International Conference on Mercury as a Global Pollutant

South River Science Team (SRST) Fall 2017 Meeting
Waynesboro, Virginia

south river SCIENCE TEAM

September 26, 2017

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Agenda

– Plenary and Synthesis Theme Summary

– South River Presence

– Wrap-up

– Discussion

Plenary and Synthesis Themes

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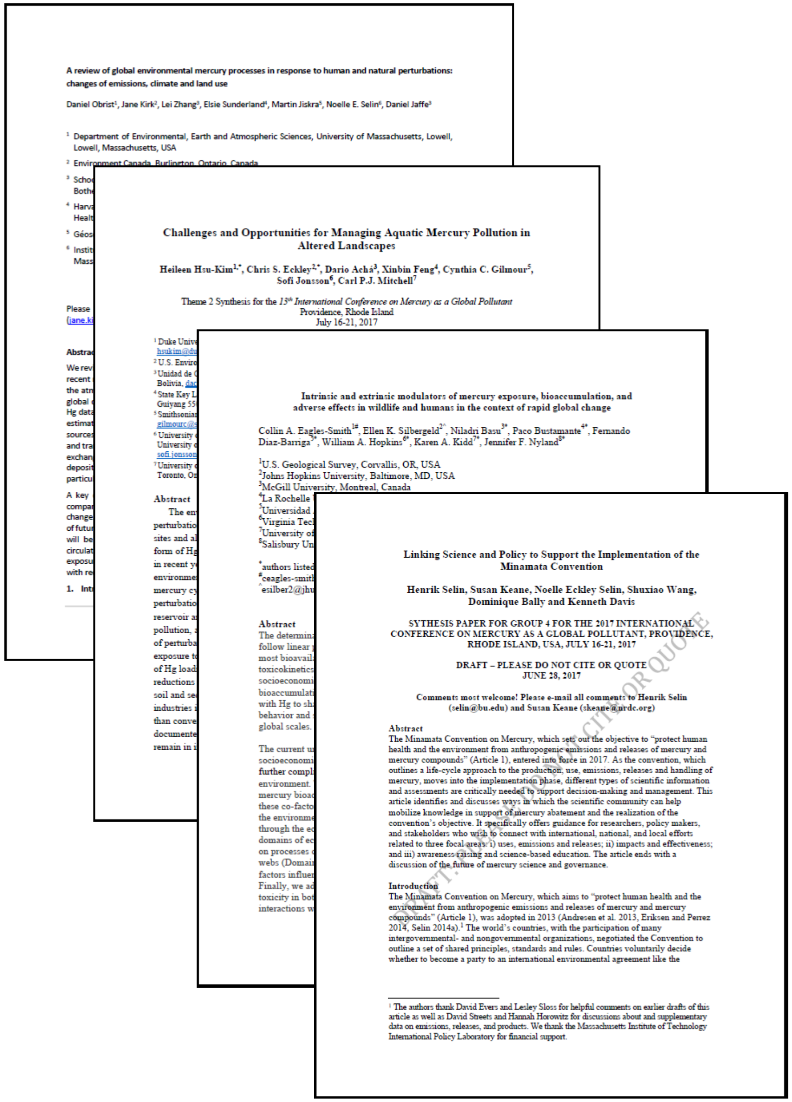
– Themes:
  1. How can scientific knowledge contribute to the implementation and effectiveness evaluation of the ***Minamata Convention***?
  2. How is mercury cycling (and bioaccumulation) changing in specific places in **response to perturbations** (e.g., climate change, remediation, nutrient control, urbanization)?
  3. How is ***global mercury cycling*** changing in response to perturbations (e.g., climate change, emissions control)?
  4. What is the ***relative risk of mercury*** exposure to human health and wildlife in the context of other risks/stressors?



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1. Minamata Convention on Mercury

– August 2017

– Global plan to control Hg and lower human exposure

– Outlines a life-cycle approach to the production, emissions, releases and the handling of mercury

– Voluntary agreement with provisions to bind parties
  - 50 countries have ratified it, with 28 pending; 40 countries are implementing

UN Environment Governing Council agrees to begin negotiations on a legally binding agreement on mercury	2009
Minamata Convention adopted and opened for signature	2013
Entry into force of the Minamata Convention	2017
First Conference of Parties	2017
Prohibition of new mercury mining	Upon entry into force for a Party
Phase-out of mercury use in acetaldehyde production[5,6]	2018
Deadline to reduce mercury use in VCM production by 50% (2010 baseline)	2020
Phase-out of mercury use in mercury-added products listed in Annex A[4]	2020
Deadline for submitting ASGM National Action Plans to the Secretariat	3 years after entry into force for Party (e.g. earliest 2020), or 3 years after notifying the Secretariat that ASGM activity is more than insignificant, whichever is later
Deadline for Parties to require use of BAT and BEP for new sources from emissions categories listed in Annex D	5 years after entry into force for a Party (e.g. earliest 2022)
Deadline to complete first effectiveness evaluation	2023
Phase-out of mercury use in chlor-alkali production[4]	2025
Deadline for Parties to require use of ELV, BAT, BEP or alternative measures for existing sources from emissions categories listed in Annex D	10 years after entry into force for a Party (e.g. earliest 2027)
Phase-out of existing primary mercury mining	15 years after entry into force for a party (e.g. earliest 2032)

