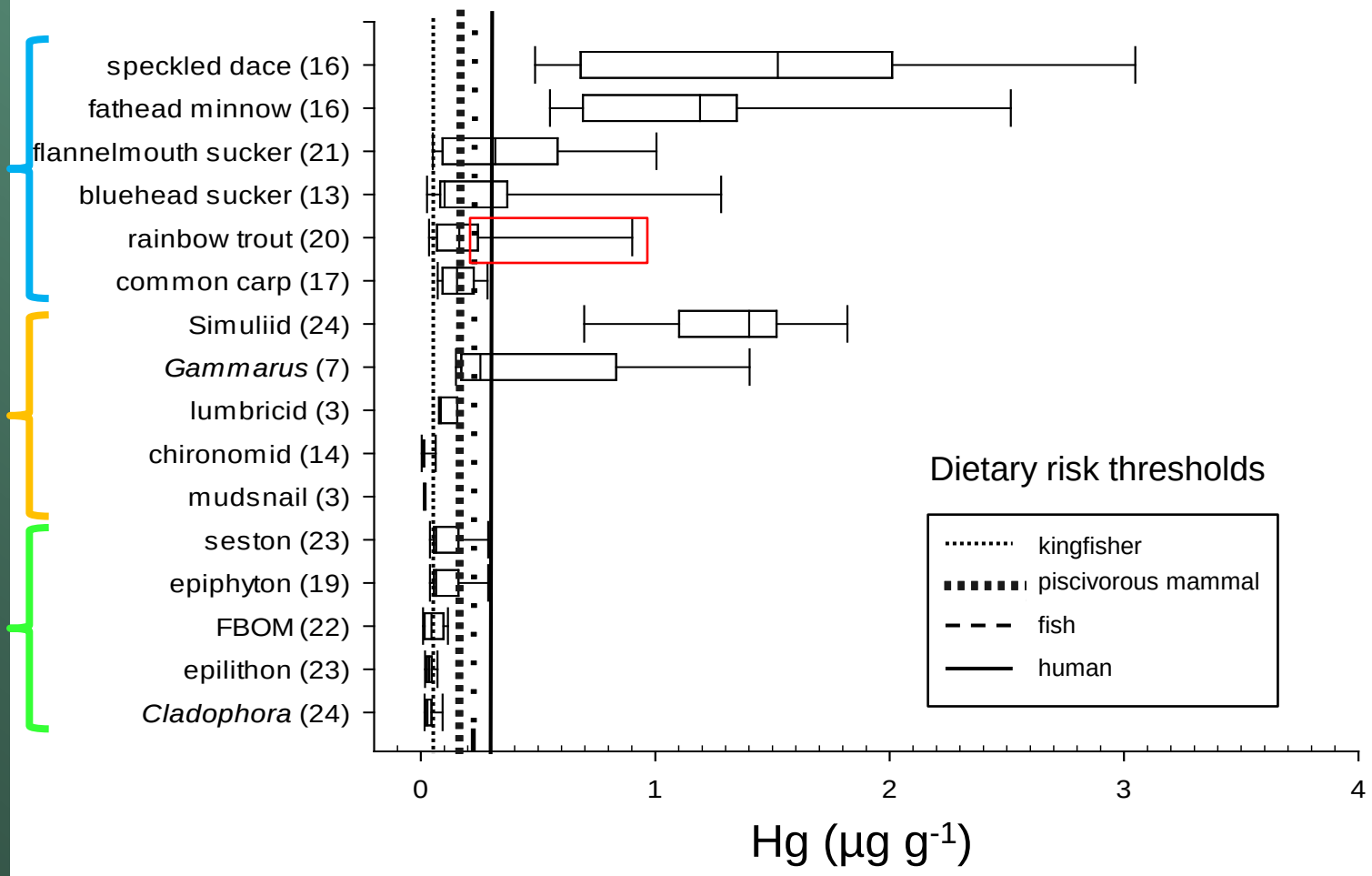


Hg and Se concentrations are relatively high throughout Grand Canyon, with no clear downstream patterns.

