The Lake Washington PCB/PBDE Study:

Modeling Bioaccumulation of PCBs in Lake Washington Fish

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Salish Sea Conference
May 1st, 2014

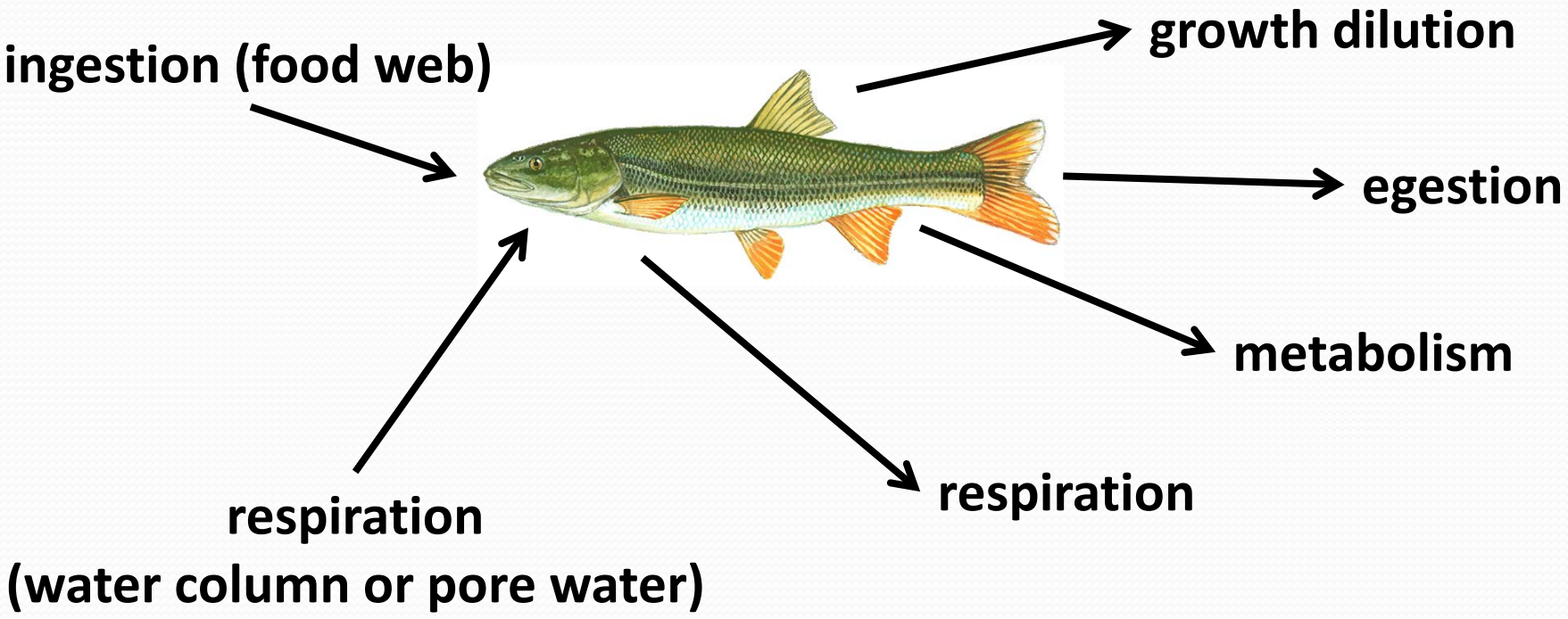
Objectives

- 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)