Source: Selin et al., 2017

1. Minimata Convention: Global Budget for Uses, Emissions and Releases

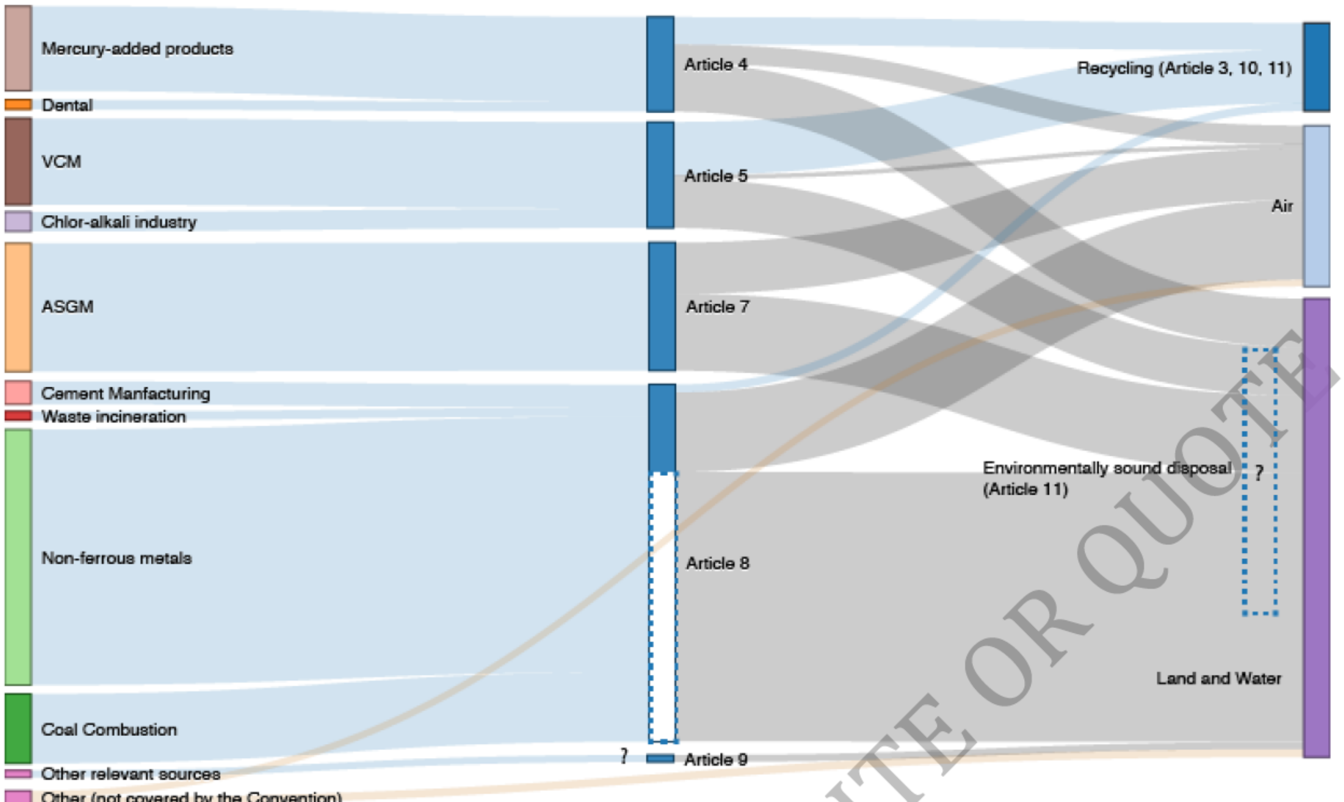
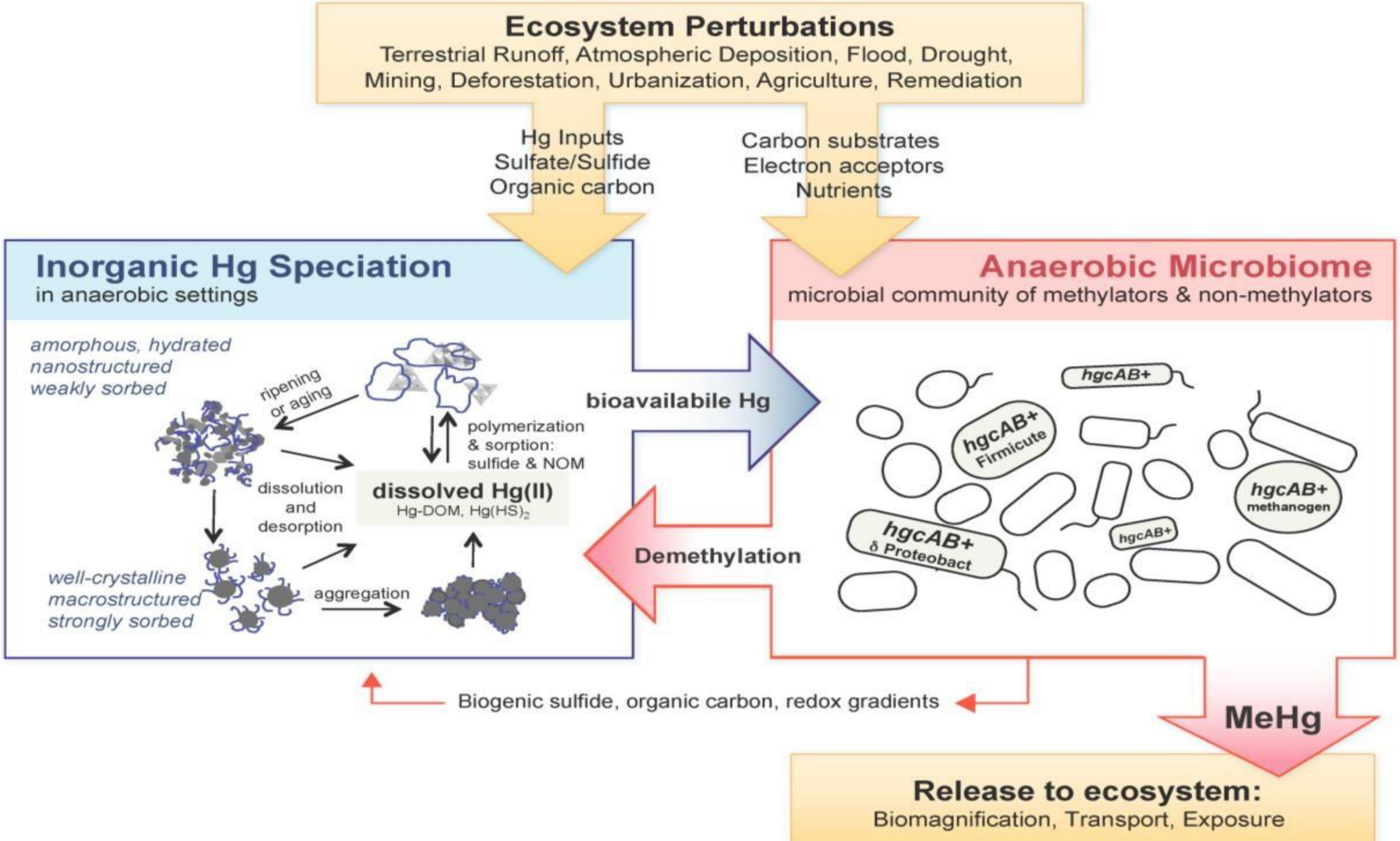