Walters et al. 2015

Hg concentrations among sites





Hg concentrations commonly exceed protective thresholds

Walters et al. 2015

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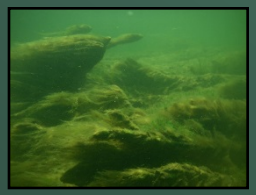
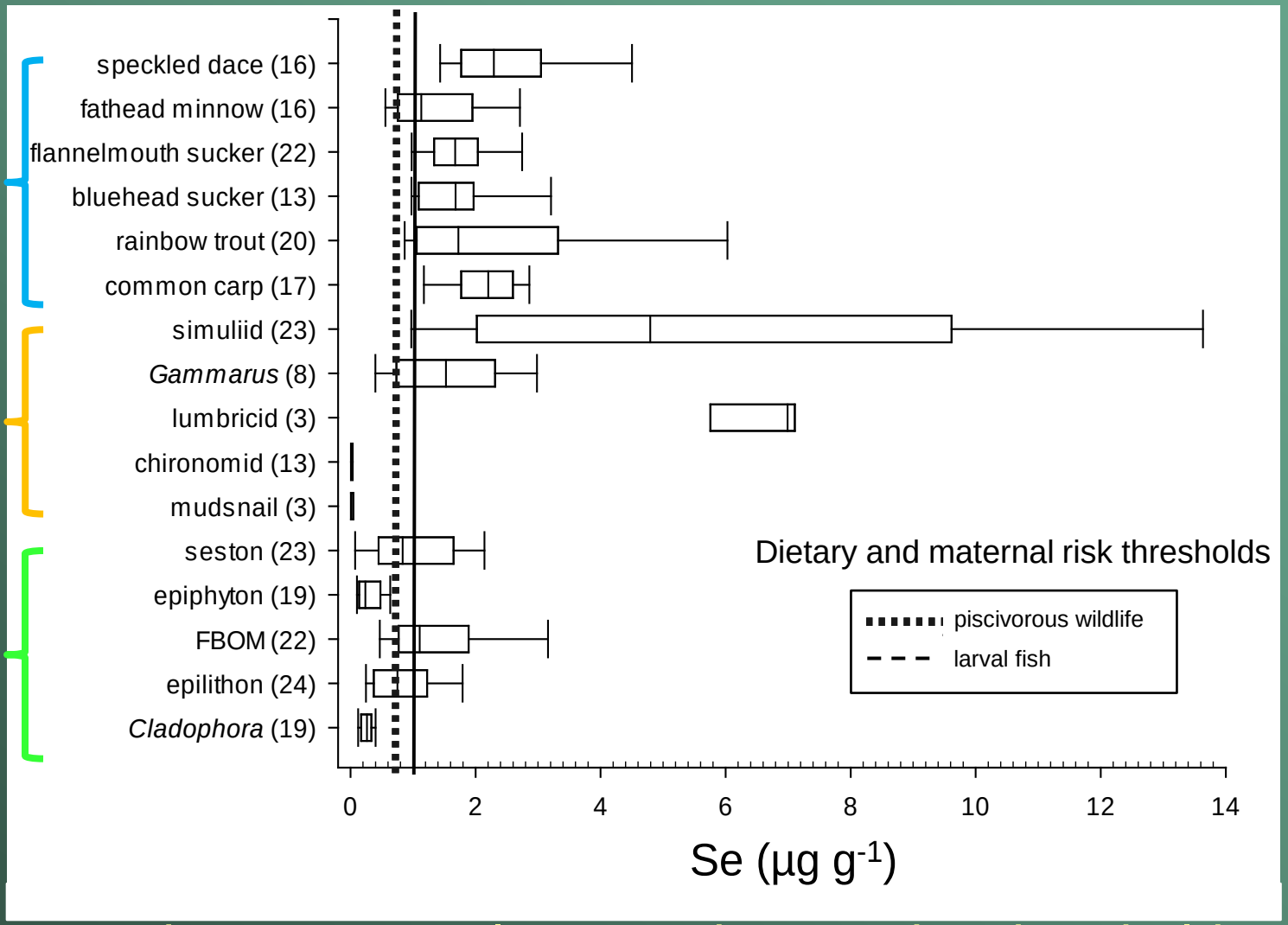
Se concentrations among sites





