An Empirical Model for Mercury in the South River Aquatic Food Web, Virginia, USA

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Introduction

Mercury (Hg) was used between 1929 and 1950 at a textile manufacturing plant in Waynesboro, Virginia, and was released and transported into surface water, sediments, soils, and biota of the South River. Mercury levels in water, sediments, and biota in the contaminated reach of the South River continue to remain elevated. Mercury concentrations in fish have not declined ,as expected, compared to fish tissue concentrations observed in 1977-1978. Peak Hg concentrations in water, sediment, and biota occur downstream of the original point of Hg release.

A Conceptual System Model (CSM) has been developed for the South River. The CSM is a somewhat simplified representation of mercury movement in the river from primary sources to high trophic level organisms based on extensive empirical data. The CSM provides a framework for a numerical quantification of IHg sources and ranking of the pathways (e.g., diet vs. aquatic) by which MeHg is accumulated in higher trophic level organisms such as fish (i.e., smallmouth bass). The model is also an important tool for integration of disparate data, and stakeholder communication. Objectives in developing a conceptual model of Hg cycling and bioaccumulation in the South River include identifying:

- Primary mercury sources and pathways to consumers
- Pathways that may be feasible to intercept to reduce fish mercury levels
- Uncertainties

Conceptual System Model Development

The Conceptual System Model was developed using existing information from a wide range of studies already carried out in the South River. The CSM incorporated several different data sets to construct a workable model of the food web, including bioaccumulation models, stable carbon and nitrogen data, fish and invertebrate community data, and site-specific diet studies. Additionally, the model used several different *in situ* methods to describe alternate routes of exposure. The conceptual model presented here focuses on base flow conditions for relative river miles (RRM) 0 to 10 of the South River (Figure 1). A schematic describing the movement of mercury in the South River is shown in Figure 2.

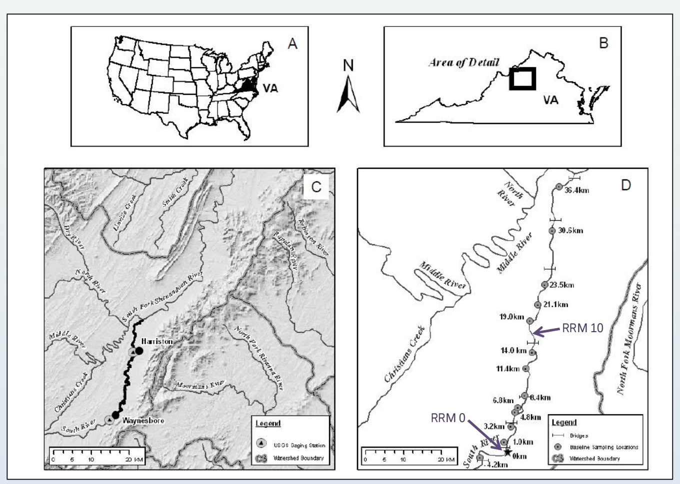

Figure 1. South River, VA Study Area for Hg. Panel C shows the study area (thick black line). Panel D, shows the sample locations and the distance of the location from the former DuPont plant in Waynesboro, VA (located at RRM 0). From Flanders et al. (2010).

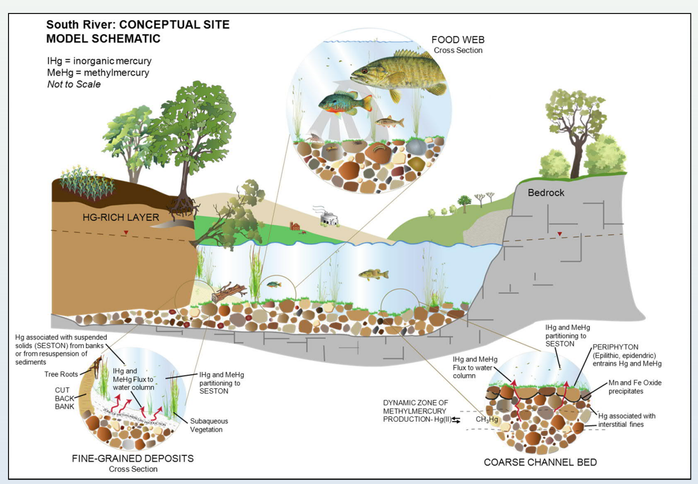

Figure 2. South River Conceptual System Model Schematic (CRG, 2012)

Data Sources

The CSM considers the bioaccumulation of MeHg by top-level predators (e.g., the smallmouth bass) via the food web. Field studies and modeling were used to identify the trophic structure of the aquatic food web in the South River and associated MeHg fluxes. Data sources included MeHg uptake studies for mayfly nymph and crayfish (Figure 3), nitrogen isotope studies of the food web, results of smallmouth bass MeHg bioaccumulation modelling (Figure 4), and fish capture and stomach content analyses for several fish species (Figure 5).