Figure 1. Global mercury budget for uses, emissions, and releases. Data from (Horowitz et al. 2014, Streets et al. 2017, United Nations Environment Programme 2017c). Question marks and dotted box indicate non-quantitative estimates. Dark blue represents Convention articles.

Source: Selin et al., 2017

2. How is mercury cycling (and bioaccumulation) changing in specific places in response to perturbations?



Other MeHg mediating elements: Se, Fe, Mn, Cu

Source: Hsu-Kim et al., 2017

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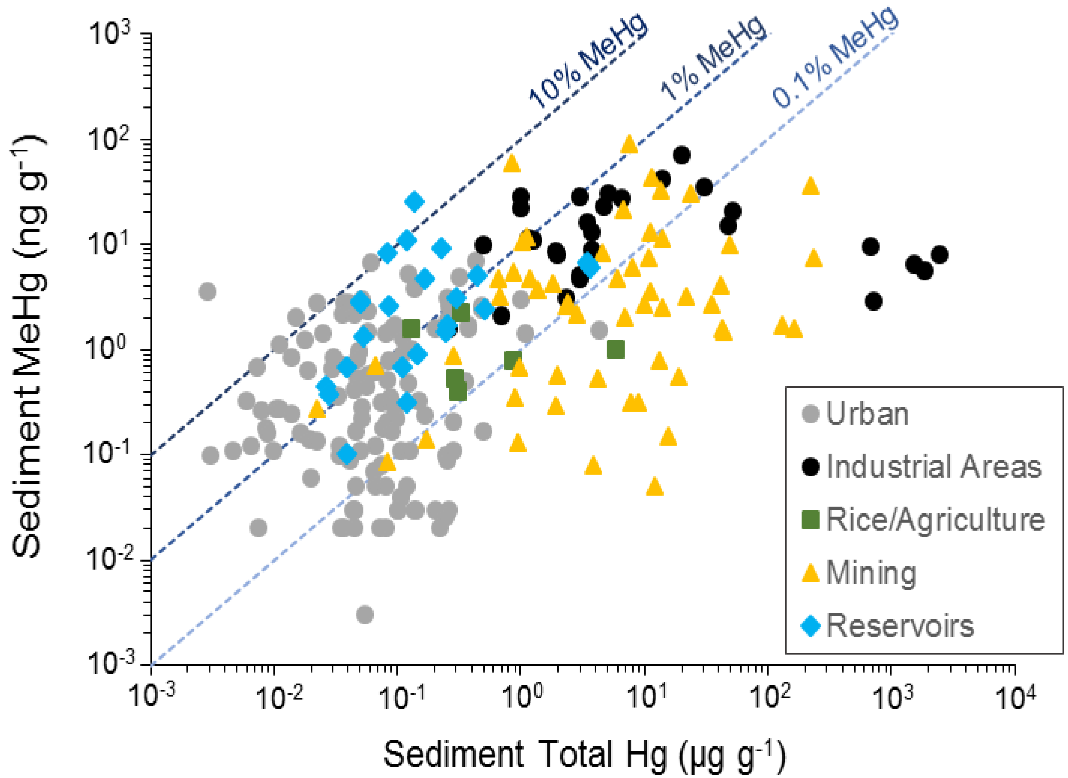