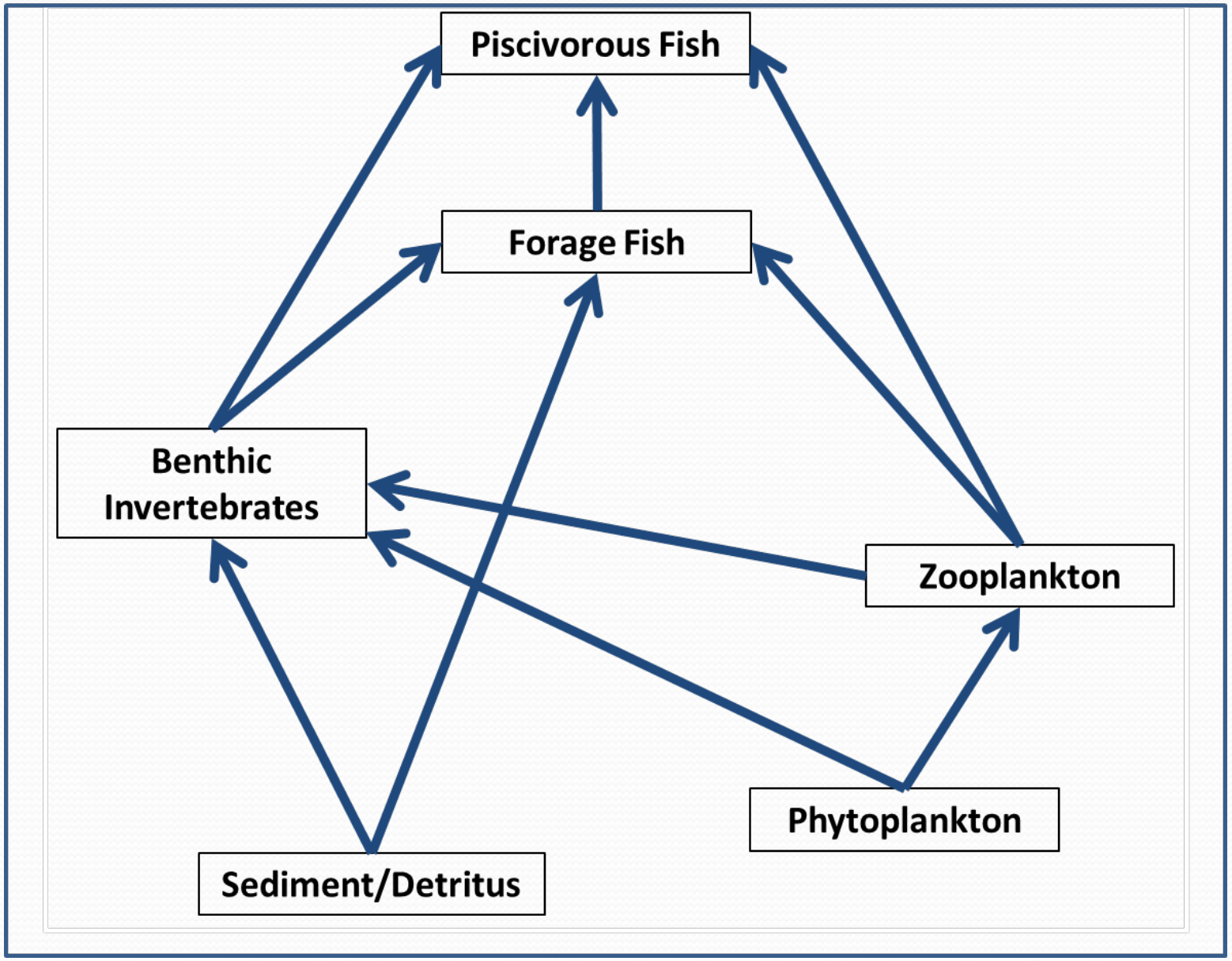
Elimination of PCBs



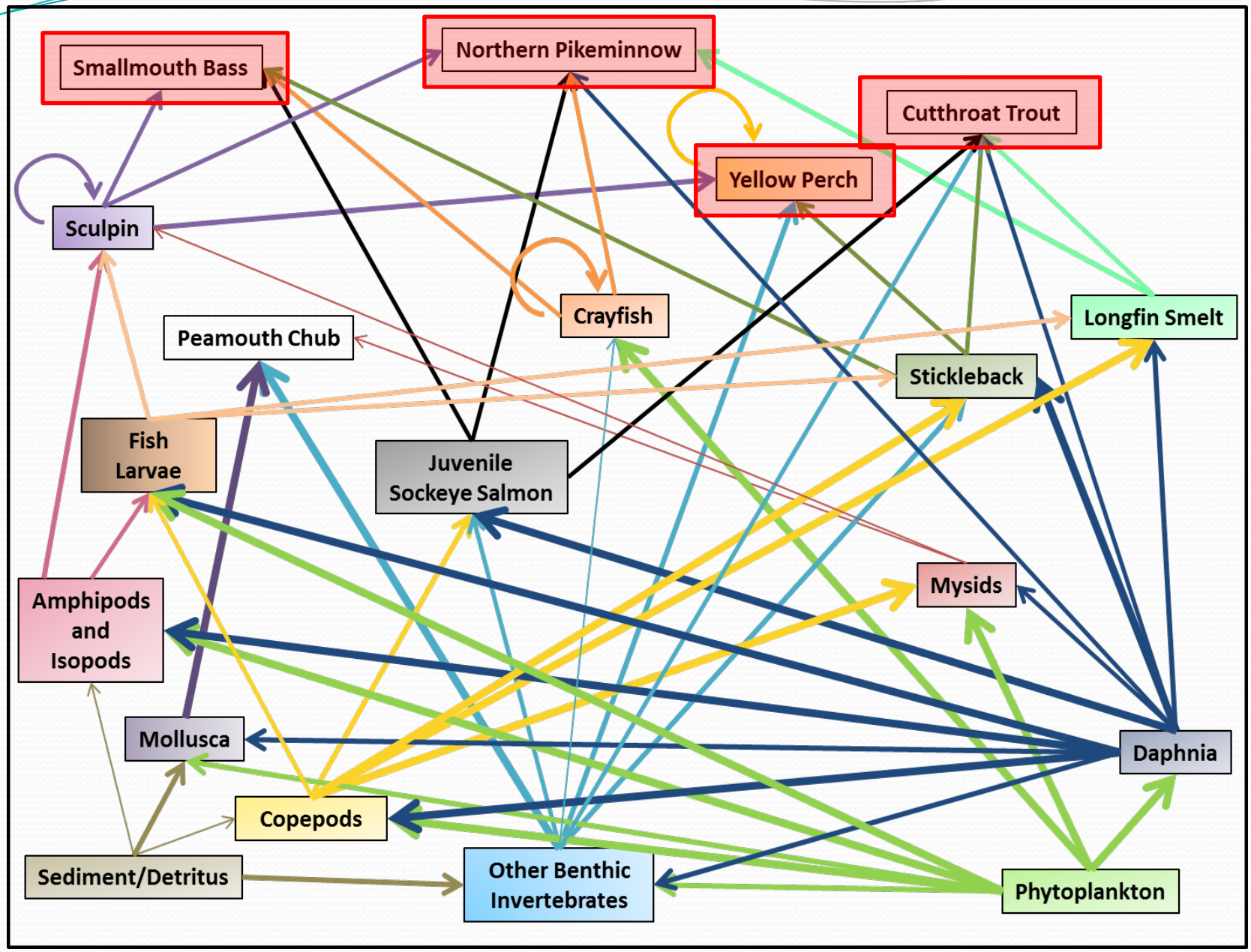
Model Development

- 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)

