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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
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Thank you to Greg Pelletier from 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

- growth dilution
- egestion
- metabolism
- 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
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

Observed Tissue Concentrations (SD)
Observed Maximum Detection Limit
Predicted Using Fate Model Water and Sediment Concentrations
Sensitivity Analysis

- Monte Carlo analysis $\rightarrow$ 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