Wide range due to
Hg species / bioavailability
and to the
habitats and
associated geochemistry
of the Landscapes

Figure 1. The cycling of Hg has been studied at a wide variety of aquatic ecosystems that have been perturbed by anthropogenic activities. Total Hg and MeHg contents at these sites span several orders of magnitude. The concerns or risks of Hg at these sites generally depend on the mobilization potential of Hg from the site as well as potential for MeHg bioaccumulation and exposure to wildlife and humans.

Source: Hsu-Kim et al., 2017

2. Synthesis Highlight: Industrial Point Sources and Remediation

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- Remediation Strategies :
  - Dredging and excavation of Hg hotspots
  - Capping and erosion control for contamination with broad spatial extent
  - In situ amendments such as nitrate addition, black carbon and ferric iron
- Lake Pena Blanca
  - Dredged reservoir sediment >0.174 mg/kg
  - Fish levels are higher than pre-remediation

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BEST MANAGEMENT PRACTICES FOR MITIGATING AQUATIC SEDIMENTS CONTAMINATED WITH MERCURY - LESSONS FROM THREE CASE STUDIES

TODOROVA, Svetoslava[1];
(1) Syracuse University, NY, USA

stodorov@syr.edu

Under the Minamata Convention (Articles 9 and 12) countries are encouraged to identify, assess, and remediate sited contaminated with mercury (Hg) in order to reduce the risks to humans and biota. However, there is an increasing concern over the potential for full recovery of lake and reservoir ecosystems, many of which have experienced a legacy of Hg contamination. While the cessation of the direct source may result in decreases of Hg concentrations in water and biota, the long-term recovery of the ecosystems is not always achieved.

Using three case studies of Hg-contaminated lakes (Calero Reservoir in California, USA, Lake Pena Blanca in Arizona, USA, and Onondaga Lake in New York, USA), this work illustrates current practices for mitigating Hg contamination in lake sediments. The three lakes experience seasonal anoxia in the hypolimnion and substantial build-up of methylmercury (MeHg). Calero Reservoir is located in the New Almaden mining district, one of the largest sources of mercury in North America. Elevated total Hg and MeHg concentration were observed in sediment, water, and biota. Engineered oxygen addition to bottom waters, using pure oxygen gas, was chosen as remedial alternative. Lake Pena Blanca receives runoff from Hg tailings of abandoned gold mines located within its watershed. Removal of the Hg source and complete excavation of the lake sediments was undertaken. New, clean sediments were placed, the lake was naturally refilled with water, and fish was restocked in the lake. Onondaga Lake received ionic Hg inputs from the waste stream of a chlor-alkali plant that operated on the shores of the lake. Elevated Hg concentrations were reported in the water column and pelagic fish. Whole-lake nitrate addition to the hypolimnion of the lake was the preferred remedial alternative.

The author compares and contrast the effectiveness of the three remediation techniques and provides recommendations for the selection of proper, cost-effective, and environmentally-sound remediation based on site-specific conditions and regulatory goals.