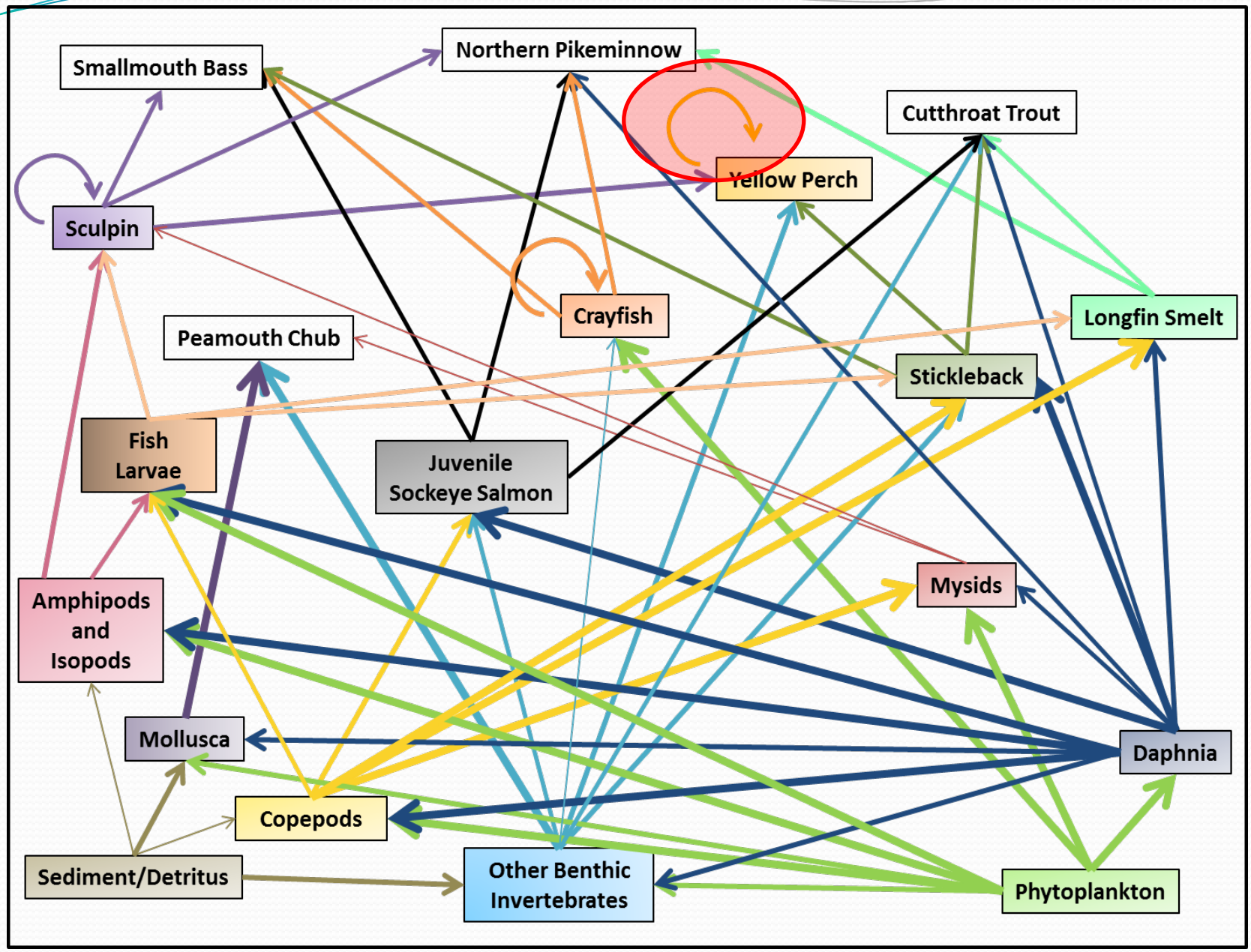
Conceptual Model



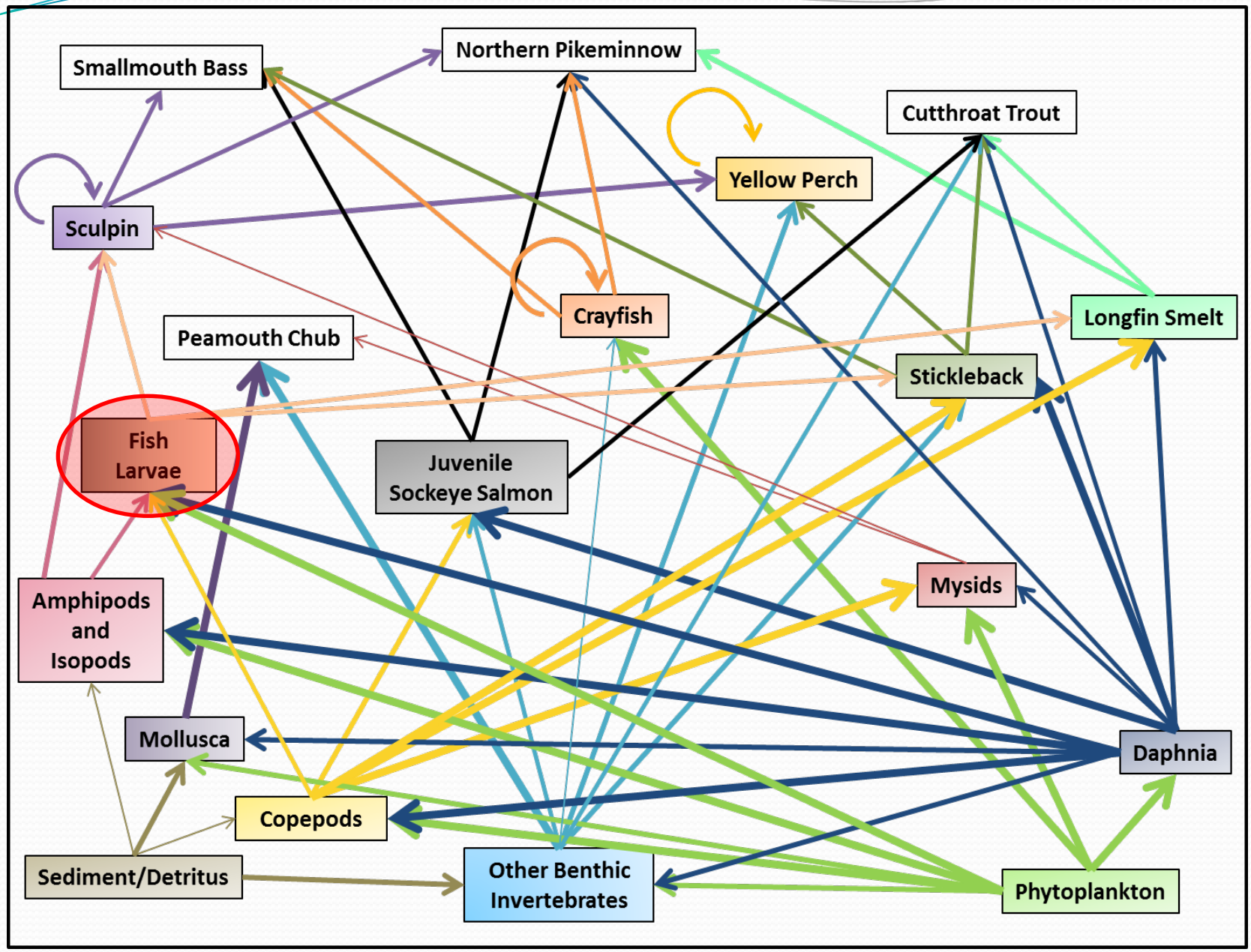