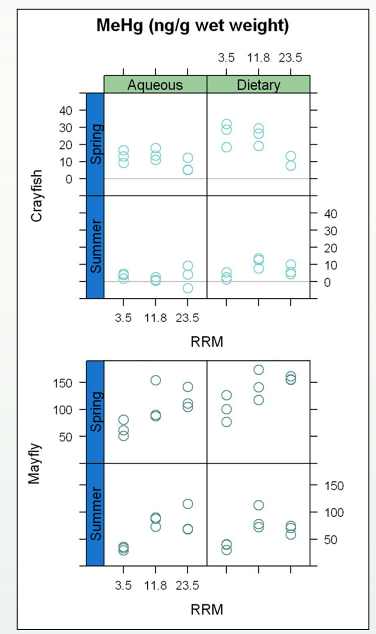

Figure 3. *In situ* MeHg uptake by crayfish and mayfly in the South River (CRG, 2012)

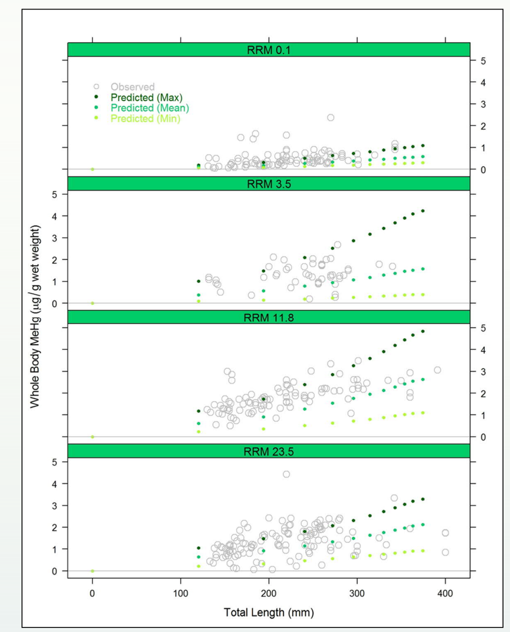

Figure 4. Predicted bioaccumulation of MeHg by smallmouth bass in the South River (CRG, 2012)

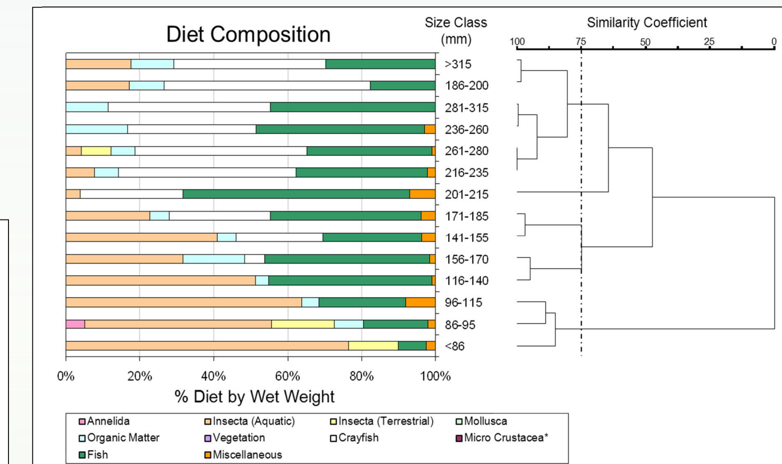

Figure 5. Diet composition of smallmouth bass in the South River (CRG, 2012)

Results

Ultimately, smallmouth bass derive the majority of their MeHg from two sources: omnivorous invertebrates (e.g., crayfish) and insectivorous fish (e.g., longnose dace, common shiner) (Figure 6). This is due to the prevalence of these items in the diet of the smallmouth bass and the high MeHg content of these organisms. Approximately half of the MeHg ultimately accumulated by smallmouth bass was derived indirectly from seston and filtered water while roughly one third was taken up by periphyton, surface coatings, and detritus associated with sediments or the sediment-water interface (where a water component to MeHg exposure is also likely involved).

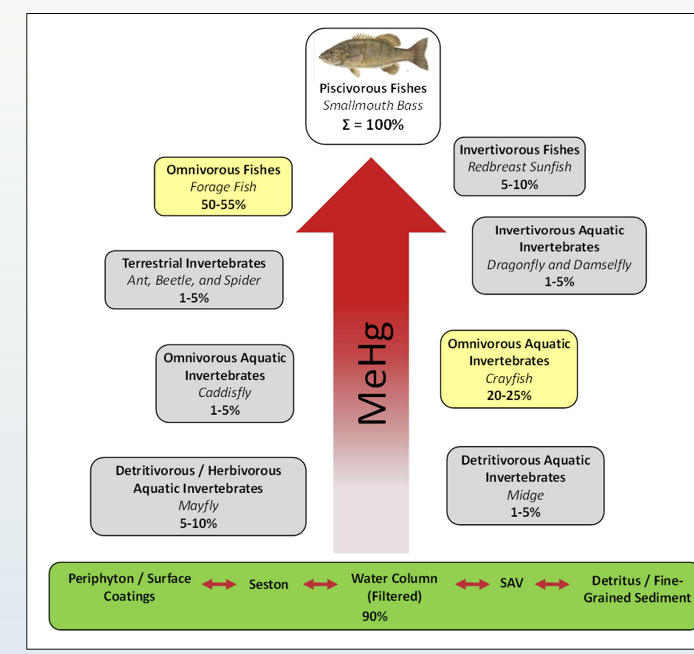

Figure 6. MeHg flow through the South River (RRM 0 to 10) food web to smallmouth bass (CRG, 2012)

References

CRG. 2012. Final Report: Ecological Study of the South River and a segment of the South Fork Shenandoah River, Virginia. September 28.

Flanders, J. R., Turner, R. R., Morrison, T., Jensen, R., Pizzuto, J., Skalak, K., and R. Stahl. 2010. Distribution, behavior, and transport of inorganic and methylmercury in a high gradient stream. Appl. Geochem. 25, 1756-1769.