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3. Hg Management Opportunities and Research Needs

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- Innovative tools for source attribution
- Risk assessment tools
- Complex biogeochemical Models
- Knowledge of the relative source loadings of Hg (surface vs. terrestrial)
- Importance of the control of solids transport
- Importance of natural organic matter
- Complex geochemistry
- Advanced techniques of data analysis

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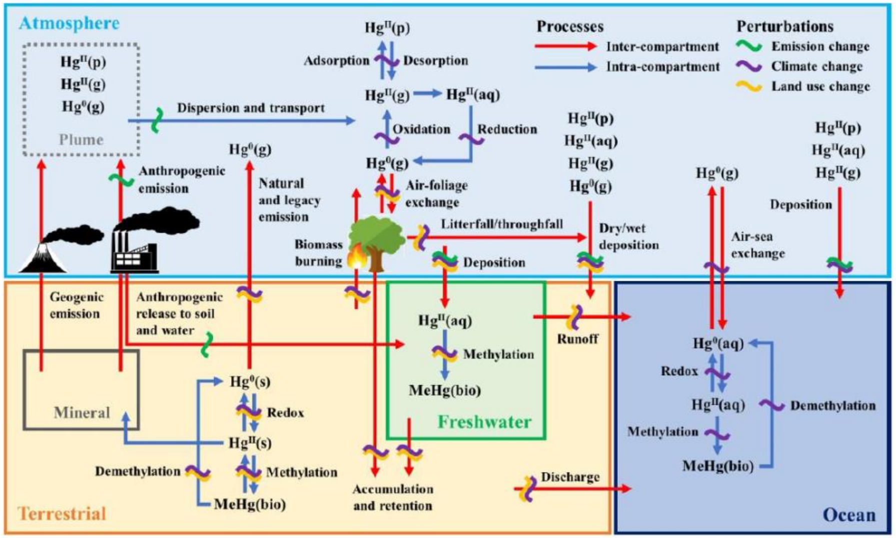
3. How is <u>global</u> mercury cycling changing in response to perturbations?

- Use of Hg isotopes continue to refine/constrain importance of sources and processes
- Changes in emissions, climate and land use will affect human exposure on a global scale
  - Uncertain as to how…