Conceptual Model



Conceptual Model



Conceptual Model



Bioaccumulation Model Testing

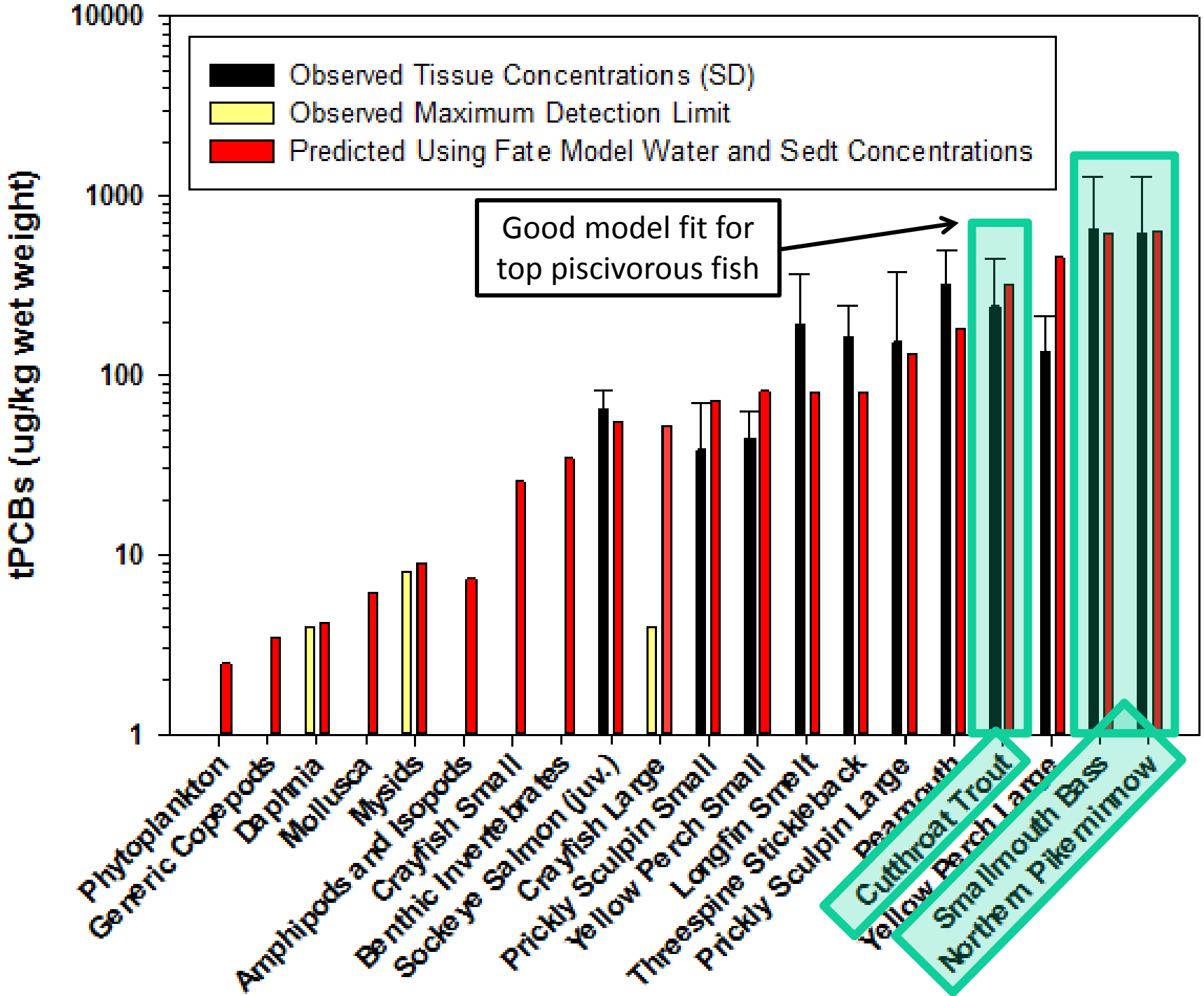
Compare predicted to observed tissue concentrations:

