Characterization of Selenium and Mercury Exposure in the Colorado River Food Web in the Grand Canyon

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Background: Selenium (Se) and mercury (Hg) biomagnify in aquatic food webs and their toxicity to fishes and terrestrial wildlife (e.g., piscivorous birds and mammals) is well documented (Hamilton 2004). A recent survey by Hinck et al (2007) documented that Se and Hg concentrations exceed fish and wildlife toxicity thresholds throughout the Colorado River Basin (CRB), and Se concentrations were particularly high. This study did not include samples from the Grand Canyon, but it is reasonable to assume that concentrations in the Colorado River within the Grand Canyon are high as well. In fact, concentrations within the Colorado River downstream of Lake Powell may be higher than those in other portions of the CRB. Lentic habitats such as Lake Powell are conducive to Se and Hg biotransformation and remobilization, and may export bioavailable species of these metals (e.g., methyl mercury, MeHg) to downstream ecosystems (Galloway & Branfireun 2004; Orr et al. 2006). Uncertainty regarding Se and Hg concentrations in the Colorado River below Glen Canyon Dam underscores the need for comprehensive exposure characterization of the system, which is required for parameterization of risk assessment models.

Objectives:

1. Quantify the extent and magnitude of Se and Hg contamination in the Colorado River.

Quantifying concentrations of Se and Hg is a critical first step in characterizing exposure and quantifying biomagnification in food webs. Se and Hg concentrations will be measured throughout the Colorado River food web. These data will be used to identify spatial patterns in metal contamination among sites and combined with existing stable isotope data to fully characterize dominant sources of Se and Hg to the Colorado River food web. Biomagnification studies of Hg and Se are comparably rare in flowing water systems (Hill et al. 1996; Orr et al. 2006) and limited to small, wadeable streams. Se and Hg concentrations in invertebrates and fishes will be compared with toxicity thresholds (U.S. Environmental Protection Agency 2004) to determine whether further research or a formal risk assessment is warranted. It should be noted that laboratory and field studies have identified chronic and acute values of Se and/or Hg in body tissues for many Colorado River taxa including *Gammarus lacustris*, chironomids, rainbow trout, flannelmouth sucker, fathead minnow, pikeminnow, common carp, channel catfish, and razorback sucker (U.S. EPA, 2004, and references therein).

2. Develop Mercury and Selenium Budgets for the Colorado River Foodweb.

Biomagnification models typically rely on stable isotope or process-based bioenergetic models to quantify the flux of contaminants across trophic levels. A more thorough approach would be to develop budgets quantifying rates of Se or Hg transfer (i.e., g m^{-2} day^{-1}). Budgets require detailed data on standing crops of organic matter as well as primary and secondary production, which are laborious to calculate. However, these data are currently being collected as part of GCMRC's Food Base research effort and will serve as the basis for budget construction. To our knowledge, only one published study has combined contaminant and secondary production data to quantify contaminant flux in a lotic food web (Runck 2007).

3. Estimate export of Mercury and Selenium from the Colorado River to Riparian Ecosystems.

In addition to providing quantitative measures of contaminant flux in the aquatic food web, secondary production data can be used to estimate contaminant flux to riparian ecosystems. Emergent aquatic insects are a major route of material transport across the aquatic-terrestrial boundary (Baxter et al. 2005). Secondary production measurements for aquatic life stages can be used to estimate production of emergent insects, which can then be combined with Se and Hg concentration data to estimate flux of contaminants to riparian ecosystems. These estimates, in turn, can be used to assess the risk of Se and Hg to terrestrial insectivores such as birds and herptiles.

Approach: We will sample 6 sites (Lees Ferry, RM30, RM62, RM125, RM 165, RM225) encompassing 225 miles of the Colorado River. All major food web components including organic matter sources, macroinvertebrates, and fish will be analyzed for metal concentrations (Table 1). Fin clips from adult humpback chub will be used to characterize Se and Hg exposure, while muscle plugs will be used for other species. Samples will be collected in June 2007. Four replicate samples of each organic matter source and stream consumer will be collected at each site. Samples of consumers will consist of composites of multiple individuals to minimize within population variance. Likewise, samples of organic matter will be composited from multiple collections taken within each sample reach to minimize within-reach variation. All samples will be analyzed for total Hg and Se. A subset of 10% of the samples will also be analyzed for MeHg. Typically, MeHg represents about 85% of the total Hg in higher trophic level fishes, but the ratios can be skewed for primary producers and consumers (Hill et al. 1996). Running a subset of samples for MeHg will allow us to estimate MeHg from total Hg without incurring the additional expense of MeHg analysis. Total cost of the Se and Hg analysis is estimated at $37,000, to be paid for by the U.S. Environmental Protection Agency.

Products: A presentation of our findings will be given to the Technical Work Group in FY09. We also anticipate at least one peer-reviewed publication to result from this research.

Table 1. Projected sample loads of various food web components for Se and Hg analysis.

Matrix	# taxa	Replication	# sites	Total
Particulate Organic Matter	Na	4	6	24
Cladophera	Na	4	6	24
Epiphyton	Na			24
Epilithon	Na	4	6	24
Macroinvertebrates	4	4	6	96
Fish	~6	4	6	144
Field blank (stand. ref. material)	1	5	1	5
Total				341

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