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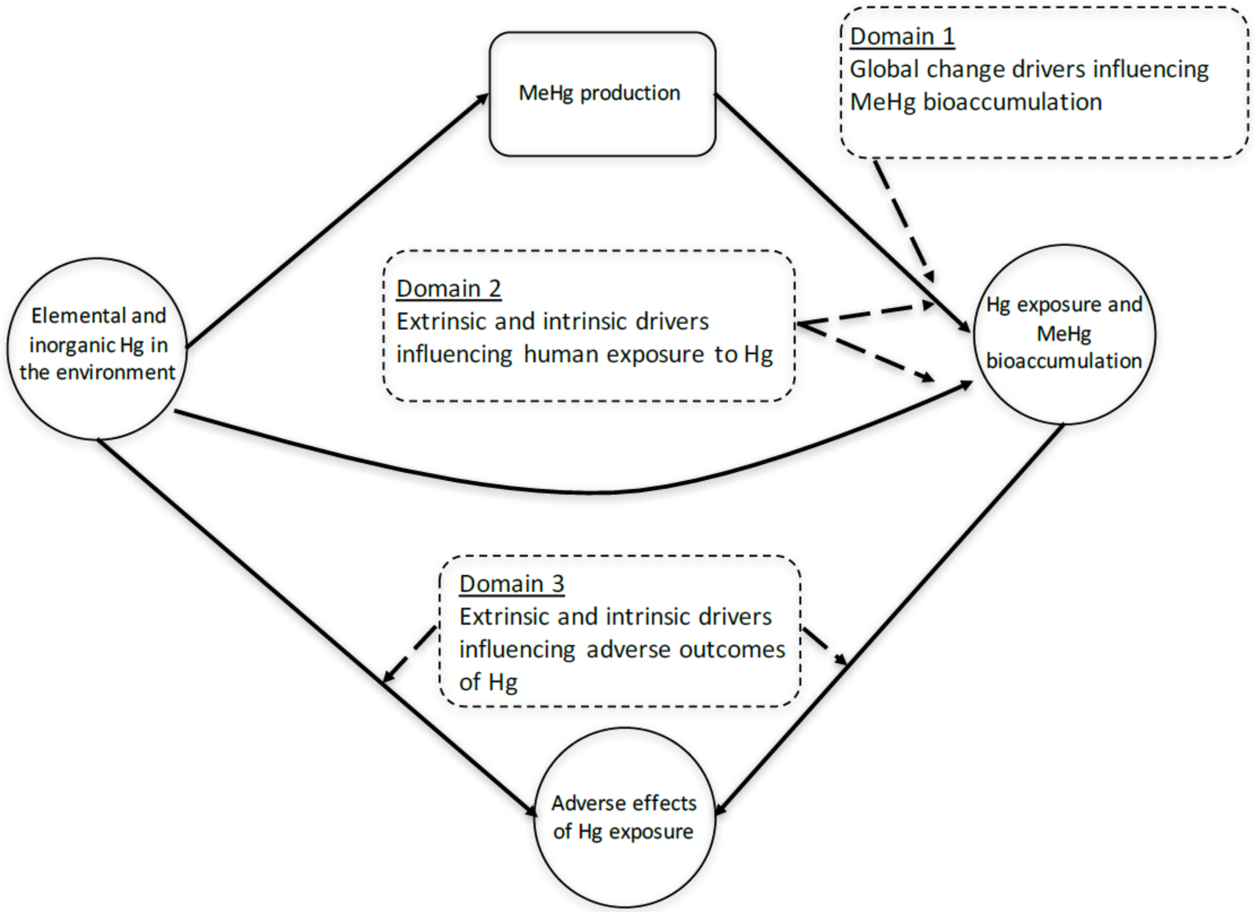
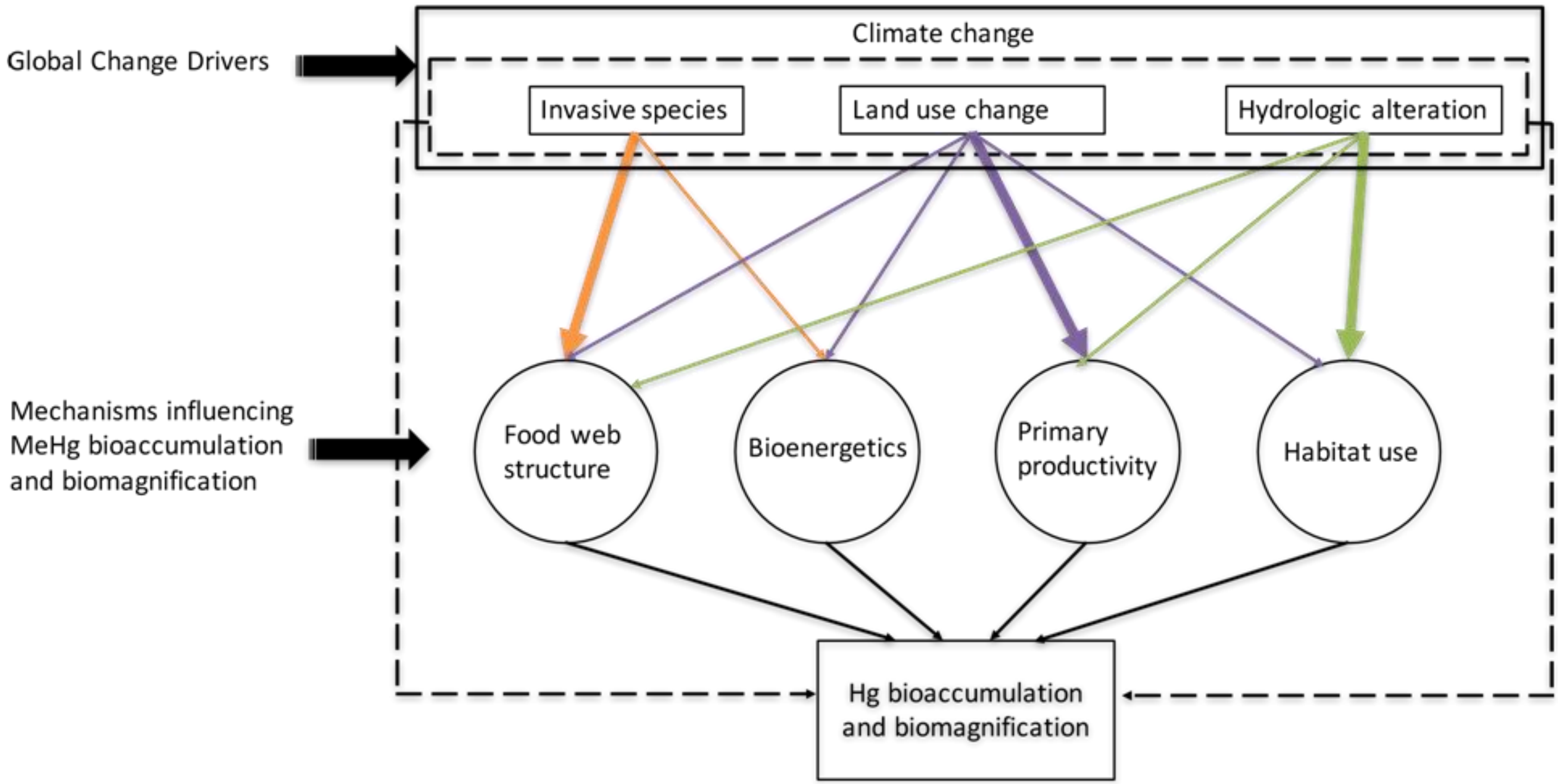
4. What is the relative risk of mercury exposure to human health and wildlife in the context of other risks/stressors?



