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The Lake Washington PCB/PBDE Study: Modeling Bioaccumulation of PCBs in Lake Washington Fish

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Modeling Bioaccumulation of PCBs in Lake Washington Fish

Carly Greyell, Jenée Colton, and Richard Jack

King County
Water and Land Resources Division
Salish Sea Conference
May 1st, 2014

Thank you to Greg Pelletier form Ecology for supporting this project.
Objectives

- Develop bioaccumulation model to predict Lake Washington fish tissue concentrations
- Pair with fate model and use to estimate impact of total PCB load reductions on fish tissue concentrations
Bioaccumulation Pathways

Uptake of PCBs (sources)
- ingestion (food web)
- respiration (water column or pore water)

Elimination of PCBs
- metabolism
- growth dilution
- egestion
- respiration
Model Development

- Adapted model of Gobas and Arnot (2004); also used for Puget Sound
- Established conceptual food web
- Defined input values:
  - **Physical**: used Lake WA specific data where available
    - (e.g., total organic carbon)
  - **Chemical**: assumed total PCBs represented by PCB-118
  - **Biological**: from Lake WA studies where available
    - (e.g., diet, lipid content, growth rate)
Conceptual Model

- **Piscivorous Fish**
- **Forage Fish**
- **Benthic Invertebrates**
- **Sediment/Detritus**
- **Zooplankton**
- **Phytoplankton**
Bioaccumulation Model Testing

Compare predicted to observed tissue concentrations:

- Used two different water & sediment tPCB inputs:
  1. Measured in Lake WA
  2. Fate model-predicted

- Calculated model bias
  Inputs measured in Lake WA = 2.3
  Inputs predicted by fate model = 1.2
Good model fit for top piscivorous fish
Uncertainty in diet:
38% “other fish” & cannibalism
Sensitivity Analysis

- Monte Carlo analysis → rank correlations between parameter values and model output
- Parameters contributing to the greatest variance:
  - Dietary absorption efficiency of lipids
  - tPCBs water concentration
  - Water, lipid and non-lipid organic matter fractions
  - Sediment concentrations of tPCBs
- Most other parameters contributed to < 10% variance
Uncertainty Analysis

- Model uncertainty is used to describe incomplete or imperfect knowledge about parameters
- Methods from Pelletier and Mohamedali (2009)
- The most sensitive parameters were included
- Chose low and high estimates for each parameter
- Outcome: overall “lowest and highest” tissue tPCB concentration estimates
Conclusions

- Bioaccumulation model performed well:
  - Fate-model derived sediment & water concentrations best
  - Model bias < 2.0 using these inputs
- Sensitivity and uncertainty analysis suggest model is conservative estimate

Next Steps:
- Refining model: e.g., further sediment and fish tissue monitoring
- Pair with fate model to estimate response of fish tissue concentration to total PCB load reductions.
References