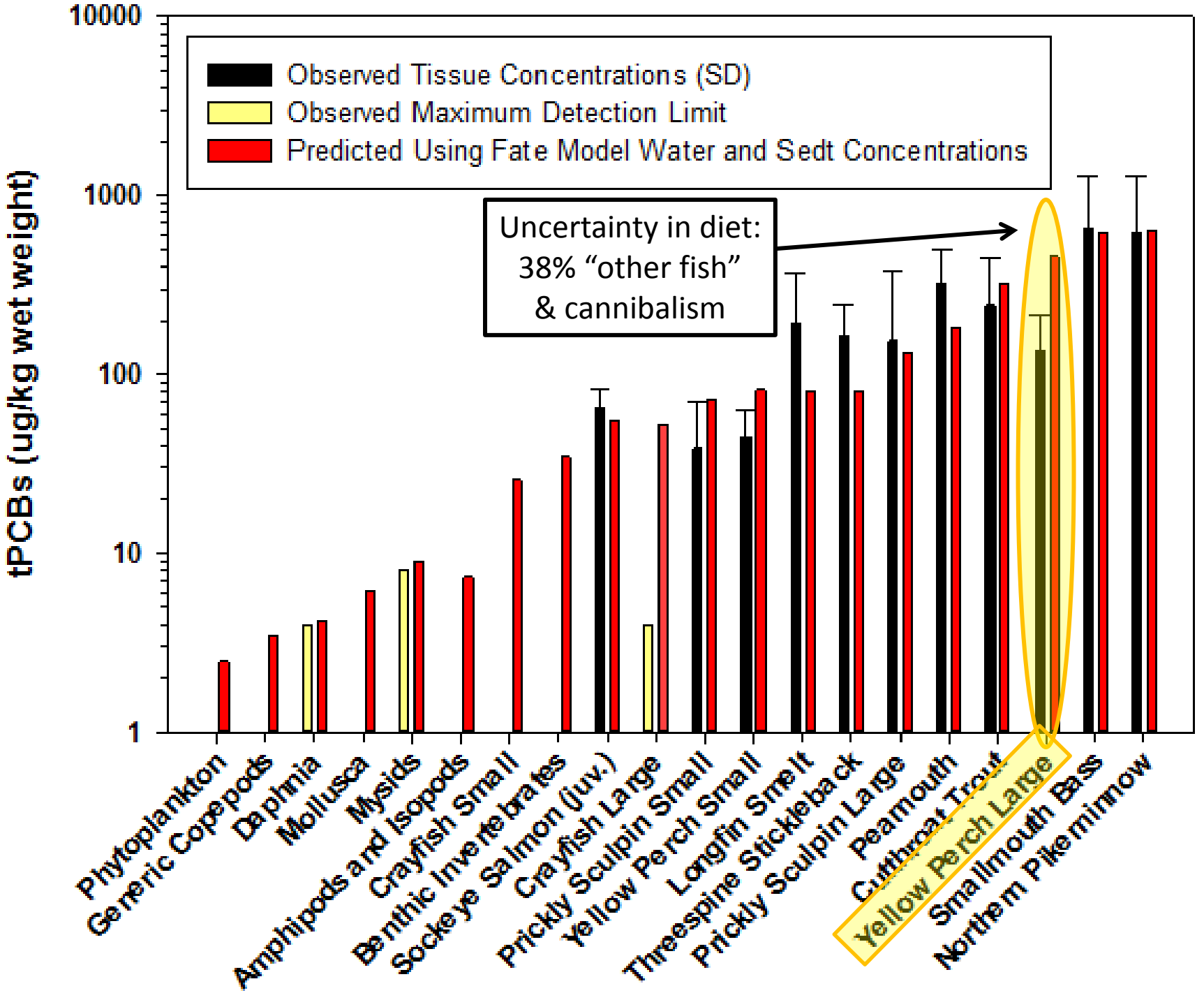
- Used two different water & sediment tPCB inputs:
  (1) Measured in Lake WA
  (2) Fate model-predicted ★

- Calculated model bias

  Inputs measured in Lake WA = 2.3

  Inputs predicted by fate model = 1.2 ★


10000
1000
100
10
1
tPCBs (ug/kg wet weight)
Observed Tissue Concentrations (SD)
Observed Maximum Detection Limit
Predicted Using Fate Model Water and Sedt Concentrations
Good model fit for top piscivorous fish
Phytoplankton
Generic Copepods
Daphnia
Mollusca
Mysids
Amphipods and Isopods
Crayfish Small
Benthic Invertebrates
Sockeye Salmon (juv.)
Crayfish Large
Prickly Sculpin Small
Yellow Perch Small
Longfin Smelt
Threespine Stickleback
Prickly Sculpin Large
Peamouth
Cutthroat Trout
Yellow Perch Large
Smallmouth Bass
Northern Pikeminnow