Se concentrations commonly exceed protective thresholds

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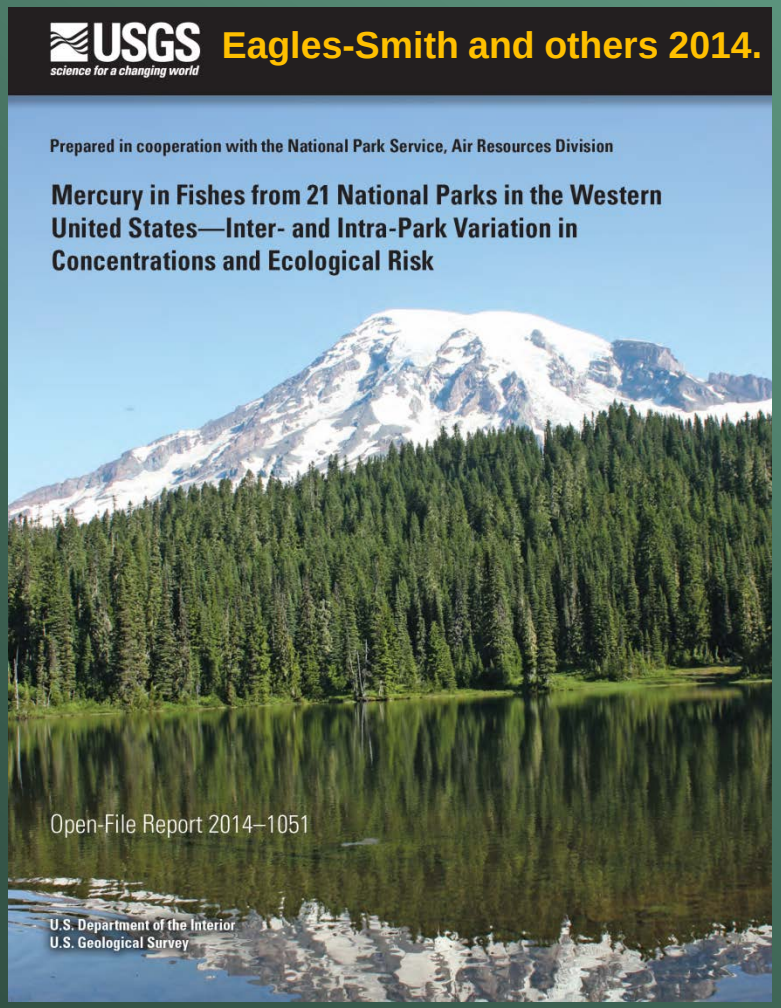
Walters et al. 2015

Where does Hg come from?



"…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…"

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

Where does Hg in Grand Canyon come from?