4. Domain 1 – Global change factors influencing MeHg bioaccumulation in food webs



4. Domain 2 Example: Economic Drivers of Exposure

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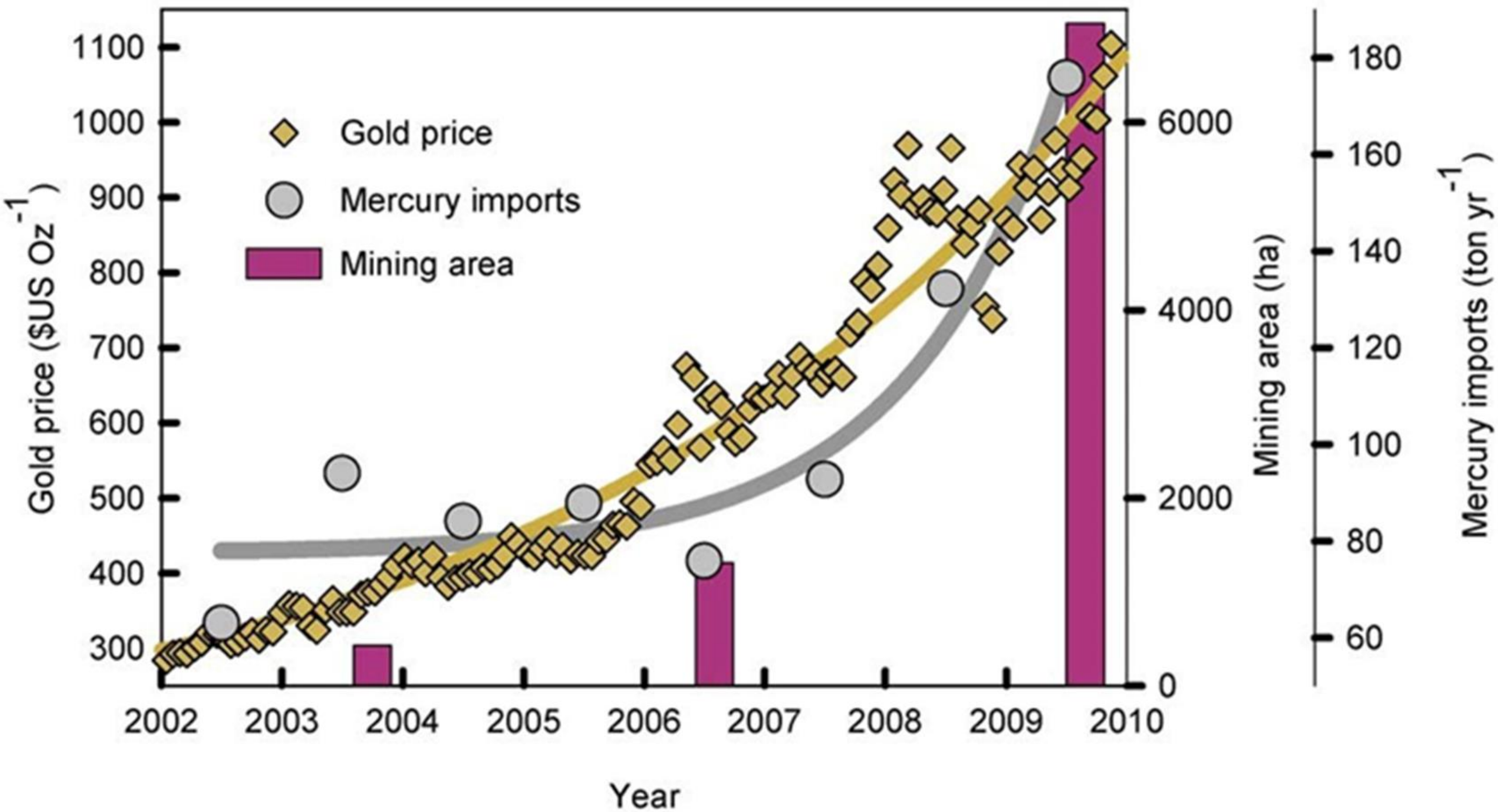

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4. Domain 3 – Interacting factors that modulate Hg toxicity and risk

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- Microbiological factors
- Immunotoxic effects/interaction with pathogens (e.g., malaria)
- Nutrients/co-occurring COPCs
- Genetics