10000
1000
100
10
1
tPCBs (ug/kg wet weight)
Observed Tissue Concentrations (SD)
Observed Maximum Detection Limit
Predicted Using Fate Model Water and Sedt Concentrations
Uncertainty in diet:
38% "other fish"
& cannibalism
Phytoplankton
Generic Copepods
Daphnia
Mollusca
Mysids
Amphipods and Isopods
Crayfish Small
Benthic Invertebrates
Sockeye Salmon (juv.)
Crayfish Large
Prickly Sculpin Small
Yellow Perch Small
Longfin Smelt
Threespine Stickleback
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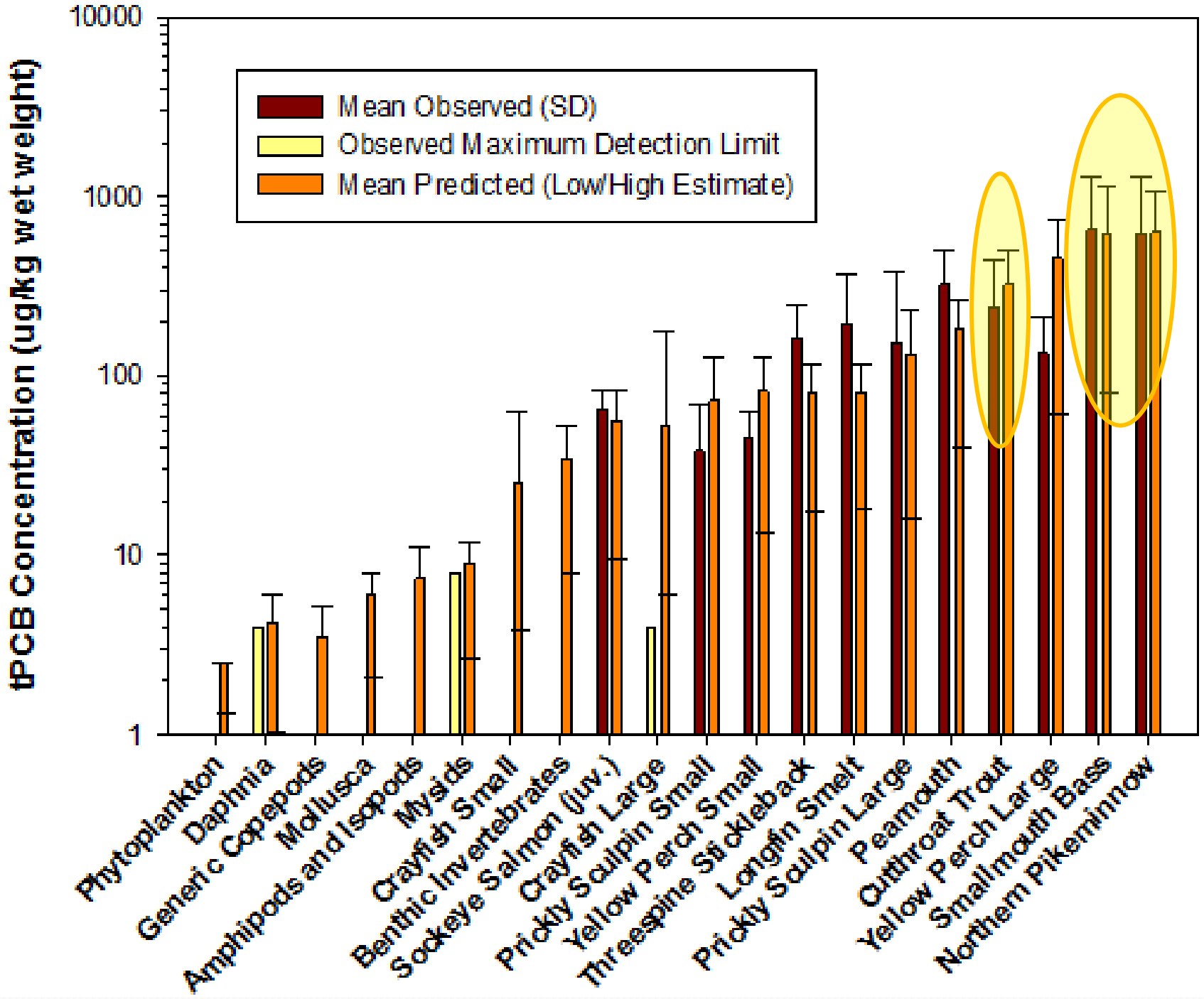
Sensitivity Analysis

- 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


tPCB Concentration (ug/kg wet weight)
10000
1000
100
10
1
Mean Observed (SD)
Observed Maximum Detection Limit
Mean Predicted (Low/High Estimate)
Phytoplankton
Daphnia
Generic Copepods
Mollusca
Amphipods and Isopods
Mysids
Crayfish Small
Benthic Invertebrates
Sockeye Salmon (juv.)
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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.