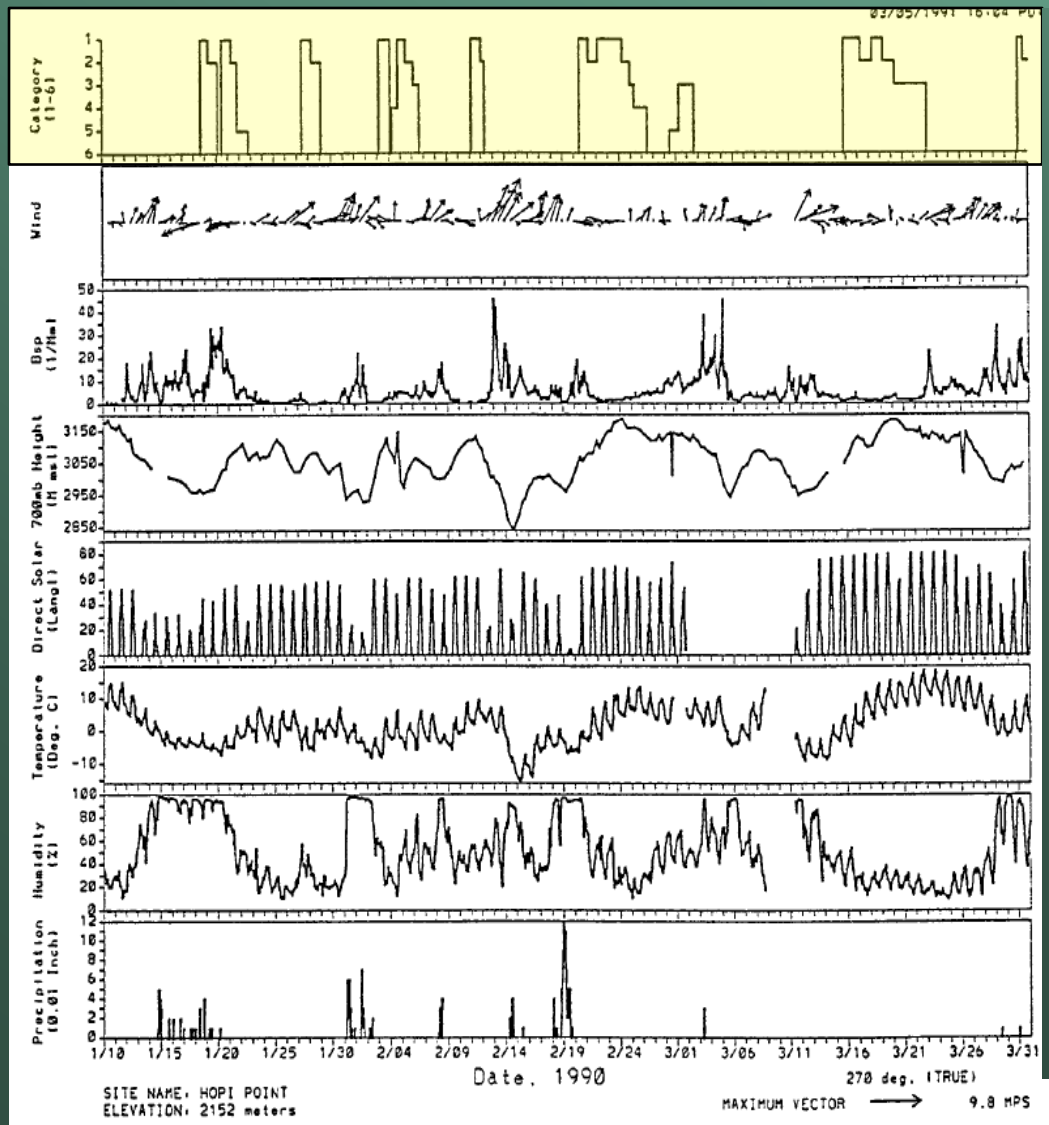

FIG. 9. Time series of surface winds, b_{sp}, direct solar radiation, temperature, relative humidity, and precipitation at Hopi Point; 700 mb heights at Tusayan; and the categories assigned when NGS emittants were probably present at the Grand Canyon for 10 January 1990–31 March 1990.

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

Emissions from Navajo Generating Station are deposited in Grand Canyon and Lake Powell.