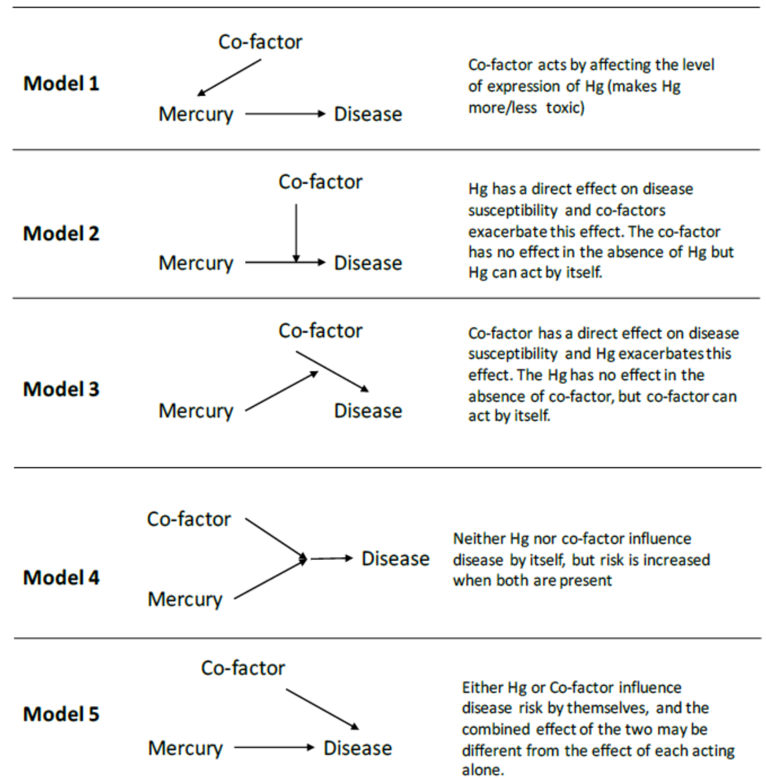

Figure 4. Conceptual model for evaluating interactions between Hg and other stressors on adverse outcomes (defined as disease). Modified from Ottman et al. 1996. An arrow from one factor (mercury, co-factor, or disease) to another indicates that the first factor has a causal influence on the second. An arrow from a factor to an arrow indicates that the factor influences the relationship between the two other factors. When two arrows merge, it indicates that two factors must both be present to influence disease risk. Cofactors in this context are synonymous with the term modifiers from an epidemiological perspective.

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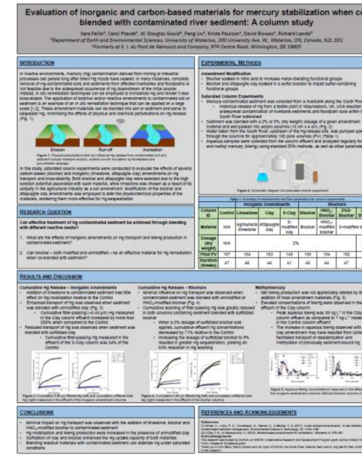
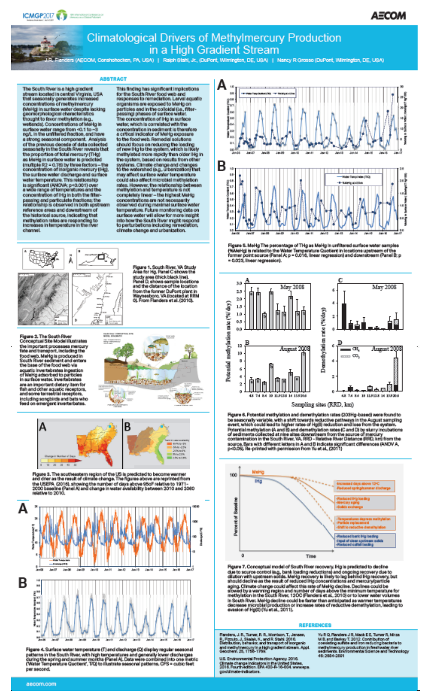
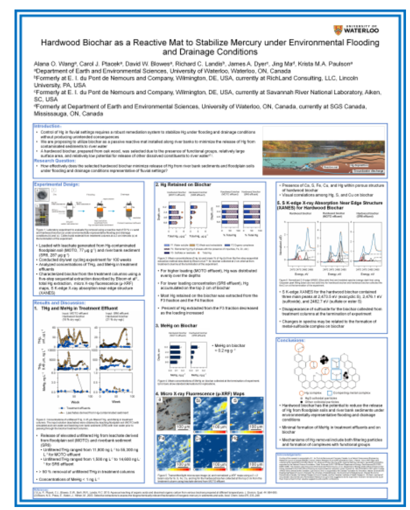
South River at ICMGP

South River Presence at ICMGP

- 10 presentations and 6 posters
- Entities presenting:
  - DuPont
  - William and Mary
  - Waterloo
  - Texas Tech
  - JMU
  - Reed Harris
  - Integral
  - Smithsonian
  - U Michigan
  - AECOM







South River Topics Presented at ICMGP

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– Ecotoxicology
  - Songbird
– Risk Assessment
  - Ecological Risk Assessment
  - Relative Risk Model
– Risk Communication
  - SRST Outreach
– Measurement Methods
  - Porewater concentration methods
  - Optical methods

– Remediation
  - Biochar
  - Activated Carbon
  - Adaptive Mgt
  - Statistical methods for predicting responses
– Geochemistry
  - Hg isotopes
  - Climate influences on methylation
– Mechanistic Modeling

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ICMGP "Take Home Messages"

- Controlling Hg on local or global scales likely to remain extremely challenging in face of perturbations like climate change
- Hg is a global pollutant but there is increased attention on industrially-impacted systems
  - South River is among the best studied sites
- Acknowledgement of difficulty in remediating aquatic systems is growing
  - Recognition that invasive remedies are not necessarily the answer
  - Amendments continue to show promise

Questions/Open Discussion

Thank You

JR.Flanders@aecom.com

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