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Meteorological Processes Affecting the Transport of Emissions from the Navajo Generating Station to Grand Canyon National Park

CHARLES G. LINDSEY,* JUN CHEN,+ TIMOTHY S. DYE, L. WILLARD RICHARDS, AND DONALD L. BLUMENTHAL

Sonoma Technology, Inc., Santa Rosa, California

(Manuscript received 27 December 1997, in final form 14 October 1998)

Where does Se come from?

areas susceptible to contamination

irrigated land

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

Seiler et al. 1999

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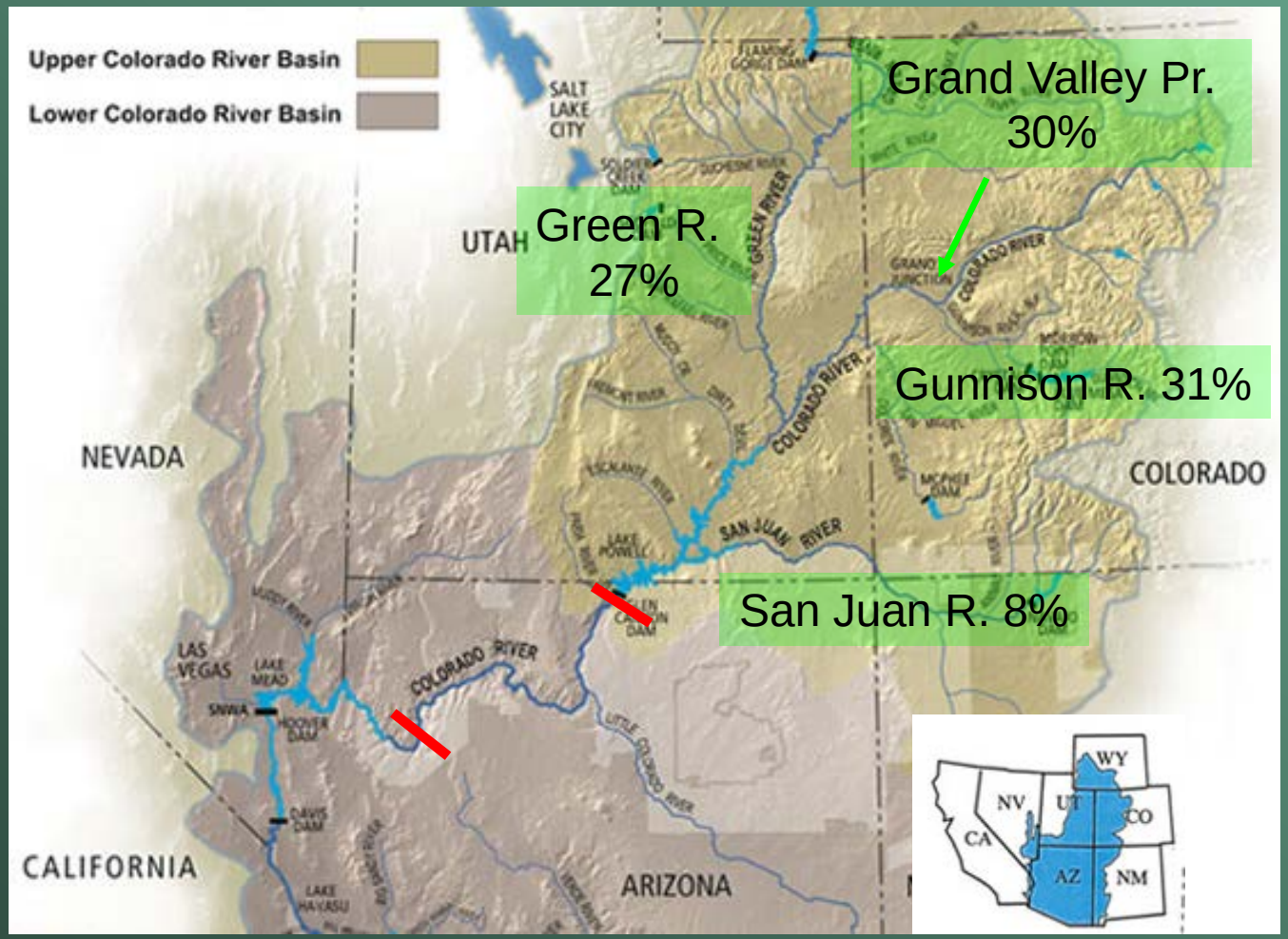
How much Se enters Glen Canyon?



irrigation 71%

natural weathering 21%

point source 8%

Lake Powell

100 kg d^{-1}

Glen Canyon

83 kg d^{-1}

29.9 MT y^{-1}

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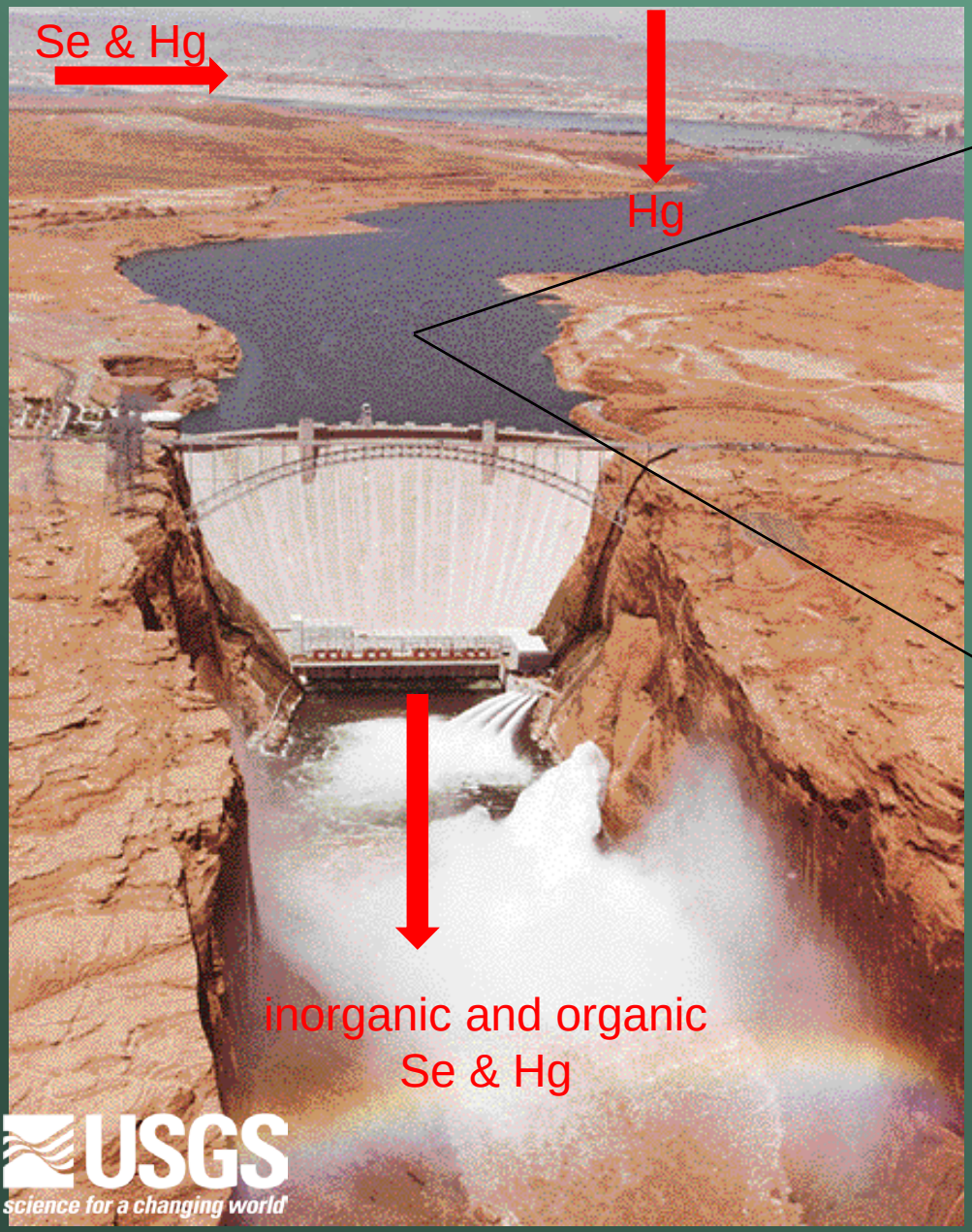
Se data 1985-94: Engberg,1999

Hg and Se Transport Model



Hg/Se cycling

inorganic Se & Hg

anaerobic conditions
microbial activity

organic Se & Hg
(bioavailable and toxic)

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

Key Findings

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Acknowledgements

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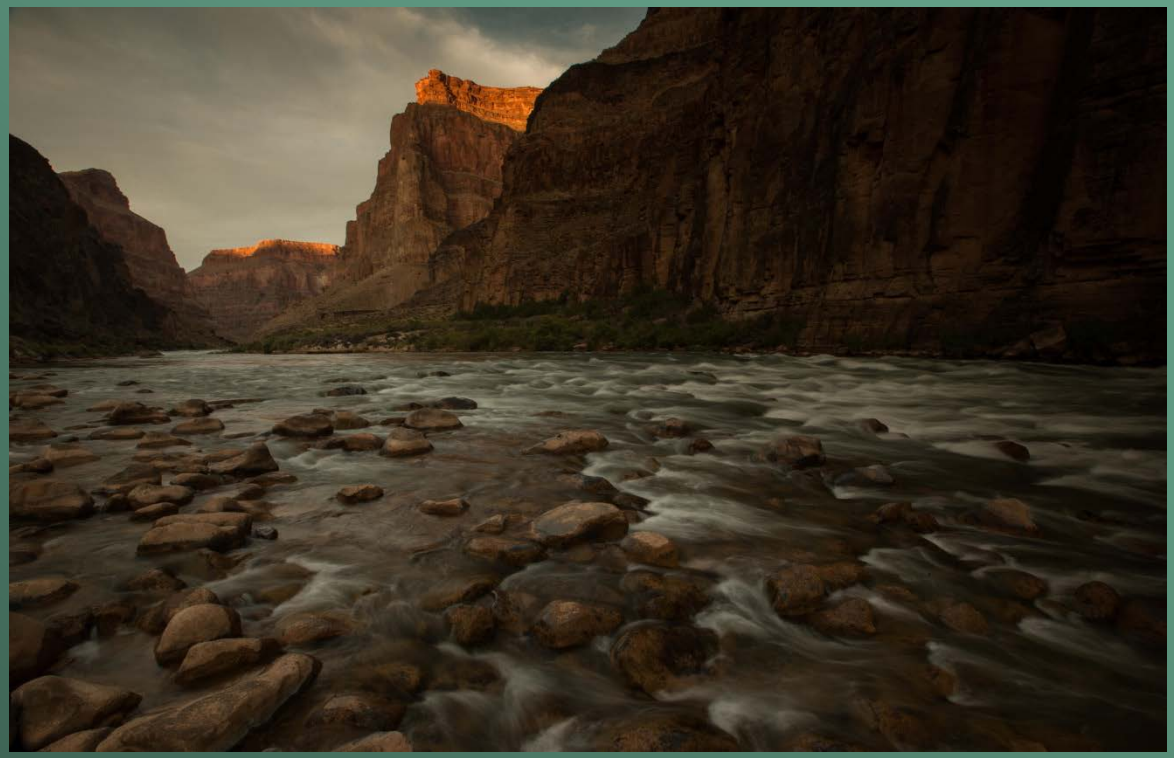

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